# **PowerLogic** ADVC Controller

## Operations Manual

**PKR39809-02**
**11/2025**



Schneider Electric

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# Safety Information

## Important Information

Read these instructions carefully, and look at the equipment to become familiar with the device before trying to install, operate, service, or maintain it. The following special messages may appear throughout this documentation or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.



The addition of this symbol to a “Danger” or “Warning” safety label indicates that an electrical hazard exists which will result in personal injury if the instructions are not followed.



This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

**⚠ DANGER**

**DANGER** indicates a hazardous situation which, if not avoided, **will result in** death or serious injury.

**⚠ WARNING**

**WARNING** indicates a hazardous situation which, if not avoided, **could result in** death or serious injury.

**⚠ CAUTION**

**CAUTION** indicates a hazardous situation which, if not avoided, **could result** in minor or moderate injury.

***NOTICE***

***NOTICE*** is used to address practices not related to physical injury.

## Please Note

Electrical equipment should be installed, operated, serviced, and maintained only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material.

A qualified person is one who has skills and knowledge related to the construction and operation of electrical equipment and its installation, and has received safety training to recognize and avoid the hazards involved.

# Safety Precautions

## Safety Rules

**⚠⚠DANGER**

**HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH**

- Apply appropriate Personal Protective Equipment (PPE) and follow safe electrical work practices. See standards or local equivalent.
- This equipment must only be installed and serviced by qualified electrical personnel.
- Perform work only after reading and understanding all of the instructions contained in this guide.
- Turn off all the power sources before working on or inside the equipment.
- Always use a properly calibrated voltage sensing device to confirm power is off.
- Use only Schneider Electric specific tools (operating crank, extraction table, and so on).
- Check all devices, covers, and doors are in correct position before turning on the power.
- Beware of potential hazards and carefully inspect the work area for tools and objects that may have been left inside the equipment.
- Do not modify the mechanical or electrical parts.
- Do not bypass the interlocks before operation.
- Do not operate with protective barriers removed.

**Failure to follow these instructions will result in death or serious injury.**

***NOTICE***

**HAZARD OF INADEQUATE STORING, INSTALLATION, AND USE CONDITIONS**

- Comply with the handling rules and avoid causing any shocks to the device.
- If the equipment is stored before its final installation, observe the storage conditions.

**Failure to follow these instructions can result in equipment damage.**

## Cleaning Instructions

**⚠⚠DANGER**

**HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH**

- Do not use solvents or alcohol for cleaning the equipment.
- Do not use high-pressure cleaner for cleaning the equipment.

**Failure to follow these instructions will result in death or serious injury.**

# About the Document

## Document Scope

This operations manual describes operation and maintenance of the PowerLogic ADVC Controller. It is exclusively intended for use by the manufacturer's staff or by persons certified for the PowerLogic ADVC Controller (training certificate).

Read these instructions carefully and look at the equipment to become familiar with the device before trying to install, operate, service or maintain it.

This guide is an integral part of the product and must be stored so that it is readily accessible at all times and can be used by persons who are going to work on the controller. If the controller is relocated to another site, this guide must be passed on to the new operators along with the unit.

As our products are subject to continuous development; we reserve the right to make changes regarding the standards, illustrations and technical data described in this guide.

This guide does not describe every imaginable individual case or every customer-specific version of the product. For more information that is not included in this guide, contact Schneider Electric.

All dimensions not specified in detail are in millimeters.

## Validity Note

This document is valid for PowerLogic ADVC Controller.

The characteristics of the products described in this document are intended to match the characteristics that are available on www.se.com. As part of our corporate strategy for constant improvement, we may revise the content over time to enhance clarity and accuracy. If you see a difference between the characteristics in this document and the characteristics on www.se.com, consider www.se.com to contain the latest information.

## Intended Use

PowerLogic ADVC Controller are designed exclusively for switching and distributing electrical power. They may only be used in the scope of the specified standards and the controller-specific technical data.

## General Cybersecurity Information

In recent years, the growing number of networked machines and production plants has seen a corresponding increase in the potential for cyber threats, such as unauthorized access, data breaches, and operational disruptions. You must, therefore, consider all possible cybersecurity measures to help protect assets and systems against such threats.

To help keep your Schneider Electric products secure and protected, it is in your best interest to implement the cybersecurity best practices as described in the Cybersecurity Best Practices document.

Schneider Electric provides additional information and assistance:

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  - Report vulnerabilities and incidents.
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  - Access the cybersecurity posture.
  - Learn more about cybersecurity in the cybersecurity academy.
  - Explore the cybersecurity services from Schneider Electric.

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## Queries

For any questions, suggestions, or need of further information about this guide, contact Schneider Electric. For additional details, visit our website www.se.com.

We always strive to provide you with the best-possible information for optimum, safe use of our products. Contact Schneider if you have any recommendations, amendments, or proposals for improvement.

# Scope of this Operations Manual

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# Document Scope

This manual describes the operation of the PowerLogic ADVC Controller Range. While every care has been taken in the preparation of this manual, no responsibility is accepted for loss or damage incurred by the purchaser or user due to an error or omission in this document. Inevitably, not all details of equipment are provided, nor are instructions for every variation or contingency during installation, operation, or maintenance. For additional information on specific problems or requirements, contact the manufacturer or your distributor.

## Automatic Circuit Reclosers using the PowerLogic ADVC Controller

An Automatic Circuit Recloser (ACR) is a system consisting of a controller (PowerLogic ADVC Controller) and appropriate switchgear connected by an umbilical control cable. The switchgear needs to be capable of breaking fault current that is a circuit breaker.

## Automatic Sectionalisers using the PowerLogic ADVC Controller

An Automatic Sectionaliser (AS) is a system consisting of a controller and appropriate switchgear connected by an umbilical control cable. The switchgear may be either a Load Break Switch (LBS) or a circuit breaker.

# Types of Compatible Switchgear

## PMSet E Series

The PMSet™ E Series switchgear is a three phase circuit breaker designed for automatic circuit reclosing. It uses ganged vacuum interrupters insulated with hydrophobic cyclo-aliphatic epoxy resin mouldings operated by a single magnetic actuator for both tripping and closing. The PMSet E Series can be used in conjunction with an PowerLogic ADVC Controller as an ACR.

**NOTE:** PMSet E Series is supported only with the PowerLogic ADVC Controller, with firmware version A50-03.04 and higher.

**PMSet E Series 38 kV Support**

Version A50-07.01 supports interfacing with and operating the PMSet E Series 38 kV switchgear. For the controller to recognize the PMSet E Series 38 kV, it is mandatory to use rev G of the control cable (ESR01-2001). The cable revision is printed on a brady label and visible on the control cable. This revision is suitable for use with both the 27 kV and the 38 kV switches.

## PMSet U Series

The PMSet U Series switchgear is a three phase circuit breaker designed for automatic circuit reclosing. It uses ganged vacuum interrupters insulated with hydrophobic cyclo-aliphatic epoxy resin mouldings operated by a single magnetic actuator for both tripping and closing. The PMSet U Series can be used in conjunction with an PowerLogic ADVC Controller as an ACR or an AS.

## RL Series

The RL Series switchgear is a three phase LBS designed for use with the PowerLogic ADVC Controller as an AS. It uses puffer interrupters inside a fully welded and sealed stainless steel tank filled with $SF_6$ gas.

## PMSet UR Series

The PMSet UR Series switchgear is a three phase circuit breaker designed for automatic circuit reclosing. It uses ganged vacuum interrupters insulated with hydrophobic cyclo-aliphatic epoxy resin moldings operated by a single magnetic actuator for both tripping and closing. The PMSet UR Series switchgear is an evolution of the U Series switchgear, with higher current support and BIL, that is equipped with 6 internal CVTs for voltage measurement.

The PMSet UR Series can be used in conjunction with a PowerLogic ADVC Controller as an ACR or an AS.

**NOTE:** PMSet UR Series is supported only with the PowerLogic ADVC Controller, with firmware version A50-19.01 and higher.

# Types of PowerLogic ADVC Controller

There is one controller in the PowerLogic ADVC Controller range covered by this manual. The PowerLogic ADVC Controller can run firmware versions 50 and higher. PowerLogic ADVC Controller can be distinguished by the different array of communications ports that can be seen above the operator interface (O.I.).

## PowerLogic ADVC Controller

The PowerLogic ADVC Controller has two RS232 ports, two Ethernet ports, three USB type A ports, and one USB type B port.

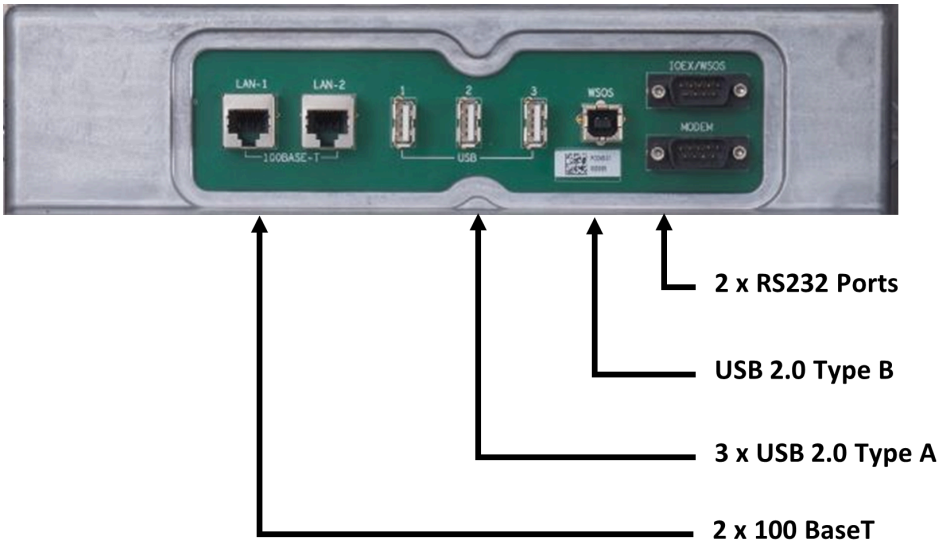



**Figure 1**
PowerLogic ADVC Controller communications ports

# Firmware identification system

The firmware running in the PowerLogic ADVC Controller Range is identified by its version which has the form

**AXX-XX.XX**.

For example, A50-01.02 would be version 50.

This precisely identifies the firmware loaded into the program memory on the controller.

In order to obtain effective technical support from the manufacturer or your distributor it is vital to record the firmware version and to quote this when making any enquiries.

Without this information it is impossible for our customer service department to identify the firmware and provide the correct support.

The firmware version can be found on the ***set*VUE** O.I. on the Switchgear Wear/ General Details, page 646 and on the ***flex*VUE** O.I. in the Table 125 ***flex*VUE** Switchgear Info, page 619 menu.

# Firmware versions

This manual covers firmware version 50 supported by the PowerLogic ADVC Controller.

# Potential Risks and Compensating Controls

Cyber threats are part of the digital world of communicating products. The PowerLogic ADVC Controller offers several different features to users to manage cyber security risks.

## Unsecure protocols

Modbus, DNP3, IEC 60870-5-101, IEC 60870-5-104, IEC 61850 (IEC 61850 MMS (Manufacturing Message Specification) and IEC 61850 GOOSE (Generic Object Oriented System Event)) protocols, and some IT protocols (Network Time Protocol (NTP), DHCP, PPP) are unsecure.

The device does not have the capability to transmit data encrypted using these protocols. If a malicious user gained access to your network, transmitted information could be disclosed or subject to tampering.

For transmitting data over an internal network, physically or logically segment the network and restrict access using standard controls such as fire walls and in particular IP Table allow lists.

For transmitting data over an external network, encrypt protocol transmissions over all external connections using an encrypted tunnel, TLS wrapper or a similar solution.

For PPP over Radio connection the customer is responsible for verifying that the cellular network is a private and protected network.

## Enclosure

The physical integrity of the installation must be ensured by the end user. Physical access to the PowerLogic ADVC Controller and the operational area must be restricted.

The PowerLogic ADVC Controller embeds a *door open* digital signal to report to the system a physical access to the cabinet or the room.

Standard PowerLogic ADVC Controller Range cubicles are equipped with 3 or 2-point locking door and a vandal resistant door handle. User provided lock can be helps to secure the cabinet door.

## Terminology

ACR refers to the complete installation consisting of three major components that is switchgear, controller, and interconnecting cable. If the switchgear is a LBS and the controller is running sectionaliser firmware, the system is referred to as an AS. Where LBS is used in this document it refers to the switchgear component only.

# General Cybersecurity Information and Non-Inclusive Terminology

## General Cybersecurity Information

In recent years, the growing number of networked machines and production plants has seen a corresponding increase in the potential for cyber threats, such as unauthorized access, data breaches, and operational disruptions. You must, therefore, consider all possible cybersecurity measures to help protect assets and systems against such threats.

To help keep your Schneider Electric products secure and protected, it is in your best interest to implement the cybersecurity best practices as described in the Cybersecurity Best Practices document.

Schneider Electric provides additional information and assistance:

- Subscribe to the Schneider Electric security newsletter.
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  - Find Security Notifications.
  - Report vulnerabilities and incidents.
- Visit the Schneider Electric Cybersecurity and Data Protection Posture web page to:
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  - Learn more about cybersecurity in the cybersecurity academy.
  - Explore the cybersecurity services from Schneider Electric.

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# General Information

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# Introduction

The PowerLogic ADVC Controller Range is designed for outdoor pole mounted operation.

All cubicle vents are screened against vermin entry, and the cubicle door is sealed. Complete sealing against water entry under all conditions is not expected, such as during operation in the rain. Instead, the design is such that if any water does enter, it will drain out of the bottom without affecting the electrical or electronic parts. A rain shield on the Power Supply Unit (PSU) will help protect Miniature Circuit Breakers (MCBs) if the door is open during driving rain. The extensive use of stainless steel and other corrosion-proof materials helps to ensure that the presence of moisture has no detrimental effects.

Condensation can be expected to form under some atmospheric conditions such as tropical storms. However, condensation will be on metal surface where it must be restricted to metal surface. The water runs out in the same way as any other water entering the cubicle. Condensation will run out of the bottom or be dried by ventilation and self-heating.

All electronic modules are fully sealed to IP65 and are self-heating.

# Cubicle Options

The PowerLogic ADVC Controller Range is available with either of two cubicles, the ultra and the smaller compact version.

Both cubicles are the same depth but the Ultra is taller and slightly wider. Both cubicles are fitted with the same vandal resistant door handle, although the ultra utilizes three point locking and the compact has a two-point locking system. Both cubicles are fitted with the same door stay mechanism which helps to secure the door open at 135°. The extra room in the ultra cubicle means that it can house an additional equipment tray whereas the compact only has room for one.

Both ultra and compact cubicles can be fitted with either of the optional O.I. that is ***set*VUE** or ***flex*VUE**.

## Ultra



Stainless steel/Mild steel

3–Point locking

2 customer trays

Dimensions

**Cubicle** height 960 mm

**Cubicle** width 463 mm

**Cubicle** depth 352 mm



**Figure 2**
Ultra cubicle with ***flex*VUE** O.I.

Figure 3 shows an PowerLogic ADVC Controller with a ***flex*VUE** O.I. housed in an Ultra cubicle. The door is held open by the door stay mechanism. The standard equipment tray can be seen against the left hand wall and the additional equipment tray can be seen at the top of the cubicle. The 3-point locking mechanism on the door is also visible.

## Compact



Stainless steel/Mild steel

2–Point locking

1 customer trays

Dimensions

**Cubicle** height 730 mm

**Cubicle** width 435 mm

**Cubicle** depth 352 mm




**Figure 3**
Compact cubicle with ***set*VUE** O.I.

Figure 3 shows an PowerLogic ADVC Controller with a ***set*VUE**O.I. housed in a compact control cubicle. The door is held open with the door stay mechanism. The standard equipment tray has been temporarily relocated to the commissioning bracket for accessibility. This is also a feature of the ultra cubicle. Note the terminal block on the DIN rail at the bottom of the tray and the two point locking mechanism on the door.

# Controller Modules

Apart from the additional equipment tray in the ultra control cubicle, both cubicles house the same equipment. The individual modules are:

- Control and Protection Enclosure (CAPE)
- Power Supply Module (PSM)
- Battery Tray and Batteries
- Equipment Tray or Accessory Mounting Tray

## CAPE




**Figure 4**
PowerLogic ADVC Controller CAPE

Figure 5 shows an PowerLogic ADVC Controller CAPE with a ***flex*VUE** O.I.

The CAPE for an PowerLogic ADVC Controller has communications ports as described in PowerLogic ADVC Controller, page 17.

The CAPEs for PowerLogic ADVC Controller have the same configuration below the O.I., for the switchgear control cable connection and main loom cable connection, as shown in Figure 6.

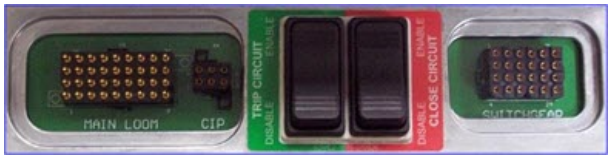



**Figure 5**
CAPE connection and isolation

Shown in Figure 6 from left to right are the following:

- Main loom connector – A 36 - way loom connector used to connect the CAPE to the auxiliary supply, batteries, temperature sensor, battery heater, and equipment tray.
- CIP - Current injection port for secondary current injection.
- Trip and close circuit isolation switches.
- Switchgear connector for the control cable connection.

The CAPE incorporates all the electronics modules and performs the following functions:

- Protection Relay
- Network Management
- Communications

- Switchgear Control
- Uninterruptible Power Supply
- O.I.

The components are assembled in a diecast aluminum enclosure to help protect the electronics against electromagnetic, electrostatic, and environmental influences. Assembly is performed in a controlled environment and the enclosure is sealed to IP65 which helps to ensure maximum reliability throughout the service life of the product.

The CAPE digitizes the Current Transformer (CT) signals and Capacitive Voltage Transformer (CVT) signals from the switchgear. These are used to perform the controller's protection, metering, and control functions.

## PSM



**Figure 6**
PSM

The PSM supplies power to the CAPE, and controls the supply from external auxiliary sources.

The PSM encloses all 115/230 Vac mains connections. Internally it provides terminals for auxiliary power supply connection. Cable-tie points are provided to attach the auxiliary supply cables. Miniature circuit breakers are used to help protect and switch the battery and auxiliary power supplies on/off. A durable cover is used to enclose all the terminations.

**⚠⚠DANGER**

**HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH**

Only qualified personnel, trained, authorized, and familiar with the contents of the latest issue of the safety guide, safety information, technical data chapters, and the equipment rating labels shall work on installation, connection, commissioning, maintenance, or servicing of the equipment.

**Failure to follow these instructions will result in death or serious injury.**

## Options

In its standard configuration the PSM will always provide one AC auxiliary supply input. At the time of order it is possible to specify an auxiliary supply voltage of 115 Vac or 230 Vac. The voltage is pre-set in the factory. The voltage is indicated on the controller rating plate. If necessary, it is possible to swap the voltage setting in the field from 230 to 115 or vice versa. If this is done the rating plate will need to up updated to show the new rating.

The standard PSM includes a single 115/230 Vac auxiliary supply input with circuit breaker, toroidal transformer, filter, and terminals. A battery circuit breaker is always fitted as well.

The PSM cover design includes space for the different circuit breaker combinations that can result from the supply options mentioned above.

Removable panels are located in the cover. To make sure these panels are not accidentally pushed out, the panels are held in place with small tabs that have to be snapped off, using pliers, before they can be removed.

IEC power outlet – An IEC power outlet can also be fitted in the chassis.

## Symbols

The following symbols are used to identify the circuit breakers on the PSM.

| Symbol | Description |
|---|---|
|  | AC Supply (115 or 230 Vac) |
|  | General Purpose Outlet (GPO) (Optional) |
|  | Battery |
|  | Second 115 or 230 VA AC Supply (Optional) |
|  | Integrated Supply Voltage Transformer (VT) (Optional) |

**NOTE:** It is possible to have 2 AC supplies and an Integrated supply fitted in the same unit.

## Ultra versus Compact Options

The following table lists the possible power supply options for the PowerLogic ADVC Controller Range using the Ultra versus Compact cubicle options.

**Table 1 ULTRA versus COMPACT Power Supply Options**

| Ultra | Compact |
|---|---|
| AC Supply | AC Supply |
| Integrated VT | Integrated VT |
| Dual AC Supply | - |
| DC Supply | - |
| **Battery Types:** | |
| Lead-Acid: 2 x 12V 7.2Ah batteries (2 x 12V 12Ah option) | Lead-Acid: 2 x 12V 7.2Ah batteries |
| LiFePO4: 1 x 24V 10Ah | - |
| **Temperature Range:** | |
| Lead-Acid batteries: -40 °C to 50 °C (Battery heater) | Lead-Acid batteries: -10 °C to 50 °C (No battery heater) |
| LiFePO4 batteries: -40 °C to 50 °C (Battery heater) | - |

**NOTE:**

1. Only the ultra cubicle can be fitted with the larger 12 Ah batteries and the battery heater option.
2. Only the ultra cubicle has the provision for a second auxiliary AC supply.

# Battery Tray and Batteries

**⚠CAUTION**

**HAZARD OF FIRE**

- Only trained and authorized personnel who are familiar with the latest safety guidelines, technical documentation, and equipment labels must handle tasks such as installing, connecting, starting up, maintaining, or servicing battery systems.
- Replace the battery with an equivalent battery to the original.
- Use only the appropriate connectors to connect the battery.
- Check the polarity before turning on power to this device.
- Do not exceed the battery's operating temperature range, refer to **Table 1 ULTRA versus COMPACT Power Supply Options** for additional information, Ultra versus Compact Options, page 26).

**Failure to follow these instructions can result in injury or equipment damage.**



**Figure 7**
2 x 7.2 Ah Batteries on tray

Figure 7 shows two 7.2 Ah batteries mounted on the battery tray in the base of an PowerLogic ADVC Controller cubicle. They are attached by velcro straps.

The battery tray is made from stainless steel and shaped to restrict movement of the batteries. It is also mounted at an angle to make battery handling easier.

An EPDM rubber battery protector mat is placed on top of the tray and velcro straps are used to hold the batteries in place. The mat is designed to help protect the batteries and straps.

A battery temperature sensor is built into the battery tray. The sensor is used by the battery charging electronics to optimize battery life.



**Figure 8**
Battery tray temperature sensor

# Equipment Tray



**Figure 9**
PowerLogic ADVC Controller equipment tray

The equipment, or customer accessory mounting tray provides a flat surface where devices such as a modem/radio or Input/Output Expander (IOEX) can be attached.

The tray is die cast aluminium and includes a variety of mounting holes and slots to facilitate the mounting of almost any type of equipment.

Ultra and compact cubicles are both fitted with an equipment tray on the left hand side wall of the cubicle. This tray is fitted with a terminal block from which power can be supplied for the installed equipment.

The side tray can be repositioned as shown in Figure 3 to a more accessible bracket for mounting and commissioning of equipment.

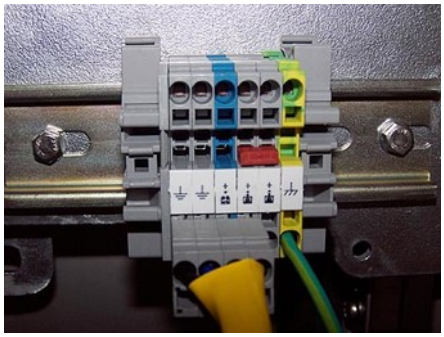


**Figure 10**
Equipment tray terminal block

The terminal block on the equipment tray provides the following from left to right:

- Two negative terminals (One for the radio supply and one for the IOEX supply).
- IOEX supply positive (blue terminal).
- Radio supply positive (two terminals linked together).
- Cubicle earth terminal.

The terminal block is connected to the 36 way plug that connects to the main loom socket.

The Ultra cubicle has an extra equipment tray at the top of the cubicle to allow for more equipment to be installed. Only the side mounted equipment tray is fitted with a terminal block.

# O.I. Options

The PowerLogic ADVC Controller can be remotely controlled via modems or other communications devices.It can be controlled locally using a laptop computer connected directly to a local port, or it can be controlled by the O.I.

The O.I. offers full functionality for changing settings, tripping and closing the switchgear or displaying current values or past events related to the switchgear function.

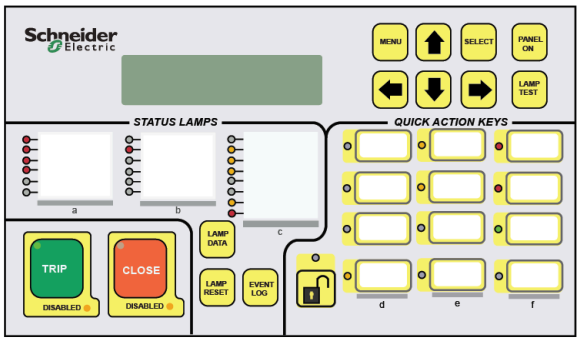
The O.I. is mounted on the CAPE inside the PowerLogic ADVC Controller cubicle and accessed by opening the cubicle door. There are two styles of O.I. available known as ***set*VUE** and ***flex*VUE**.

Either O.I. can be used with PowerLogic ADVC Controller regardless of the cubicle type that is ultra or compact. The required O.I. needs to be determined at the time of order as they cannot be interchanged in the field.

The O.I. incorporates all the necessary electronics to function independently from the PowerLogic ADVC Controller hardware and firmware platforms that is the platform remains the same regardless of which interface is used.

The two O.I.s are shown in the figure below:

*flexVUE*
Operator Interface




*setVUE*
Operator Interface

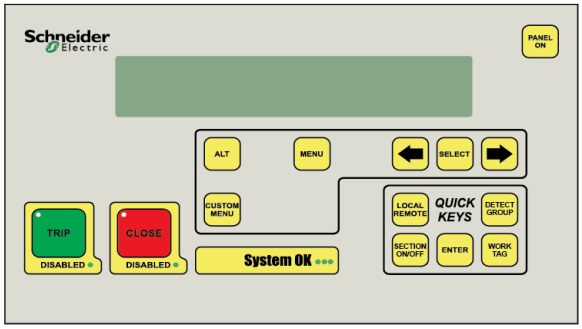



**Figure 11**
O.I. options available for PowerLogic ADVC Controller

# Panel Settings are Read-only When in Remote Mode

With A50-13.xx, there is now a feature to disable any setting changes via the Front Panel, when the controller is in Remote Mode (RM).

When the Panel Settings are read-only when in RM feature is selected, and the controller is put into RM, all panel pages except the Local/Remote Control field are set to read-only mode.

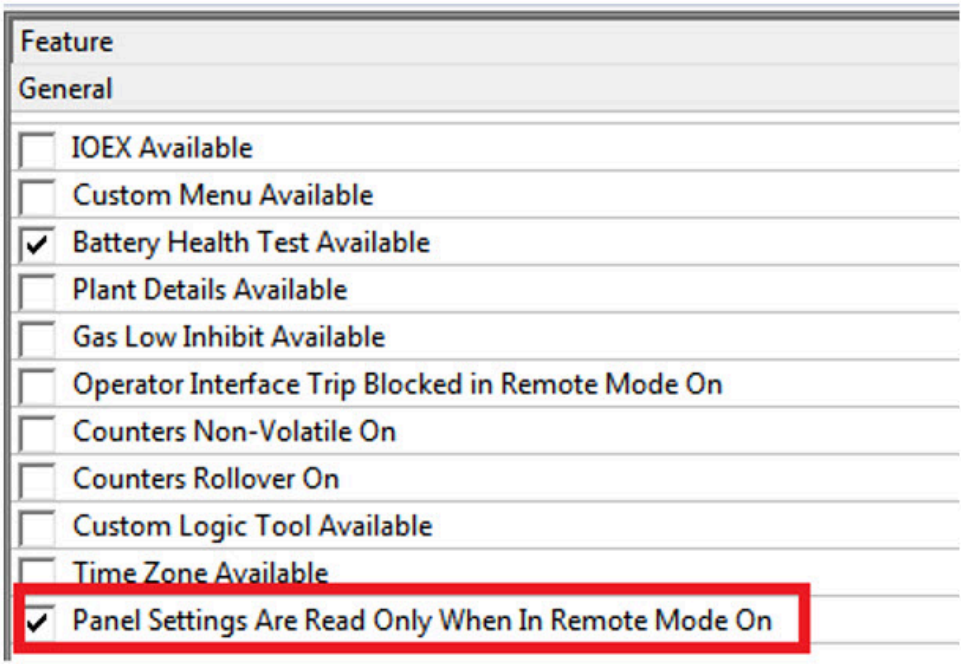



**Figure 12**
Enabling Panel Settings are Read-only in RM feature

# Technical Specifications

## What's in This Chapter

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Ratings and Specifications....32
General Specifications....32
Power System Measurements....34
$SF_6$ Gas Pressure Measurements....35

# Firmware Versions

Version 50 is the latest release of firmware for the PowerLogic ADVC Controller.

# Ratings and Specifications

## Duty Cycle

Maximum allowable duty cycle at full short circuit current rating:

- Open-0.5 s-Close. (PMSet E Series and PMSet UR Series); Open-0.3 s-Close (PMSet U Series)
- Open-2 s-Close
- Open-2 s-Close
- Open followed by 300 s recovery time

## CTs

There is no access to CT connections on the equipment. This data is supplied for information only.

| Parameter | Value |
|---|---|
| Ratio | 2000:1 (PMSet U Series, PMSet UR Series, and RL Series) |
| | 1000:1 (PMSet E Series) |
| Accuracy 10...800 A | ±0.5% |
| Accuracy 800...12,500 A | ±2.5% |

# General Specifications

| Parameter | Value |
|---|---|
| Cubicle material (ULTRA) | Stainless and mild steel |
| Cubicle material (COMPACT) | Stainless and mild steel |
| Cubicle shell sealing | IP 65 (ULTRA), IP 54 (COMPACT) |
| Electronic enclosure sealing | IP 65 |
| Wind loading resistance of structure | >160 km/hr |
| Wind loading on door when latched in open position | >60 km/hr |
| Angle of door opening | 135° |
| Operating temperature range with Lead-Acid batteries | -10...50 °C |
| Operating temperature range with LiFePO4 battery | 0...50 °C |
| Extended operating temperature range (optional battery heater required) | -40...50 °C |
| Maximum radiation | 1.1 kW/m$^2$ |
| Humidity | 0...100% |
| Standard control cable length(1) | 7 m |

| Parameter | Value |
|---|---|
| Maximum vertical separation from Schneider ACR's and AS's with standard (7 m) control cable | 5 m |
| Maintenance interval(2) | 5 years |
| Auxiliary supply voltage (LV AC mains supply) | As ordered ± 20% |
| Required auxiliary supply rating | 100 VA |
| Lead-Acid batteries (12 Ah batteries are supplied with the battery heater) | 2 x 12 V, 7.2 Ah or 2 x 12 V, 12 Ah |
| LiFePO4 batteries | 1 x 24 V, 10 Ah |
| Lead-Acid batteries hold up time (fully charged at 25 °C) | 28 hours with 7.2 Ah or 46 hours with 12 Ah |
| LiFePO4 battery hold up time (fully charged at 25 °C) | 43 hours |
| Battery replacement interval(2) | 5 years |
| Lead-Acid batteries low voltage at 0 °C(3) | 23 V |
| LiFePO4 battery low voltage at 0 °C(3) | 23 V |
| Lead-Acid batteries high voltage at 0 °C(3) | 32 V |
| LiFePO4 battery high voltage at 0 °C(3) | 27.7 V |
| Earthing | 10 mm earth stud |
| Battery heater power (where fitted) | 10 W |
| Battery heater element life | 30,000 hours(4) |
| **Radio/Modem**(5) | |
| Radio/Modem power supply voltage (set by user) | 5...15 Vdc |
| Radio/Modem power supply continuous current(6) | 3 A |
| Radio/Modem power supply max current | 8 A for 30 s with 10% duty cycle |
| Radio/Modem power supply continuous power | 45 W |
| Radio/Modem power supply peak power | 120 W for 15 min at 10% duty cycle |
| Radio/Modem space - side compartment | 250 x 70 x 185 mm |
| Radio/Modem space - upper compartment (ULTRA only) | 185 x 300 x 215 mm |
| Radio/Modem interface | IP, RS-232, USB-to-RS-232 |
| Radio/Modem power shutdown time (user configurable) | 1...1440 min |
| Shutdown time increment | 10 s |
| **Secondary Injection Ratings** | |
| Continuous secondary current | 0.8 A |
| Short time secondary current | 12 A for 3 s |
| Short time current recovery time | 60 s |

(1) Other control cable lengths available, 4,11 and 20 m.

(2) Battery replacement interval is influenced by environmental temperature.

(3) Temperature compensated at 48 mV/°C.

(4) If the heater is required for 6 months at say an average 10 hours per day, it would be required for approximately 2,000 hours running time per year, thus giving 15 years life.

(5) A radio or modem may be fitted by the manufacturer or by the utility, for remote communications. Space, power and data interfaces are provided within the control cubicle.

(6) For an external VT, the maximum continuous current drawn from the radio supply must be limited to 0.5 A.

# Power System Measurements

HV line measurements on all three phases are made as follows:

| Parameter | Value |
|---|---|
| Voltage Range (RMS Phase/Earth) U27/UR27/ E27 | 2...15 kV |
| Voltage Range (RMS Phase/Earth) W | 2...24 kV |
| Voltage Range (RMS Phase/Earth) RL15/RL27 | 2…15 kV |
| Voltage Range (RMS Phase/Earth) RL38 | 2…22 kV |
| Voltage Resolution | 1 V |
| Voltage Accuracy(1) | 2.5% ± 25 V |
| Live Terminal Threshold Voltage range(2) | 2...15 kV |
| Live Terminal Threshold Voltage setting resolution | 1 V |
| Live Terminal Threshold Voltage accuracy(1) | 5% ± 250 V |
| **Ratings and Specifications** | |
| Live terminal threshold hysteresis | -20% |
| Phase current range (true RMS) | 1.5...800 A |
| Earth current range (true RMS) | 1...800 A |
| Current resolution | 1 A |
| Phase current accuracy(1) | ± 1.0% ± 1 A over range 10...800 A |
| Earth current accuracy(1) | ± 1.0% ± 1 A over range 10...800 A |
| Apparent power range | 0...36 MVA: PMSet U Series |
| Apparent power resolution | 1 kVA |
| Apparent power accuracy(1) | ± 3% over range 20...800 A |
| Real power range(3)(4) | -36...+36 MW: PMSet U Series |
| Real power accuracy(1) | ± 3% at (Power Factor) PF> 0.9 |
| Real power resolution | 1 kVA |
| Reactive Power Range | 0...36 MVAR: PMSet U Series |
| Reactive power Resolution | 1 kVAR |
| Reactive power accuracy(1) | ± 4% at PF = 0.5 |
| Unsigned PF | 0.0...1.0 |
| PF resolution | 0.01 |
| PF accuracy | ± 0.05 |
| Measurement filter time constant (step response) | 2 s |
| Measurement update rate | 0.5 s |

(1) Includes accuracy of switchgear CT and VTs.

(2) Used for live/dead display, live load blocking and loss of supply detection.

(3) In database for transmission by a protocol.

(4) Used to accumulate kWh reading for weekly maximum demand data.

# $SF_6$ Gas Pressure Measurements

Gas pressure measurement is only available when the switchgear for an ACR or AS uses $SF_6$ as the insulating medium, that is RL Series switchgear.

| Parameter | Value |
|---|---|
| **RL Series** | |
| Nominal pressure at 20 °C | 105 kPa gauge at 25 °C |
| Gas pressure display resolution | 1 kPa |
| Gas pressure display accuracy | ± 10 kPa |
| Gas high alarm setting | 65 kPa gauge at 25 °C |
| Gas low alarm setting | ± 10 kPa |

# Operator Interfaces

## What's in This Chapter

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***set*VUE** O.I. ..... 44

# *flex*VUE O.I.

The ***flex*VUE** O.I. provides the user with 20 indicator lamps and 12 Quick Action Keys (QAK), each with their own indicator lamps that are totally configurable by the user through the Windows Switchgear Operating System (WSOS) software application. This interface provides the user with instant feedback about the switchgear, and minimizes the need to navigate through layers of menu structure to find information.

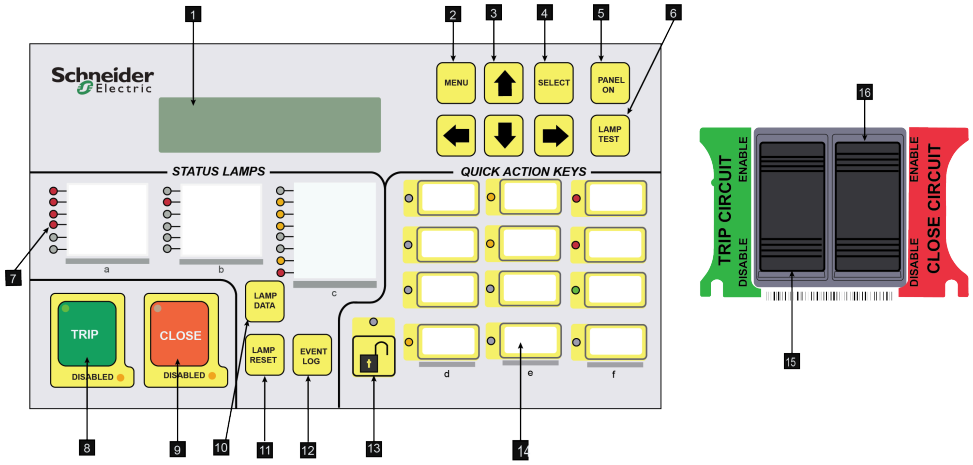



**Figure 13**
***flex*VUE** O.I.

The functions of the items identified in the figure above are described in the table below.

**Table 2 *flex*VUE O.I. functions**

| Sl.No | Item | Description(1) |
|---|---|---|
| 1 | Display | Back-Lit Liquid Crystal Display (LCD). 2 lines × 20 Character |
| 2 | **MENU** Key | Pressing the MENU key allows the user to enter the configuration menu from where it is possible to navigate the LCD menu structure, select fields and edit settings. |
| 3 | Arrow/Navigation Keys | The ARROW keys are used to browse between display groups, fields and change values. |
| 4 | Arrow/Navigation Keys | SELECT is used to select fields or values when setting changes are being made. |
| 5 | **PANEL ON** Key | PANEL ON: turns the O.I. on or off.<br>An optional door switch is available to turn the O.I. on when an operator opens the door and off when the door is closed. If the controller is fitted with this option the Panel On key can be used to turn the O.I. off/on while the door is open. Closing the door turns the O.I. off. |
| 6 | **LAMP TEST** Key | LAMP TEST: tests all lamps on the O.I.<br>The purpose is to alert the user of any lamps or colors that may not be working correctly. The test simultaneously cycles all lamps through Red, Orange and Green. |
| 7 | Indicator Lamps | These lamps are used to provide instant indication of the controller and switchgear status. Depending on the configuration, the lamps can be RED, GREEN or ORANGE and ON, OFF or FLASHING. The multiple colors allow for grouping of similar functions e.g. red for protection, orange for voltage and green for system health. |
| 8 | **TRIP** Key | Trips the switchgear to Lockout and the green(2) lamp located inside the button indicates the open state of the recloser. |
| 9 | **CLOSE** Key | Closes the switchgear and the red(2) lamp located inside the button indicates the close state. |
| 10 | **LAMP DATA** Key | LAMP DATA is used to display additional data specific to each status lamp. |
| 11 | **LAMP RESET** Key | Resets the Status Lamps. Lamps requiring further attention from the operator will remain lit. Note that some of the status lamps such as controller power and terminal live are continuously updated and therefore not affected by the reset command. |
| 12 | **EVENT LOG** Key | Displays the switchgear and controller Event Log on the LCD display. Earlier events can be viewed by pressing the UP arrow key. |
| 13 | Quick Action Key Unlock | To use the QAK, an operator must first press the Unlock key(3). The lamp above the unlock key will remain lit while the QAK are active.<br>To deactivate the QAK an operator can press the unlock key again. The lamp will turn off. |

**Table 2 *flex*VUE O.I. functions (Continued)**

| Sl.No | Item | Description(1) |
|---|---|---|
| | | Alternatively the QAK will be deactivated automatically a short configurable delay after the last Quick Action Key was selected. |
| 14 | QAK | QAK allow the user to activate/deactivate functions directly from the interface without having to use the menu.<br>The status of the function is indicated by the lamp next to the key. The lamp can be configured to be red, green or orange in color and steady or flashing.<br>Before using the QAK it is necessary to unlock them using the unlock key(3) described above.<br>Pressing a Quick Action Key will apply the action without any further confirmation and the lamp next to the key will indicate the changed status. |
| 15 | Enable/Disable **TRIP CIRCUIT** key | Disables all electrical trip operations. When the switch is in the disable position, the trip circuit in the switchgear is electrically disconnected from the control electronics. Thus the switch provides a physical isolation point for the control circuitry.<br>The switchgear cannot be opened electrically, an audible alarm in the O.I. will sound and the disable Light Emitting Diode (LED) in the **TRIP CIRCUIT** key will flash. The **TRIP CIRCUIT** key operates normally when the switch is in the enable position. This switch helps to prevent a close operation, so that the switchgear cannot be closed if unable to trip. |
| 16 | Enable/Disable **TRIP CIRCUIT** key | Disables all electrical close operations. When the switch is in the disable position, the close circuit in the switchgear is electrically disconnected from the control electronics. Thus the switch provides a physical isolation point for the control circuitry.<br>The switchgear cannot be closed electrically and an audible alarm in the O.I. will sound and the disabled LED in the **CLOSE CIRCUIT** key will flash.<br>The **CLOSE CIRCUIT** key operates normally when the switch is in the Enable position. |

(1) All descriptions assume default Operator Control Panel (OCP) map is installed.

(2) Lamp colors are configurable.

(3) Use of Unlock key is optional according to configuration.

# Display

The ***flex*VUE** O.I. features a two line x 20 character display. The menu that runs on this interface organizes the individual pages into display groups.

It is possible to navigate to any page and to view or change settings using the navigation keys located to the right of the display.




**Figure 14**
***flex*VUE** O.I. Navigation keys and Display

The top line of the display shows the title of the menu or sub-menu and is always in capital letters.

The bottom line may display a sub-menu of the menu on top line in which case it will also be in capitals.

When the bottom line is not in all capitols it indicates that it is a read-only or editable field.

# Display Groups

The O.I. displays are organized into three logical groups. Within each group is a menu of pages and those menus have various sub-menus. An overview of the default ***flex*VUE** menu structure is shown in the Figure 15.

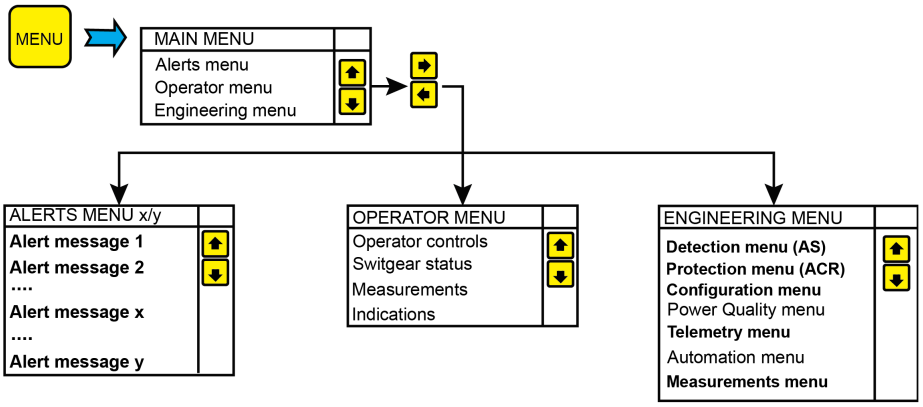
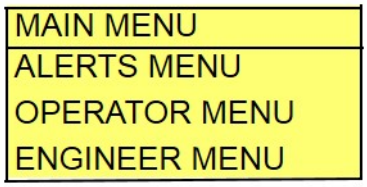



**Figure 15**
***flex*VUE** O.I. Menu structure

Pressing the **MENU** key will always bring the display back to the main menu page from where any of the three main menu display groups can be selected and entered.




The three main menu display groups that can be displayed on the ***flex*VUE** O.I. LCD display are described below.

**ALERTS MENU**




- This group displays Normal Alerts which are meant to warn operators that an abnormal condition exists. A normal alert could be to warn the operator that the close circuit switch is in the disable position. This would sound an alarm and cause an Alerts Active message to alternate with the title line on the display.
- Pressing the right arrow key when the alert is active will enter the Alerts Menu and display details of the active alert.




**NOTE:** The PowerLogic ADVC Controller can also generate Critical Alerts to warn of an imminent trip/close operation or trip/close coil failure. These alerts have nothing to do with the Alerts menu. No menu navigation is possible when a critical alert is active but the QAKs can be used

**OPERATOR MENU**



- Pressing the right arrow key when the above page is displayed will enter the Operator Menu and allow access to the operator sub-menus.
- The Operator Menu contains all of the displays and settings required for routine operation of the device.

**ENGINEER MENU**




- Pressing the right arrow key when the above page is displayed will enter the Engineer Menu and allow access to the Engineer sub-menus.
- The Engineer Menu contains more comprehensive metering as well as historical displays and allows access to all the settings required to configure all of the protection, communications and control functions.

For a complete listing of pages in the ***flex*VUE** menus refer to Appendix J, page 613 **flexVUE** Menu.

## Navigation

The **Panel On** key turns the O.I on or off. An optional door switch is available to turn the O.I on when an operator opens the door and off when the door is closed. If the controller is fitted with this option the button can be used to turn the O.I off/on while the door is open. Closing the door will turn the O.I off.

**Lamp Test** tests all LEDs on the O.I. The purpose of this is to alert the user to any LEDs or colors that may not be working correctly.

**Event Log** displays the event log on the LCD display.

The **Menu** key enters the menu structure from where an operator or engineer can display data and modify settings.

The arrow keys are used to navigate through the structure and to change settings. The UP and DOWN arrows scroll through the available options, RIGHT to progress to the next level and LEFT to return to the previous level. The **Select** key is used to select fields to be changed and apply values when changes are made.

For more information on how to navigate around the ***flex*VUE** menu see Appendix J, page 613 ***flex*VUE** menu.

# Status Lamps

The Status Lamps are used to indicate the controller and switchgear status. All 20 lamps are configurable and users can choose to change the default configuration. WSOS includes a tool to modify the logic function for each lamp and a utility to print new labels. Please see flexVUE customisation for more information.

## Lamp Data

Printed labels are provided to identify each status lamp but additional data for each lamp can be displayed on the LCD by pressing the **LAMP DATA** key. In **LAMP DATA** mode, the arrow keys can be used to navigate to the status lamp of interest and display the additional information.

## Lamp Reset

Pressing the **Lamp reset** key clears the status lamps. This forces the indicators to the logic false state. However, the status lamps are continuously updated and will change back to the logic true state if the conditions are still true.

Example: if the battery supply was OK prior to pressing the reset key, it will again indicate OK afterwards.

## Default Configuration

The Status Lamps are programmed in the factory to a default configuration.

The default configuration is shown below. Each lamp indicates the state of the function described next to it. When a state is active, the lamp is lit.

For example, when the recloser is in Lockout the lamp next to Lockout in position a-1 will be on.

Conversely if the lamp is off, the recloser is not in a lockout state.

It is possible that more than one lamp will be lit at a given time.

Example, when a recloser tripped to lockout due to an over current fault on Phase A, both Lockout (a-1) and A-Phase O/C (a-2) lamps will be lit.

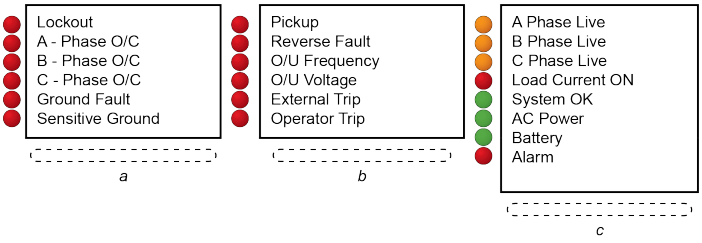



**Figure 16**
***flex*VUE** O.I. Status lamps

The table below describes the default function and color of each lamp.

**Table 3 *flex*VUE Status Lamp descriptions**

| LED No. | Color | Description | Possible causes |
|---|---|---|---|
| **Column A** | | | |
| a-1 | Red | Lockout | Recloser has tripped to lockout due to a protection sequence or operator command. Automatic close operations are not possible and the operator has to close the recloser using the O.I. or a remote command. |
| a-2 | Red | A-Phase O/C | The most recent trip of the recloser was caused by an over current event due to a fault on the relevant network phases. |
| a-3 | Red | B-Phase O/C | |
| a-4 | Red | C-Phase O/C | |
| a-5 | Red | Ground Fault | The most recent trip was caused by a ground (earth) fault. |
| a-6 | Red | Sensitive Ground | The most recent trip was caused by a sensitive ground (earth) fault. |
| **Column B** | | | |
| b-1 | Red | Pickup | One of the protection elements detected a value outside the normal range, for example when the phase current exceeds the phase trip setting value. |
| b-2 | Red | Reverse Fault | Protection has operated in the reverse direction due to power flow from the load side to the source side of the recloser. |
| b-3 | Red | O/U Frequency | An over or under frequency event has caused the recloser to trip. |
| b-4 | Red | O/U Voltage | An over or under voltage event has caused the recloser to trip. |
| b-5 | Red | External Trip | An external device has instructed the controller to trip the switchgear. |

**Table 3 *flex*VUE Status Lamp descriptions (Continued)**

| LED No. | Color | Description | Possible causes |
|---|---|---|---|
| b-6 | Red | Operator Trip | A local or remote operator has tripped the recloser. |
| **Column C** | | | |
| c-1 | Orange | A Phase Live | The source or load side bushing of the relevant phases are live. |
| c-2 | Orange | B Phase Live | |
| c-3 | Orange | C Phase Live | |
| c-4 | Red | Load Current ON | Red when a load current greater than 2 A is flowing through the switchgear. |
| c-5 | Green | System OK | The controller is functioning normally. Maintenance may be required when the lamp is flashing red. Consult the Event Log. |
| c-6 | Green | AC Power | Flashing Red lamp when Auxiliary is OFF. |
| c-7 | Green | Battery | Flashing Red lamp when Battery is OFF, not detected or test failed. |
| c-8 | Red | Alarm | Flashing Red lamp when Trip or Close circuits are isolated, contact life is low or the switchgear is locked. |

# Quick Action Keys (QAK)

Actions that are most likely to be performed by line personnel can be linked to the 12 QAK of the ***flex*VUE** interface.

Selecting a quick action will apply that action without any additional confirmation and the lamp next to the key can be used to indicate when the action is active.

A typical action is to toggle features on/off, for example: Work tag ON/OFF LOCAL/RM ; Ground fault protection ON/OFF; etc. The action keys can also be configured to turn options ON, such as protection groups. For example, pressing the Protection Group B key will make Group B active and therefore deactivate whichever group was active prior to the key press.

## QAK Unlock Key

The Unlock key, symbolized by an open padlock, is used to enable the QAKs. This feature was incorporated to avoid features being activated or deactivated accidentally.

The QAK Unlock key is configurable through the OCP Configuration Tool, page 80 in WSOS but by default, an operator has to unlock the QAKs before they can be used and a LED above the Unlock Key changes from red to green when the QAKs are unlocked.

The QAKs can be locked by pressing the Unlock key again or they will lock automatically after a configurable delay (10 s by default) if no QAKs are pressed.

If required, users can disable the locking feature on any or all of the QAKs.

For example, to activate the Ground Fault element the operator must press the following keys:

1. Quick Action Unlock Key – The LED on this key must change from red to green to indicate that the QAKs are unlocked.
2. Ground Fault Key – The LED on this key must change from OFF to ON (Red) to indicate that Ground Fault protection is activated.

# Default Configuration

The QAKs are programed in the factory to a default configuration but can be changed to suit operational requirements. WSOS includes a tool to modify the logic function and lamp for each QAK and a utility to print new labels. Refer to flexVUE customisation for more information.

The default configuration has been chosen to provide access to frequently used actions and is shown below:

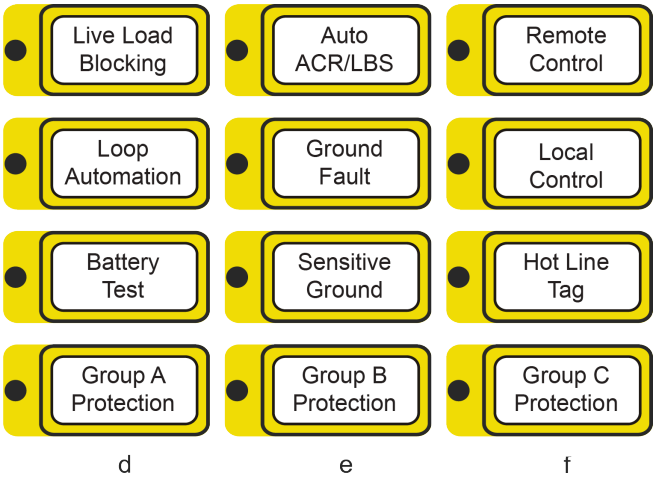



**Figure 17**
***flex*VUE** O.I. Default QAKs

The table below describes the function of each of the default QAKs. Pressing each key causes its Action which is confirmed by its LED changing to the Color shown.

**Table 4 *flex*VUE O.I. default QAK descriptions**

| QAK ID | Color | Description | Action |
|---|---|---|---|
| **Column D** | | | |
| d-1 | Red | Live Load Blocking | Toggles the Live Load Blocking feature ON/OFF. |
| d-2 | Red | Loop Automation | Toggles the Loop Automation feature ON/OFF. |
| d-3 | Red | Battery Test | Performs a Battery Test. |
| d-4 | Red | Group A Protection | Protection Group A becomes Active. |
| **Column E** | | | |
| e-1 | Red | Auto ACR/LBS | Toggles Auto Reclose ON/OFF (for ACRs) or Sectionalise Auto/Off (for ASs). |
| e-2 | Red | Ground Fault | Toggles Earth (Ground) Fault protection ON/OFF. |
| e-3 | Red | Sensitive Ground | Toggles Sensitive Earth (Ground) Fault protection ON/OFF. (Providing Ground Fault is ON) |
| e-4 | Red | Group B Protection | Protection Group B becomes Active. |
| **Column F** | | | |
| f-1 | Red | Turns REMOTE control ON (and LOCAL control OFF). | Turns REMOTE control ON (and LOCAL control OFF). |
| f-2 | Red | Turns LOCAL control ON (and REMOTE control OFF). | Turns LOCAL control ON (and REMOTE control OFF). |

**Table 4 *flex*VUE O.I. default QAK descriptions (Continued)**

| QAK ID | Color | Description | Action |
|---|---|---|---|
| f-3 | Red | Toggles Hot Line Tag (Work Tag) Applied/OFF. | Toggles Hot Line Tag (Work Tag) Applied/OFF. |
| f-4 | Red | Protection Group C becomes Active. | Protection Group C becomes Active. |

# *set*VUE O.I.

The design and operation of the ***set*VUE** O.I. is similar to that used with earlier Schneider Electric ACR and AS controllers.

The interface comprises:

- LCD Character display. (4 rows x 40 characters)
- Trip/Close keys with LED switchgear status and disable indication.
- System **OK** LED indication.
- 8 x General command keys (Panel ON, Custom Menu, ALT, Menu, Left Arrow, Select, Right Arrow, and Enter.

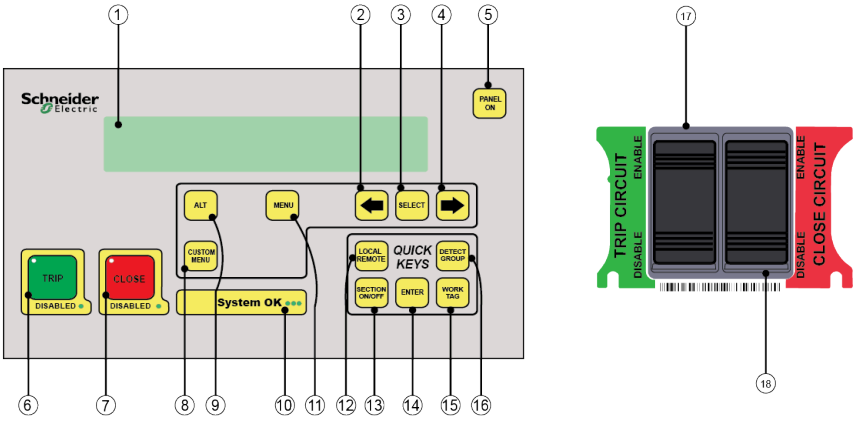



**Figure 18**
***set*VUE** O.I.

The functions of the items identified in the figure above are described in the table below.

**Table 5 *set*VUE O.I. functions**

| Sl.No | Item | Description |
|---|---|---|
| 1 | Display | Back-Lit LCD. 4 lines × 40 Character. |
| 2 | **LEFT** arrow key | Selects the previous screen in a display group or, if a setting is selected, decreases its value. |
| 3 | **SELECT** key | Selects a data field/setting so that it can be changed. |
| 4 | **RIGHT** arrow key | Selects the next screen in a display group or, if a setting is selected, increases its value. |
| 5 | **PANEL ON** key | Turns the O.I. on. The O.I. will turn on when the cubicle door is opened. |
| 6 | **TRIP** key | Generates a switchgear trip request to the **CAPE** when the O.I. is active. A green lamp is embedded in the key to indicate the switchgear is open. Another lamp is used to indicate whether this keys operation is **DISABLED**. |
| 7 | **CLOSE** key | Generates a switchgear close request to the **CAPE** when the O.I. is active. A red lamp is embedded in the key to indicate the switchgear is closed. Another lamp is used to indicate whether this keys operation is **DISABLED**. |
| 8 | **CUSTOM MENU** key | Gives access to the custom menus which were configured using WSOS5. The custom menu may be configured to provide a regular, updated data display by allowing a cycle of up to 12 screens. |

**Table 5 *set*VUE O.I. functions (Continued)**

| Sl.No | Item | Description |
|---|---|---|
| 9 | **ALT** key | Gives access to an alternative event log display. |
| 10 | **SYSTEM OK** | The 3 lamps flash while the controller is operating normally. |
| 11 | **MENU** scroll key | Displays the first page of the next menu group. Pressing the **MENU** key after changing a setting causes the setting change to take effect. |
| **QUICK KEYS** | | |
| 12 | **LOCAL/REMOTE** quick key | Default linkage is to **LOCAL/REMOTE**. |
| 13 | **AUTO ON/OFF** quick key | Default linkage is to **AUTO ON/OFF**. |
| 14 | **ENTER** key | Confirms a setting change that has been made. (Unlike the adjacent Quick Keys, the **ENTER**key is not configurable.) |
| 15 | **PROTECTION GROUP** quick key | Default linkage is to Protection Group Quick Keys. |
| 16 | **EARTH PROTECTION** quick key | Default linkage is to Earth Protection Quick Keys. |
| 17 | Enable/Disable **TRIP CIRCUIT** key | Disables all electrical trip operations. When the switch is in the disable position, the trip circuit in the switchgear is electrically disconnected from the control electronics. Thus the switch provides a physical isolation point for the control circuitry. The switchgear cannot be opened electrically, an audible alarm in the O.I. will sound and the disable LED in the **TRIP CIRCUIT** key will flash. The **TRIP CIRCUIT** key operates normally when the switch is in the enable position. This switch helps to prevent a close operation, so that the switchgear cannot be closed if it's not able to trip. |
| 18 | Enable/Disable **CLOSE CIRCUIT** key | Disables all electrical close operations. When the switch is in the disable position, the close circuit in the switchgear is electrically disconnected from the control electronics. Thus the switch provides a physical isolation point for the control circuitry. The switchgear cannot be closed and an audible alarm in the O.I. will sound and the disabled LED in the **CLOSE CIRCUIT** key will flash. The **CLOSE CIRCUIT** key operates normally when the switch is in the Enable position. |

# Display

The ***set*VUE** O.I. features a 4 line x 40 character display. The menu that runs on this display organizes the individual pages into display groups. It is possible to navigate to any page and to view or change settings using the navigation keys located below the display.

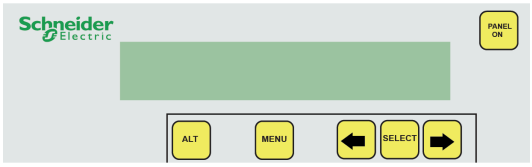



**Figure 19**
***set*VUE** Navigation keys and display

## Display Groups

There are a minimum five display groups in the ***set*VUE** menu system and a sixth one for automation if an automation feature is available.

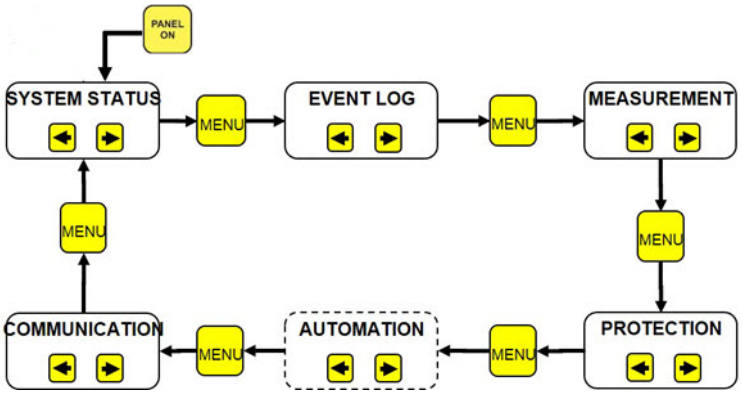



**Figure 20**
***set*VUE** O.I. Menu structure

The display group a page being displayed belongs to can be identified by the letter that appears in the top right hand corner of the screen.

**Table 6 *set*VUE O.I. Menu Identifiers**

| Code | Display Group |
|---|---|
| S | System Status |
| E | Event Log |
| M | Measurement |
| P/D | Protection/Detection(1) |
| A | Automation |
| C | Communications |
| (1) Display group P is displayed for an Auto Recloser and will be substituted by a D for an Auto Sectionaliser. | |

## Navigation

The display can be cycled through the display groups by pressing the **MENU** key.

Navigation is always in the same direction as indicated in Display Groups, page 45 above. Within each display group, navigation through the individual pages occurs by pressing the left and right arrow keys.

Navigation in both directions is possible and all display groups are circular.

# Quick Keys

The Quick Keys consist of four user configurable keys that provide the capability for the operator to quickly access commonly used settings without having to navigate to the relevant page on the display.

The default configuration for these keys is shown below.

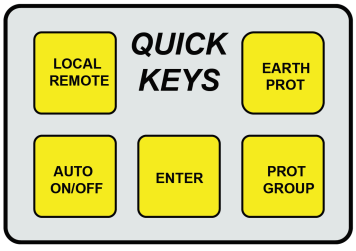



**Figure 21**
Default ***set*VUE** O.I. Quick Keys

## Using the Quick Keys

If a setting is to be changed via the Quick Keys, no other keys on the O.I. need to be used.

Example: If the controller is in Local mode and it is required to change to remote control mode, press the Local/Remote key. That will cause that setting to appear on the screen in change mode (flashing). Every time the Local/Remote key is pressed, the setting will toggle between local and RM. When remote is displayed, press the Enter key.

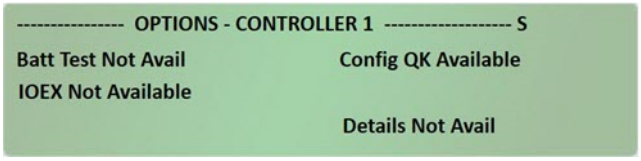
If the **Prot Group** key is being used to change the active protection group and more than two protection groups are configured, pressing that key will cause the display to cycle through the available groups.

> **NOTE:** The Enter key on the Quick Keys pad has the same function as the Menu key.

## Configuring the Quick Keys

The Quick Keys on the ***set*VUE** O.I. can be configured either via the O.I. or via WSOS.

Firstly, configurable quick keys must be made available through feature selection. This can be done on the O.I. if options are available by navigating to the Options – Controller 1 page in the system status menu.




That will cause the Quick Key Selection page below to be displayed, also in the system status menu. The fields on this page have the same positional arrangement as the quick keys on the O.I.




Select the first field to be changed and cycle through the available options until the required function is displayed and press the Menu key.

A set of stick-on labels are provided with each controller to change the text on the quick keys to match the new function.

The functions available for Quick Key selection are:

- Cold Load
- Live Load Blocking
- LOCAL/Remote
- Negative Phase Sequence (NPS) Protection
- Reset Flags
- Work Tag
- Battery Test
- Reverse Cold Load
- Auto On/Off
- Earth Protection
- Protection Group
- Blank (no function)

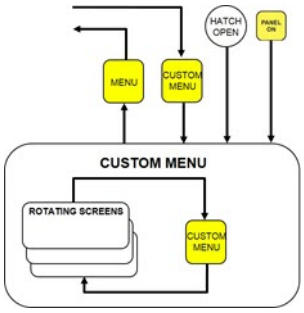
For details on how to configure the quick keys using WSOS, see Quick Keys, page 46.

## Custom Menu

The custom menu makes the O.I. easier to use by only displaying the pages that are relevant to operators performing basic functions.

In order to use the custom menu, it must have previously been configured through WSOS which is explained in setVUE Custom Menu, page 95.

If custom menus have been configured, an operator can access them by pressing the custom menu key.




Continuing to press the custom menu key will cause the display to scroll through the pages that are configured. Alternatively, the display may have been configured to scroll automatically when the O.I. is on.

The display can be returned to the normal menu by pressing the Menu key.

# Operator Functions

## What's in This Chapter

Local and Remote Control Modes ..... 50
Setting Changes ..... 51
Delayed Operations ..... 54
Work Tag/Hot Line Tag ..... 56
Trip/Close Isolate ..... 59
System Measurements ..... 59
Event Log ..... 60

# Local and Remote Control Modes

An important feature of the PowerLogic ADVC Controller is that it is always in one of two control modes, that is local or remote, and the work tag can be applied by local or remote operators.

The control mode and the tag provides operational safety by specifying the circumstances under which the ACR or AS can be closed.

## Definition of a Local or Remote Operator

There are three types of LOCAL operator:

- O.I.
- An IOEX card designated as local. This might apply, for example, to an IOEX card used in a substation to provide control from a remote panel inside a building.
- A PC running WSOS5 connected to a local port on the CAPE.

There are also three types of **REMOTE** operator:

- An IOEX card designated as remote. This might apply, for example to an IOEX card used to interface to a Supervisory Control and Data Acquisition (SCADA) system Remote Terminal Unit (RTU).
- A SCADA control protocol. These are always designated as remote operators. Full information is given in the relevant protocol manual.
- A PC running WSOS5 communicating via radios or modems connected to a telemetry port configured as a remote port.

  **NOTE:** The local/RM can only be set from the O.I. and not via WSOS or through a remote connection.

## Local Mode

In this mode, only a local operator can manually close the switchgear. (An ACR can still close automatically with the auto-reclose function during a protection sequence or due to an automatic feature such as loop automation if enabled.)

This means that an operator can go to the PowerLogic ADVC Controller, set local control mode and know that remote closing is disabled.

Only a local operator can apply or remove the work tag when the PowerLogic ADVC Controller is in local mode.

## Remote Mode (RM)

In this mode, only a remote operator can manually close the switchgear. (An ACR can still close automatically with the auto-reclose function during a protection sequence or due to an automatic feature such as loop automation if enabled).

Only a remote operator can apply or remove the work tag when the controller is in RM.

If the local operator is denied a close operation due to a work tag being applied or because the controller is in RM, then, the O.I. will display a message or alert advising that operation is not allowed and either changing to local control and/or removing the work tag is necessary.

For safety reasons, a local or remote operator can always trip the switchgear regardless of whether the controller is in Local or RM.

# Setting Changes

There are three types of settings that can be changed:

- Operator settings
- Password protected settings
- Protection settings

# Operator Settings

Operator settings are settings likely to be changed in routine daily operations and do not require a password to be entered.

## Changing Operator Settings on *flex*VUE

Start by finding the display page containing the setting to be changed:

1. Press the **MENU** key to enter the menu structure.
2. Press the Down arrow key and then the Right arrow key to enter the operator Menu.
3. Press the Up and Down arrow keys to navigate to the setting to be changed.
4. Press the **SELECT** key.
5. Use the Up and Down arrow keys to change the setting.
6. Press the **SELECT** key to accept the change; or press the Left arrow key to escape without changing the setting.

Alternatively, if the setting to be changed has been assigned to a QAK the following procedure can be used:

1. Press the Quick Action Key **UNLOCK** key.
2. Press the required QAK within 10 s (configurable).

   **NOTE:** Actions are executed without any confirmation and the lamp on the QAK indicates that the state has changed.

## Changing Operator Settings on *set*VUE

Start by finding the display page containing the setting to be changed:

1. Press the **MENU** key until the group containing the setting to be changed is displayed.

   **NOTE:** The communications group is divided into subgroups for different protocols. Press **SELECT** to display the subgroup you require.
2. Press the Left or Right arrow key to display the page containing the setting to be changed
3. Press **SELECT** until the setting to be changed is highlighted. A highlighted setting will flash.
4. Once you have selected the setting to be changed, use the Left and Right arrow keys to change its setting. Then press **ENTER** to activate the new setting.

Alternatively, if the setting to be changed has been assigned to a Quick Key it can be used to go directly to the relevant page where you will find the highlighted setting. See Quick Keys, page 46.

# Password Protected Settings

Some settings are password protected. When changing these settings, an operator will be prompted for a password which must be entered before the setting can be changed.

## Entering the password on *flex*VUE

When prompted to enter a password on ***flex*VUE**, follow these steps:

1. Press the Up or Down arrow keys to find the required character for the password.
2. Press the Right arrow key.
3. Repeat steps 1 and 2 until the password is complete.
4. Press **SELECT** to enter the password.

   **NOTE:** User do not require to enter the password again while the O.I. remains ON.

The default factory password is AAAA but can be changed using WSOS software. The factory password does not need to be remembered as the controller prompts for it automatically.

## Entering the password on *set*VUE

When prompted to enter a password on ***set*VUE**, follow these steps:

1. Press either of the Left or Right arrow keys until the first character of the password is displayed.
2. Press the **SELECT** key.
3. Repeat steps 1 and 2 until the password is complete.
4. Press **ENTER**.

   **NOTE:** User do not require to enter the password again while the O.I. remains ON.

The default factory password is AAAA but can be changed using WSOS software. The factory password does not need to be remembered as the controller prompts for it automatically.

# Protection Settings

Protection settings are also password protected. They differ from other password protected settings in that if the setting being changed is in the active protection group, a two-step process is required to put the changed setting into service. Until they are put into service, changed settings are saved. This allows several changes can be saved and put into service together.

## Changing Protection Settings on *flex*VUE

Once the first Active Protection Group setting is changed, the following screen will appear:



This message will be displayed if all the following are true:

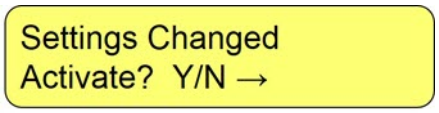
- Settings are changed within the **ACTIVE PROTECTION GROUP**.
- The current setting is the first one to be changed.
- Before changing this setting, all the current settings were **ACTIVE** in service.

Once this message appears there are three options:

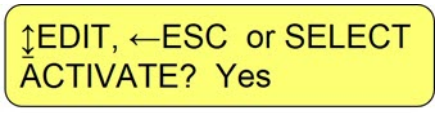
1. NO ACTION: The new setting will automatically go into service if the operator ignores the above message, turns the O.I. off or the interface turns off automatically.
2. Press **SELECT**: If the operator presses the **SELECT** key, the new setting is put into service. The operator can continue to browse the menu. With all the current settings in active service, continuing to change settings will cause the operator to be prompted again when the first of the new settings is saved.
3. Press the **ARROWS**: This will allow the operator to continue to browse and change settings with a view to eventually putting them into service as a group.

## Exiting the Protection Menu

The operator will not be prompted to **ACTIVATE** the settings again until they try to exit the Protection menu, when the following screen will appear:




Pressing the Right arrow key will display the following screen:







When the operator scrolls to YES and presses SELECT, the settings are put in service. If the operator scrolls to NO and presses the SELECT key, the following message is displayed: (scrolling)




## Re-Entering the Protection Menu

If the operator exits the Protection Menu without activating the saved settings, when the Protection Menu is re-entered at a later point in time, providing the settings haven't been put into service by an O.I. shutdown, the process will run through the same activation sequence as shown in Exiting the Protection Menu, page 53.

## Changing Protection Settings on *set*VUE

Protection settings on the ***set*VUE** O.I. are password protected. To change a protection setting, follow the steps detailed in the Operator Settings section above. In addition, enter the password when prompted. When the setting change is completed by pressing **ENTER**, the following message will flash at the top of the screen:

**Active Protection setting has changed**

At this point, the changed setting will be displayed but not in service. If further setting changes are required, they can be made now.

When all of the required setting changes are completed, press **ENTER**.

The following text will be displayed:

**Active Protection Setting has changed**

**The changed active PROTECTION SETTINGS are now in service.**

**Select the MENU or ENTER key to continue.**

# Delayed Operations

In an environment such as a substation, occupational health and safety regulations may require personnel to vacate the area where switchgear is operating. The PowerLogic ADVC Controller with the ***flex*VUE** O.I. facilitates this requirement with a feature known as Delayed Trip/Close Operation. On controllers with a ***set*VUE** O.I., the feature is known as Hit and Run.

# Delayed Trip/Close Operation

It is possible to set, via the OCP Configuration Tool, page 80 in WSOS, a separate delay for the trip and close buttons on the ***flex*VUE** O.I. This delay will be active for all the operator trip/close requests via the O.I. It does not affect protection, automation or remote trip/close requests. If immediate action is required, the operator can press the button a second time to cancel the countdown and trip/close immediately.

To cancel the trip/close request during countdown the operator can press the opposite key. Otherwise the LCD displays the countdown to operation.

Both settings have a range of: OFF, 10...120 s (increments of 1 s). The factory defaults are OFF. Trip and Close delays can have different time settings or one or both can be off.

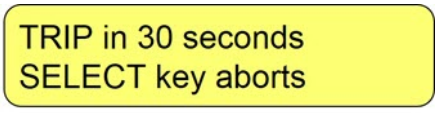
## Using Delayed Operation

When active, Delayed Operation is the default action for the **TRIP** and/or **CLOSE** keys. So, if Delayed Operation has been configured for the controller, the local operator has no option other than to use it. However, if it is not required it can be bypassed as explained below.

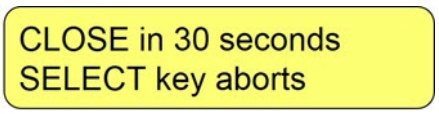
To trip/close the switchgear after a pre-set interval.

- Press the **TRIP** or **CLOSE** key.

The ***flex*VUE** screen will display the message below:




or



The displayed time will count down and the CAPE will *beep* every 2 s while the timer is running. The beeping will become more rapid during the final 10 s.

## Cancelling a Delayed TRIP or Close Operation

To CANCEL the delayed trip operation once the countdown timer has started:

- Press the **SELECT** key.

Or

- Press the **CLOSE** key.

If the Trip operation has been successfully cancelled, the screen will display:




To CANCEL the delayed close operation once the countdown timer has started:

- Press the **SELECT** key

Or

- Press the **TRIP** key.

If the Close operation has been successfully cancelled, the screen will display:




## Bypassing the Delayed Operation

If the switchgear must be operated without any unnecessary delay:

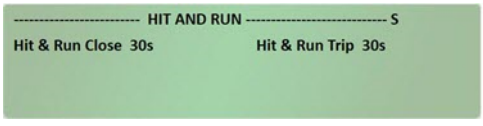
- Press the TRIP or CLOSE key a second time (with the countdown timer running).

# Hit and Run

The Hit and Run feature on PowerLogic ADVC Controllers with the ***set*VUE** O.I. provides a delay between a local operator control **TRIP** or **CLOSE** request and when the switchgear operates.

## Making Hit and Run Available

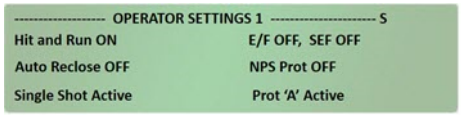
Hit and Run can only be made available via WSOS and then needs to be activated at the O.I. before it can be used. So even though it may have been made available, the local operator can choose whether or not to use it. There is no change to the local operator trip/close operation of the device when Hit and Run is turned OFF. When Hit and Run has been made available, the page below will appear towards the end of the system status menu.




Both settings have a range of: OFF, 10...120 s (increments of 5 s). The factory defaults are OFF. Trip and Close delays can have different time settings or one or both can be OFF.

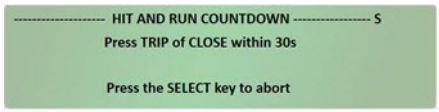
## Activating Hit and Run

Once Hit and Run has been configured it can be activated by the operator at the Operator Settings 1 page in the System Status menu by selecting the Local/ Remote control field (top left) and navigating to the Hit and Run On setting. See below:




When Hit and Run is turned ON the operator has a countdown period of 30 s (non-configurable) in which to press either **TRIP** or **CLOSE**, otherwise the setting will revert to the setting prior to turning Hit and Run ON.

While the 30 s non-configurable timer is running, the screen below is displayed.




Instead of waiting for the 30 s timer to expire, the operation can be aborted by pressing the **SELECT** key.

If the switchgear is closed and the operator presses the TRIP key, the following screen will be displayed and the countdown to operate will start to run:




The O.I. will *beep* every two seconds while the Hit and Run countdown is running. The beeping will become more rapid during the final 10 s.

## Aborting Hit and Run

The operation can still be aborted at any time before the Trip/Close Time expires by pressing the **SELECT** key.

## Hit and Run Events

An event will be recorded in the Event Log at the start of the Hit and Run period and the end of a Hit and Run countdown or time out.

# Work Tag/Hot Line Tag

**⚠WARNING**

**HAZARD OF UNINTENDED EQUIPMENT OPERATION**

The work tag must be activated before starting work on live lines.

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

Applying the Work Tag to make sure that closing cannot take place at all, either by a local operator, a remote operator, or automatically. Once applied, neither a local operator, remote operator, or the Auto- Reclose function can close the recloser. Therefore, Work Tag affords protection for operators working on live lines.

Work Tag does not help prevent the switchgear from tripping.

Work Tag mode is activated when Work Tag is applied irrespective of Auto Reclose mode status, and is deactivated when the Work Tag is removed.

If the Work Tag is deactivated whilst Auto Reclose is ON, then the Auto Reclose mode will be entered immediately.

If a protection trip occurs while the Work Tag is applied, an event is logged to identify it as a Work Tag trip.

**NOTE:** In some countries, such as the United States of America, **WORK TAG** is also referred to as the **HOT LINE TAG**.

# Applying and Removing the Work Tag

Only a local operator can apply/remove the tag when the controller is in Local Mode and only a remote operator can apply/remove the tag when the controller is in RM. A local operator can remove the Work Tag that was applied by a remote operator but they must first put the controller into Local Mode. A remote operator cannot change the control mode.

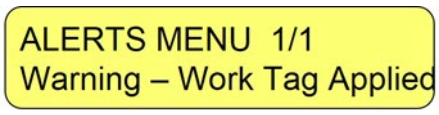
## Applying the Work Tag on *flex*VUE

The work tag can be applied on the ***flex*VUE** O.I. at:

**OPERATOR MENU** > **OPERATOR CONTROLS** > Work Tag, page 617

or through a QAK if one has been assigned the work tag function.

When the work tag is applied on the ***flex*VUE** O.I. it creates an alert displayed in the **ALERTS MENU** as shown below:




If the local operator attempts a manual close from the ***flex*VUE** O.I. when the Work Tag is applied the Event Log will record that the Operation was denied due to the Work Tag being applied.

## Applying the Work Tag on *set*VUE

The work tag can be applied on the ***set*VUE** O.I. at:

**SYSTEM STATUS** > **SWITCHGEAR STATUS** > Work Tag, page 644

or through a Quick Key if one has been assigned the Work Tag function.

When the work tag is applied on the setVUE O.I. the message below appears on the title line of the display.




If the local operator attempts a manual close from the ***set*VUE** O.I. when the work tag is applied the event log will record that the operation was denied due to the work tag being applied.

## Applying the Work Tag on WSOS

The work tag can also be applied through the WSOS software application.

When the Hot Line Tag setting is applied all closing operation of the switchgear is blocked. This includes auto-reclosing and remote/local operator action. Whilst the Hot Line Tag is applied a Hot Line Tag protection curve is active. This curve is independent of single shot and auto-reclose trip curves.

To apply Hot Line Tag select the corresponding button on the WSOS Control page shown below.

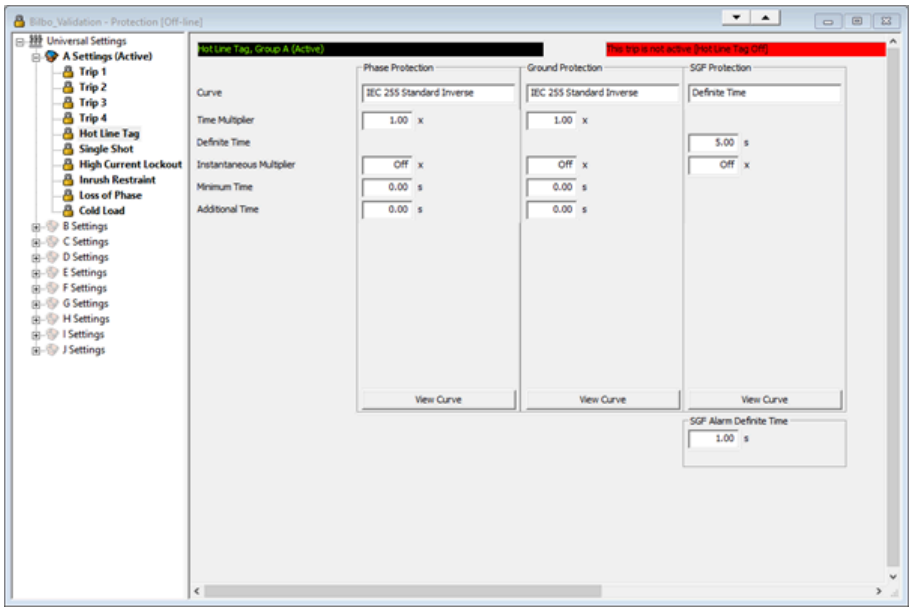



**Figure 22**
WSOS Control page

To open the Hot Line Tag Window:

- From the main menu select **Display** > **Protection** > **Hot Line Tag** to see the Hot Line Tag window of the Active Switchgear.
- Click on the Protection button in the Display Tool bar to see the Hot Line Tag window of the Active Switchgear and then select Hot Line Tag.
- Open Switchgear Explorer, expand the required Switchgear, and then select **Protection** > **Hot Line Tag**.

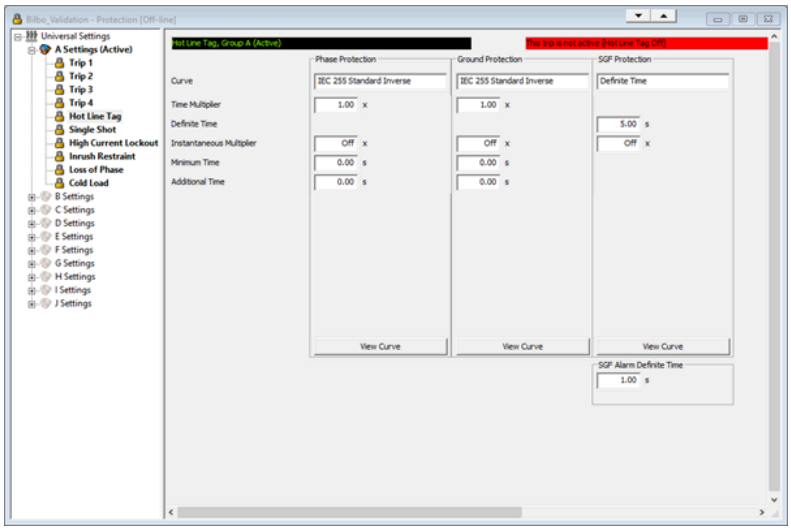



**Figure 23**
Hot Line Tag Window

**Hot Line Tag Window Settings:**

The settings required to set up Hot Line Tag protection curve are almost identical to those of an auto-reclose trip protection curve. Refer to the Trip Settings for more information. Any differences between auto-reclose trip curve settings and Hot Line Tag trip curve settings are identified.

# Trip/Close Isolate

The Trip and Close Enable/Disable switches are located on the CAPE below the O.I.

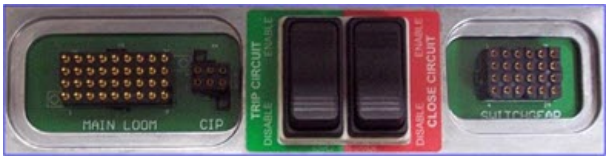



**Figure 24**
Trip and Close Enable/Disable Switches

## Enable/Disable TRIP Switch

Disables ALL Trip Operations. When the switch is in the Disable position the trip circuit in the switchgear is electrically disconnected from the control electronics.

Thus, the switch provides a physical isolation point for the control circuitry. The switchgear cannot be opened electrically, an audible alarm will sound and the DISABLED LED in the TRIP key will flash.

The TRIP key operates normally when the switch is in the Enable position. This switch also helps to prevent a close operation to avoid the possibility of closing onto a fault and not being able to trip.

## Enable/Disable CLOSE Switch

Disables ALL Close Operations. When the switch is in the Disable position the close circuit in the switchgear is electrically disconnected from the control electronics. Thus the switch provides a physical isolation point for the control circuitry. The switchgear cannot be closed and an audible alarm in the O.I. will sound and the DISABLED LED in the CLOSE key will flash.

The CLOSE key operates normally when the switch is in the Enable position.

# System Measurements

System Measurements are a condensed version of the full range of measurements available on the PowerLogic ADVC Controller. They provide a snapshot of the power system measurements in real time.

System Measurements display three phase values for power and PF but the current and voltage values are three phase averages.

System Measurements are displayed on the flexVUE and setVUE operator interfaces, page 701.

# Event Log

The PowerLogic ADVC Controller maintains a log of up to 30,000 events that reflect changes to the status of the switchgear, control electronics, and programmable logic. The log also records setting changes.

The events can be viewed on the LCD display. The event log display will update automatically with new events. The most recent event appears on the bottom line of the screen and older events can be viewed by scrolling upwards. When the event log is full, the newest events replace oldest events.

All events are date and time stamped to a 10 ms resolution and displayed in the order that they occurred. The source of each event is also recorded.

It is possible to apply event category filters when viewing events. WSOS software can also be used to upload and display the event log. WSOS also supports source identification and filtering as well as text and Date/Time searches. The uploaded event log can be saved as a text or .csv file.

## Event Log on the *flex*VUE

The ***flex*VUE** O.I. has a dedicated **EVENT LOG** key. Pressing this key is the only way the Event Log can be displayed on the ***flex*VUE** O.I.

When the Event Log is initially displayed the Event Log header appears on the top line and only one event, the most recent, is displayed on the bottom line.




Note that on the initial Event Log page shown above, the time stamp has a resolution of 1 minute and the event is truncated.

To view the complete Date/Time stamp with a resolution of 10 ms, press the Left Arrow key.

Pressing the Right Arrow key from the initial display will enable the complete event description to be viewed. See below:

If the complete event description is longer than the 20 characters available, the display will automatically scroll to reveal the entire event.

Once scrolling is commenced by pressing the Up Arrow key, separate events can be viewed on each line. If the log is scrolled via the Down Arrow key until the end or most recent event is displayed the Event Log header will reappear on the top line. In this way the most recent event can be identified.

## Event Sources

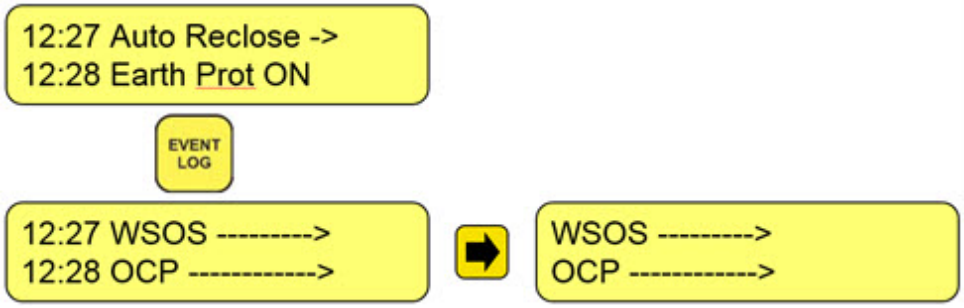
The source of an event can vary. For example, a Work Tag Applied/OFF setting change event could have been triggered from IOEX, the O.I, local WSOS, remote WSOS over Ethernet, or a SCADA protocol.

The source of individual events can be seen in an abbreviated format by pressing the **EVENT LOG** key while the Event Log is displayed. This will add a fourth

screen to each line of the Event Log which can be displayed by pressing the Right Arrow key. The additional screen provides space for setting change details.

## Example

In the example below, pressing the **EVENT LOG** key revealed that Auto Reclose was either turned on or off via WSOS and that Earth Protection was turned on via the OCP.




Possible event sources are shown in the table below:

**Table 7 WSOS Event Sources**

| Source | Explanation |
|---|---|
| WSOS | Windows Switchgear Operating System |
| OCP | OCP |
| PTCL | SCADA Protocol |
| IOEX | IOEX Card |

**NOTE:** If a setting is changed via WSOS over Transmission Control Protocol/ Internet Protocol (TCP/IP), then the first four characters of the user name, logged into the PC running WSOS, will be logged.

Sometimes the event log record for a setting change does not include enough information to identify the actual setting that was changed. For example, an event that reads Time Mult 1.00 identifies that a Time Multiplier setting for a particular protection curve was changed to 1.00. Pressing the **EVENT LOG** key when that setting change event was displayed may reveal for instance that it refers to the Group A, Trip 1 Phase Protection curve. (A:PH:T1)

## Event Log Filtering

The PowerLogic ADVC Controller can log a very large number of events. However it is possible to filter the events to show only those of interest.

The active filter determines which events appear in the Event Log when it is viewed on the operator panel.

Up to six filter categories can be active at any one time. All possible events fall into at least one of the filter categories and some fall into more than one.

The effect of the filter is to or the categories that is if two categories are selected, events that fall into one or the other category will be displayed.

To access the event filter, display the Event Log and press the **SELECT** key. Filter No 1 will appear on the screen. The other five filter settings can be displayed using the Up and Down arrow keys. The default setting for filter No 1 is **All** which makes the other five filter settings redundant. Their defaults are all **Blank**.

When the filter has been configured as required, pressing the **EVENT LOG** key will activate the new settings and return the display to the Event Log.

The following categories can be selected for the Event log filter:

**Table 8 Event Log Categories**

| Filter Category | Events Shown |
|---|---|
| All | All events are shown |
| Settings | All setting changes with source WSOS, O.I., IOEX or Protocol |
| Protection | All protection related events |
| Protocol | All SCADA related messages and changes |
| WSOS | All changes with WSOS as the source. |
| Panel | All changes made from the Panel |
| IOEX | All IOEX messages |
| Switchgear | All messages from the switchgear |
| Power Quality | All quality of supply messages |
| Controller | All controller hardware related events |
| Network | All electrical system events |

The figure below is a graphical representation of how to navigate the Event Log on the ***flex*VUE** O.I.

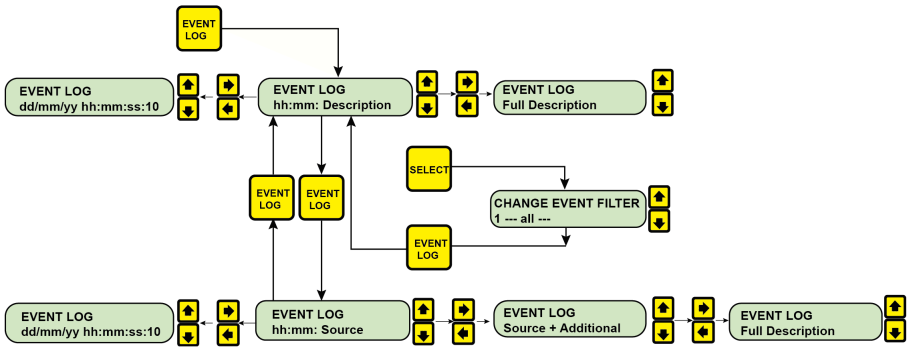



**Figure 25**
***flex*VUE** O.I. Event Log Navigation

# Event Log on *set*VUE

On the ***set*VUE** O.I., the event log display group is one of the main display groups shown in Appendix K.1 setVUE Menu Structure, page 636.

To view the Event Log on the ***set*VUE** O.I., press **MENU** until the title line displays **EVENT LOG** with the letter E in the top right hand corner.

When the Event Log is initially displayed, the three most recent events are shown with the most recent on the bottom line. The title line will disappear and four events will be displayed once the Left Arrow key is pressed. From there, the event log can be scrolled for earlier and more recent events using the Left and Right Arrow keys. If the event log is scrolled back to the most recent event, the title line will reappear.

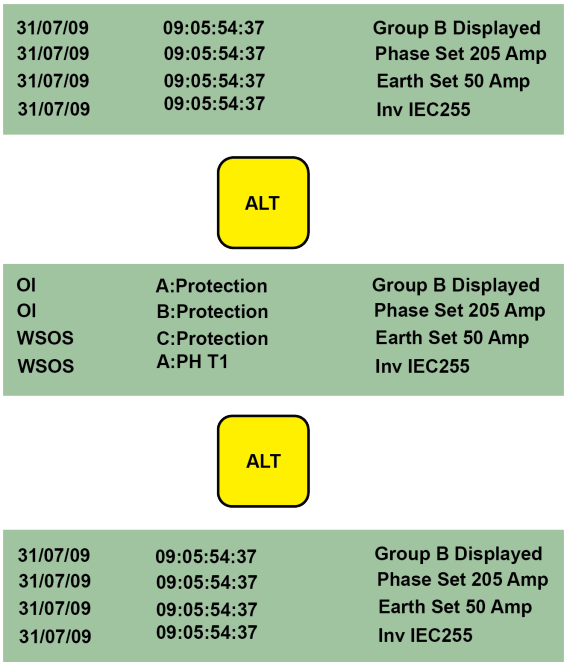
## Event Sources

The source of an event can vary. For example, a Work Tag Applied/OFF setting change event could have been triggered from IOEX, the O.I., local WSOS5, remote WSOS5 over TCP/IP, or SCADA protocol.

If the **ALT** key is pressed whilst the event log is on the display then the date and time details are replaced with extra information that includes the source. Pressing the Alt key again will red is play the date and time information.

## Setting Change Events

The PowerLogic ADVC Controller logs all setting changes regardless of the source. Pressing the **ALT** key when setting changes are being displayed in the event log will display not only the source but also extra information that could include the protection group, curve and trip number. Pressing the **ALT** again will return the Event Log display to normal including Date/Time stamps.




In the above example, extra information regarding setting changes was displayed.

**Event 1** (top) – The O.I. was used to change the displayed protection group from A to B.

**Event 2** – The O.I. was used to change the Phase Trip setting from Group B to 205 Amps.

**Event 3** – WSOS was used to change the Earth Trip setting for Group C to 50 Amps.

**Event 4** (bottom) – WSOS was used to change the Phase Trip 1 protection curve in Group A to IEC255 standard Inverse.

## Event Log Filtering

It is possible to filter the events displayed by the ***set*VUE** panel to show only those of interest at the time.

Up to six filter categories can be active at any one time.

The effect of the filter is to OR categories that is if two categories are selected, events that fall into one or the other category will be displayed.

The event filter can be accessed by pressing the **SELECT** key. The Event Log display will change to the **Change Event Filter** page shown below.



By default, filter No 1 is set to **ALL** which makes the other five filters redundant and they are set to **BLANK**. Each filter field can be selected and any of the available categories can be assigned to that field.

The following categories can be selected for the Event log filter:

**Table 9 Event Log Filter Categories**

| Filter Category | Events Shown |
|---|---|
| All | All events are shown |
| Settings | All setting changes with source WSOS, Panel, IOEX or Protocol |
| Protection | All protection related events |
| Protocol | All SCADA related messages and changes |
| WSOS | All changes with source WSOS |
| Panel | All changes with source Panel |
| IOEX | All IOEX messages |
| Switchgear | All messages from the switchgear |
| Power Quality | All quality of supply messages |
| Controller | All controller hardware related events |
| Network | All electrical system events |

A filter configuration as shown below would cause only events that were either protection related, setting changes or messages from the switchgear to be displayed.




Press the **MENU** key to activate the new settings and return to the Event Log display after the Change Event Filter has been configured.

The figure below is a graphical representation of how to navigate the Event Log on the ***set*VUE** panel.

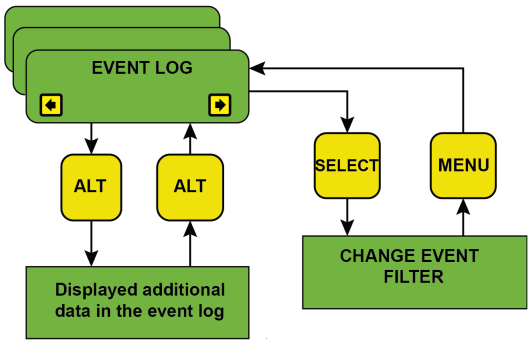



**Figure 26**
***set*VUE** O.I. Event Log Navigation

# PC Software

## What's in This Chapter

Introduction to WSOS ..... 66
WSOS Software Tools ..... 78

# Introduction to WSOS

Basic configuration of the PowerLogic ADVC Controller can be performed by either the O.I. or using the WSOS software. Some advanced features can only be configured through WSOS.

WSOS is an alternative PowerLogic ADVC Controller interface. It is a software package, based on Microsoft Windows®, for a Personal Computer (PC) that allows management, control, and monitoring of a population of PowerLogic ADVC controller.

WSOS provides easy access to all switchgear functions from opening/closing, configuring protection and communication parameters through to accessing measurement and analytical data. By using a desktop or portable PC, engineers can manage many devices either remotely through a communications link or locally through a serial, USB or Ethernet connection.

WSOS provides:

- Local language support
- Advanced controller support
- SCADA communications capture tool
- Controller firmware loading
- Switchgear explorer
- Launch pad
- Switchgear status
- Event log and filtering
- Feature selection page
- Setting pages

WSOS provides facilities for

- Online and offline management of all protection settings.
- Tripping and Closing of the switchgear and other operator control functions.
- Uploading of historical data (for example, event record or demand measurements) to the computer, which can be taken away and processed elsewhere.

# Password Control

The correct password is required to be entered when changing device parameters and settings. The password required when changing settings depends on whether the setting being changed belongs to the Operator, Telecontrol or Protection/Detection group.

These passwords are all *CAPM* by default but can be changed if the System password which defaults to *WSOS* is known.

There is one other password in WSOS known as the Remote Access password which defaults to *000000* (6 zeros). WSOS will request this password if a setting is attempted to be changed remotely but the password is in fact stored in the controller. In summary, WSOS passwords and their defaults are shown in the table below:

| Password | Default | Stored |
|---|---|---|
| System | WSOS | WSOS PC |
| Operator | CAPM | WSOS PC |
| Telecontrol | CAPM | WSOS PC |
| Protection/Detection | CAPM | WSOS PC |
| Remote Access | 000000 (6 zeros) | Controller |

Passwords can be changed in WSOS through Password Control in the WSOS Customise menu.

Password Control also allows timeouts to be configured. The options are:

- No Password Time Out
- Password Times Out After n minutes (n = 5 minutes by default)
- Require Password Every Time

Only one password can be active at one time. So even if a password is set to not time out, it will be cancelled when another password is entered.

# WSOS5 versus O.I.

Most PowerLogic ADVC Controller settings and/or features are available through both the O.I. and WSOS, however:

Some are available on the O.I. only and some through WSOS5 only. Other features are specific to WSOS5. The following sections give details.

## Functions available through the operator interface and not WSOS

The functions available through the O.I. and not WSOS are:

- Switchgear LOCAL/RM
- Maximum Demand Indication (MDI) reset

## Functions available through WSOS and not the O.I.

The functions available through the WSOS and the O.I. are:

- Switchgear Cable Entry Module (SCEM) data read/writing and viewing
- Event log history find by text and date
- Event log history include and exclude text filter
- Configurable history configuration and viewing and graphing
- Harmonic history configuration and viewing
- Waveform capture data retrieval, storage, and viewing
- Waveform generation
- Configuration of IOEX2 maps
- Configuration of communications protocol maps
- Configuration of ***flex*VUE** O.I. mapping
- Communications capture
- Feature selection Available/Not Available for certain features
- VT Configurator
- Custom menu configuration
- Standard menu first screen configuration
- PowerLogic ADVC Controller Password configuration
- Configuration of Custom Logic Tool (CLT) maps
- Creation/configuration of User-Defined curves
- Configuration of DNP3 Secure Authentication

## WSOS Only Features

Some WSOS features are WSOS only and not supported by the controller.

- Launch pad
- Switchgear explorer
- Switchgear navigator
- Switchgear status
- Automatic data retrieval (ADR)

  **NOTE:** Enhancement to ADR can be configured in WSOS to retrieve data from multiple controllers on a regular basis. Prior to version 5.16.25, data retrieval over a TCP/IP connection was done in a sequential manner, where in WSOS would connect to each controller one at a time to retrieve the data configured via ADR. With 5.16.25, this task has been modified to allow WSOS to establish simultaneous TCP/IP connections to multiple controllers. GEX69813.
- Operator Log
- Communications Output Log
- Display and printing of settings
- PowerLogic ADVC Controller firmware loader
- Communication statistics
- Settings retrieval and storage
- Settings export/import
- Configurable Protocol Tool
- IOEX Editor
- Intelligent Loop Automation Schemes
- NTP Setup
- SCADA Communications Diagnostics
- Batch Change Configuration
- OCP Configuration Tool
- CLT
- DNP3 Secure Authentication
- Four user password levels - operation, telecontrol, protection, and system

## System Properties

WSOS System Properties can be opened in WSOS by selecting Properties in the Customise menu.

The System Properties contains the following pages:

- Directories: Includes information on where directories associated with WSOS are located.
- Mail: Contains the Mail Profile used when emailing Switchgear files and in the reporting of WSOS issues to Schneider Electric.
- Log: Logging provides diagnostic support for WSOS to help Schneider Electric to make sure that WSOS is running as it must.
- Start up: The Start Up page specifies which of the Launch Pad pages to load when WSOS starts up, or whether to show the Launch Pad at all.
- Colors: The Colors Page allows you to customize the color of the text and its background for special fields in WSOS.
- Advanced: The Advanced page contains customizable user interface options for WSOS.

- Upgrade: The Upgrade page contains options on how to handle different WSOS switchgear file versions.
- Convert: The Convert page contains an option to convert all the WSOS4 version files to WSOS5 version files.
- Fonts: The Fonts page contains an option to change the font of the switchgear explorer and other tree control fonts.
- Dots per inch: The dots per inch page contains an option to change the dots per inch displayed on the screen.

# New Switchgear Device Wizard

The New Switchgear Device Wizard will guide you through the process of creating a new switchgear file. The file will be saved in the switchgear directory as setup in Directories under System Properties.

## To Open the New Switchgear Wizard

- Select **New** in the file menu or
- Select the **New Switchgear** icon on the main tool bar or
- Right click in the switchgear explorer and select **New Switchgear** from the popup menu.

Any of the above actions will launch the **New Switchgear Device Wizard** shown below.

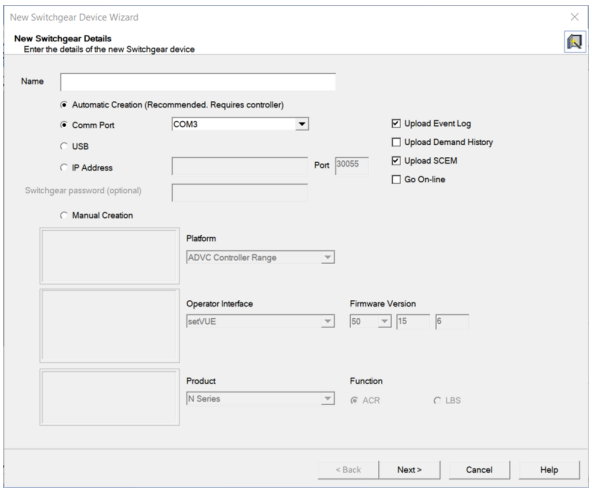



**Figure 27**
WSOS New Switchgear Device Wizard page

This dialogue consists of the following fields:

- **Name** – The name of the switchgear. This name must be unique, no longer than 29 characters, and must not contain any of the following characters ~^:*?<>/”.
- **Platform** – The platform on which the switchgear operates.
- **O.I.**
- **Product** – The type of switchgear
- **Function** – The function the switchgear will perform that is ACR or LBS.
- **Firmware Version** – Select the version of the firmware loaded in the controller.

This wizard offers two ways of creating a new switchgear file:

- Automatic
- Manual

**Automatic:**

This is the preferred method but requires that the PC running WSOS be connected to the controller that is powered up, through a Serial, USB or Ethernet port.

To use this method, enter a Name for the switchgear and select the communications medium. If Serial or IP Address are selected their details are also needed. If USB is selected, a list of connected USB devices will be displayed for selection at the next step.

When all details have been entered, selecting the **Next >** button will initiate WSOS going on line and reading the settings and relevant information from the device. When the Read Switchgear Settings is complete, the new switchgear file will be ready to use.

**Manual:**

If it is not possible to go on line to the controller and read the settings when the file is being created, the only option is to use the manual method. This method requires that Manual Creation is selected and information regarding Name, Platform, O.I., Product, Function, and Firmware Version are entered. When all details are complete, select the **Next >** button and follow the prompts to manually create a new switchgear file.

> **NOTE:** When creating the switchgear file manually, it is important that the right firmware version is chosen. The firmware version will determine the features available and configurable in the controller.

# WSOS Communications Configuration

If a switchgear file has been created manually its communications settings will need to be configured before it can communicate with the controller. Each switchgear file has its own unique communications settings that can be configured by selecting **WSOS Communications** in the **Customize** menu.

This will launch the **Communications Configuration** dialogue box shown below.

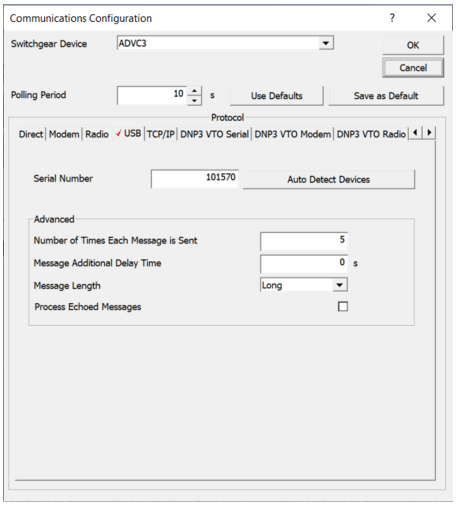



**Figure 28**
WSOS Communications Configuration page

The communications configuration window contains the following fields:

- **Switchgear Device**: This is the name of the selected switchgear for which the settings on this window apply. To change the Switchgear that you are configuring, select the appropriate switchgear name from the combo box.
- **COMMS Channel**: Only displayed when the direct protocol is selected.
- **Polling Period**: The number of seconds between when WSOS polls the Switchgear for information.

- **Active Protocol**: Each of the tabs represent a communications protocol for use in WSOS. The active protocol is identified by a tick in the protocols tab. To change the active protocol, select the tab of the protocol you would like to use.
- **Save as Default**: Store all the communications properties to a default data file for the selected communication channel. This default data can subsequently be used when setting up a new switchgear.
- **Use Default**: Used to set all the communications properties from a previously saved configuration.

The preferred WSOS protocol is USB, which will be described here.

A USB connection requires a USB Type A to Type B cable connected between a USB port on the PC and the dedicated WSOS USB Type B port on the controller PowerLogic ADVC3.

**NOTE:** WSOS version 5.16.xx installs USB drivers that work with PowerLogic ADVC3 Controllers.

A USB configuration requires the serial number of the controller to be entered in the Serial Number field on the USB tab. Each PowerLogic ADVC Controller is programmed with a unique Serial number, and is visible in the barcode sticker. If the serial number is not known, select the Auto Detect Devices button.

This will open a new window displaying all the connected USB devices.

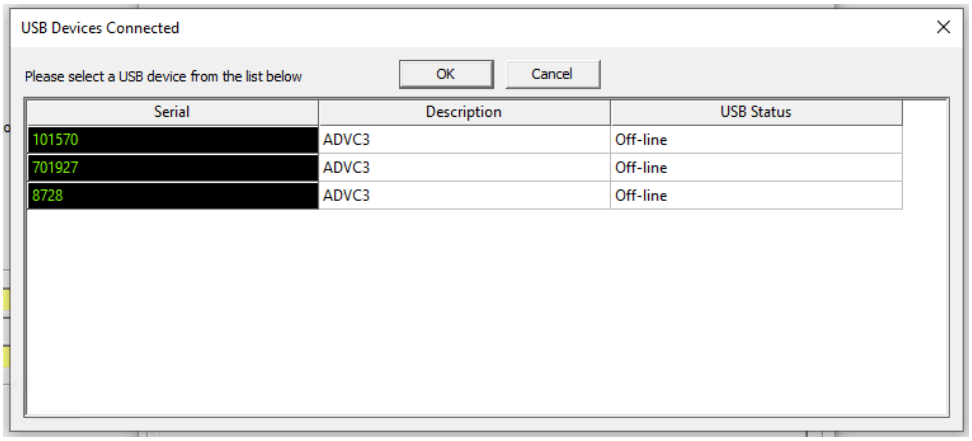



**Figure 29**
WSOS USB Devices Connected page

Select the serial number corresponding to the controller being configured and select **OK**.

The switchgear file is now configured for a USB connection which can be confirmed at the bottom of the WSOS screen.

## Store settings on the Controller

A Store Settings command is now available via the Options menu in WSOS. This can be used to instruct the controller to commit settings to non-volatile memory immediately, when WSOS is online to the controller. This option can be exercised with the older firmware versions of PowerLogic ADVC, to commit settings changes to permanent memory.

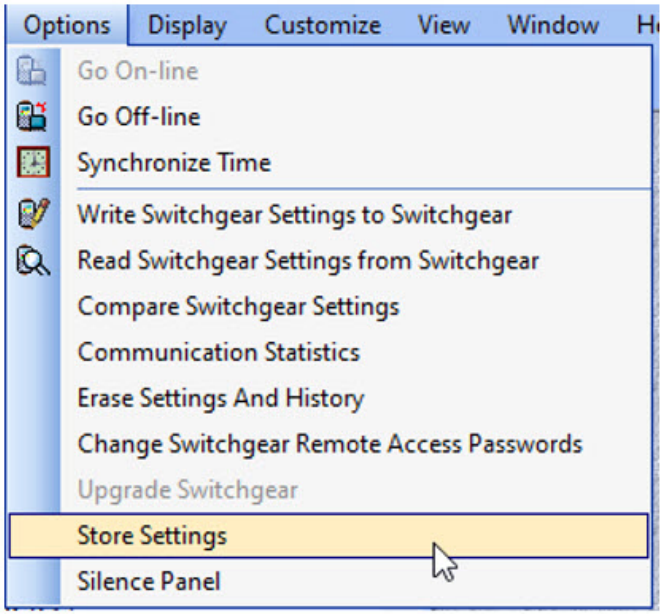



**Figure 30**
Store Settings navigation in WSOS5

# Updating Controller Firmware

The PowerLogic ADVC Controller supports firmware versions 50+. PowerLogic ADVC Controller files have an *.advc* extension.

Updating the firmware in an PowerLogic ADVC Controller can be carried out through WSOS by using the procedure below or via USB Memory Stick.

## WSOS Update Procedure

Select **ADVC Loader Tool** in the **Customize** menu to launch the **ADVC Loader Wizard**.

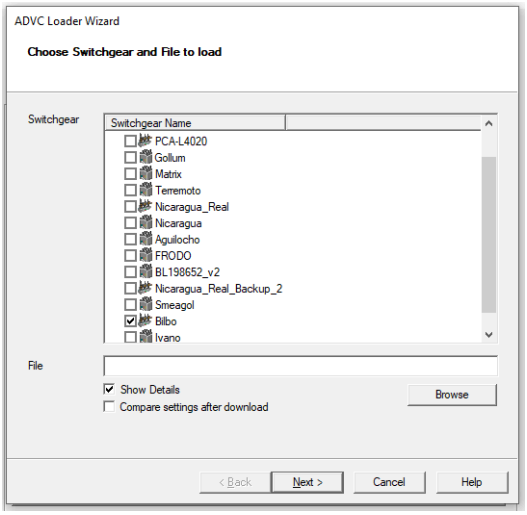



**Figure 31**
WSOS ADVC Loader Wizard page

The ADVC loader wizard will display a list of switchgear in the current working directory. The switchgear file that the wizard was launched from will be selected. Other switchgear can be selected also providing WSOS can connect to them. Select the Browse button and browse to the file to be loaded.

There are three optional check boxes at the bottom of the page:

- Show details
- Compare settings after download
- Force download

## Configurable Secure File Copy (SCP) Port Number

When upgrading the firmware on an PowerLogic ADVC Controller via TCP/IP, WSOS sends the firmware package to the controller via the Secure Copy Protocol, which uses the standard port number 22.

The PowerLogic ADVC Controller is often installed with a Radio or other communication front end device, which could also use the standard TCP port 22 to help prevent an over-the-air firmware upgrade of the PowerLogic ADVC Controller.

With version 5.16.25, this port has been made configurable. If the Radio or front end communication device supports port forwarding, then over-the-air upgrade can be achieved by configuring the SCP port number to use in WSOS and setting up a forwarding rule in the front-end device to forward all communications to the port number 22 PowerLogic ADVC Controller.

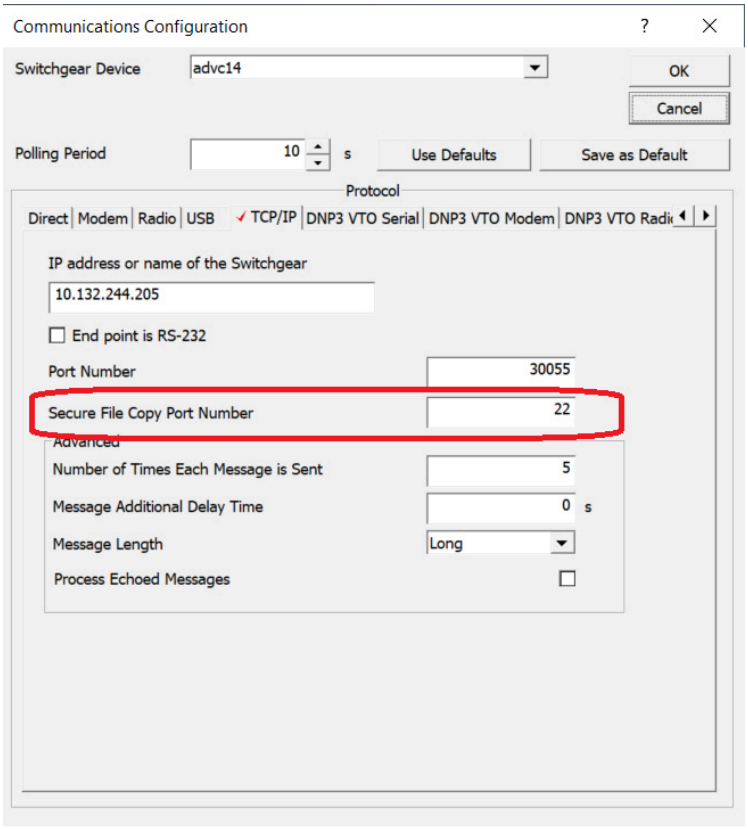



**Figure 32**
SCP Port setting

**NOTE:** After installing WSOS5 5.16.25, all switchgear files will be updated to add attributes related to the changes made to ADR and the configurable SCP port. These may show up as unsaved changes when closing WSOS. The user will need to click *Yes* button when presented with the WSOS Save Settings window. This will not modify any configuration related to the controller.

## Show Details

If this box is ticked, the window that appears while the load is in progress will list the individual software modules and their progress as they are being loaded. If this

box is unticked, only the main progress bar for the entire software load will be shown.

## Compare settings after download

If this box is ticked, the Wizard will launch the Compare Settings function immediately after the download to confirm that none of the switchgear settings have changed during the load.

## Force Download

When a software load is initiated, the wizard compares the software being loaded with the software in the controller. If the software versions are the same, the wizard will not proceed and display:

All up to date. Nothing to load. Finished.

If it is suspected that the software in the controller is corrupt, the same version can be loaded again with the force download check box selected.

Once the wizard had been configured, select the **Next >** button to initiate the firmware load procedure.

When the procedure is complete and the controller has automatically re-booted, a successful load can be confirmed by going on-line with WSOS and opening the configuration page which displays the firmware version loaded in the controller.

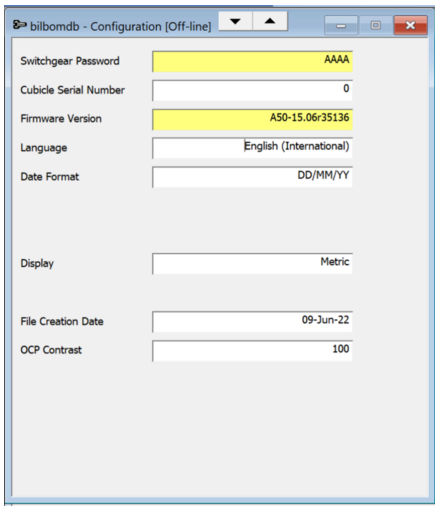



**Figure 33**
WSOS Configuration page

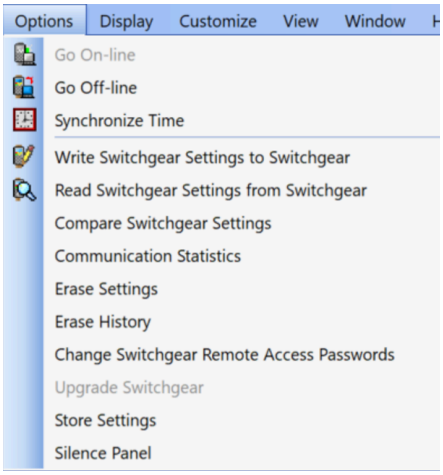
# Reading and Writing Switchgear Settings

When working with WSOS it is important to understand what is meant by off-line and on-line files. The off-line file is stored on the PC and displayed by WSOS while it is off-line. When WSOS goes on line to a controller, the displayed settings may not change but WSOS is now showing the settings stored in the controller i.e. the on-line file. To change a setting in the controller using WSOS, either change it while WSOS in on-line or change it while WSOS is off-line, then go on-line and write it to the controller.

# Read Switchgear Settings

When WSOS is on-line, switchgear settings can be written to and read from the controller using wizards that can be opened from:

- The switchgear connection tool bar if configured or
- The options menu




The read switchgear settings from switchgear command launches the **Read Settings Wizard** where the information to read can be selected using the tick boxes for each setting group.

The read will effectively copy the settings in the controller and write them to the WSOS Off-Line file.

Tick the boxes for the settings to be read and click **Next >**.
When the Read is complete, the wizard displays information to show which settings have been successfully read from the controller.

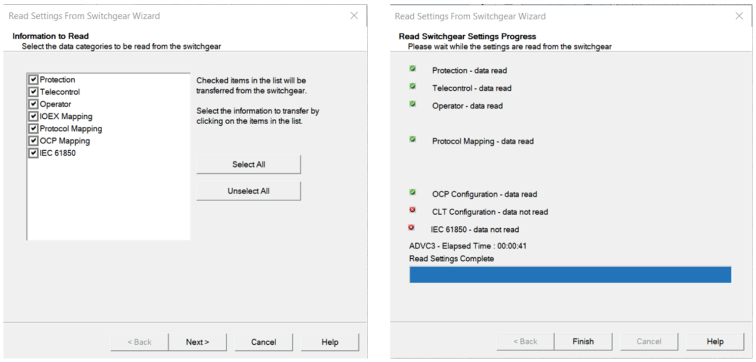



**Figure 34**
WSOS Read Settings pages

# Write Switchgear Settings

When the **Write Setting Wizard** is launched it opens with a warning that this action will overwrite the settings in the controller with the settings in the off-line file.

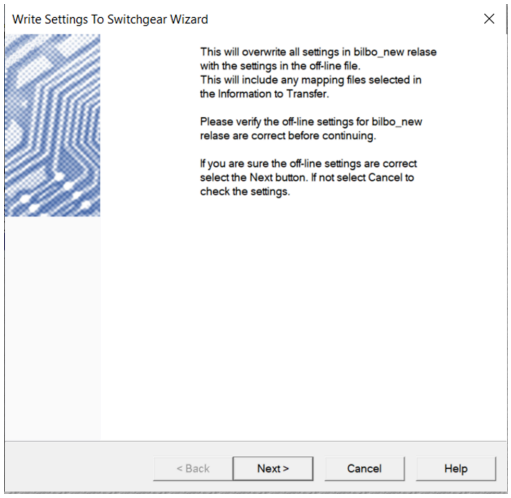



**Figure 35**
WSOS Write Settings to Switchgear Wizard

1. Select **Next >** to proceed with the Write command.
2. The wizard will display the check boxes for each of the setting groups, similar to the read wizard.
3. Tick the required check boxes and click **Next >** to start the write process.
4. When the Write is complete, the wizard will indicate which setting groups were written and if any were not written.

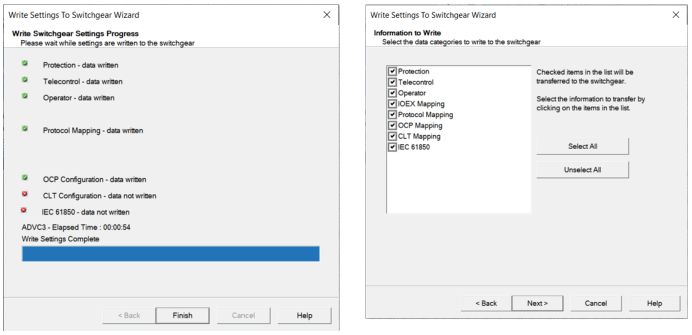



**Figure 36**
WSOS Writing Settings to Switchgear pages

# Firmware Upgrade via USB Memory Stick

Version A50-07.01 now provides support for upgrading the firmware on the controller via a USB memory stick.

To use this feature, an encrypted image of the firmware is prepared via WSOS5 5.16.15 and copied to a specific location on the USB storage device.

This can be done by navigating the **Firmware Loading Options** menu item under the **Customize** menu in WSOS5 5.16.15.

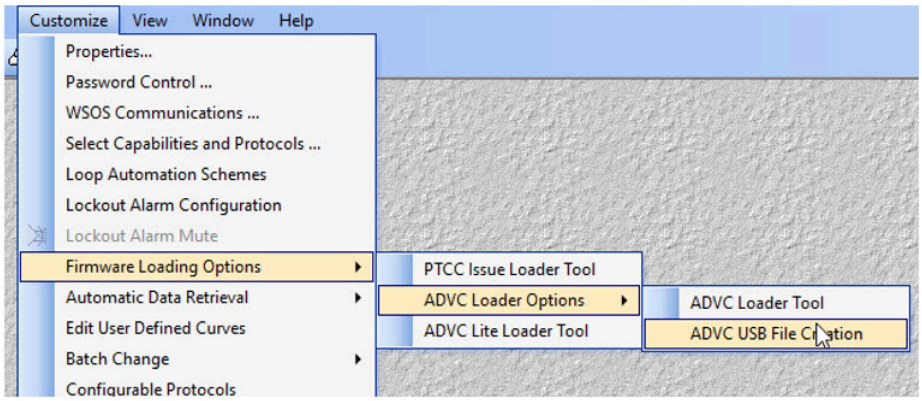



**Figure 37**
USB Firmware upgrade

On inserting a USB storage device and then selecting this option, the below dialog is displayed.

The required firmware file (version greater than A50-07.01) can be selected via the **Browse** option. Once selected, additional options for retrieving data from the controller can also be chosen. The final step is to click on the **Save to USB** button.

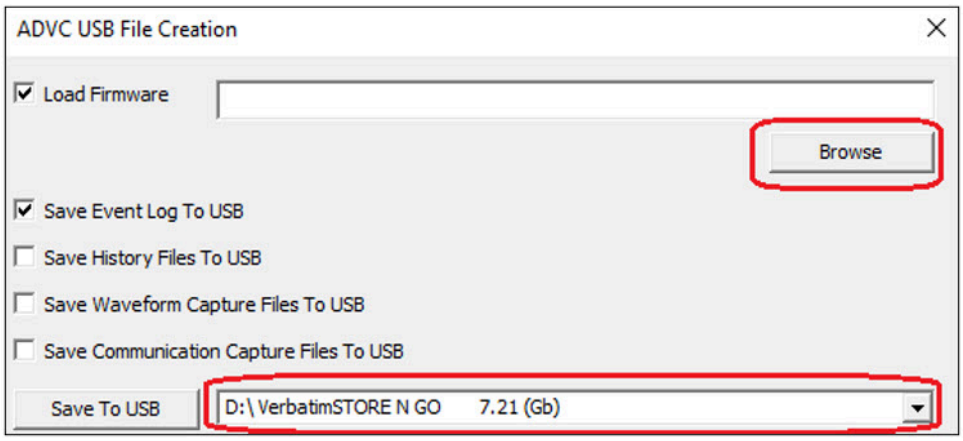



**Figure 38**
Save to USB options

This ***prepared*** USB storage device can now be inserted into any of the ports on the PowerLogic ADVC Controller. On insertion, the user needs to follow the instructions on the panel to execute the upgrade/retrieve the data. The controller will indicate completion of the selected tasks on the Panel.

**NOTE:** It is not possible to downgrade the firmware on the controller via this option. The controller will reject any attempts to downgrade.

# WSOS Software Tools

The WSOS application includes several tools that can be used to configure software features supported by WSOS. The operation of each of these tools are described in dedicated technical manuals and a brief overview is included in this document.

## Protocol Configuration Tool

### Overview

The Protocol Configuration Tool allows WSOS users to generate custom mappings for supported protocols and load them into an PowerLogic ADVC Controller.

## Launching the Protocol Configuration Tool

The **Protocol Configuration Tool** can be launched by selecting configurable protocols in the WSOS customize menu when WSOS is off-line.

This will open the protocol configuration dialogue box shown below:

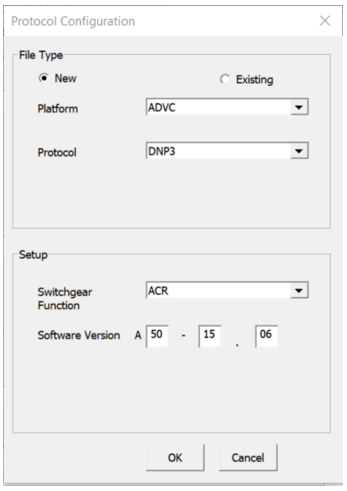



**Figure 39**
WSOS Protocol Configuration page

Choose **New** or **Existing** depending on whether a new protocol mapping file is being created or an existing file is being opened.

Choose **Platform**> **PowerLogic ADVC** for PowerLogic ADVC3 controllers.

The protocol configuration tool supports:

- DNP3
- IEC 60870-5-101/4
- Modbus

For PowerLogic ADVC controllers complete the setup information and select **OK**.

> **NOTE:** When reusing an existing protocol map, please check that the firmware version in the controller is equal to or higher than the firmware version that the map was created for.

## Technical Manual

When the Protocol Configuration Tool opens, a new menu entitled protocol configuration tool will appear in the WSOS main menu bar.

From this menu, the technical manual for the protocol configuration tool can be opened from:

**Protocol Configuration Tool Help**> **Manual**.

Protocol technical manuals are also available from the help menu.

# IOEX Configuration Tool

## Overview

The configurable IOEX tool allows WSOS users to generate custom I/O mappings for an IOEX.

Logic can be applied to each point with up to five sets of logic or actions for each input and one trigger action for each output.

## IOEX Available

The PowerLogic ADVC Controller can support two IOEX devices but the first IOEX must be made available either through WSOS feature selection:

**Display**> **Configuration**> **Feature Selection**> **General**
or through the operator interface, page 697.

## Launching the IOEX Configuration Tool

The IOEX configuration tool can be launched by selecting

**IOEX**> **Configure ADVC IOEX** Mappings in the **Customize** menu when WSOS is off-line.

That will open the **Open OCP Configuration** dialogue box shown below.

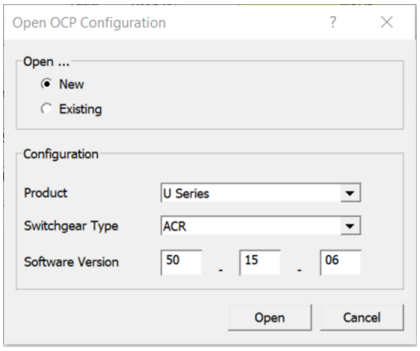



**Figure 40**
WSOS File Options page

Choose **New** or **Existing** depending on whether a new IOEX mapping file is being created or an existing file is being opened.

Complete the setup information and select **OK**.

That will leave the IOEX Configuration Tool open to configure a new mapping.

## Technical Manual

The technical manual for the IOEX configuration tool can be opened by selecting manual in the IOEX configuration tool help menu.

# O.I. (*flex*VUE) Configuration Tool

## Overview

***flex*VUE** O.I.s are shipped from the factory with a **Master OCP Map** to suit all 94 switchgear types. The OCP Configuration Tool allows users to create customized maps to suit their requirements and/or preferences. Global settings as well as individual settings for each status lamp and QAK are configurable. The tool includes an application to print labels for customized maps.

## Launching the OCP Configuration Tool

The OCP configuration tool can be launched by selecting **OCP Configuration Tool**> **Open** in the customize menu.

That will open the **Open OCP Configuration** dialogue box shown below.

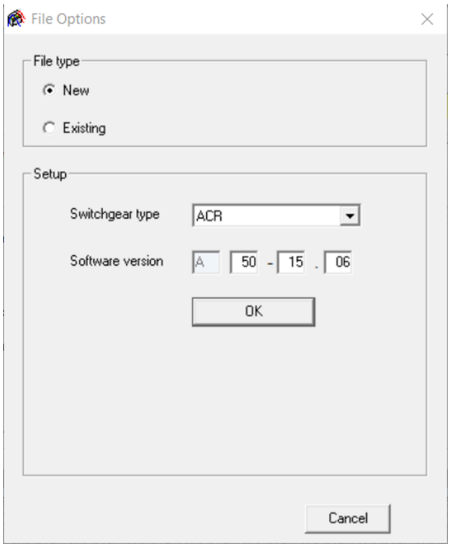



**Figure 41**
WSOS Open OCP Configuration page

Choose **New** or **Existing** depending on whether a New OCP configuration file is being created or an **Existing** file is being opened.

Complete the configuration information and select **Open**.

When the OCP configuration tool opens, a **New** menu entitled OCP configuration tool will appear in the WSOS main menu bar.

More detailed information on the OCP configuration tool can be found in flexVUE customisation.

# Custom Logic Tool (CLT)

## Overview

The CLT provides the user with an opportunity to develop additional logic functionality for the PowerLogic ADVC Controller Range. By evaluating user-defined collections of digital and analogue data points from the existing protocol database, the CLT is used to alert operators of specific conditions that may exist on-site. Based on these conditions, it is also possible to program basic actions automatically if required.

## Launching the CLT

The CLT can be launched by selecting **CLT**> **Open** in the customize menu.

This will open the **Open CLT Configuration** dialogue box shown below:

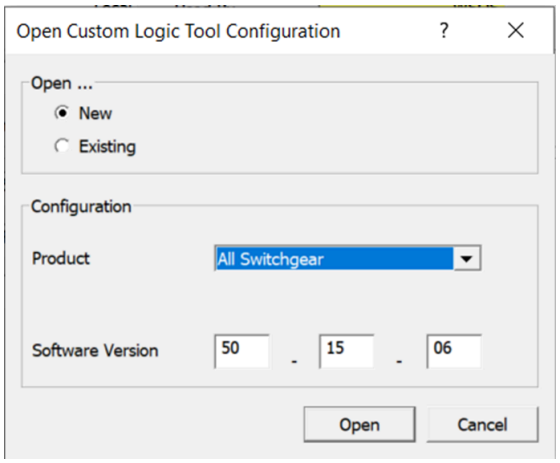



**Figure 42**
WSOS Open CLT Configuration page

Choose **New** or **Existing** depending on whether a **New** CLT configuration file is being created or an **Existing** file is being opened.

Complete the configuration information and select **Open**.

## User Guide

When the CLT configuration tool opens, a new menu entitled CLT logic tool will appear in the WSOS main menu bar.

From this menu, the user guide for the CLT can be downloaded by selecting **Open Manual**.

> **NOTE: Faster CLT** The CLT functionality used to have an inherent 500 ms delay in evaluating expressions that used on any of the controller's Analogue data as a data point. With version A50-11.xx, we have now introduced a new class for Analogue data points, under Appendix A_10. These appear as 40 ms Analogs in the Logic Expression Builder tool and are available for use within the CLT only.

# Controller Customization

## What's in This Chapter

Introduction....84
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Time Zone....87
***set*VUE** Quick Keys....88
O.I. Customization....90

# Introduction

## Feature Selection

Feature Selection refers to the ability to make PowerLogic ADVC Controller features Available or Not Available as well as Allowing or Not Allowing selected functions.

Making a feature Not Available not only disables the features logic but also removes all reference to the feature in WSOS and on the O.I. The complexity of the user interface is therefore reduced as only the features in use are displayed.

## Feature Selection in WSOS

Feature Selection can be opened in WSOS by selecting **Configuration** > **Feature Selection** in the **Display** menu.

## Categories

Feature selection is divided into five categories with each category including several settings:

### Protection

- Protection Off Allowed
- NPS Off Allowed(1)
- Sequence Components Available
- Earth Fault (EF) Protection Off Allowed
- Directional Blocking ON1
- Directional Protection ON1
- Automatic Protection Group Selection (APGS) Available
- Sensitive Earth Fault (SEF) Protection Available
- Under/Over Voltage (UOV) Protection Available
- Reset Curves Available
- Sequence Reset Clears Fault Flag ON
- Under/Over Frequency (UOF) Protection Available
- Extended Standard Protection ON
- Extended Minimum Time Per Curve ON1
- Conditional Auto Reclose Available
- Per Trip Thresholds (PTT) Available1
- Per Element Reclose Time ON1
- Fault Locator Available
- Sync Check Available
- Second Order Harmonic Inrush Restraint (SOHIR) Available
- Per Element Protection Available1
- Close on Fault Trip Available1
- Voltage Blocked Auto Reclose Available1
- Neutral Voltage Displacement Available

(1) Only in WSOS Feature Selection.

- Close Blocking Available[1]
- Broken Conductor Available

## Automation

- Loop Automation Available
- Auto Changeover (ACO) Available

## General

- Hit and Run Available
- IOEX Available
- Quick Key Configuration Available
- Display Panel Options Available
- Custom Menu Available
- Battery Health Test Available
- Plant Details Available
- Gas Low Inhibit Available
- O.I. Trip Blocked in RM ON
- Counters Non-Volatile ON
- Counters Rollover ON
- Custom Logic Tool (CLT)Available
- Time Zone Available
- Panel Settings are Read-only When in RM

## Communications

- Radio Data Interface (RDI) Driver Available
- DNP3 Available
- IEC60870-5-101/4 Available
- Modbus Available
- SCADA Communications Diagnostics Available(2)
- Hayes Modem Driver Available[2]
- MITS Available[2]
- Switchgear Operating System (SOS) Multidrop Driver Available[2]
- TCP/IP Available
- Protocol Monitor Available
- SCADA Output Control Mode Enabled
- NTP Available
- DNP3 Security Available
- Dynamic UPD Mode for DNP3 Available

## Power Quality

- Supply Outage Available

(2) At the time of preparing this operational manual, these features are available only on the ADVC2 controller. Please contact your Schneider Electric representative, should you need these features on the PowerLogic ADVC3 controller.

- Waveform Capture Available
- Harmonics Available
- Sag/Swell Available

Feature Selection is also available via the operator interface, page 701.

# Plant Details

The purpose of the plant details display is to provide information about the device that might be relevant to an operator or commissioning technician.

Plant details need to be made available through WSOS Feature Selection at:

**Display** > **Configuration** > **Feature Selection** > **General**.

Plant details can also be made available for ACR, page 698 or AS, page 699 on the O.I.

When available, Plant details can be entered on the status page in WSOS and are displayed on the Plant Details, page 678 in the system status menu on the ***set*VUE** O.I.

The details entered can be American Standard Code for Information Interchange (ASCII) text or numbers limited to 90 characters.

**NOTE:** Plant details are not displayed on the ***flex*VUE** O.I.

The WSOS status page is shown below with plant details in the bottom left hand corner.

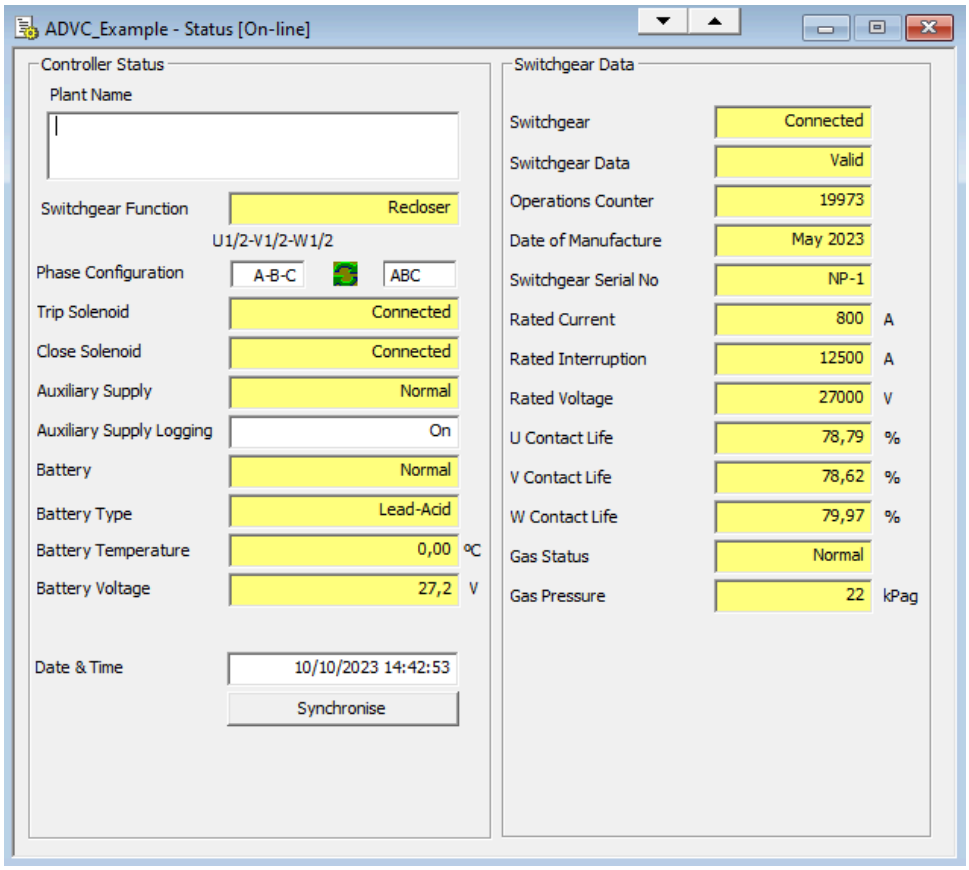


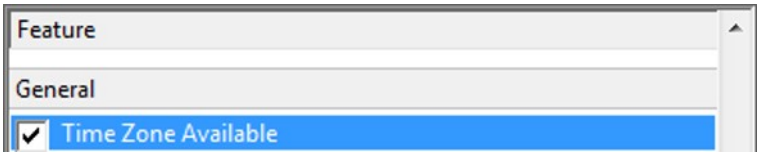

**Figure 43**
WSOS Status page

# Time Zone

The Time Zone feature allows the PowerLogic ADVC Controller to be configured for the time zone where it is located. It also allows the system time to be automatically adjusted for daylight saving during certain times of the year.

Time Zone is an optional feature that must be made available through feature selection before it can be used.

In WSOS: **Display** > **Configuration** > **Feature Selection** > **General**




# Time Zone and Daylight Saving Configuration

Once Time Zone has been made available, Time Zone and Daylight Saving settings can be configured on the configuration setting page in WSOS by going to:

**Display** > **Configuration** > **Time Zone and NTP Configuration**.

There is also an option on this page to select SCADA master station time synchronization using Universal Time Coordinated (UTC) instead of local time.

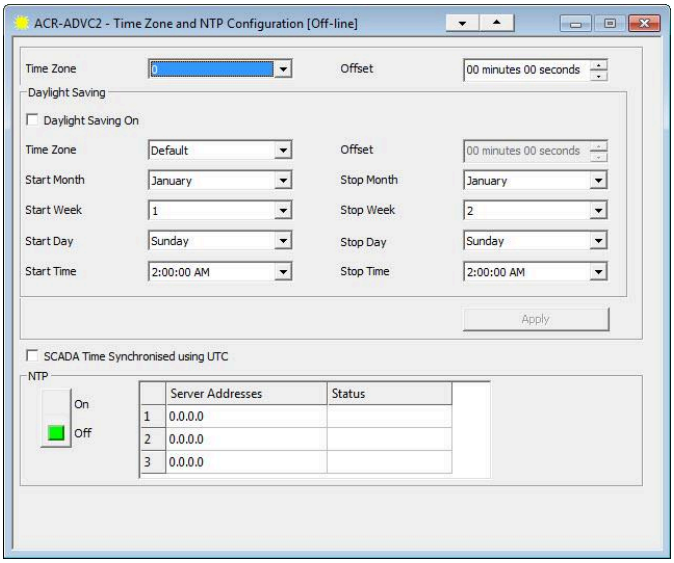



**Figure 44**
Time Zone and NTP Configuration settings

> **NOTE:** Time Zone and Daylight savings settings can only be configured via WSOS. These are not available for configuring via either of the O.I.s.

The below table describes the settings associated with Time Zone and Daylight Saving configuration.

**Table 10 Time Zone and Daylight Saving Configuration settings**

| Setting | Description |
|---|---|
| Time Zone | The time zone where the PowerLogic ADVC Controller is located.<br>Positive values are ahead of UTC<br>Negative values are behind UTC |
| Offset | Any offset from the standard time zone value. |
| **Daylight Saving** | |

**Table 10 Time Zone and Daylight Saving Configuration settings (Continued)**

| Setting | Description |
|---|---|
| Daylight Saving On | Select this to enable time adjustments due to daylight saving. |
| Time Zone | The time zone for when daylight saving is active. |
| Offset | Any offset from the daylight saving time zone value. |
| Start Month | The month when daylight saving will start. |
| Start Week | The week within the start month when daylight saving will start. |
| Start Day | The day of the week within the start week when daylight saving will start. |
| Start Time | The time on the start day when daylight saving will start. |
| Stop Month | The month when daylight saving will stop. |
| Stop Week | The week within the stop month when daylight saving will stop. |
| Stop Day | The day of the week within the stop week when daylight saving will stop. |
| Stop Time | The time on the stop day when daylight saving will stop. |
| Apply Button | When any value is changed in the time zone or daylight saving sections, the Apply button is enabled. This button must be selected for changes to be saved, otherwise the changes will be lost. |
| SCADA Time Synchronized using UTC | When this tick box is selected, SCADA synchronizes the PowerLogic ADVC Controller's time using UTC. When it is not selected, SCADA synchronizes the PowerLogic ADVC Controller's time using local time. |

## Time Zone and Daylight Saving Events

Any changes to the time zone or daylight saving settings will be recorded in the event log when they are enabled. Events are also logged to record the start and end of the daylight saving period.

Some examples of these events are shown in the figure below:

| | Date/Time | Source | Event Text |
|---|---|---|---|
| 1 | 15/03/2017 10:08:25.670 PM | | 15/03/2017 10:08:25 PM |
| 2 | 15/03/2017 12:08:25.616 PM | WSOS | Daylight Saving: Stop Time 12:00:00 AM |
| 3 | 15/03/2017 12:08:25.603 PM | WSOS | Daylight Saving: Stop Month March |
| 4 | 15/03/2017 12:08:25.592 PM | WSOS | Daylight Saving: Start Time 12:00:00 AM |
| 5 | 15/03/2017 12:08:25.585 PM | WSOS | Daylight Saving: Start Month October |
| 6 | 15/03/2017 12:08:25.577 PM | WSOS | Daylight Saving: Time Zone 10 |
| 7 | 15/03/2017 12:08:25.570 PM | WSOS | Standard Time Zone 10 |

**Figure 45**
Sample of Time Zone and Daylight Saving Events

## *set*VUE Quick Keys

The quick keys are provided to assist users not familiar with the menu structure on the ***set*VUE** O.I. to change commonly used settings more easily.

Controllers are shipped from the factory with default quick keys as shown but they can be configured individually for other functions if required.

Configuration of the quick keys using the ***set*VUE** O.I. was described in Configuring the Quick Keys, page 47. Refer to that section for more details. They can also be configured through WSOS which is explained here.

Firstly, quick key configuration must be made available through feature selection. When available, the quick key configuration page can be opened by selecting quick key configuration in the display menu.

The page in WSOS displays the quick keys in the same arrangement that they appear on the O.I.

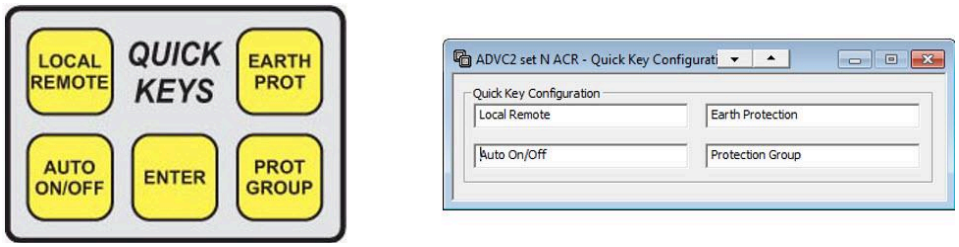



**Figure 46**
Quick Key Arrangement

The fields on the WSOS quick key configuration page can be changed in the same way as any other setting. They can be changed directly when WSOS is on-line or they can be changed off-line and the new settings written to the controller.

A set of stick-on labels is provided with each controller to change the text on the quick keys to match the new function.

The functions available for quick key selection are:

- Cold Load
- Live Load Blocking
- LOCAL/Remote
- NPS Protection
- Reset Flags
- Work Tag
- Battery Test
- Reverse Cold Load
- Auto On/Off
- Earth Protection
- Protection Group
- Blank (no function)

# O.I. Customization

## *flex*VUE Customisation

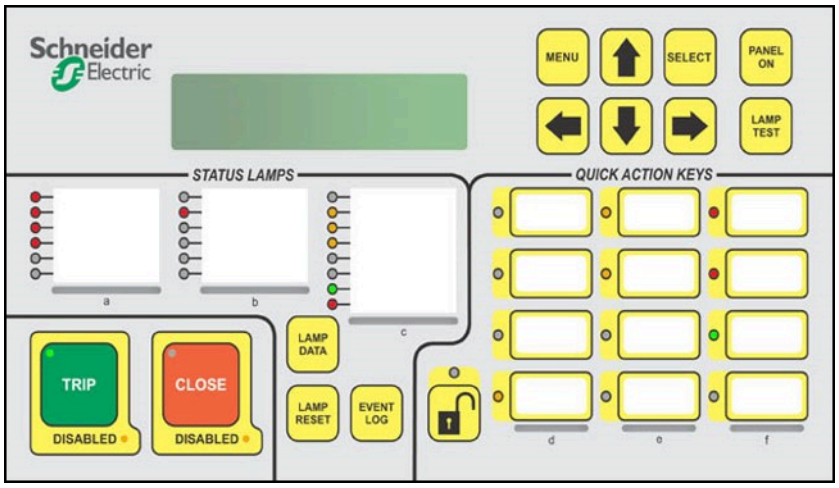



**Figure 47**
***flex*VUE** O.I. layout

The ***flex*VUE** O.I. has the following configurable lamps and keys:

- 20 **Status Lamps** (a1 – c8)
- 12 **QAK** with imbedded LED's (d1 – f4)

Each of the functions below are fully configurable as well:

- Trip and Trip Disabled
- Close and Close Disabled
- Quick Action Key Unlock

The OCP Configuration Tool which can be launched from WSOS is a software tool provided for this purpose. For details of how to launch the OCP Configuration Tool, refer to Launching the OCP Configuration Tool, page 80 in PC Software (WSOS).

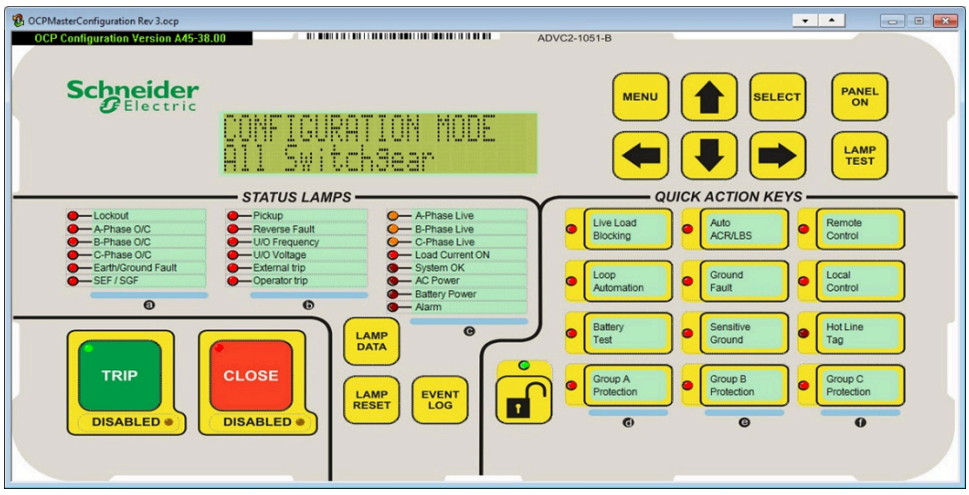



**Figure 48**
***flex*VUE** O.I.

The OCP Configuration Tool can be used to configure/customize the following:

- The function of the Status Lamps and QAK.
- The Description of **Status Lamps** and **QAK**.
- The Lamp color for **TRUE/FALSE** state.
- Flashing of lamps.

- Locking of QAK.
- Set QAK Active when the O.I. is **OFF**.
- Display status of Status lamps and Quick Action Key lamps when the O.I. is **OFF**.
- Set **TRIP** and **CLOSE** buttons active when the O.I. is **OFF**.
- Delay operation of **TRIP** and **CLOSE** buttons.

## Global OCP Settings

Right clicking the mouse with the cursor anywhere over the OCP display will open the **Customize Global OCP Settings** page.

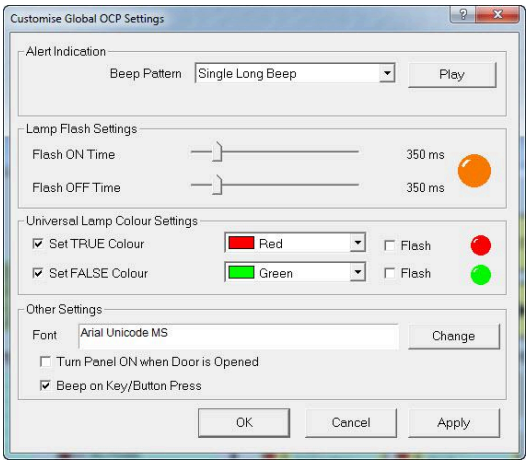



**Figure 49**
Customize Global OCP Settings page

This dialogue can be used to:

- Select and play the **Beep Pattern**.
- Set the **Flash On**/**Flash Off** time settings for the lamps.
- Select **Universal Lamp Color Settings** (leave unchecked if lamps are to be assigned colors individually).
- Select a font for the display.
- Select if the O.I. must turn On when the door is opened.
- Select if a beep is required when a key or button is pressed.

## Status Lamps

Status Lamps are configured individually by left clicking with the mouse on the lamp to be configured.

Selecting the Status Lamp for Lockout (a1), will open the **Customize Status Lamp** dialogue box below.

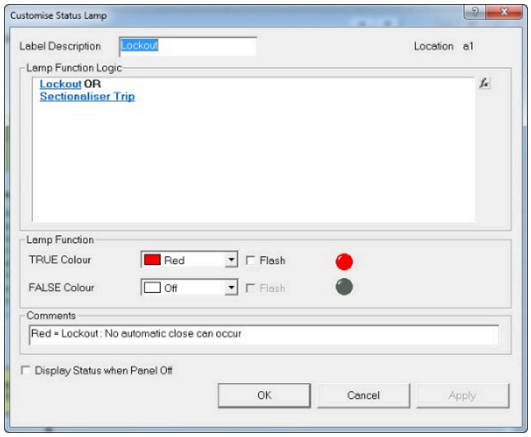



**Figure 50**
Customize Status Lamp page

This dialogue can be used to:

- Change the name (Label Description) of the status lamp. The **Label Description** determines how the lamp is identified when the **LAMP DATA** key is pressed.
- Change the **Lamp Function Logic** that determines the True and False states.
- Set the colors to represent True and False states.
- Edit comments to be displayed when the Lamp Data button is pressed.
- Determine if the status must be displayed when the O.I, is off.

If it is required to change **Lamp Function Logic**, that needs to be done through the **Logic Expression Builder** which is opened by selecting the **fx** button to the right of the Lamp Function Logic field.

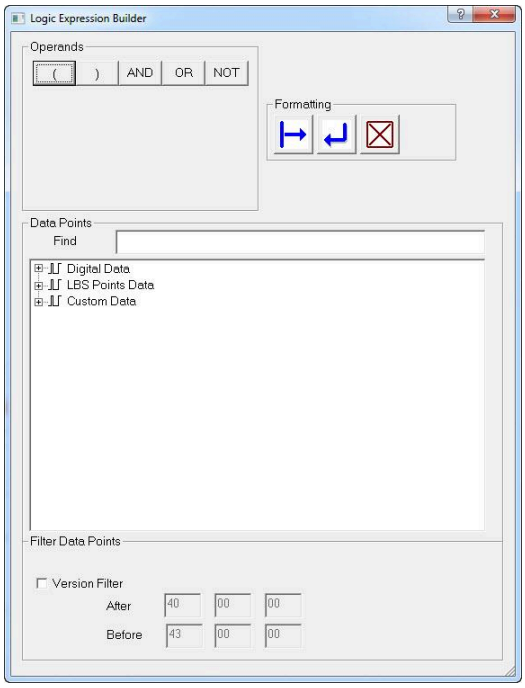



**Figure 51**
OCP Logic Expression Builder

All data points available to be assigned to this status lamp can be found by expanding the tree structures in the Data Points field. The following features are also included:

- A Find box is provided to make finding specific points easier.
- Logic expressions can be built using the Operands provided at the top of the dialogue box.
- Formatting buttons are also provided to assist in making the expression more readable.

## QAKs

QAKs are configured by left clicking with the mouse on the QAKs to be configured.

Selecting the QAKs for **Live Load Blocking** (d1) will open the dialogue box below:

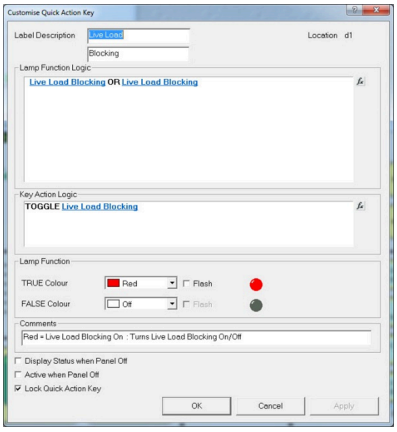



**Figure 52**
Customize QAKs

This dialogue can be used to:

- Change the name (**Label Description**) of the QAK.
- Change the **Lamp Function Logic** that determines the True and False states.
- Change the Key Action Logic that determines the action caused by pressing the key.
- Set the colors to represent True and False states.
- Determine if the status must be displayed when the O.I. is off.
- Determine if the key must be still active when the O.I. is off.
- Determine if the key action is controlled by the Unlock Key status.

There are two **Logic Expression Builders** associated with configuring a QAK and they are opened by selecting the **fx** buttons for each logic field.

The Logic Expression Builder for the lamp function is the same as for the Status Lamps.

There is a different **Logic Expression Builder** for the Key Action Logic.

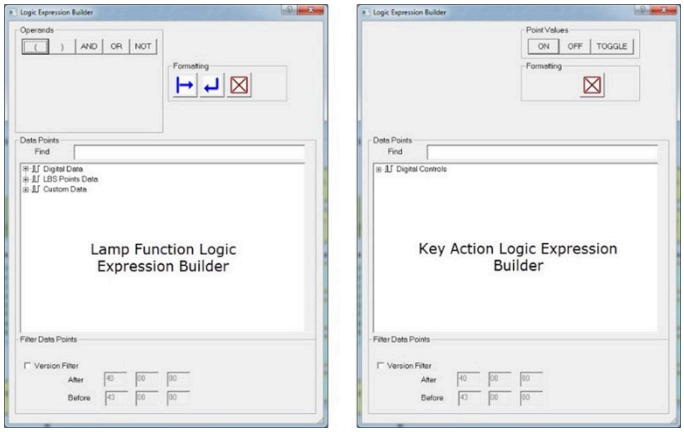



**Figure 53**
Logic Expression Builder for QAKs and Lamp

All data points available to be assigned to this QAK can be found by expanding the tree structure in the Data Points field. The following features are also provided:

- A Find box is provided to make finding specific points easier.
- Expressions can be built using the Point Values provided to determine if pressing the key must turn the selected function on, turn it off, or toggle through the available options.
- A formatting button is provided to delete all text if required.

## Unlock Key

Unless configured otherwise, QAKs are normally locked helps to prevent accidental QAKation. To use the QAKs, an QAKator must first press the Unlock key. The lamp above the unlock key will be green (default) while the QAKs are active. To deactivate the QAKs an operator can press the unlock key again. The lamp will turn red (default).

Alternatively, the QAKs will be deactivated automatically a short configurable delay (default 10 s) after the last QAK was selected.

To customize the Quick Action Unlock key, place the cursor over the padlock symbol and click the left mouse button. This will open the **Customize Unlock Key** dialogue box.

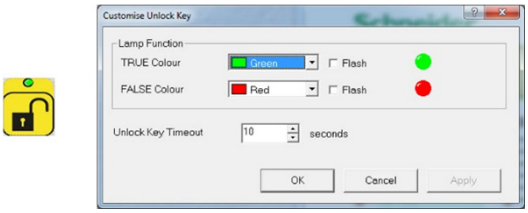



**Figure 54**
Customize Unlock Key page

This dialogue can be used to change the time out period as well as the colors that indicate QAKs are locked and unlocked.

## Trip and Close buttons

The Trip and Close buttons and the Trip and Close Disable lamps are configured separately. Therefore, there are four dialogues associated with customizing these functions.

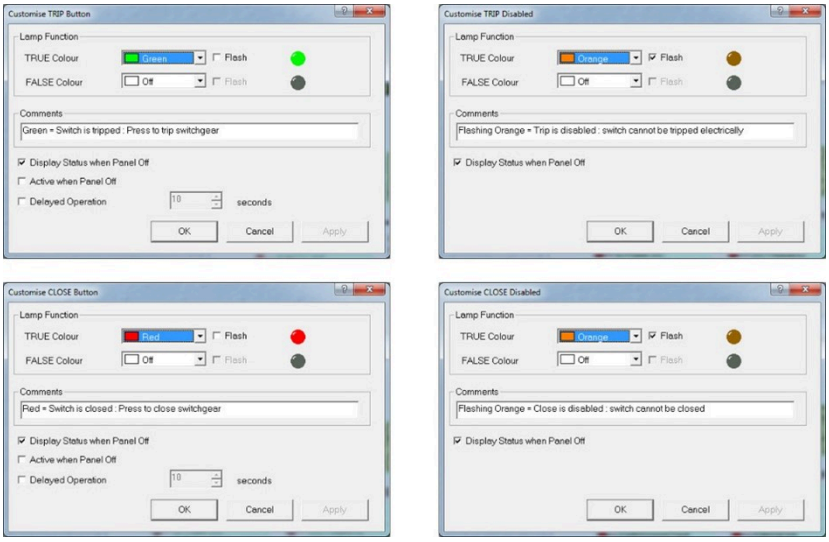



**Figure 55**
Customize Trip and Close Keys

The Trip and Close dialogues can be used to:

- Select the True/False colors for the lamps.
- Determine if the status is displayed when the O.I. is off.
- Determine if the button must be active when the O.I. is off.
- Determine if the action must be delayed and what that delay must be.

The Trip and Close Disable dialogues can be used to:

- Select the True/False colors for the Disabled lamps.
- Determine if the status must be displayed when the O.I. is off.

All dialogues provide for comments to be added for later reference.

# *set*VUE Custom Menu

ThePowerLogic ADVC Controller with ***set*VUE** O.I. supports two types of menu configuration.

- Standard Menu
- Custom Menu

## Standard Menu

The standard menu contains all available screens as described in Appendix K setVUE Menu, page 634.

## Custom Menu

The custom menu is a user defined collection of standard PowerLogic ADVC Controller screens duplicated in a separate menu. It can be configured to only show those pages required for standard operation thus making the operation of the O.I. more user friendly. Up to 40 pages can be mapped to the custom menu.

The custom menu can only be configured through WSOS and the feature must firstly be made available in feature selection.

# Custom Menu Configuration

Configuration can be done on-line or it can be done in an off-line file and the Operator settings written to the controller when on-line.

Once the custom menu has been made available, the menu configuration dialogue box can be opened by selecting

**Configuration** > **Menu** Configuration in the Display menu.

This will open the Menu Configuration dialogue box below.

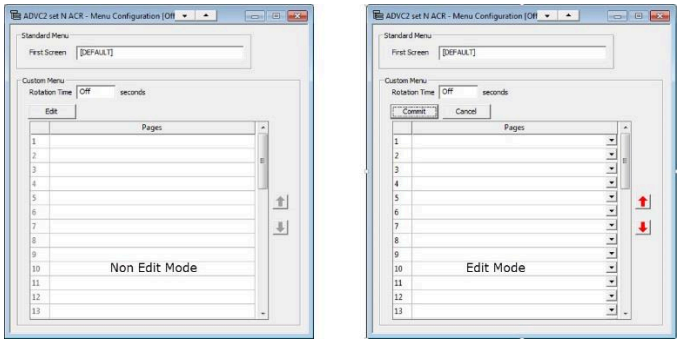



**Figure 56**
***setVUE*** Menu Configuration pages

When the **Edit** button is pressed in the non-edit mode, the display changes to the edit mode allowing pages to be added and deleted.

In the Edit mode, the Edit button is replaced by **Commit** and **Cancel** buttons.

To add a page, click in a spare cell and choose a page from the drop down list.

To delete a page, select that page and press delete on the keyboard.

When the required custom menu pages are displayed, press Commit to make them active and return to the non-edit display.

The **Rotation Time** can also be configured on this page (rotational mode is explained below).

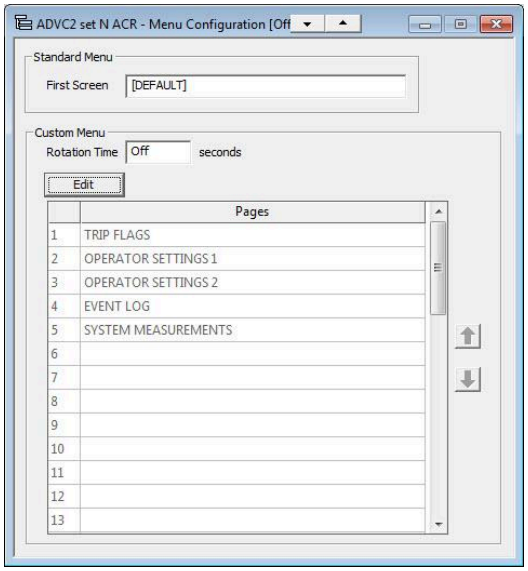



**Figure 57**
Custom Menu Configuration

## Operation

Normally there is only one Maximum Time setting for each protection group. It's a global setting which means that it applies to all trip settings in that group that use an inverse curve for timing.

When the Extended Maximum Time per curve feature is on, there is a separate Maximum Time setting for each inverse curve that has been applied (Maximum 18).

This feature also reduces the minimum value for Maximum Time settings from 2.0 s to 0.2 s. The maximum setting remains at 180.0 s.

The figure below shows the Global Settings and Trip 1 pages with Extended Maximum Timer per Curve Off. In this configuration, Maximum Time is a global setting. One setting per group appears on the Global Settings page.

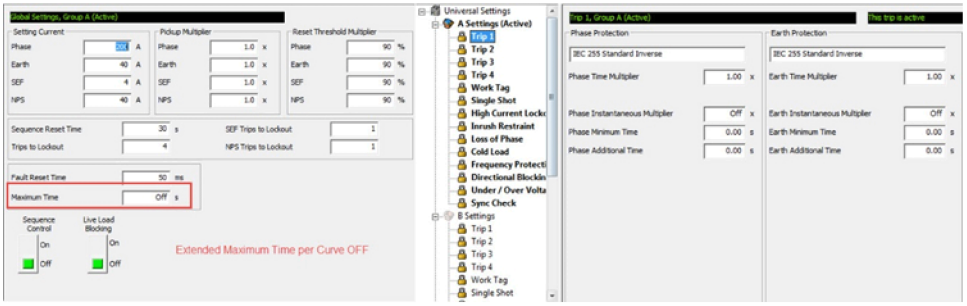



**Figure 58**
Extended Maximum Time per Curve OFF

In the figure below with Extended Maximum Time per Curve On, the Maximum Time setting no longer appears on the Global Settings page. Instead, a separate Maximum Time setting is included for each trip setting for which an inverse curve is selected.

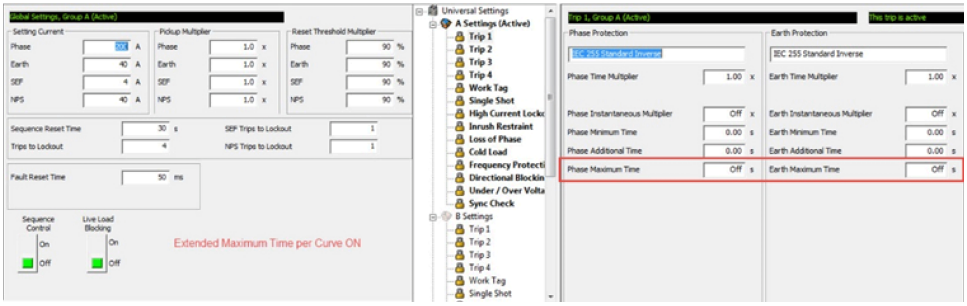



**Figure 59**
Extended Maximum Time per Curve ON

## Custom/Standard Menu Navigation

The custom and standard menus are designed to coexist on the controller.

The standard menu is always available by pressing the **MENU** key.

Navigation differs depending on whether the menu being used is:

- Standard
- Custom without screen rotation
- Custom with screen rotation

## Custom Menu with Rotation Mode Disabled

- Pressing the **MENU** key at any time, will move the user out of the custom menu to the next standard menu display group.

- Pressing the **CUSTOM MENU** key, will move the user to the next screen in the custom menu.
- When displaying the custom menu screens, operation of the Quick Keys, the **ALT** key, the **SELECT** key and Arrow keys are as per standard display group behavior for example, **SELECT** key highlights a setting and Arrow keys move to the previous or next screen.

## Custom Menu with Rotation Mode Enabled

- Pressing any key will halt rotation.
- When a quick key operation is completed that is the **MENU** or **ENTER** or **CUSTOM MENU** key is pressed, rotation is automatically resumed.
- The **ALT** key, **SELECT** key and Arrow keys perform normal operations. Rotation is resumed by – pressing the **CUSTOM MENU** key.
- Pressing the **MENU** key will move the user to, the next standard display group.
- Pressing the **CUSTOM MENU** key, returns the user to the custom display group and restarts rotation.

## First Screen Selection

When standard menus only are used, the first screen seen by an operator on power up is selectable from any page in the menu.

Selection of the first screen can only be made through WSOS

**Display** > **Configuration** > **Menu Configuration**

If the custom menu is used, and rotating screens mode is active, the first screen feature is overridden.

If the custom menu is used, and the first screen selected is unavailable in the menu then the controller will default to the Trip Flags screen.

If the standard menu is active, the selected screen might still not be available if the feature associated with that screen has been made Not Available or Not Allowed in Feature Selection.

In this case the Trip Flags will be the first screen.

# Configuration

## Local Settings

The PowerLogic ADVC Controller has several settings that enable a user to customize its behavior according to global location.

In WSOS, most of these settings are found on the Configuration page.

**Display** > **Configuration** > **Configuration**

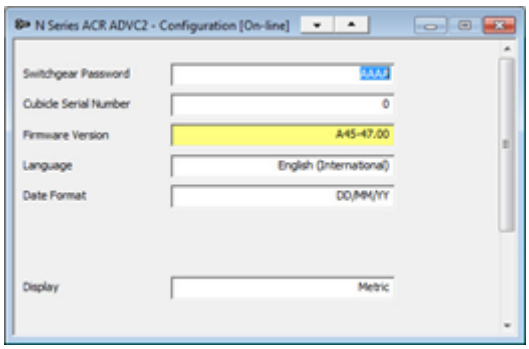


**Figure 60**
WSOS Configuration page

Local settings can also be found on the operator interface, page 701.

## Language Support

The O.I. can display text in multiple languages:

- English (International)
- English (USA)
- Portuguese

The language displayed on the O.I. can be changed from either the O.I. or from WSOS.

## Display Settings Units

Setting units can be displayed in either Imperial or Metric for example, gas pressure can be displayed in either kPag or psig.

Other settings that will be affected by a change of setting units include Distance to Fault measurements.

The Setting Units displayed can be changed from either the O.I. or WSOS.

## Date Format

The date cam be displayed in either of two formats:

- DD/MM/YYYY
- MM/DD/YYYY

The date format can be changed from either the O.I. or WSOS.

## GMT Offset

Determines the Greenwich Mean Time Offset for the protocol’s date/time.

## System Frequency

The System Frequency can set corresponding to the frequency of the system where the device is installed. The options are:

- 50 Hz
- 60 Hz

In WSOS the system frequency is selected on the Measurement page.

**Display** > **Measurement**

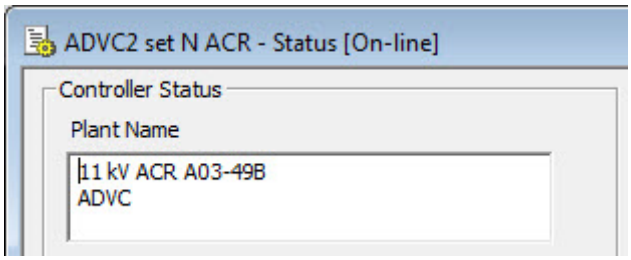
## Cubicle Serial Number

This setting can be entered by an operator through WSOS and is used to identify the control cubicle by its unique serial number.

# Plant Name

When the O.I. is activated, the Start Up screen is displayed briefly. The text Intelligent Power which appears by default, can be replaced by a user defined 20 characters message or Plant Name. The purpose of the **Plant Name** is to help operators identify the plant that they might be planning to operate.

The text required to be displayed by the O.I. on start-up can be entered in the **Plant Name** field on the WSOS Status page.




he **Plant Name** field on the WSOS Status page will accept 90 characters but only the first 20 are displayed on the O.I.

Changing the **Plant Name** will generate a record in the Event Log.

# Communications

## What's in This Chapter

Communications Ports ..... 102
Communications Port Configuration ..... 105
Supported Protocols ..... 111
Communications Features ..... 136

# Communications Ports

## PowerLogic ADVC Communications Ports

The PowerLogic ADVC Controller has eight configurable communications ports located on the CAPE above the O.I.

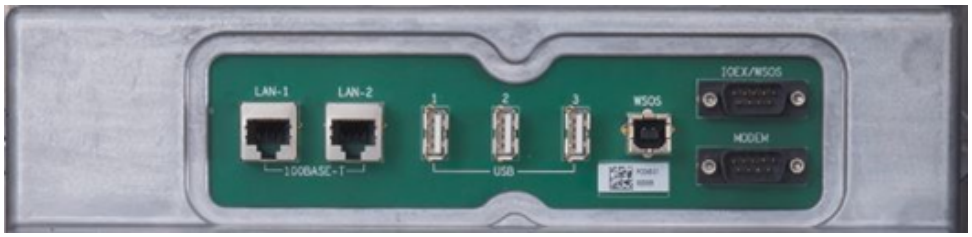



**Figure 61**
PowerLogic ADVC Controller Communications Ports

A summary of these ports and their possible uses are shown in the table below.

**Table 11 PowerLogic ADVC Controller Communications Ports**

| Port Label | Type | Comment |
|---|---|---|
| IOEX/WSOS | RS-232 | Suitable for IOEX or local WSOS. No handshaking lines. |
| MODEM | RS-232 | Suitable for RS232 devices requiring handshaking lines (modems etc). Supports Request to Send (RTS), Clear to Send (CTS), Data Terminal ready (DTR), Data Carrier Detect (DCD). |
| WSOS | USB 2.0 Type B | Dedicated to local WSOS communications |
| USB-1 | USB 2.0 Type A | Can be used for USB to RS232, USB to RS485, Modem, Bluetooth or for a Storage Device. |
| USB-2 | USB 2.0 Type A | Can be used for USB to RS232, USB to RS485, Modem, Bluetooth or for a Storage Device. |
| USB-3 | USB 2.0 Type A | Can be used for USB to RS232, USB to RS485, Modem, Bluetooth or for a Storage Device. |
| Local Area Network (LAN)-1 | 100BaseT Ethernet | Can be used for WSOS or communications protocols over TCP/IP. |
| LAN-2 | 100BaseT Ethernet | Can be used for WSOS or communications protocols over TCP/IP. |

## RS232 IOEX/WSOS

This RS232 port is suitable for use with an IOEX or for local WSOS communications. The mode is Local by default but can be configured as Remote if required.

A modem could be connected to this port but no handshaking lines are provided. The factory assigned default baud rate is 57600.

This port uses a standard 9 pin D male socket with the following pin connections.

**Table 12 RS-232 IOEX/WSOS Port Pin Connections**

| Pin No. | Direction | Use |
|---|---|---|
| 1 | - | Not connected |
| 2 | To ADVC | Rx Data (RxD) |
| 3 | From ADVC | Tx Data (TxD) |
| 4 | - | Not connected |

**Table 12 RS-232 IOEX/WSOS Port Pin Connections (Continued)**

| Pin No. | Direction | Use |
|---|---|---|
| 5 | - | 0 V (ground/earth) |
| 6 | - | Not connected |
| 7 | - | Not connected |
| 8 | - | Not connected |
| 9 | - | Reserved |

## RS232 Modem

This RS232 Modem port supports RTS, CTS, DTR, and DCD handshaking lines as well as Collision Avoidance. It is suitable for connection to conventional modems with flow control features that require that support.

The mode is Remote by default but can be configured as Local if required. The factory assigned default baud rate is 115200.

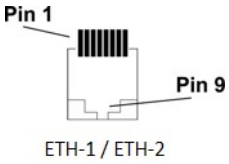
This port uses a standard 9 pin D male socket with the following pin connections.

**Table 13 RS-232 Modem Port Pin Connections**

| Pin No. | Direction | Use |
|---|---|---|
| 1 | To ADVC | DCD |
| 2 | To ADVC | RxD |
| 3 | From ADVC | TxD |
| 4 | From ADVC | DTR |
| 5 | - | 0 V (ground/earth) |
| 6 | - | Not connected |
| 7 | From ADVC | RTS |
| 8 | To ADVC | CTS |
| 9 | - | Reserved |

## LAN 1 and LAN2 (Ethernet)

The PowerLogic ADVC Controller has two 100Base-T Ethernet ports each with a baud rate of 100 M bits per second. Their physical ports are RJ45 female connectors.




The Ethernet ports can be used to run WSOS or supported communications protocols over TCP/IP.

The PowerLogic ADVC Controller implements an on-board switch to provide the support for 2 LAN interfaces.

**NOTICE**

**HAZARD OF LOSS OF COMMUNICATION OR UNRESPONSIVE CONTROLLER**

If both the LAN ports are configured, it is essential that they be configured with IP addresses for 2 distinct subnets.

**Failure to follow these instructions can result in equipment damage.**

**NOTICE**

**HAZARD OF LOSS OF COMMUNICATION**

If the controller is connected to a LAN or Wide Area Network (WAN) then it is strongly recommended that:

- Fire walls be used to limit user access to the controller
- Ethernet switches be used to limit the volume of Ethernet data reaching the controller's 100Base-T port (Use of Ethernet hubs is not recommended).

**Failure to follow these instructions can result in equipment damage.**

## USB WSOS

The USB WSOS port is dedicated to running the WSOS software and cannot be used for any other purpose.

Connect a PC running WSOS to this port using a USB Type A to Type B cable.




WSOS USB Port

The connector is a USB type B socket with the following pinout.

**Table 14 USB WSOS Port Pin Connections**

| Pin No. | Name | Description |
|---|---|---|
| 1 | Vcc | + 5 VDC |
| 2 | D- | Data - |
| 3 | D+ | Data + |
| 4 | Gnd | Ground |

## USB-1, USB-2, and USB-3

The PowerLogic ADVC Controller comes with 3 general purpose USB 2.0 Type A ports, which are USB-1, USB-2, and USB-3.

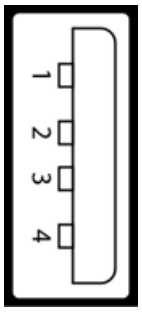



**Figure 62**
USB Type A Port

These ports can be configured to use a suitable USB-RS232 converter, must there be need for additional RS232 ports. Any of the protocols, which can be configured to run on the RS232 port, can then be configured to run off the USB-1/2/3 ports, with a converter attached.

The pinout for all these ports are according to the USB2.0 specification as shown in the below table:

**Table 15 USB Type A port pin out**

| Pin | Name | Description |
|---|---|---|
| 1 | VBUS | +5V |
| 2 | D- | Data - |
| 3 | D+ | Data + |
| 4 | GND | Ground |

The USB Type A ports are not isolated from one another or from the controller electronics. They therefore can only be connected to devices inside the controller that are powered by the controller radio supply, including modems, optical isolators, and radios.

| ***NOTICE*** |
|---|
| **HAZARD OF USB ERROR**<br>When using a USB adaptor, it is strongly recommended that the adaptor be tested on a PC first, to make sure that it is functional and not damaged/faulty.<br>**Failure to follow these instructions can result in equipment damage.** |

# Communications Port Configuration

Communications ports on the PowerLogic ADVC Controller can be configured through WSOS on the Port Configuration page which can be launched from:

**Display** > **Switchgear Communications** > **Ports** > **Port Configuration**

The Port Selection page in WSOS displays a list of the controllers ports and any applications that are running on those ports. Open this page by going to:

**Display** > **Switchgear Communications** > **Port** > **Port Selection**

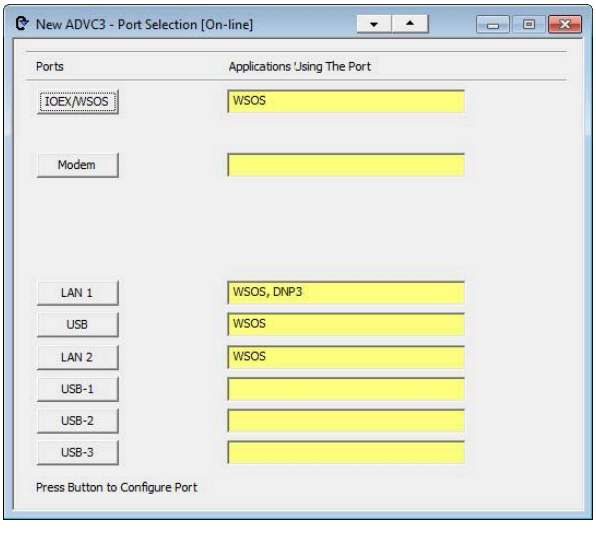



**Figure 63**
Port Selection page for the PowerLogic ADVC Controller

A port configuration page of a specific port can be opened by selecting the button for that port.

Communication ports can also be configured on the operator interface, page 701.

# PowerLogic ADVC Controller

## IOEX/WSOS

**Table 16 Configuration settings for the IOEX/WSOS port on the PowerLogic ADVC Controller**

| Setting | Description |
|---|---|
| Status | Indicates whether the port is in use by an application within the controller.<br>WSOS is using this port by default<br>Options: In Use, Enabled<br>Factory default is In Use<br>This is a read-only field |
| Driver | This setting is not applicable to the IOEX/WSOS port. |
| Mode | Can be either Local or RM.<br>A port used for a SCADA protocol must be set to Remote.<br>WSOS or IOEX could be either Local or Remote according to the application. |
| Used By | Displays the application that has been assigned to this port for example, WSOS, DNP3<br>WSOS is running on RS232 Port A by default.<br>If no application have been assigned this field will be blank.<br>Factory default is WSOS<br>This is a read-only field |
| Baud Rate | Configured for the baud rate at which this port is required to run.<br>Options: 300, 600, 1200, 4800, 9600, 19200, 38400, 57600, 115200<br>Factory default is **115200** |
| Parity | The type of parity to be used by this port.<br>Options: None, Even, Odd<br>Factory default is None |
| Stop Bits | The number of stop bits to be appended to a transmitted byte.<br>Options 1, 2<br>Factory default is 1 |
| Preamble | Determines whether the port transmits some preamble characters prior to transmitting a message. The message itself is not otherwise modified. Some modems require these characters to assist with message reception and synchronization at the master station. Start of frame filtering at the master station provides identification of the transmitted message.<br>Enabled means that the preamble characters are transmitted prior to a message transmission.<br>Disabled means that the message is transmitted without any preamble characters.<br>Options: Enabled, Disabled<br>Factor default is Disabled |
| First Character in Hex | This is the first character to be transmitted as a preamble. The character is specified by entering its ASCII code in hexadecimal format.<br>Range: 0x0 to 0xFF<br>Factory default is 55 |

**Table 16 Configuration settings for the IOEX/WSOS port on the PowerLogic ADVC Controller (Continued)**

| Setting | Description |
|---|---|
| Last Character in Hex | This is the last character that will be sent as part of the preamble. The character is specified by entering its ASCII code in hexadecimal format.<br>Range: 0x0 to 0xFF<br>Factory default is FF |
| Repeat First Character | This is the number of times the first character will be repeated as part of the preamble e.g. if all preamble settings are at their default values, the preamble sent would be: 0x55, 0x55, 0x55, 0xFF. |

# Modem

**Table 17 Configuration settings for the Modem Port on the PowerLogic ADVC Controller**

| Setting | Description |
|---|---|
| Status | Indicates whether the port is in use by an application within the controller.<br>Options: In Use, Enabled<br>Factory default is Enabled<br>This is a read-only field |
| Driver | This field indicates the driver attached to the port. Default: **None**(1) |
| Mode | Can be either Local or RM.<br>A port used for a SCADA protocol must be set to emote.<br>WSOS or IOEX could be either Local or Remote according to the application. |
| Used By | Displays the application that has been assigned to this port e.g. WSOS, DNP3<br>If no application has been assigned this field will be blank.<br>This is a read-only field |
| Baud Rate | Configured for the baud rate at which this port is required to run.<br>Options: 300, 600, 1200, 4800, 9600, 19200, 38400, 57600, 115200<br>Factory default is **115200** |
| Parity | The type of parity to be used by this port.<br>Options: None, Even, Odd<br>Factory default is **None** |
| Stop Bits | The number of stop bits to be appended to a transmitted byte.<br>Options 1, 2<br>Factory default is **1** |
| RTS | **Ready to Send**<br>Determines whether RTS is asserted for the pre-transmission time prior to transmission of data as well as the post-transmission time after transmission.<br>Pre and post transmission RTS is required on most radio and modems.<br>Options: Enabled, Disabled<br>Factor default is Disabled |
| CTS | **Clear to Send**<br>If the modem does not support a CTS signal and/or the cabling has no CTS wiring then this setting must be set to CTS Ignore.<br>When set to CTS Ignore, the protocol asserts RTS as normal but does not check for a returned CTS input signal. If the modem supports a CTS signal, setting CTS to Don't Ignore allows data to be transmitted only when CTS is asserted.<br>Option: Don't Ignore, Ignore<br>Factory default is Ignore |

**Table 17 Configuration settings for the Modem Port on the PowerLogic ADVC Controller (Continued)**

| Setting | Description |
|---|---|
| DTR | **Data Terminal Ready**<br>If the modem supports DTR, this setting must be Enabled which will cause the DTR signal to be permanently asserted.<br>Options: Enabled, Disabled<br>Factor default is Disabled |
| Pre Transmission | If RTS support is Enabled, pre-transmission is the time delay between when RTS is asserted to when the message starts.<br>Range: 0...300 ms<br>Factory default is 250 ms |
| Post Transmission | If RTS support is Enabled, post-transmission is the time after the last character is sent before RTS is negated.<br>Range: 0...300 ms<br>Factory default is **35 ms** |
| DCD | **Data Carrier Detect**<br>If the modem does not support a DCD signal this setting must be set to Ignore. Even if the modem does support DCD, this setting is usually set to Ignore.<br>This is because most point-to-point systems using conventional modems run as full duplex so that DCD is always asserted during normal operation. When set to DCD Ignore, the protocol will use any received data to build an incoming packet irrespective of DCD input signal. Also, the protocol will transmit irrespective of the DCD input signal.<br>If the modem supports DCD, this setting can be set to Don't Ignore. When set to this mode, the protocol will only read data and build an incoming protocol packet when DCD is asserted. In addition, the protocol will not transmit when DCD is asserted. This is necessary for multi-dropped systems or ones shared with voice users or some radio modems.<br>Option: Don't Ignore, Ignore<br>Factory default is Ignore |
| CA Delay | **Collision Avoidance Delay**<br>On a multi-drop communications link this setting can be used to provide priority access. If the controller prepares to transmit and finds that the link is busy (DCD asserted), it will wait until it is no longer busy, then wait for a back off time determined by:<br>Back off time = CA Delay + (random delay between zero and the CA Delay time)<br>After the back off time, the device will try again. If still unsuccessful, the controller will continue in an indefinite loop until it is successful.<br>If the DCD usage is configured for DCD Ignore, the CA Delay time is disabled.<br>Range: 0...180 000 ms<br>Factory default is 1000 ms. |
| Preamble | Determines whether the port transmits some preamble characters prior to transmitting a message. The message itself is not otherwise modified. Some modems require these characters to assist with message reception and synchronization at the master station. Start of frame filtering at the master station provides identification of the transmitted message.<br>Enabled means that the preamble characters are transmitted prior to a message transmission.<br>Disabled means that the message is transmitted without any preamble characters.<br>Options: Enabled, Disabled<br>Factory default is Disabled |
| First Character in Hex | This is the first character to be transmitted as a preamble. The character is specified by entering its ASCII code in hexadecimal format.<br>Range: 0x0 to 0xFF<br>Factory default is 55 |
| Last Character in Hex | This is the last character that will be sent as part of the preamble. The character is specified by entering its ASCII code in hexadecimal format.<br>Range: 0x0 to 0xFF |

**Table 17 Configuration settings for the Modem Port on the PowerLogic ADVC Controller (Continued)**

| Setting | Description |
|---|---|
| | Factory default is FF |
| Repeat First Character | This is the number of times the first character will be repeated as part of the preamble for example, if all preamble settings are at their default values, the preamble sent would be: 0x55, 0x55, 0x55, 0xFF |
| (1) At the time of preparing this Operations Manual, the serial communication drivers, like RDI, Hayes, MITS, etc. are supported only on the PowerLogic ADVC Controller. | |

## LAN-1 and LAN-2

**Table 18 Configuration settings for the LAN-1 and LAN-2 ports on the PowerLogic ADVC Controller**

| Setting | Description |
|---|---|
| Status | Indicates whether the port is in use by an application within the controller.<br>WSOS is permanently running on both of these ports by default.<br>Options: In Use, Enabled<br>Factory default is in use<br>This is a read-only field |
| Mode | Can be either Local or RM.<br>A port used for a SCADA protocol must be set to Remote.<br>IOEX could be either Local or Remote according to the application. |
| Used By | Displays the application that has been assigned to this port for example, WSOS, DNP3<br>Multiple applications can run on this port simultaneously.<br>WSOS is running on LAN-1 and LAN-2 ports by default.<br>Factory default is WSOS<br>This is a read-only field |
| Current Settings | These are the settings for this port currently in use by the controller.<br>All these fields are read-only |
| IP Address | **Internet Protocol Address**<br>The IP address of the controller. |
| Subnet Mask | The IP Subnet Mask of the controller |
| Default Gateway | The IP address of the controller's default gateway. |
| DHCP | **Dynamic Host Configuration Protocol**<br>The DHCP mode of the controller.<br>If Enabled, the controller obtains its IP address and subnet mask from a DHCP server located on the network. The IP and subnet mask are not configurable.<br>If Disabled, the controller uses the IP address and subnet mask configured in the users settings. |

**Table 18 Configuration settings for the LAN-1 and LAN-2 ports on the PowerLogic ADVC Controller (Continued)**

| Setting | Description |
|---|---|
| New Settings | These fields show the settings to be applied. They are the same settings as those in the current settings above.<br>The IP and Subnet Mask settings are greyed out and cannot be changed if DHCP is checked.<br>If DHCP is not checked, the IP address and subnet mask must be configured by the user prior to selecting the *Apply* button.<br>If DHCP Enable is checked, selecting the *Apply* button will obtain an IP Address, Subnet Mask and Default Gateway from the DHCP server which will be applied. |
| Statistics | **Receive Ethernet CRC Error Count**<br>Displays the number of CRC error messages received since this count was last reset.<br>This field is read-only |

## USB/WSOS

| Setting | Description |
|---|---|
| Status | Indicates whether the port is in use by an application within the controller.<br>Options: In Use<br>This port is always in use by WSOS<br>This is a read-only field |
| Mode | Can be either Local or RM.<br>If this port is being accessed remotely it must be set to Remote.<br>Options: Local, Remote<br>Factory default is Local |
| Used By | This port is permanently dedicated to WSOS. No other applications can use this port.<br>Options: WSOS<br>This is a read-only field |

## USB-1, USB-2, and USB-3

At the time of writing, these ports can only be used with USB to RS232 converters. In which case their configuration and operation is similar to the IOEX/WSOS port.

The main differences being:

- No application is running on these ports by default
- Their default Mode is Remote
- Their default Baud Rate is 115200

# Supported Protocols

The PowerLogic ADVC Controller combines the functions of a protection/detection relay and switchgear controller into a single Intelligent Electronic Device (IED).

Electricity supply utilities frequently link the PowerLogic ADVC Controller into their SCADA systems as a RTU.

To make this possible, the PowerLogic ADVC Controller provides:

- Mounting space for a radio or modem in the control cubicle.
- A power supply for the radio or modem.
- An embedded protocol handler for the required SCADA protocol in the controller firmware.

The following communications protocols are supported by the PowerLogic ADVC Controller Range:

- DNP3
- IEC 60870-5-101
- IEC 60870-5-104
- Modbus

# DNP3

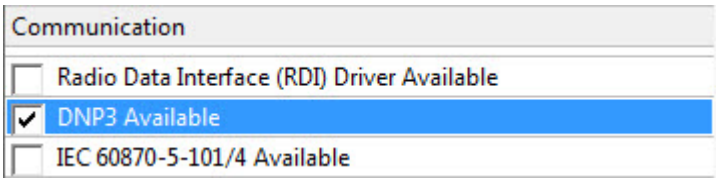
There is a five step procedure required in order to enable the PowerLogic ADVC Controller to communicate with a SCADA master station using the DNP3 protocol:

1. Check that DNP3 is available.
2. Select a communications port for DNP3.
3. Configure the communications settings for the selected port.
4. Assign the selected port to DNP3.
5. Configure the DNP3 settings.

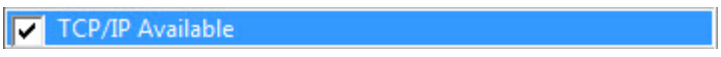
## Step 1 – Check that DNP3 is Available

The DNP3 communications protocol is available in the PowerLogic ADVC Controller Range by default. Otherwise it can be made available through Feature Selection in WSOS at:

**Display** > **Configuration** > **Feature Selection** > **Communications**.




**NOTE:** If DNP3 is required to run on an Ethernet port, TCP/IP must also be made available.




DNP3 can also be made available via the operator interface, page 698.

## Step 2 - Select a Communications Port

The PowerLogic ADVC Controller Range has a number of communications ports that can be connected to RS232, RS485, Ethernet or Frequency Shift Keying (FSK) devices for the transmission of DNP3 messages.

On the PowerLogic ADVC Controller, DNP3 can run on the following ports:

- LAN 1 or 2 (TCP/IP must be available)
- Modem
- IOEX/WSOS(3)
- USB 1,2 3[3] (if USB to Serial converters are fitted)

**NOTE:** Serial ports are only available for DNP3 if they are not being used for another purpose for example, WSOS or IOEX.

## Step 3 - Port Configuration

Once the port that IEC60870-5-101 is to run on has been selected, configure the port to suit the application and hardware being used.

The chosen port can be selected and configured in WSOS on the **Port Configuration** page.

Open this page by going to:

**Display** > **Switchgear Communications** > **Ports** > **Port Configuration**.

Open this page and choose the tab for the selected port.

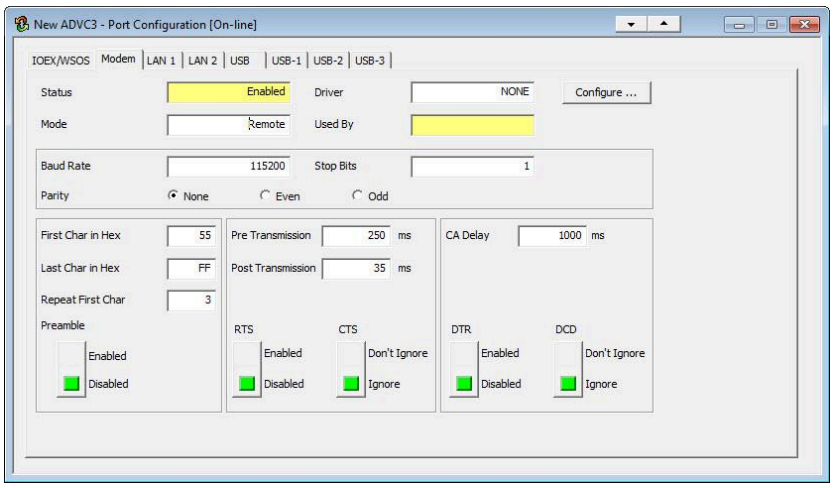



**Figure 64**
WSOS Port Configuration (Modem) Page

The above figure shows the **Port Configuration** page for an PowerLogic ADVC Controller with the Modem port tab selected. An example of a setting required to be compatible with the connected radio/modem would be the Baud Rate which may need to be changed from the default 115200.

## Step 4 - Assign the Selected Port to DNP3

The DNP3 port can be selected on the DNP3 Communications Configuration page in WSOS.

This page can be opened in WSOS by going to:

**Display** > **Switchgear Communications** > **Protocols** > **DNP3** > **Communications Configuration**.

(3) These ports do not support the flow control normally required when modems are used.

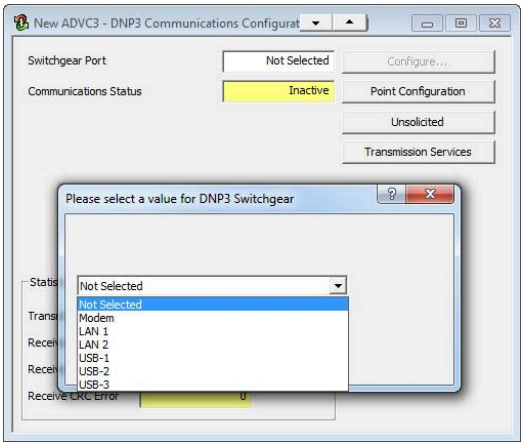



**Figure 65**
Port Selection on the DNP3 Communications Configuration page

Once the **Switchgear Port** has been selected, the Configure button to its right becomes active and can be used to open the configuration page for that port.

The **Switchgear Port** for DNP3 can also be selected on the operator interface, page 701.

## Step 5 - Configure the DNP3 Settings

Finally, the DNP3 settings need to be configured for the protocol to operate according to the requirements of the SCADA system in use.

The settings are contained on at least four pages in WSOS. Five if DNP3 is being configured to run on an Ethernet port.

DNP3 configuration pages can be opened in WSOS by going to:

**Display** > **Switchgear Communications** > **Protocols** > **DNP3**

From there, there are four or five options available:

- DNP3 Communications Configuration
- DNP3 Point Configuration
- DNP3 Unsolicited

  **NOTE:** DNP3 Unsolicited response behavior has been corrected to correctly buffer when the Unsolicited max count for any Class is set to 256 and above. Unsolicited max count for any class set less than 255 was not impacted.
- DNP3 Transmission Services
- DNP3 IP Networking (If DNP3 is running on an Ethernet port)

Two more options are added to this menu when the DNP3 Security feature is enabled. They are:

- DNP3 Security Statistics
- DNP3 Secure Authentication

Generally, the recommended option is to open the DNP3 Communications Configuration page first which has buttons from where all the other configuration pages can be opened.

The default DNP3 settings have been carefully selected and very few must need to be changed for the protocol to run.

Probably the most critical setting is the DNP3 address on the Transmission Services page which is unique to each device.

The Master Station address on the DNP3 Unsolicited page is also required if Unsolicited Responses are either On or Forced.

**NOTE:** For more details on the DNP3 Communications Protocol implementation on the PowerLogic ADVC Controller, refer to ADC01-DOC-146.

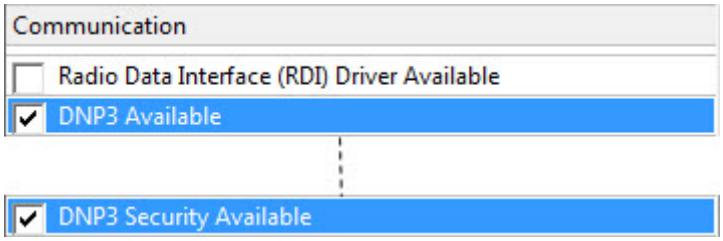
## DNP3 Security

The PowerLogic ADVC Controller implements version 5 of the secure authentication feature as specified in the IEEE standard document 1815-2012.

DNP3 Secure Authentication functionality for the PowerLogic ADVC Controller can only be enabled and configured through WSOS.

DNP3 and DNP3 Security must firstly be made available through Feature Selection in WSOS.

**Display** > **Configuration** > **Feature Selection** > **Communications**




### Secure Authentication

Once DNP3 Security has been made available, Secure Authentication can be configured through WSOS by going to:

**Display**> **Switchgear Communications** > **Protocols** > **DNP3** > **DNP3 Secure Authentication**.

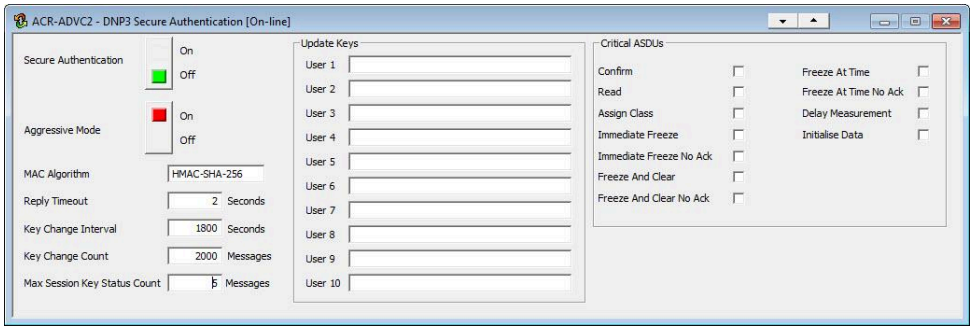



**Figure 66**
DNP3 Secure Authentication Configuration settings

This page allows the configuration of operational parameters for **DNP3 Secure Authentication**, along with Update Keys (secret keys shared between the master station and outstation) for up to 10 users.

When a user issues a critical DNP3 request that is one which requires authentication, and it is successfully authenticated, the PowerLogic ADVC Controller will write two events to the Event Log. One event shows the type of request and the other shows the ID of the requesting user.

The configurable settings for DNP3 Secure Authentication are described in the table below.

**Table 19 DNP3 Secure Authentication Configuration settings**

| Setting | Description |
|---|---|
| Secure Authentication On/Off | This turns the Secure Authentication feature On and Off.<br>While Off, the controller will not respond to any source authentication message from the master station, nor will it require authentication for accessing ASDU's. |
| Aggressive Mode On/Off | This allows (or helps prevent) Aggressive mode operation in DNP3 Secure Authentication.<br>For more information on aggressive mode please consult the standard. |
| Message Authentication Code (MAC) Algorithm | This determines which algorithm the controller uses to encode the MAC in DNP3 Secure Authentication messages.<br>The options are:<br>• HMAC-SHA-256 (truncated to 16 octets)<br>• HMAC-SHA-1 (truncated to 10 octets) |
| Reply Timeout | The interval after which the controller will implement the Reply Timeout DNP3 Security Statistic (See section on Security Statistics). |
| Key Change Interval | The interval after which the controller expects a session key to have been changed by the master. If the key has not been changed by this time, the controller will invalidate the current session. |
| Key Change Count | The number of transmitted messages after which the controller expects a session key to have been changed by the master.<br>If the key has not been changed after this many messages, thFe controller will invalidate the current session. |
| Max Session Key Status Count | The maximum number of session key status requests that the controller will respond to during a given session. |
| Update Keys | DNP3 Secure Authentication is performed on a per-user basis.<br>Each user has an associated Update Key.<br>The Update Key is a 32 character ASCII string of hexadecimal digits i.e. 0-9 and A-F.<br>WSOS allows configuration of up to 10 users.<br>Update Keys must be common between the master and outstation.<br>**NOTE:** Update Keys must be kept check with a customer's organization. This security requirement extends to the WSOS switchgear configuration files, where the keys are stored. |
| Critical ASDU's | Secure Authentication is required for accessing critical ASDU's only.<br>As per the DNP3 Standard (IEEE 1815-2012), some ASDU's are always critical (Write, Select, Operate etc.).<br>Others are optionally critical, and can be configured on the DNP3 Secure Authentication page in WSOS. |

## DNP3 Security Statistics

As per the DNP3 Standard (IEEE 1815-2012), the PowerLogic ADVC Controller maintains a number of statistics associated with DNP3 Secure Authentication. These statistics are displayed by WSOS on the DNP3 Security Statistics page.

**Display**> **Switchgear Communications** > **Protocols** >**DNP3** > **DNP3 Security Statistics**

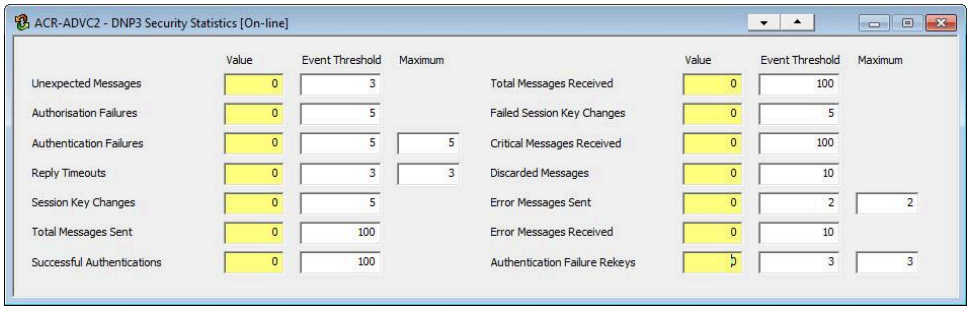



**Figure 67**
DNP Security Statistics values and settings

> **NOTE:** Statistics can also be read using DNP3 Read requests, for objects in group 121. The map for statistics points is fixed, as per table 7-6 of IEEE 1815-2012.

Each statistic recorded has an associated event threshold, configurable on the **DNP3 Security Statistics** page.

Each time a threshold is reached, the PowerLogic ADVC Controller will generate a DNP3 event. Note that for events to be generated, the corresponding statistic point must be assigned a non-zero DNP3 class.

When a DNP3 map is written to the PowerLogic ADVC Controller, the class of all security statistics points is automatically reset to zero.

To assign a non-zero class to any point, a DNP3 Assign Class request must be issued for that point.

Classes assigned in this way will persist until the next time a DNP3 map is written to the PowerLogic ADVC Controller.

Some statistics have associated, configurable maximum values. The meaning of and behavior corresponding to these maximum values is defined in the DNP3 Standard IEEE 1815-2012.

## Dynamic UDP Mode for DNP3

This feature allows the DNP3 service on the controller to determine the details of the Client station (IP address, Port no., DNP3 address) from a received DNP3 request. This feature is available for use only when configured to communicate via UDP.

To use this feature, the following configurations need to be selected/turned ON.

- Transport protocol must be **UDP**.
- **Port in Request** must be turned **ON**.
- **In Request** must be selected in **DNP3 Address** (Unsolicited Page) configuration.
- Client IP addresses must **NOT** be configured, and just left as default.

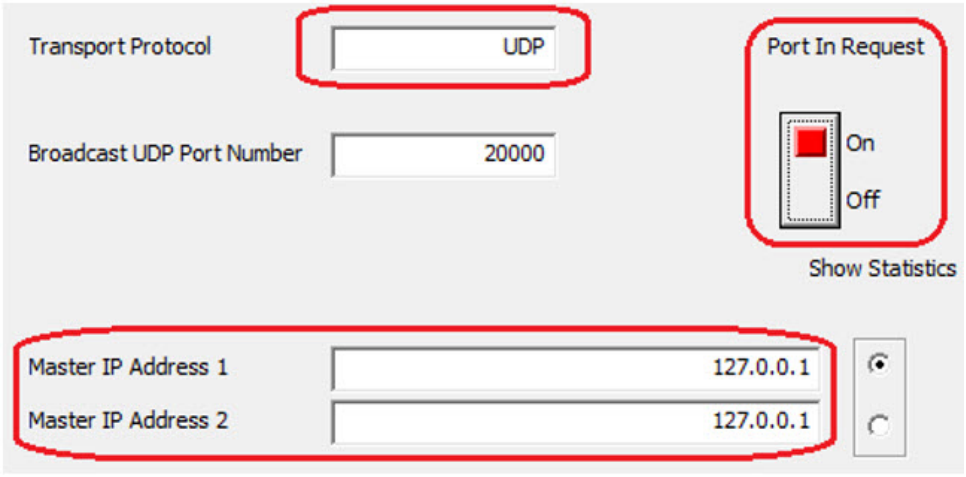



**Figure 68**
Dynamic UDP - IP Networking configuration

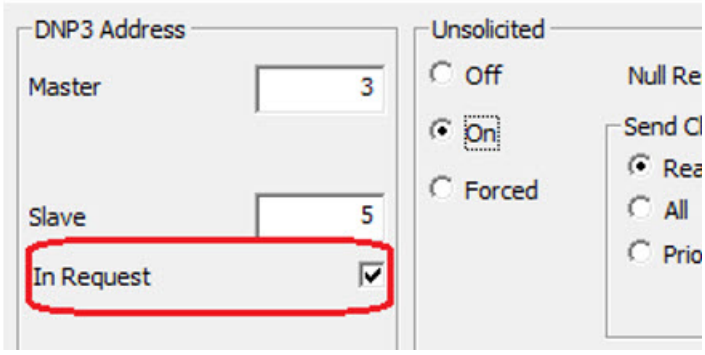



**Figure 69**
DNP3 Address

**NOTE:** When the controller is configured in this mode, and Unsolicited support is turned ON, Unsolicited responses will not be sent to the Client on warm/ hard service restart. Instead, the controller will depend on the client to initiate a connection first.

## Configurable Unsolicited NULL Message

As per the DNP3 standard, any Server that supports Unsolicited response will send out an initial **Unsolicited NULL Response** to Client, publishing this capability.

With version A50-07.01, sending of this initial response is now made configurable. This configuration is available on the Unsolicited page in WSOS5 5.16.15.

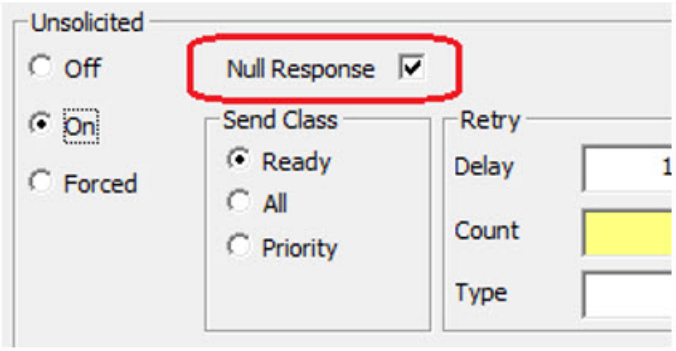



**Figure 70**
Unsolicited NULL Response

## Binary Double Bits Support

Binary Double Bits are available on the protocol map version A50-12.00 and later. To enable Binary Double Bits for an old map, it must be upgraded first.

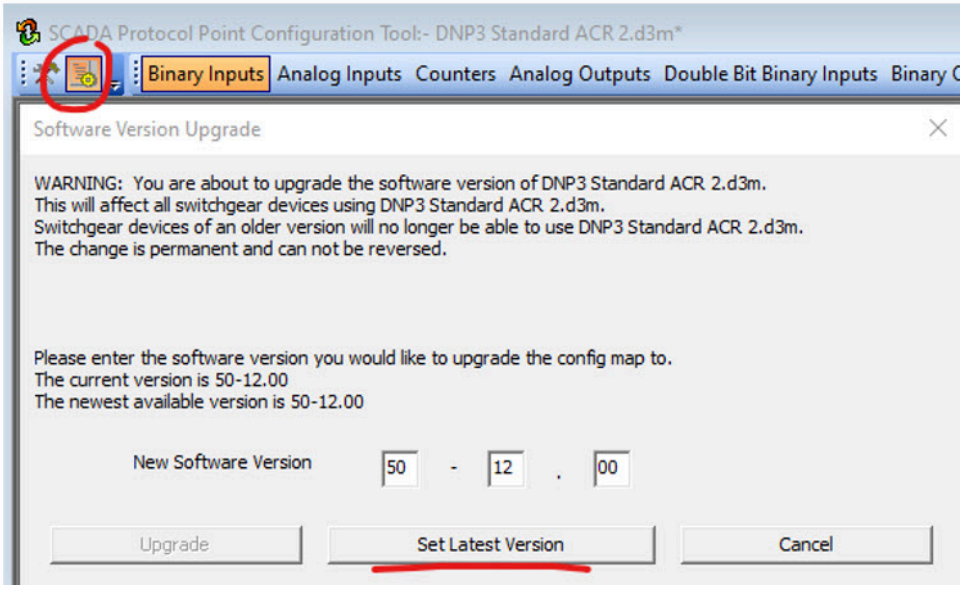



**Figure 71**
Upgrading DNP3 map

Double Bit Binary points are assigned the same way as other points except they are assigned as pairs. If the same point is assigned as both points in a pair the 2nd point is usually inverted as per the example of the **Operator Trip** points in Figure 40.

| Address | Name | Enabled | Invert | Class | Time Stamp | Comments |
|---|---|---|---|---|---|---|
| 0.0 | Switchgear Tripped-open | ☑ | ☐ | 1 | ☐ | |
| 0.1 | Switchgear Closed | | ☐ | | | |
| 1.0 | Operator Trip | ☑ | ☐ | 1 | ☐ | |
| 1.1 | Operator Trip | | ☑ | | | |

**Figure 72**
Double Bit Binary Input map

## Individual Time Stamps for DNP3

The DNP3 protocol map version A50-12.00 and later supports timestamps for individual binary and analogue **input** points. When a timestamp is enabled for a protocol point the event of the said point will have an absolute time stamp.

The event objects variation depends if the time stamp is enabled as shown in below table.

| **Event objects variations with or without timestamps** | | | |
|---|---|---|---|
| **Input Event** | **Group** | **Variation with time stamp enabled** | **Variation with time stamp disabled** |
| Binary | 2 | 2 | 1 |
| Double-bit Binary | 4 | 2 | 1 |
| Analogue | 32 | 3 (32bit)(1) | 1 (32bit)(1) |
| | | 4 (16bit) | 2 (16bit) |
| (1) Analog data size, which is configurable from the DNP3 Point Configuration dialog on WSOS. | | | |

When upgrading a DNP3 protocol map from an older version to A50-12.00+ WSOS will bring up the dialog shown in Figure 41. Selecting **Yes** enables time stamp for all the existing binary, double-bit binary and analogue inputs.




**Figure 73**
Upgrading DNP3 protocol map to A50-12.00 or later

> **NOTE:** When using a protocol map of version A50-12.00 or higher, the Analog Time and Binary Time settings on the Point Configuration page are ignored.

The DNP3 protocol point configuration tool for a protocol map version A50-12.00 and later has a new **Time Stamp** column to configure the timestamp setting for each point on the map (see Figure 42). The tool allows the user to easily set or clear the Time Stamp option for all inputs by right clicking on the Time Stamp column above row zero.

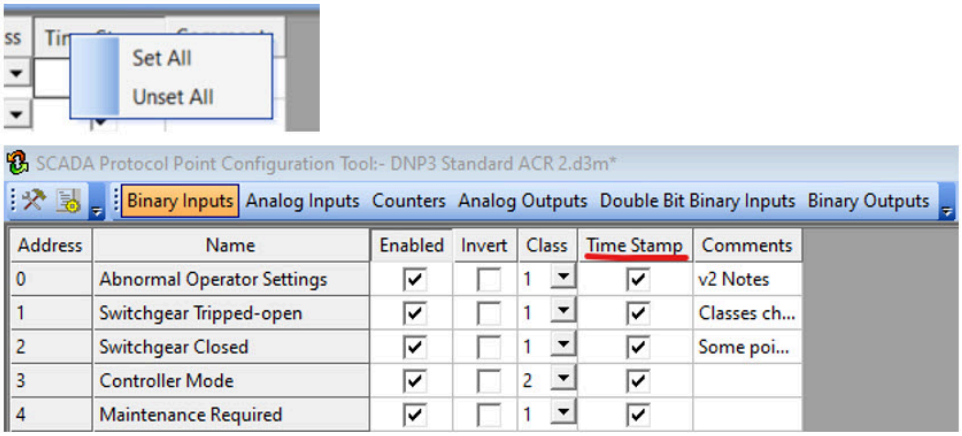
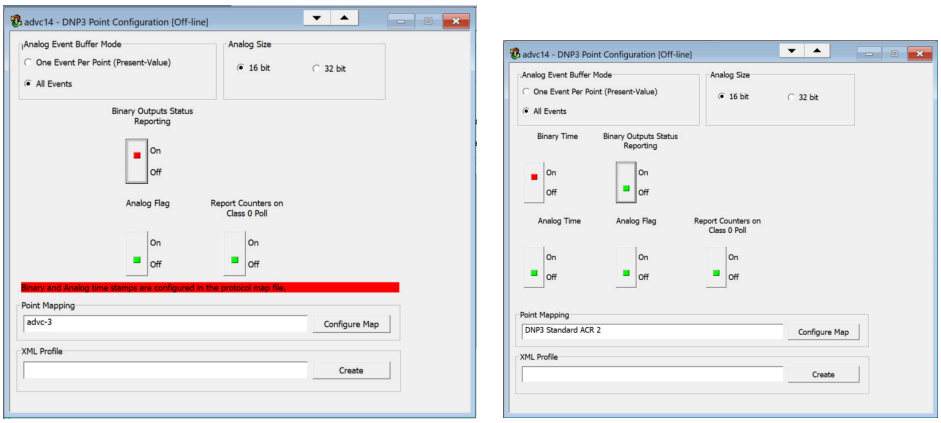



**Figure 74**
The timestamp configuration checkboxes on the Protocol Point Configuration Tool

**Note**: Customers using older point map versions and who do not wish to avail of the option to configure individual time stamps for binary and analogue points may continue to use older map versions so long as new points added after version 50.12 are not required to be configured.

It must be noted that if the map deployed uses version 50.12 or later the global binary and analogue time stamps settings are removed from the DNP3 Point Configuration Dialogue box as the settings is no longer valid on map versions 50.12 and later.



## Unsolicited Retry Delay when Offline Setting for DNP3

The **Delay When Offline** setting is the delay for retrying Unsolicited messages when the Client is **offline**. The Client is considered **offline** when the **Max Retries** count for Unsolicited messages is reached, and the Client has not Acknowledged/ Confirmed the Unsolicited Message. With A50-13.xx, when the **Delay When Offline** is enabled, the controller will wait for the configured time to restart the Unsolicited Retry mechanism. The controller may retry sooner when another reportable event is generated and stored in the event buffer.

The setting is available only on WSOS. The **Delay When Offline** setting (Figure 43) is located with other unsolicited settings on the **DNP3 Unsolicited** window.

The **Delay When Offline** can be set to a value from 1 to 43200 minutes or **off**. If the **Delay When Offline** setting is set to **off** unsolicited messages are not retried when **offline**.

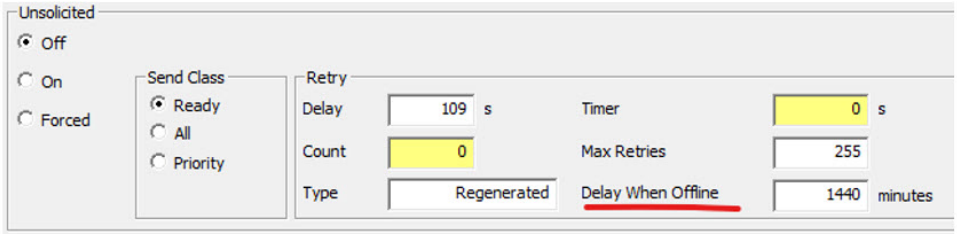


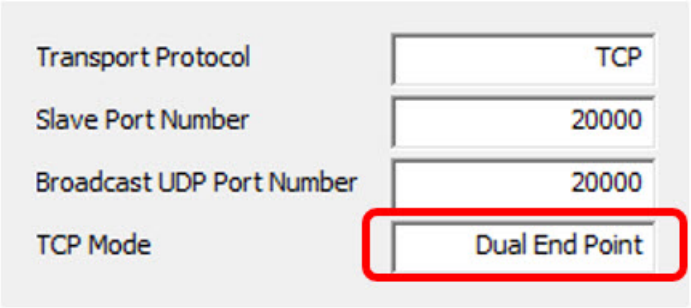

**Figure 75**
**Delay When Offline** setting for unsolicited retries

## Dual End and Listen Mode for DNP3

DNP3 TCP connection has been modified to have two modes: *Listen End Point* and *Dual End Point*. The *Listen End Point* mode is a **server** mode where the controller will not initiate a connection to the configured Client. In the *Dual End Point* mode, the controller initiates a connection when unsolicited reporting is enabled and unsolicited events are generated, and there is no active connection to the Client. By default, the controller is configured to be in the *Dual End Point* mode, for backwards compatibility.

The mode can be changed from WSOS5 from **DNP3 IP Networking** window, which is located at:

**Switchgear Communications > Protocols > DNP3 > DNP3 IP Networking**




## Concurrent and Single Session Support for DNP3

The *Concurrent Session Management* mode maintains 1 session per connection to the controller, with a max of 2 active sessions at any given point of time. Events generated within the controller will copied to both these sessions and subsequently reported to the corresponding Clients, either as a response to a poll or via Unsolicited reporting if enabled for each session.

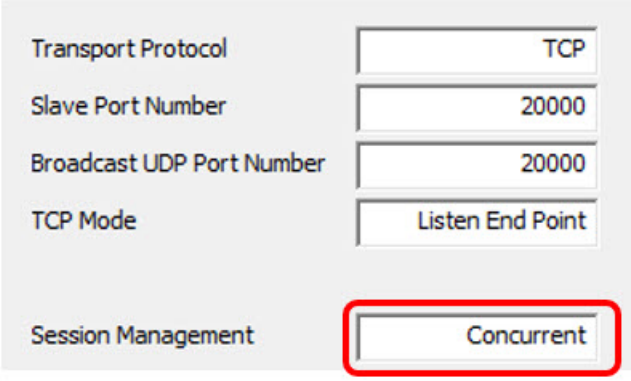
The new *Single Session Management* option allows for a single DNP3 session for multiple connections to the controller. In the single session management mode, a new connection from a client will force an existing connection to be disconnected.

This feature is useful when the controller is used in a network designed with redundant client, and the fail over between clients are managed externally to the controller.

When in the *Dual End Point* mode only the *Single Session* management is available.

The mode can be changed from WSOS5 through **DNP3 IP Networking** window, which is located at:

**Switchgear Communications > Protocols > DNP3 > DNP3 IP Networking**




## Keep Alive Messaging for DNP3

When enabled, **Keep Alive Messaging** keeps the connection open by sending link status messages to the client every **Keep Alive Timer** period. If **Keep Alive Messaging** is disabled, the connection is closed after **Keep Alive Timer** period expires.

> **NOTE:** The off mode only applies when the *TCP mode* of the DNP3 IP Networking is in *Listening mode*.

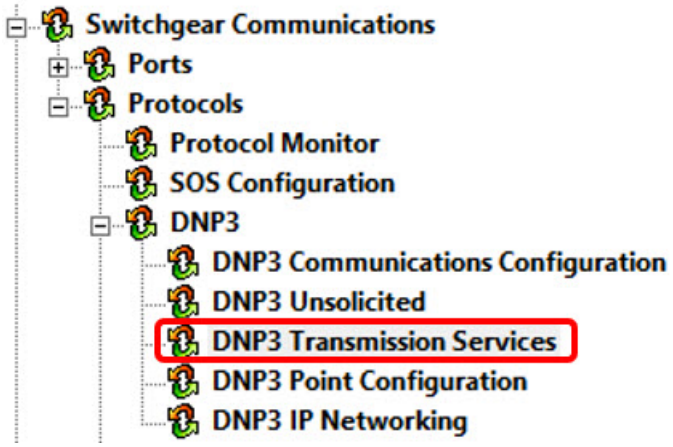



**Figure 76**
Location of the Keep Alive Messaging setting

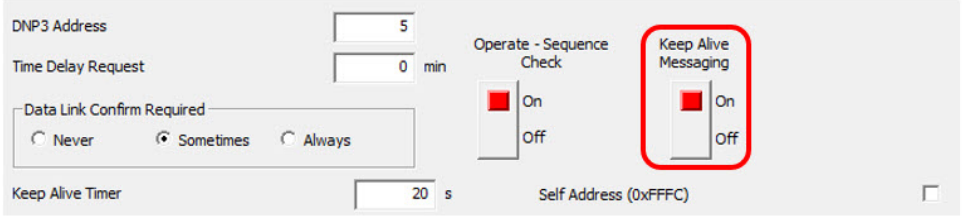



**Figure 77**
Keep Alive Messaging configuration

## Self Address for DNP3

The **Self Address** feature is defined by the DNP3 standard. It enables the client to connect without knowing the DNP3 address of the controller (server). It does this by querying for the controller's DNP3 address with the server address set to 0xFFFC. The controller will then respond with the configured DNP3 server address, in its response. Enable this capability in the controller from the DNP3 transmission services page in WSOS.

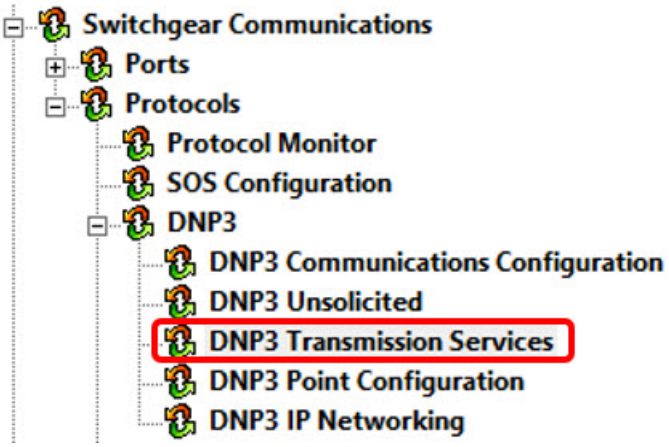



**Figure 78**
Location of the **Self Address** setting

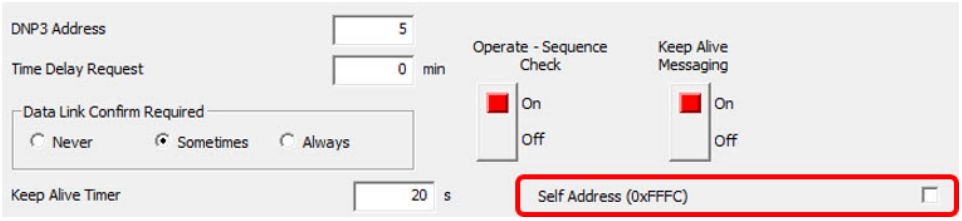



**Figure 79**
Self Addressing configuration

This feature works only for a general poll. The controller will reject any controls when the Client sets the server address to 0xFFFC.

## DNP3 and Protocol Monitor Restart Enhancements

When the PowerLogic ADVC DNP3 is configured as Unsolicited OFF, an additional option in the DNP3 Unsolicited dialogue box is provided to enable initiation of a TCP connection. Separate options are provided for each of the DNP3 Classes (Class 1, 2 and 3) and can be configured using the WSOS DNP3 Unsolicited dialogue box as shown in below figure. This configuration option is unique to TCP/IP protocol by an ethernet channel.

- Switchgear port must be selected either Ethernet LAN1 or LAN2.
- DNP3 Client IP address must be configured.
- The Transport protocol must be configured as TCP.

If enabled, the controller will initiate a TCP Connection to the DNP3 Client once the selected event class type has reached its configured Max Count. Upon receiving the request, the Client must complete the TCP connection process. Once this TCP connection is established, the Client can poll the PowerLogic ADVC RTU using the DNP3 self-addressing commands. The Client terminates the TCP connection once the polling process is complete.

Class 1 and 2 buffers are not user configurable rather they are fixed at 512 events each before the FIFO principle is applied. Class 3 buffer size is user configurable between 450 and 5760 events. Digital, Analog, and Counter events can all be configured as class 3 events. Note that this setting is independent from the Class 3 Unsolicited Max Count which remains configurable between 1 and 450.

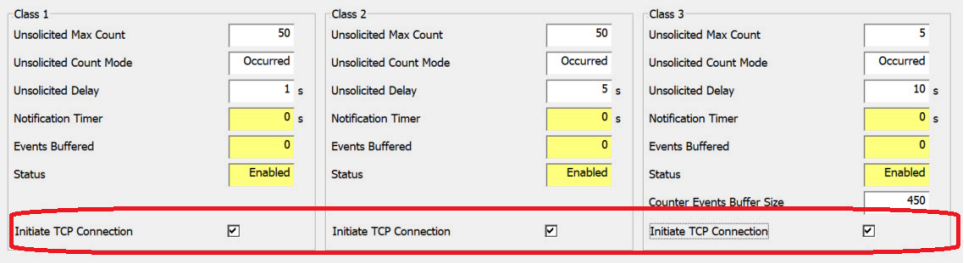



**Figure 80**
DNP3 Initiate TCP Connection for each class settings

This firmware release also allows users to configure the Controller not to report DNP3 Counter Objects (20 to 23) in response to a DNP3 Client Class 0 Poll. This option can be configured in the DNP3 Point Configuration dialogue box as shown in below figure. A Client Class 0 poll is a static poll intended to retrieve the Present values, the most-recently measured, computed, or obtained values.

Range: On/Off

Default: Off

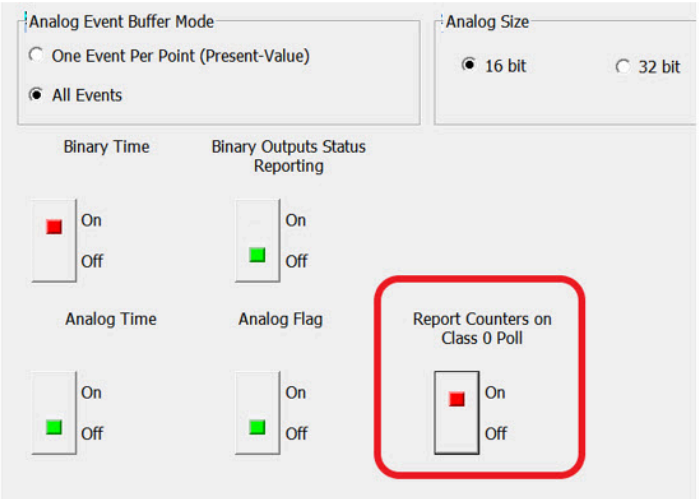



**Figure 81**
Settings for Report Counters for Class 0 Poll

With the inclusion of Initiate TCP connection option, to improve the self-healing capability of radio or modem communications, the Protocol Monitor feature has been enhanced to allow power cycling of the Radio Power Supply if the number of failed TCP connection attempts exceeds a user configured Maximum Connection Failures count as shown in Figure 83.

The Protocol Monitor feature must be made available via the Feature Selection page of WSOS5, under the Communication Category as per Figure 83.

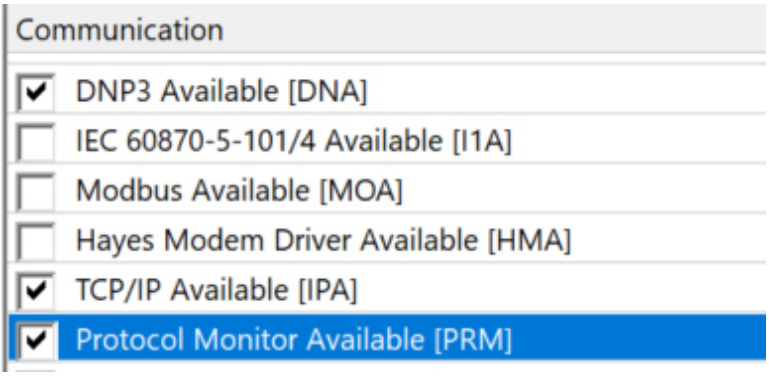



**Figure 82**
Protocol Monitor feature selection page

If the controller fails to connect to the client, it increments its internal client Connection Failures Count and when the count of successive failed attempts reaches the configured Maximum Connection Failures quantity, the Protocol Monitor function will power cycle the Radio Power Supply if the Radio/Modem Power cycle option is turned ON. The Maximum Count Failure setting can be configured from 1 to 100.

Range: 1 to 100

Default: Off

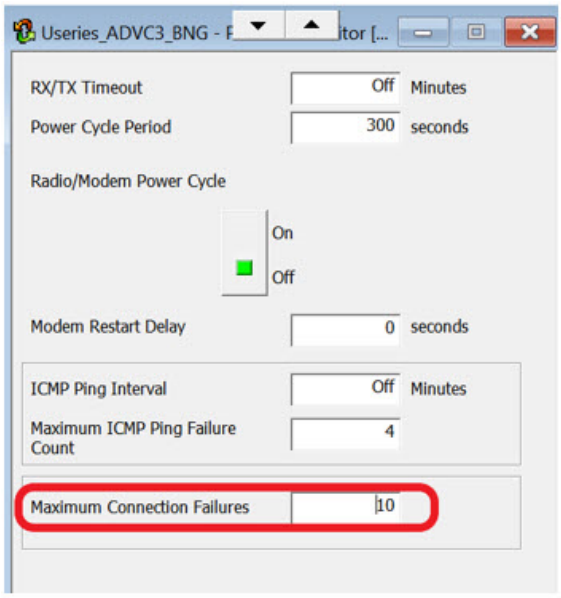
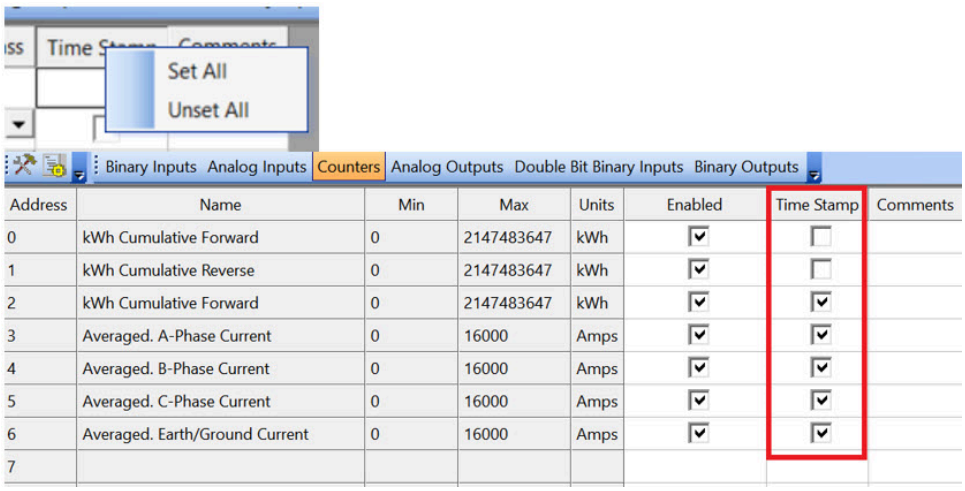



**Figure 83**
Protocol Monitor Restart Maximum Connection Failure setting

## Counter Time Stamp Setting

The Protocol Configuration Tool provides an option to configure counter time stamps with point map versions A50-14.00 and above by checking the Time Stamp check box setting on a per point basis as shown in Figure 19. Right clicking on the Time Stamp Box allows the user to enable or disable all Counter Time Stamps. This setting is similar to the changes made to the management of time stamps for Binary, Double Binary and Analogue inputs which were introduced with F/W release of A50-13.00 (refer below in this document).




| Address | Name | Min | Max | Units | Enabled | Time Stamp | Comments |
|---|---|---|---|---|---|---|---|
| 0 | kWh Cumulative Forward | 0 | 2147483647 | kWh | ☑ | ☐ | |
| 1 | kWh Cumulative Reverse | 0 | 2147483647 | kWh | ☑ | ☐ | |
| 2 | kWh Cumulative Forward | 0 | 2147483647 | kWh | ☑ | ☑ | |
| 3 | Averaged. A-Phase Current | 0 | 16000 | Amps | ☑ | ☑ | |
| 4 | Averaged. B-Phase Current | 0 | 16000 | Amps | ☑ | ☑ | |
| 5 | Averaged. C-Phase Current | 0 | 16000 | Amps | ☑ | ☑ | |
| 6 | Averaged. Earth/Ground Current | 0 | 16000 | Amps | ☑ | ☑ | |
| 7 | | | | | | | |

**Figure 84**
Timestamp configuration check box on the Counter window

Users with A50.15.04 or later and older point map versions (i.e., prior to point map version A50-14.00) who wish to avail of Counter Time Stamps must upgrade the existing point map to the map version A50.14.00 or later. Follow the steps outlined

below and in Figures 21 and 22 to upgrade a protocol map to map version A50.14.00 or later using WSOS5.

Using WSOS5, Open an existing point map > Select the Protocol Configuration Tool menu > Select Version Upgrade > Select Set Latest version > Select Upgrade.

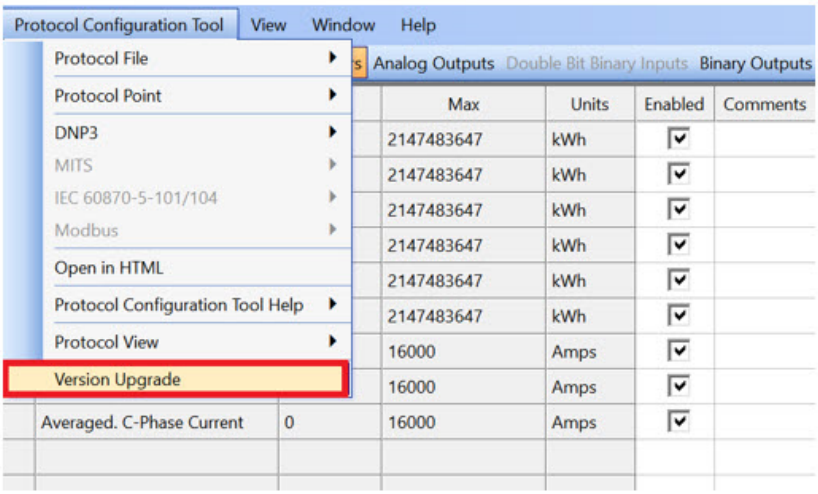



**Figure 85**
Navigation for Version Upgrade

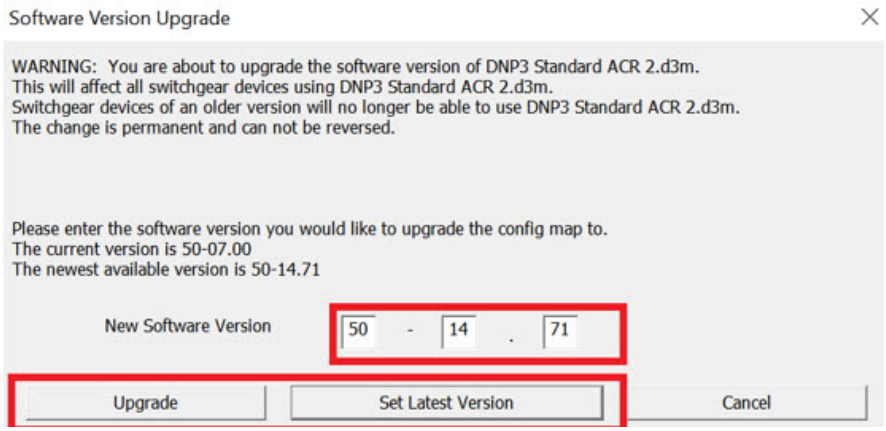



**Figure 86**
Version setting and version upgrade page

When upgrading a DNP3 point map from an older version to A50-14.00 and later, WSOS will bring up the dialog shown in Figure 22. Selecting Yes enables time stamps for all the existing counter inputs. Note that this will apply a time stamp to all analogue and binary points also.




**Figure 87**
Time stamp update message in WSOS5

Remark: Customers using older point map versions and who do not wish to avail of the option to deploy counter time stamps or have the flexibility to configure individual time stamps for binary and analogue points may continue to use older map versions so long as new points added after version 50.12 are not required to be configured.

It must be noted that if the map deployed uses version 50.12 or later the global binary and analogue time stamps settings are removed from the DNP3 Point Configuration dialogue box as the settings is no longer valid on map versions 50.12 and later.

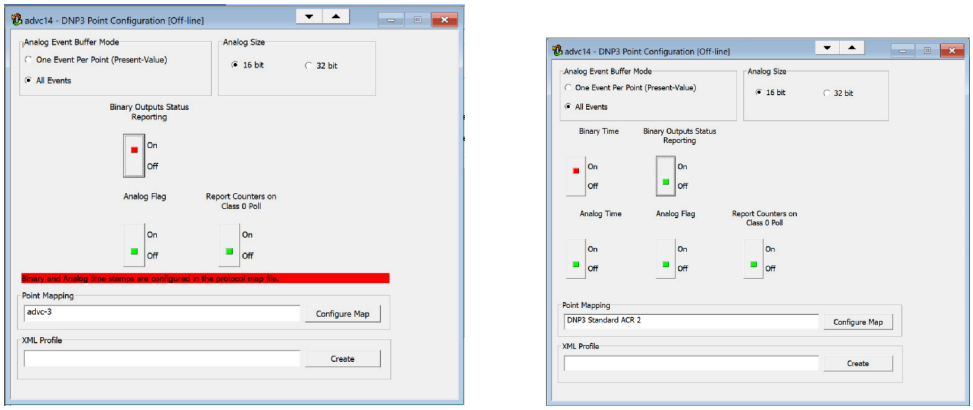



**Figure 88**
DNP3 Point Configuration dialogue box with map versions pre and post 50.12.00

## UKPN Counter Scaling

Counter Scaling is used to convert the internal counter value before its transfer as a DNP3 counter.

> **NOTE:** This feature is comprehensively documented in Application Note DNP3 Counter Scaling in AppNote_DNP3 Counter Scaling_A50-15.xx.

# IEC 60870-5-101

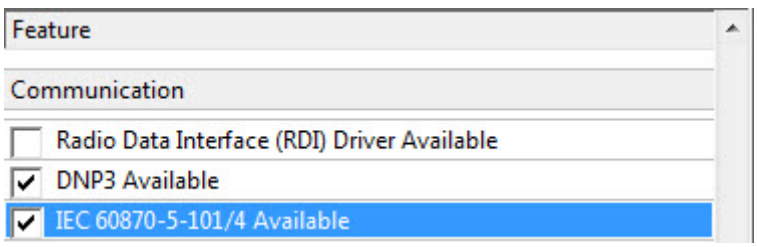
There is a five-step procedure required to enable the PowerLogic ADVC Controller to communicate with a SCADA master station using the IEC 60870-5-101 protocol:

1. Check that IEC 60870-5-101 is available.
2. Select a communications port for IEC 60870-5-101.
3. Configure the communications settings for the selected port.
4. Assign the selected port to IEC 60870-5-101.
5. Configure the IEC 60870-5-101 settings.

## Step 1 - Check that IEC 60870-5-101 is Available

The IEC 60870-5-101 communications protocol is included in all PowerLogic ADVC Controller firmware releases but before it can be configured or assigned to a communications port it may need to be made available. This can be done through Feature Selection in WSOS at:

**Display** > **Configuration** > **Feature Selection** > **Communications**




IEC 60870-5-101 can also be made available via the operator interface, page 698.

## Step 2 - Select a Communications Port

The PowerLogic ADVC Controller Range has several communications ports that can be connected to RS232, RS485 or FSK devices for the transmission of IEC 60870-5-101 messages.

On the PowerLogic ADVC Controller, IEC 60870-5-101 can run on the following ports:

- Modem
- IOEX/WSOS(4)
- USB 1,2 3[3] (if USB to Serial converters are fitted)

**NOTE:** Serial ports are only available for IEC60870-5-101 if they are not being used for another purpose for example, WSOS or IOEX.

## Step 3 - Port Configuration

Once the port that DNP3 is to run on has been selected, that port must be configured to suit the application and hardware being used.

The chosen port can be selected and configured in WSOS on the Port Configuration page.

Open this page by going to:

**Display** > **Switchgear Communications** > **Ports** > **Port Configuration**

Open this page and choose the tab for the selected port.

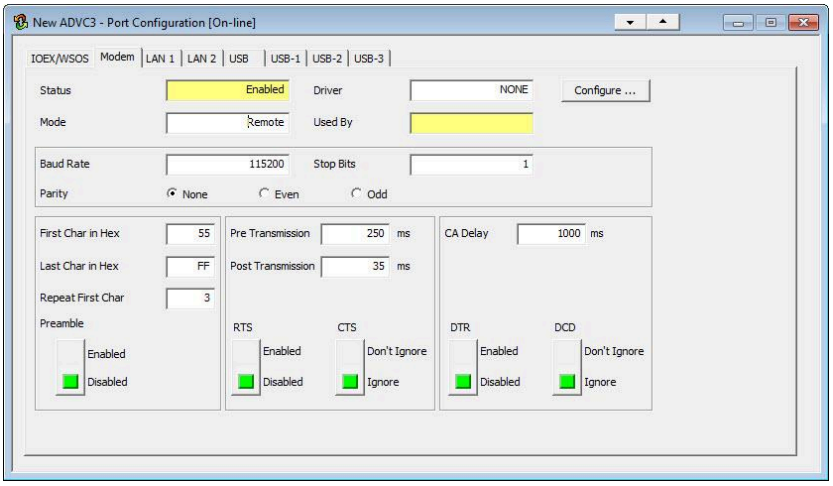



**Figure 89**
WSOS Port Configuration (Modem) Page

The above figure shows the Port Configuration page for an PowerLogic ADVC Controller with the Modem port tab selected. An example of a setting required to be compatible with the connected radio/modem would be the Baud Rate which may need to be changed from its default value of 115200.

## Step 4 - Assign the Selected Port to IEC60870-5-101

The IEC60870-5-101 port can be selected on the IEC60870-5-101 Communications Configuration page in WSOS.

This page can be opened in WSOS by going to:

**Display** > **Switchgear Communications** > **Protocols** > **IEC60870-5-101/4** > **IEC60870-5-101/4 Communications Configuration**

(4) These ports do not support the flow control normally required when modems are used.

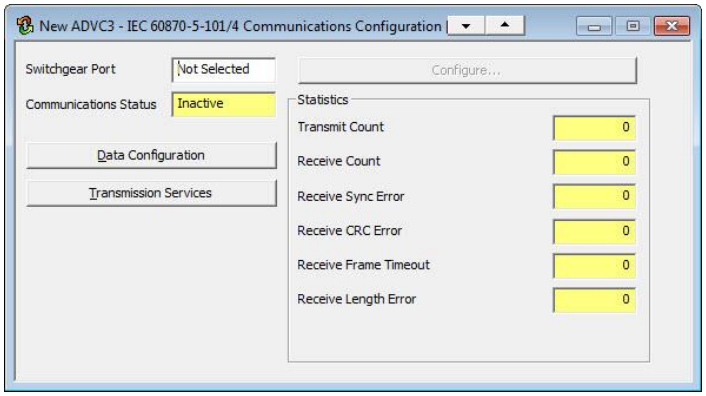



**Figure 90**
Port Selection on the IEC60870-5-101 Communications Configuration Page

Once the **Switchgear Port** has been selected, the Configure button to its right becomes active and can be used to open the configuration page for that port.

The **Switchgear Port** for IEC60870-5-101 can also be selected on the operator interface, page 701.

## Step 5 - Configure the IEC 60870-5-101 Settings

Finally, the IEC 60870-5-101 settings need to be configured which helps to ensure the protocol operates according to the requirements of the SCADA system in use.

The settings are contained on three pages in WSOS.

IEC 60870-5-101 configuration pages can be opened in WSOS by going to:

**Display** > **Switchgear Communications** > **Protocols** > **IEC60870-5-101**

From there, there are three options available:

- IEC 60870-5-101/4 Data Configuration
- IEC 60870-5-101/4 Communications Configuration
- IEC 60870-5-101/4 Transmission Services

Generally, the recommended option is to open the IEC 60870-5-101 Communications Configuration page first as the other two configuration pages can be opened from there.

The default IEC 60870-5-101 settings have been carefully selected and very few must need to be changed for the protocol to run.

Probably the most critical settings are the Link and Common Addresses on the Transmission Services page which are unique to each device.

For more details on the IEC 60870-5-101 Communications Protocol implementation on the PowerLogic ADVC Controller, refer to ADC01-DOC-246.

# IEC 60870-5-104

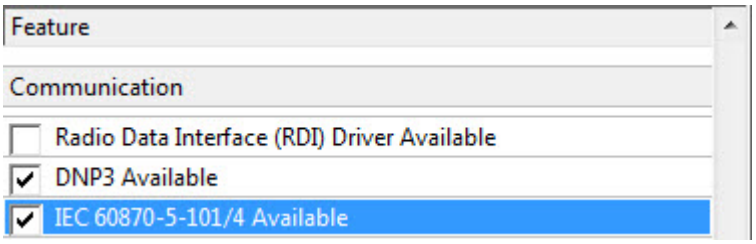
There is a five-step procedure required to enable the PowerLogic ADVC Controllerto communicate with a SCADA master station using the IEC 60870-5-104 protocol:

1. Check that IEC 60870-5-101/4 and TCP/IP are available.
2. Select a communications port for IEC 60870-5-104.
3. Configure the communications settings for the selected port.
4. Assign the selected port to IEC 60870-5-104.
5. Configure the IEC 60870-5-104 settings.

## Step 1 - Check that IEC 60870-5-101/4 is Available

The IEC 60870-5-101/4 communications protocol is included in all PowerLogic ADVC Controller firmware releases but before it can be configured or assigned to a communications port it may need to be made available. This can be done through **Feature Selection** in WSOS at:

**Display** > **Configuration** > **Feature Selection** > **Communications**




IEC 60870-5-101/4 can also be made available via the operator interface, page 698.

TCP/IP must also be available for IEC 60870-5-104 to be used.




## Step 2 - Select a Communications Port

The IEC 60870-5-104 protocol must run on an Ethernet port.

On the PowerLogic ADVC Controller that could be either LAN-1 or LAN-2.

## Step 3 - Port Configuration

Once the port that IEC 60870-5-104 is to run on has been selected, that port has to be configured to suit the application and hardware being used.

The chosen port can be selected and configured in WSOS on the Port Configuration page.

Open this page by going to:
**Display** > **Switchgear Communication** > **Ports** > **Ports Configuration**

Open this page and choose the tab for the selected port.

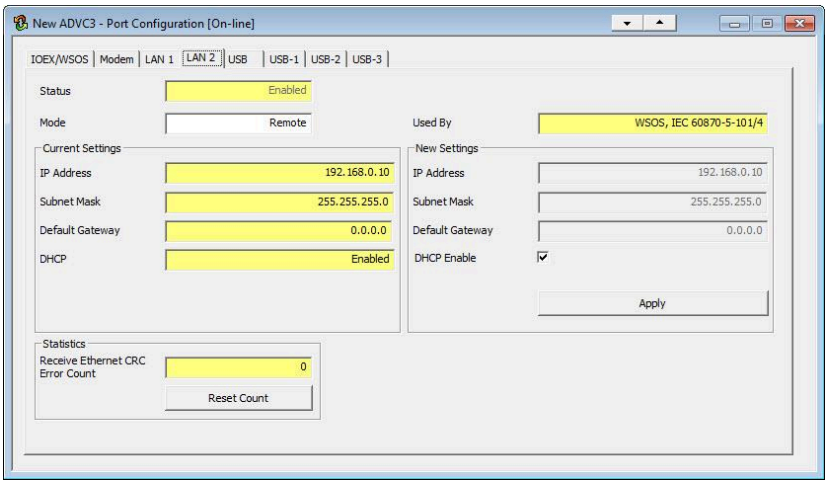



**Figure 91**
WSOS Port Configuration (LAN-2) Page

The above figure shows the **Port Configuration** page for an PowerLogic ADVC Controller with the **LAN-2** port tab selected.

If the PowerLogic ADVC Controller is connected to a **DHCP** server, its **IP address**can be found by selecting **DHCP Enable** and selecting the **Apply** button.

## Step 4 - Assign the Selected Port to IEC 60870-5-104

The IEC 60870-5-104 port can be selected on the IEC 60870-5-101/4 **Communications Configuration** page in WSOS.

This page can be opened in WSOS by going to:

**Display** > **Switchgear Communications** > **Protocols** > **IEC60870-5-101/4** > **IEC 60870-5-101/4 Communications Configuration**

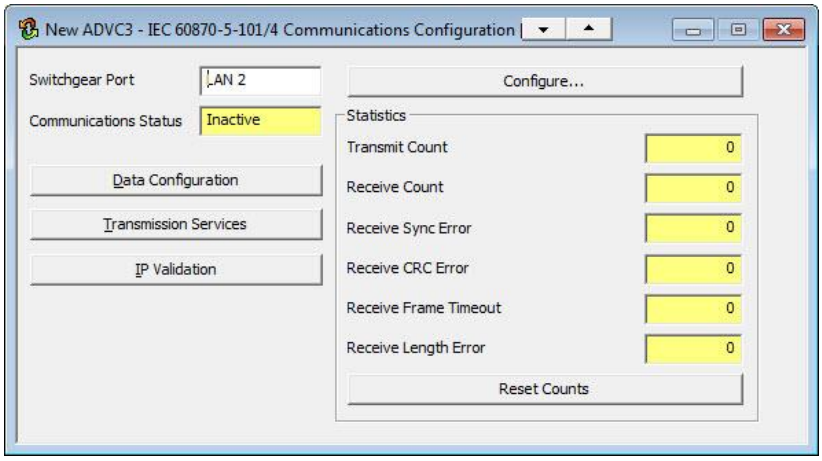



**Figure 92**
Port Selection on the IEC 60870-5-101/4 Communications Configuration Page

Once the **Switchgear Port** has been selected, the Configure button to its right becomes active and can be used to open the configuration page for that port.

The **Switchgear Port** for IEC 60870-5-104 can also be selected on the operator interface, page 701.

## Step 5 - Configure the IEC 60870-5-104 Settings

Finally the IEC 60870-5-104 settings need to be configured which helps to ensure the protocol operates according to the requirements of the SCADA system in use.

The settings are contained on four pages in WSOS.

IEC 60870-5-104 configuration pages can be opened in WSOS by going to:

**Display** > **Switchgear Communications** > **Protocols** > **IEC60870-5-101/4**

From there, there are four options available:

- IEC 60870-5-101/4 Data Configuration
- IEC 60870-5-101/4 Communications Configuration
- IEC 60870-5-101/4 Transmission Services
- IEC 60870-5-101/4 IP Validation

Generally, the recommended option is to open the IEC 60870-5-101/4 Communications Configuration page first as the other three configuration pages can be opened from there.

The default IEC 60870-5-104 settings have been carefully selected and very few must need to be changed for the protocol to run.

Probably the most critical setting is the Common Address on the Transmission Services page which is unique to each device.

For more details on the IEC 60870-5-104 Communications Protocol implementation on the PowerLogic ADVC Controller, refer to ADC01-DOC-246.

**NOTE: IEC 104 Intermediate Status Time stamp**

- Time stamp of the Intermediate status using IEC 014 protocol was reported as the new position time stamp which has been corrected to reflect the actual intermediate status time stamp.

# Modbus

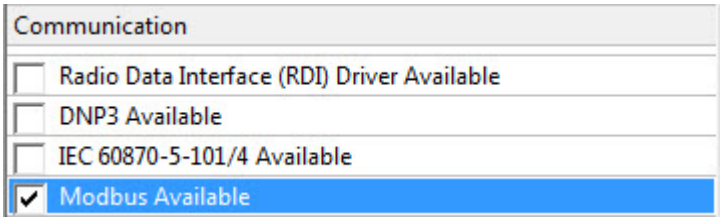
There is a five-step procedure required in order to enable the PowerLogic ADVC Controller to communicate with a SCADA master station using the Modbus protocol:

1. Check that Modbus is available.
2. Select a communications port for Modbus.
3. Configure the communications settings for the selected port.
4. Assign the selected port to Modbus.
5. Configure the Modus settings.

## Step 1 - Check that Modbus is Available

The Modbus communications protocol is included in all PowerLogic ADVC Controller firmware releases but before it can be configured or assigned to a communications port it may need to be made available through Feature Selection in WSOS at:

**Display** > **Configuration** > **Feature Selection** > **Communications**




If Modbus is required to run on an Ethernet port, TCP/IP must also be made available.




Modbus can also be made available via the operator interface, page 698.

## Step 2 - Select a Communications Port

The PowerLogic ADVC Controller Range has several communications ports that can be connected to RS232, RS485, Ethernet, or FSK devices for the transmission of Modbus messages.

On the PowerLogic ADVC Controller, Modbus can run on the following ports:

- LAN 1 or 2 (TCP/IP must be available)
- Modem
- IOEX/WSOS, page 112
- USB 1,2 3, page 112(if USB to Serial converters are fitted)

  **NOTE:** Serial ports are only available for Modbus if they are not being used for another purpose for example, WSOS or IOEX.

## Step 3 - Port Configuration

Once the port that Modbus is to run on has been selected, that port must be configured to suit the application and hardware being used.

The chosen port can be selected and configured in WSOS on the **Port Configuration** page.

Open this page by going to:

**Display** > **Switchgear Communications** > **Ports** > **Port Configuration**

Open this page and choose the tab for the selected port.

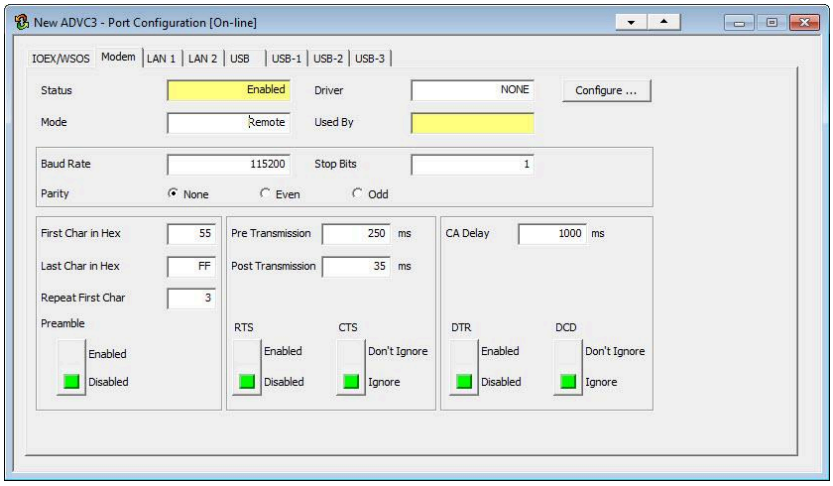



**Figure 93**
WSOS Port Configuration (Modem) Page

The above figure shows the **Port Configuration** page for an PowerLogic ADVC Controller with the Modem port tab selected.

An example of a setting required to be compatible with the connected radio/ modem would be the Baud Rate which may need to be changed from its default value of 115200.

## Step 4 - Assign the Selected Port to Modbus

The Modbus port can be selected on the Modbus Communications Configuration page in WSOS.

This page can be opened in WSOS by going to:

**Display** > **Switchgear Communications** > **Protocols** > **Modbus** > **Modbus Communications Configuration**.

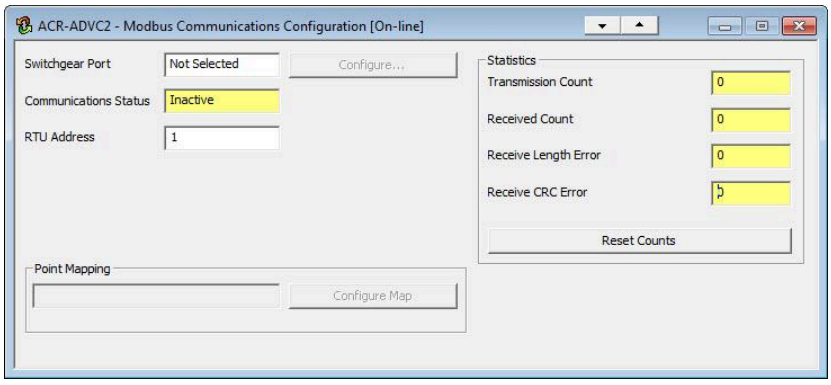



**Figure 94**
Port Selection on the Modbus Communications Configuration Page

Once the **Switchgear Port** has been selected, the Configure button to its right becomes active and can be used to open the configuration page for that port.

The **Switchgear Port** for Modbus can also be selected on the operator interface, page 701.

## Step 5 - Configure the Modbus Settings

Configuring Modbus may only require that a unique RTU address be assigned to each device.

This can be done in WSOS on the Modbus Communications Configuration page when the Switchgear Port was assigned.

If Modbus is running on an Ethernet port, Modbus IP Networking may need to be configured.

Modbus IP networking can be configured in WSOS by going to:

**Display>Switchgear Communications>Protocols>Modbus>Modbus IP Networking**

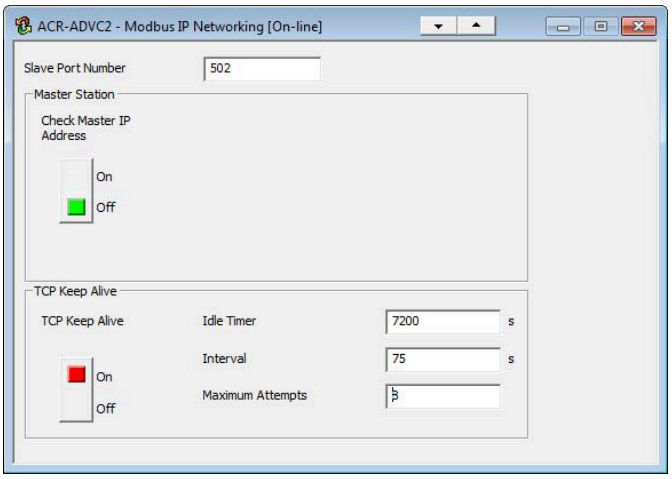



**Figure 95**
Modbus IP Networking Configuration settings

Modbus IP networking can also be configured on the operator interface, page 701. For more details on the Modbus Communications Protocol implementation on the PowerLogic ADVC Controller, refer to ADC01-DOC-357.

# GOOSE Support

Release version A50-05.04 included the initial version of IEC 61850 on the ADVC3 platform. The initial release provided support for Server and MMS.

Release version A50-07.01 now extends the IEC 61850 support to include GOOSE as well. This has been certified to meet the conformance tests according to IEC 61850-10 Edition 2, the UCA International Users Group Edition 2 Server Test Procedures version 1.0.

WSOS 5.16.15 will need to be installed to activate and configure the IEC 61850 feature. Once installed, the default .ICD file is copied to the installation path, under an IEC 61850 folder.

The IEC 61850 support can be activated via WSOS 5.16.15, by selecting IEC 61850 in the Feature selection window, under the Communication category.

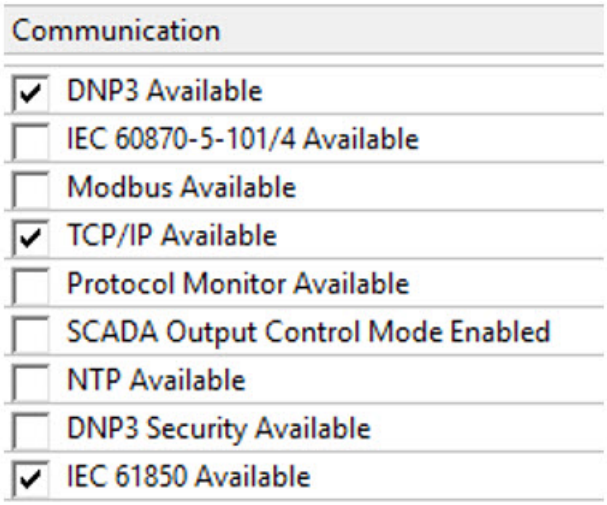



**Figure 96**
IEC 61850 feature selection

Creation of a .CID file can be done via the IEC 61850 configuration tool in WSOS. The configuration tool can be launched by selecting the **IEC 61850 Configuration** menu item under the **Customize** menu.

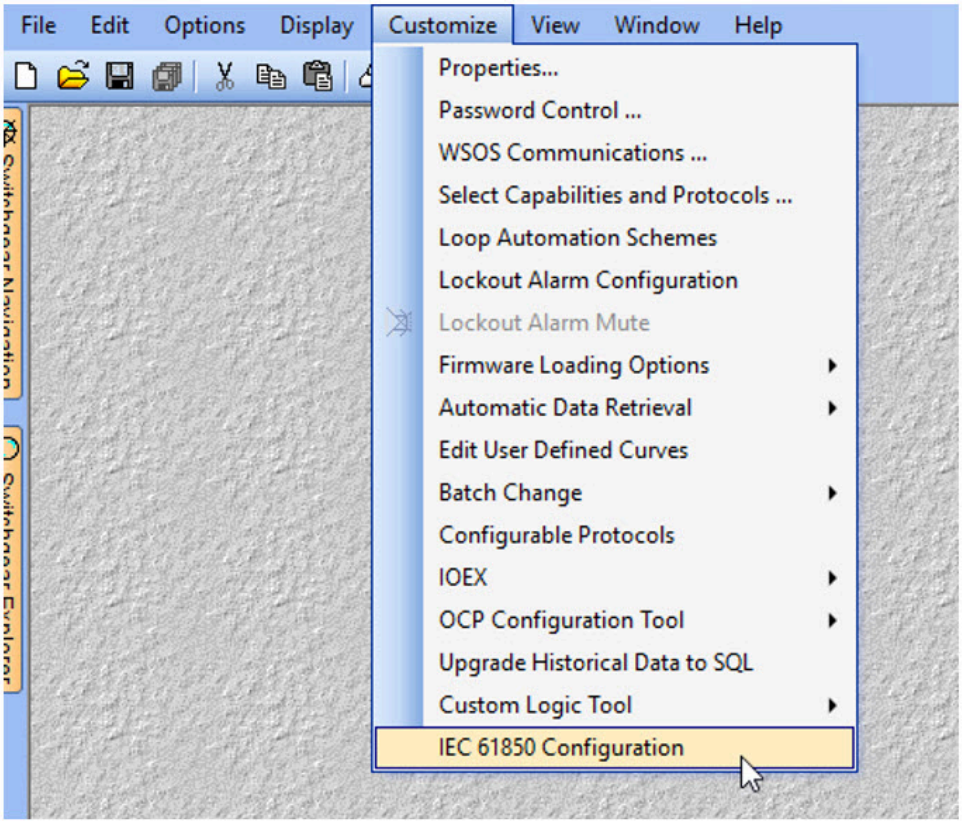



**Figure 97**
IEC 61850 Configurator

The controller specific IEC 61850 settings are available via **Switchgear Communications > Protocols** menu items.

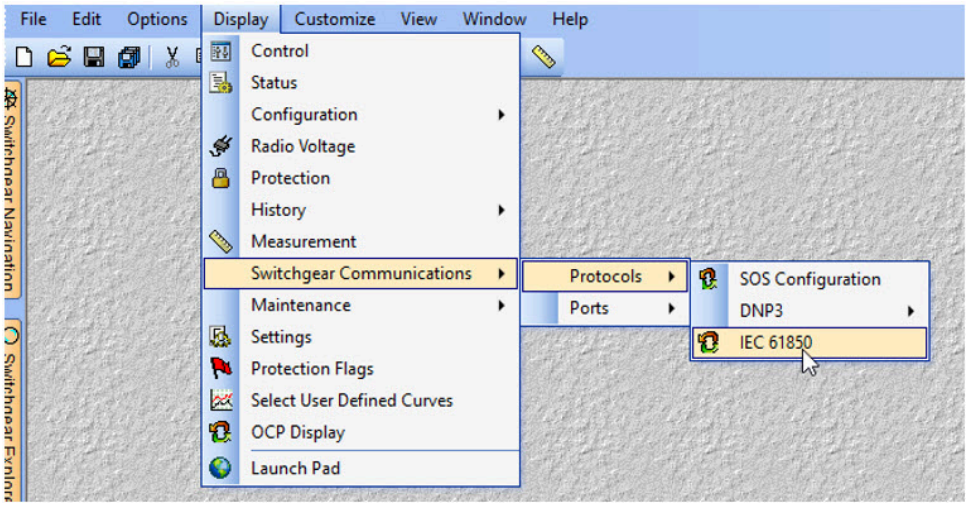



**Figure 98**
Controller settings

Once the .CID file is created, it needs to be selected in the controller's IEC 61850 settings page. This can then be written to the controller via the **Write Switchgear settings to Switchgear** option from the **Options** menu in WSOS5.

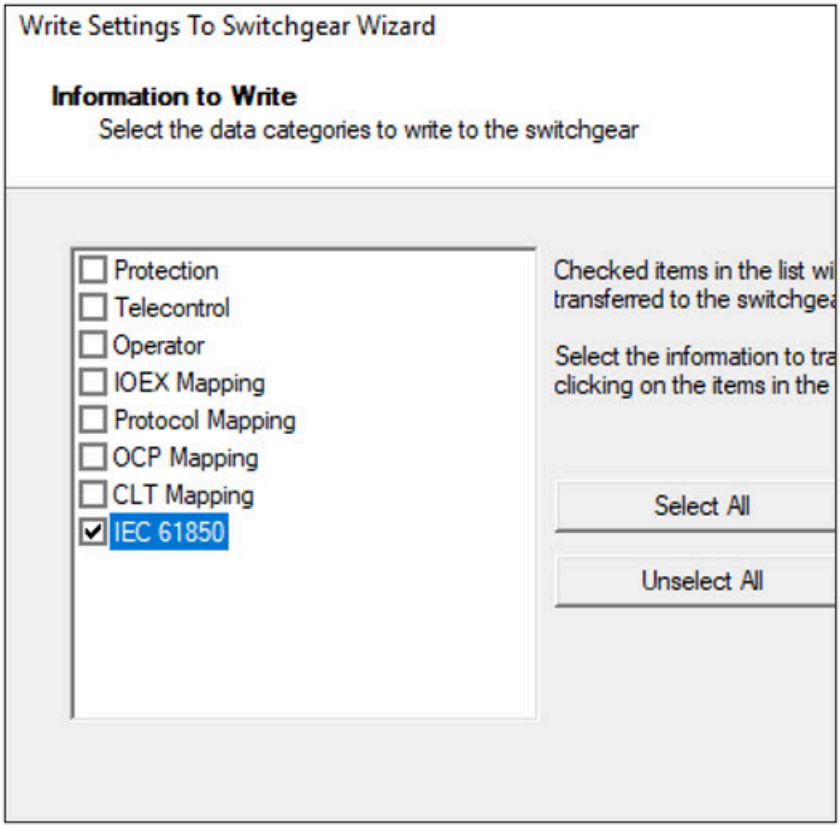



**Figure 99**
Write CID file

## IEC-61850

For more details on the IEC-61850 protocols implementation on the PowerLogic ADVC Controller, refer to WSOS - IEC61850 Configuration user manual.

# Communications Features

## Protocol Monitor

### Introduction

This feature works in conjunction with either the DNP3 or IEC 60870-5-101/4 communications protocols.

When Protocol Monitor is enabled, the PowerLogic ADVC Controller will cycle the power to the communications peripheral device if it detects that the protocol has stopped communicating with the master station. This forces a re-initialisation of the communications device. The duration for which the peripheral communication device is without power is configurable.

### Protocol Monitor Configuration

Protocol Monitor must be made available through WSOS Feature Selection.

**Display** > **Configuration** > **Feature Selection** > **Communications**.

**NOTE:** Protocol Monitor Available will not appear in the Communication section on the WSOS Feature Selection page unless either DNP3 or IEC 6087-5-101/4 are available.

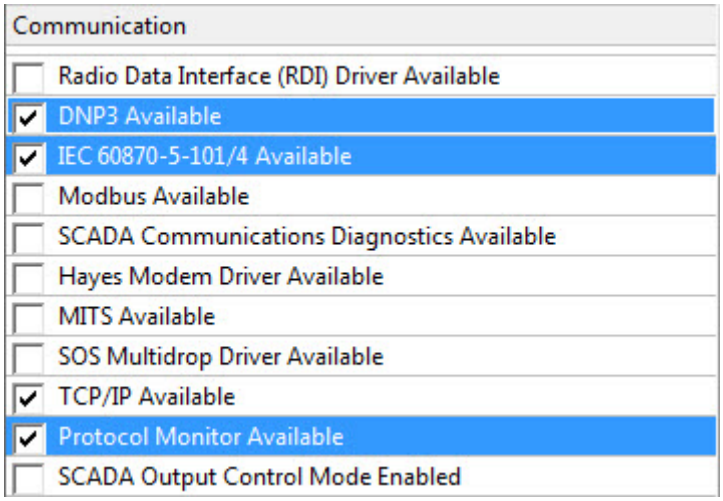



**Figure 100**
Protocol Monitor Available

Once Protocol Monitor has been made available, an additional page is added to the configuration pages for DNP3 or IEC 60870-5-101/4 depending on which of these protocols is available.

**Display** > **Switchgear Communications** > **Protocols** > **DNP3**

Or

**Display** > **Switchgear Communications** > **Protocols** > **IEC 60870-5-101/4**

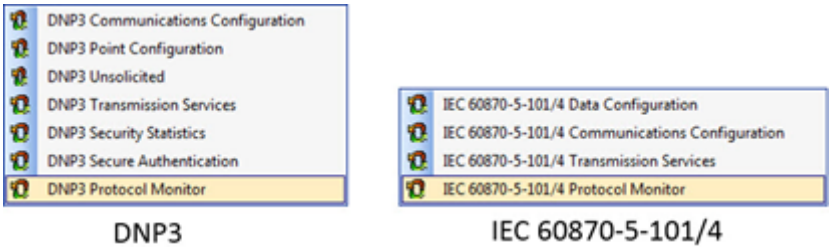



**Figure 101**
Protocol Monitor is added to the menu for the Protocol configuration pages

Selecting Protocol Monitor from the menus shown above will launch the Protocol Monitor configuration page.

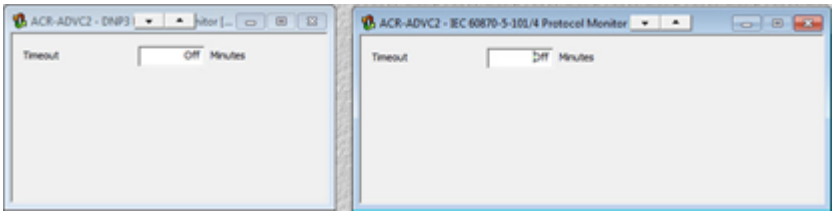



**Figure 102**
Initial Protocol Monitor configuration pages

When the Protocol Monitor Configuration page is initially opened, **Timeout** is the only available setting with **Off** as the default setting.

> **NOTE:** If DNP3 and IEC 6087-5-101/4 are both available, separate settings pages as shown in the Figure 102 can be opened. In this case, these pages display the same settings and changing a setting on one page automatically changes the same setting on the other page.

Once the **Timeout** setting is changed from the default **Off** to a value between 1 and 1400 minutes, settings are displayed for **Power Cycle Period** and **Radio/Modem Power Cycle On/Off** as shown in the figure below.

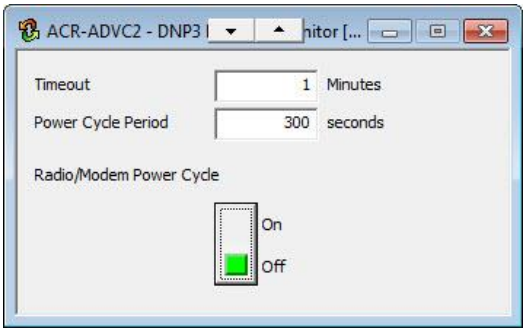



**Figure 103**
Protocol Monitor Configuration page

**Table 20 Protocol Monitor Configuration settings**

| Setting | Description |
|---|---|
| Timeout | The duration after which the Protocol Monitor would cycle the power to the radio/modem no communications be detected.<br><br>Range: Off, 1 – 1400 minutes<br><br>Factor default is Off |
| Power Cycle Period | The duration for which the power to the radio/modem would remain switched off prior to being turned back on.<br><br>Range: 3 to 86 400 s<br><br>Factory default is 300 s |
| Radio/Modem Power Cycle On/Off | Off means that the feature is not operating.<br><br>On means that the power to the radio/modem will be cycled after the Timeout period has expired.<br><br>Options: On, Off<br><br>Factory default is Off |

## Protocol Monitor Operation

If **Radio/Modem Power Cycle** is **On**, the Radio/Modem power supply will turn off when there has been no communications with the master station for the **Timeout** period.

The Radio/Modem power supply will stay off for the **Power Cycle Period** before coming back on.

The Radio/Modem power cycle will not occur if the **Timeout** setting is **Off**.

### Protocol Monitor Changes

The Protocol Monitor has been updated with additional configuration options. There is now an option to configure an ICMP ping based connectivity monitoring to the Client. When enabled, the controller will send out ICMP ping packets to the Client's IP address that is configured for the protocol. The frequency of packets sent out is configurable as shown. The setting value range is from 1...1440 minutes. The radio/modem is power cycled if the response is not received for Maximum ICMP Ping Failure Count consecutive requests, which can be set from 1...100.

> **NOTE:** Protocol Monitor can only be configured for use with DNP3 and IEC 101/104. Additionally, the ICMP ping mechanism is designed to work for SCADA connections over TCP/IP and require a valid Client IP to be configured.

The RX/TX Timeout setting corresponds to the previous Timeout setting and corresponds to the Rx and Tx packet counts for the protocol. With this release, the configurable maximum value has been extended to 10080 minutes.

The Modem Restart Delay setting is an additional delay before the modem is restarted after the configured RX/TX Timeout period has expired or after the Maximum ICMP Ping Failure Count is reached.

# SCADA Output Control Mode

## Overview

The SCADA Output Control Mode enables Local/Remote control of all SCADA binary and analogue outputs (controls).

When the SCADA Output Control Mode is enabled, placing the PowerLogic ADVC Controller in local control mode helps to prevent remote SCADA operators from operating the switchgear or performing any other controls.

## Normal Local/Remote Operation

When the PowerLogic ADVC Controller is in Local control mode, certain SCADA binary controls are disabled (off-line). They are:

- Switchgear Close
- Work Tag On
- Work Tag Off

All binary controls as well as all analogue controls are on-line when the PowerLogic ADVC Controller is in Remote control mode.

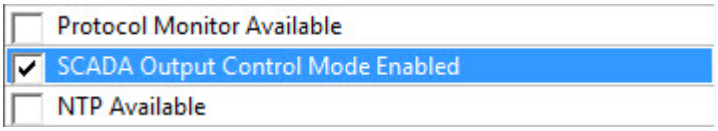
## Modified Local/Remote Operation

Operational requirements may dictate that all SCADA binary controls be disabled when the PowerLogic ADVC Controller is in Local control mode.

In this case **SCADA Output Control Mode** must be enabled.

The **SCADA Output Control Mode** can only be enabled via WSOS Feature Selection.

**Display** > **Configuration** > **Feature Selection** > **Communications**.




When **SCADA Output Control Mode** is enabled and the PowerLogic ADVC Controller is in Local control mode, all **binary** and **analogue** controls are **off-line**.

Enabling the S**CADA Output Control Mode** makes no difference to the operation of the PowerLogic ADVC Controller when it is in Remote control mode.

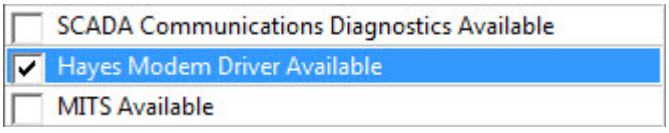
In Remote control mode, all binary and analogue controls are always on-line.

# Hayes Compatible Modem Support

The **Hayes modem driver** is an optional feature that must be made available through Feature Selection if it is required for use with a Hayes compatible modem.

In WSOS go to:

**Display**> **Configuration**> **Feature Configuration**> **Communications**




The Hayes modem driver can also be made available via the operator interface, page 698.

The Hayes interface is both a physical hardware interface and a logical flow control protocol for the control or modems. It is used to command a modem to dial another modem or to disconnect one modem from another.

The physical layer of the Hayes interface includes:

- DTR can be used to reset the modem.
- DCD t is used to determine if the modem has successfully connected to another modem.
- Radio Power Supply – can be cycled to reset the modem.

Hayes compatible modems that have dialling/auto answer capability can be connected to RS232 ports on an PowerLogic ADVC Controller that support the above features.

On the PowerLogic ADVC Controller that would be RS232 ports C and D.

Hayes can then be selected as the driver in the settings for the connected port.

## Hayes Modem Driver Configuration

The Hayes Modem Driver Configuration can be opened in WSOS at:

**Display**> **Switchgear Communications**> **Drivers**> **Hayes Modem**

Or from the **Configure** button on the Port Configuration page when Hayes is selected as the driver.

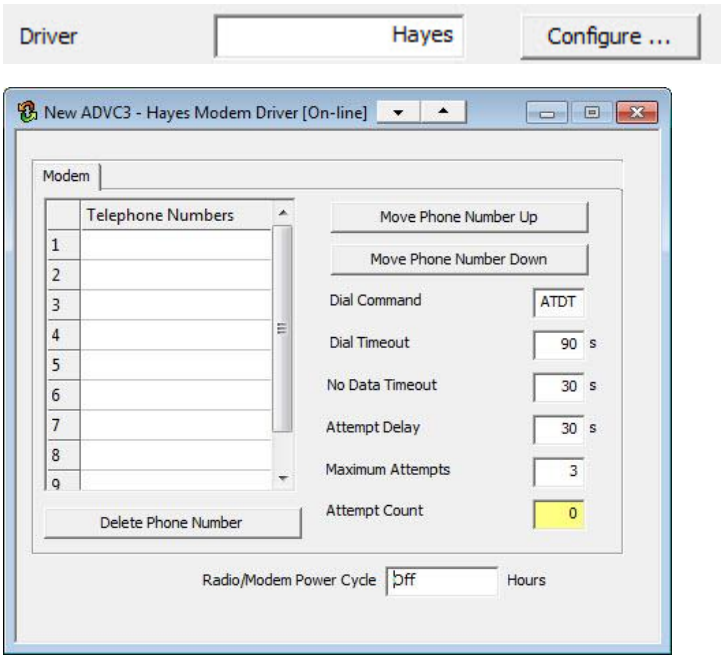



**Figure 104**
Hayes Modem Driver Configuration settings

A set of up to 10 Public Switched Telephone Network (PSTN) numbers that the driver will call when it next needs to be polled by the master station can be entered in the fields provided for **Telephone Numbers**.

Each phone number can be a maximum of 20 digits.

The digits can be any ASCII character from 0x20 t 0x7E.

The order of dialling is sequential according to the number 1...10 assigned.

The order itself can be rearranged via the **Move Phone Number Up** and **Move Phone Number Down** buttons.

If repeat dialling of a particular number is required, it can be entered into the list multiple times.

The Hayes modem driver configuration settings are described in the table below:

**Table 21 Hayes Modem Driver Configuration settings**

| Setting | Description |
|---|---|
| Dial Command | The dial command precedes the dial out phone number.<br>Modem dial can be either pulse (decadic) **ATDP**, tone Attention Dial Tone **(ATDT)** or **ATD**.<br>Range: ATDT, ATDP, ATD<br>Default ATDT |
| Dial Timeout (s) | The next phone number is dialled if the DCD has not been asserted within this time.<br>Range: 20 to 999 s<br>Default: 90 s |
| No Data Timeout (s) | The driver will disconnect the modem if it has not received, or transmitted any data for this time.<br>Range: 10 to 999 s<br>Default: 30 s |
| Attempt Delay (s) | The delay before the next connection attempt.<br>An attempt ends after either the DCD line is asserted, or all numbers in the phone list have been dialled.<br>There are additional delays to the *Dial Timeout*.<br>• Disconnect delay for each phone number (6.2 s),<br>• Power down delay (60 s) if the end of the phone list is reached.<br>The *Attempt Delay* is in addition to the above times.<br>Range: 0 to 86400 s<br>Default: 30 s |

**Table 21 Hayes Modem Driver Configuration settings (Continued)**

| Setting | Description |
|---|---|
| Maximum Attempts | The maximum number of connection attempts.<br><br>There will be no more connection attempts from the ADVC once this limit is reached. The dial out capability is re-enabled when valid messages are received while the DCD line is asserted.<br><br>If the attempts are set to 255, attempts will be unlimited.<br><br>Range: 1 to 255<br><br>Default: 3 |
| Radio Power Supply Cycle | This determines the minimum frequency that the radio power supply will be cycled.<br><br>The modems are normally powered via the radio power supply. For some modems, cycling their power is the only way they can be reset.<br><br>This setting affects all modems that are using the radio power supply.<br><br>Unless this is On, cycling of the radio power supply will not be possible.<br><br>If two modems are using the Hayes driver, the power down will not begin unless both drivers are ready to power down.<br><br>**NOTE:** The driver does not consider all devices using the radio power supply, only devices using the Hayes driver. Any other devices using the radio power supply but not using this driver will be disrupted by a power cycle even if in operation.<br><br>Range: Off, 1 to 48 hours<br><br>Default: Off |

## Hayes Modem Driver Operation

Once a Hayes compatible modem has been connected to the selected port and the driver has been correctly configured, the ADVC is able to initiate a call to a remote device if, for example, there are change-of-state events to be reported.

The ADVC uses the list of 10 phone numbers configured for the Hayes modem. If it fails to establish communications via one number, it will try the next number on the list.

**NOTE:** The list of phone numbers for Hayes modem operation is configurable via WSOS only.

The Hayes driver uses the state of the DCD input from the modem to determine the status of the modem. If DCD is asserted, then the modem is on-line. If DCD is negated, the modem is off-line.

When a communications port is assigned the Hayes driver, its DCD is set to Don't Ignore and that field becomes read-only.

The modem must be configured to:

- Auto answer any call
- Not return results codes
- Not echo commands

If possible, the modem must also be configured to reset when it receives an On-to-Off change of the DTR. DTR needs to be enabled to allow this feature.

To establish a remote connection, the driver issues an **ATD**, **ATDT** or **ATDP** Hayes command followed by the currently active telephone number.

The driver will then wait up to the **Dial Timeout** setting (default is 90 s) for the modem to assert the DCD line. If the modem fails to assert the DCD line within the configured time then the dial out attempt is aborted, the next configured phone number is selected and another attempt to dial out is made.

If the DCD line is asserted, or all the numbers in the Telephone Numbers list have been dialled, then this is counted as a dial out attempt. However, if the data is not sent, then the next dial out attempt will begin after the **Attempt Delay** setting (default is 30 s). This will happen no more than **Max Attempts** times (default is 3).

After successful communications (that is a phone line has been established) the driver will hang up the modem after the **No Data Timeout** setting (default is 30 s) if not data has been received or transmitted.

The active phone number is reset to the head of the list.

To hang up the modem, the driver will:

1. Send +++
2. Wait 1.2 s
3. Send ATH
4. Wait 5 s
5. Toggle the DTR line if enabled.

The driver will then check that the modem has negated the DCD line. If the DCD is still asserted and the radio power cycle is On, the driver will turn the radio power supply (AUX+) Off for 1 minute to disconnect power from the modem and reset it. If after the radio power reset, the dial out sequence initialization conditions are still met then a new sequence is initiated.

## Statistics

### Attempt Count

This is a read-only field which displays the number of attempts that have been made to connect to the master station.

An attempt will call each of the PSTN numbers in the list until a connection is established. An attempt ends after either the DCD line is asserted, or all numbers in the Telephone Numbers list have been dialled.

**NOTE:** The Attempt Count does not indicate the number of phone calls made.

# SOS Multi-drop Driver

The PowerLogic ADVC Controller Range supports WSOS communications using the SOS Multi-drop driver.

When WSOS communications uses a point to point connection, addressing is not required. However, when some forms of shared communication media such as RS485 or Radio are used, addressing is required and this can be achieved via the SOS Multi-drop driver. Radios with an RS232 interface can be used with RS232 ports that support handshaking lines.

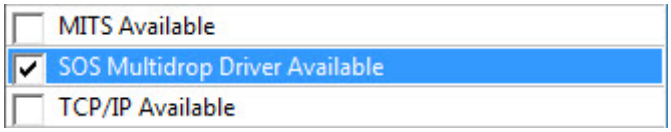
On the ADVC3 controller that would be the Modem port.

**NOTE:** The IOEX/WSOS RS232 port on the PowerLogic ADVC Controller does not have handshaking lines so are not supported by the SOS Multi-drop driver.

The SOS Multi-drop Driver is an optional feature and must be made available through Feature Selection before it can be used.

In WSOS go to:

**Display**>**Configuration**> **Feature Configuration**> **Communications**.




The SOS Multi-drop driver can also be made available via the operator interface, page 698.

## RS232 Radio

An RS232 radio can be connected to the Modem port on PowerLogic ADVC. The driver uses the state of the DCD input from the radio to determine the radio's status.

If DCD is asserted the radio in on-line. If DCD is negated the radio is off-line.

If the driver is active, the communication ports DCD field is set to DCD Do not ignore and this field becomes read-only.

# Network Time Protocol (NTP)

## Introduction

NTP is a networking protocol for clock synchronization between computer systems over packet-switched, variable-latency data networks.

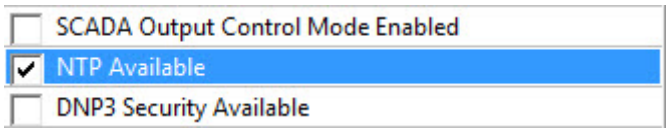
When the NTP feature is enabled, the PowerLogic ADVC Controller is able to work as a NTP client and synchronize to an NTP server.

The WSOS **Synchronize Time** function will not be operable when NTP is On. The button in the **Switchgear Connection** tool bar on WSOS will be greyed out. Similarly, the operator will not be allowed to manually change the controllers date and time when NTP is On. The **Date and Time** edit box in the Control and Status windows in WSOS will also be greyed out.

The PowerLogic ADVC Controller will also reject or ignore any request to change the date or time remotely that is through WSOS or SCADA, when NTP is On.

NTP is an optional feature and must be made available through Feature Selection before it can be used. In WSOS go to:

**Display** > **Configuration** > **Feature Selection** > **Communications**




NTP can also be made available via the operator interface, page 698.

**NOTE:** NTP cannot be made available unless Time Zone and TCP/IP are already available.

# NTP Configuration

Once NTP has been made available it can be configured in WSOS by going to:

**Display** > **Configuration** > **Time Zone and NTP Configuration**.

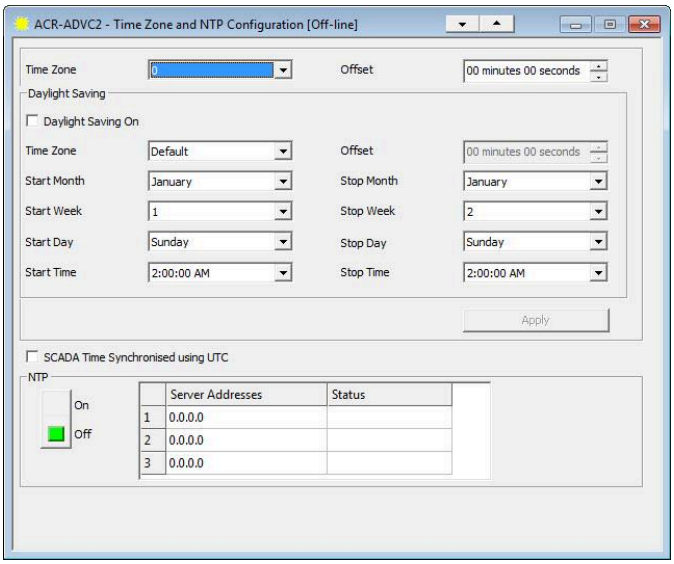



**Figure 105**
Time Zone and NTP Configuration settings

NTP has an **On/Off** control and three fields where server addresses can be entered. Only valid IP addresses can be entered and host names are not supported.

**Table 22 NTP Configuration settings**

| Setting | Description |
|---|---|
| NTP On/Off | Turns NTP On or Off. |
| Server Addresses | These are the IP addresses of up to three servers with which the PowerLogic ADVC Controller time can be synchronized.<br><br>The default IP is 0.0.0.0 which indicates that the server is not configured. |
| Status | Read-only fields that display the status of corresponding server addresses. |

Possible Status indications are described in the table below.

**Table 23 NTP Status Indications**

| Setting | Description |
|---|---|
| Synchronized | The server is chosen by the NTP client and the NTP client acquires time from this server. |
| Reachable | This server is reachable from the protocol level. |
| Not Reachable | The server is not reachable from the protocol level. |

# Power System Measurements

## What's in This Chapter

Introduction ..... 147
WSOS Measurements ..... 148
***flex*VUE** Measurements ..... 148
***set*VUE** Measurements ..... 151

# Introduction

## Measured Values

The PowerLogic ADVC Controller measures up to 10 power system components:

- A, B, and C phase current.
  - From CTs in each phase of 3 phase switchgear.
- Sensitive earth/ground current (three phase switchgear only)
  - A measurement of the spill current in the common connection between the three CT secondary currents on the PCOM board.
  - Only used for SEF protection/detection up to 80 A primary and not displayed as an analogue measurement.
- Phase to Earth voltage on all six terminals (if available)
  - From CVT built into all six bushings on RL Series and PMSet UR Series switchgears. Or from the I bushings on PMSet U Series switchgears.

## Derived Values

The controller uses the measured values to derive many system measurements including:

- Earth current
  - The vector sum of the three phase currents on three phase switchgear.
- Frequency
  - The frequency of the voltage on the source and load sides of the switchgear.
- Phase to phase voltages
  - Calculated from the phase to earth voltages.
- Total and per phase power (kW, kVA, kVAR)
  - Calculated from the phase currents and phase to earth voltages according to the designated power direction.
- Total and per phase PF
  - Calculated from the phase relationship between current and voltage phasors.
- Harmonics
  - Second to sixteenth harmonic plus total harmonic distortion for voltage and current.
- Sequence components
  - Positive Phase Sequence (PPS), NPS and Zero Phase Sequence (ZPS) voltages as well as PPS and NPS currents.

The PowerLogic ADVC Controller can also measure the internal values listed below:

- CAPE temperature
- Switchgear temperature on PMSet U Series and PMSet UR Series Circuit Breakers
- Auxiliary voltage
- Gas pressure on RL Series switchgear
- Battery voltage

# WSOS Measurements

System analogue measurements are displayed by WSOS on the Measurement page.

**Display** > **Measurement**

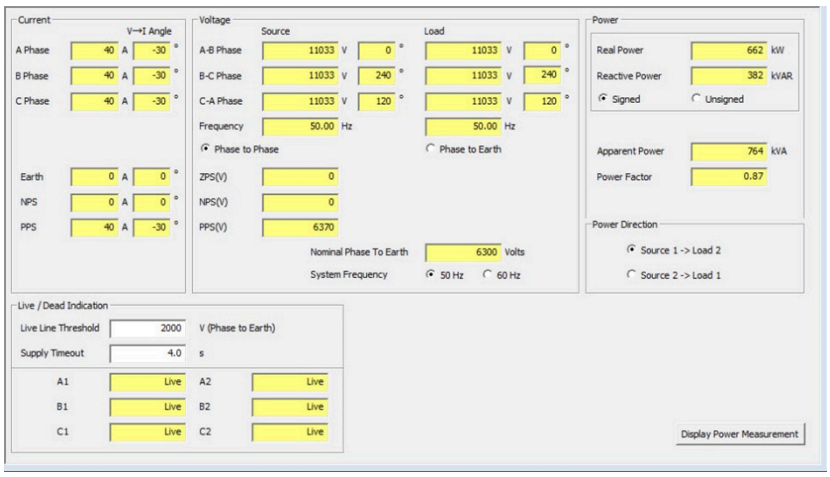



**Figure 106**
WSOS Measurements page

Per phase real, reactive, apparent power, and PF are displayed on a separate page along with Power Meter, page 157 measurements.

This page can be opened by selecting the Display Power Measurement button on the measurement page.

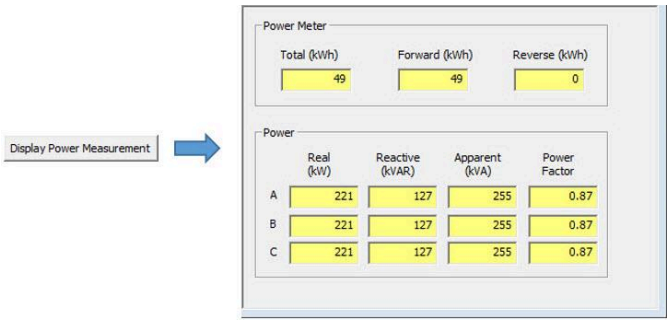



**Figure 107**
Per Phase Power and Power Meter

# *flex*VUE Measurements

On the ***flex*VUE** O.I. measurements can be found in the Operator and Engineer menus.

# Operator Menu

The Operator menu displays a summary in the system measurements sub menu:

**Operator Menu**> **Measurements**> System Measurements, page 619.

- Current — Average value of the three phase currents
- Voltage — Average value of the three phase-earth or phase-phase voltages
- Frequency — Frequency of the voltage on the selected bushing
- Source Frequency — Frequency of the voltage on the source side
- Load Frequency — Frequency of the voltage on the load side
- PF — PF of the three phase system
- Power P — three phase real power
- Power Q — three phase reactive power

As well as separate sub menus for current and Phase Indication:

**Operator Menu**> **Measurement**> Current, page 620.

Displays phase and earth current amplitudes and angles with respect to their corresponding phase to earth voltages. PPS and NPS currents magnitude and angles are also displayed if sequence components are available.

- A phase current and the angle with respect to A phase-earth voltage
- B phase current and the angle with respect to B phase-earth voltage
- C phase current and the angle with respect to C phase-earth voltage
- Earth current and the angle with respect to the zero sequence voltage
- PPS current and the angle with respect to PPS voltage (If sequence components are available)
- NPS current and the angle with respect to NPS voltage (if sequence components are available)

**Operator Menu**> **Measurement**> Phase indication, page 620.

Displays the Live/Dead status for each bushing with voltage measurement capability.

- Live/Dead status of the A phase bushing on the 1 (I) side
- Live/Dead status of the B phase bushing on the 1 (I) side
- Live/Dead status of the C phase bushing on the 1 (I) side
- Live/Dead status of the A phase bushing on the 2 (x) side
- Live/Dead status of the B phase bushing on the 2 (x) side
- Live/Dead status of the C phase bushing on the 2 (x) side

  **NOTE:** Live/Dead status is determined by the Live Line Threshold and Supply Timeout settings.

# Engineer Menu

A more comprehensive measurement display can be found in the Engineer menu at.

**Engineer Menu**> Measurements Menu, page 634.

The Measurements menu on the ***flex*VUE** O.I. contains sub-menus for: Current, Voltage, Frequency, Power, and Energy.

## Current

**Engineer Menu**> **Measurements Menu**> Current, page 634.

Includes separate sub-menus for:

- Magnitude and Angle
  - Displays phase and earth current amplitudes and angles with respect to their corresponding voltages.
- Sequence
  - Displays PPS and NPS current and angles when sequence components are available.

## Voltage

**Engineer Menu**> **Measurements Menu**> Voltage, page 634.

Includes separate sub-menus for:

- Phase/Line SRC-LD
  - Displays magnitudes in either Phase-Earth or Phase-Phase values as selected in Metering Parameters, page 632 as well as relative phase angles for the source and load sides if available.
- Sequence
  - Displays positive, negative and zero sequence voltages when sequence components are available.

## Frequency

**Engineer Menu**> **Measurements Menu**> Frequency, page 635.

Displays the frequency of the voltage on the designated frequency bushing as well as separate frequency measurements for the source and load sides if available.

## Power

**Engineer Menu**>**Measurements Menu**> Power, page 635.

Displays separate sub-menus for:

- Three phase
  - Three phase measurements for real power, reactive power and PF.
- A Phase
  - Real power, reactive power and PF measurements for A phase.
- B Phase
  - Real power, reactive power and PF measurements for B phase.
- C Phase
  - Real power, reactive power and PF measurements for C phase.

## Energy

**Engineer Menu**> **Measurements Menu**> Energy, page 635.

Displays Total, Forward, and Reverse energy measurements in kWhr.

# *setVUE* Measurements

On the ***setVUE*** O.I. the measurements can be found in a dedicated Measurements, page 654 menu.

The Measurements menu includes pages for: System Measurements, Current, Voltage, Sequence Voltage, Frequency and Power.

## System Measurements

A three phase summary page with average values for voltage and current.

- Average phase current
- Average phase voltage
- Frequency
- Total real power
- Total reactive power
- PF

## Current

Displays phase and earth current amplitudes and angles with respect to their corresponding voltages. PPS and NPS currents magnitude and angles are also displayed if sequence components are available.

- A phase current and the angle with respect to A phase-earth voltage
- B phase current and the angle with respect to B phase-earth voltage
- C phase current and the angle with respect to C phase-earth voltage
- Earth current and the angle with respect to the ZPS voltage.
- PPS current and the angle with respect to the PPS voltage (if sequence components are available).
- NPS current and the angle with respect to the NPS voltage (if sequence components are available).

## Voltage

Displays magnitudes in either Phase-Earth or Phase-Phase values as selected as well as relative phase angles for the source and load sides if available.

### Source Side

- A-E or A-B voltage and angle with respect to reference Ø-E or Ø-Ø voltage
- B-E or B-C voltage and angle with respect to reference Ø-E or Ø-Ø voltage
- C-E or C-A voltage and angle with respect to reference Ø-E or Ø-Ø voltage

### Load Side

- A-E or A-B voltage and angle with respect to reference Ø-E or Ø-Ø voltage
- B-E or B-C voltage and angle with respect to reference Ø-E or Ø-Ø voltage
- C-E or C-A voltage and angle with respect to reference Ø-E or Ø-Ø voltage

## Sequence Voltage

Displays PPS, NPS and ZPS voltages when sequence components are available.

- Zero sequence voltage
- Positive sequence voltage
- Negative sequence voltage

## Frequency

Frequency of Source and Load side voltages if available.

- Frequency of the voltage on the source side
- Frequency of the voltage on the load side

## Power

Real power, reactive power and PF per phase.

- A Phase
  - Real power; Reactive power; PF
- B Phase
  - Real power; Reactive power; PF
- B Phase
  - Real power; Reactive power; PF

**NOTE:** Energy (Power Meter) readings are not displayed on the ***set*VUE** O.I. They are only displayed on the ***flex*VUE** O.I. and in WSOS.

## Current Measurement

All compatible switchgear suitable, page 16 for use with the PowerLogic ADVC Controller are fitted with 2000:1 CTs in each phase. Details of the Current Transformers, page 32 can be found in the Technical Specifications.

Phase and Earth current values are displayed as a Magnitude and Angle where:

- **Magnitude** is the real-time RMS value.
- **Angle** is the current angle relative to the corresponding phase to earth voltage angle.

**NOTE:** Earth current angle is the current angle relative to the zero sequence voltage angle.

## Example

The figure below shows current and voltage simulation with all angles referenced to A phase to earth voltage on the U bushing.

The resultant current measurements in WSOS display the angles as shown:

- A Phase 330 - 0 (360) = -30
- B Phase 215 - 240 = -25
- C Phase 85 - 120 = -35

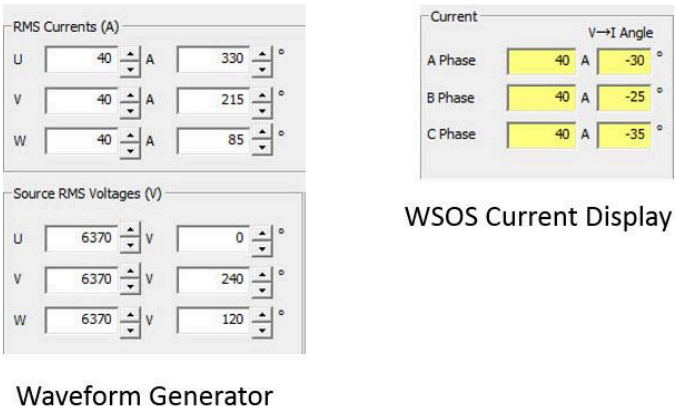



**Figure 108**
Current measurements in WSOS display the angles

The output of these CTs is sampled at the rate of 3200 samples per second (at 50 Hz) by the PowerLogic ADVC Controller. The current values used by the protection algorithms are updated every 2.5 ms.

For measurement purposes 200 samples of the 5 ms data are accumulated into 500 ms data blocks and averaged over 2 s.

# Voltage Measurement

Voltage measurement is achieved by means of CVTs built into the switchgear bushings. These CVT's consist of a brass mesh cylinder moulded around the central conductor which forms a capacitor that interprets the line voltage through the measurement of the capacitive current to earth.

RL Series and PMSet UR Series switchgears have CVT's built into all six bushings. The E-27 kV switch has RVDs built into all six bushings. PMSet U Series switchgear only have CVT's on the I side as standard. External CVT's can be fitted to the X side bushings if voltage measurement is required on both sides of the switch (only PMSet U series).

More details can be found in Power System Measurements, page 34 in the Technical Specifications.

Unlike electromagnetic VTs, these CVT's do not have a set ratio and are calibrated at the factory prior to the ACR or AS being shipped. The calibration values for each bushing are stored in memory in the SCEM card mounted in the switchgear. The calibration values for the PMSet E Series range are stored in the controller that it was paired with during calibration. The calibration files are also made available/accessible and can be written to any controller that is meant to be used with the PMSet E Series.

# Terminal Designation or Phase Configuration

Switchgear bushings have their own identification and are not associated with any particular phase.

Any phase can be connected to any bushing but analogue measurements for current and voltage need to be identified by their phase.

This means that the correct bushing/phase association needs to be configured according to the actual installation.

Setting the phase configuration correctly will also helps to ensure that faulted phase indications are correct regardless of which bushing the faulted phase is connected to.

The **Phase Configuration** can be set in WSOS on the Status page:

**Display** > **Status**

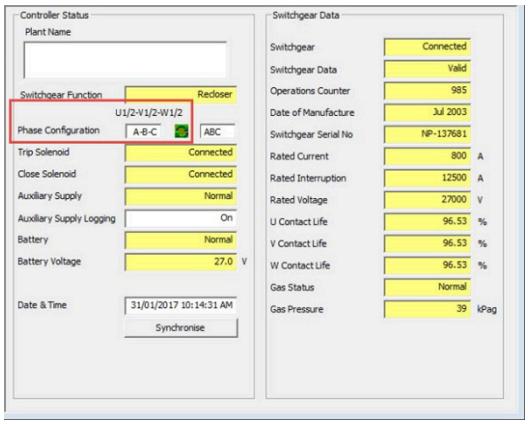
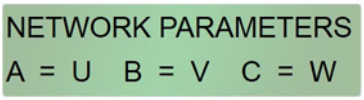



**Figure 109**
Phase Configuration setting on the WSOS Status page

The **Phase Configuration** setting can also be found on the operator interface, page 701.




The default setting A-B-C would be required for the connections shown on the left of the figure below. The connections shown on the right hand side would require the setting to be changed to C-B-A.

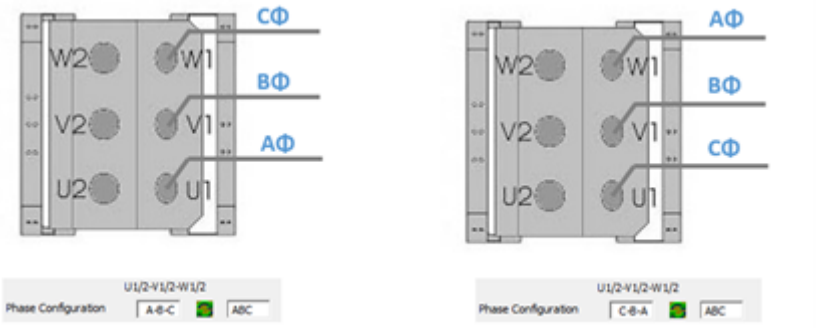



**Figure 110**
Phase Configuration settings to suit the Switchgear Connections

# Phase Rotation

The Phase Rotation setting is ABC by default. When the ACR or AS is installed in a network with ACB rotation this setting needs to be changed helps to ensure that the analogue measurements are reported correctly.

The Phase Rotation setting is also found in WSOS on the Status page.

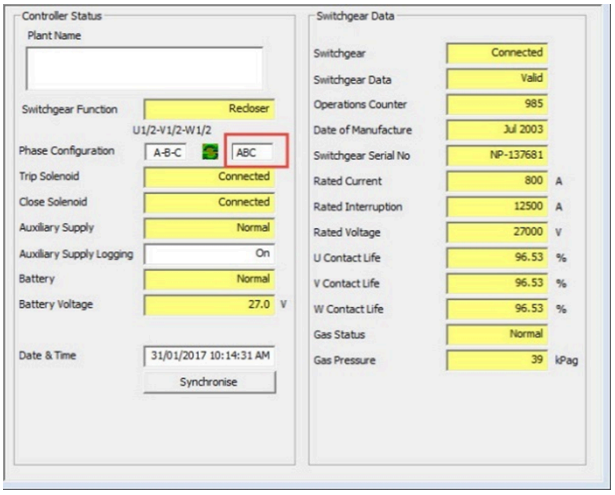



**Figure 111**
Phase Rotation setting on the WSOS Status page

The Phase Rotation setting can also be found on the operator interface, page 701.

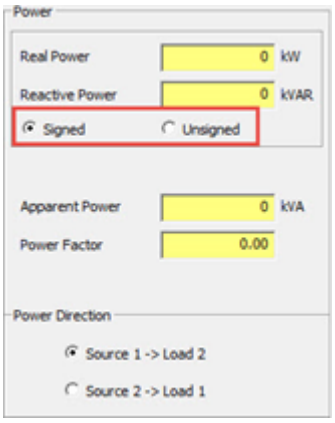
# Power Measurement

The PowerLogic ADVC Controller can calculate:

- Real power in kW
- Reactive power in kVAR
- Apparent power in kVA
- PF

On a three phase and per phase basis.

**Real and reactive power** can be either signed or unsigned as configured in WSOS on the Measurement page:




Power **Signed** or **Unsigned** can also be selected on the operator interface, page 701.

> **NOTE:** Signing only applies to **Real and Reactive Power**. **Apparent Power** and **PF** are not signed values.

## Power Flow Direction

The correct sign for the power measurement is dependent on the correct Power Flow Direction setting.

When power flows through the switchgear from source to load, it is deemed to be positive power flow.

When power flows through the switchgear from load to source, it is deemed to be negative power flow.

As the switchgear can be installed on a pole with either side connected to the source of supply, this setting must be checked as part of the commissioning procedure.

## Example

The example shown below is an PMSet N Series switchgear with the 1 side connected to the source. In this case power flow in the 1 side and out the 2 side would be positive and require the **Power Direction** to be set for **Source 1** > **Load 2** as shown.

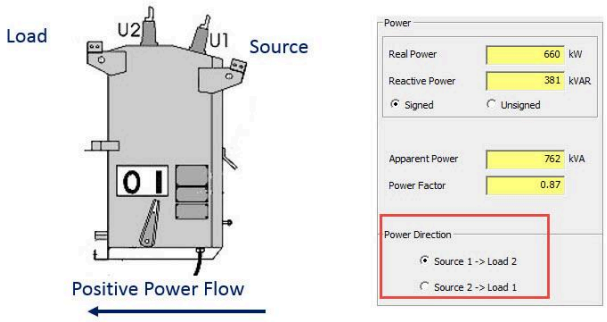



**Figure 112**
Power Direction setting according to orientation of the switchgear

The Power Flow Direction can also be configured on the operator interface, page 701.

# Live/Dead Indication

The Live/Dead status of each bushing on the switchgear is determined by two settings:

- Live Line Threshold
- Supply Timeout

The **Live Line Threshold** is a phase to earth value and is 2000 V by default. It is configurable between 2000 V and 15000 V.

The **Supply Timeout** setting is 4.0 s by default and configurable between 0.1 s and 100.0 s. Both settings can be found in WSOS on the measurement page above the **Live/Dead indications**:

**Display** > **Measurement**.

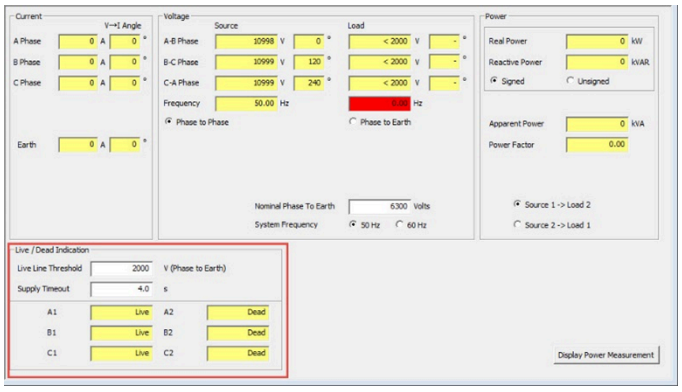



**Figure 113**
Live/Dead Indications and settings

The **Live Line Threshold** and **Supply Timeout** settings can be configured on the operator interface, page 701.

The Live/Dead status is displayed on the operator interface, page 701.

For a Live terminal to become Dead, it must fall below the **Live Line Threshold** setting for the **Supply Timeout** time.

Similarly, for a Dead terminal to become Live it must rise above the **Live Line Threshold** for the **Supply Timeout** time.

Hysteresis of approximately 20% of the **Live Line Threshold** setting is built in helps to prevent frequent status changes due to voltages fluctuating around the threshold.

## Power (Energy) Meter

The **Power Meter** displays Total, **Forward** and **Reverse** energy through the switchgear in kilowatt hours.

It can be displayed in WSOS by selecting the Display Power Measurement button on the Measurement page.




These readings are not displayed on the ***set*VUE** O.I. but can be found on the ***flex*VUE** O.I. at:

**Engineer Menu** > **Measurements Menu** > Energy, page 635.

Depending on the Signed/Unsigned setting, the Total (kWh) represents either the net energy flow or the total accumulated energy flow.

If Power is signed and equal amounts of energy flow through the switchgear in each direction, they would cancel each other out and the total would be zero.

If Power is unsigned, Total would read the accumulated energy flow irrespective of the flow direction.

The integrated real energy flow in both the forward and reverse directions are also measured independently.

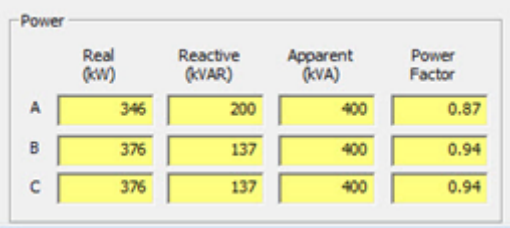
Power Meter measurements can be reset to zero with the WSOS Erase Settings and History command.

They can also be reset with the appropriate communications protocol command.

All three values are available for Configurable History, page 491 logging.

# Per Phase Power Measurements

The dialogue box that opens in WSOS when Display Power Measurement is clicked on the Measurement page also displays per phase power measurements.




Real time measurements for **Real (kW)**, **Reactive (kVAR)**, **Apparent (kVA) Power** and **PF** are displayed on a per phase basis.

Apart from Apparent Power, these measurements are also displayed on the operator interface, page 702.

# Automatic Circuit Recloser (ACR)

## What's in This Chapter

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ACR Protection Features ..... 198
Directional Protection and Blocking..... 222
Voltage Operated Protection Elements..... 278
Frequency Protection ..... 295

# Basic Protection Operation and Auto Recloser

## Introduction to Automatic Recloser

In electrical distribution systems, an ACR is a circuit breaker equipped with an IED controller that can automatically reclose the circuit breaker after it has opened to clear a fault on the feeder.

ACR's are effective on overhead distribution systems since many faults on these systems are momentary short circuits rather than permanent faults. If the fault clears before the circuit breaker recloses, power will be restored to the section of line where the momentary fault occurred.

A lightning strike would be an example of the type of event that could cause a momentary fault.

## Automatic Reclose Sequence

An ACR with an PowerLogic ADVC Controller configured for 4 Trips to Lockout can reclose up to three times to restore supply. If the fault is still present after the third trip/reclose sequence, the circuit breaker will trip and go to **Lockout**. When the ACR is in lockout it can no longer close automatically. It can still be closed manually, either locally or remotely.

The **Trips to Lockout** setting can be configured for 1...4. So if Trips to Lockout = 2, only one automatic reclose will be attempted and if the fault is still present the device will go to lockout after the second trip.

An automatic reclose sequence starts with a protection trip (trip 1). If the fault is permanent, the sequence will end when the device goes through its configured number of trips to lockout.

If the fault clears before the Trips to Lockout setting is reached, the circuit breaker will stay closed after the next reclose and start the Sequence Reset Timer.

The **Sequence Reset Timer** is a configurable setting and can be between 3 s and 180 s.

Once the set time expires, the sequence is reset and any subsequent fault will cause the first trip in a new sequence. If however the fault returns before the Sequence Reset Timer expires and it causes a protection trip, that trip will be the next one in the same sequence that is Trip 2, 3, or 4.

> **NOTE:** The Sequence Reset Timer will only start timing after an automatic reclose providing no fault is detected. If the fault is still present, the protection will pick up again and hold the sequence reset time to zero.

Another situation that can occur is if no fault is present when an automatic reclose occurs but comes back before the Sequence Reset Timer expires. This will reset the sequence reset time to zero and start the trip timer.

Yet another situation can occur where the switchgear automatically closes onto a fault that clears before a trip occurs. In this case the Fault Reset will start the Sequence Reset Timer which will reset the sequence if it expires.

## Protection Pickup

Before the protection system can operate to trip the circuit breaker, a protection pickup must occur. A pickup condition occurs when a measured quantity (For example, current, voltage, frequency and so on) has exceeded a threshold setting. A protection pickup can sometimes initiate a protection trip instantaneously that is without any intended delay. Or it can start a trip timer and cause a protection trip after that timer expires.

If the protection is in the pickup state and a trip timer is running, providing the condition that caused that pickup remains constant, a protection trip must eventuate at some point.

## Fault Reset

Not all protection pickups necessarily result in a protection trip. Where trip timers are involved, the quantity that caused the pickup may drop back below a reset threshold setting before the trip timer expires. This is known as a Fault Reset.

A configurable **Fault Reset Time** setting determines how long the quantity that caused the pickup must be below the reset threshold setting before the fault is reset. So if the quantity dips below the reset threshold setting for less than the Fault Reset Time setting, the fault will not reset.

## Protection Trip

A protection trip occurs when the controller sends a trip signal to the circuit breaker in response to a fault it has detected on the feeder. A protection trip may or may not lead to an automatic reclose depending on the configuration settings stored in the controller.

## Automatic Reclose

An automatic reclose is effectively a check to see if a fault that caused a protection trip is still on the line. The ACR can check one, two, or three times before giving up depending on how the auto reclose settings have been configured.

## Sequence Reset

Sequence reset is a means of ending an auto reclose sequence if the fault clears before the ACR goes to lockout.

# Basic Protection

An ACR is a complete protection system consisting of:

- Measurement sensors such as CT and VTs.
- A protection relay capable of detecting, locating and initiating the clearing of a fault.
- Switchgear capable of breaking fault current.

Some of the protection elements of the PowerLogic ADVC Controller are current operated such as Phase Over current, Earth Fault, SEF, and NPS.

Some are voltage operated such as Under and Over Voltage (UOV) and Under and Over Frequency (UOF).

Some types of protection use both current and voltage elements such as Directional Protection and Blocking.

## Basic Current Protection Elements

The basic current operated protection elements in the PowerLogic ADVC Controller are:

- Phase Over current
- EF
- SEF
- NPS

**NOTE:** Phase Over current, EF and SEF protection are available by default but EF and SEF can be turned Off. NPS protection requires Sequence Components to be made available in Feature Selection before it can be used.

All circuit breakers used with the PowerLogic ADVC Controller as an ACR are fitted with 2000:1 (or a 1000:1 for the PMSet E Series) CTs on each phase. The CT secondary currents are continually sampled by the controller to detect over current faults on the system.

- The Phase Over current element deals with the actual CT secondary values.
- The EF element deals with the vector sum of the phase currents.
- The SEF element deals with analogue measurement of the spill current < 80 A primary and uses a low pass frequency filter to remove harmonic content.
- The NPS element deals with a value calculated in real time using the Fortescue formula for sequence components.

$$I_2 = (I_a + I_b \text{ phase shifted } 240° + Ic \text{ phase shifted } 120°) / 3$$

There is one global Trips to Lockout setting that applies to Phase Over current and EFs. SEF and NPS each have their own Trips to Lockout settings. They can also be set for between 1 and 4 trips but cannot exceed the global Trips to Lockout setting.

The global Trips to Lockout setting determines the maximum number of trips that can occur in a single sequence.

A sequence can end after less than the maximum number of trips if either the SEF or NPS Trips to Lockout settings is reached.

## Global Protection Settings

Global protection settings are settings that apply regardless of which trip is active.

The Global Protection Settings for the active protection group determine if a protection pick up of any of the basic current operated protection elements has occurred. They do this by comparing the measured or calculated current for each element with the Setting Current and Pickup Multiplier setting for that element.

Protection Pickup occurs when the measured current exceeds the Setting Current x the highest active multiplier for that element.

**NOTE:** At this stage, the only multiplier being considered is the Pickup Multiplier.

With the settings in the figure below, the phase pickup current would be 200 x 1.0 = 200 A that is the Phase Setting Current (200 A) x the Phase Pickup Multiplier (1.0).

So in this case, the pickup current and the setting current for the Phase element are the same.

The image below shows a changed Phase Pickup Multiplier setting of x1.2. With these settings, the phase pickup current would be 240 A, that is 200 A x 1.2.

So, in this case the pickup current and the setting current for the Phase element are not the same.

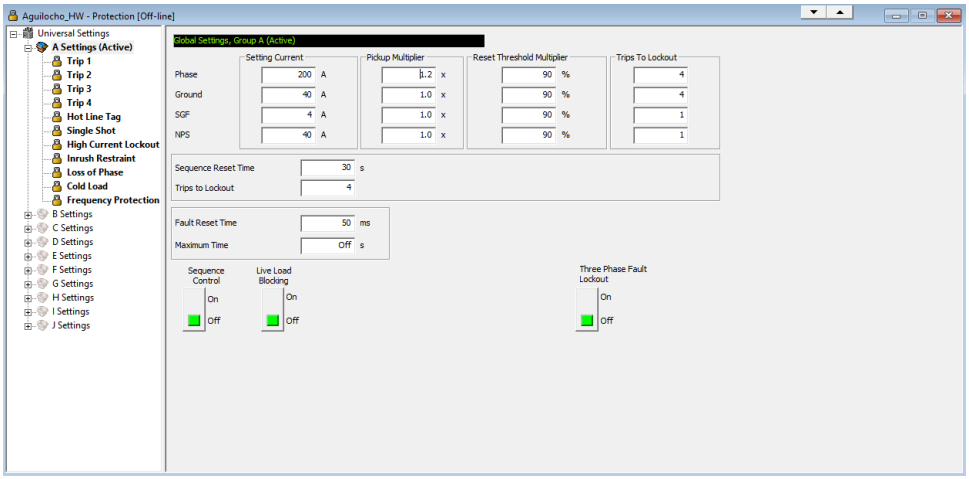



**Figure 114**
Independent Trips to Lockout

A Fault Reset occurs when the measured current has fallen back below the pickup level by a set amount for a set time.

The **Reset Threshold Multiplier** setting for each element determines the level at which the measured quantity must drop to after a pickup to start the **Fault Reset Time**. These settings are all 90% by default and can be configured between 90% and 100%. There is one Fault Reset Time setting for all four elements which defaults to 50 ms. It can be set between 0 ms and 10000 ms.

## Fault Reset Operation

If after a Phase Over current pickup, the current falls to between 90% and 100% of the Pickup Current, a Protection Paused event is logged. At this point the trip timer freezes and will recommence if the current rises back above the pickup. The current going back above the pickup in this case will cause a Protection Timing event. This is not a Pickup as the controller is already in a pickup state and cannot record another pickup unless the fault that caused the pickup has reset.

If the current falls below 90% of the pickup current, a Protection Resetting event is logged and the Fault Reset Timer starts.

If the Fault Reset Timer expires before the current rises back above 90%, the protection pickup will reset and an event (Max Current) will be logged to record the highest fault current sampled while the pickup was active. In this case protection timing will start again at the next pickup event.

If a fault is sustained long enough for a protection trip to occur, a Current at Trip event will be logged to indicate the measured fault current at the time of the trip. Max Current events will also occur as well as a Protection Resetting event followed by a Protection Reset event.

If after a pickup, the current falls into the band between the pickup current and the reset threshold (90-100% of the Setting Current by default), protection is said to be in a Paused state. In the **Paused** state, the pickup is still active but the trip timer is frozen.

## The Pickup Multiplier effect on the Pause band

With the default Phase Over current settings shown below, the pickup current is 200 A and the reset threshold is 180 A (90% of 200 A). The pause band is 20 A wide, 180 A...200 A.




When the Pickup Multiplier is changed to x 1.5 as shown below, the pickup current becomes 300 A and the reset threshold changes to 270 A. This makes the pause band 30 A wide, 270 A...300 A.




The **Maximum Time** setting is a Global Setting which helps to ensure that a fault will never take longer than a predetermined time to cause a trip. This setting is Off by default but can be configured for between 2 s and 180 s.

# Active Trip

While the Global Protection Settings determine if a protection pickup has occurred, the time to trip is determined by which trip is active at the time.

At any given time, a trip is active for each element. The active trip depends on whether Auto Reclose is on and if it is on, where any sequence in progress is up to.

If Auto Reclose is off, then the Single Shot trip is active. Even if Auto Reclose is on, the Single Shot trip will be active for the Single Shot Reset Time following a manual close. The Work Tag trip is always active if the Work Tag is applied.

The table below shows which trip is active when the associated settings are applied and at which point in an automatic reclose sequence. Assumes 4 Trips to Lockout.

**Table 24 Active Trip Conditions**

| Active Trip | Auto Reclose | Work Tag | Active when.. |
|---|---|---|---|
| Trip 1 | ON | OFF | No sequence is in progress. |
| Trip 2 | ON | OFF | Sequence has advanced one trip. |
| Trip 3 | ON | OFF | Sequence has advanced two trips. |
| Trip 4 | ON | OFF | Sequence has advanced three trips. |
| Single Shot | OFF | OFF | Always |
| | ON | OFF | For SS Reset Time following a manual close. |
| Work Tag | ON or OFF | ON | Always |

# Trip Settings

Each trip has individual trip settings for **Phase** Over current, **EF**, **SEF**, and **NPS**.

Trips 1, 2, and 3 can also have Auto Reclose Time settings depending on the global Trips to Lockout setting.

Trip Settings can be configured in WSOS by selecting Protection in the Display menu and selecting the trip to be configured from the tree structure in the left pane.

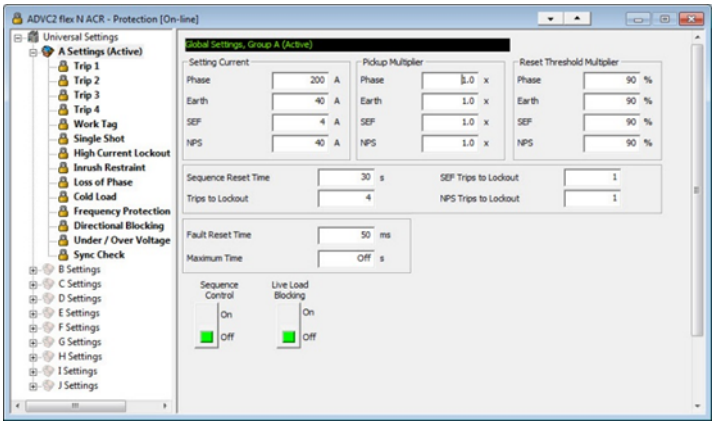



**Figure 115**
WSOS Global Settings page – Trip Settings

Protection trip settings can also be configured on the operator interface, page 701.

## Independent Trips to Lockout

With A50-11.xx, it is now possible to independently configure the Trips to Lockout for Phase and Earth/Ground Faults, within each protection group.

The option to configure this is available in WSOS5 5.16.19, via the Global Settings page for each Protection Group, as shown in below figure.

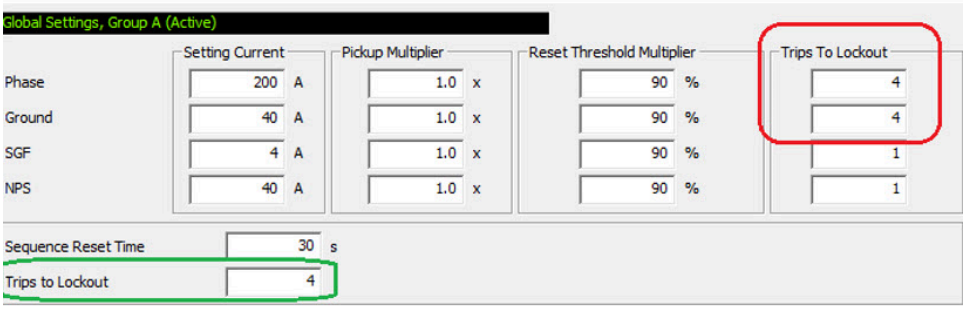



**Figure 116**
Independent Trips to Lockout

When upgrading the PowerLogic ADVC to firmware version A50-11.xx, the previously configured Trips to Lockout value is used as the configuration value for these independent configurations.

This capability has been extended to the Sectionalizer configuration as well, where in the Trip After Supply Interrupts can be configured independently for Phase and Earth/Ground, for each Detection Group, as shown in below figure.

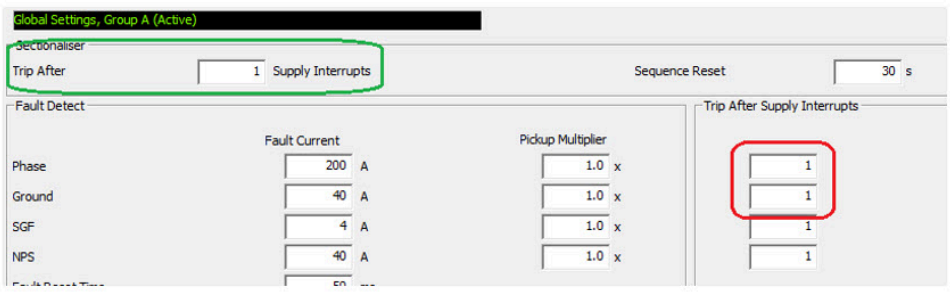



**Figure 117**
Independent Trip After Supply Interrupts

## Three Phase Fault Lockout

A50-11.xx supports a new Three Phase fault Lockout configuration, for each protection group. When enabled, the Phase Trips to Lockout configuration is overridden for a Three Phase fault, and the controller will go to Lockout at the first Trip.

This setting is available in the in the Global Settings page, for each Protection Group, in WSOS5 5.16.19, as shown in the below figure.

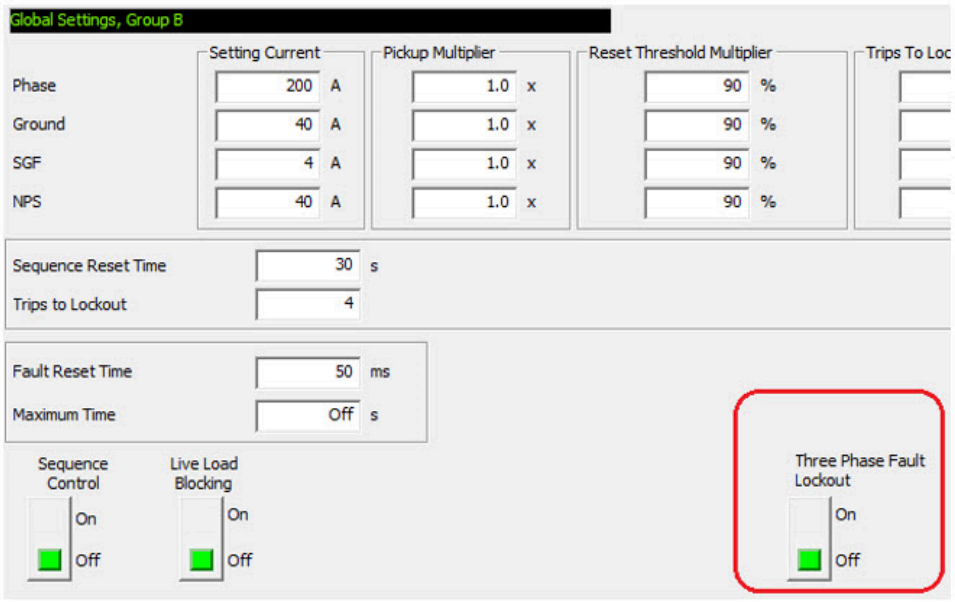



**Figure 118**
Three Phase fault Lockout

The following event log shows the above described behavior, when this setting is enabled.

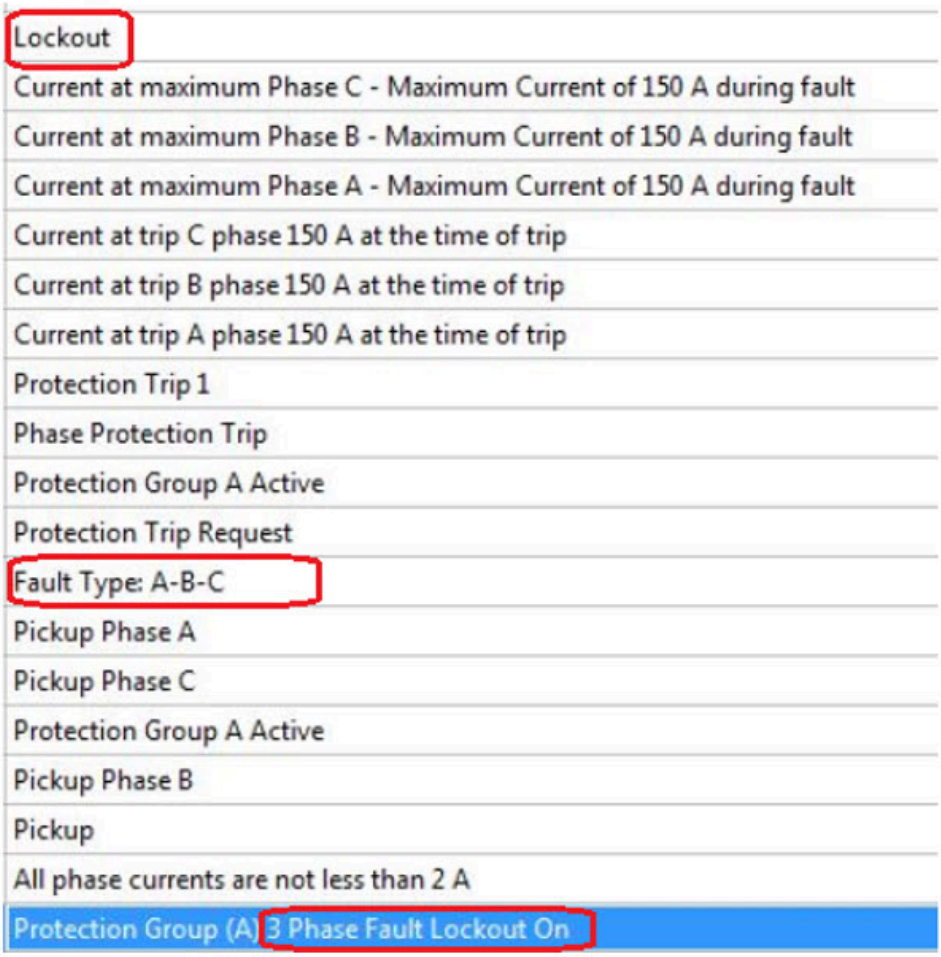



**Figure 119**
Three Phase fault Lockout Event Log

## Timed Trip Block Feature

This feature allows a user to block protection elements from tripping indefinitely or for a user configurable time after a current based protection pick up whilst the Block Control remains set. This delay applies if the Trip 1 curve or single shot curve is active. If configured, the means to enable or disable blocking can be by Protocol Control, OCP, QAK, Custom Logic Output, IEC 61850 Control or by IOEX input.

The user can elect to block the trip indefinitely while the control is enabled or to helps to prevent tripping for a user configurable time after a pickup while the block control is enabled.

If a user time is configured and the block is enabled, a trip request is blocked from the time the pick-up commences until the block time expires. If the calculated trip time exceeds the block time, the block time has no effect. If the block time exceeds the calculated Trip Time, the block time acts as a minimum time modifier. If the current drops below the pick-up threshold, the trip block timer is reset.

Separate configuration options are provided for Phase, Earth, SEF and NPS elements on a per group basis. In addition, options are provided to block only Definite Time and Inverse DefiniteMinimum Time (IDMT) elements, or instantaneous elements or both for all four elements on a per group basis.

The Timed Trip Block feature must be made available via the Feature Selection page of WSOS5, under Protection category. Refer Figure 120.

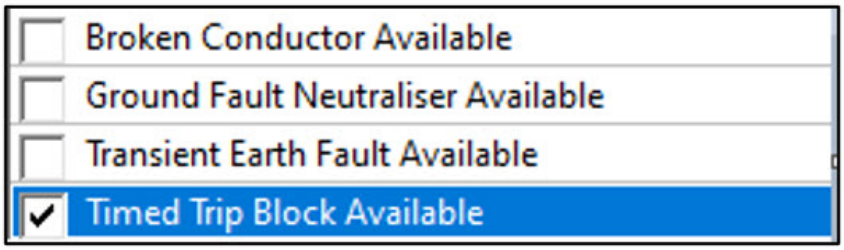



**Figure 120**
Timed Trip Block feature selection page

The WSOS5 configuration options for the Timed Trip Block feature are outlined below.




**Figure 121**
Timed Trip Block settings page

- **Block Instantaneous:**
  - When configured and enabled, only the instantaneous element is blocked when Trip 1 or single shot is active. Instantaneous can be selected as the only curve or as an overlay on an IDMT curve and either would be blocked. The behavior of IDMT and Definite Time elements is not affected by this setting.
  - The Block can be enabled/cleared by Protocol Control, OCP, QAK, Custom Logic Output, IEC 61850 Control or by IOEX input for each protection type individually.

> **⚠CAUTION**
>
> **HAZARD OF UNINTENDED EQUIPMENT OPERATION**
>
> User must make sure remote blocking is limited to definite times or limit usage only for the validation or pre-commissioning stages.
>
> **Failure to follow these instructions can result in injury or equipment damage.**

- **Block IDMT/Definite Time:**
  - When configured and enabled, IDMT and Definite Time elements are blocked when Trip 1 or single shot is active. The behavior of instantaneous elements or instantaneous elements overlaid on an IDMT curve is not affected by this setting.
  - The Block can be enabled/cleared by Protocol Control, OCP, QAK, Custom Logic Output, IEC 61850 Control or by IOEX input for each protection type individually. Refer to the CAUTION message above.

- **Block Time:**
  - If enabled and configured, single shot or protection trip 1 IDMT or Definite time and/or instantaneous Trip requests will be blocked for the selected element for the user configured time or indefinitely if set to Trip Blocked by Control. If set to a configured time, and if the Block Control is enabled, the timer commences upon a pick-up and tripping is no longer blocked after the time expires. The block time acts as an effective minimum time to the configured Trip time. The configurable Block time is 10 ms...5000 ms.
  - Note that the block is active for the first trip or single shot trip.
  - The Timer is reset if the current drops below the pick-up threshold. This means that if the protection element does not reset and if it picks up again, then as the protection element has already timed out, another trip request will be blocked for the duration of the Timed Trip Block setting. If a user time is configured, a trip request is blocked from the time the pick-up commences until the Block Time expires. If the calculated trip time exceeds the block time, the block time has no effect. If the block time exceeds the calculated Trip Time, the block time acts as a minimum time modifier. If the current drops below the pick-up threshold, the trip block timer is reset.

  **IMPORTANT:** Assertion of the remote block control points for indefinite period shall lead to blocking the Trip function indefinitely.

  **NOTE:** The table below outlines the database points available Timed Trip Block feature. For more details refer the N00-331 Database.

These digital control points are available and can be set/cleared by Protocol Control, OCP, QAK, Custom Logic Output, IEC 61850 Control or by IOEX input.

- This feature can be configured for IDMT and Definite Time Elements and/or Instantaneous elements.

**Table 25 New Operator/Protection/Detection Flags**

| Appendix/ Sub Appendix | Point | Name | Description | Set = 1 | Clear = 0 | Version introduced |
|---|---|---|---|---|---|---|
| A1.2 | 73 | External Phase Trip Block | An external point (may come from a different controller) to block phase trip. | Phase trip block is ON. | Phase trip block is OFF. | 50-14.00 |
| A1.2 | 74 | External Earth Trip Block | An external point (may come from a different controller) to block earth trip. | Earth trip block is ON. | Earth trip block is OFF. | 50-14.00 |
| A1.2 | 75 | External SEF Trip Block | An external point (may come from a different controller) to block SEF trip. | SEF trip block is ON. | SEF trip block is OFF. | 50-14.00 |
| A1.2 | 76 | External NPS Trip Block | An external point (may come from a different controller) to block NPS trip. | NPS trip block is ON. | NPS trip block is OFF. | 50-14.00 |

**Table 26 New Digital Controls**

| Appendix/Sub Appendix | Point | Name | Description | Set = 1 | Clear = 0 | Version introduced |
|---|---|---|---|---|---|---|
| B.1 | 128 | External Control Phase Trip Block | External control (may come from a different controller) to block phase trip. | External control to block phase trip ON. | External control to block phase trip OFF. | 50-14.00 |
| B.1 | 129 | External Control Earth Trip Block | External control (may come from a different controller) to block earth trip. | External control to block earth trip ON. | External control to block earth trip OFF. | 50-14.00 |

**Table 26 New Digital Controls (Continued)**

| Appendix/Sub Appendix | Point | Name | Description | Set = 1 | Clear = 0 | Version introduced |
|---|---|---|---|---|---|---|
| B.1 | 130 | External Control SEF Trip Block | External control (may come from a different controller) to block SEF trip. | External control to block SEF trip ON. | External control to block SEF trip OFF. | 50-14.00 |
| B.1 | 131 | External Control NPS Trip Block | External control (may come from a different controller) to block NPS trip. | External control to block NPS trip ON. | External control to block NPS trip OFF. | 50-14.00 |

## Protection Groups

There are up to 10 groups of protection settings (referred to as Protection Groups A, B, C, D, E, F, G, H, I, and J). Each Protection Group can have different settings. Users can nominate which one of the 10 protection groups is active. The active protection group settings are used for fault detection and timing.

Normally only one protection group can be active at one time. The exception is when Directional Protection is on. Directional protection uses two protection groups, one for forward faults and one for reverse faults.

If Directional Protection is on, the user must choose between five pairs, A/B, C/D etc. where the first group in the pair is for forward faults and the second group is for reverse faults.

If less than ten protection groups are required, the controller can be configured for a lower number.

The only way to change the number of configured protection groups is to change the setting in WSOS while it is off-line and do a Write Switchgear Settings to the Switchgear with the Protection tick box selected.

**NOTE:** Prior to writing the new settings, the current settings must be read and saved from the controller.

# Basic Protection Enhancements

There are some protection enhancements features which can fundamentally change the operation of the protection function from the way it has already been described.

These enhancements are either off or unavailable by default and will not change the way the protection operates unless evoked by the user.

Each of the functions listed below can be either turned on or made available in WSOS in the Protection group in Feature Selection.

- Extended Standard Protection
- Extended Maximum Time per Curve
- Per Element Protection
- PTT
- Per Element Reclose Time
- Reset curves
- Close on Fault Trip

Feature Selection/Protection can be found in WSOS by navigating to:

**Display**> **Configuration**> **Feature Selection**> **Protection**.

With the exception of Per Element Protection, PTT and Close on Fault Trip, these features can also be evoked on the operator interface.

Extended Standard Protection, page 697

Extended Maximum Time per Curve, page 697

Per Element Reclose Time, page 697

Reset curves, page 697

## Extended Standard Protection

This feature is used when it is required to have different Protection Control settings associated with each configured protection group.

Protection Control settings include:

- Protection On/Off
- Auto Reclose On/Off
- NPS Protection Trip/Alarm/Off
- EF Protection On/Off
- SEF Protection On/Off
- SEF Alarm On/Off

In normal operation that is with **Extended Standard Protection Off**, these settings are global. That means that once they have been configured on the WSOS Control page they become operational regardless of which protection group is active.

Extended Standard Protection functionality allows the On/Off status for these settings to be determined by the active protection group.

Selecting **Extended Standard Protection On**, immediately adds Protection Control settings to each configured protection group. The Control page always displays the operational Protection Control settings that is the settings that are in service at the time. Another set of Protection Control settings now appears on the Global Settings page for each configured protection group. Refer Figure 122.

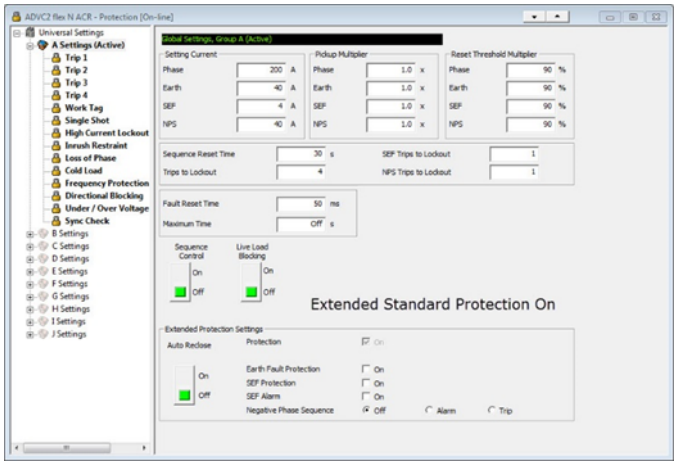



**Figure 122**
Extended Standard Protection settings

The settings in the figure above labelled **Extended Protection Settings** are the **DEFAULT** Protection Control settings for that group. These default settings can be configured differently for each protection group.

When the active protection group is changed, the **default** Protection Control settings for the group that becomes active become the operational Protection Control settings and appear on the Control page.

So if Group A is active and the operational Protection Control settings are:

- Protection On
- Auto Reclose Off
- NPS Protection Off
- EF Protection Off
- SEF Protection Off
- SEF Alarm Off

Then Group B is made active and the Group B Default Protection Control settings are:

- Protection On
- Auto Reclose On
- NPS Protection Trip
- EF Protection On
- SEF Protection On
- SEF Alarm On

The appearance of the Control page will change as shown in the figure below:

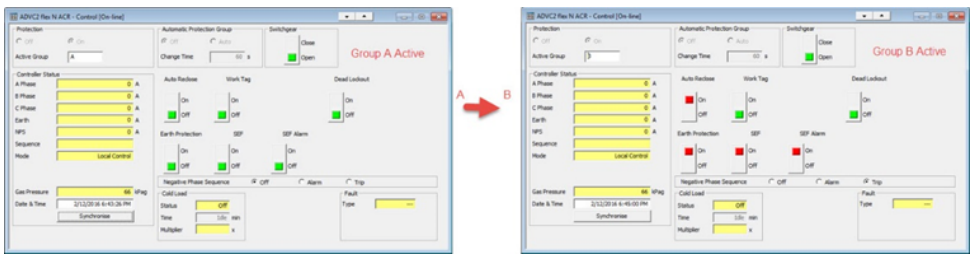



**Figure 123**
WSOS Control Page with Extended Standard Protection

It can be seen from the above figure that when the active protection group was changed from A to B, the Group B **default** Protection Control settings became the operational settings shown on the Control page.

These default settings are referred to as **non-volatile** as they will be retained in the protection group settings despite changes to the operational settings when their group is active.

### QAKs/Quick Keys

If changes are made to any of the operational Protection Control settings using the QAKs/Quick Keys, the changed setting will stay in force until either:

- The protection group is changed, or
- It is changed by the operator again

## Extended Maximum Time per Curve

Extended Maximum Time per Curve changes the way the Maximum Time setting can be used.

Instead of a global Maximum Time setting, it allows a Maximum Time setting to be applied to each trip setting for each element that uses an inverse curve for the protection timing.

### Making the feature available

In order to use this feature, Extended Maximum Time per Curve must be made available by the operator via the WSOS Feature Selection menu.

The Feature Selection menu can be found by navigating through:

**Display**> **Configuration**> **Feature Selection**.

### Operation

Normally there is only one Maximum Time setting for each protection group. It's a global setting which means that it applies to all trip settings in that group that use an inverse curve for timing.

When the Extended Maximum Time per curve feature is on, there is a separate Maximum Time setting for each inverse curve that has been applied. (Maximum 18)

This feature also reduces the minimum value for Maximum Time settings from 2.0 s to 0.2 s. The maximum setting remains at 180.0 s.

The figure below shows the Global Settings and Trip 1 pages with Extended Maximum Timer per Curve Off. In this configuration, Maximum Time is a global setting. One setting per group appears on the Global Settings page.

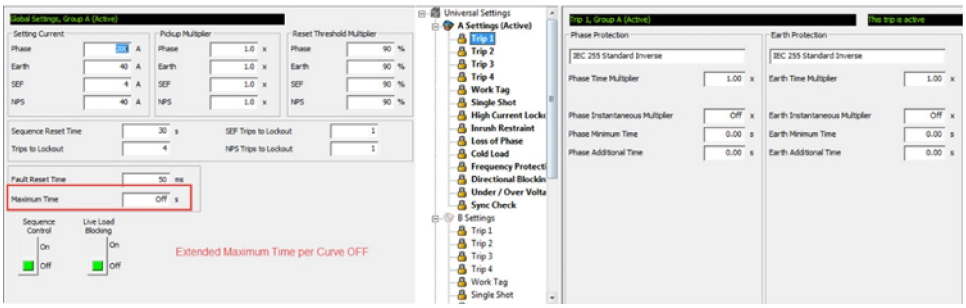



**Figure 124**
Extended Maximum Time per Curve OFF

In the figure below with Extended Maximum Time per Curve On, the Maximum Time setting no longer appears on the Global Settings page. Instead, a separate Maximum Time setting is included for each trip setting for which an inverse curve is selected.

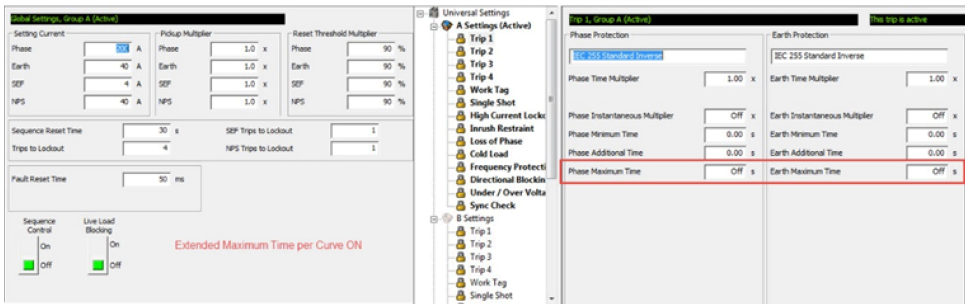



**Figure 125**
Extended Maximum Time per Curve ON

# Per Element Protection

This feature provides the operator with the option of selecting to generate an alarm or trip an ACR on a per element basis. All protection elements encapsulated under the Phase Over current, EF, SEF and NPS protection can each be individually configured to:

- Alarm Only
- Trip
- Off

When any element is configured to Alarm only, a protection operation will not trip the switchgear, but only register an alarm.

When Extended Standard Protection, page 171 is also enabled, it provides the operator the option to configure different Trip and Alarm settings on a per group basis.

## Making the feature available

In order to use this feature, Per Element Protection must be made available by the operator via the WSOS Feature Selection menu.

The Feature Selection menu can be found by navigating through:

**Display**> **Configuration**> **Feature Selection**.

## Configuration

Once this feature has been enabled, the operator will be able to configure the actions required for each protection element, either OFF, Alarm or Trip.

These options are available for the following Protection elements:

- Phase Overcurrent
- EF
- SEF
- NPS

The additional settings are displayed on the WSOS Control page shown in the Figure 126.

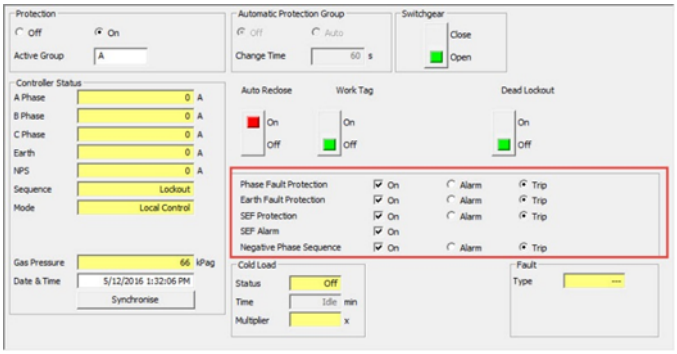



**Figure 126**
WSOS Per Element Protection

Per Element Protection can also be configured on the operator interface, page 697.

The table below explains the changes that occur with the protection elements affected when Per Element Protection is enabled. It assumes that Protection is ON, Sensitive EF Protection is available, Sequence Components are available and NPS OFF is allowed.

**Table 27 Per Element Protection Available/Not Available**

| Element | Per Element Protection Not Available | Per Element Protection Available |
|---|---|---|
| Phase | Phase protection is always On (when Protection is ON). | Phase protection can be ON (Trip), Off or Alarm. |
| Earth | EF protection can be ON (Trip) or OFF. | EF protection can be ON (Trip), OFF or Alarm. |
| SEF | SEF protection can be ON (Trip) or OFF. | SEF protection can be ON (Trip), OFF or Alarm. |
| SEF Alarm | SEF Alarm can be ON or OFF. | SEF Alarm can be ON or OFF. (no change) |
| NPS | NPS protection can be ON (Trip), OFF or Alarm. | NPS protection can be ON (Trip), OFF or Alarm. (no change) |

## Alarm Mode

When the Alarm mode is chosen for any of these elements, a fault detected by the corresponding element will not cause the switchgear to trip. Instead, an alarm will be logged when the trip would have occurred if enabled.

## Supply Interrupt

If the fault resets and the upstream device trips within the **Supply Fail Time**, a **Supply Interrupt** will be logged for the faulted element. The Supply Interrupt Flag is an indication that the fault was downstream of the ACR that is it performs the function of a fault passage indicator.

The conditions required to generate a Supply Interrupt are:

1. Fault detection.
2. Fault reset.
3. Source supply goes to zero volts within the Supply Fail Time following step 2.

Once a Supply Interrupt Flag has been set, it can be cleared by any of the following:

- Any switchgear close.
- Any phase current above 2 A.
- Any phase to earth voltage above the Live Line Threshold on both sides.

The **Supply Fail Time** is available in the WSOS **Universal Settings** page shown below.

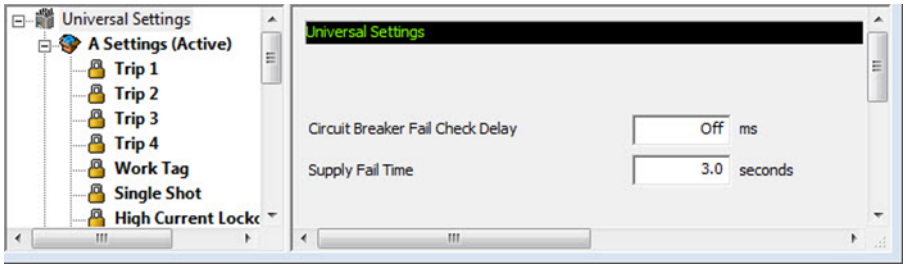



**Figure 127**
Supply Fail Time setting

The **Supply Fail Time** can also be configured on the operator interface, page 697.

Alarms generated by this feature are available for transmission via SCADA.

## Supply Interrupt Flags

In addition to the SCADA alarm point, the Supply Interrupt Flags are available on the WSOS Protection Flags page in the Display menu as well as on the operator interface, page 697.

## Per Element Protection + Extended Standard Protection

When Extended Standard Protection is also made available, the operator can configure the per element action on a per group basis as shown in the figure below. The configuration can be unique to each Protection group and will become effective when that group is made active.

The features of the Extended Standard Protection still apply. Refer to Extended Standard Protection, page 171 for details on this feature.

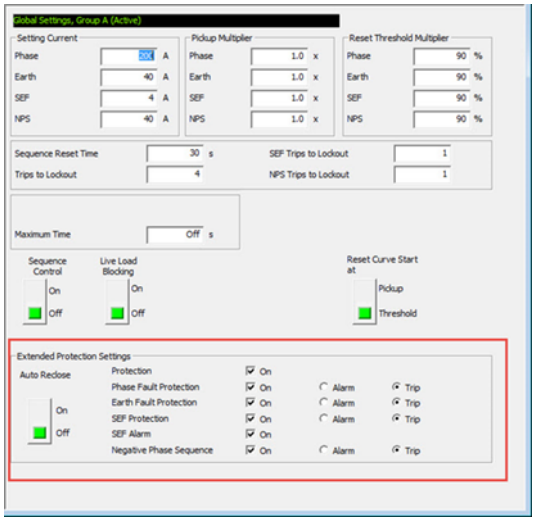



**Figure 128**
Extended Protection settings

# PTT

When the PTT feature is available it enables the setting of trip thresholds for Trips 1-4, Single Shot and Work Tag.

Setting Currents, Pickup Multipliers, and Reset Threshold Multipliers which are otherwise global settings for each element can be individually configured for each element for each trip (Max 24 per protection group).

## Configuration

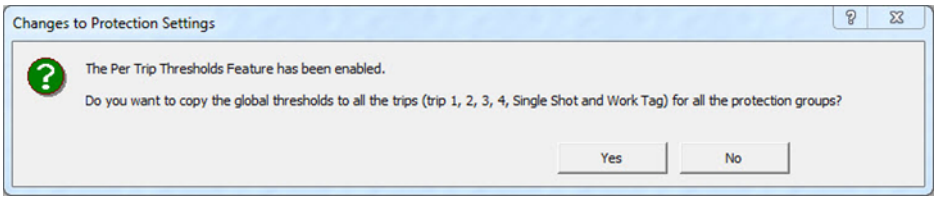
In order to use this feature, PTT must be made available by the operator via the WSOS Feature Selection menu.

The Feature Selection menu can be found by navigating through:

**Display**> **Configuration**> **Feature Selection**.

## Operation

Selecting PTT in Feature Selection causes WSOS to display a message prompting the user to copy the global threshold settings for each element to all the trips (Trip 1, 2, 3, 4, Single Shot, and Work Tag) in each of the protection groups. See below.




Selecting **Yes** won't change any effective protection settings initially but will allow each element for each trip to be configured with individual threshold settings. Selecting **No** will use values from the last time PTT was enabled. If PTT has not been enabled before it will use the default values. See table below:

**Table 28 PTT Default Settings**

| PTT Default Settings | | | |
|---|---|---|---|
| **Setting** | **Trips 1/2/3/4** | **Single Shot** | **Work Tag** |
| Phase setting current (Amps) | 200 | 200 | 200 |
| Phase pickup multiplier | 1.0 | 1.0 | 1.0 |
| Phase reset threshold multiplier (%) | 90 | 90 | 90 |
| Earth setting current | 40 | 40 | 40 |
| Earth pickup multiplier | 1.0 | 1.0 | 1.0 |
| Earth reset threshold multiplier (%) | 90 | 90 | 90 |
| SEF setting current | 4 | 4 | 4 |
| SEF pickup multiplier | 1.0 | 1.0 | 1.0 |
| SEF reset threshold multiplier (%) | 90 | 90 | 90 |
| NPS setting current | 40 | 40 | 40 |
| NPS pickup multiplier | 1.0 | 1.0 | 1.0 |
| NPS reset threshold multiplier (%) | 90 | 90 | 90 |

The default values for PTT are the same as the default global threshold values.

When PTT are enabled, the global thresholds are no longer displayed by WSOS on the global settings page as shown in the Figure 130.

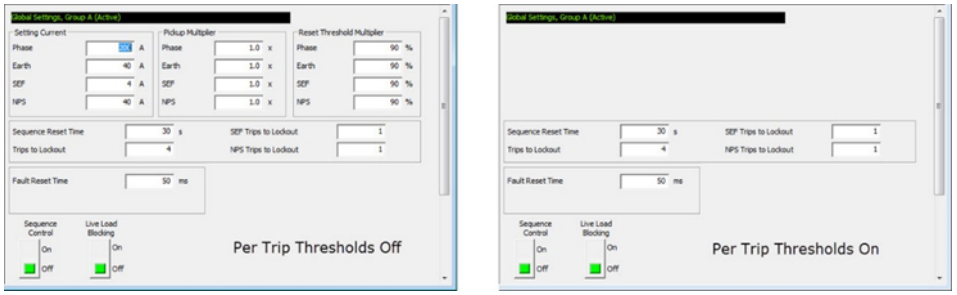



**Figure 129**
PTT On and Off

Instead, threshold settings for each element are displayed on the individual trip setting pages as per the Trip 1 settings below:

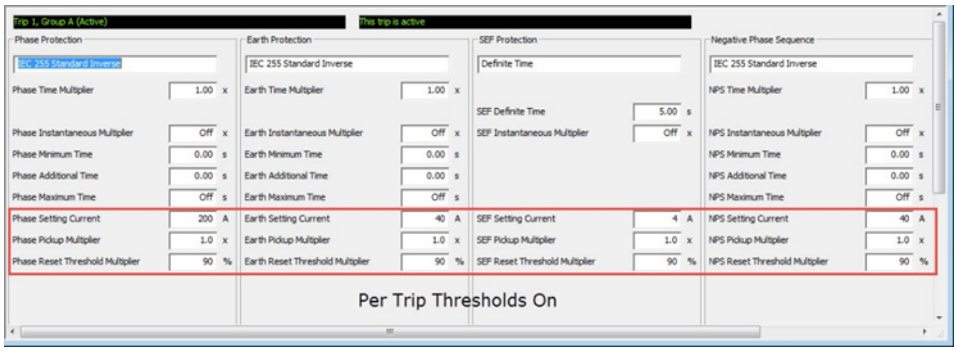



**Figure 130**
Trip 1 settings with PTT On

## PTT Default Settings

### *flex*VUE

When PTT is enabled, the global pickup pages for Phase, Earth, SEF, and NPS are not displayed. Instead three additional pages for Setting, Pickup and Reset are added to the Protection Trip Settings sub menus for each of the four elements for each of the six trips if configured.

### *set*VUE

When PTT is enabled, setting currents and multipliers for Phase/Earth/SEF/NPS are not displayed on the Protection Setting pages 1-3 and Protection Setting 4 is not displayed at all. An additional Threshold page appears preceding the Trip page for each element.

See the Protection Menu, page 661 table in Appendix K.4.

Incorrect settings can cause unlimited auto reclose attempts when PTTs are enabled.

| ***NOTICE*** |
| --- |
| **HAZARD OF UNDESIRED BEHAVIOR OF APPLICATION**<br><br>Attention must be paid to the fault current settings for each Trip and it is strongly recommended to test these settings prior to commissioning the controller.<br><br>**Failure to follow these instructions can result in equipment damage.** |

If auto reclose is on and the Setting Current for a trip in a sequence is higher than for a trip earlier in the sequence it is possible to get into a continuous Trip – Sequence Reset cycle.
An example of how this could happen is explained below.

Trip 1 Phase Setting Current = 100 A

Trip 2 Phase Setting Current = 300 A

A 200 A fault will cause Trip 1 but the ACR will reclose successfully as the fault level is below the Trip 2 setting. As soon as the Sequence Reset time expires, Trip 1 will again become the active trip. That will cause another Trip 1 followed by a sequence reset and the cycle will continue.

## Per Element Reclose Time

There are normally separate Reclose Time settings associated with Trip 1, Trip 2 and Trip 3, depending on the global Trips to Lockout setting. The ACR will automatically reclose after a trip that occurs during an automatic reclose sequence according to the reclose time configured for that trip. This is regardless of the protection element that actually caused the trip.

The controller uses trip counters to determine when the applicable Trips to Lockout setting has been reached and the device must go to lockout. There are separate trip counters for:

- Phase Fault and EF protection
- SEF protection
- NPS protection

When **Per Element Reclose Time On** is selected, individual reclose times can be configured for Phase and Earth protection elements for trips up to trip (Trips to Lockout -1) that is if global Trips to Lockout = 4, Trips 1, 2, and 3 can be configured. SEF and NPS elements can also be configured for individual reclose times for the same trips providing their individual Trips to Lockout settings are > 1.

The table below shows which per element trips can be configured with a Reclose Time when:

- Trips to Lockout = 4
- SEF Trips to Lockout = 1
- NPS Trips to Lockout =1

**Table 29 Per Element Reclose Time settings with 4 Trips to Lockout**

| | Phase | Earth | SEF | NPS |
|---|---|---|---|---|
| Trip 1 | Reclose Time | Reclose Time | - | - |
| Trip 2 | Reclose Time | Reclose Time | - | - |
| Trip 3 | Reclose Time | Reclose Time | - | - |

When:

- Trips to Lockout = 3
- SEF Trips to Lockout = 2
- NPS Trips to Lockout = 1

The elements indicated in the table below can be configured with individual reclose times.

**Table 30 Per Element Reclose Time settings with 3 Trips to Lockout**

| | Phase | Earth | SEF | NPS |
|---|---|---|---|---|
| Trip 1 | Reclose Time | Reclose Time | Reclose Time | - |
| Trip 2 | Reclose Time | Reclose Time | Reclose Time(1) | - |
| Trip 3 | - | - | - | - |

(1) If Trip 1 was caused by the Phase or Earth protection and Trip 2 is caused by SEF, an auto reclose will occur as neither the Trips to Lockout or the SEF Trips to Lockout counts have been reached.

Per Element Reclose Times can be configured in WSOS with the individual element protection settings for each trip as shown below for Trip 1.

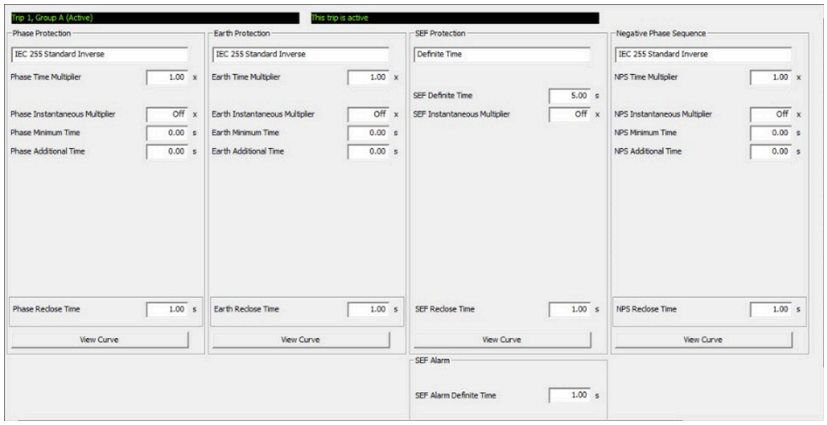



**Figure 131**
Per Element Reclose Times

When Per Element Reclose Times are on, all applicable reclose times can be configured on the operator interface, page 702.

## Reset Curves

The fault reset time for an ACR is normally a definite time setting configurable between 0 and 10000 ms. The default value is 50 ms.

The Reset Curves feature provides an alternative way of determining the time taken for a fault to reset. It allows an ACR to emulate an induction disc relay and thus coordinate with an upstream device of this type.

The time it takes for a fault to reset following a protection pickup is determined by the Reset Curve and Time Multiplier for the element of the active trip as well as the magnitude of current still flowing in that element.

Reset Curves can be made available through WSOS in Feature Selection or via the operator interface, page 697.

When Reset Curves are made available, the Fault Reset Time setting is removed from the WSOS Global Settings page.

An additional setting is added to allow the reset curve to start at Pickup or Threshold.

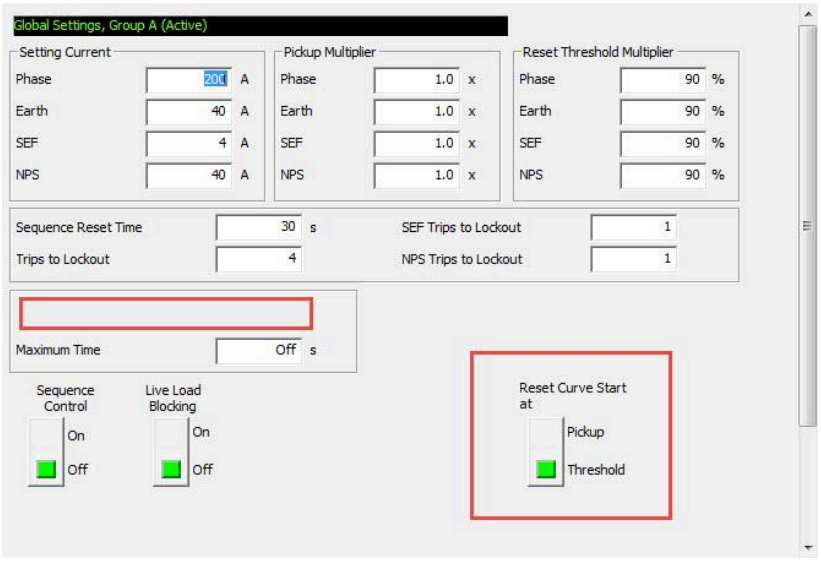



**Figure 132**
Global Settings with Reset Curve Selected

A less obvious change is the **Reset Threshold Multiplier** setting range for each element that is extended from 90% ... 100% to 10% ... 100%.

Phase Reset Curve settings are also added to the trip settings for each element for Trips 1...4, Single Shot and Work Tag.

By default all of these settings are 50 ms Definite Time which provides the same behavior as when Reset Curves are not available.

Definite Time can be configured for between 0 s and 100 s with a 10 ms resolution. Instantaneous Only is also an option, as well as an inverse time curve.

Any one of six standard inverse time curves can be selected:

IEC255 Standard Inverse

IEC255 Very Inverse

IEC255 Extremely Inverse

IEEE Standard Moderately Inverse

IEEE Standard Very Inverse

IEEE Standard Extremely Inverse

Tables listing the reset times and formula for calculating these times can be found in Appendix G – Reset Curve Timing Tables, page 576.

The figure below shows the Trip 1 settings with Reset Curve settings applied.

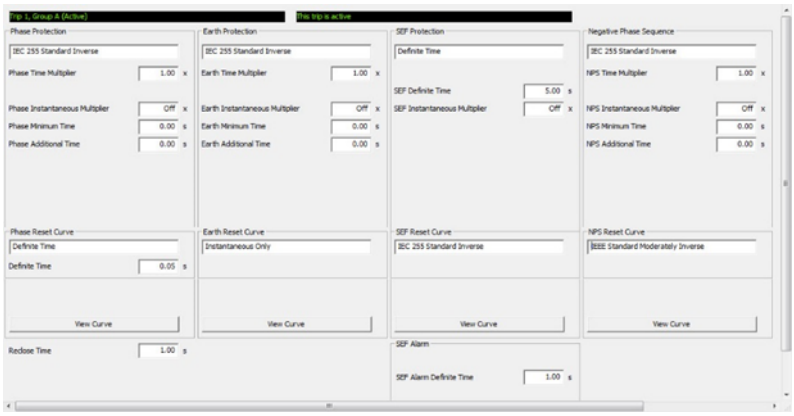



**Figure 133**
Trip 1 Reset Curve settings

When Reset Curves are used, the Curve Viewer in WSOS displays both the Pickup and Reset curves on a single graph.

The curves displayed will change to reflect the applied global settings for:

- Setting Current
- Pickup Multiplier
- Reset Threshold Multiplier
- Reset Curve Start at

## Reset Curve Start at

There are two options concerning where the reset curve must start. They are:

- Pickup – the curve is plotted from the setting current x pickup multiplier.
- Threshold – the curve is plotted from the pickup current x reset threshold multiplier.

If the **Reset Threshold Multiplier** setting = 100%, the **Reset Curve Start** at setting will have no effect because the pickup and reset currents are the same that is 200 A when the settings below are applied.

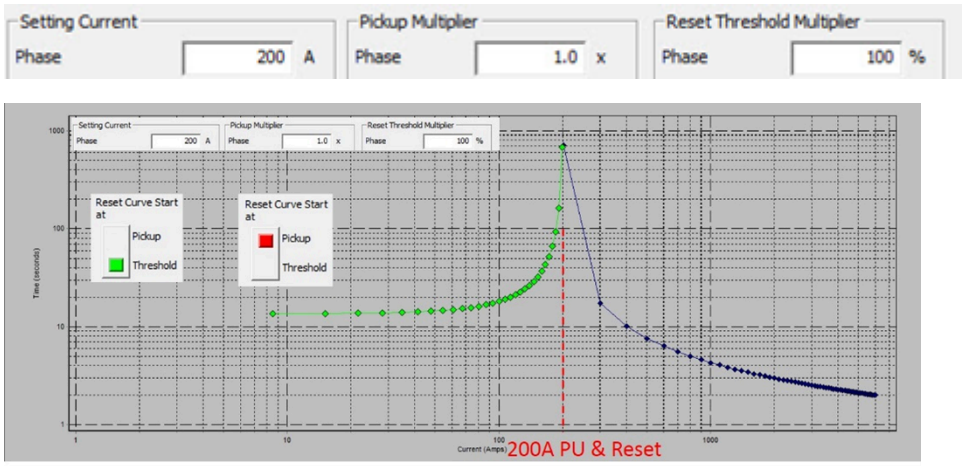



**Figure 134**
Pickup and Reset Curves with 100% Reset Threshold Multiplier

If the **Reset Threshold Multiplier** setting is changed to 80%, the pickup value will remain at 200 A but the reset threshold will change to 160 A, that is 80% of 200 A.

If the reset curve is set to start at threshold, the shape of the reset curve will not change but its starting point will move from 200 A to 160 A as shown below.

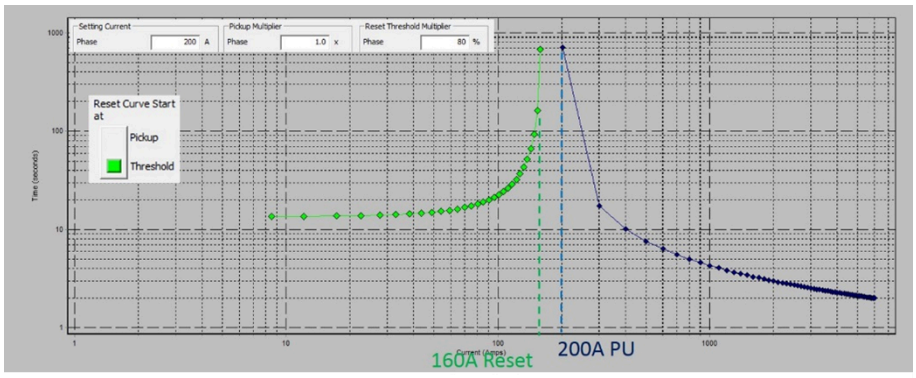



**Figure 135**
80% Reset Threshold Multiplier and Reset Curve starting at Threshold

Changing the **Reset Curve Start at** setting to **Pickup** will move the reset curve starting point back to 200 A, but the effective curve will still start at 160 A due to the **Reset Threshold Multiplier** setting of 80%. This changes the shape of the reset curve because it is truncated at 160 A.

So for currents less than the reset threshold (160 A in this case) reset time will be the same when the reset curve starts at pickup.

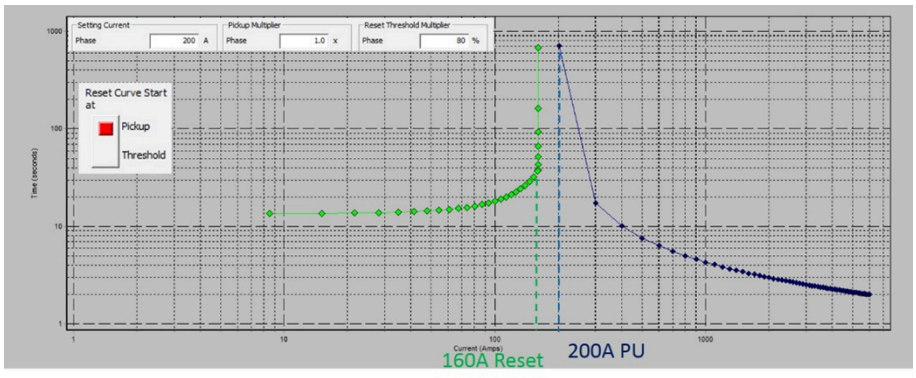



**Figure 136**
Pickup and Reset Curves with Reset Curve Start at Pickup

## Reset Curve Example

This example describes the sequence of events that occur when a permanent threephase 400 A per phase fault is detected downstream from an ACR with the protection settings shown in the figure below.

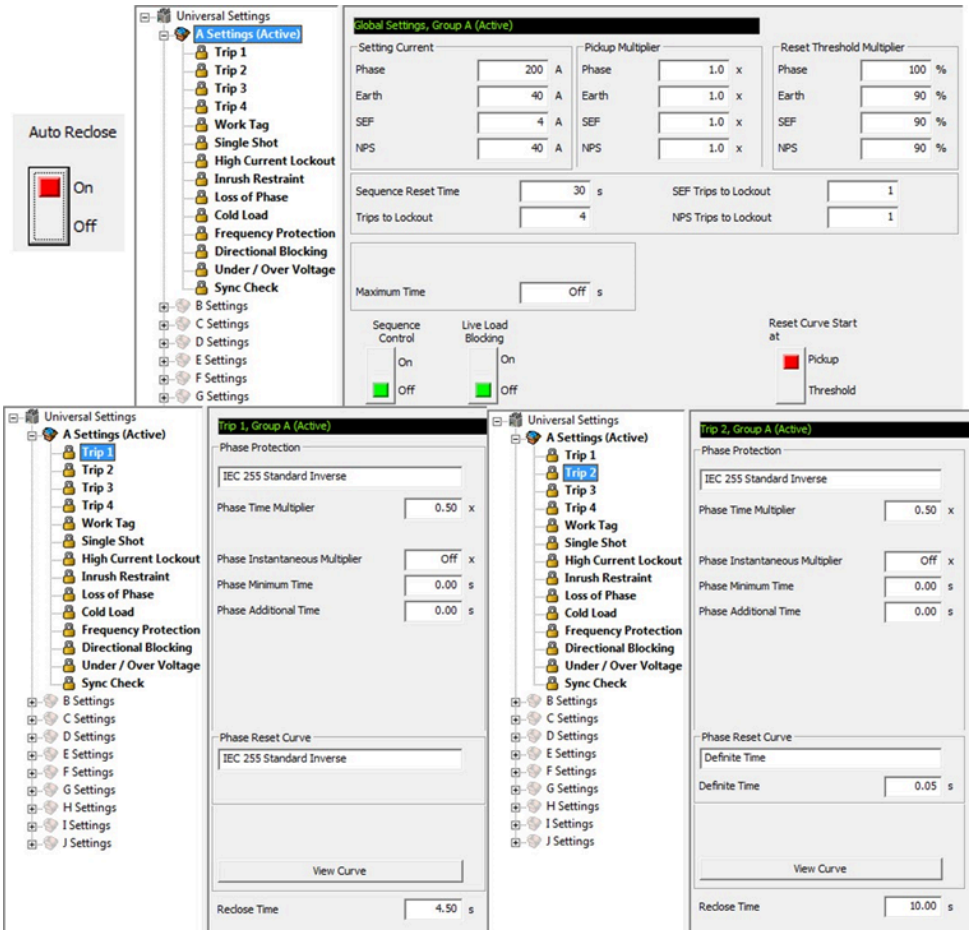



**Figure 137**
Protection Settings for an ACR with Reset Curves Available

400 A is 2 x the Phase Setting Current so according to the Trip 1 Phase Protection curve (IEC 255 SI) and Time Multiplier (0.5) this will cause the ACR to trip in 5.015 s.

Refer to Appendix D, page 564 for IEC 255 Inverse Time Tables.

When the ACR trips, the current will go to zero and the fault reset timing will start. According to the Trip 1 Time Multiplier (0.5) and Reset Curve (IEC 255 SI) the reset time must be 6.75 s. Refer to Appendix G – Reset Curve Timing Tables, page 576.

The Reclose Time setting for Trip 1 is 4.5 s. This is shorter that the fault reset time (6.75 s), so the fault will not have fully reset when the ACR automatically recloses. The fault will have two thirds reset (4.5/6.75) which is analogous to an induction disc for a protection relay having travelled two thirds of the way back to its rest position.

When the ACR closes back onto the 400 A fault, it will record a **Protection Element Timing** event in the Event Log. Instead of a trip time of 5.015 s as occurred for Trip 1, the trip time for Trip 2 will be two thirds of that 3.34 s (5.015 x 0.667).

# Close on Fault Trip

The **Close on Fault Trip** is a feature to help ensure that a single shot trip occurs if the switchgear is closed onto a fault when the protection is in the alarm mode.

It applies whenever a downstream fault is cleared by an upstream device within the **Maximum Fault Period** of the switchgear being closed by an operator.

The required conditions for a Close on Fault Trip to occur are:

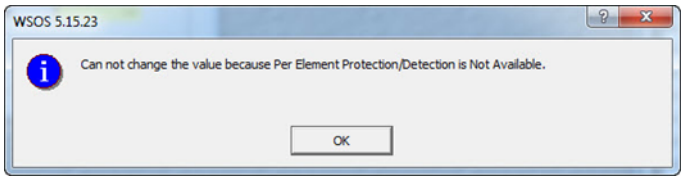
- The Close on Fault Trip feature enabled.
- Switchgear close by a local or remote operator.
- At least one bushing is live at the time of the close request.
- Switchgear has to have closed onto a fault (A fault alarm is raised after the close).
- Supply is lost within the Maximum Fault Period from the close.

## Configuration

**Close on Fault Trip** can be made available in WSOS Feature Selection only if **Per Element Protection** is already available.




Attempts to make Close on Fault Trip available when Per Element Protection is not available will cause WSOS to display the message below.




Similarly an attempt to disable the Pre Element Protection feature when the Close on Fault Trip feature is enabled will also be rejected.

## Maximum Fault Period

The configuration parameter required for the **Close on Fault Trip** feature is the **Maximum Fault Period**. When the Close on Fault Trip feature is enabled, a configuration page by that name is added to the settings for each protection group displayed by WSOS. The Maximum Fault Period is 10 s by default and can be configured from 1 s...180 s in 1 s steps.

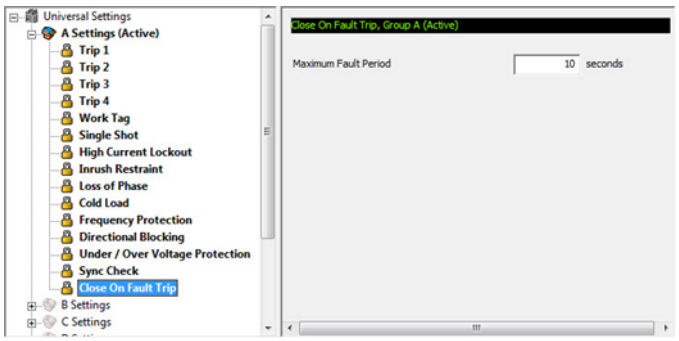



**Figure 138**
Close On Fault Trip setting

The **Maximum Fault Period** can also be set via the O.I. on ***flex*VUE** at:

**Engineer Menu** > **Protection Control** > Fault period, page 630,

and on ***set*VUE** on the Protection Setting 8, page 661 in the Protection menu.

# Protection Discrimination/Timing

The PowerLogic ADVC Controller has a range of protection setting options that enable an ACR to implement discrimination with other protection devices on a distribution network. The time delay between pickup and trip for a given fault can be determined by the protection settings applied to the active trip.

Types of discrimination used by the PowerLogic ADVC Controller are:

- Time-based discrimination – Definite Time
  - Time-based discrimination consists of assigning different time delays to the over current protection devices distributed through the power system.
    - Advantages:
      - ◊ It provides back-up
      - ◊ Simple to implement
    - Disadvantages
      - ◊ The longest fault clearance time occurs for faults closest to the source where the fault level is the highest.
- Current-based discrimination – Instantaneous Only
  - Current-based discrimination works on the principle that the further the fault is from the source, the lower the fault current will be. Each protection device must only pick up for faults located in the section of feeder immediately downstream.
    - The main drawback to using Instantaneous Only is that it does not provide back-up for the downstream device.
    - In practice it is difficult to define the settings for two cascading protection devices and still helps to ensure that discrimination unless there are transformers between sections.
- Discrimination based on time and current - Inverse Curves or IDMT
  - A combination of both time and current can be used to achieve total discrimination with built-in redundancy or back-up.
  - Inverse time curves helps to ensure that the higher the fault current, the shorter the tripping time.

## Definite Time

The Definite Time characteristic causes the protection element to operate at a fixed time after the element has picked up, regardless of the magnitude of the fault current. The current must be above the pickup setting throughout the Definite Time delay. Definite Time can be modified by an instantaneous setting only. The threshold current multipliers, and minimum, additional, and maximum times do not apply.

**Table 31 Definite Time Protection Settings/Specifications**

| Definite Time Protection Settings/Specifications | |
|---|---|
| Definite Time range | 0.01 ... 100 s |
| Definite Time resolution | 0.01 s |
| Timing Accuracy(1) | ± 50 ms |
| (1) Timing refers to time to initiate operation of the circuit breaker (opening and closing times are in addition). | |

## Instantaneous Only

The Instantaneous Only characteristic causes the protection element to operate without any intended delay when the current is above the pickup setting. In practice, the protection algorithms take a certain minimum time to calculate the

current, so the minimum operating time is greater than zero. Instantaneous characteristics can be modified by an Instantaneous Multiplier and a Minimum Time setting where the trip needs to be delayed by a set time.

Available as an additional modifier on inverse or definite time protection curves or as an alternative without inverse or definite time. Instantaneous protection can be applied to Phase, Earth, SEF, and NPS protection.

**Table 32 Instantaneous Only Settings/Specifications**

| Instantaneous Only Settings/Specifications | |
|---|---|
| Multiplier of Trip Current Setting (applies to both phase and earth) | 1 ... 30 |
| Resolution of Multiplier Setting | 0.1 |
| Maximum Effective Setting | 12.5 kA |
| Trip Current Setting Accuracy | ± 10% |
| Transient Overreach for X/R < 10 | < 5% |
| Transient Overreach for X/R > 10 | < 10% |

## Inverse Current/Time

The Inverse Current Time characteristic causes the protection element to operate in a time inversely proportional to the magnitude of the current. There are many different inverse time characteristics. Some have been standardized by organizations such as IEC and IEEE.

The PowerLogic ADVC Controller supports the following standard IDMT curves:

- IEC 255 – Appendix D, page 564
  - Standard Inverse
  - Very Inverse
  - Extremely Inverse
- IEEE – Refer Appendix E, page 566
  - Standard Moderately Inverse
  - Standard Very Inverse
  - Standard Extremely Inverse

There are also 42 non-standard (TCC) curves available for coordinating with fuses and older style hydraulic ACRs etc. Refer to Appendix F, page 568.

The basic characteristics of the Inverse Time curves can be modified by the use of time multipliers, instantaneous multipliers, additional times, minimum times, and maximum times.

## User Defined Curves

User defined curves can be created using the User Defined Curve Editing tool which is part of WSOS. The tool can be used to create curves with up to 60 time/current points. Up to five user defined curves may be written to each controller.

## Plotting IDMT Curves

Inverse Time Curves are normally represented on a time/current graph with current on the x axis and time on the y axis. The graph is normally drawn using log – log scales. The current axis can be graduated in amps or in multiples of the trip setting current.

The figure below shows an IEC255 Standard Inverse curve plotted on a log – log scale with the current axis graduated in amps.

To determine the tripping time for a 400 A fault (2 x Setting Current), draw a vertical line from 400 A on the current axis up until it hits the curve and then draw a horizontal line to the left until it hits the time axis. The trip time for a 400 A fault read off the time axis is just over 10 s (Actual 10.029 s).

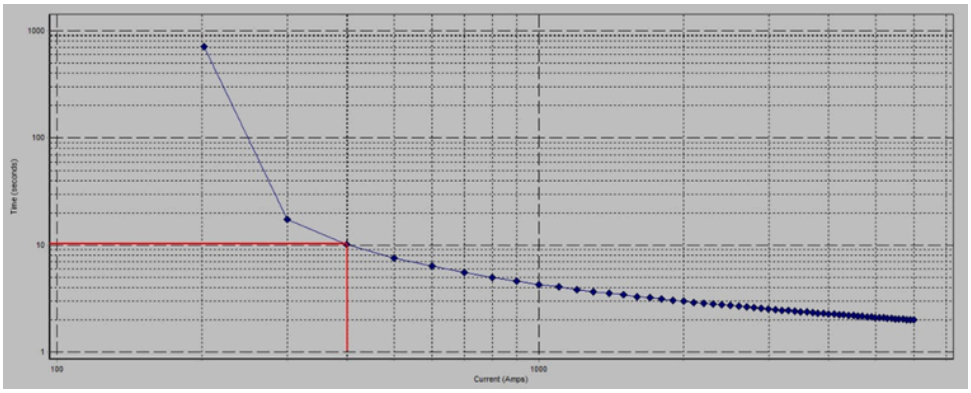



**Figure 139**
Reading Trip Time from IDMT Curve

Formulas for the standard inverse curves can be found in Appendix D, page 564 and Appendix E, page 566.

Trip times are calculated for the fault current as a multiple of the **Setting Current**.

> **NOTE:** The **Pickup Multiplier** changes the pickup current but doesn't change the curve for fault currents higher than the pickup current. This is illustrated in the Figure 140 and 141.

The first figure below shows an IEC255 Standard Inverse curve where the **Setting Current** and the pickup current are both 200 A.

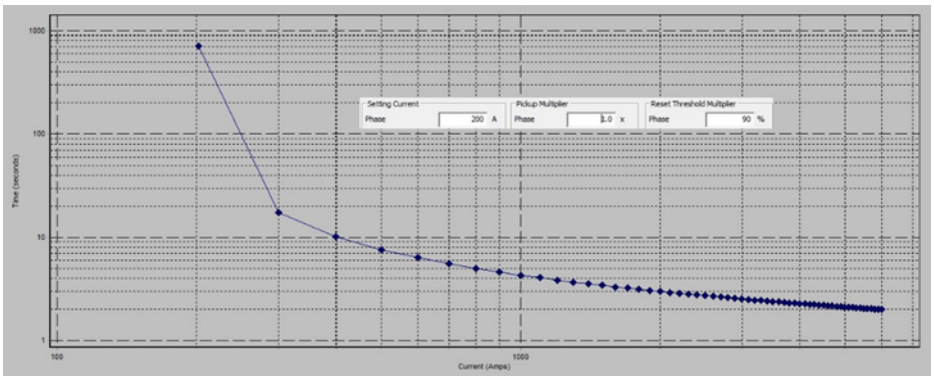



**Figure 140**
IEC255 SI Curve with Default Settings

The second figure shows the same curve but with a **Pickup Multiplier** of 1.5. This raises the pickup current from 200 A to 300 A but note that the trip times for fault currents > 300 A don't change.

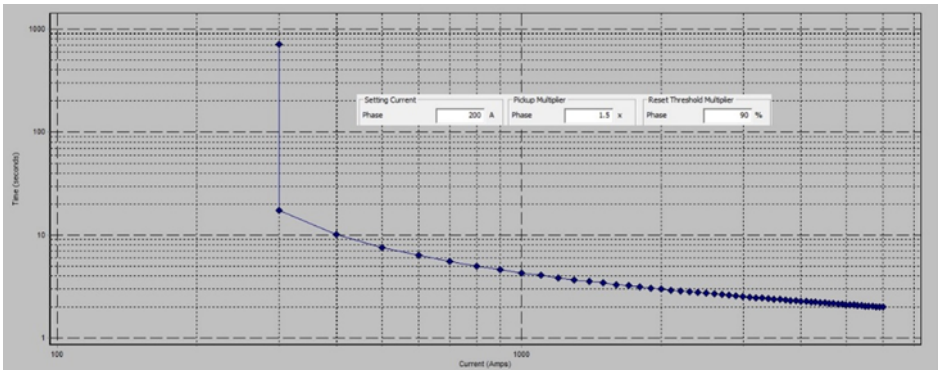


**Figure 141**
IEC255 SI Curve with Pickup Multiplier x 1.5

The trip time for a 400 A (x2) fault in both of the above cases is 10.029 s.

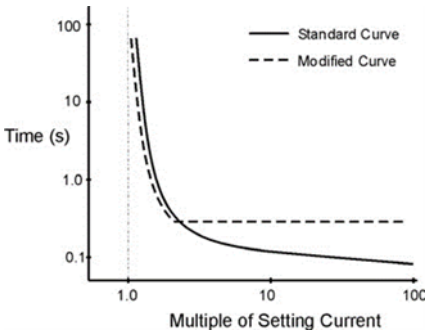
## Curve Modifiers

Inverse Current/Time characteristics can be changed with the following curve modifiers.

- Minimum Time
- Maximum Time
- Additional Time
- Time Multiple
- Threshold Multiplier
- Instantaneous Multiplier

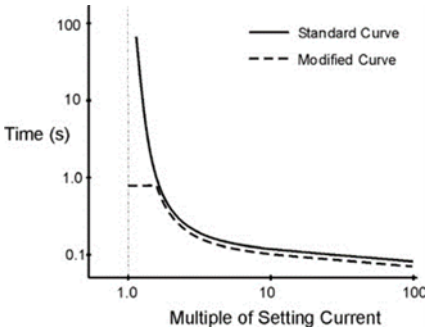
**Minimum Time**

This setting modifies the time current characteristic so that the operating time is not less than the Minimum Time regardless of the current magnitude. This can be used to provide grading between ACRs and fuses on the same feeder. See figure below.



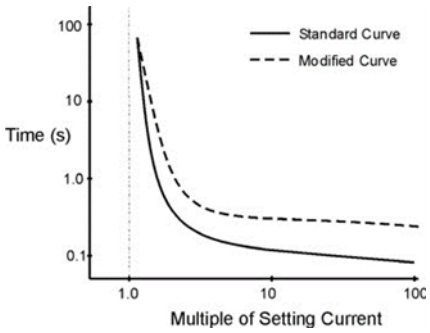

**Maximum Time**

This setting modifies the time current characteristic so that the operating time is not more than the Maximum Time regardless of the current magnitude. This is used to guarantee tripping when the current is only slightly above the pickup setting. See figure below.



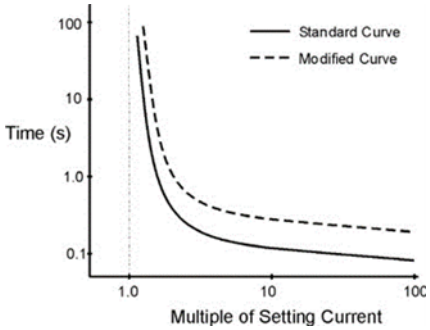
### Additional Time

This setting modifies the time current characteristic so that the operating time is greater than the standard time specified by the time current characteristics by a fixed additional amount. This can be used to provide grading between multiple ACRs on the same feeder. See figure below.



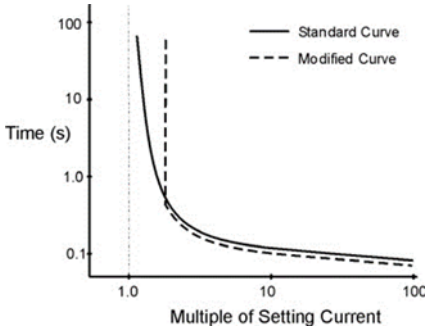

### Time Multiplier

This setting modifies the time current characteristic so that the operating time is a multiple of the standard time specified by the time current characteristics. This can be used to provide grading between multiple ACRs on the same feeder. See figure below.




### Threshold Multiplier

This setting modifies the time current characteristic so that the protection will not operate unless the current exceeds the Pickup Setting X the Threshold Multiplier. This can be used to provide grading between an ACR and an upstream or downstream protection device on the same feeder, when the other devices have a different time/current characteristic. See figure below.



### Instantaneous Multiplier

An Instantaneous Multiplier can be applied to an Inverse Time characteristic. This setting forces an instantaneous trip if the current exceeds the Pickup Setting X Instantaneous Multiplier. This can be used to provide faster tripping for high current faults.

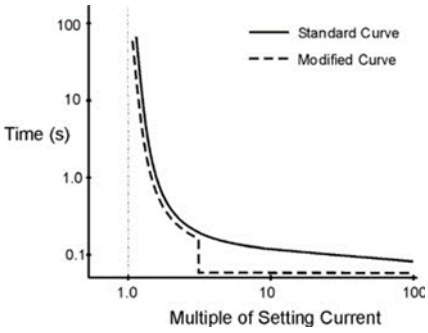



**Table 33 Inverse Time Protection Settings/Specifications**

| **Inverse Time Protection Settings/Specifications** | |
|---|---|
| Inverse Time Curves available | Refer App. D, E, F |
| Phase Setting Current Range | 10...1260 Amp |
| Earth Setting Current Range | 10...1260 Amp |
| Setting Current Resolution | 1 Amp |
| Setting Current Accuracy(1) | 5% |
| Maximum Current for which curve applies | 12.5 kA |
| Maximum Setting Current Multiple for which curve applies | × 30 |
| Time Multiplier | 0.01...25.0 |
| Time Multiplier Resolution | 0.01 |
| Maximum Time to Trip(2) | 2...180 s |
| Extended Maximum Time to Trip(3) | 0.2...180 s |
| Maximum Time to Trip Setting Resolution | 0.1 s |
| Minimum Time to Trip(4) | 0...2 s |
| Minimum Time to Trip Setting Resolution | 0.01 s |
| Additional Time to Trip(4) | 0.0...30.0 s |
| Additional Time to Trip Setting Resolution | 0.01 s |
| Phase Threshold Multiplier(4)(5) | 1...10 |
| Resolution of Phase Threshold Multiplier Setting | 0.1 |
| Earth Threshold Multiplier(4)(6) | 1...10 |
| Resolution of Earth Threshold Multiplier | 0.1 |
| Reset Threshold Multiplier Range (Phase, Ground/Earth, and NPS) | 90%...100%(6)<br>10%...100%(7) |
| Resolution of Reset Threshold Multiplier Setting | 0.1% |
| Timing Accuracy(8) | 5%, ± 20 ms |
| NPS Trip Current Setting Range | 1...1260 Amp |
| NPS Trip Current Setting Resolution | 1 Amp |
| NPS Trip Current Setting Accuracy | ± 10% |

**Table 33 Inverse Time Protection Settings/Specifications (Continued)**

| Inverse Time Protection Settings/Specifications | |
|---|---|
| NPS Trips in sequence to Lockout | 1...4 |
| (1) Current accuracy applies to protection relay function only and excludes accuracy of CTs. | |
| (2) Applies to inverse time and instantaneous protection only. | |
| (3) Available when Extended Maximum Time to Trip is On. | |
| (4) Applies to inverse time protection only. | |
| (5) A trip is inhibited when the line current < setting current x threshold multiplier. | |
| (6) Valid if Reset Curves is turned off. | |
| (7) Valid if Reset Curves is turned on. | |
| (8) Timing refers to time to initiate operation of circuit breaker (opening and closing times are in addition). | |

# Current Operated Protection Elements

## Phase Overcurrent

Phase overcurrent protection monitors the RMS current in each phase in order to detect single phase, phase to phase or three phase faults.

A phase protection pickup occurs when the measured current ≥ the phase setting current x the phase pickup multiplier. A tripping time is calculated based on the magnitude of the fault current and the settings for the active trip, page 164.

The phase current values are updated every 5 ms while the pickup is active and the time to trip is continually being recalculated. Unless the fault resets, page 161, a protection trip will ensue. FCR

Phase overcurrent pickup, reset thresholds and multiplier settings are global that is they apply to all trips. Timing is determined by settings configured individually for Trips 1 – 4, Single Shot and Work Tag.

Configuration options for Phase O/C are listed in the table below.

**Table 34 Phase Overcurrent Configuration Options**

| Phase O/C Configuration Settings | Range/Options | Resolution | Default |
|---|---|---|---|
| **Global Settings** | | | |
| Setting Current | 10...260 A | 1.0 A | 200 A |
| Pickup Multiplier | 1.0...10.0 | 0.1 | 1.0 |
| Reset Threshold Multiplier | 90-100%<br>10-100%(1) | 1.0% | 90% |
| **Per Trip Timing Settings** | | | |
| **Curve Options** | | | |
| Inverse Time Curves | 3 x IEC255 Refer Appendix D, page 564<br>3 x IEEE Refer Appendix E, page 566<br>42 x TCC Refer Appendix F, page 568<br>Up to 5 User Defined Curves<br>Definite Time Instantaneous Only | | IEC255 Standard Inverse |
| Other Curves | | | |
| **Inverse Time Curve Modifiers** | | | |

**Table 34 Phase Overcurrent Configuration Options (Continued)**

| Phase O/C Configuration Settings | Range/Options | Resolution | Default |
|---|---|---|---|
| **Global Settings** | | | |
| Time Multiplier | 0.01...25.00 | .01 | 1.00 |
| Instantaneous Multiplier | Off, 1.0...30.0 | 0.1 | Off |
| Minimum Time | 0.00...2.00 s | 0.01 s | 0.00 s |
| Additional Time | 0.00...30.00 s | 0.01 s | 0.00 s |
| Maximum Time(2) | Off, 0.2...180.0 s | 0.1 s | Off |
| **Other Curves** | | | |
| Definite Time | 0.01...100.00 s | 0.01 s | 1.00 s |
| Definite Time Instantaneous Multiplier | Off, 1.0...30.0 s | 0.1 s | Off |
| Instantaneous Only | x 1.0 – x 30.0 | 0.1 | 1.0 |
| Instantaneous Minimum Time | 0.00–2.00 s | 0.01 s | 0.00 s |
| (1) Reset Threshold Multiplier setting range is 10% - 100% when Reset Curves are available.<br>(2) This is a global setting unless Extended Minimum Time per Curve is On. | | | |

# Earth Fault (EF)

The EF elements are driven by the residual current that is the real-time vector sum of the three phase currents. The residual or earth current is calculated by digitally summing the phase currents sampled every 5 ms.

Residual current = A phase current + B phase current + C phase current or $I_e = I_a + I_b + I_c$

> **NOTE:** The Zero Sequence Current (Io) is defined as $I_o = (I_a + I_b + I_c) / 3$ Therefore the Zero Sequence Current (Io) is one third of the residual or earth current.

An EF pickup occurs when the measured current ≥ the earth setting current x the earth pickup multiplier. A tripping time is calculated based on the magnitude of the fault current and the settings for the active trip, page 164 and updated every sample.

Unless the fault resets, page 161, a protection trip will ensue.

EF pickup, reset thresholds and multiplier settings are global that is they apply to all trips. Timing is determined by settings configured individually for Trips 1 – 4, Single Shot and Work Tag.

Configuration options for EF protection are listed in the table below.

**Table 35 EF Protection Configuration Options**

| Phase overcurrent Configuration Settings | Range/Options | Resolution | Default |
|---|---|---|---|
| **Global Settings** | | | |
| Setting Current | 10...1260 A | 1.0 A | 40 A |
| Pickup Multiplier | 1.0...10.0 | 0.1 | 1.0 |
| Reset Threshold Multiplier | 90...100%<br>10...100%(1) | 1.0% | 90% |

**Table 35 EF Protection Configuration Options (Continued)**

| Phase overcurrent Configuration Settings | Range/Options | Resolution | Default |
|---|---|---|---|
| **Global Settings** | | | |
| **Per Trip Timing Settings** | | | |
| **Curve Options** | | | |
| Inverse Time Curves | 3 x IEC255 Refer Appendix D, page 564<br>3 x IEEE Refer Appendix E, page 566<br>42 x TCC Refer Appendix F, page 568<br>Up to 5 User Defined Curves | | IEC255 Standard Inverse |
| Other Curves | Definite Time Instantaneous Only | | |
| **Inverse Time Curve Modifiers** | | | |
| Time Multiplier | 0.01...25.00 | .01 | 1.00 |
| Instantaneous Multiplier | Off, 1.0...30.0 | 0.1 | Off |
| Minimum Time | 0.00...2.00 s | 0.01 s | 0.00 s |
| Additional Time | 0.00...30.00 s | 0.01 s | 0.00 s |
| Maximum Time(1) | Off, 0.2...180.0 s | 0.1 s | Off |
| **Other Curves** | | | |
| Definite Time | 0.01...100.00 s | 0.01 s | 1.00 s |
| Definite Time Instantaneous Multiplier | Off, 1.0...30.0 s | 0.1 s | Off |
| Instantaneous Only | x 1.0...x 30.0 | 0.1 | 1.0 |
| Instantaneous Minimum Time | 0.00...2.00 s | 0.01 s | 0.00 s |

(1) This is a global setting unless Extended Minimum Time per Curve is On.
(2) Reset Threshold Multiplier setting range is 10%...100% when Reset Curves are available.

# Sensitive Earth Fault (SEF)

SEFs are low level earth faults < 80 A primary.

The SEF elements are driven by measured residual current. The residual current used for the SEF element is determined by measuring the current in the common connection between the three CT secondary currents on the PCOM board.

Residual current = A phase current + B phase current + C phase current or $I_e = I_a + I_b + I_c$

> **NOTE:** Zero Sequence Current ($I_o$) is defined as $I_o = (I_a + I_b + I_c) / 3$ Therefore the Zero Sequence Current ($I_o$) is one third of the residual or earth current.

A SEF pickup occurs when the measured current ≥ the SEF setting current x the SEF pickup multiplier. A tripping time is calculated based on the magnitude of the fault current and the settings for the active trip, page 164 and updated every sample.

Unless the fault resets, page 161, a protection trip will ensue.

SEF pickup, reset thresholds and multiplier settings are global that is they apply to all trips. Timing is determined by settings configured individually for Trips 1...4, Single Shot and Work Tag.

Configuration options for SEF protection are listed in the table below.

**Table 36 SEF Protection Configuration Options**

| Phase O/C Configuration Settings | Range/Options | Resolution | Default |
|---|---|---|---|
| **Global Settings** | | | |
| Setting Current | 10...1260 A | 1.0 A | 4 A |
| Pickup Multiplier | 1.0...10.0 | 0.1 | 1.0 |
| Reset Threshold Multiplier | 90...100%<br>10...100%(2) | 1.0% | 90% |
| **Per Trip Timing Settings** | | | |
| **Curve Options** | | | |
| Inverse Time Curves | 3 x IEC255 Refer Appendix D, page 564<br>3 x IEEE Refer Appendix E, page 566<br>42 x TCC Refer Appendix F, page 568<br>Up to 5 User Defined Curves | | Definite Time |
| Other Curves | Definite Time Instantaneous Only | | |
| **Inverse Time Curve Modifiers** | | | |
| Time Multiplier | 0.01...25.00 | .01 | 1.00 |
| Instantaneous Multiplier | Off, 1.0...30.0 | 0.1 | Off |
| Minimum Time | 0.00...2.00 s | 0.01 s | 0.00 s |
| Additional Time | 0.00...30.00 s | 0.01 s | 0.00 s |
| Maximum Time(1) | Off, 0.2...180.0 s | 0.1 s | Off |
| **Other Curves** | | | |
| Definite Time | 0.01...100.00 s | 0.01 s | 1.00 s |
| Definite Time Instantaneous Multiplier | Off, 1.0...30.0 s | 0.1 s | Off |
| Instantaneous Only | x 1.0...x 30.0 | 0.1 | 1.0 |
| Instantaneous Minimum Time | 0.00...2.00 s | 0.01 s | 0.00 s |
| (1) This is a global setting unless Extended Minimum Time per Curve is On. | | | |

# Transient Earth (Ground) Fault Protection

Transient Earth Fault Protection (TEF) (also referred as Transient Ground Fault) allows the controller to be configured to detect transients earth faults in compensated or isolated neutral networks. Depending on the configuration, the controller will alarm or trip when a TEF is detected.

TEF detection and direction determination are derived by processing and evaluating the neutral-point displacement voltage and the residual current waveforms using a TEF process method.

**NOTE:** This feature is comprehensively documented in Application TEF in AppNote_TEF_A50-15.xx.

# Negative Phase Sequence (NPS) [4]

[4]NPS protection can only be used if Sequence Components are available.

The NPS elements are driven by the NPS current ($I_2$) which is calculated in real time by digitally summing the phase currents sampled every 5 ms and applying the Fortescue formula for sequence components.

$I_2 = (I_a + I_b \text{ phase shifted } 240° + I_c \text{ phase shifted } 120°) / 3$

An NPS pickup occurs when the measured current ≥ the NPS setting current x the NPS pickup multiplier. A tripping time is calculated based on the magnitude of the fault current and the settings for the active trip, page 164. While the pickup is active, tripping times are calculated for each sample. Unless the fault resets, page 161, a protection trip will ensue.

NPS pickup, reset thresholds and multiplier settings are global that is they apply to all trips. Timing is determined by settings configured individually for Trips 1...4, Single Shot and Work Tag.

**Table 37 NPS Protection Configuration Options**

| NPS Configuration Settings | Range/Options | Resolution | Default |
|---|---|---|---|
| **Global Settings** | | | |
| Setting Current | 10 A...1260 A | 1.0 A | 40 A |
| Pickup Multiplier | 1.0...10.0 | 0.1 | 1.0 |
| Reset Threshold Multiplier | 90%...100%<br>10%...100%(1) | 1.0% | 90% |
| **Per Trip Timing Settings** | | | |
| **Curve Options** | | | |
| Inverse Time Curves | 3 x IEC255 Refer Appendix D, page 564<br>3 x IEEE Refer Appendix E, page 566<br>42 x TCC Refer Appendix F, page 568<br>Up to 5 User Defined Curves | | IEC255 Standard Inverse |
| Other Curves | Definite Time Instantaneous Only | | |
| **Inverse Time Curve Modifiers** | | | |
| Time Multiplier | 0.01...25.00 | .01 | 1.00 |
| Instantaneous Multiplier | Off, 1.0...30.0 | 0.1 | Off |
| Minimum Time | 0.00...2.00 s | 0.01 s | 0.00 s |
| Additional Time | 0.00...30.00 s | 0.01 s | 0.00 s |
| Maximum Time(2) | Off, 0.2...180.0 s | 0.1 s | Off |
| **Other Curves** | | | |
| Definite Time | 0.01...100.00 s | 0.01 s | 1.00 s |
| Definite Time Instantaneous Multiplier | Off, 1.0...30.0 s | 0.1 s | Off |
| Instantaneous Only | x 1.0...x 30.0 | 0.1 | 1.0 |
| Instantaneous Minimum Time | 0.00...2.00 s | 0.01 s | 0.00 s |

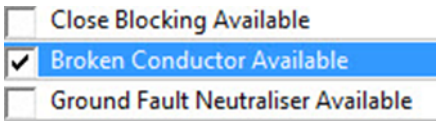
(1) Reset Threshold Multiplier setting range is 10%...100% when Reset Curves are available.
(2) This is a global setting unless Extended Minimum Time per Curve is on.

# Broken Conductor

Open circuit faults due to broken conductors or mal operation of switchgear will not cause an increase in current and are not detected by standard over current protection.

This type of fault will cause an unbalance and produce NPS current. The broken conductor algorithm is based on monitoring the relationship between NPS aND PPS currents and is independent of load fluctuations.

Broken Conductor can only be used if it has been made available either through WSOS in Feature Selection.




Or it can be made available on the operator interface.

Broken Conductor has separate Protection and Alarm functions with individual On/Off and configuration settings. If available it can be configured on the Broken Conductor page in the WSOS Protection menu.

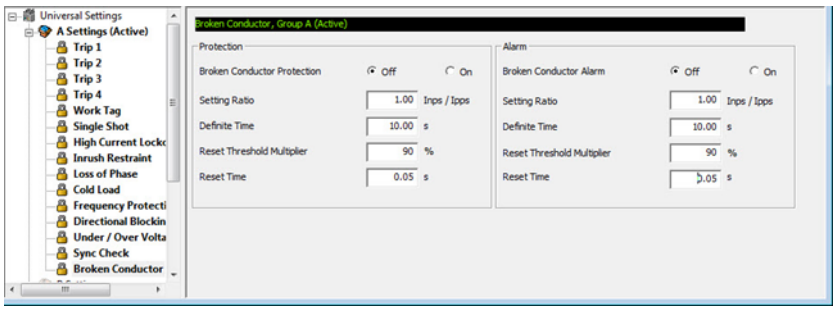



**Figure 142**
WSOS Broken Conductor settings

Broken Conductor settings can be configured on the operator interface, page 697.

## Broken Conductor Protection

A Broken Conductor protection pickup will occur when the following conditions are present:

- Broken Conductor is Available
- Broken Conductor Protection is On
- The real time $I_{nps}/I_{pps}$ ratio exceeds the configured $I_{nps}/I_{pps}$ Setting Ratio

A Broken Conductor pickup will be recorded in the Event Log.

A pickup will start the trip timer and if the pickup persists for the Definite Time setting, the controller will send a trip request to the switchgear.

A Broken Conductor trip event will also be logged.

## Fault Reset

A Broken Conductor pickup will reset if the $I_{nps}/I_{pps}$ ratio drops to the Reset Threshold for the Reset Time. The Reset Threshold is 90% of the $I_{nps}/I_{pps}$ ratio by default. A Broken Conductor reset event will be recorded in the Event Log.

# Broken Conductor Alarm

Broken Conductor Alarm functions in a similar manner to Broken Conductor Protection, except that it will not cause a protection trip. Instead a Broken Conductor Alarm event log entry will be made and any of the Broken Conductor Alarm SCADA points configured into the active protocol map will be asserted.

**NOTE:** The Broken Conductor feature is available for ACR's with all switchgears.

A description of settings available for Broken Conductor protection and alarm functions are given in table.

**Table 38 Broken Conductor Protection settings**

| **Broken Conductor Protection Settings** | |
|---|---|
| **Settings** | **Description** |
| Off/On | Turns the Broken Conductor Protection off or on. |
| Setting Ratio | The threshold at which the Broken Conductor protection element will pick up. |
| Definite Time | The switchgear will trip once the definite time has expired. |
| Reset Threshold Multiplier | This is the percentage of the Broken Conductor pickup value at which reset timing begins. |
| Reset Time | Reset time will start when the $I_{nps}/I_{pps}$ ratio drops below the Reset Threshold.<br><br>When the Reset Time expires, the fault will be reset. |

**Table 39 Broken Conductor Alarm settings**

| **Broken Conductor Protection Settings** | |
|---|---|
| **Settings** | **Description** |
| Off/On | Turns the Broken Conductor Alarm off or on. |
| Setting Ratio | The threshold at which the Broken Conductor Alarm will pick up. |
| Definite Time | The Broken Conductor alarm and SCADA point will be asserted once the Definite Time has expired. |
| Reset Threshold Multiplier | This is the percentage of the Broken Conductor Alarm pickup value at which reset timing begins. |
| Reset Time | Reset time will start when the $I_{nps}/I_{pps}$ ratio drops below the Reset Threshold.<br><br>When the Reset Time expires, the fault will be reset. |

The range, resolution and defaults for Broken Conductor configuration settings are shown in the table below.

**Table 40 Broken Conductor Configuration and Specifications**

| **Broken Conductor Protection Settings/Specifications** | | | |
|---|---|---|---|
| **Broken Conductor Configuration Settings** | **Range/Options** | **Resolution** | **Default Setting** |
| **Trip** | | | |
| Broken Conductor Protection | On, Off | N/A | Off |
| Setting Ratio ($I_{nps}/I_{pps}$) | 0.10...1.00 | 0.01 | 1.0 |
| Definite Time | 0.10...300.00 s | 0.01s | 10.00 s |
| **Protection Reset** | | | |
| Reset Threshold Multiplier | 90...100% | 1% | 90% |
| Reset Time | 0.00...100.00 s | 0.01 s | 0.05 s |

**Table 40 Broken Conductor Configuration and Specifications (Continued)**

| Broken Conductor Protection Settings/Specifications | | | |
|---|---|---|---|
| **Broken Conductor Configuration Settings** | **Range/Options** | **Resolution** | **Default Setting** |
| **Trip** | | | |
| **Alarm** | | | |
| Broken Conductor Alarm | On, Off | N/A | Off |
| Setting Ratio ($I_{nps}/I_{pps}$) | 0.10...1.00 | 0.01 | 1.0 |
| Definite Time | 0.10...300.00 s | 0.01 s | 10.00 s |
| **Alarm Reset** | | | |
| Reset Threshold Multiplier | 90...100% | 1% | 990% |
| Reset Time | 0.00...100.00 s | 0.01 s | 0.05 s |

# ACR Protection Features

## Single Shot

If Auto Reclosing is not required, Auto Reclose can be turned off and the ACR will operate as a conventional circuit breaker. In this case the ACR is said to be in Single Shot mode.

Even when a device is normally operated in automatic reclose mode, there may be some circumstances where auto reclosing is not required.

For example, if a fault is detected as soon as the ACR is closed, that fault is unlikely to be of a transient nature. This situation is handled by causing a manual close to put the ACR into Single Shot mode for a configured time. So if the switchgear is closed onto a fault manually, it will trip and go directly to lockout even though Auto Reclose is On.

## Single Shot Protection Settings

Single Shot mode uses dedicated protection settings for each configured element which can be more appropriate to the situation. For example, closing onto a fault would normally warrant a fast tripping time.

Single Shot settings for OC, EF, SEF, and NPS protection can be configured in the same manner as for Trips 1, 2, 3, and 4. The OC, EF, SEF, and NPS Single Shot Protection trip settings can be selected individually via separate protection pages. Each page is similar to the normal protection trip setting pages.

In WSOS the Single Shot settings can be configured on the Single Shot page.

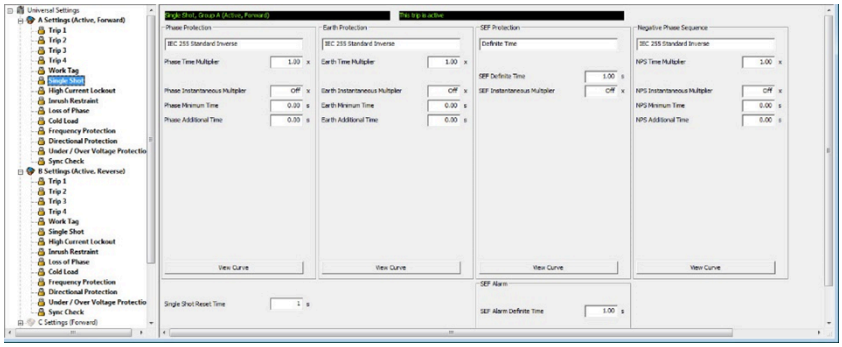


**Figure 143**
WSOS Single Shot settings

Single Shot settings can also be configured on the operator interface, page 697.

If the ACR trips in Single Shot mode it generates a **Single Shot** event preceded by Active Protection Group and Fault Type events.

## Single Shot Activation/Deactivation

Single Shot is activated when:

- Auto Reclose is Off and Work Tag is not applied.
- The switchgear is closed by operator command irrespective of the Auto Reclose setting.

Single Shot is de-activated when:

- Auto Reclose is turned back On.
- Work Tag is not active and the Single Shot Timer expires after a manual close without a protection pickup occurring.

  **NOTE:** When the Work Tag is applied the ACR is always in **Work Tag mode** regardless of the Auto Reclose or Single Shot settings.

## Single Shot Reset Time

The Single Shot Reset timer starts when the switchgear is manually closed and runs for the pre-set number of seconds. The default setting is 1 s and it can be configured for between 0 s and 180 s.

If the Single Shot Reset Timer is configured for zero seconds, Single Shot mode will not be activated by a manual close and Auto Reclose will always be enabled if it's On.

The Single Shot Reset Time setting can be found in WSOS on the

**Protection** > **Single Shot page**.

The Single Shot Reset Timer can also be configured on the operator interface, page 697.

There are a number of scenarios that can occur involving the Single Shot Reset Timer.

### Scenario 1 – Single Shot Timer initiated by an operator close.

This is the normal operation.

The single shot timer starts to run when an operator close occurs.

If no fault is detected, the timer times out, the switchgear goes into Auto Reclose mode if configured and stays closed.

### Scenario 2 – Protection Pickup during Single Shot timing.

In this scenario a protection pickup occurs during the Single Shot running time which resets the Single Shot Timer.

If the fault persists, a single shot trip will occur after the time to trip expires.

**NOTE:** The time to trip may be longer than the Single Shot Reset Timer. In other words it doesn't matter how long the time to trip is, as long as pickup occurred when the single shot timer was running, it will result in a single shot trip.

### Scenario 3 – Protection Reset during Single Shot timing.

If a pickup that occurred while the single shot timer was running is followed by a protection reset, the single shot timer will restart.

The ACR will continue to be in single shot mode until the timer expires.

## Single Shot Summary

- An ACR will go directly to Lockout following a protection trip if it is in Single Shot mode.
- Providing the Work Tag has not been applied, an ACR will be in Single Shot mode if:
  - Auto Reclose is Off.
  - An operator has closed the device. Providing the Single Shot Reset Timer has not been set to zero.
- The timing of a trip that occurs when the ACR is in Single Shot mode is determined by dedicated Single Shot settings for the particular type of fault.

# Work Tag

Applying the Work Tag helps to ensure that closing cannot take place at all, either by a local operator, a remote operator or automatically. Once applied, neither a local user, remote user or the Auto Reclose function can close the switchgear.

The Work Tag is used to helps protect operators working on live lines. It is normally applied when the switchgear is closed to allow live line work to be carried out without the possibility of an automatic reclose must a protection trip occur.

If a protection trip does occur when the Work Tag is applied, the ACR will always go to lockout even if Auto Reclose is On.

The time to trip will be determined by the Work Tag protection settings and Work Tag Trip will be recorded in the Event Log.

The Work Tag cannot be applied to a closed ACR if there is anything preventing a protection trip for example, if the Trip Circuit is isolated.

## Work Tag Configuration

Work Tag can be applied with WSOS on the Control page or on the operator interface, page 697.

> **NOTE:** Work Tag is an operator setting and does not require a password to be applied or removed.

When Work Tag is applied to an ACR with the ***flex*VUE** O.I. it generates an Alert that can be viewed in the Alerts menu. On the ***set*VUE** O.I. a message **Warning – Work Tag Applied** flashes on the top of the display accompanied by an audible alert.

## Work Tag Protection Settings

Work Tag protection settings are used to provide appropriate protection timing when the Work Tag has been applied.

Work Tag settings for overcurrent, EF, SEF, and NPS protection can be configured in the same manner as for Trips 1, 2, 3, and 4. The overcurrent, EF, SEF, and NPS Work Tag Protection trip settings can be selected individually via separate protection pages. Each page is similar to the normal protection trip setting pages.

In WSOS the Work Tag settings can be configured on the Work Tag page or they can be configured on the operator interface, page 697.

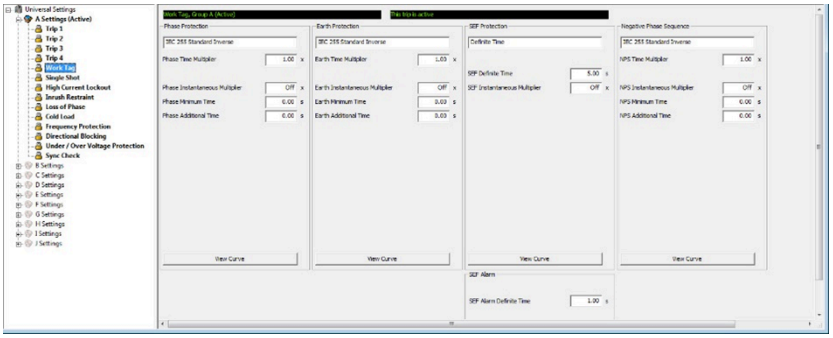


**Figure 144**
WSOS Work Tag settings

## Work Tag and Controller Mode

An important feature of the ADVC controller is that it is always in one of two control modes, that is either Local, page 50 or Remote, page 50, and can have a Work Tag applied by Local or Remote operators. See Definition of a Local or Remote Operator, page 50.

The control mode and the Work Tag status specify the circumstances under which the switchgear can be closed to help ensure operational safety. Only a remote operator can apply/remove the Work Tag when the controller is in RM.

This means that for a local operator to remove the Work Tag which was applied by a remote operator, they must first put the controller into Local mode.

**NOTE:** A remote operator cannot take control in this way because the control mode can only be changed via the O.I.

## Work Tag and Single Shot Mode

Work Tag and Single Shot modes will both cause an ACR to go directly to Lockout if a protection trip occurs that is they both helps to prevent automatic closing.

The difference between these two modes is that Work Tag helps to prevent manual closing as well.

## Work Tag Summary

- The switchgear cannot be closed by any means when Work Tag is applied.
- Dedicated Work Tag protection settings determine the trip timing for faults that occur when the Work Tag is applied.
- An ACR will always be in Work Tag mode if the Work Tag is applied, regardless of the Single Shot status or Auto Reclose setting.

# Automatic Protection Group Selection (APGS)

APGS can be used to automatically change the active protection group to suit the network configuration without the need for operator intervention.

APGS works by automatically changing between protection groups depending on the direction of power flow through the switchgear.

## The Selection Rules

Each pair of protection groups (A and B), (C and D), (E and F), (G and H), and (I and J) contains one primary and one alternate protection group.

The number of pairs that are available depends on how many protection groups have been configured (minimum 2 required).

When the power is in the positive direction (source to load), primary protection group A, C, E, G, or I is used.

When the power is in the negative direction (load to source), alternate protection group B, D, F, H, or J is used.

For APGS to generate a change from primary to alternate protection group, the power flow must be > 50 kW in the negative direction for longer than the set period.

To revert to the primary protection group the power must be > 50 kW in the positive direction for longer than the set period.

## APGS Applications

Sometimes an ACR is used at a location in a supply network where the power flow can be in either direction depending on the configuration of the network.

One example of this is a network tie point where the operator may have to select a different group of protection settings to compensate for a change in power flow when changing the network configuration.

Emergency switching configurations may require more than one protection group.

APGS is utilized by the Loop Automation function to change the active protection group during system reconfiguration.

## APGS Configuration

APGS is an additional protection feature that must be made available before it can be configured and enabled.

APGS can be made available through Feature Selection in WSOS:

**Display** > **Configuration** > **Feature Selection** > **Protection**

It can also be made available on the operator interface, page 697.

Once APGS is available it can be configured for a Change Time between 10 s and 180 s (default 60 s) and set to Auto.

In WSOS this is done on the Control page.

APGS Change Time and APGS Auto can be configured on the O.I.

## Disabling APGS

Certain operator actions will cause APGS to be disabled.

- A change to the Power Direction setting.
- Selection of an active protection group other than Protection Auto.
- Setting APGS to Not Available.

**Table 41 APGS Settings/Specifications**

| Automatic Protection Group Selection Settings/Specifications | |
|---|---|
| Auto Change Time | 10...180 s |
| Auto Change Time Resolution | 1.0 s |

# SEF Alarm

The SEF Alarm is a facility whereby a SEF will trigger an alarm without tripping the switchgear.

An SEF Alarm Definite Time delay can be configured which is independent of the SEF Trip protection timing. This allows the SEF Trip and Alarm functions to be operational at the same time.

## SEF Alarm Configuration

SEF Protection must be available for the SEF Alarm to be used.

The SEF Alarm On/Off control is displayed in WSOS on the Control page as well as on the operator interface.

## SEF Alarm Timing

The SEF Alarm Definite Time is a separate setting for each trip within a protection group.

If SEF Alarm is being used with 4 Trips to Lockout, six SEF Alarm Definite Time settings will need to be configured: Trip 1, Trip 2, Trip 3, Trip 4, Single Shot, and Work Tag.

Each setting is configurable between 0.10 s and 999.00 s in steps of 0.01 s.

## SEF Alarm settings in WSOS

In WSOS there is an SEF Alarm Definite Time setting on each Trip page below the SEF Protection settings as shown below for Trip 1.

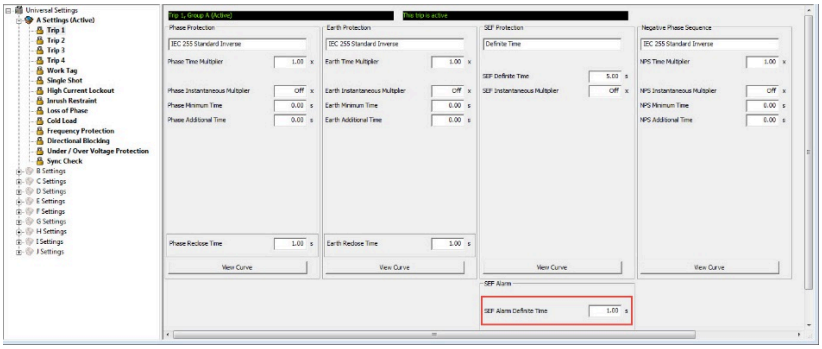


**Figure 145**
WSOS SEF Alarm Definite Time setting

These settings also appear on the operator interface.

When activated, the SEF Alarm will log an event in the Event Log.

SEF Alarm On/Off events are also recorded.

The SEF Alarm can be mapped to a Status Lamp or lamp on the ***flex*VUE** O.I.

The SEF Alarm is also available for mapping through the Configurable Protocol Tool for reporting via SCADA.

# NPS Alarm

Providing Sequence Components are available, NPS can be configured for either Alarm or Trip regardless of whether Per Element Protection, page 174 is available.

## NPS Alarm Configuration

In WSOS this setting can be configured on the Control page.




The NPS Alarm can also be selected on the operator interface. Auto Reclose On/ Off.

## NPS Alarm Operation

When NPS Alarm is selected, an NPS fault will not cause a protection trip. A protection pickup according to the Global NPS Setting Current setting and timing according to the NPS protection settings for the active trip will occur. But instead of a protection trip when the time to trip expires, the Event Log will record: NPS Alarm.

Other events normally associated with a protection pickup:

- Pickup NPS
- Protection Group Active

Will also be logged. And when the fault is removed:

- Protection Reset
- NPS Max Current

Will be logged.

NPS Mode Alarm is also logged when NPS Alarm is selected.

The NPS Alarm can be mapped to a Status Lamp or QAK lamp on the ***flex*VUE** O. I.

The NPS Alarm is also available for mapping through the Configurable Protocol Tool for reporting via SCADA.

# Protection Off

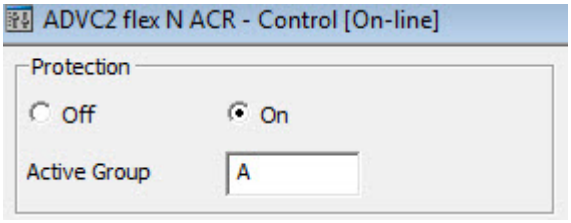
This setting turns off all of the protection features and therefore the ACR can only be tripped or closed manually.

## Protection Off Configuration

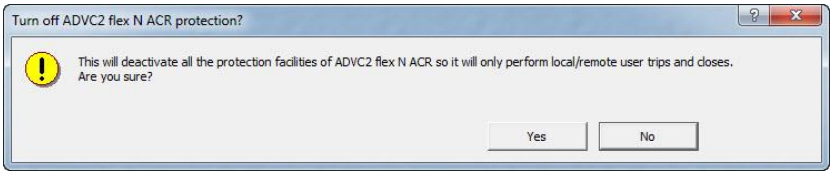
By default, Protection Off is not allowed. If it is required to turn protection off, Protection Off must be configured for allowed in either:

WSOS: **Display** > **Configuration** > **Feature Selection**> **Protection** or on the operator interface, page 697.

Once Protection Off has been made available, protection can be turned off in WSOS on the Control page.




When Protection is turned off, WSOS will display the message below:




An operator must select **Yes** in the above message to turn Protection Off.

Protection can also be turned Off via the O.I:

***flex*VUE**: **Operator Menu** > **Operator Controls** > Auto Reclose On/Off Options for this setting field are:

- Auto Reclose On
- Auto Reclose Off
- Protection Off

If protection is Off, selecting either **Auto Reclose On** or **Auto Reclose Off** will turn protection On.

***set*VUE**: via the Auto Reclose On/Off field on Operator Settings 1 in the System Status menu.

Options for this setting field are:

- Auto Reclose On
- Auto Reclose Off
- Protection Off

If protection is Off, selecting either **Auto Reclose On** or **Auto Reclose Off** will turn protection On.

## Protection Off Operation

A Protection OFF event is logged whenever protection is turned off.

A Protection ON event is logged whenever protection is turned on.

When Protection is Off:

- **Operator Menu** > **Indications** > Flags displays Pickup Flags instead of Trip Flags on the ***flex*VUE** menu.
- The Trip Flags, page 639 page is replaced by the Pickup Flags, page 639 page on the ***set*VUE** O.I.
- Protection pickups are still logged when overcurrent setting thresholds are exceeded.
- Maximum current events are still logged when pickups reset.
- If a Loss of Phase (LOP) event occurs, the ACR will not trip but the LOP, A, B, or C Pickup Flags are set.
- If an UOF condition is detected, the ACR will not trip but the Frequency Pickup Flag is set.
- If an NPS fault is detected, the ACR will not trip but the NPS Pickup Flag will be set.

# Dead Lockout

Dead Lockout will help to prevent the ACR from automatically reclosing after a protection trip unless one or more of either the source side or load side terminals are live.

A Dead Lockout situation is one where an upstream circuit breaker has also tripped and is still open when the ACR reclose time expires. In this case reclosing the ACR would serve no purpose as fault may be upstream of the ACR instead of downstream.

## Dead Lockout Configuration

Dead Lockout can be turned On in WSOS on the Control page or on the operator interface, page 697.

## Dead Lockout Operation

Dead Lockout is only active when Auto Reclose is On.

Following a protection operation, the controller will check the Live/Dead status of each bushing. If none of the bushings are live, reclosing will be aborted. The ACR will go to lockout and a Dead Lockout event will be recorded in the Event Log.

## Dead Lockout on PMSet U Series

Dead Lockout cannot be turned On if the source side voltages are unavailable.

Therefore an ACR with PMSet U Series switchgear that does not have voltage sensing on the X side cannot use Dead Lockout if the X side is the designated Source.

# Sequence Control

This feature is used where there are two or more ACR's on a feeder which can become uncoordinated if the fault is still present when a downstream device trips and recloses.

This is most likely to happen when ACR's in series are configured for fast first trips and slow second trips in order to coordinate with fuses on spur lines.

Sequence Control causes the ACR to step to the next count in the auto reclose sequence on reset of all protection elements regardless of whether or not the ACR tripped.

The sequence will only advance if Auto Reclose is On and the Single Shot Reset Timer has timed out.

## The Problem

Consider the following possible sequence of events:

- A fault occurs downstream of two ACR's in series.
- Both ACR's pick up but only the downstream device trips as its Trip 1 time is intentionally shorter than the upstream device's Trip 1 time.
- The downstream ACR moves to Trip 2 in its sequence and automatically recloses.
- The fault is still present and both ACR's pick up again but the upstream device is still on Trip 1 which is a shorter trip time than the downstream device's Trip 2 time.

- The upstream ACR trips and clears the fault for the downstream device which resets before its trip time expires.

This would be a mal-operation causing an unnecessary loss of supply to the load connected between the two ACR's.

## The Solution

The solution would be to turn Sequence Control On on the upstream device. This would cause the upstream ACR to step to Trip 2 settings in sync with the downstream device when that device tripped.

## Sequence Control Configuration

Sequence Control can be turned On in WSOS on the Protection Global Settings page or on the operator interface, page 697.

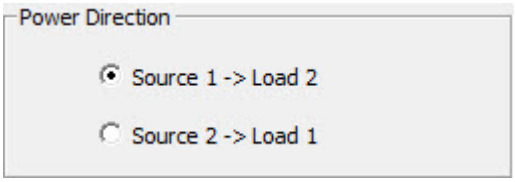
Sequence Control is configured per protection group.

# Live Load Blocking

Live Load Blocking is used where there is a possibility of the ACR switchgear being inadvertently closed when the **load side** is **energized** with an incompatible supply.

## Critical Settings

The **load side** is as defined by the Power Direction, page 155 setting




And **energized** is as defined by the Live Line Threshold setting:




Which is configurable between 2000 V and 15000 V in 1 Volt steps.

Both of these critical settings can be configured in WSOS on the Measurement page:

**Display** > **Measurement**

The Power Direction, page 155 and Live Line Threshold settings can also be configured on the O.I.

## Live Load Blocking Configuration

Live Load Blocking is Off by default but can be turned On in WSOS on the Protection Global Settings page, or on the operator interface, page 697.

Live Load Blocking is configured per protection group.

## Live Load Blocking Operation

If Live Load Blocking is On, all close requests, manual or automatic, will be disregarded if any load side bushing is live.

An O.I. close request that is denied by Live Load Blocking will generate the following events:

- Panel Close Request
- Live Load Blocking
- Operation Denied

| Live Load Blocking Settings/Specifications | |
|---|---|
| Live Load Threshold Voltage | 2...15 kV |

# High Current Lockout

High Current Lockout(HCL) is an additional protection feature which operates in conjunction with the protection elements.

It is one of several features that can cause an ACR to go to lockout earlier than it normally would according to the Trips to Lockout settings.

Usage of HCL helps to prevent the ACR from closing back onto a heavy fault. Alternatively it can limit the number of times this can happen. It is important to note that HCL does not affect tripping. It merely determines if an automatic reclose must occur.

## HCL Configuration

HCL can be enabled and configured in WSOS on the HCL page in the Protection settings.

Or on the operator interface, page 697.

HCL is configured per protection group.

## HCL Operation

Apart from the On/Off control, there are two settings that determine how HCL operates:

- Lockout Current
- Active Trip No

If HCL is On and a sequence is in progress:

The controller checks the following during each dead time when an automatic reclose is pending:

1. Does the trip current measurement for the most recent protection trip exceed the Lockout Current setting?
2. Is the trip number of the most recent protection trip equal to or greater than the Active Trip No.?

If the answer to both the above is **Yes**, the ACR records that the High Current setting was exceeded and goes to lockout.

HCL is recorded in the Event Log.

## HCL and Single Shot

HCL can occur when an ACR is closed onto a fault. In this case the ACR will perform a Single Shot trip and go directly to lockout even if Auto Reclose is On.

Consequently there are two factors helps preventing an auto reclose in this situation:

1. Single Shot Active
2. HCL

This situation can be identified by events in the Event Log, typically:

- Phase Protection Trip
- Single Shot
- Max Current ≥ 1000 A (where 1000 A is the Lockout Current setting)

**Table 42 HCL Settings/Specifications**

| HCL Settings/Specifications | |
|---|---|
| Maximum Effective Setting | 12.5 kA |
| Minimum Effective Setting | 10 A |
| Current Setting Resolution | 1 A |
| Accuracy | ± 15% |

## High Neutral Current Lockout Summary

**High Neutral Current Lockout** is an additional protection feature which operates in conjunction with the other protection elements. It detects that an Earth current is above a defined threshold and raises a high current condition. A lockout of the controller will occur when it is tripped. It requires Earth protection to be on to operate. The operation is basically identical to **HCL (phase)** excepting that it uses Earth (Neutral) current as the measurement.

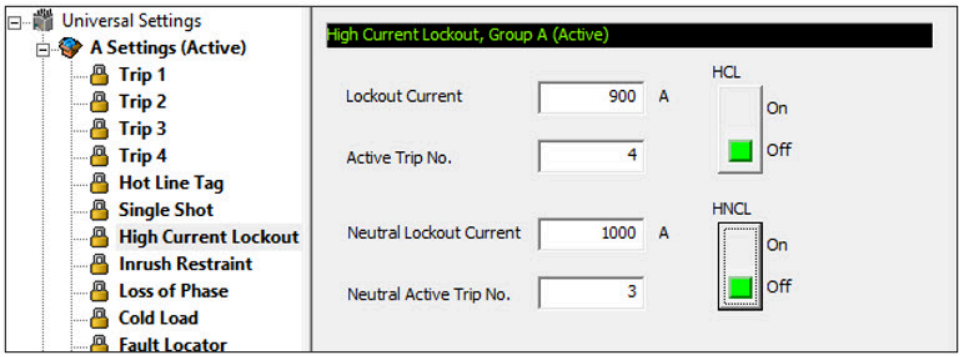



**Figure 146**
High Neutral current lockout

## Inrush Restraint

When closing onto typical loads, there may be an initial surge in current caused by phenomena such as:

- Transformer magnetizing currents
- Motor starting currents
- Start-up current of incandescent and arc lights

These surges are transient and referred to as Inrush Current. Depending on the active protection settings at the time, this inrush current may cause overcurrent protection to operate unnecessarily.

The purpose of Inrush Restraint helps to prevent the ACR from tripping due to inrush current.

The PowerLogic ADVC Controller supports two modes of operation for Inrush Restraint, Zero Detect and SOHIR. This section describes the Zero Detect mode. SOHIR, page 341, or SOHIR is described in the next section.

## Inrush Restraint Configuration

Inrush Restraint can be enabled and configured in WSOS on the **Protection** > **Inrush Restraint** page shown in the figure below.

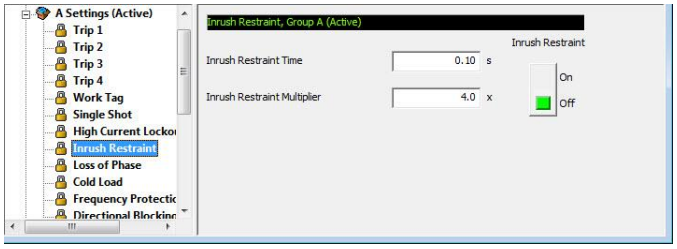



**Figure 147**
WSOS Inrush Restraint settings

Or on the operator interface, page 705.

Inrush Restraint is configured per protection group.

## Inrush Restraint Operation

Inrush Restraint works by raising the Phase, Earth and NPS threshold current settings for a short period of time to allow the inrush current to subside.

> **NOTE:** Inrush Restraint does not affect SEF thresholds or settings configured for Definite Time tripping.

Apart from the On/Off control there are two settings that determine how Inrush Restraint operates as shown in the below:

| Setting | Default | Description |
|---|---|---|
| Inrush Restraint Time | 0.10 s | The time Inrush Restraint will remain active once triggered. |
| Inrush Restraint Multiplier | X4 | Setting current multiplier while Inrush Restraint is active. |

- Inrush Restraint is armed for operation whenever the load current goes to zero.
- When the load current goes from zero to non-zero, the Inrush Restraint is activated and the Inrush Restraint Multiplier is applied to the Phase, Earth, and NPS pickup thresholds for the Inrush Restraint Time.

## Example

In the example below, the Inrush Restraint multiplier (2) was applied to the trip setting (100 A) from when the current went from zero to non-zero. This could have been caused by the switchgear being closed and taking load or the switchgear could have been already closed and the load could have been caused by either an upstream or downstream device closing.

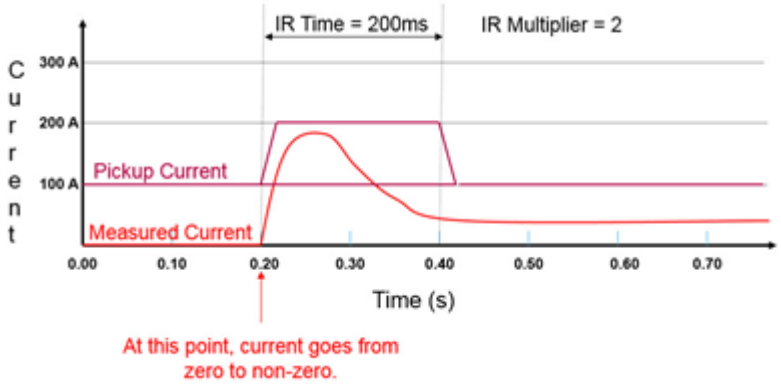



**Figure 148**
Inrush Restraint Time/Current diagram

The Inrush Restraint Multiplier of 2 caused the trip setting to go from 100 A to 200 A for the duration of the Inrush Restraint Time setting (200 ms). This effectively masked the inrush current which had returned to a steady state level before the Inrush Restraint Time expired and the configured setting was restored.

In this case a pickup event would have been logged when the measured current exceeded the pickup threshold that is 100 A, but the protection timing would not have started.

If the measured current had been higher than the pickup threshold when the inrush restraint timer expired, the protection timing for that element would have started. If the current remained above the pickup threshold for the protection trip time the ACR would trip.

## Inrush Restraint Summary

- Inrush Restraint helps to prevent the ACR from tripping unnecessarily due to short lived inrush current such as magnetizing current associated with energizing a transformer.
- Pickup and Max Current events are still logged according to the Fault Detect setting for each element even though the Inrush Multiplier is being applied.
- Inrush Restraint affects Phase, Earth, and NPS protection but does not apply to Definite Time or SEF protection.
- Inrush Restraint is triggered by currents going from zero to non-zero. So if normal load currents are expected to drop below 2.5 A Inrush cannot be used and must be left off.

**Table 43 Inrush Restraint Settings/Specifications**

| **Inrush Restraint Settings/Specifications** | |
|---|---|
| Inrush Restraint Multiplier Range | 1...30 |
| Inrush Restraint Multiplier Resolution | 0.1 |
| Inrush Restraint Time Range | 0.05...30 s |
| Inrush Restraint Time Resolution | 0.01 |
| Timing Accuracy | ± 20 ms |

# Second Order Harmonic Inrush Restraint (SOHIR)

SOHIR offers an alternative to the traditional Zero-Detect method of Inrush Restraint explained in Inrush Restraint Operation, page 210.

High inrush current is often due to magnetizing current when a transformer is energized.

Magnetizing currents are distinguished by their high second order harmonic content.

SOHIR provides rapid harmonic detection of inrush current based on harmonic content.

## Making SOHIR Available

SOHIR is an optional feature and can be made available through WSOS at:

**Display** > **Configuration** > **Feature Selection** > **Protection** or on the operator interface, page 697.

## SOHIR Configuration

When SOHIR has been made available, an additional field, **Inrush Restraint Type**, is added to the Inrush Restraint settings. The setting options for this field are:

- Zero Detect
- SOHIR

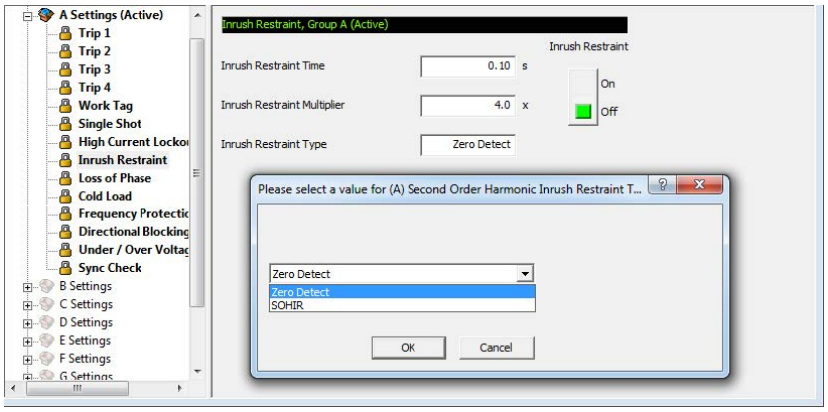



**Figure 149**
Inrush Restraint Type setting

If SOHIR is selected as the **Inrush Restraint Type**, two more settings are added:

- Inrush Restraint Threshold
- Inrush Restraint Algorithm

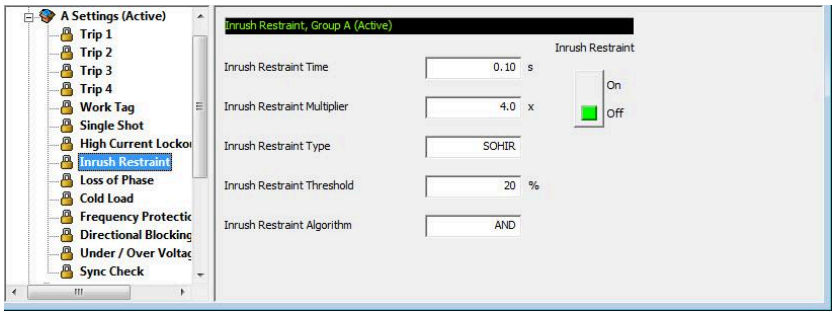



**Figure 150**
Inrush Restraint SOHIR settings

SOHIR can be configured using the parameters described in the table below:

**Table 44 SOHIR Settings Descriptions**

| Setting | Default | Description |
|---|---|---|
| Inrush Restraint Time | 0.10 s | The time Inrush Restraint will remain active once triggered. |
| Inrush Restraint Multiplier | X4 | Setting current multiplier while Inrush Restraint is active |
| Inrush Restraint Threshold | 20% | The 2nd harmonic component of current on the line (expressed as a percentage of the fundamental component) required for SOHIR to activate. |
| Inrush Restraint Algorithm | AND | Configured for either AND or OR. In the case of AND logic, all phases must have harmonics above the threshold setting, in order for SOHIR to become active. In the case of OR logic, only the phase with the highest current needs to have harmonics above the threshold setting. |

SOHIR can also be configured on the operator interface, page 697.

SOHIR is configured per protection group.

## SOHIR Operation

SOHIR monitors pickups by either Phase, Earth or NPS protection elements.

- Once a pickup is detected, SOHIR restrains all overcurrent protection trips from the Phase, Earth or NPS elements (except those using Definite Time curves) for 30 ms.
- During this 30 ms time period, SOHIR calculates the harmonics on the faulted phases as a percentage of the fundamental component.
- If one or more phases has a second harmonic component above the Inrush Restraint Threshold setting, a decision is made on whether to become active based on the Inrush Restraint Algorithm.
- If SOHIR does become active it will restrain all overcurrent trips from the Phase, Earth and NPS element for the configured Inrush Restraint Time.

SOHIR will be deactivated if either:

- Harmonics measured during the 30 ms period are below the threshold.
- The Inrush Restraint timer has expired.

Once SOHIR has been deactivated it cannot reactivate until all relevant protection elements have reset.

# Cold Load Pickup

When a typical load has been without supply for a period of time (hours) it loses its diversity.

When power is restored the load is initially higher than usual because many or all of the thermostat controlled devices such as heaters, refrigeration, air conditioners etc. will turn on.

The longer the period without supply the greater the loss of diversity and the higher the load current will be when supply is restored.

If the supply is off long enough the load will eventually lose diversity altogether and any further extension of the outage will not cause the initial load current when supply is restored to increase any further.

The increase in load current after a prolonged outage could cause overcurrent protection to operate unnecessarily.

The purpose of the Cold Load Pickup (CLP) feature is to automatically compensate for the loss of diversity by adjusting the overcurrent pickup thresholds until the load regains its diversity and steady state load conditions return.

It works by measuring the time that supply was lost and then temporarily raising the Setting Current for the selected elements according to the time the load has been without supply.

## CLP Configuration

CLP can be selected **On** or **Off** for the **Phase** overcurrent, **Earth** Fault, **SEF**, and **NPS** elements independently. It is configured by setting two parameters:

- Cold Load Time – default 120 minutes
- Cold Load Multiplier – default x 2.0

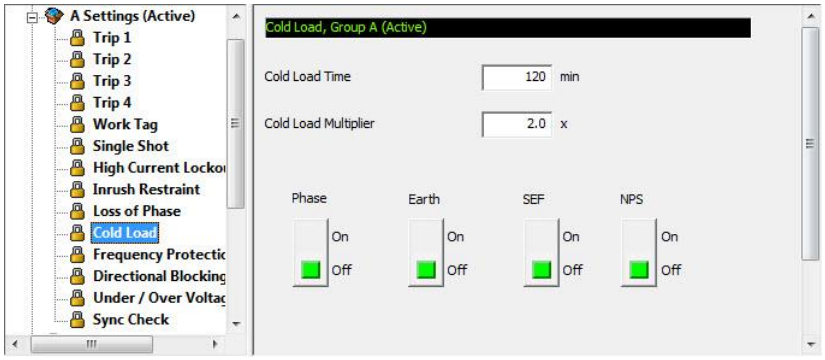



**Figure 151**
WSOS Cold Load settings

The default settings effectively say that the load is expected to completely lose its diversity when it's been without supply for 120 minutes after which time the Setting Currents for the selected elements would need to be raised x 2 that is doubled.

CLP can be configured in WSOS on the

**Protection** > **Cold Load page** or on the operator interface, page 697.

CLP is configured per protection group.

## CLP Operation

The Cold Load Multiplier setting is the maximum value for the multiplier applied to the Setting Current for the selected protection elements.

Whenever the Cold Load timer is running, the actual multiplier being applied is known as the **Operational Cold Load Multiplier (OCLM)**.

The Operational Cold Load Multiplier is calculated using the following formula:

$$\text{Operational Cold Load Multiplier} = 1 + \frac{\text{Operational Cold Load Time}}{\text{User Set Cold Load Time}} \times \text{User Set Cold Load Multiplier} - 1)$$

Where the Operational Cold Load Time is the time the supply has been lost minus any time it's been back on.

So when the supply is off, the Operational Cold Load Time is increasing and when the supply is on, the Operational Cold Load Time is decreasing.

This means the OCLM will have a minimum value of 1, and a maximum value equal to the User Set Cold Load Multiplier setting.

Consider a situation where the supply has been off for 60 minutes. If the controller was configured with the default CLP settings, the OCLM would be:

$$\text{Operational Cold Load Multiplier} = 1 + \frac{60}{120} \times (2 - 1)$$

Therefore after the supply had been off for 60 minutes, a multiplier of 1.5 would be applied to the Setting Currents.

So the OCLM would increase linearly from x1 to x2 over a 120 minute period while the supply was off.

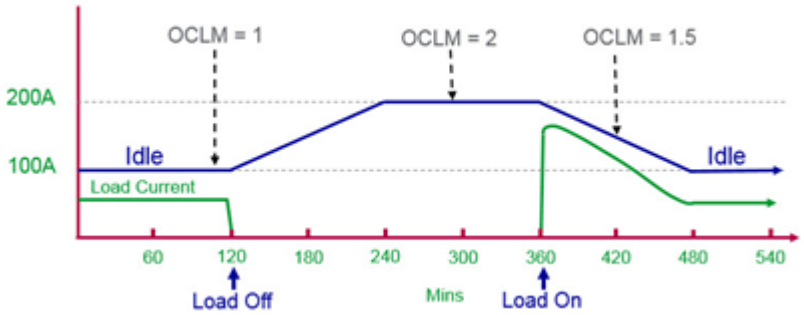
When the supply is restored, the OCLM would start at x2 and decrease linearly to x1 over the next 120 minutes if the supply stays on.

While the Cold Load timer is running the controller calculates the OCLM every minute.

## CLP Example

The situation described above is depicted graphically in the figure below.

**NOTE:** The Setting Current is 100 A.

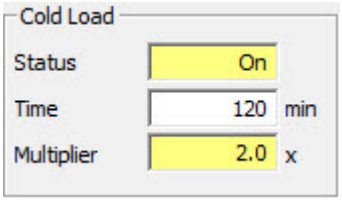



In this example the supply goes off for four hours. Over the first two hours, the OCLM increases from x1 to x2. The supply stays off for another two hours but the OCLM doesn't increase any further because it's reached its maximum setting. When the supply comes back on, the load current is significantly higher than usual but doesn't cause a protection pickup because it doesn't exceed the Setting Current x the OCLM.

Over the next two hours the OCLM ramps down from x2 to x1 and is always above the load current which also tapers off over that time.

## CLP Status

The current status of the CLP is displayed by WSOS on the Control page.




The **Status** is read-only and can be either Off, On or Idle.

Off – means that the feature is off and will have no effect on the protection settings.

On – means that at least one of the CLP protection elements is on and the displayed Multiplier is being applied to the Setting Current for that elements.

Idle – means that the feature is on but not currently affecting the protection settings.

**Time** – is the Operational Cold Load Time. Note this field is configurable.

**Multiplier** – is the current OCLM and is read-only.

The CLP Status is also displayed on the operator interface.

CLP cannot be turned On or Off via the Status display. That can only be done by selecting/deselecting one of the protection elements in the CLP protection settings.

## Cold Load Status on Power Up

The CLP status can be changed from the status display by changing the time.

Consider a situation where the load has been off and the controller powered down for some hours due to module replacement/maintenance etc.

The controller was powered down during the outage so when it is powered up again it assumes the load to be diverse that is the Operational Cold Load Time is zero and the CLP status will be Idle.

Because the CLP status time is an operator setting it can be manually adjusted to reflect the duration of the outage and thus allow for the load that might occur when the ACR goes back into service.

## Example

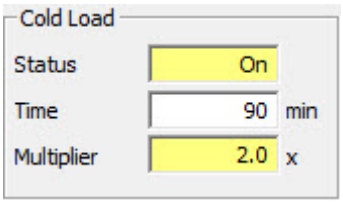
If the CLP settings are:

Cold Load Time 180 minutes

Cold Load Multiplier x3

And it is expected that the Setting Currents need to be doubled for the anticipated increase in load.

That can be achieved by setting the Cold Load Operational Time to 90 minutes as shown below.




Changing the Operational Cold Load Time automatically changes the Operational Cold Load Multiplier according to the active Cold Load settings.

## CLP Summary

- The user-set Cold Load time and Cold Load Multiplier are protection settings, only the Cold Load Status/Time is an operator setting.
- Only the protection elements that are selected, Phase, Earth, SEF, and NPS, are affected by the Cold Load Multiplier.
- Definite Time settings are not affected.
- CLP cannot be used if normal load currents are expected to drop below 2.5 A.

  **NOTE:** It is possible for Cold Load and Inrush Restraint to be applying multipliers at the same time.

In this situation, Inrush will use the Operational Cold Load Multiplier if it is the higher.

**Table 45 CLP Settings/Specifications**

| CLP Settings/Specifications | |
|---|---|
| Cold Load Multiplier Range | 1...5 |
| Cold Load Multiplier Resolution | 0.1 |
| Cold Load Time Constant Range | 1...480 minutes |
| Cold Load Time Constant Resolution | 1 minute |
| Timing Accuracy | ± 1 minute |

# Conditional Auto Reclose

Conditional Auto Reclose is a means of inhibiting an automatic reclose operation unless a predetermined condition has been met.

This feature works in conjunction with an IOEX card and requires a custom IOEX mapping file incorporating two dedicated database points.

- One database point indicates the ACR's intent to trip.
- The second database point will block reclose operations if not asserted.

There is a maximum time that can elapse between when the ACR trips and when a conditional auto reclose can occur, otherwise the ACR will go to lockout.

## History

This feature was added for operators with distributed generation (DG) downstream of an ACR helps to prevent out-of-phase reclosing occurring where ACR operation causes islanding of DG devices.

The figure below depicts a system with an ACR and three downstream DG devices which exchange signals when the ACR protection operates.

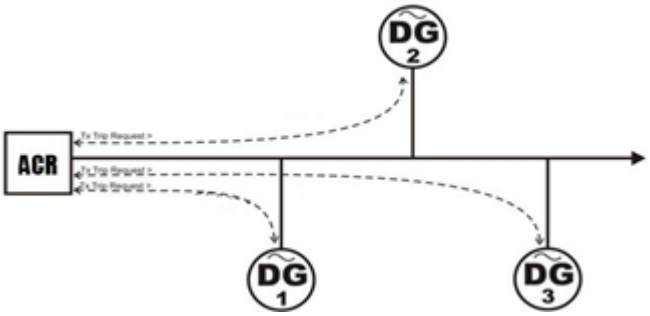



**Figure 152**
Conditional Auto Reclose Situation

## Conditional Auto Reclose Configuration

Conditional Auto Reclose must be made available before it can be used.

In WSOS this feature can be made available by selecting:

**Display** > **Configuration** > **Feature Selection** > **Protection** > **Conditional Auto Reclose Available**.

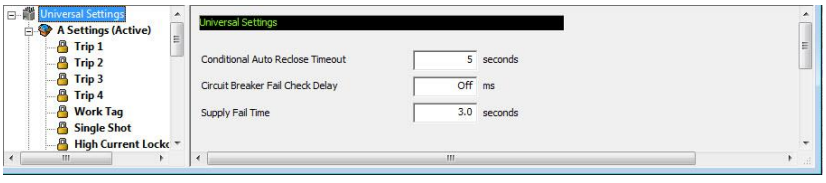
On it can be made available on the operator interface, page 697.

Once Conditional Auto Reclose has been made available it can be configured with a single setting: Conditional Auto Reclose Timeout.

This setting determines the maximum time that can elapse between when the ACR trips and when a conditional automatic reclose can occur.

To configure this setting in WSOS go to:

**Display** > **Protection** > **Universal Settings**.




The Conditional Auto Reclose Timeout setting can also be configured on the operator interface, page 697.

# IOEX Configuration

There are two database points available in the IOEX Configuration Toolbox that can be used to build an IOEX map for use with Conditional Auto Reclose.

| **Digital Controls (IOEX Input)** | |
|---|---|
| **Name** | **Description** |
| Conditional Auto Reclose | This point is checked prior to each Auto Reclose only when the Conditional Auto Reclose feature is available.<br><br>If this point is high, then an automatic reclose is allowed. Otherwise the reclose is delayed until this point goes high providing it does so within a configurable time out period. If the time out period expires before this point goes high the ACR will go to lockout. |
| **Digital Data (IOEX Output)** | |
| **Name** | **Description** |
| Trip Request | This point is set when a Trip Request is issued. |

## IOEX Outputs

The IOEX map requires a separate Output configured for each DG device required to be tripped. The figure below shows Outputs 2, 3, and 4 configured for DG's 1, 2, and 3 respectively.

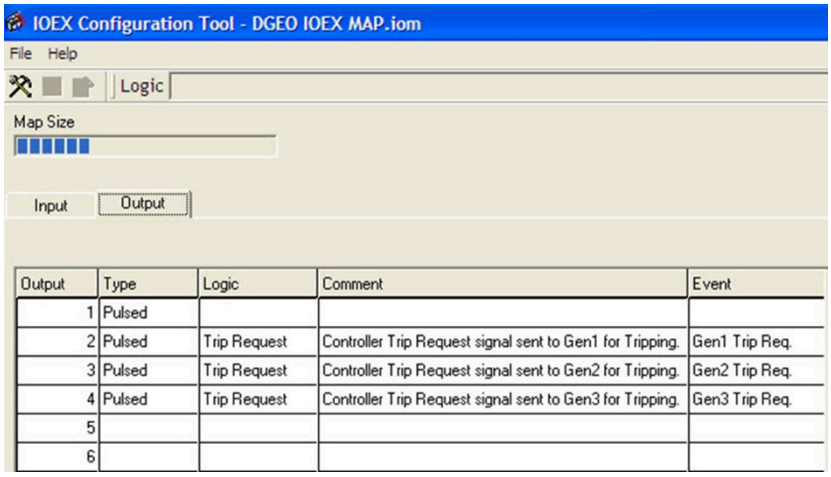



**Figure 153**
IOEX Outputs for Conditional Auto Reclose map

## IOEX Inputs

The IOEX 6 Input shown in the figure below must be hardwired permanently High but is only asserted when its logic is True.

The logic requires Inputs 2, 3, and 4 to be wired to go High when they receive trip confirmation signals from DG devices 1, 2, and 3 respectively.

Alternatively, trip confirmation signals can be bypassed by Protocol IOEX controls.

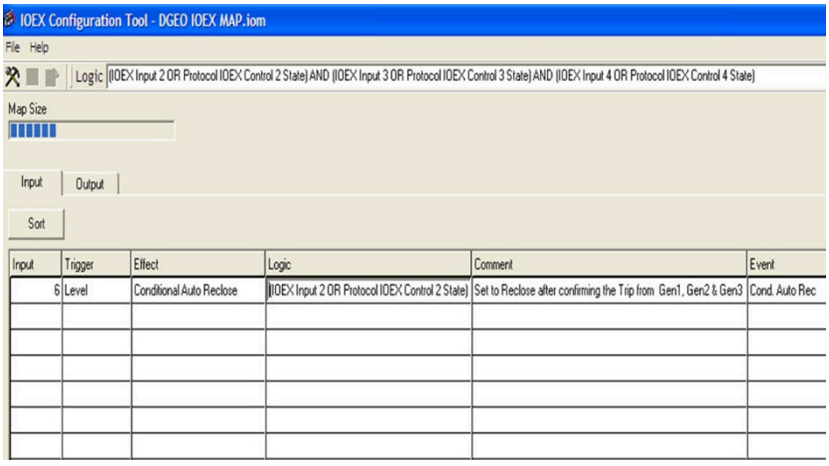



**Figure 154**
IOEX Input for Conditional Auto Reclose map

The logic for the IOEX Inputs is shown in the figure below.

> **NOTE:** Each input is OR'd with a protocol IOEX control that can be used to bypass individual DG devices if required.

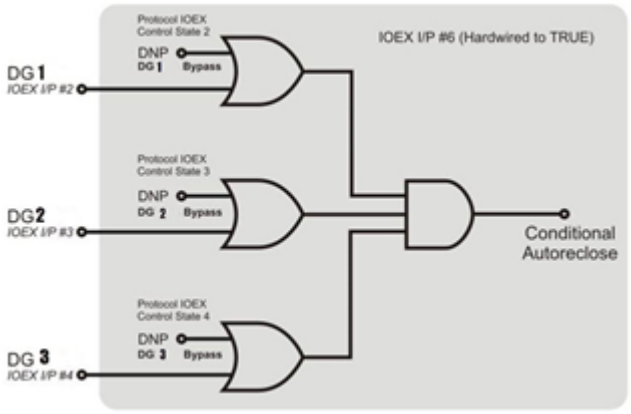



**Figure 155**
Conditional Auto Reclose IOEX Input Logic

## Conditional Auto Reclose Operation

- Separate IOEX outputs are asserted for each downstream DG device when the controller sends a trip signal to the ACR switchgear.
- These outputs are used to send trip signals (commonly known as Transfer Trip Signals) to the DG devices.
- When each DG device trips, it sends a signal back to the ACR to assert an IOEX input that identifies with that particular device.
- When a trip confirmation signal has been received from each DG device, the logic for the IOEX Conditional Auto Reclose input becomes true and the Auto Reclose inhibit is removed.

There are a number of scenarios that can occur.

**Scenario No 1** – All trip confirmation signals received from DG devices within the Reclose Time.

- If the applicable Auto Reclose Time has not already expired before all of the DG confirmation signals are received, the ACR will automatically reclose as configured.

**Scenario No 2** – All DG trip confirmation signals received within the Auto Reclose Conditional Timeout period.

- If the Auto Reclose Time expires before the trip confirmation signal is received from all of the DG devices, automatic reclose will still occur providing they are all received within the Auto Reclose Conditional Timeout period.

**Scenario No 3** – Some DG trip confirmation signals received after the Auto Reclose Conditional Timeout period.

- If not all of the DG trip confirmation signals have been received by the time the Auto Reclose Conditional Timeout period expires, the ACR will go to Lockout.

## Conditional Auto Reclose Bypass

The signals from individual DG devices can be by-passed with SCADA controls if required.

Either a trip confirmation signal OR a SCADA IOEX control for the same input will satisfy the logic for that input.

# Ground Fault Neutralizer

The Ground Fault Neutralizer (GFN) features allows the PowerLogic ADVC Controller protection to better deal with Earth and Sensitive Earth Faults in systems with resonant earthing along with GFN/Rapid Earth Current limiting devices.

## GFN Configuration

If required to be used, GFN must firstly be made available through feature selection.

This can only be done in WSOS at:

**Display** > **Configuration** > **Feature Selection** > **Protection** > **GFN Available**.

Once GFN has been made available it can be enabled and configured in WSOS by opening the Protection page and selecting Universal Settings.

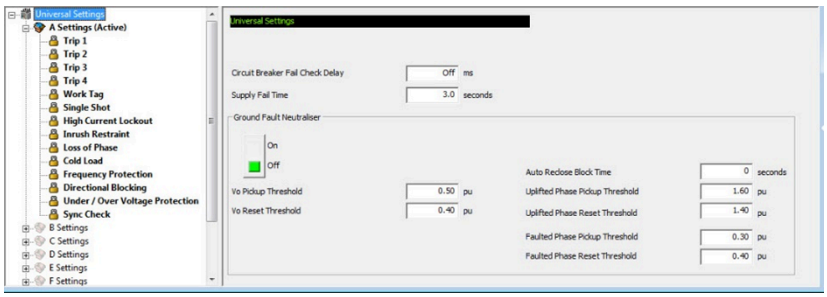



**Figure 156**
WSOS GFN settings

GFN is configured with the following settings.

### GFN On/Off

Enable/Disable the GFN functionality.

### Auto Reclose Block Time

This is a user configurable timer which is triggered when GFN resets on clearance of a network earth fault. Auto Reclose functionality will be disabled until the expiry of this timer.

The rest of the settings are based on voltage measurement and detection of a network earth fault. All these voltage setting values are configured on a per unit basis with reference to the nominal Phase–Ground/Earth voltage setting.

### $V_0$ Pickup Threshold

If the measured zero sequence voltage exceeds the $V_0$ Pickup Threshold setting value it will trigger a GFN pickup condition.

### $V_0$ Reset Threshold

If the measured zero sequence voltage value is less than the $V_0$ Reset Threshold setting it will trigger a GFN reset condition.

**NOTE:** The Zero Sequence Voltage setting value must be carefully chosen considering the default system $V_0$ prevailing in the network.

### Uplifted Phase Pickup Threshold

If the measured phase–ground/earth voltage on any two phases exceeds the Uplifted Phase Pickup Threshold setting value it will trigger a GFN pickup condition.

This setting monitors the phase–ground/earth voltage for any of the two un-faulted phases. Generally, this voltage setting must be more than the nominal phase–ground/earth voltage.

### Uplifted Phase Reset Threshold

If the measured phase–ground/earth voltage on any two phases is less than the Uplifted Phase Reset Threshold setting value it will trigger a GFN reset condition.

### Faulted Phase Pickup Threshold

If the measured phase–ground/earth voltage on any one phase exceeds the Faulted Phase Pickup Threshold setting it will trigger a GFN pickup condition.

Generally, this voltage setting must be less than the nominal phase–ground/earth voltage.

## GFN Operation

GFN is asserted for a network ground/EF when each of the following criteria are met:

1. Zero Sequence Voltage ($V_0$) magnitude is greater than or equal to a user defined GFN threshold setting.
2. Phase-Earth voltages on two phases are above a user defined GFN uplifted phase voltage threshold setting.
3. Phase-Earth voltage on one phase is less than a user defined GFN faulted phase voltage threshold setting.

The following functions of the ACR are disabled when GFN is asserted:

- EF protection
- SEF protection
- Automatic Reclose

On clearance of a ground/EF and when GFN resets, the following ACR functions are in immediate effect:

- EF protection
- SEF protection
- Start of user configured Auto Reclose block time
- Inhibit of Auto Reclose function until the user configured block time expires

A recurrence of a ground/EF that causes GFN to be asserted before the expiry of the Auto Reclose Block time will result in:

- EF protection disabled
- SEF protection disabled
- Auto Reclose functionality disabled and the Auto Reclose Block timer reset to the user configured value

A recurrence of a ground/EF that causes GFN to be asserted after the expiry of the Auto Reclose Block time will result in:

- EF protection disabled
- SEF protection disabled
- Auto Reclose functionality disabled

**Table 46 GFN Settings/Specifications**

| **GFN Settings/Specifications** | | |
|---|---|---|
| **Setting** | **Minimum Value** | **Maximum Value** |
| $V_0$ Pickup Threshold | $V_0$ Reset Threshold setting + 0.02 pu | 2.00 pu |
| $V_0$ Reset Threshold | 0.00 pu | $V_0$ Pickup Threshold – 0.02 pu |
| Auto Reclose Block Time | 0 s | 3600 s |
| Uplifted Phase Pickup Threshold | Uplifted Phase Reset Threshold setting + 0.02 pu | 2.00 pu |
| Uplifted Phase Reset Threshold | 0.00 pu | Uplifted Phase Pickup Threshold – 0.02 pu |
| Faulted Phase Pickup Threshold | 0.00 pu | Faulted Phase Reset Threshold setting – 0.02 pu |
| Faulted Phase Reset Threshold | Faulted Phase Pickup Threshold setting + 0.02 pu | 2.00 pu |

# Directional Protection and Blocking

## Directional Blocking

### Overview

ASs are sometimes installed in network configurations where power flow could be in either direction through the switchgear.

Directional Blocking can be used when the ACR is only required to trip for faults on either the load or source side. When power flows from Source to Load, the power flow is deemed to be forward. Reverse power flows from Load to Source.

The Source and Load sides of the switchgear are configurable through the Power Direction setting.




The Power Direction setting can be found on the WSOS Measurements page, page 148 or on the operator interface, page 697.

Directional Blocking is an optional protection feature that will only allow a fault to cause a protection trip when power flow is in the designated directions for the faulted element.

Each overcurrent element, Phase, Earth, SEF, and NPS if configured can be set for a Fault Detection Direction of:

- Forward Fault
- Reverse Fault
- Forward and Reverse Fault (non-directional)

Directional Blocking uses only one active detection group that determines the pickup and detection timing for faults detected in the designated fault detection direction for each element.

If a fault is determined to be in the designated fault detection direction, detection will be armed.

If a fault is determined to not be in the designated fault detection direction, detection will be blocked.

Directional Blocking can only be turned on from the WSOS Feature Selection page.

It can't be turned on from the Options pages on the ***set*VUE** O.I. or the Feature Selection pages on the ***flex*VUE** O.I.

## Determining Direction

The user must set a **Characteristic Angle** for each element. The Characteristic Angle is essentially a prediction of the expected fault angle when a forward fault occurs. The fault angle is defined according to the polarising method for each element and is effectively the phasor relationship between the fault current and the polarising voltage. A forward fault is one where the fault angle is within ± 90° of the Characteristic Angle.

For any given fault, the actual fault angle will be determined by network characteristics such as line resistance and reactance as well as fault characteristics such as the nature of the short circuit, solid, or arcing etc.

It is not necessary that the fault angle matches the Characteristic Angle precisely. There are only two possibilities for direction, forward and reverse. As long as the fault angle is at the Characteristic Angle ± 90° it will be recognized as a forward fault. Otherwise it is a reverse fault.

Each element takes 20 ms to determine the direction of a fault once it has been detected. This delay occurs prior to the trip timing and adds to the actual time to trip.

The figure below demonstrates a Characteristic Angle of +45° with phasors representing possible fault angles on either side. Both of these fault angles represent forward faults as they are well within the forward fault region (135° to -45°).

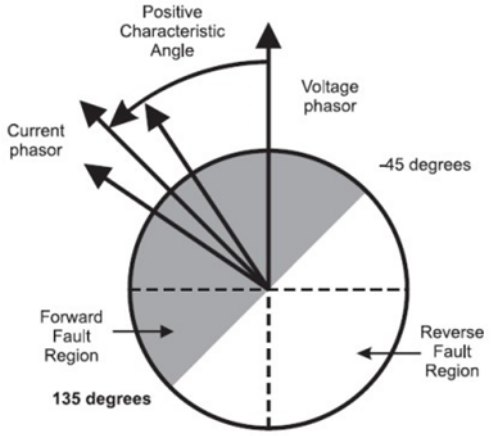



**Figure 157**
Directional Blocking Forward and Reverse Sectors

## Low V Block

In order to determine the direction of a fault that caused a pickup, the controller requires a Polarizing Voltage. If there is a bolted phase fault on the terminals of the switchgear there may not be sufficient voltage to determine the direction of the fault. Directional Blocking includes two settings per element to deal with low polarising voltage.

- Low Block
- Low Threshold

If the polarising voltage is below the Low Threshold setting for the faulted element, the Low Block setting will determine what action must be taken.

If Low Block is **Off**, the fault is assumed to be in the tripping direction and the device will trip according to the fault level.

If Low Block is **On**, Polarizing voltage below the Low Threshold setting will helps to prevent tripping.

## Sector Width

Each element will have either a **Forward Sector Width** setting if the Tripping Direction is Trip Forward, or a **Reverse Sector Width** setting if the Tripping Direction is Trip Reverse.

If the Tripping Direction is set for Trip Forward and Reverse, Sector Width is meaningless and the setting is not displayed.

The **Forward Sector Width** setting is the angle that the deviation of the calculated fault angle from the Characteristic Angle needs to be equal to or less than to be deemed a forward fault.

The **Reverse Sector Width** setting is the angle that the deviation of the calculated fault angle from the Characteristic Angle plus 180° needs to be equal to or less than to be deemed a reverse fault.

## $V_{zps}$ Balance

$V_{zps}$ is the polarising voltage for many of the polarising methods used by Directional Blocking.

Even in un-faulted networks the ZPS voltage is not likely to be zero because the three phase voltages are not going to be balanced.

This could lead to problems in high impedance fault conditions because the $V_{zps}$ due to an earth fault might be dominated by the $V_{zps}$ due to out of balance phase voltages, and this could lead to an incorrect determination of direction.

$V_{zps}$ Balancing is provided to overcome this by continuously balancing the phase voltages under normal conditions and compensating for imbalance between the three phase voltage measurements.

$V_{zps}$ Balance can be turned On in WSOS on the Directional Blocking page or on the operator interface.

When balancing is enabled, the zero sequence voltage is continually balanced at the rate of 0.6% of phase to earth voltage per second until zero $V_{zps}$ has been achieved.

Balancing is paused when any of the following conditions occur:

- Detection pickup
- The SCEM data is not valid
- The switchgear is open
- Any of the bushings are dead

$V_{zps}$ Balance status is displayed in WSOS under Controller Status on the Control page.

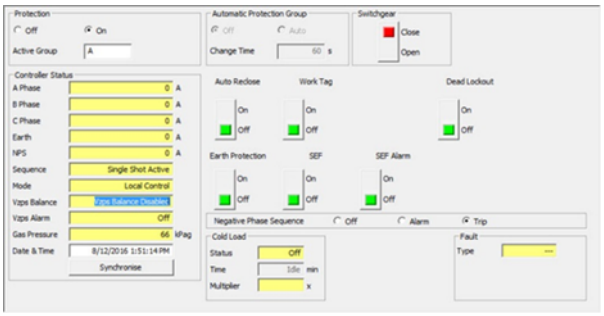



**Figure 158**
WSOS $V_{ZPS}$ Balance Status

When balancing is enabled the status displays **$V_{zps}$ Balancing** while the system is continually adjusting for balance, and **$V_{zps}$ Paused** when the balancing is suspended for one of the reasons above.

When balancing is disabled the display shows **$V_{zps}$ Balance Disabled**.

## High $V_{zps}$ Alarm

The Directional Blocking facility includes a High ZPS Voltage alarm. This indication can be useful in unearthed neutral networks for earth fault detection.

The high $V_{zps}$ alarm is asserted whenever the Alarm Set-point is exceeded for the Alarm Timeout period. Regardless of whether SEF protection is picked up or not. The alarm is cleared when $V_{zps}$ falls below the Alarm Set-point again.

The High $V_{zps}$ Alarm can be turned on and configured via WSOS on the Directional Blocking page.

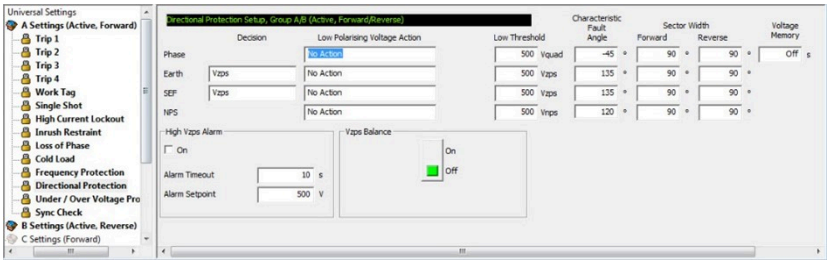


**Figure 159**
WSOS High $V_{ZPS}$ Alarm settings

High $V_{zps}$ Alarm can also be configured on the operator interface, page 703.

The alarm status is displayed by WSOS on the Control page under Controller Status as well as on the operator interface.

The High $V_{ZPS}$ alarm is available for transmission by telemetry protocols.

# Phase Overcurrent Directional Blocking

The direction of a phase overcurrent fault can be determined by the relationship between the phase current and phase voltage in the faulted phases.

The tripping direction for phase faults may be:

- Trip Forward
- Trip Reverse
- Trip Forward and Reverse (that is non directional)

In order to minimize the effect of reduced voltage in faulted phases, phase protection uses quadrature voltage for polarization.

However the quadrature voltage angle is compensated by 90° to offset the inherent 90° phase shift. This gives a fault angle that relates to the phase angle between the phase current and the phase voltage.

## Example

Consider a single A phase fault where the A phase current lags the A phase – earth voltage by 45°,

The fault current would be IA and the polarising voltage would be the quadrature voltage $V_{B-C}$ + 90°.

The fault angle would be ($V_{B-C}$ + 90°) → $I_A$.

Assuming balanced voltages and ABC rotation with A phase at 0°, $V_{B-C}$ would be at 270°.

Compensated $V_{B-C}$ would be 360° or 0°.

Therefore the fault angle would be (360 → -45) = 315° = -45°.

## Phase Characteristic Fault Angle

The Characteristic Angle defines the forward and reverse fault regions for the network.

When a phase fault is detected, its fault angle is calculated and compared to the Phase Characteristic Angle to determine if the fault is forward or reverse.

If the fault angle is within ± 90°(5) of the Characteristic Angle the fault is forward, otherwise it is a reverse fault.

The Phase Characteristic Angle is configurable over the range -179° to 180°.

-45° is the default Characteristic Angle for Phase faults. So an A phase fault where the fault current lagged the polarising voltage by 45° would be a forward fault in the centre of the forward sector. The Angle at Fault reported in the Event Log would be -45° .

When Protection Groups A and B are active, the Event Log will also record:

(5) Assumes default settings for Forward and Reverse Sector Widths that is 90°

- Forward Pickup Phase A
- Protection Group A Active
- Forward Phase Protection Trip
- Angle at Fault -45°
- Polarising Voltage at Trip $V_{QUAD}$
- Polarising Voltage at the Maximum $V_{QUAD}$

A reverse fault where the fault current led the polarising voltage by 135° would log the events below.

- Reverse Pickup Phase A
- Protection Group B Active
- Reverse Phase Protection Trip
- Angle at Fault 135°
- Polarising Voltage at Trip $V_{QUAD}$
- Polarising Voltage at the Maximum $V_{QUAD}$

Phase fault currents and their associated quadrature voltages are shown in the table below.

| Fault Current | Quadrature Voltage |
|---|---|
| $I_A$ | $V_{B-C}$ |
| $I_B$ | $V_{C-A}$ |
| $I_C$ | $V_{A-B}$ |

## Phase Sector Width

The default Forward and Reverse Sector Width settings for phase protection are both 90°. These are ± settings and equate to actual sector widths of 180°.

The forward sector is centred on the Characteristic Angle and the reverse sector is centered on the Characteristic Angle –180°.

The likelihood of a fault angle causing an incorrect direction determination may be lessened by either increasing or decreasing the Sector Width setting. The range of these settings is 45° to 135° which equate to actual sector widths of 90° and 270° respectively.

## Phase Low Voltage Block

When the Phase Low Block setting is On, tripping is blocked if the polarising voltage is below the Low Threshold setting.

The Event Log will record the following events:

- Phase Directional Low $V_{Blocked}$
- Polarizing Voltage Low $V_{QUAD}$

When the Phase Low Block setting is Off, the polarising voltage is disregarded and the action is entirely based on the calculated fault angle relative to the Phase Characteristic Fault Angle.

So if the polarising voltage is below the Low Threshold setting, a protection trip will occur but no fault angle will be logged.

The Event Log will record:

- Pickup
- Phase Directional Low $V_{Armed}$
- Polarizing Voltage Low $V_{QUAD}$
- Phase Protection Trip

- Phase Low V
- Polarizing Voltage at trip $V_{QUAD}$
- Polarizing Voltage at the maximum $V_{QUAD}$

The default Phase Low Threshold setting is 500 $V_{QUAD}$ configurable over the range 150...15,000 $V_{QUAD}$.

## Phase Low Voltage Reset

Once the polarising voltage for phase faults has been deemed to be Low, it will not return to Normal until either the fault resets or the measured polarising voltage exceeds the Low Threshold setting by 10%. So if the Low Threshold setting is 500 $V_{QUAD}$ and a Low Voltage condition exists, $V_{QUAD}$ will have to rise to 550 $V_{QUAD}$ before the Low V condition is cancelled.

## Phase Voltage Memory

Three phase faults are the most likely to cause a low voltage condition. In this case a memorized voltage can be used for polarization.

Voltage Memory is Off by default so if this feature is required to be used it must be enabled and configured for a time period between 0.01...10.00 s.

When Voltage Memory is enabled, the controller maintains a memory of the polarising voltage $V_{QUAD}$ updated every 4 ms. If a three phase fault causes all three phase voltages to drop sharply, the last value of $V_{QUAD}$ sampled before it fell below the Low Threshold setting is frozen in memory. That value is maintained in memory and used for polarization for the configured Voltage Memory time.

When a memorized voltage has been used for polarization, the values are identified in the Event Log by an asterisk '*'. For example,

- Angle at Fault* -45°
- Polarizing Voltage at Trip* $V_{QUAD}$

After the Voltage Memory time expires, the memorized polarising voltage is set to zero. However if the controller is in pickup when the Voltage Memory time expires, the direction that was determined using the memorized voltage will be maintained as long as the pickup is active.

If a pickup occurs after the memorized polarising voltage has been set to zero, the Low V Block action will be used.

# EF Directional Blocking

The tripping direction for EFs may be:

- Trip Forward
- Trip Reverse
- Trip Forward and Reverse (that is non directional)

When EF Directional Blocking is used, one of three methods can be used to determine the direction of an EF.

- $V_{ZPS}$
- Wattmetric
- Ir Cos (Ø)

$V_{ZPS}$ is the default option. The Decision setting determines the method used. Operating Quantities, Fault Angles and default Characteristic Angles for each method are shown in the table below.

**Table 47 Directional Blocking EF Polarizing Methods**

| Polarizing Method (Decision) | Operating Quantity | Fault Angle | Angle logged on Trip | Default Characteristic Angle |
|---|---|---|---|---|
| $V_{ZPS}$ | Earth Current Ir ($I_{ZPS}$x3) | $V_{ZPS} \rightarrow I_{ZPS}$ | $V_{ZPS} \rightarrow I_{ZPS}$ | 135° Configurable |
| Wattmetric | Residual Power<br>($V_{ZPS}$x3) x ($I_{ZPS}$x3) x Cos (FA) | $V_{ZPS} \rightarrow I_{ZPS}$ | ($V_{ZPS} \rightarrow I_{ZPS}$) – CA (180°) | 180° Fixed |
| Ir Cos (Ø) | Active Earth Current<br>($I_{ZPS}$x3) x Cos (FA) | $V_{ZPS} \rightarrow I_{ZPS}$ | $-V_{ZPS} \rightarrow I_{ZPS}$ – CA (180°) | 180° Fixed |

## Earth $V_{ZPS}$ Polarization

With Earth $V_{ZPS}$ polarization, the operating quantity is earth current (3 x $I_{ZPS}$) and the fault angle is the zero sequence current angle with respect to the zero sequence voltage angle ($V_{ZPS} \rightarrow I_{ZPS}$).

For demonstration purposes, the figure below substitute's residual current and voltage for zero sequence current and voltage. Although they have different magnitudes, the angles are the same.

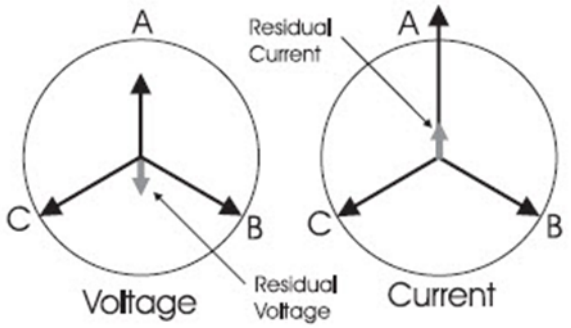



**Figure 160**
EF Current and Voltage Phasors

This figure shows phasor diagrams for voltage and current during a hypothetical purely resistive A phase to EF on an earthed neutral system.

The fault causes A phase voltage to reduce and the residual voltage phasor is 180° out of phase as shown in Figure 160.

The current in A phase is increased and the residual current phasor is in phase with A phase current.

The fault angle for this fault is 180° that is the residual current is 180° out of phase with the residual voltage.

The actual fault angle for an EF is determined by the network characteristics (line resistance and reactance, neutral earthing arrangement) and the fault characteristic (such as the nature of the short-circuit – solid or arcing, fault impedance, and earth resistance).

## Earth Ir Cos (Ø) Characteristic Fault Angle

When a forward EF occurs on a compensated earthing system, $V_{ZPS}$ and $I_{ZPS}$ are assumed to be 180° out of phase.

Therefore the Characteristic Angle for Ir Cos (Ø) is fixed at 180°.

The Ir Cos (Ø) Fault Angle for a given fault is the Zero Sequence Current angle relative to the Zero Sequence Voltage angle $V_{ZPS} \rightarrow I_{ZPS}$.

The Angle at Fault recorded in the Event Log is the fault angle relative to the Characteristic Angle which is fixed at 180°.

So a fault with a Fault Angle ($V_{ZPS} \rightarrow I_{ZPS}$) = 135° would log an Angle at Fault of -45° (135°-180°) which indicates that the fault angle is lagging the Characteristic Angle by 45°.

Other events that are logged for the above fault include:

- Forward Pickup Earth
- Forward Earth Protection Trip
- Angle at Fault -45°
- Quantity at trip Earth/SEF $I_R$Cos Ø – xx.xx A
- Polarizing Voltage at trip $V_{ZPS}$
- Quantity at the maximum Earth/SEF – Maximum $I_R$Cos Ø - xx.xx A
- Polarizing Voltage at the maximum $V_{ZPS}$

## Earth $V_{ZPS}$ Sector Width

The default Forward and Reverse Sector Width settings for earth protection are both 90°. These are ± settings and equate to actual sector widths of 180°.

The likelihood of a fault angle causing an incorrect direction determination may be lessened by either increasing or decreasing the Sector Width setting. The range of these settings is 45° to 135° which equate to actual sector widths of 90° and 270° respectively.

## Earth $V_{ZPS}$ Low Voltage Block

When the Earth Low Block setting is On, tripping is blocked if the polarising voltage is below the Low Threshold setting.

The Event Log will record the following events:

- Earth Directional Low V Blocked
- Polarizing Voltage Low $V_{ZPS}$

When the Low Block setting is Off, the polarising voltage is disregarded and the action is entirely based on the calculated fault angle in relative to the Earth Characteristic Fault Angle.

So if the polarising voltage is below the Earth Low Threshold setting, a protection trip will occur but no fault angle will be logged.

The Event Log will record:

- Earth Directional Low V Armed
- Polarizing Voltage Low $V_{ZPS}$
- Earth Protection Trip
- Earth Low $V_{ZPS}$
- Polarizing Voltage at trip $V_{ZPS}$
- Polarizing Voltage at the maximum $V_{ZPS}$

The default Earth Low Threshold setting is 500 $V_{ZPS}$ configurable over the range 150...15,000 $V_{ZPS}$.

## Earth $V_{ZPS}$ Low Voltage Reset

Once the polarising voltage has been deemed to be Low, it will not return to Normal until either the fault resets or the measured polarising voltage exceeds the Low Threshold setting by 10%. So if the Low Threshold setting is 500 $V_{ZPS}$ and a Low Voltage condition exists, $V_{ZPS}$ will have to rise to 550 $V_{ZPS}$ before the Low V condition is cancelled.

# Earth Wattmetric Polarizing

Wattmetric is the method normally recommended to be used with a compensated or resistance earthed system. The Wattmetric method for earth fault detection may be applied in all types of distribution systems having low earth-fault values. This includes isolated-neutral high-impedance earthed and compensated systems.

The Wattmetric value is in Watts and is defined as the in-phase residual power given by:

$$\text{Residual Power} = \text{Residual Voltage} \times \text{Residual Current} \times \cos(\emptyset)$$
$$= (V_{ZPS} \times 3) \times (I_{ZPS} \times 3) \times \cos(\emptyset)$$

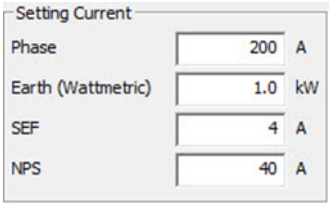
Where Ø is the Fault Angle that is the angle between $V_{ZPS}$ and $I_{ZPS}$.

$V_{ZPS}$ is the polarising voltage.

When Wattmetric is selected as the Earth Directional Blocking Decision WSOS displays this message:




This is because the Earth Pickup Threshold (Setting Current) is now in kilo Watts (kW) as shown below.




The Wattmetric Earth pickup threshold can be set between 0.1 kw and 500.0 kW.

## Earth Wattmetric Characteristic Fault Angle

When a forward earth fault occurs on a compensated earthing system, $V_{ZPS}$ and $I_{ZPS}$ are assumed to be 180° out of phase.

Therefore the Characteristic Angle for Wattmetric is fixed at 180°.

> **NOTE:** When the directional earth fault decision is Wattmetric, the Characteristic Angle is fixed and not displayed.

The Wattmetric Fault Angle for a given fault is the Zero Sequence Current angle relative to the Zero Sequence Voltage angle $V_{ZPS} > I_{ZPS}$.

The Angle at Fault recorded in the Event Log is the fault angle relative to the Characteristic Angle which is fixed at 180°.

So a fault with a Fault Angle ($V_{ZPS} > I_{ZPS}$) = 135° would log an Angle at Trip of -45° (135°-180°) which indicates that the fault angle is lagging the Characteristic Angle by 45°.

When the Earth Tripping Direction is Trip Forward, the above fault will log the following events:

- Forward Pickup Earth
- Earth Directional Armed
- Earth Protection Trip
- Angle at Fault -45°
- Quantity at trip Earth/SEF Wattmetric – xx.xx kW
- Polarizing Voltage at trip $V_{ZPS}$
- Quantity at the maximum Earth/SEF – Maximum Wattmetric - xx.xx kW
- Polarizing Voltage at the maximum $V_{ZPS}$

**NOTE:** The sign of the residual power logged indicates the direction of the fault. A '-' indicates a forward fault and '+' indicates a reverse fault.

## Earth Wattmetric Sector Width

The default Forward and Reverse Sector Width settings for earth protection when the Decision is Wattmetric are both 90°.

These are ± settings and equate to actual sector widths of 180°.

The forward sector is centred on the Characteristic Angle $V_{ZPS} \rightarrow I_{ZPS}$ = 180° and the reverse sector is centred on $V_{ZPS} \rightarrow I_{ZPS}$ = 0°.

The likelihood of a fault angle causing an incorrect direction determination may be lessened by either increasing or decreasing the Sector Width setting. The range of these settings is 45° to 135° which equate to actual sector widths of 90° and 270° respectively.

## Earth Wattmetric Low Voltage Block

When the Earth Low Block setting is On, tripping is blocked if the polarising voltage is below the Low Threshold setting.

In this situation the ACR will still record fault resetting events when the apparent fault goes away as shown:

- Earth Directional Low V Blocked
- Polarizing Voltage Low $V_{ZPS}$
- Quantity at the maximum Earth/SEF – Maximum Wattmetric xx.xx kW
- Polarizing Voltage at the maximum $V_{ZPS}$

When the Low Block setting is **Off**, the polarising voltage is disregarded and the action is entirely based on the calculated fault angle in relative to the Earth Characteristic Fault Angle.

So if the polarising voltage is below the Earth Low Threshold setting, a protection trip will occur but no fault angle will be logged.

The Event Log will record:

- Earth Directional Low $V_{Armed}$
- Polarizing Voltage Low $V_{ZPS}$
- Earth Protection Trip
- Earth Low $V_{ZPS}$
- Quantity at trip Earth/SEF Wattmetric xx.xx kW
- Polarizing Voltage at trip $V_{ZPS}$
- Quantity at the maximum Earth/SEF Wattmetric xx.xx kW
- Polarizing Voltage at the maximum $V_{ZPS}$

The default Earth Low Threshold setting is 500 $V_{ZPS}$ configurable over the range 150...15 000 $V_{ZPS}$.

## Earth Wattmetric Voltage Memory

When Wattmetric is selected as the Decision for directional earth faults, a Voltage Memory time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

Consider a reverse earth fault where $V_{ZPS}$ and $I_{ZPS}$ are in phase and $V_{ZPS}$ is above the Low Threshold setting.

If the earth fault Tripping Direction is Trip Reverse, and the Voltage Memory setting is 2.00 s, this fault will cause a reverse pickup and Earth Directional Armed will be logged.

If $V_{ZPS}$ then drops below the Low Threshold setting before the switchgear trips, this will not cause a Low V condition as the controller will continue to use the last sampled value of $V_{ZPS}$ that was above the threshold as the polarising voltage while the pickup is active.

If the fault persists long enough to cause a trip, the memorized voltage and corresponding fault angle recorded in the Event Log will be identified by an asterisk '*'.

The Event Log will report the following events:

- Reverse Pickup Earth
- Earth Directional Armed
- Earth Protection Trip
- Angle at Fault* 180°
- Quantity at trip Earth/SEF Wattmetric xx.xx kW
- Polarising Voltage at trip* $V_{ZPS}$ 514 V
- Quantity at the maximum Earth/SEF Maximum Wattmetric xx.xx kW
- Polarising Voltage at the maximum $V_{ZPS}$ 601 V

**NOTE:**

- The Angle at Fault and Polarising Voltage at trip events above are identified as memorized values.
- The Polarising Voltage at trip $V_{ZPS}$ would be expected to be just above the Low Threshold setting (default 500 V).
- The Polarising Voltage at the maximum is not a memorized value as $V_{ZPS}$ was above the Low Threshold setting when the fault first appeared.

## Earth Wattmetric Fault Hold Time

When Wattmetric is selected as the Decision for directional earth faults, a Fault Hold Time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

The effect of the Fault Hold Time is to pause the protection timing for a set period after a fault that caused a pickup has gone away.

When the fault hold time is 2.00 s, a forward earth fault with a tripping time of 3.0 s that goes away after 1.5 s for 1.0 s and then returns will cause a trip after another 1.5 s.

Because the hold time, that is the time that the fault went away for (1.0 s), is a shorter duration than the Fault Hold Time (2.0 s), the pickup will remain active while protection timing is paused and the tripping time will be extended by the Fault Hold Time setting.

The Event Log will record a Paused event to mark the start of the hold time. The events recorded from pickup with relevant time stamps would be:

| Event | Time Stamp |
|---|---|
| Forward Pickup Earth | 00:00:00.00 |
| All protection elements resetting | 00:00:00.00 |

| Event | Time Stamp |
|---|---|
| All protection elements paused | 00:00:01.50 |
| Protection element timing | 00:00:01.50 |
| Forward Earth Protection Trip | 00:00:02.50 |
| Angle at Fault 0° | 00:00:04.00 |
| Quantity at trip Earth/SEF Wattmetric -xx.xx kW | 00:00:04.00 |
| Polarising Voltage at trip $V_{ZPS}$ | 00:00:04.00 |

The fault was paused during the 1.0 s hold time so never reset. When the fault returned a Protection Element Timing event was logged.

**NOTE:** This was not a pickup as a pickup was already active.

The time between pickup and trip would be 4.0 s that is 3.0 s tripping time plus 1.0 s hold time.

## Earth Ir Cos (Ø) Polarising

The Ir Cos (Ø) operating characteristic is used in similar situations to Wattmetric. The operating value is defined as the active component of the residual current given by:

$$\text{Active Earth Current} = \text{Residual Current x Cos } (Ø)$$
$$= (I_{ZPS} \text{ x } 3) \text{ x Cos } (Ø)$$

Where Ø is the Fault Angle that is the angle between the $V_{ZPS}$ and $I_{ZPS}$ phasors.

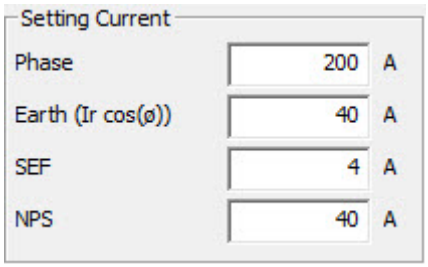
This feature works in a similar manner to Wattmetric with the following differences.

- The Active Current threshold is adjustable in the range 10 to 1260 A in steps of 1 A with a default value of 40 A.
- Ir Cos (Ø) is the value used to determine whether a fault is present, that is the pickup value.

When Ir cos(Ø) is selected as the polarising decision for directional EFs, WSOS displays this message:




This is because the Earth Pickup Threshold (Setting Current) is now set in Ir Cos (Ø) units as shown below.




## Earth Ir Cos (Ø) Characteristic Fault Angle

When a forward EF occurs on a compensated earthing system, $V_{ZPS}$ and $I_{ZPS}$ are assumed to be 180° out of phase.

Therefore the Characteristic Angle for Ir Cos (Ø) is fixed at 180°.

**NOTE:** When the directional EF decision is Ir Cos (Ø), the Characteristic Angle is fixed and not displayed.

The Ir Cos (Ø) Fault Angle for a given fault is the Zero Sequence Current angle relative to the Zero Sequence Voltage angle $V_{ZPS} \rightarrow I_{ZPS}$.

The Angle at Fault recorded in the Event Log is the fault angle relative to the Characteristic Angle which is fixed at 180°.

So a fault with a Fault Angle ($V_{ZPS} \rightarrow I_{ZPS}$) = 135° would log an Angle at Trip of -45° (135°-180°) which indicates that the fault angle is lagging the Characteristic Angle by 45°.

When the Earth Tripping Direction is Trip Forward, the above fault will log the following events:

- Forward Pickup Earth
- Earth Directional Armed
- Earth Protection Trip
- Angle at Fault -45°
- Quantity at trip Earth/SEF $I_R$ Cos Ø – xx.xx A
- Polarizing Voltage at trip $V_{ZPS}$
- Quantity at the maximum Earth/SEF – Maximum $I_R$ Cos Ø - xx.xx A
- Polarizing Voltage at the maximum $V_{ZPS}$

## Earth Ir Cos (Ø) Sector Width

The default Forward and Reverse Sector Width settings for earth protection when the Decision is Ir Cos (Ø) are both 90°. These are ± settings and equate to actual sector widths of 180°.

Sector Width settings are identical for all elements and Decision settings. For more information, refer to Sector Width, page 253.

## Earth Ir Cos (Ø) Low Voltage Block

When the Earth Low Block setting is On, tripping is blocked if the polarising voltage is below the Low Threshold setting.

In this situation the ACR will still record fault resetting events when the apparent fault goes away as shown:

**Fault On**

- Earth Directional Low V Blocked.
- Polarizing Voltage Low $V_{ZPS}$

**Fault Off**

- Quantity at the maximum Earth/SEF – Maximum Ir Cos Ø xx.xx A
- Polarizing Voltage at the maximum $V_{ZPS}$

When the Low Block setting is Off, the polarising voltage is disregarded and the action is entirely based on the calculated fault angle in relative to the Earth Characteristic Fault Angle.

So if the polarising voltage is below the Earth Low Threshold setting, a protection trip will occur but no fault angle will be logged.

The Event Log will record:

- Earth Directional Low V Armed
- Polarizing Voltage Low $V_{ZPS}$
- Earth Protection Trip
- Earth Low $V_{ZPS}$
- Quantity at trip Earth/SEF Ir Cos Ø xx.xx kW

- Polarizing Voltage at trip $V_{ZPS}$
- Quantity at the maximum Earth/SEF Ir Cos Ø xx.xx kW
- Polarizing Voltage at the maximum $V_{ZPS}$

The default Earth Low Threshold setting is 500 $V_{ZPS}$ configurable over the range 150...15,000 $V_{ZPS}$.

## Earth Ir Cos (Ø) Voltage Memory

When Ir Cos (Ø) is selected as the Decision for directional EFs, a Voltage Memory time between 0.01 s and 10.00 s or OFF can be configured.

The default setting is 2.00 s.

Consider a reverse EF where $V_{ZPS}$ and $I_{ZPS}$ are in phase and $V_{ZPS}$ is above the Low Threshold setting.

If the EF Tripping Direction is Trip Reverse, and the Voltage Memory setting is 2.00 s, this fault will cause a reverse pickup and Earth Directional Armed will be logged. If $V_{ZPS}$ then drops below the Low Threshold setting before the switchgear trips, this will not cause a Low V condition as the controller will continue to use the last sampled value of $V_{ZPS}$ that was above the threshold as the polarising voltage while the pickup is active.

If the fault persists long enough to cause a trip, the memorized voltage and corresponding fault angle displayed in the Event Log will be identified by an asterisk '*'.

The Event Log will report the following events:

- Reverse Pickup Earth
- Earth Directional Armed
- Earth Protection Trip
- Angle at Fault* 180°
- Quantity at trip Earth/SEF Ir Cos Ø xx.xx A
- Polarizing Voltage at trip* $V_{ZPS}$ 514 V
- Quantity at the maximum Earth/SEF Maximum Ir Cos Ø xx.xx A
- Polarizing Voltage at the maximum $V_{ZPS}$ 601 V

**NOTE:**

- The Angle at Fault and Polarizing Voltage at trip events above are identified as memorized values.
- The Polarizing Voltage at trip $V_{ZPS}$ would be expected to be just above the Low Threshold setting (default 500 V).
- The Polarizing Voltage at the maximum is not a memorized value as $V_{ZPS}$ was above the Low Threshold setting when the fault first appeared.

## Earth Ir Cos (Ø) Fault Hold Time

When Ir Cos (Ø) is selected as the Decision for directional EFs, a Fault Hold Time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

The effect of the Fault Hold Time is to pause the protection timing for a set period after a fault that caused a pickup has gone away.

When the fault hold time is 2.00 s, a forward EF with a tripping time of 3.0 s that goes away after 1.5 s for 1.0 s and then returns will cause a trip after another 1.5 s. Because the hold time, that is the time that the fault went away for (1.0 s), is a shorter duration than the Fault Hold Time (2.0 s), the pickup will remain active while protection timing is paused and the tripping time will be extended by the Fault Hold Time setting.

The Event Log will record a Paused event during the hold time. The events recorded from pickup with relevant time stamps would be:

| Event | Time Stamp |
|---|---|
| Forward Pickup Earth | 00:00:00.00 |
| Earth Directional Armed | 00:00:00.00 |
| All protection elements resetting | 00:00:01.50 |
| All protection elements paused | 00:00:01.50 |
| Protection element timing | 00:00:02.50 |
| Earth Protection Trip | 00:00:04.00 |
| Quantity at trip Earth/SEF Ir Cos (Ø) xx.xx A | 00:00:04.00 |
| Polarizing Voltage at trip $V_{ZPS}$ | 00:00:04.00 |

The fault was paused during the 1.0 s hold time so never reset. When the fault returned a *Protection Element Timing* event was logged.

**NOTE:** this was not a pickup as a pickup was already active.

The time between pickup and trip would be 4.0 s that is 3.0 s tripping time plus 1.0 s hold time.

# SEF Directional Block

SEF Directional Blocking works the same way as EF and can use the same three methods to determine the direction of a SEF.

- $V_{ZPS}$
- Wattmetric
- Ir Cos (Ø)

$V_{ZPS}$ is the default option. The Decision setting determines the method used. Operating Quantities, Fault Angles, and default Characteristic Angles for each method are shown in the table below.

**Table 80 Directional Blocking SEF Polarizing Methods**

| Polarizing Method (Decision) | Operating Quantity | Fault Angle | Angle logged on Trip | Default Characteristic Angle |
|---|---|---|---|---|
| $V_{ZPS}$ | Earth Current (Ir) | $V_{ZPS} \rightarrow I_{ZPS}$ | $V_{ZPS} \rightarrow I_{ZPS}$ | 135° Configurable |
| Wattmetric | Residual Power<br>$V_{ZPS}$ x $I_{ZPS}$ x Cos (FA) | $V_{ZPS} \rightarrow I_{ZPS}$ | ($V_{ZPS} \rightarrow I_{ZPS}$) – CA (180°) | 180° Fixed |
| Ir Cos (Ø) | Active Earth Current<br>$I_{ZPS}$ x Cos (FA) | $V_{ZPS} \rightarrow I_{ZPS}$ | $-V_{ZPS} \rightarrow I_{ZPS}$ – CA (180°) | 180° Fixed |

Tripping direction options for SEFs regardless of the polarising method are:

- Trip Forward
- Trip Reverse
- Trip Forward and Reverse (that is non directional)

SEF has a default setting current of 4 A and can be configured for between 1 A and 80 A.

## SEF $V_{ZPS}$ Polarising

With SEF $V_{ZPS}$ polarization, the fault angle is the zero sequence current angle with respect to the zero sequence voltage angle ($V_{ZPS} \rightarrow I_{ZPS}$).

For demonstration purposes, the figure below substitute's residual current and voltage for zero sequence current and voltage. Although they have different magnitudes, the angles are the same.

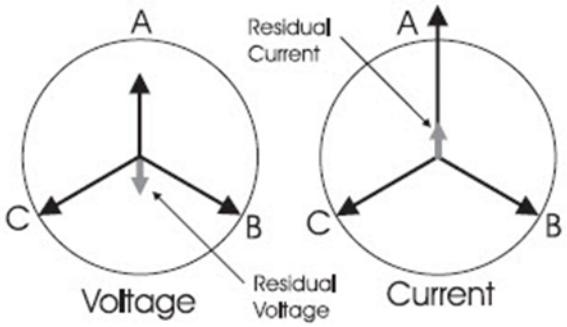



**Figure 161**
SEF Current and Voltage Phasors

This figure shows phasor diagrams for voltage and current during a hypothetical purely resistive A phase to EF on an earthed neutral system.

The fault causes A phase voltage to reduce and the residual voltage phasor is 180° out of phase as shown. The current in A phase is increased and the residual current phasor is in phase with A phase current.

The fault angle for this fault is 180° that is the residual current is 180° out of phase with the residual voltage.

The actual fault angle for an EF is determined by the network characteristics (line resistance and reactance, neutral earthing arrangement) and the fault characteristic (such as the nature of the short-circuit – solid or arcing, fault impedance and earth resistance).

## SEF $V_{ZPS}$ Characteristic Fault Angle

The Characteristic Angle setting for SEF $V_{ZPS}$ polarising is configurable between -179° and 180°.

A typical Characteristic Angle for systems with solidly or impedance earthed transformer neutrals would be approximately +135°.

+135° is the default Characteristic Angle for SEF Directional Blocking. So an A phase to EF where the residual current led the residual voltage by 135° would be a forward fault in the centre of the forward sector.

For this fault the Event Log would record:

- Forward Pickup SEF
- SEF Directional Armed
- SEF Protection Trip
- Angle at Fault 135°
- Polarizing Voltage at trip $V_{ZPS}$
- Polarizing Voltage at the maximum $V_{ZPS}$

## SEF $V_{ZPS}$ Sector Width

The default Forward and Reverse Sector Width settings for SEF protection are both 90°. These are ± settings and equate to actual sector widths of 180°.

Sector Width settings are identical for all elements and Decision settings. For more information, refer to Sector Width, page 253.

### SEF $V_{ZPS}$ Low Voltage Block

When the SEF Low Block setting is On, tripping is blocked if the polarising voltage is below the Low Threshold setting. The Event Log will record the following events:

- SEF Directional Low V Blocked.
- Polarizing Voltage Low $V_{ZPS}$

When the Low Block setting is **Off**, the polarising voltage is disregarded and the action is entirely based on the calculated fault angle in relative to the SEF Characteristic Fault Angle. So if the polarising voltage is below the Earth Low Threshold setting, a protection trip will occur but no fault angle will be logged. Instead the Event Log will record:

- SEF Directional Low $V_{Armed}$
- Polarizing Voltage Low $V_{ZPS}$
- SEF Protection Trip
- SEF Low $V_{ZPS}$
- Polarizing Voltage at trip $V_{ZPS}$
- Polarizing Voltage at the maximum $V_{ZPS}$

### SEF $V_{ZPS}$ Low Voltage Reset

Once the polarising voltage has been deemed to be Low, it will not return to Normal until either the fault resets or the measured polarising voltage exceeds the Low Threshold setting by 10%. So if the Low Threshold setting is 500 $V_{ZPS}$ and a Low Voltage condition exists, $V_{ZPS}$ will have to rise to 550 $V_{ZPS}$ before the Low V condition is cancelled.

## SEF Wattmetric Polarizing

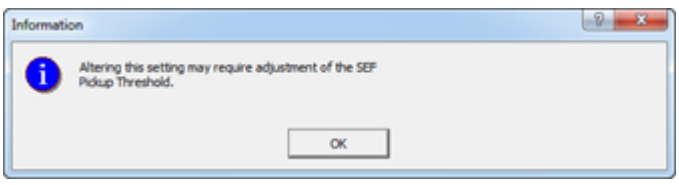
The Wattmetric method for SEF detection may be applied in all types of distribution systems having low EF values. This includes isolated-neutral high-impedance earthed and compensated systems.

The Wattmetric value is in Watts and is defined as the in-phase residual power given by:

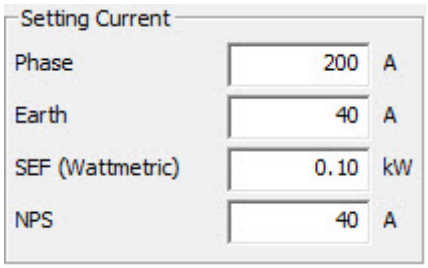
$$\text{Active Earth Current} = \text{Residual Current} \times \text{Cos}(\text{Ø}) = (I_{ZPS} \times 3) \times \text{Cos}(\text{Ø})$$

Where Ø is the Fault Angle that is the angle between $V_{ZPS}$ and $I_{ZPS}$. $V_{ZPS}$ is the polarising voltage.

When Wattmetric is selected as the SEF Directional Blocking Decision WSOS displays this message:




This is because the SEF Pickup Threshold (Setting Current) is now in kilo Watts (kW) as shown below.




The Wattmetric SEF pickup threshold can be set between 0.01 kw and 10.0 kW.

## SEF Wattmetric Characteristic Fault Angle

When a forward SEF occurs on a compensated earthing system, $V_{ZPS}$ and $I_{ZPS}$ are assumed to be 180° out of phase.

Therefore the Characteristic Angle for Wattmetric is fixed at 180°.

The Wattmetric Fault Angle for a given fault is the Zero Sequence Current angle relative to the Zero Sequence Voltage angle $V_{ZPS} \rightarrow I_{ZPS}$.

The Angle at Fault recorded in the Event Log following a fault is the fault angle relative to the Characteristic Angle which is fixed at 180°.

So a fault with a Fault Angle ($V_{ZPS} \rightarrow I_{ZPS}$) = 135° would log an Angle at Trip of -45° (135°-180°). Which indicates that the Fault Angle is lagging the Characteristic Angle by 45°.

When the Earth Tripping Direction is Trip Forward, the above fault will log the following events:

- Forward Pickup SEF
- SEF Directional Armed
- SEF Protection Trip
- Angle at Fault -45°
- Quantity at trip Earth/SEF Wattmetric – xx.xx kW
- Polarising Voltage at trip $V_{ZPS}$
- Quantity at the maximum Earth/SEF – Maximum Wattmetric - xx.xx kW
- Polarising Voltage at the maximum $V_{ZPS}$

## SEF $V_{ZPS}$ Sector Width

The default Forward and Reverse Sector Width settings for SEF protection are both 90°. These are ± settings and equate to actual sector widths of 180°.

Sector Width settings are identical for all elements and Decision settings. For more information, refer to Sector Width, page 253.

## SEF Wattmetric Low Voltage Block

When the SEF Low Block setting is On, tripping is blocked if the polarising voltage is below the Low Threshold setting.

In this situation the ACR will still record fault resetting events when the apparent fault goes away as shown:

**Fault On**

- SEF Directional Low $V_{Blocked}$
- Polarizing Voltage Low $V_{ZPS}$

**Fault Off**

- Quantity at the maximum Earth/SEF – Maximum Wattmetric xx.xx kW
- Polarizing Voltage at the maximum $V_{ZPS}$

When the Low Block setting is Off, the polarising voltage is disregarded and the action is entirely based on the calculated fault angle relative to the SEF Characteristic Fault Angle. So if the polarising voltage is below the SEF Low Threshold setting, a protection trip will occur but no fault angle will be logged.

The Event Log will record:

- SEF Directional Low $V_{Armed}$
- Polarizing Voltage Low $V_{ZPS}$
- SEF Protection Trip
- SEF Low $V_{ZPS}$
- Quantity at trip Earth/SEF Wattmetric xx.xx kW
- Polarizing Voltage at trip $V_{ZPS}$
- Quantity at the maximum Earth/SEF Wattmetric xx.xx kW
- Polarizing Voltage at the maximum $V_{ZPS}$

The default SEF Low Threshold setting is 500 $V_{ZPS}$ configurable over the range 150...15 000 $V_{ZPS}$.

## SEF Wattmetric Voltage Memory

When Wattmetric is selected as the Decision for directional SEFs, a Voltage Memory time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

Consider a reverse SEF where $V_{ZPS}$ and $I_{ZPS}$ are in phase and $V_{ZPS}$ is above the SEF Low Threshold setting.

If the SEF Tripping Direction is Trip Reverse, and the SEF Voltage Memory setting is 2.00 s, this fault will cause a reverse pickup and SEF Directional Armed will be logged.

If $V_{ZPS}$ then drops below the SEF Low Threshold setting before the switchgear trips, this will not cause a Low V condition as the controller will continue to use the last sampled value of $V_{ZPS}$ that was above the threshold as the polarising voltage while the pickup is active.

If the fault persists long enough to cause a trip, the memorized voltage and corresponding fault angle will be identified by an asterisk ‘*’.

The Event Log will report the following events:

- Reverse Pickup SEF
- SEF Directional Armed
- SEF Protection Trip
- Angle at Fault* 180°
- Quantity at trip Earth/SEF Wattmetric xx.xx kW
- Polarizing Voltage at trip* $V_{ZPS}$ 514 V
- Quantity at the maximum Earth/SEF Maximum Wattmetric xx.xx kW
- Polarizing Voltage at the maximum $V_{ZPS}$ 601 V

  **NOTE:**

  - The Angle at Fault and Polarizing Voltage at trip events above are identified as memorized values.
  - The Polarizing Voltage at trip $V_{ZPS}$ would be expected to be just above the Low Threshold setting (default 500 V).
  - The Polarizing Voltage at the maximum is not a memorized value as $V_{ZPS}$ was above the Low Threshold setting when the fault first appeared.

## SEF Wattmetric Fault Hold Time

When Wattmetric is selected as the Decision for directional SEFs, a Fault Hold Time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

The effect of the Fault Hold Time is to pause the protection timing for a set period after a fault that caused a pickup has gone away.

When the fault hold time is 2.00 s, a forward SEF with a tripping time of 3.0 s that goes away after 1.5 s for 1.0 s and then returns will cause a trip after another 1.5 s. Because the hold time, that is the time that the fault went away for (1.0 s), is a shorter duration than the Fault Hold Time (2.0 s), the pickup will remain active while protection timing is paused and the tripping time will be extended by the Fault Hold Time setting.

The Event Log will record a Paused event during the hold time.

The events recorded from pickup with relevant time stamps would be:

| Event | Time Stamp |
|---|---|
| Forward Pickup SEF | 00:00:00.00 |
| SEF Directional Armed | 00:00:00.00 |
| All protection elements resetting | 00:00:01.50 |
| All protection elements paused | 00:00:01.50 |
| Protection element timing | 00:00:02.50 |
| SEF Protection Trip | 00:00:04.00 |
| Quantity at trip Earth/SEF Wattmetric xx.xx kW | 00:00:04.00 |
| Polarizing Voltage at trip $V_{ZPS}$ | 00:00:04.00 |

The fault was paused during the 1.0 s hold time so never reset. When the fault returned a Protection Element Timing event was logged.

**NOTE:** This was not a pickup as a pickup was already active.

The time between pickup and trip would be 4.0 s that is 3.0 s tripping time plus 1.0 s hold time.

## SEF Ir Cos (Ø) Polarising

The Ir Cos (Ø) operating characteristic is used in similar situations to Wattmetric. The operating value is defined as the active current component of the zero sequence current with respect to the zero sequence voltage given by:

$$\text{Active Earth Current} = \text{Residual Current x Cos } (Ø)$$
$$= (I_{ZPS} \text{ x } 3) \text{ x Cos } (Ø)$$

Where Ø is the Fault Angle that is the angle between the $V_{zps}$ and $I_{zps}$ phasors.

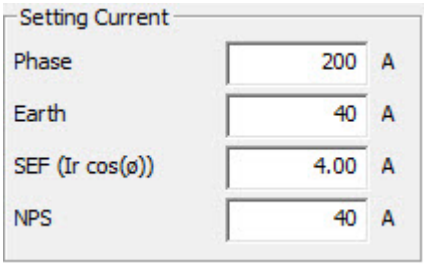
This feature works in a similar manner to Wattmetric with the following differences.

- The Active Current threshold is adjustable in the range 0.05 to 20 A in steps of 0.01 A with a default value of 4 A.
- Ir Cos (Ø) is the value used to determine whether a fault is present, that is the pickup value.

When Ir cos (Ø) is selected as the polarising decision for directional SEFs, WSOS displays this message:




This is because the SEF Pickup Threshold (Setting Current) is now set in Ir Cos (Ø) units as shown.




## SEFs Ir Cos (Ø) Characteristic Fault Angle

When a forward SEF occurs on a compensated earthing system, $V_{ZPS}$ and $I_{ZPS}$ are assumed to be 180° out of phase.

Therefore the Characteristic Angle for Ir cos (Ø) is fixed at 180°.

> **NOTE:** When the directional SEF decision is Ir cos (Ø), the Characteristic Angle is fixed and not displayed.

The Ir cos (Ø) Fault Angle for a given fault is the Zero Sequence Current angle relative to the Zero Sequence Voltage angle $V_{ZPS} \rightarrow I_{ZPS}$.

The Angle at Fault recorded in the Event Log is the fault angle relative to the Characteristic Angle which is fixed at 180°.

So a fault with a Fault Angle ($V_{ZPS} \rightarrow I_{ZPS}$) = 135° would log an Angle at Trip of -45° (135°-180°). Which indicates that the fault angle is lagging the Characteristic Angle by 45°.

When the SEF Tripping Direction is Trip Forward, the above fault will log the following events:

- Forward Pickup SEF
- SEF Directional Armed
- SEF Protection Trip
- Angle at Fault -45°
- Quantity at trip Earth/SEF Ir Cos Ø – xx.xx A
- Polarizing Voltage at trip $V_{ZPS}$
- Quantity at the maximum Earth/SEF – Maximum Ir Cos Ø - xx.xx A
- Polarizing Voltage at the maximum $V_{ZPS}$

## SEF Ir Cos (Ø) Sector Width

The default Forward and Reverse Sector Width settings for SEF protection when the Decision is Ir Cos (Ø) are both 90°. These are ± settings and equate to actual sector widths of 180°.

The likelihood of a fault angle causing an incorrect direction determination may be lessened by either increasing or decreasing the Sector Width setting. The range of these settings is 45° to 135° which equate to actual sector widths of 90° and 270° respectively.

## SEF Ir Cos (Ø) Low Voltage Block

When the SEF Low Block setting is On, tripping is blocked if the polarising voltage is below the SEF Low Threshold setting.

In this situation the ACR will still record fault resetting events when the apparent fault goes away as shown:

**Fault On**

- SEF Directional Low V Blocked.
- Polarizing Voltage Low $V_{ZPS}$

**Fault Off**

- Quantity at the maximum Earth/SEF – Maximum Ir CosØ xx.xx A
- Polarizing Voltage at the maximum $V_{ZPS}$

When the SEF Low Block setting is Off, the polarising voltage is disregarded and the action is entirely based on the calculated fault angle relative to the SEF Characteristic Fault Angle.

So if the polarising voltage is below the SEF Low Threshold setting, a protection trip will occur but no fault angle will be logged.

The Event Log will record:

- SEF Directional Low $V_{Armed}$
- Polarizing Voltage Low $V_{ZPS}$
- SEF Protection Trip
- SEF Low $V_{ZPS}$
- Quantity at trip Earth/SEF Ir CosØ xx.xx kW
- Polarizing Voltage at trip $V_{ZPS}$
- Quantity at the maximum Earth/SEF Ir CosØ xx.xx kW
- Polarizing Voltage at the maximum $V_{ZPS}$

The default SEF Low Threshold setting is 500 $V_{ZPS}$ configurable over the range 150...15,000 $V_{ZPS}$.

## SEF Ir Cos (Ø) Voltage Memory

When Ir Cos (Ø) is selected as the Decision for directional SEFs, a Voltage Memory time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

Consider a reverse SEF where $V_{ZPS}$ and $I_{ZPS}$ are in phase and $V_{ZPS}$ is above the SEF Low Threshold setting.

If the SEF Tripping Direction is Trip Reverse, and the Voltage Memory setting is 2.00 s, this fault will cause a reverse pickup and SEF Directional Armed will be logged.

If $V_{ZPS}$ then drops below the SEF Low Threshold setting before the switchgear trips, this will not cause a Low V condition as the controller will continue to use the last sampled value of $V_{ZPS}$ that was above the threshold as the polarising voltage while the pickup is active.

If the fault persists long enough to cause a trip, the memorized voltage and corresponding fault angle will be identified by an asterisk '*'.

The Event Log will report the following events:

- Reverse Pickup SEF
- SEF Directional Armed
- SEF Protection Trip
- Angle at Fault* 180°
- Quantity at trip Earth/SEF Ir CosØ xx.xx A

- Polarizing Voltage at trip* $V_{ZPS}$ 514 V
- Quantity at the maximum Earth/SEF Maximum Ir CosØ xx.xx A
- Polarizing Voltage at the maximum $V_{ZPS}$ 601 V

**NOTE:**

- The Angle at Fault and Polarizing Voltage at trip events above are identified as memorized values.
- The Polarizing Voltage at trip $V_{ZPS}$ would be expected to be just above the Low Threshold setting (default 500 V).
- The Polarizing Voltage at the maximum is not a memorized value as $V_{ZPS}$ was above the Low Threshold setting when the fault first appeared.

### SEF Ir Cos (Ø) Fault Hold Time

When Ir Cos (Ø) is selected as the Decision for directional SEFs, a Fault Hold Time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

The effect of the Fault Hold Time is to pause the protection timing for a set period after a fault that caused a pickup has gone away.

When the fault hold time is 2.00 s, a forward SEF with a tripping time of 3.0 s that goes away after 1.5 s for 1.0 s and then returns will cause a trip after another 1.5 s. Because the hold time, that is the time that the fault went away for (1.0 s), is a shorter duration than the Fault Hold Time (2.0 s), the pickup will remain active while protection timing is paused and the tripping time will be extended by the Fault Hold Time setting.

The Event Log will record a Paused event during the hold time.

The events recorded from pickup with relevant time stamps would be:

| Event | Time Stamp |
|---|---|
| Forward Pickup SEF | 00:00:00.00 |
| SEF Directional Armed | 00:00:00.00 |
| All protection elements resetting | 00:00:01.50 |
| All protection elements paused | 00:00:01.50 |
| Protection element timing | 00:00:02.50 |
| SEF Protection Trip | 00:00:04.00 |
| Quantity at trip Earth/SEF Ir Cos (Ø) xx.xx A | 00:00:04.00 |
| Polarizing Voltage at trip $V_{ZPS}$ | 00:00:04.00 |

The fault was paused during the 1.0 s hold time so never reset. When the fault returned a Protection Element Timing event was logged.

**NOTE:** This was not a pickup as a pickup was already active.

The time between pickup and trip would be 4.0 s that is 3.0 s tripping time plus 1.0 s hold time.

## Negative Phase Sequence Directional Blocking

**NOTE:** Negative Phase Sequence protection is not available by default. Sequence Components must be made available before it can be used.

The direction of Negative Phase Sequence (NPS) overcurrent faults can be determined by their Fault Angle.

The Fault Angle is the relationship between the negative phase sequence current $I_{NPS}$ and the negative phase sequence voltage $V_{NPS}$. that is $V_{NPS} \rightarrow I_{NPS}$.

For example, $V_{NPS}$ = 60°, $I_{NPS}$ = 180° Therefore NPS Fault Angle = 120°

$V_{NPS}$ is used as the polarising voltage and a Low Block setting is used to determine the action taken when $V_{NPS}$ is below the Low Threshold setting.

The tripping direction for NPS faults may be:

- Trip Forward
- Trip Reverse
- Trip Forward and Reverse (that is non directional)

Operational values for directional NPS are shown below:

| Polarizing Method | Fault Angle | Characteristic Fault Angle (default) | Low Threshold (default) | Range |
|---|---|---|---|---|
| $V_{NPS}$ | $V_{NPS} \rightarrow I_{NPS}$ | 120° | $V_{NPS}$=500 V | Adjustable $V_{NPS}$300 to 2000 V |

## NPS Characteristic Fault Angle

The Characteristic Fault Angle is the expected fault angle for a forward NPS overcurrent fault.

For NPS protection, the Characteristic Angle can be configured for a value between -179° and 180°.

120° is the default Characteristic Angle for NPS faults. So an NPS fault where the NPS current $I_{NPS}$ leads the NPS voltage $V_{NPS}$ by 120° would be a forward fault in the centre of the forward sector.

When the Tripping Direction is forward and the Forward Sector Width is the default 90°, NPS faults with fault angles between 30° and 210° (-150°) would cause NPS Directional Protection to Arm and potentially trip.

The Angle at Fault reported in the Event Log would be 120°.

The Event Log will also record:

- Pickup NPS
- NPS Directional Armed
- NPS Protection Trip
- Angle at Fault 120°
- Polarising Voltage at Trip $V_{NPS}$
- Polarising Voltage at the Maximum $V_{NPS}$

## NPS Sector Width

The default Forward and Reverse Sector Width settings for NPS protection are both 90°. These are ± settings and equate to actual sector widths of 180°.

Sector Width settings are identical for all elements and Decision settings. For more information, refer to Sector Width, page 253.

The likelihood of a fault angle causing an incorrect direction determination may be lessened by either increasing or decreasing the Sector Width setting.

The range of these settings is 45° to 135° which equate to actual sector widths of 90° and 270° respectively.

## NPS Low Voltage Block

When the NPS Low Block setting is On, tripping is blocked if the polarising voltage is below the Low Threshold setting.

The Event Log will record the following events:

- NPS Directional Low $V_{Blocked}$
- Polarising Voltage Low $V_{NPS}$

When the Phase Low Block setting is Off, the polarising voltage is disregarded and the action is entirely based on the calculated fault angle relative to the Phase Characteristic Fault Angle. So if the polarising voltage is below the Low Threshold setting, a protection trip will occur but no fault angle will be logged.

The Event Log will record:

- Forward Pickup Negative Phase Sequence
- NPS Directional Low $V_{Armed}$
- Negative Phase Sequence Protection Trip
- Polarising Voltage Low $V_{NPS}$
- Negative Phase Sequence Protection Trip
- Negative Phase Sequence Low $V_{NPS}$
- Polarising Voltage at trip $V_{NPS}$
- Polarising Voltage at the maximum $V_{NPS}$

The default Phase Low Threshold setting is 500 $V_{QUAD}$ configurable over the range 150...15,000 $V_{QUAD}$.

## NPS Low Voltage Reset

Once the polarising voltage for NPS faults has been deemed to be Low, it will not return to Normal until either the fault resets or the measured polarising voltage exceeds the Low Threshold setting by 10%. So if the Low Threshold setting is 500 $V_{NPS}$ and a Low Voltage condition exists, $V_{NPS}$ will have to rise to 550 $V_{NPS}$ before the Low V condition is cancelled.

**Table 49 Directional Protection Settings/Specifications**

| **Directional Protection Settings/Specifications** | |
|---|---|
| System Phase/Earth Nominal Voltage for correct operation | 2...25 kV |
| **Phase Directional Protection** | |
| Phase Characteristic Angle setting range | ± 180 ° |
| Phase Characteristic Angle setting resolution | 1 ° |
| Phase Characteristic Angle accuracy | ± 10 ° |
| Time to determine direction for phase faults | 20 ms |
| Minimum Quadrature Polarising Voltage for Phase Directional Protection to operate | 150 V |
| **Earth/SEF Directional Protection** | |
| Earth/SEF Characteristic Angle setting range | ± 180 ° |
| Earth/SEF Characteristic Angle setting resolution | 1 ° |
| Characteristic Angle accuracy from 2...5 A earth current | ± 30 ° |
| Characteristic Angle accuracy from 5...20 A earth current | ± 20 ° |
| Characteristic Angle accuracy above 20 A earth current | ± 20 ° |

**Table 49 Directional Protection Settings/Specifications (Continued)**

| **Directional Protection Settings/Specifications** | |
|---|---|
| Time to determine direction for EFs | 20 ms |
| Time to determine fault direction for SEF faults | 500 ms |
| Minimum Zero Sequence Polarising Voltage $V_{ZPS}$ for Earth<br><br>Directional Protection to operate | 15 V |
| Minimum Zero Sequence Polarising Voltage $V_{ZPS}$ for SEF<br><br>Directional Protection to operate | 15 V |
| Minimum SEF Definite time when Directional Protection is ON | 0.1 s |
| **NPS Directional Protection** | |
| NPS Characteristic Angle Setting range | ±180° |
| NPS Characteristic Angle Setting resolution | 1° |
| NPS Characteristic Angle Accuracy | ±10° |
| Time to determine fault direction for NPS faults | 20 ms |
| Minimum Negative Sequence Polarising Voltage $V_{NPS}$ for NPS Directional Protection to operate | 300 V |
| **Control** | |
| Low Polarising Voltage Action | No Action, Use Forward, Use Reverse |
| Forward Sector Width | 45°...135° |
| Reverse Sector Width | 45°...135° |
| Phase Low Threshold | 150...15,000 $V_{QUAD}$ |
| Phase Voltage Memory | Off<br><br>0.01...10.00 s |
| Earth Decision | $V_{ZPS}$, Wattmetric, Ir Cos (Ø) |
| Earth Low Threshold | 15...15,000 $V_{ZPS}$ |
| Earth Wattmetric Characteristic Angle | 180° Fixed |
| Earth Ir Cos (Ø) Characteristic Angle | 180° Fixed |
| Earth Voltage Memory | Off,<br><br>0.01...10.00 s |
| EF Hold Time | Off,<br><br>0.01...10.00 s |
| SEF Decision | $V_{ZPS}$, Wattmetric,<br><br>Ir Cos (Ø) |
| SEF Low Threshold | 15...15,000 $V_{ZPS}$ |
| SEF Wattmetric Characteristic Angle | 180° Fixed |
| SEF Ir Cos (Ø) Characteristic Angle | 180° Fixed |
| SEF Voltage Memory | Off,<br><br>0.01...10.00 s |
| SEF Fault Hold Time | Off,<br><br>0.01...10.00 s |
| NPS Low Threshold | 200...3,000 $V_{NPS}$ |
| **$V_{ZPS}$ Balance** | |
| Residual Earth Voltage dynamic balance limit | 0 % |

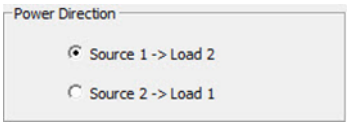
**Table 49 Directional Protection Settings/Specifications (Continued)**

| **Directional Protection Settings/Specifications** | |
|---|---|
| Residual Earth Voltage dynamic balance rate | 0.6% per s |
| | |
| High $V_{ZPS}$ Alarm Timeout | 1...180 s |
| High $V_{ZPS}$ Alarm Set point | 15...15,000 V |
| **Wattmetric and Ir Cos (Ø) Pickup Settings** | |
| Earth Wattmetric Pickup Setting | 0.1...500.0 kW |
| Earth Ir Cos (Ø) Pickup Setting | 10...1260 A |
| SEF Wattmetric Pickup Setting | 0.01...10.00 kW |
| SEF Ir Cos (Ø) Pickup Setting | 0.05...20.00 A |

# Directional Protection

## Overview

ACRs are sometimes installed in network configurations where power flow could be in either direction through the switchgear. Directional Protection can be used when the ACR is required to coordinate with different protection devices depending on which side of the switchgear the fault is detected that is whether the power flow during a fault is forward or reverse. When power flows from Source to Load, the power flow is deemed to be forward. Reverse power flows from Load to Source. The Source and Load sides of the switchgear are configurable through the Power Direction setting.




The Power Direction setting can be found on the WSOS Measurements page, page 148 or on the operator interface, page 697.

Directional Protection is an optional protection feature that uses separate protection groups to determine pickup thresholds and protection timing depending on which side of the switchgear the fault has been detected.

> **NOTE:** Because the direction of the fault needs to be determined before the correct protection settings can be applied, there is a minimum delay of approximately 20 ms that applies to all types of directional overcurrent protection that is Phase, Earth, SEF, and NPS.

When Directional Protection is On, there are always two protection groups active. One group is for forward faults and the other is for reverse faults. If the controller is configured for ten protection groups, five pairs will be available as shown in the table below.

**Table 50 Directional Protection Active Protection Group Pairs**

| **Forward** | **Reverse** |
|---|---|
| Group A | Group B |
| Group C | Group D |
| Group E | Group F |
| Group G | Group H |
| Group I | Group J |

Which pair becomes active when Directional Protection is turned On depends on which group was previously active. If Group A was active, Groups A and B will become active. If Group D was active, Groups C and D will become active.

The active protection groups can be changed to another pair once Directional Protection is On.

WSOS will display a warning message to advise which protection groups will become active when Directional Protection is turned On.




**NOTE:** if an odd number of protection groups have been configured, not all will be available for Directional Protection for example, if five groups have been configured only two pairs (A+B and C+D) can be selected.

Directional Protection can only be turned on from the WSOS Feature Selection page. It can't be turned on from the Options pages on the ***set*VUE** O.I. or the Feature Selection pages on the ***flex*VUE** O.I.

## Directional Protection Configuration

When Directional Protection is On, the active protection groups have duplicate directional protection settings. Changing a setting in one group, either forward or reverse, automatically changes that setting in the other group.

Some differences exist in the Global Settings for the two active groups. There are two settings that are common to both groups when Directional Protection is On.

- Live Load Blocking
- Sequence Reset Time

These settings are only displayed in the Global Settings for the forward protection group.

## Sequence Reset Time

There is a single Sequence Reset Timer setting for both the forward and reverse protection groups. Whenever a successful automatic reclose occurs following a protection trip, the sequence reset timer will start.

When the timer expires, both the forward and reverse sequence counters will be reset to zero.

If another trip occurs after an automatic reclose before the sequence reset timer has expired, the timer will reset and start again when the next automatic reclose occurs providing the protection has not picked up.

## Trips to Lockout

Although each protection group has its own Trips to Lockout settings, the number of trips to lockout in a single sequence can never exceed 4.

If a sequence begins when a fault causes a trip in the forward direction, it will be forward Trip 1. If after an auto reclose, another fault is detected in the reverse direction thus causing a reverse protection trip that would be Trip 1 of the reverse protection sequence.

If this pattern continues, the ACR will go to lockout after the 4th trip even if neither protection group has reached its Trips to Lockout setting.

A lockout applies to both the forward and reverse protection groups, it is not possible to have a lockout in one direction only.

## Auto Reclose

When Directional Protection is On, each protection group has its own Auto Reclose On/Off setting.

An automatic reclose will only occur following a protection trip if:

- Auto Reclose is On for the protection group that was active for that trip, and
- The global Auto Reclose setting was On.

The global Auto Reclose setting is the usual setting found in WSOS on the Control page or on the operator interface, page 697.

Once the Global Auto Reclose setting is On, the forward and reverse Auto Reclose settings can be configured independently. So it's possible to configure just forward or reverse protection for auto reclose as well as both.

In WSOS, the Forward and Reverse Auto Reclose settings can be found on the Global Settings page for Forward and Reverse protection groups respectively.

As well as on the operator interface, page 697.

## Auto Restore

Auto Restore is an alternative feature to Auto Reclose for each protection group that is the two features are mutually exclusive.

Auto Restore is used to close an ACR with Directional Protection after the fault that tripped the device has been cleared and supply has been restored to both sides of the switchgear.

Selecting Auto Reclose Off for any of the protection groups allows Auto Restore to be configured.

Auto Restore is configured by selecting the Auto Restore On setting and entering a value for the Auto Restore Time between 3 and 1800 s.

This can be done in WSOS on the Global Settings pages or on the operator interface, page 697.

> **NOTE:** Auto Restore must be On before an Auto Restore Time can be entered.

Auto Restore would normally be used where the ACR was part of a closed loop topology to restore the loop to the condition it was in prior to the fault.

Auto Restore will close the ACR after it has done a Single Shot trip due to a fault and the voltage on both sides of the switchgear has been restored to normal operating values for the Auto Restore time.

### Some points to note regarding Auto Restore:

> **NOTE:** See the below points regarding Auto Restore

- Auto Restore and Auto Reclose are mutually exclusive.
- Auto Restore will only operate if there is voltage sensing on both sides of the switchgear. Otherwise the Auto Restore On/Off field and Auto Restore Time will be unavailable.
- If Auto Restore is On, the ACR can't go to lockout as this would imply that there will not be any further automatic close attempts – instead of Lockout, an End of Sequence event is logged. When an End of Sequence event is logged, the message ACR will close if Source and Load are restored is displayed on the O.I.

- The Auto Restore timer starts running when the voltage on both sides of the switchgear is restored to normal. The countdown timer is displayed on the O.I.
- When Auto Restore performs a close, the ACR is in Single Shot mode and thus will go to Lockout if a trip occurs before the Single Shot Timer expires.

## Operation

Direction Protection is continuously monitoring the line voltage and current in order to determine the direction of power flow through the switchgear.

It is also monitoring the pickup thresholds for each configured element for each of the active protection groups.

When any pickup threshold in either of the active groups is exceeded, the power flow direction is checked to determine if the fault has occurred on the Source or Load side of the switchgear.

If the fault is discovered to be on the Load side and a forward protection group trip setting has been exceeded, a Pickup Forward event is logged and the protection calculates the time to trip according to the forward protection group settings for the faulted element.

If the active protection groups are A and B, then Group A is used.

If the fault is discovered to be on the Source side and a reverse protection group trip setting has been exceeded, a Pickup Reverse event is logged and the protection calculates the time to trip according to the reverse protection group settings. In this case, Group B.

## Determining Direction

The user must set a **Characteristic Angle** for each element. The Characteristic Angle is essentially a prediction of the expected fault angle when a forward fault occurs. The fault angle is defined according to the polarising method for each element and is effectively the phasor relationship between the fault current and the polarising voltage. A forward fault is one where the fault angle is within ± 90° of the Characteristic Angle.

For any given fault, the actual fault angle will be determined by network characteristics such as line resistance and reactance as well as fault characteristics such as the nature of the short circuit, solid, or arcing etc.

It is not necessary that the fault angle matches the Characteristic Angle precisely. There are only two possibilities for direction, forward and reverse. As long as the fault angle is at the Characteristic Angle ± 90° it will be recognized as a forward fault. Otherwise it is a reverse fault.

Each element takes 20 ms to determine the direction of a fault once it has been detected. This delay occurs prior to the trip timing and adds to the actual time to trip.

The figure below demonstrates a Characteristic Angle of +45° with phasors representing possible fault angles on either side. Both of these fault angles represent forward faults as they are well within the forward fault region (135° to -45°).

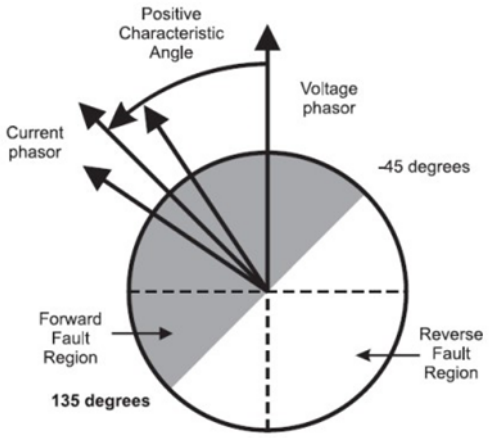



**Figure 162**
Directional Blocking Forward and Reverse Sectors

## Low Polarising Voltage Action

In order to determine the direction of a fault that caused a pickup, the controller requires a Polarising Voltage. If there is a bolted phase fault on the terminals of the switchgear there may not be sufficient voltage to determine the direction of the fault.

Directional Protection includes two settings per element to deal with low polarising voltage.

- Low Polarising Voltage Action
- Low Threshold

If the polarising voltage is below the Low Threshold setting for the faulted element, the Low Polarising Voltage Action setting will determine what action must be taken.

The options are:

- Use Forward
- Use Reverse
- No Action (default setting)

**No Action** means that the Low Threshold setting determines if the fault detect must be considered valid.

The following points must be noted if the No Action option is being selected:

- An overcurrent fault will not cause a trip if the polarising voltage is below the Low Threshold setting and the No Action option is selected that is A low V condition will operate as an inhibit to a trip.
- A Pickup is still logged for an overcurrent fault when the polarising voltage is below the Low Threshold setting and the No Action option is selected.
- A Pickup that occurs when the polarising voltage is low and the No Action option is selected will only reset when the current has dropped below the reset threshold for the fault reset time.

## Sector Width

Directional Protection uses separate Sector Width settings for Forward and Reverse. The likelihood of a fault angle causing an incorrect direction determination may be lessened by either increasing or decreasing one or both of the Sector Width settings.

Both settings are ± 90° by default and can be configured over a range of 45° to 135° which equate to actual sector widths of 90° and 270° respectively. However they cannot be configured to cause the sectors to overlap.

Example: If say the Forward Sector Width is configured for 130°, the maximum setting available for the Reverse Sector Width is 50°.

The minimum setting is always 45° so the Forward and Reverse Sector Width settings can be configured such that not all fault angles will fall into either sector. If this happens, the protection will not pick up or trip. Instead if it happens for an A Phase fault for example, the Event Log will record the following events:

- Forward Out of Sector Phase A
- Reverse Out of Sector Phase A

**NOTE:** The forward sector is centred on the Characteristic Angle and the reverse sector is centred on the Characteristic Angle –180°.

The **Forward Sector Width** setting is the angle that the deviation of the calculated fault angle from the Characteristic Angle needs to be equal to or less than to be deemed a forward fault.

The **Reverse Sector Width** setting is the angle that the deviation of the calculated fault angle from the Characteristic Angle plus 180° needs to be equal to or less than to be deemed a reverse fault.

## $V_{zps}$ (ZPS Voltage) Balance

$V_{zps}$ is the polarising voltage for many of the polarising methods used by Directional Blocking.

Even in un-faulted networks the ZPS voltage is not likely to be zero because the three phase voltages are not going to be perfectly balanced.

This could lead to problems in high impedance fault conditions because the $V_{zps}$ due to an earth fault might be dominated by the $V_{zps}$ due to out of balance phase voltages, and this could lead to an incorrect determination of direction.

$V_{zps}$ Balancing is provided to overcome this by continuously balancing the phase voltages under normal conditions and compensating for imbalance between the three phase voltage measurements.

$V_{zps}$ Balance can be turned On in WSOS on the Directional Blocking page.

Or on the operator interface, page 701.

When balancing is enabled, the zero sequence voltage is continually balanced at the rate of 0.6% of phase to earth voltage per second until zero $V_{zps}$ has been achieved.

Balancing is paused when any of the following conditions occur:

- Detection pickup
- The SCEM data is not valid
- The switchgear is open
- Any of the bushings are dead

$V_{zps}$ Balance status is displayed in WSOS under Controller Status on the Control page.

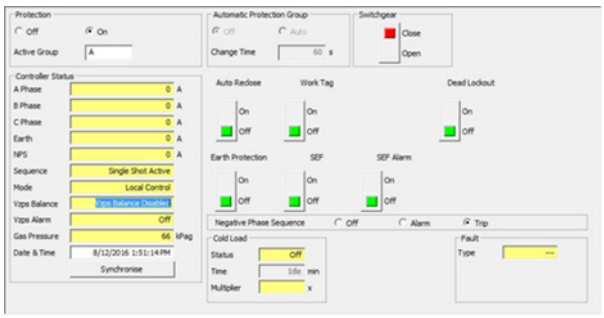



**Figure 163**
WSOS $V_{ZPS}$ Balance Status

When balancing is enabled the status displays **$V_{zps}$ Balancing** while the system is continually adjusting for balance, and **$V_{zps}$ Paused** when the balancing is suspended for one of the reasons above.

When balancing is disabled the display shows **$V_{zps}$ Balance Disabled**.

## High $V_{zps}$ Alarm

The Directional Blocking facility includes a High ZPS Voltage alarm. This indication can be useful in unearthed neutral networks for earth fault detection.

The high $V_{zps}$ alarm is asserted whenever the Alarm Set-point is exceeded for the Alarm Timeout period. Regardless of whether SEF protection is picked up or not. The alarm is cleared when $V_{zps}$ falls below the Alarm Set-point again.

The High $V_{zps}$ Alarm can be turned on and configured via WSOS on the Directional Blocking page.

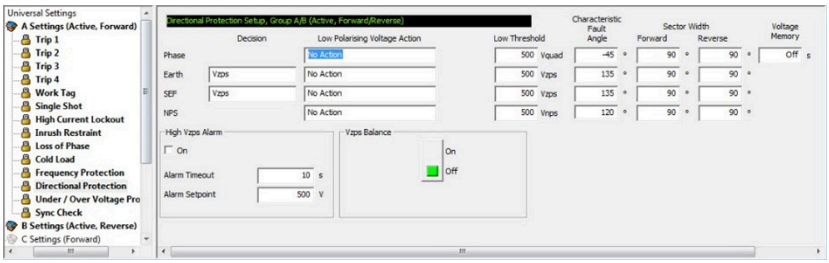



**Figure 164**
WSOS High $V_{ZPS}$ Alarm settings

High $V_{zps}$ Alarm can also be configured on the operator interface, page 701.

The alarm status is displayed by WSOS on the Control page under Controller Status as well as on the operator interface, page 701.

The High $V_{ZPS}$ alarm is available for transmission by telemetry protocols.

# Phase Overcurrent Directional Protection

The direction of a phase overcurrent fault can be determined by the relationship between the phase current and phase voltage in the faulted phases.

In order to minimize the effect of reduced voltage in faulted phases, phase protection uses quadrature voltage for polarization.

However the quadrature voltage angle is compensated by 90° to offset the inherent 90° phase shift. This gives a fault angle that relates to the phase angle between the phase current and the phase voltage.

**Example**

Consider a single A phase fault where the A phase current lags the A phase – earth voltage by 45°.

The fault current would be $I_A$ and the polarising voltage would be the quadrature voltage $V_{B-C}$ + 90°.

The fault angle would be ($V_{B-C}$ + 90°) → $I_A$

Assuming balanced voltages and ABC rotation with A phase at 0°, $V_{B-C}$ would be at 270°

Compensated $V_{B-C}$ would be 360° or 0°.

Therefore the fault angle would be (360 → -45) = 315° = - 45°.

## Phase Characteristic Fault Angle

The Characteristic Angle defines the forward and reverse fault regions for the network.

When a phase fault is detected, its fault angle is calculated and compared to the Phase Characteristic Angle to determine if the fault is forward or reverse.

If the fault angle is within ± 90°(6) of the Characteristic Angle the fault is forward, otherwise it is a reverse fault.

The Phase Characteristic Angle is configurable over the range -179° to 180°.

-45° is the default Characteristic Angle for Phase faults. So an A phase fault where the fault current lagged the polarising voltage by 45° would be a forward fault in the centre of the forward sector. The Angle at Fault reported in the Event Log would be -45° .

When Protection Groups A and B are active, the Event Log will also record:

- Forward Pickup Phase A
- Protection Group A Active
- Forward Phase Protection Trip
- Angle at Fault -45°
- Polarising Voltage at Trip $V_{QUAD}$
- Polarising Voltage at the Maximum $V_{QUAD}$

A reverse fault where the fault current led the polarising voltage by 135° would log the events below.

- Reverse Pickup Phase A
- Protection Group B Active
- Reverse Phase Protection Trip
- Angle at Fault 135°
- Polarising Voltage at Trip $V_{QUAD}$
- Polarising Voltage at the Maximum $V_{QUAD}$

Phase fault currents and their associated quadrature voltages are shown in the table below.

| Fault Current | Quadrature Voltage |
|---|---|
| $I_A$ | $V_{B-C}$ |
| $I_B$ | $V_{C-A}$ |
| $I_C$ | $V_{A-B}$ |

## Phase Sector Width

The default Forward and Reverse Sector Width settings for phase protection are both 90°. These are ± settings and equate to actual sector widths of 180°.

Sector Width settings are identical for all elements and Decision settings. For more information, refer to Sector Width, page 253.

## Phase Low Polarising Voltage Action

In order to determine the direction of a phase fault that caused a pickup, the controller requires sufficient quadrature voltage, page 256 for each faulted phase. If there is a bolted phase fault on the terminals of the switchgear there may not be sufficient polarising voltage for the controller to determine the direction of the fault.

(6) Assumes default settings for Forward and Reverse Sector Widths that is 90°

Directional Phase Protection includes two settings that deal with low polarising voltage.

- Low Polarising Voltage Action
- Low Threshold

If the polarising voltage is below the Low Threshold setting for phase faults, the Low Polarising Voltage Action setting will determine what action must be taken.

The options are:

- Use Forward
- Use Reverse
- No Action (default setting)

More information on the No Action option can be found here.

The Phase Low Threshold setting can be configured for between 150...15000 V.

When Use Forward or Use Reverse actions are selected, a fault with low polarising voltage will cause a trip as though it was a normal fault in the selected direction. The only indication that the polarising voltage was low would be the Polarising Voltage at trip $V_{QUAD}$ event which would record a value lower than the Phase Low Threshold setting.

When No Action is selected, a fault with low polarising voltage will cause a pickup followed by a Polarising Voltage at trip $V_{QUAD}$ event reporting the low value of polarising voltage. It will not cause a protection trip. The pickup condition will remain active until the fault resets.

## Phase Low Voltage Reset

Once the polarising voltage for phase faults has been deemed to be Low, it will not return to Normal until either the fault resets or the measured polarising voltage exceeds the Low Threshold setting by 10%. So if the Low Threshold setting is 500 $V_{QUAD}$ and a Low Voltage condition exists, $V_{QUAD}$ will have to rise to 550 $V_{QUAD}$ before the Low V condition is cancelled.

## Phase Voltage Memory

Three phase faults are the most likely to cause a low voltage condition. In this case a memorized voltage can be used for polarization.

Voltage Memory is Off by default so if this feature is required to be used it must be enabled and configured for a time period between 0.01...10.00 s.

When Voltage Memory is enabled, the controller maintains a memory of the polarising voltage $V_{QUAD}$ updated every 4 ms. If a three phase fault causes all three phase voltages to drop sharply, the last value of $V_{QUAD}$ sampled before it fell below the Low Threshold setting is frozen in memory. That value is maintained in memory and used for polarization for the configured Voltage Memory time.

When a memorized voltage has been used for polarization, the values are identified in the Event Log by an asterisk '*'. For example,

- Angle at Fault* -45°
- Polarizing Voltage at Trip* $V_{QUAD}$

After the Voltage Memory time expires, the memorized polarising voltage is set to zero. However if the controller is in pickup when the Voltage Memory time expires, the direction that was determined using the memorized voltage will be maintained as long as the pickup is active.

If a pickup occurs after the memorized polarising voltage has been set to zero, the Low V Block action will be used.

# EF Directional Protection

When EF Directional Protection is enabled, it can use one of three methods to determine the direction of an EF.

- $V_{ZPS}$
- Wattmetric
- Ir Cos (Ø)

$V_{ZPS}$ is the default option. The Decision setting determines the method used. Operating Quantities, Fault Angles and default Characteristic Angles for each method are shown in the table below.

**Table 51 Directional Protection EF Polarization Methods**

| Polarising Method (Decision) | Operating Quantity | Fault Angle | Angle logged on Trip | Default Characteristic Angle |
|---|---|---|---|---|
| $V_{ZPS}$ | Earth Current Ir ($I_{ZPS}$x3) | $V_{ZPS}$ →$I_{ZPS}$ | $V_{ZPS}$ → $I_{ZPS}$ | 135° Configurable |
| Wattmetric | Residual Power<br>($V_{ZPS}$x3) x ($I_{ZPS}$x3) x Cos (FA) | $V_{ZPS}$ → $I_{ZPS}$ | $V_{ZPS}$ → $I_{ZPS}$ | 180° Fixed |
| Ir Cos (Ø) | Active Earth Current<br>($I_{ZPS}$x3) x Cos (FA) | $V_{ZPS}$ → $I_{ZPS}$ | $V_{ZPS}$ → $I_{ZPS}$ | 180° Fixed |

## Earth $V_{ZPS}$ Polarizing

With $V_{ZPS}$ polarization, the operating quantity is earth current (3 x $I_{ZPS}$) and the fault angle is the zero sequence current angle with respect to the zero sequence voltage angle ($V_{ZPS}$ → $I_{ZPS}$).

For demonstration purposes, the figure below substitute's residual current and voltage for zero sequence current and voltage. Although they have different magnitudes, the angles are the same.

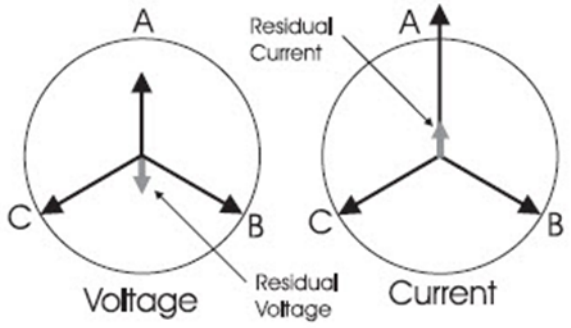



**Figure 165**
EF Current and Voltage Phasors

This figure shows phasor diagrams for voltage and current during a hypothetical purely resistive A phase to EF on an earthed neutral system.

The fault causes A phase voltage to reduce and the residual voltage phasor is 180° out of phase as shown.

The current in A phase is increased and the residual current phasor is in phase with A phase current.

The fault angle for this fault is 180° that is the residual current is 180° out of phase with the residual voltage.

The actual fault angle for an EF is determined by the network characteristics (line resistance and reactance, neutral earthing arrangement) and the fault characteristic (such as the nature of the short-circuit – solid or arcing, fault impedance and earth resistance).

## Earth $V_{ZPS}$ Characteristic Fault Angle

The default Characteristic Angle for Earth Directional Protection is +135° . So an A phase to EF where the residual current led the residual voltage by 135° would be a forward fault in the centre of the forward sector.

The Characteristic Angle setting for Earth $V_{ZPS}$ polarising is configurable between -179° and 180°.

A typical Characteristic Angle for systems with solidly or impedance earthed transformer neutrals would be approximately +135°.

If this fault occurs when Protection Groups A and B are active the Event Log would record:

- Forward Pickup Earth
- Protection Group A Active
- Forward Earth Protection Trip
- Angle at Fault 135°
- Polarising Voltage at trip $V_{ZPS}$
- Polarising Voltage at the maximum $V_{ZPS}$

The same fault in the opposite direction would record:

- Reverse Pickup Earth
- Protection Group B Active
- Reverse Earth Protection Trip
- Angle at Fault -45°
- Polarising Voltage at trip $V_{ZPS}$
- Polarising Voltage at the maximum $V_{ZPS}$

## Earth $V_{ZPS}$ Sector Width

The default Forward and Reverse Sector Width settings for earth protection are both 90°. These are ± settings and equate to actual sector widths of 180°.

Sector Width settings are identical for all elements and Decision settings. For more information, refer to Sector Width, page 253.

## Earth $V_{ZPS}$ Low Polarising Voltage Action

In order to determine the direction of an EF that caused a pickup when $V_{ZPS}$ polarization is used, the controller expects Zero Sequence Voltage to be above the Earth Low Threshold setting.

The Low Threshold is one of two settings that deal with low polarising voltages. The other is the Low Polarising Voltage Action.

If the polarising voltage is below the Low Threshold setting for EFs, the Low Polarising Voltage Action setting will determine what action must be taken.

The options are:

- Use Forward
- Use Reverse
- No Action (default setting)

More information on the No Action option can be found here.

The Earth Low Threshold setting can be configured for between 15...15,000 Volts.

When Use Forward or Use Reverse actions are selected, a fault with low polarising voltage will cause a trip as though it was a normal fault in the selected direction. The only indication that the polarising voltage was low would be the Polarising Voltage at trip $V_{ZPS}$ event which would record a value lower than the Earth Low Threshold setting.

When No Action is selected, an EF with low polarising voltage will cause a pickup followed by a Polarising Voltage Low $V_{ZPS}$ event reporting the low value of polarising voltage. It will not cause a protection trip. The pickup condition will remain active until the fault resets.

### Earth $V_{ZPS}$ Low Voltage Reset

Once the polarising voltage has been deemed to be Low, it will not return to Normal until either the fault resets or the measured polarising voltage exceeds the Low Threshold setting by 10%. So if the Low Threshold setting is 500 $V_{ZPS}$ and a Low Voltage condition exists, $V_{ZPS}$ will have to rise to 550 $V_{ZPS}$ before the Low V condition is cancelled.

## Earth Wattmetric Polarising

Wattmetric is the method normally recommended to be used with a compensated or resistance earthed system. The Wattmetric method for EF protection may be applied in all types of distribution systems having low earth-fault values. This includes isolated-neutral high-impedance earthed and compensated systems.

The Wattmetric value is in Watts and is defined as the in-phase residual power given by:

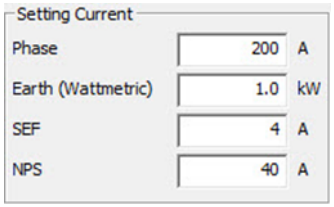
$$\text{Residual Power} = \text{Residual Voltage} \times \text{Residual Current} \times \cos(\text{Ø})$$
$$= (V_{ZPS} \times 3) \times (I_{ZPS} \times 3) \times \cos(\text{Ø})$$

Where Ø is the Fault Angle that is the angle between $V_{ZPS}$ and $I_{ZPS}$. $V_{ZPS}$ is the polarising voltage.

When Wattmetric is selected as the Earth Directional Protection Decision WSOS displays this message:




This is because the Earth Pickup Threshold (Setting Current) is now in kilo Watts (kW) as shown.




The Wattmetric Earth pickup threshold can be set between 0.1 kW...500.0 kW.

### Earth Wattmetric Characteristic Fault Angle

When a forward EF occurs on a compensated earthing system, $V_{ZPS}$ and $I_{ZPS}$ are assumed to be 180° out of phase.

Therefore the Characteristic Angle for Wattmetric is fixed at 180°.

The Wattmetric Fault Angle for a given fault is the Zero Sequence Current angle relative to the Zero Sequence Voltage angle $V_{ZPS} \rightarrow I_{ZPS}$

The Angle at Fault recorded in the Event Log following a fault is the fault angle relative to the Characteristic Angle which is fixed at 180°.

So a fault with a Fault Angle ($V_{ZPS} \rightarrow I_{ZPS}$) = 135° would log an Angle at Trip of -45° (135°-180°). Which indicates that the Fault Angle is lagging the Characteristic Angle by 45°.

A forward EF with a fault angle of 135° will log the following events:

- Forward Pickup Earth
- Protection Group A Active
- Forward Earth Protection Trip
- Angle at Fault -45°
- Quantity at trip Earth/SEF Wattmetric – xx.xx kW
- Polarising Voltage at trip $V_{ZPS}$
- Quantity at the maximum Earth/SEF – Maximum Wattmetric - xx.xx kW
- Polarising Voltage at the maximum $V_{ZPS}$

## Earth $V_{ZPS}$ Sector Width

The default Forward and Reverse Sector Width settings for earth protection are both 90°. These are ± settings and equate to actual sector widths of 180°.

Sector Width settings are identical for all elements and Decision settings. For more information, refer to Sector Width, page 253.

## Earth Wattmetric Low Polarising Voltage Action

In order to determine the direction of an EF that caused a pickup when Wattmetric polarization is used, the controller requires Zero Sequence Voltage to be above the Earth Low Threshold setting.

The Earth Low Threshold is one of two settings that deal with low polarising voltages. The other is the Low Polarising Voltage Action.

If the polarising voltage is below the Low Threshold setting for EFs, the Low Polarising Voltage Action setting will determine what action must be taken.

The options are:

- Use Forward
- Use Reverse
- No Action (default setting)

More information on the No Action option can be found here.

The Earth Low Threshold setting can be configured for between 15...15,000 Volts. The default value is 500 $V_{ZPS}$.

When Use Forward or Use Reverse actions are selected, a fault with low polarising voltage will cause a fault detection as though it was a normal fault in the selected direction.

The only indication that the polarising voltage was low would be the Polarising Voltage Low $V_{ZPS}$ event which would record a value lower than the Earth Low Threshold setting.

When No Action is selected, an EF with low polarising voltage will cause a pickup followed by a Polarising Voltage Low $V_{ZPS}$ event reporting the low value of polarising voltage. It will not cause a fault detection. The pickup condition will remain active until the fault resets.

## Earth Wattmetric Low Voltage Reset

Once the polarising voltage for EFs has been deemed to be Low, it will not return to Normal until either the fault resets or the measured polarising voltage exceeds the Low Threshold setting by 10%. So if the Low Threshold setting is 500 $V_{ZPS}$ and a Low Voltage condition exists, $V_{ZPS}$ will have to rise to 550 $V_{ZPS}$ before the Low V condition is cancelled.

## Earth Wattmetric Voltage Memory

When Wattmetric is selected as the Decision for directional EFs, a Voltage Memory time between 0.01...10.00 s or OFF can be configured. The default setting is 2.00 s.

Consider a reverse EF where $V_{ZPS}$ and $I_{ZPS}$ are in phase and $V_{ZPS}$ is above the Low Threshold setting.

If the EF Tripping Direction is Trip Reverse, and the Voltage Memory setting is 2.00 s, this fault will cause a reverse pickup and Earth Directional Armed will be logged.

If $V_{ZPS}$ then drops below the Low Threshold setting before the switchgear trips, this will not cause a Low V condition as the controller will continue to use the last sampled value of $V_{ZPS}$ that was above the threshold as the polarising voltage while the pickup is active.

If the fault persists long enough to cause a trip, the memorized voltage and corresponding fault angle recorded in the Event Log will be identified by an asterisk '*'.

The Event Log will report the following events:

- Reverse Pickup Earth
- Earth Directional Armed
- Earth Protection Trip
- Angle at Fault* 180°
- Quantity at trip Earth/SEF Wattmetric xx.xx kW
- Polarising Voltage at trip* $V_{ZPS}$ 514 V
- Quantity at the maximum Earth/SEF Maximum Wattmetric xx.xx kW
- Polarising Voltage at the maximum $V_{ZPS}$ 601 V

**NOTE:**

- The Angle at Fault and Polarising Voltage at trip events above are identified as memorized values.
- The Polarising Voltage at trip $V_{ZPS}$ would be expected to be just above the Low Threshold setting (default 500 V).
- The Polarising Voltage at the maximum is not a memorized value as $V_{ZPS}$ was above the Low Threshold setting when the fault first appeared.

## Earth Wattmetric Fault Hold Time

When Wattmetric is selected as the Decision for directional EFs, a Fault Hold Time between 0.01...10.00 s or OFF can be configured.

The default setting is 2.00 s.

The effect of the Fault Hold Time is to pause the protection timing for a set period after a fault that caused a pickup has gone away.

When the fault hold time is 2.00 s, a forward EF with a tripping time of 3.0 s that goes away after 1.5 s for 1.0 s and then returns will cause a trip after another 1.5 s. Because the hold time, that is the time that the fault went away for (1.0 s), is a shorter duration than the Fault Hold Time (2.0 s), the pickup will remain active while protection timing is paused and the tripping time will be extended by the Fault Hold Time setting.

The Event Log will record a Paused event during the hold time.

The events recorded from pickup with relevant time stamps would be:

| Event | Time Stamp |
|---|---|
| Forward Pickup Earth | 00:00:00.00 |
| All protection elements resetting | 00:00:00.00 |
| All protection elements paused | 00:00:01.50 |
| Protection element timing | 00:00:01.50 |
| Forward Earth Protection Trip | 00:00:02.50 |
| Angle at Fault 0° | 00:00:04.00 |
| Quantity at trip Earth/SEF Wattmetric -xx.xx kW | 00:00:04.00 |
| Polarizing Voltage at trip $V_{ZPS}$ | 00:00:04.00 |
| Quantity at the maximum Earth/SEF – Maximum Wattmetric –xx.xx kW | 11:57:44.392 |
| Polarising Voltage at the maximum $V_{ZPS}$ | 11:57:44.392 |

The pickup was paused during the 1.0 s hold time so never reset. When the fault returned a Protection Element Timing event was logged.

**NOTE:** This was not a pickup as a pickup was already active.

The time between pickup and trip would be 4.0 s that is 3.0 s tripping time plus 1.0 s hold time.

## Earth Ir Cos (Ø) Polarising

The Ir Cos (Ø) operating characteristic is used in similar situations to Wattmetric.

The operating value is defined as the active component of the residual current given by:

Active Earth Current = Residual Current x Cos (Ø)

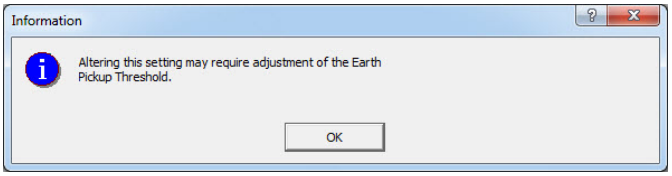
= ($I_{ZPS}$ x 3) x Cos (Ø)

Where Ø is the Fault Angle that is the angle between the $V_{ZPS}$ and $I_{ZPS}$ phasors.

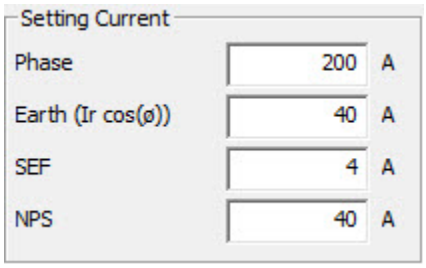
This feature works in a similar manner to Wattmetric with the following differences.

- The Active Current threshold is adjustable in the range 10 to 1260 A in steps of 1 A with a default value of 40 A.
- Ir Cos (Ø) is the value used to determine whether a fault is present, that is the pickup value.

When Ir Cos (Ø) is selected as the polarising decision for directional EFs, WSOS displays this message:




This is because the Earth Pickup Threshold (Setting Current) is now set in Ir Cos (Ø) units as shown.




## Earth Ir Cos (Ø) Characteristic Fault Angle

When a forward EF occurs on a compensated earthing system, $V_{ZPS}$ and $I_{ZPS}$ are assumed to be 180° out of phase.

Therefore the Characteristic Angle for Ir Cos (Ø) is fixed at 180°.

The Ir Cos (Ø) Fault Angle for a given fault is the Zero Sequence Current angle relative to the Zero Sequence Voltage angle $V_{ZPS} \rightarrow I_{ZPS}$

The Angle at Fault recorded in the Event Log is the fault angle relative to the Characteristic Angle which is fixed at 180°.

So a fault with a Fault Angle ($V_{ZPS} \rightarrow I_{ZPS}$) = 135° would log an Angle at Fault of -45° (135°-180°) which indicates that the fault angle is lagging the Characteristic Angle by 45°.

Other events that are logged for the above fault include:

- Forward Pickup Earth
- Forward Earth Protection Trip
- Angle at Fault -45°
- Quantity at trip Earth/SEF $I_R$Cos Ø – xx.xx A
- Polarizing Voltage at trip $V_{ZPS}$
- Quantity at the maximum Earth/SEF – Maximum $I_R$Cos Ø - xx.xx A
- Polarizing Voltage at the maximum $V_{ZPS}$

## Earth Ir Cos (Ø) Sector Width

The default Forward and Reverse Sector Width settings for earth protection when the Decision is Ir Cos (Ø) are both 90°. These are ± settings and equate to actual sector widths of 180°.

Sector Width settings are identical for all elements and Decision settings. For more information, refer to Sector Width, page 253.

## Earth Ir Cos (Ø) Low Polarising Voltage Action

In order to determine the direction of an EF that caused a pickup when Ir Cos (Ø) polarization is used, the controller expects Zero Sequence Voltage to be above the Earth Low Threshold setting.

The Earth Low Threshold is one of two settings that deal with low polarising voltages. The other is the Low Polarising Voltage Action.

If the polarising voltage is below the Low Threshold setting for EFs, the Low Polarising Voltage Action setting will determine what action mustbe taken.

The options are:

- Use Forward
- Use Reverse
- No Action (default setting)

More information on the No Action option can be found here.

The Earth Low Threshold setting can be configured for between 15...15,000 Volts.

When Use Forward or Use Reverse actions are selected, a fault with low polarising voltage will cause a trip as though it was a normal fault in the selected direction. The only indication that the polarising voltage was low would be the Polarising Voltage at trip $V_{ZPS}$ event which would record a value lower than the Earth Low Threshold setting.

When No Action is selected, an EF with low polarising voltage will cause a pickup followed by a Polarising Voltage Low $V_{ZPS}$ event reporting the low value of polarising voltage. It will not cause a protection trip. The pickup condition will remain active until the fault resets.

## Earth Ir Cos (Ø) Low Voltage Reset

Once the polarising voltage for EFs has been deemed to be Low, it will not return to Normal until either the fault resets or the measured polarising voltage exceeds the Low Threshold setting by 10%. So if the Low Threshold setting is 500 $V_{ZPS}$ and a Low Voltage condition exists, $V_{ZPS}$ will have to rise to 550 $V_{ZPS}$ before the Low V condition is cancelled.

## Earth Ir Cos (Ø) Voltage Memory

When Ir Cos (Ø) is selected as the Decision for directional EFs, a Voltage Memory time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

Consider a forward EF at the Characteristic Angle with $V_{ZPS}$ above the Earth Low Threshold setting and an expected tripping time of 3.5 s. If this fault is applied for 2.0 s and then $V_{ZPS}$ drops below the Low Threshold setting, the controller will retain the last $V_{ZPS}$ value that was sampled above the threshold for the Voltage Memory time.

This means that the low voltage condition is effectively ignored and the protection trip will still occur in the expected tripping time of 3.5 s.

The memorized voltage and corresponding fault angle will be identified by an asterisk '*'.

The Event Log will report the following events:

- Forward Pickup Earth
- Forward Earth Protection Trip
- Angle at Fault* 0°
- Quantity at trip Earth/SEF Ir Cos (Ø) - xx.xx A
- Polarising Voltage at trip* $V_{ZPS}$ – 544 V
- Quantity at the maximum Earth/SEF Maximum Ir Cos (Ø) - xx.xx A
- Polarising Voltage at the maximum $V_{ZPS}$ – 601 V

  **NOTE:**

  - The Angle at Fault and Polarising Voltage at trip events above are identified as memorized values.
  - The Polarising Voltage at trip* $V_{ZPS}$ would be expected to be just above the Low Threshold setting (default 500 V).
  - The Polarising Voltage at the maximum is not a memorized value as $V_{ZPS}$ was above the Low Threshold setting when the fault first appeared.

## Earth Ir Cos (Ø) Fault Hold Time

When Ir Cos (Ø) is selected as the Decision for directional EFs, a Fault Hold Time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

The effect of the Fault Hold Time is to pause the protection timing for a set period after a fault that caused a pickup has gone away.

When the fault hold time is 2.00 s, a forward EF with a tripping time of 3.0 s that goes away after 1.5 s for 1.0 s and then returns will cause a trip after another 1.5 s. Because the hold time, that is the time that the fault went away for (1.0 s), is a shorter duration than the Fault Hold Time (2.0 s), the pickup will remain active while protection timing is paused and the tripping time will be extended by the Fault Hold Time setting.

The Event Log will record a Paused event during the hold time. The events recorded from pickup with relevant time stamps would be:

| Event | Time Stamp |
|---|---|
| Forward Pickup Earth | 00:00:00.00 |
| All protection elements resetting | 00:00:01.50 |
| All protection elements paused | 00:00:01.50 |
| Protection element timing | 00:00:02.50 |
| Forward Earth Protection Trip | 00:00:04.00 |
| Angle at Fault 0° | 00:00:04.00 |
| Quantity at trip Earth/SEF Ir Cos (Ø) -xx.xx A | 00:00:04.00 |
| Polarising Voltage at trip $V_{ZPS}$ | 00:00:04.00 |
| Quantity at the maximum Earth/SEF – Maximum Ir Cos (Ø) –xx.xx A | 11:57:44.392 |
| Polarising Voltage at the maximum $V_{ZPS}$ | 11:57:44.392 |

The pickup was paused during the 1.0 s hold time so never reset. When the fault returned a Protection Element Timing event was logged.

**NOTE:** This was not a pickup as a pickup was already active.

The time between pickup and trip would be 4.0 s that is 3.0 s tripping time plus 1.0 s hold time.

# SEF Directional Protection

When SEF Directional Protection is enabled, it can use one of three methods to determine the direction of a SEF.

- $V_{ZPS}$
- Wattmetric
- Ir Cos (Ø)

$V_{ZPS}$ is the default option. The Decision setting determines the method used. Operating Quantities, Fault Angles and default Characteristic Angles for each method are shown in the table below.

**Table 52 Directional Protection SEF Polarising Methods**

| Polarising Method (Decision) | Operating Quantity | Fault Angle | Angle logged on Trip | Default Characteristic Angle |
|---|---|---|---|---|
| $V_{ZPS}$ | Earth Current (Ir) | $V_{ZPS} \rightarrow I_{ZPS}$ | $V_{ZPS} \rightarrow I_{ZPS}$ | $V_{ZPS} \rightarrow I_{ZPS}$ |
| Wattmetric | Residual Power<br>$V_{ZPS}$ x $I_{ZPS}$ x Cos (FA) | $V_{ZPS} \rightarrow I_{ZPS}$ | $V_{ZPS} \rightarrow I_{ZPS}$ | $V_{ZPS} \rightarrow I_{ZPS}$ |
| Ir Cos (Ø) | Active Earth Current<br>$I_{ZPS}$ x Cos (FA) | $V_{ZPS} \rightarrow I_{ZPS}$ | $V_{ZPS} \rightarrow I_{ZPS}$ | $V_{ZPS} \rightarrow I_{ZPS}$ |

## SEF VZPS Polarising

With SEF $V_{ZPS}$ polarization, the fault angle is the zero sequence current angle with respect to the zero sequence voltage angle ($V_{ZPS} \rightarrow I_{ZPS}$).

For demonstration purposes, the figure below substitute's residual current and voltage for zero sequence current and voltage. Although they have different magnitudes, the angles are the same.

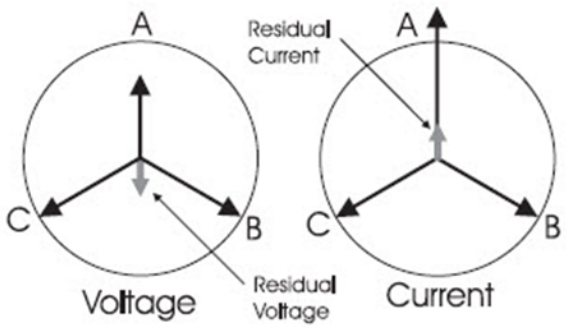



**Figure 166**
SEF Current and Voltage Phasors

This figure shows phasor diagrams for voltage and current during a hypothetical purely resistive A phase to earth fault on an earthed neutral system.

The fault causes A phase voltage to reduce and the residual voltage phasor is 180° out of phase as shown. The current in A phase is increased and the residual current phasor is in phase with A phase current.

The fault angle for this fault is 180°. That is, the residual current is 180° out of phase with the residual voltage

The actual fault angle for an earth fault is determined by the network characteristics (line resistance and reactance, neutral earthing arrangement) and the fault characteristic (such as the nature of the short-circuit – solid or arcing, fault impedance and earth resistance).

## SEF $V_{ZPS}$ Characteristic Fault Angle

The default Characteristic Angle for SEF Directional Protection is +135°. So an A phase to earth fault where the residual current led the residual voltage by 135° would be a forward fault in the centre of the forward sector.

The Characteristic Angle setting for SEF $V_{ZPS}$ polarising is configurable between -179° and 180°.

A typical Characteristic Angle for systems with solidly or impedance earthed transformer neutrals would be approximately +135°.

If this fault occurs when Protection Groups A and B are active the Event Log would record:

- Forward Pickup SEF
- Protection Group A Active
- Forward SEF Protection Trip
- Angle at Fault 135°
- Polarising Voltage at trip $V_{ZPS}$
- Polarising Voltage at the maximum $V_{ZPS}$

The same fault in the opposite direction would record:

- Reverse Pickup SEF
- Protection Group B Active
- Reverse SEF Protection Trip

- Angle at Fault -45°
- Polarising Voltage at trip $V_{ZPS}$
- Polarising Voltage at the maximum $V_{ZPS}$

## SEF $V_{ZPS}$ Sector Width

The default Forward and Reverse Sector Width settings for SEF protection are both 90°. These are ± settings and equate to actual sector widths of 180°.

Sector Width settings are identical for all elements and Decision settings. For more information, refer to Sector Width, page 253.

## SEF $V_{ZPS}$ Low Polarising Voltage Action

In order to determine the direction of a SEF that caused a pickup when VZPS polarization is used, the controller expects Zero Sequence Voltage to be above the SEF Low Threshold setting.

The Low Threshold is one of two settings that deal with low polarising voltages. The other is the Low Polarising Voltage Action.

If the polarising voltage is below the Low Threshold setting for SEFs, the Low Polarising Voltage Action setting will determine what action be taken.

The options are:

- Use Forward
- Use Reverse
- No Action (default setting)

More information on the No Action option can be found here.

The SEF Low Threshold setting can be configured for between 15 and 15000 $V_{ZPS}$. The default value is 500 $V_{ZPS}$.

When Use Forward or Use Reverse actions are selected, a fault with low polarising voltage will cause a trip as though it was a normal fault in the selected direction. The only indication that the polarising voltage was low would be the Polarising Voltage at trip $V_{ZPS}$ event which would record a value lower than the Earth Low Threshold setting.

When No Action is selected, a SEF with low polarising voltage will cause a pickup followed by a Polarising Voltage Low $V_{ZPS}$ event reporting the low value of polarising voltage. It will not cause a protection trip. The pickup condition will remain active until the fault resets.

## SEF $V_{ZPS}$ Low Voltage Reset

Once the polarising voltage has been deemed to be Low, it will not return to Normal until either the fault resets or the measured polarising voltage exceeds the Low Threshold setting by 10%. So if the Low Threshold setting is 500 $V_{ZPS}$ and a Low Voltage condition exists, $V_{ZPS}$ will have to rise to 550 $V_{ZPS}$ before the Low V condition is cancelled.

# SEFs Wattmetric Polarising

The Wattmetric method for SEF detection may be applied in all types of distribution systems having low EF values. This includes isolated-neutral high-impedance earthed and compensated systems.

The Wattmetric value is in Watts and is defined as the in-phase residual power given by:

$$\text{Residual Power} = \text{Residual Voltage} \times \text{Residual Current} \times \cos(\varnothing)$$
$$= (V_{ZPS} \times 3) \times (I_{ZPS} \times 3) \times \cos(\varnothing)$$

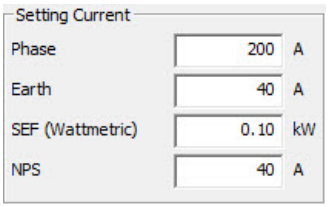
Where Ø is the Fault Angle i.e. the angle between $V_{ZPS}$ and $I_{ZPS}$.

$V_{ZPS}$ is the polarising voltage.

When Wattmetric is selected as the SEF Directional Protection Decision WSOS displays this message:




This is because the SEF Pickup Threshold (Setting Current) is now in kilo Watts (kW) as shown.




The Wattmetric SEF pickup threshold can be set between 0.01 kW and 10.0 kW.

## SEF Wattmetric Characteristic Fault Angle

When a forward SEF occurs on a compensated earthing system, $V_{ZPS}$ and $I_{ZPS}$ are assumed to be 180° out of phase.

Therefore the Characteristic Angle for Wattmetric is fixed at 180°.

The Wattmetric Fault Angle for a given fault is the Zero Sequence Current angle relative to the Zero Sequence Voltage angle $V_{ZPS} \rightarrow I_{ZPS}$.

The Angle at Fault recorded in the Event Log following a fault is the fault angle relative to the Characteristic Angle which is fixed at 180°.

So a fault with a Fault Angle ($V_{ZPS} \rightarrow I_{ZPS}$) = 135° would log an Angle at Trip of -45° (135°-180°). Which indicates that the Fault Angle is lagging the Characteristic Angle by 45°.

When the Earth Tripping Direction is Trip Forward, the above fault will log the following events:

- Forward Pickup SEF
- SEF Directional Armed
- SEF Protection Trip
- Angle at Fault -45°
- Quantity at trip Earth/SEF Wattmetric – xx.xx kW
- Polarising Voltage at trip $V_{ZPS}$
- Quantity at the maximum Earth/SEF – Maximum Wattmetric - xx.xx kW
- Polarising Voltage at the maximum $V_{ZPS}$

## SEF Wattmetric Sector Width

The default Forward and Reverse Sector Width settings for SEF protection are both 90°. These are ± settings and equate to actual sector widths of 180°.

Sector Width settings are identical for all elements and Decision settings. For more information, refer to Sector Width, page 253.

## SEF Wattmetric Low Polarising Voltage Action

In order to determine the direction of a SEF that caused a pickup when Wattmetric polarization is used, the controller expects Zero Sequence Voltage to be above the SEF Low Threshold setting.

The SEF Low Threshold is one of two settings that deal with low polarising voltages. The other is the Low Polarising Voltage Action.

If the polarising voltage is below the Low Threshold setting for SEFs, the Low Polarising Voltage Action setting will determine what action must be taken.

The options are:

- Use Forward
- Use Reverse
- No Action (default setting)

More information on the No Action option can be found here.

The SEF Low Threshold setting can be configured for between 15 and 15 000 $V_{ZPS}$. The default setting is 500 $V_{ZPS}$.

When Use Forward or Use Reverse actions are selected, a fault with low polarising voltage will cause a trip as though it was a normal fault in the selected direction. The only indication that the polarising voltage was low would be the Polarising Voltage at trip $V_{ZPS}$ event which would record a value lower than the SEF Low Threshold setting.

When No Action is selected, a SEF with low polarising voltage will cause a pickup followed by a Polarising Voltage Low $V_{ZPS}$ event reporting the low value of polarising voltage. It will not cause a protection trip. The pickup condition will remain active until the fault resets.

## SEF Wattmetric Low Voltage Reset

Once the polarising voltage for SEFs has been deemed to be Low, it will not return to Normal until either the fault resets or the measured polarising voltage exceeds the Low Threshold setting by 10%. So if the Low Threshold setting is 500 $V_{ZPS}$ and a Low Voltage condition exists, $V_{ZPS}$ will have to rise to 550 $V_{ZPS}$ before the Low V condition is cancelled.

## SEF Wattmetric Voltage Memory

When Wattmetric is selected as the Decision for directional SEF, a Voltage Memory time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

Consider a forward SEF at the Characteristic Angle with $V_{ZPS}$ above the SEF Low Threshold setting and an expected tripping time of 3.5 s. If this fault is applied for 2.0 s and then $V_{ZPS}$ drops below the Low Threshold setting, the controller will retain the last $V_{ZPS}$ value that was sampled above the threshold for the Voltage Memory time.

This means that the low voltage condition is effectively ignored and the protection trip will still occur in the expected tripping time of 3.5 s.

The memorized voltage and corresponding fault angle logged following the trip will be identified by an asterisk '*'.

The Event Log will report the following events:

- Forward Pickup SEF
- Protection Group A Active
- Forward SEF Protection Trip
- Angle at Fault* 0°
- Quantity at trip Earth/SEF Wattmetric xx.xx kW

- Polarising Voltage at trip* $V_{ZPS}$ 514 V
- Quantity at the maximum Earth/SEF Maximum Wattmetric xx.xx kW
- Polarising Voltage at the maximum $V_{ZPS}$ 601 V

**NOTE:**

- The Angle at Fault and Polarising Voltage at trip events above are identified as memorized values.
- The memorized Polarising Voltage at trip* $V_{ZPS}$ would be expected to be just above the Low Threshold setting (default 500 V).
- The Polarising Voltage at the maximum is not a memorized value as $V_{ZPS}$ was above the Low Threshold setting when the fault first appeared.

## SEF Wattmetric Fault Hold Time

When Wattmetric is selected as the Decision for directional SEFs, a Fault Hold Time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

The effect of the Fault Hold Time is to pause the protection timing for a set period after a fault that caused a pickup has gone away.

When the fault hold time is 2.00 s, a forward SEF with a tripping time of 3.0 s that goes away after 1.5 s for 1.0 s and then returns will cause a trip after another 1.5 s. Because the hold time, that is the time that the fault went away for (1.0 s), is a shorter duration than the Fault Hold Time (2.0 s), the pickup will remain active while protection timing is paused and the tripping time will be extended by the Fault Hold Time setting.

The Event Log will record a Paused event during the hold time.

The events recorded from pickup with relevant time stamps would be:

| Event | Time Stamp |
|---|---|
| Forward Pickup SEF | 00:00:00.00 |
| SEF Directional Armed | 00:00:00.00 |
| All protection elements resetting | 00:00:01.50 |
| All protection elements paused | 00:00:01.50 |
| Protection element timing | 00:00:02.50 |
| SEF Protection Trip | 00:00:04.00 |
| Quantity at trip Earth/SEF Wattmetric xx.xx kW | 11:57:44.392 |
| Polarizing Voltage at trip $V_{ZPS}$ | 11:57:44.392 |

The fault was paused during the 1.0 s hold time so never reset. When the fault returned a Protection Element Timing event was logged.

**NOTE:** This was not a pickup as a pickup was already active.

The time between pickup and trip would be 4.0 s that is 3.0 s tripping time plus 1.0 s hold time.

# SEF Ir Cos (Ø) Polarising

The Ir Cos (Ø) operating characteristic is used in similar situations to Wattmetric.

The operating value is defined as the active current component of the zero sequence current with respect to the zero sequence voltage given by:

$$\text{Active Earth Current} = \text{Residual Current x Cos } (Ø)$$
$$= (I_{ZPS} \text{ x } 3) \text{ x Cos } (Ø)$$

Where Ø is the Fault Angle i.e. the angle between the $V_{ZPS}$ and $I_{ZPS}$ phasors.

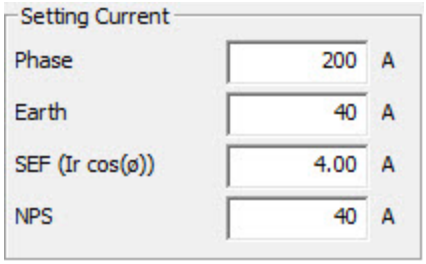
This feature works in a similar manner to Wattmetric with the following differences.

- The Active Current threshold is adjustable in the range 0.05 to 20 A in steps of 0.01 A with a default value of 4 A.
- Ir Cos (Ø) is the value used to determine whether a fault is present, that is the pickup value.

When Ir cos (Ø) is selected as the polarising decision for directional SEFs, WSOS displays this message:




This is because the SEF Pickup Threshold (Setting Current) is now set in Ir Cos (Ø) units as shown.




## Earth Ir Cos (Ø) Characteristic Fault Angle

When a forward EF occurs on a compensated earthing system, $V_{ZPS}$ and $I_{ZPS}$ are assumed to be 180° out of phase.

Therefore the Characteristic Angle for Ir Cos (Ø) is fixed at 180°.

The Ir Cos (Ø) Fault Angle for a given fault is the Zero Sequence Current angle relative to the Zero Sequence Voltage angle $V_{ZPS} \rightarrow I_{ZPS}$.

The Angle at Fault recorded in the Event Log is the fault angle relative to the Characteristic Angle which is fixed at 180°.

So a fault with a Fault Angle ($V_{ZPS} \rightarrow I_{ZPS}$) = 135° would log an Angle at Fault of -45° (135°-180°) which indicates that the fault angle is lagging the Characteristic Angle by 45°.

Other events that are logged for the above fault include:

- Forward Pickup Earth
- Forward Earth Protection Trip
- Angle at Fault -45°
- Quantity at trip Earth/SEF Ir Cos (Ø) – xx.xx A
- Polarising Voltage at trip $V_{ZPS}$
- Quantity at the maximum Earth/SEF – Maximum $I_R$CosØ - xx.xx A
- Polarising Voltage at the maximum $V_{ZPS}$

## SEF Ir Cos (Ø) Sector Width

The default Forward and Reverse Sector Width settings for SEF protection are both 90°. These are ± settings and equate to actual sector widths of 180°.

Sector Width settings are identical for all elements and Decision settings. For more information, refer to Sector Width, page 253.

## SEF Ir Cos (Ø) Low Polarising Voltage Action

In order to determine the direction of a SEF that caused a pickup when Ir Cos (Ø) polarization is used, the controller expects Zero Sequence Voltage to be above the SEF Low Threshold setting.

The SEF Low Threshold is one of two settings that deal with low polarising voltages. The other is the Low Polarising Voltage Action.

If the polarising voltage is below the Low Threshold setting for SEF faults, the Low Polarising Voltage Action setting will determine what action must be taken.

The options are:

- Use Forward
- Use Reverse
- No Action (default setting)

More information on the No Action option can be found here.

The Earth Low Threshold setting can be configured for between 15 and 15 000 Volts.

When Use Forward or Use Reverse actions are selected, a fault with low polarising voltage will cause a trip as though it was a normal fault in the selected direction. The only indication that the polarising voltage was low would be the *Polarising Voltage at trip* $V_{ZPS}$ event which would record a value lower than the SEF Low Threshold setting.

When No Action is selected, an SEF fault with low polarising voltage will cause a pickup followed by a Polarising Voltage Low $V_{ZPS}$ event reporting the low value of polarising voltage. It will not cause a protection trip.

The pickup condition will remain active until the fault resets.

## SEF Ir Cos (Ø) Low Voltage Reset

Once the polarising voltage for SEF faults has been deemed to be Low, it will not return to Normal until either the fault resets or the measured polarising voltage exceeds the Low Threshold setting by 10%.

So if the Low Threshold setting is 500 $V_{ZPS}$ and a Low Voltage condition exists, $V_{ZPS}$ will have to rise to 550 $V_{ZPS}$ before the Low V condition is cancelled.

## SEF Ir Cos (Ø) Voltage Memory

When Ir Cos (Ø) is selected as the Decision for directional SEFs, a Voltage Memory time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

Consider a forward SEF fault at the Characteristic Angle with $V_{ZPS}$ above the SEF Low Threshold setting and an expected tripping time of 3.5 s. If this fault is applied for 2.0 s and then $V_{ZPS}$ drops below the Low Threshold setting, the controller will retain the last $V_{ZPS}$ value that was sampled above the threshold for the Voltage Memory time.

This means that the low voltage condition is effectively ignored and the protection trip will still occur in the expected tripping time of 3.5 s.

The memorized voltage and corresponding fault angle will be identified by an asterisk '*'.

The Event Log will report the following events:

- Forward Pickup SEF
- Forward SEF Protection Trip
- Angle at Fault* 0°
- Quantity at trip Earth/SEF Ir Cos (Ø) - xx.xx A

- Polarising Voltage at trip* $V_{ZPS}$ 544 V
- Quantity at the maximum Earth/SEF Maximum Ir Cos (Ø) - xx.xx A
- Polarising Voltage at the maximum $V_{ZPS}$ 601 V

**NOTE:**

- The Angle at Fault and Polarising Voltage at trip events above are identified as memorized values.
- The Polarising Voltage at trip* VZPS would be expected to be just above the Low Threshold setting (default 500 V).
- The Polarising Voltage at the maximum is not a memorized value as $V_{ZPS}$ was above the Low Threshold setting when the fault first appeared.

### SEF Ir Cos (Ø) Fault Hold Time

When Ir Cos (Ø) is selected as the Decision for directional SEFs, a Fault Hold Time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

The effect of the Fault Hold Time is to pause the protection timing for a set period after a fault that caused a pickup has gone away.

When the fault hold time is 2.00 s, a forward SEF with a tripping time of 3.0 s that goes away after 1.5 s for 1.0 s and then returns will cause a trip after another 1.5 s. Because the hold time, that is the time that the fault went away for (1.0 s), is a shorter duration than the Fault Hold Time (2.0 s), the pickup will remain active while protection timing is paused and the tripping time will be extended by the Fault Hold Time setting.

The Event Log will record a Paused event during the hold time.

The events recorded from pickup with relevant time stamps would be:

| Event | Time Stamp |
|---|---|
| Forward Pickup SEF | 00:00:00.00 |
| All protection elements resetting | 00:00:01.50 |
| All protection elements paused | 00:00:01.50 |
| Protection element timing | 00:00:02.50 |
| Forward SEF Protection Trip | 00:00:04.00 |
| Angle at Fault 0° | 00:00:04.00 |
| Quantity at trip Earth/SEF Ir Cos (Ø) -xx.xx A | 00:00:04.00 |
| Polarising Voltage at trip $V_{ZPS}$ | 00:00:04.00 |
| Quantity at the maximum Earth/SEF – Maximum Ir Cos (Ø) –xx.xx A | 11:57:44.392 |
| Polarising Voltage at the maximum $V_{ZPS}$ | 11:57:44.392 |

The pickup was paused during the 1.0 s hold time so never reset. When the fault returned a Protection Element Timing event was logged.

**NOTE:** This was not a pickup as a pickup was already active.

The time between pickup and trip would be 4.0 s that is 3.0 s tripping time plus 1.0 s hold time.

## NPS Directional Protection

**NOTE:** NPS protection is not available by default. Sequence Components must be made available before it can be used The direction of NPS overcurrent faults can be determined by their Fault Angle.

The Fault Angle is the relationship between the NPS current $I_{NPS}$ and the NPS voltage $V_{NPS}$. that is $V_{NPS} \rightarrow I_{NPS}$

for example, $V_{NPS}$ = 60°, INPS = 180° Therefore NPS Fault Angle = 120°

NPS Voltage ($V_{NPS}$) is used as the polarising voltage for NPS faults.

Operational values for directional NPS are shown below:

| Polarising Method | Fault Angle | Characteristic Fault Angle (default) | Low Threshold (default) | Range |
|---|---|---|---|---|
| $V_{NPS}$ | $V_{NPS} \rightarrow I_{NPS}$ | 120° | $V_{NPS}$= 500 V | Adjustable $V_{NPS}$300 to 2000 V |

## NPS Characteristic Fault Angle

The NPS Characteristic Fault Angle is the expected fault angle for a forward NPS overcurrent fault.

The Default Characteristic Angle for NPS EF Directional Protection is 120°. So an NPS fault where the NPS current $I_{NPS}$ leads the NPS voltage $V_{NPS}$ by 120° would be a forward fault in the centre of the forward sector.

For NPS protection, the Characteristic Angle can be configured for a value between -179° and 180°.

When an NPS fault is detected, its fault angle is calculated and compared to the NPS Characteristic Angle to determine if the fault is forward or reverse. If the fault angle is within ± 90° (7) of the Characteristic Angle the fault is forward, otherwise it's a reverse fault.

When Protection Groups A and B are active, an NPS fault at the Characteristic Angle would log the following events:

- Forward Pickup NPS
- Protection Group A Active
- Forward NPS Protection Trip
- Angle at Fault 120°
- Polarising Voltage at Trip $V_{NPS}$
- Polarising Voltage at the Maximum $V_{NPS}$

A reverse NPS fault where the fault current lags the polarising voltage by 60° would log the events below.

- Reverse Pickup NPS
- Protection Group B Active
- Reverse NPS Protection Trip
- Angle at Fault -60°
- Polarising Voltage at Trip $V_{NPS}$
- Polarising Voltage at the Maximum $V_{NPS}$

## NPS Sector Width

The default Forward and Reverse Sector Width settings for NPS protection are both 90°. These are ± settings and equate to actual sector widths of 180°.

Sector Width settings are identical for all elements and Decision settings. For more information, refer to Sector Width, page 253.

(7) Assumes default settings for Forward and Reverse Sector Widths that is 90°.

The likelihood of a fault angle causing an incorrect direction determination may be lessened by either increasing or decreasing the Sector Width setting.

The range of these settings is 45° to 135° which equate to actual sector widths of 90° and 270° respectively.

## NPS Low Polarising Voltage Action

In order to determine the direction of an NPS fault that caused a pickup, the controller requires sufficient polarising voltage $V_{NPS}$.

Directional NPS Protection includes two settings that deal with low polarising voltage.

- Low Polarising Voltage Action
- Low Threshold

If the polarising voltage is below the Low Threshold setting for NPS faults, the Low Polarising Voltage Action setting will determine what action must be taken.

The options are:

- Use Forward
- Use Reverse
- No Action (default setting)

More information on the No Action option can be found here.

The NPS Low Threshold setting can be configured for between 300...2,000 V.

When Use Forward or Use Reverse actions are selected, a fault with low polarising voltage will cause a trip as though it was a normal fault in the selected direction. The only indication that the polarising voltage was low would be the Polarising Voltage at trip $V_{NPS}$ event which would record a value lower than the NPS Low Threshold setting.

When No Action is selected, a fault with low polarising voltage will cause a pickup followed by a Polarising Voltage Low $V_{NPS}$ event reporting the low value of polarising voltage. It will not cause a protection trip. The pickup condition will remain active until the fault resets.

## NPS Low Voltage Reset

Once the polarising voltage for NPS faults has been deemed to be Low, it will not return to Normal until either the fault resets or the measured polarising voltage exceeds the Low Threshold setting by 10%. So if the Low Threshold setting is 500 $V_{NPS}$ and a Low Voltage condition exists, $V_{NPS}$ will have to rise to 550 $V_{NPS}$ before the Low V condition is cancelled.

**Table 49 Directional Protection Settings/Specifications**

| **Directional Protection Settings/Specifications** | |
|---|---|
| System Phase/Earth Nominal Voltage for correct operation | 2...25 kV |
| **Phase Directional Protection** | |
| Phase Characteristic Angle setting range | ± 180 ° |
| Phase Characteristic Angle setting resolution | 1 ° |
| Phase Characteristic Angle accuracy | ± 10 ° |
| Time to determine direction for phase faults | 20 ms |
| Minimum Quadrature Polarising Voltage for Phase Directional Protection to operate | 150 V |
| **Earth/SEF Directional Protection** | |
| Earth/SEF Characteristic Angle setting range | ± 180 ° |

**Table 49 Directional Protection Settings/Specifications (Continued)**

| **Directional Protection Settings/Specifications** | |
|---|---|
| Earth/SEF Characteristic Angle setting resolution | 1 ° |
| Characteristic Angle accuracy from 2...5 A earth current | ± 30 ° |
| Characteristic Angle accuracy from 5...20 A earth current | ± 20 ° |
| Characteristic Angle accuracy above 20 A earth current | ± 20 ° |
| Time to determine direction for EFs | 20 ms |
| Time to determine fault direction for SEF faults | 500 ms |
| Minimum Zero Sequence Polarising Voltage $V_{ZPS}$ for Earth<br><br>Directional Protection to operate | 15 V |
| Minimum Zero Sequence Polarising Voltage $V_{ZPS}$ for SEF<br><br>Directional Protection to operate | 15 V |
| Minimum SEF Definite time when Directional Protection is ON | 0.1 s |
| **NPS Directional Protection** | |
| NPS Characteristic Angle Setting range | ±180° |
| NPS Characteristic Angle Setting resolution | 1° |
| NPS Characteristic Angle Accuracy | ±10° |
| Time to determine fault direction for NPS faults | 20 ms |
| Minimum Negative Sequence Polarising Voltage $V_{NPS}$ for NPS Directional Protection to operate | 300 V |
| **Control** | |
| Low Polarising Voltage Action | No Action, Use Forward, Use Reverse |
| Forward Sector Width | 45°...135° |
| Reverse Sector Width | 45°...135° |
| Phase Low Threshold | 150...15,000 $V_{QUAD}$ |
| Phase Voltage Memory | Off<br><br>0.01...10.00 s |
| Earth Decision | $V_{ZPS}$, Wattmetric, Ir Cos (Ø) |
| Earth Low Threshold | 15...15,000 $V_{ZPS}$ |
| Earth Wattmetric Characteristic Angle | 180° Fixed |
| Earth Ir Cos (Ø) Characteristic Angle | 180° Fixed |
| Earth Voltage Memory | Off,<br><br>0.01...10.00 s |
| EF Hold Time | Off,<br><br>0.01...10.00 s |
| SEF Decision | $V_{ZPS}$, Wattmetric,<br><br>Ir Cos (Ø) |
| SEF Low Threshold | 15...15,000 $V_{ZPS}$ |
| SEF Wattmetric Characteristic Angle | 180° Fixed |
| SEF Ir Cos (Ø) Characteristic Angle | 180° Fixed |
| SEF Voltage Memory | Off, |

**Table 49 Directional Protection Settings/Specifications (Continued)**

| **Directional Protection Settings/Specifications** | |
|---|---|
| | 0.01...10.00 s |
| SEF Fault Hold Time | Off,<br>0.01...10.00 s |
| NPS Low Threshold | 200...3,000 $V_{NPS}$ |
| **$V_{ZPS}$ Balance** | |
| Residual Earth Voltage dynamic balance limit | 0 % |
| Residual Earth Voltage dynamic balance rate | 0.6% per s |
| | |
| High $V_{ZPS}$ Alarm Timeout | 1...180 s |
| High $V_{ZPS}$ Alarm Set point | 15...15,000 V |
| **Wattmetric and Ir Cos (Ø) Pickup Settings** | |
| Earth Wattmetric Pickup Setting | 0.1...500.0 kW |
| Earth Ir Cos (Ø) Pickup Setting | 10...1260 A |
| SEF Wattmetric Pickup Setting | 0.01...10.00 kW |
| SEF Ir Cos (Ø) Pickup Setting | 0.05...20.00 A |

# Voltage Operated Protection Elements

## UOV Protection

UOV protection continuously compares real time voltage measurements with thresholds derived from the Nominal Phase to Earth Voltage setting and, in conjunction with the Phase Logic setting, determines if the measured voltages is within or outside of the normal voltage band limits.

If the measured voltage is deemed to be outside the normal voltage band for an unacceptable length of time, UOV protection can either generate an alarm or trip the switchgear as configured.

Other features of UOV protection include:

- Following a UOV trip, the switchgear can be automatically closed once the normal voltage state has been restored.
- UOV protection can be forced Off in the case of excessive voltage protection trip/close sequences within a set time.
- Normal Voltage close can be forced Off if the voltage does not recover within a set time following a trip.

## UOV Protection Configuration

In order for **UOV protection** to be enabled and configured it must be available. The feature can be made available in WSOS on the Feature Selection page by going to:

**Display** > **Configuration** > **Feature Selection** > **Protection** > **UOV Protection**.

UOV protection can also be made available on the operator interface.

Once UOV protection has been made available, UOV protection can be configured **On** or **Off** individually. If either Under or Over Voltage protection is **On**, it can be individually configured to either **Alarm** or **Trip**.

UOV protection can be configured in WSOS on the UOV page in the Protection menu.

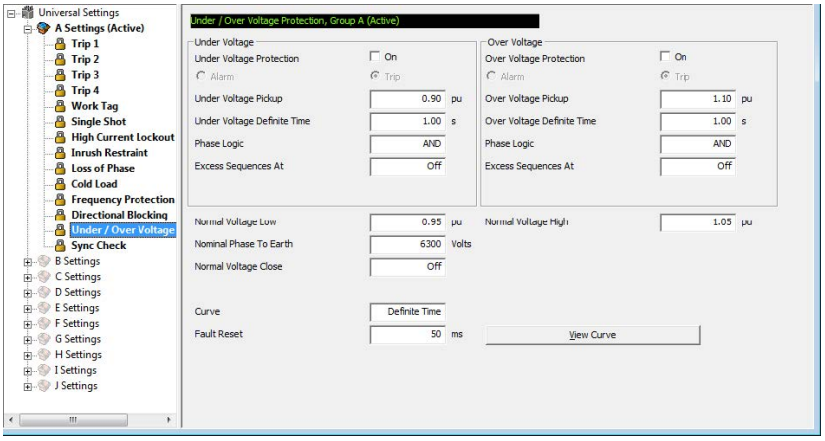



**Figure 167**
WSOS UOV Protection settings

UOV Protection can also be configured on the operator interface.

**NOTE:** UOV protection threshold settings are configured in per unit values based on the Nominal Phase to Earth voltage setting.

## Dead-bands

A voltage dead-band of 0.02 pu is used to provide hysteresis and helps to prevent a voltage value that is fluctuating around a pickup threshold from causing excessive events for example pickup/reset.

With the default Normal Phase to Earth setting of 6300 V, the dead band would be 0.02 x 6300 = 126 V.

This dead-band will affect the minimum/maximum range of values for threshold settings. For example, the maximum value for the Under Voltage Pickup setting would be the Normal Voltage Low setting – 0.02 pu.

The dead-bands also affect the normal voltage range depending on whether the measured voltage is normal or abnormal.

When the voltage is in the Normal voltage range the high and low thresholds are:

- **High**: Voltage is greater than the Normal Voltage High setting + the dead-band.
- **Low**: Voltage is less than the Normal Voltage Low setting – the dead-band.

When the voltage is outside the Normal voltage range the normal thresholds are:

**Normal**: Voltage

- Is less than or equal to the Normal Voltage High setting.
- Greater than or equal to the Normal Voltage Low setting.

UOV Protection can be configured with the following settings:

**Table 54 UOV Protection settings**

| Under Voltage Protection | |
|---|---|
| **Setting** | **Description** |
| Under Voltage Protection | On or Off |
| Under Voltage Mode | Trip or Alarm (Only applicable when Under Voltage Protection is On). |
| Under Voltage Pickup | The voltage expressed as a per unit value at which an Under Voltage pickup will occur.<br><br>Range: 0.50 per unit – (Normal Voltage Low setting -0.02 per unit). |

**Table 54 UOV Protection settings (Continued)**

| Under Voltage Protection | |
|---|---|
| **Setting** | **Description** |
| | Default: 0.9 per unit |
| Under Voltage Definite Time | The time that an under voltage condition will take to cause an alarm or trip depending on the *UV mode* setting. (Only applicable when the Curve setting is Definite Time).<br>Range: 0.01...300.00 s. Default: 1.0 s |
| Under Voltage Phase Logic | The phase logic that applies to Under Voltage protection.<br>Range: AND/OR/Average. Default: AND |
| Under Voltage Excess Sequences At | The number of Under Voltage trip/close sequences that can occur within a given time before Under Voltage protection is turned Off.<br>Range: Off, 1...20 Default: Off |
| Excess Sequences In | The time in which the number of UV trip/close sequences configured in Excess Sequences A must occur for UV protection to be turned Off. (Only applicable when Excess Sequences At is not Off). |
| **Over Voltage Protection** | |
| Over Voltage Protection | On or Off |
| Over Voltage Mode | Trip or Alarm (Only applicable when Over Voltage Protection is On). |
| Over Voltage Pickup | The voltage expressed as a per unit value at which an Over Voltage pickup will occur.<br>Range (Normal Voltage High setting + 0.02 per unit) - 2.00 per unit<br>Default 1.1 per unit |
| Over Voltage Definite Time | The time that an over voltage condition will take to cause an alarm or trip depending on the OV mode setting. (Only applicable when the Curve setting is Definite Time).<br>Range: 0.01...300.00 s. Default: 1.0 s |
| Over Voltage Phase Logic | The phase logic that applies to Over Voltage protection.<br>Range: AND/OR/Average. Default: AND |
| Over Voltage Excess Sequences At | The number of Over Voltage trip/close sequences that can occur within a given time before Over Voltage protection is turned Off.<br>Range: Off, 1...20 Default: Off |
| Excess Sequences In | The time in which the number of OV trip/close sequences configured in Excess Sequences At must occur for OV protection to be turned Off. (Only applicable when Excess Sequences At is not Off). |
| **UOV Protection** | |
| Normal Voltage Low | The voltage expressed as a per unit value below which it is considered to be below the normal voltage range.<br>Range: Under Voltage Pickup + 0.02 per unit – 1.00 per unit<br>Default: 0.95 per unit. |
| Normal Voltage High | The voltage expressed as a per unit value above which it is considered to be above the normal voltage range.<br>Range: 1.00 per unit - Over Voltage Pickup - 0.02 per unit.<br>Default: 1.05 per unit. |
| Nominal Phase to Earth | Defines the nominal phase to earth system voltage. This is a critical setting as it is used to derive the per unit values configured for other settings.<br>Range: 2000...25,000 V<br>Default: 6,300 V |

**Table 54 UOV Protection settings (Continued)**

| Under Voltage Protection | |
|---|---|
| **Setting** | **Description** |
| Recovery Time Out | The time period allocated for the recovery of the voltage to within the Normal System Voltage range after an Under or Over Voltage trip. (Only applicable if Normal Voltage Close is On).<br><br>Range: Off, 1...1440 minutes.<br><br>Default: Off |
| Normal Voltage Close | This setting determines whether the switchgear must automatically reclose following a UOV trip if the source voltage returns to within normal limits within a set time.<br><br>Range: On/Off Default: Off |
| Normal Voltage Close After | The time that the source voltage must have returned to and stayed within the UOV Normal Voltage thresholds (plus dead-bands) before an automatic Normal Voltage Close takes place.<br><br>(Only applicable if Normal Voltage Close is On).<br><br>Range: 1...1000 s<br><br>or<br><br>1 s - ((Recovery Time Out setting/60) – 1) s – When Recovery Time Out is On.<br><br>Default: 10 s |
| Curve | This setting is used to select the Voltage – Time curve.<br><br>Range: Definite Time, User Curve 1 to 5.<br><br>Default: Definite Time. |
| Fault Reset | The time it takes for a UOV alarm to reset after the voltage returns to normal (± the dead-band) following a UOV pickup.<br><br>Range: 0...10,000 ms<br><br>Default: 50 ms |

## UOV Protection Curves

UOV protection uses a form of voltage/time curve to provide an envelope beyond which protection trips or alarms will occur. The curves available are:

- Definite Time – This option is always available and if selected requires UOV to be configured with individual times between 0.01...300.00 s.
- User Defined – If a customized curve is required it can be configured using the curve editor in WSOS. Up to five user defined curves can be loaded into an PowerLogic ADVC Controller and are then available for selection.

## Phase Logic

The individual UOV Phase Logic settings control the method by which measured voltages are evaluated against their respective Pickup and Normal thresholds.

This setting determines the conditions required to generate UOV protection pickup or reset events.

- **AND** – When ALL the measured phase voltages deviate beyond the UOV thresholds.
- **OR** – When ANY measured phase voltage deviates beyond the UOV thresholds.
- **Average** – When the numerical average of all three measured phase voltages deviates beyond the UOV thresholds.

## Normal Voltage Band

For the correct operation of the UOV protection, a Normal Voltage band needs to be defined.

The Normal Voltage band defines the range within which the voltage is considered normal.

For the default settings shown below:




The normal range of voltages would be between 0.95 pu and 1.05 pu. Which with a Nominal Phase to Earth voltage of 6300 V would relate to:

(0.95 x 6300) to (1.05 x 6300) = 5985 V to 6615 V (phase to earth)

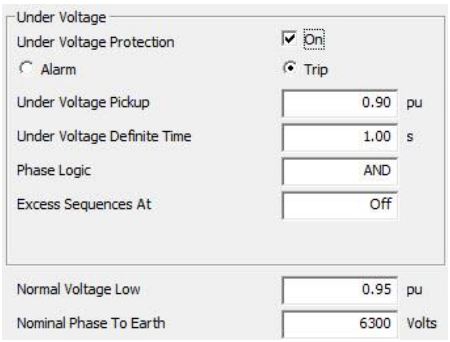
Which would equate to 10366 V to 11457 V (phase to phase)

If the voltage moves outside this band then the voltage is abnormal that is either High or Low. Each change of state is recorded in the Event Log.

## Under Voltage Protection Operation

Under Voltage protection can be configured to either trip the switchgear or generate an alarm if the measured system voltage goes below the pre-set limits for a pre-set time.

Consider the Under Voltage protection configured to trip with the default settings shown below:




Each phase to earth voltage will cause a Low Voltage condition if it falls below 5985 V (0.95 x 6300). These events would be recorded in the Event Log.

The Phase Logic is set to AND which means that all three phase to earth voltages would need to fall below 5670 V (0.9 x 6300) to cause an Under Voltage pickup.

If that happens and each voltage remains below this value plus the dead-band setting 5796 V (0.92 pu) for the Definite Time setting of 1.0 s, the PowerLogic ADVC Controller will send a trip request to the switchgear.

Immediately following the trip, the Event Log will record the minimum voltage for each phase sampled during the fault in per unit values.

The following events would be logged:

| Time | Event |
|---|---|
| 00:00:00.00 | A Voltage Low |
| 00:00:00.00 | B Voltage Low |
| 00:00:00.00 | C Voltage Low |
| 00:00:10.00 | UV Pickup |
| 00:00:11.00 | Protection Trip Request |

| Time | Event |
|---|---|
| 00:00:11.00 | UV Trip |
| 00:00:11.00 | A Min 0.88 pu |
| 00:00:11.00 | B Min 0.88 pu |
| 00:00:11.00 | C Min 0.88 pu |

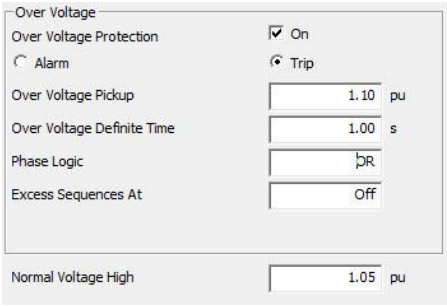
If the Under Voltage protection mode was set to Alarm, there would have been no Protection Trip Request and the Event Log would have recorded UV Alarm instead of UV Trip.

The Minimum Voltage events would have still been recorded when the under voltage condition reset.

## Over Voltage Protection Operation

Over Voltage protection can be configured to either trip the switchgear or generate an alarm if the measured system voltage goes above the pre-set limits for a pre-set time.

Consider the Over Voltage protection configured to trip with the settings shown below:




The Phase Logic is set to OR which means that only one or more of the phase to earth voltages need to rise above the Over Voltage Pickup setting to cause an Over Voltage pickup.

Consider a case where only A phase voltage initially goes just above the Normal Voltage High setting of 6615 V (1.05 pu) and records a Voltage High event.

If sometime later it rises further to exceed 6930 V (1.1 x 6300) it will cause an Over Voltage pickup.

Providing the A phase voltage remains above the pickup value minus the dead-band (that is 68904 V or 1.08 pu), for one second according to the Definite Time setting, the PowerLogic ADVC Controller will send a trip request to the switchgear.

Immediately following the trip, the Event Log will record the maximum voltage sampled for each faulted phase during the fault in per unit values.

The following events would be logged:

| Time | Event |
|---|---|
| 00:00:00.00 | A Voltage High |
| 00:00:10.00 | Over Voltage Pickup |
| 00:00:11.00 | Protection Trip Request |
| 00:00:11.00 | Over Voltage Trip |
| 00:00:11.00 | A Max 1.2 pu |

If the Over Voltage protection mode was set to Alarm, there would have been no Protection Trip Request and the Event Log would have recorded Over Voltage Alarm instead of Over Voltage Trip.

The Maximum Voltage events for the faulted phases would have still been recorded when the Over voltage condition reset.

Under and Over Voltage alarms are available for transmission by SCADA protocols. They can also be mapped to IOEX outputs and ***flex*VUE** operator interface lamps and are available for use with the WSOS Configurable Logic Tool.

## Average Phase Logic Events

When the Phase Logic is set to Average, only one event is logged for Voltage High and Low events as well as Minimum and Maximum voltage events.

Examples are shown below:

- ABC Voltage High
- ABC Voltage Low
- ABC Min 0.84 pu
- ABC Max 1.16 pu

## Pickup Thresholds and Reset

The **Pickup** thresholds are expressed as per unit values based on the Nominal Phase to Earth Voltage setting. A Pickup occurs when the measured voltage is:

- **Under Voltage**
  - Less than or equal to the Under Voltage Pickup setting.
- **Over Voltage**
  - Greater than or equal to the Over Voltage Pickup setting.

**Fault Reset** occurs following a pickup when the voltage then becomes:

- **Under Voltage**
  - Greater than the Under Voltage Pickup setting plus the dead-band for the Fault Reset time OR less than the Live/Dead threshold.
- **Over Voltage**
  - Less than the Over Voltage Pickup setting minus the dead-band for the Fault Reset Time.

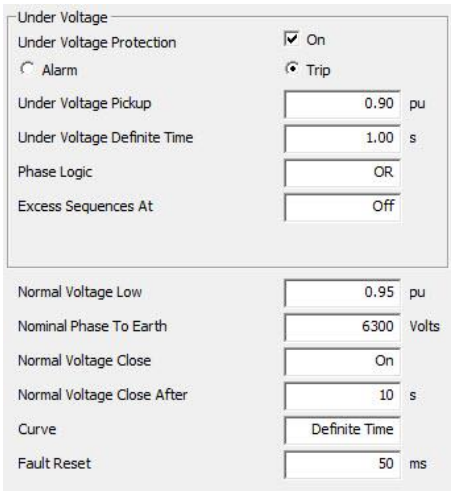
## Normal Voltage Close

A Normal Voltage Close closes the ACR automatically after an Under or Over Voltage protection trip when the following are ALL true:

- The trip was attributed to the UOV protection.
- Normal Voltage Close was On before the UOV trip and is still On.
- The voltage on ALL source phases have returned to and stayed Normal for the duration of the Normal Voltage Close Time plus the fault reset time. This means that the fault must reset before Normal Voltage Close timing starts.
- The Normal Voltage Close timing is aborted every time the measured voltage is not Normal.

  **NOTE:** Auto Reclose does not apply to UOV protection trips.

The settings below show a Normal Voltage Close configured to occur after a delay of 10 s.




If a Normal Voltage Close occurred due to the voltage returning to normal 5 s after an Under Voltage trip caused by a fault on A phase, the following events would be logged:

| Time | Event |
|---|---|
| 00:00:00.00 | UV Pickup |
| 00:00:01.00 | Protection Trip Request |
| 00:00:01.00 | UV Trip |
| 00:00:01.00 | A Min 0.88 pu |
| 00:00:01.00 | UV Reset |
| 00:00:06.00 | A Voltage Normal |
| 00:00:16.00 | NV Close |

## Recovery Time Out

The **Recovery Time Out** setting determines how long a **Normal Voltage Close** will remain pending after a UOV protection trip.

The maximum value for the Normal Voltage Close time is the Recovery Time Out time minus 1 s (when Recovery Time Out is On).

The figure below shows a maximum Normal Voltage Close After time of 599 s due to the Recover Time Out setting of 10 minutes.

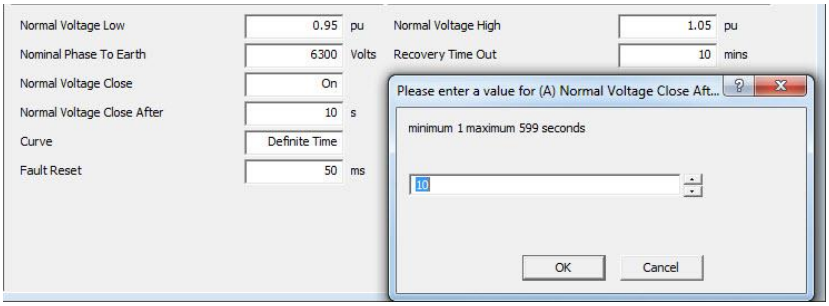



**Figure 168**
WSOS Normal Voltage Close setting

Should the switchgear NOT close subsequent to a UOV protection trip within the configured Recovery Time Out period, the ACR will go to Lockout.

A UOV Recover Time Out event will be logged and a SCADA alarm point will be set.

If the voltage on the source side bushings drops below the Live/Dead threshold, the Normal Voltage Close will be aborted and the ACR will go to Lockout.

## Excess UOV Protection Sequences

A Under Voltage (or Over Voltage) Sequence is a Under Voltage (or Over Voltage) trip followed by a Normal Voltage Close.

If the number of Under Voltage (or Over Voltage) sequences equals a configured threshold within a configured time period, then Under Voltage (or Over Voltage) protection will be turned Off by forcing Under Voltage Trip (or Over Voltage Trip) to Off.

An event will be logged and a SCADA alarm point will be set at the time of the last Close

For example,

- Under Voltage Excess Sequence
- Over Voltage Excess Sequence

The time period is a rolling window that is updated every minute. If the Excess Sequences In setting is 10 minutes, the count will always be the number of sequences that occurred in the 10 minutes prior to the most recent update.

## Changing Settings

If any protection settings, or settings from the following list change during a UOV protection sequence, the sequence will be aborted. If the switchgear was tripped due to UOV protection the ACR will go to Lockout.

- Power Direction (Source/Load designation)
- Protection On/Off
- UOV Protection Available

## Single Sided CVT Switchgear

UOV protection may be used on a PMSet U Series ACR with voltage measurement on only one side but Normal Voltage Close can only be configured if the voltage measurement is on the designated Source side.

If Normal Voltage Close is On when the Source/Load designation is changed it will be forced Off.

If the Source/Load designation is changed while a normal voltage close is pending, the ACR will go to Lockout.

## Over Voltage Protection Sequence Example

The figure below is a graphical representation of a voltage fluctuation that caused an **Over Voltage trip** before recovering to cause a **Normal Voltage Close**.

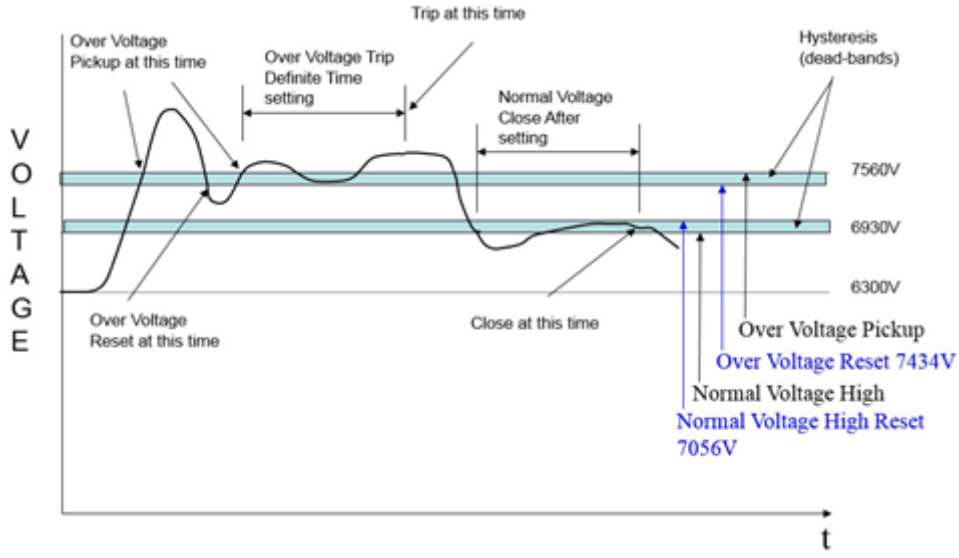



**Figure 169**
Over Voltage Protection Sequence

The settings in service at the time were:

- Nominal Phase to Earth Voltage = 6300 V
- Over Voltage Pickup = 1.2 pu = 7560 V
- Normal Voltage High = 1.1 pu = 6930 V
- And Dead-band = 0.02 pu = 126 V
- Therefore: Over Voltage Reset = 7560 V–126 V = 7434 V
- Normal Voltage High Reset = 6930 V + 126 V = 7056 V

### Sequence of Events

The first time the frequency went below the Under Frequency Pickup (48.0 Hz) it caused a pickup, but it went back up above the Under Frequency Reset (48.2 Hz) and reset before the Under Frequency Trip After number of cycles had completed.

The next time the frequency went below 48.0 Hz it caused another pickup and this time stayed below 48.2 Hz long enough to cause an Under Frequency trip.

Sometime later the frequency went back up above the Under Frequency Normal At setting (49.0 Hz) which started the Normal Frequency Close After timer. Because the frequency then stayed above the Under Frequency Normal Reset value (48.8 Hz) until the Normal Frequency Close After time out expired, the switchgear would have closed.

## UOV Protection Summary

- UOV protection, when enabled, can be configured individually.
- Under Voltage protection will cause a protection trip or generate an alarm as configured when the source side voltages fall below the Under Voltage Pickup setting for a time determined by the curve selected.
- Over Voltage protection will cause a protection or generate an alarm as configured when the source side voltages rise above the Over Voltage Pickup setting for a time determined by the curve selected.
- UOV protection uses logic based on **AND**, **OR**, or **Average** evaluation to determine if an under or over voltage condition exists.
- Tripping times can be configured for Definite Time or a user defined Time/ Voltage curve.
- The ACR can be configured to automatically reclose after an under or over voltage protection trip if the system voltage returns to normal.

- A time limit can be put on the time it takes the voltage to recover after a trip and cause a reclose.
- A limit can be put on the number of times the switchgear trips and recloses before the feature is disabled.

**Table 55 UOV Protection Settings/Specifications**

| UOV Protection Settings/Specifications | |
|---|---|
| Voltage accuracy | 2.5% ± 25 V |
| Dead Band (hysteresis) | 2.0% of nominal system voltage |
| Voltage value updated | 31.25 ms |
| Measured voltage evaluation | Once/1.125 s |
| Measured voltage averaged over | 0.25 s |
| Trip delay – time setting resolution | 0.1 s |
| Trip delay range | 0.0...60.0 s |
| Trip voltage setting resolution | 1.0% |
| Nominal Phase to Earth Voltage | 2.0...25.0 kV |
| Nominal Phase to Earth Voltage resolution | 1 V |
| Nominal Voltage range | 2.0...25.0 kV |
| Nominal Voltage close time | 1...1000 s |
| Sequence recovery time out | 0...1000 s |
| Excess Sequences | Off, 1...20 |
| Excessive sequence accumulation time | 0...2880 minutes |
| Under Voltage Pickup | 0.5...0.93(1) |
| Over Voltage Pickup | 1.02...2.00(1) |
| Normal Voltage High | 1.00...1.98(1) |
| Normal Voltage Low | 0.52...1.00(1) |
| UOV Fault Reset Time | 0...10 s |
| UOV Fault Reset Time resolution | 10 ms |
| UOV Definite Time | 10 ms...100 s |
| UOV Definite Time resolution | 10 ms |
| (1) Per unit. Used for voltage description in relative terms based on a nominal system voltage. | |

# Neutral Voltage Displacement

Neutral Voltage Displacement (NVD) uses a voltage element for EF protection. It calculates the residual voltage by phasor addition of the three phase to earth voltages and compares that value to the NVD Setting Voltage to determine if an EF has occurred.

This type of EF protection is typically used where generation embedded into a distribution system may become disconnected from the main system earth rendering current based EF protection unreliable.

NVD protection can be run as a two stage system with the first stage generating an alarm and the second stage causing a protection trip. This can be used in insulated systems for example where it is common for the system to have been designed to withstand an over voltage on the associated healthy phase for a number of hours after an EF has occurred.

An alarm at the early stages of detection may allow the fault to be located and isolated. Otherwise the switchgear will be tripped to clear the fault when the second stage times out.

## NVD Configuration

If NVD protection is required to be used it must firstly be made available. This can be done through WSOS Feature Selection at:

**Display** > **Configuration** > **Feature Selection** or on the operator interface, page 697.

Once NVD has been made available it can be configured in WSOS at:

**Display** > **Protection** > **NVD**.

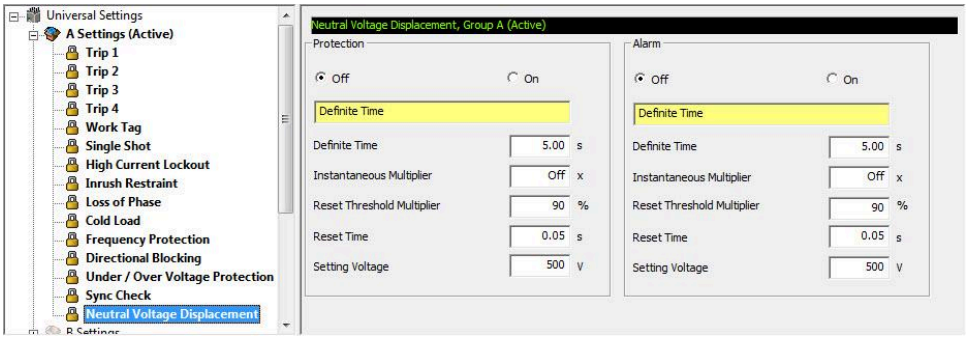



**Figure 170**
WSOS NVD settings

A description of the NVD Protection and Alarm settings appear in the table below.

**Table 56 NVD Settings**

| Setting | Description |
|---|---|
| Curve (read-only) | Definite Time is the only curve currently available. |
| Setting Voltage | The minimum value of neutral voltage that will cause a pickup of the NVD protection or alarm elements. |
| Definite Time | The time delay after a pickup occurs before either the protection element causes a trip or the alarm element logs an alarm. |
| Reset Time | The time it takes for either a protection or alarm pickup to reset after the neutral voltage falls back below the Setting Voltage. |
| Reset Threshold Multiplier | The percentage of the Setting Voltage below which the neutral voltage must fall for the reset timer to start. |
| Protection | Can be either On or Off independently of the Alarm function. |
| Alarm | Can be either On or Off independently of the Protection function. |
| Instantaneous Multiplier | Can be used to apply an instantaneous modifier to the Definite Time curve above a set multiple of the Setting Current. |

NVD Protection, page 290 and NVD Alarm, page 291 can also be configured on the operator interface.

## NVD Configuration Range Increased

The NVD setting voltage range has been extended to maximum value of to 65000 V as shown in below figure. This is to facilitate extreme fault cases where the NVD value could rise to 90% of 3 x Vpn. NVD Setting Voltage can be configured via WSOS or by the Operator Control Panel.

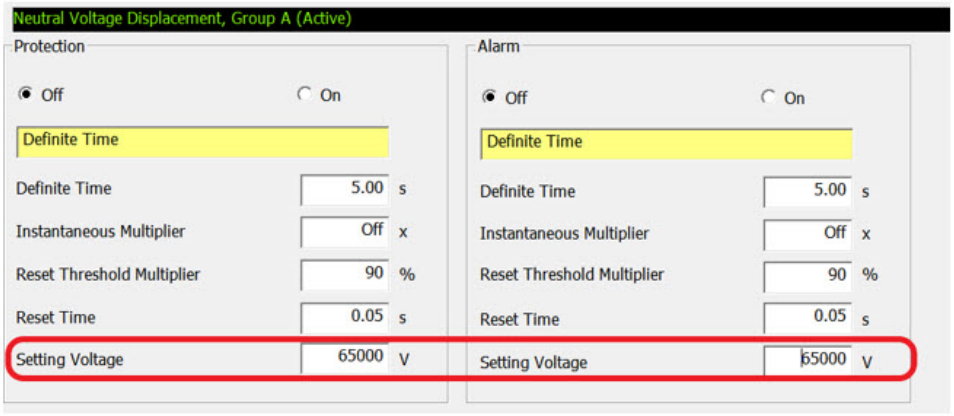



**Figure 171**
NVD Voltage settings page

## NVD Functions

NVD has separate Protection and Alarm functions. Each can be configured independently on the PowerLogic ADVC Controller once NVD has been made available.

A common practice is to incorporate both functions into a two stage system with the alarm as the first stage followed by protection for the second stage.

The PowerLogic ADVC Controller already has and existing High $V_{ZPS}$ Alarm function that can be used in conjunction with Directional Protection and Blocking that provides similar functionality to the NVD Alarm. Both alarms are recorded in the Event Log and can be monitored by WSOS or SCADA. The main difference is that the High $V_{ZPS}$ Alarm operates on zero sequence voltage V0 whereas the NVD Alarm operates on the residual or neutral voltage which is equal to V0 x 3. The High $V_{ZPS}$ and NVD Alarms operate independently of each other.

## NVD Operation

The PowerLogic ADVC Controller continually calculates the neutral voltage by phasor addition of the three phase to earth voltages. This calculated value is compared with the value of the Setting Voltages configured for the Protection and Alarm functions. Both functions will record a pickup in the Event Log when their Setting Voltages are exceeded.

## NVD Protection

Only the NVD protection function can cause a protection trip.

A NVD protection pickup will start the trip timing that will run for the Definite Time setting providing the pickup remains active. At the end of the Definite Time the controller will send a protection trip to the switchgear.

If the calculated neutral voltage falls below the Protection Setting Voltage but remains above the reset level determined by the Reset Threshold Multiplier, protection timing will pause. It will stay in this paused state until either the neutral voltage exceeds the setting again, in which case timing will restart, or the neutral voltage drops below the reset threshold causing the pickup to reset.

When the calculated neutral voltage falls below the reset threshold the reset timer will start to run. If the neutral voltage stays below the threshold until the Reset Time expires the pickup will be reset.

A NVD protection trip will always cause the ACR to go to lockout regardless of the Auto Reclose setting.

## NVD Alarm

The NVD Alarm is configured independently of the Protection function but the settings are identical.

NVD Alarm operates in the same manner as the protection but only generates an alarm and not a protection trip.

**Table 57 NVD Settings/Specifications**

| NVD Settings | | | | | | |
|---|---|---|---|---|---|---|
| **Item** | **Default** | **Range** | | **Step Size** | **Units** | **Function** |
| | | **Min** | **Max** | | | |
| Curve | Definite Time | | | | | Both |
| Setting Voltage | 500 | 15 | 15000 | 1 | Volts | Both |
| Definite Time | 5.00 | 0.00 | 100.00 | 0.01 | Seconds | Both |
| Reset Time | 0.05 | 0.00 | 100.00 | 0.01 | Seconds | Both |
| Reset Threshold Multiplier | 90 | 90 | 100 | 1 | % | Both |
| Protection | Off | On | Off | N/A | N/A | Protection |
| Alarm | Off | On | Off | N/A | N/A | Alarm |
| Instantaneous Multiplier | Off | 1.0 | 30.0 | 0.1 | X | Both |

# Loss of Phase Protection

Loss of Phase protection (LOP) is a voltage operated element that can detect faults upstream of the ACR.

LOP protection operates when the phase to earth voltage on one or two phases falls below a user defined LOP Voltage for a user defined LOP Timeout period. LOP can either trip the switchgear or generate an alarm depending on the mode selected.

An LOP protection trip will always cause the ACR to go to Lockout. That is, no automatic reclose can occur.

LOP protection will also operate after the Loss of Phase Timeout if one or two phases become live after all three were dead.

## LOP Protection Settings

LOP protection is always available but can be selected Off if not required.

LOP protection can be in one of three operating modes:

- OFF
- Trip
- Alarm

**Table 58 LOP Protection Settings**

| LOP Setting | Description |
|---|---|
| Off | LOP protection is non-operational |
| Trip | LOP protection operation will trip the switchgear |
| Alarm | LOP protection operation will not cause the switchgear to trip. Instead an alarm will be recorded in the Event Log and can be reported via a SCADA protocol or via an IOEX output, ***flex*VUE** status lamp etc. |

Once LOP protection has been set to either Trip or Alarm it will operate according to two settings:

- LOP Voltage
  - The phase to earth voltage on one or two phases must fall below to start the LOP timer.
- LOP Timeout
  - The time a LOP condition exists before either a protection trip occurs or an alarm is generated.

## LOP Protection Configuration

LOP protection can be configured in WSOS on the LOP page:

**Display** > **Protection** > **LOP**

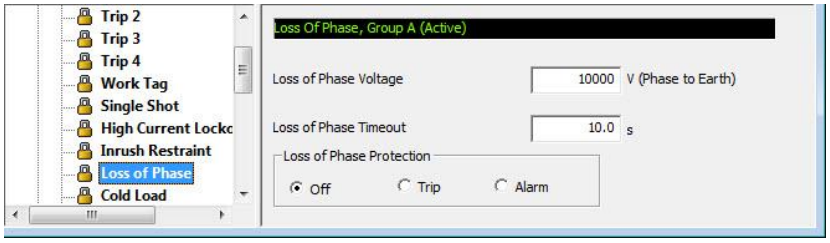



**Figure 172**
WSOS LOP settings

LOP protection can also be configured on the O.I.

## LOP Protection Operation

When the voltage on one or two phases drops below the LOP Voltage setting, the LOP Timeout timer starts to run.

If the voltage on at least one of those phases stays below the LOP Voltage setting until the LOP Timeout timer expires, LOP protection will operate according to the settings applied, either:

- LOP Off
- LOP Trip
- LOP Alarm

When LOP protection trips the switchgear the phase or phases that caused the trip will be logged in the Event Log and identified by the Trip Flags.

## LOP Protection Timing

When one or two phases are lost, the LOP Timeout timer and the Supply Timeout timer start to run simultaneously.

When the Supply Timeout timer expires, an event (for example, Ai Dead) is logged to indicate that the phases is dead.

When the LOP Timeout timer expires, another event (for example, A Phase LOST) is logged. The LOP Timeout timer can be checked by adding the Supply Timeout setting to the period measured between the two events.

If LOP protection is set to Trip, the ACR will trip immediately A Phase LOST is logged.

This event will be followed by Protection Trip Request and LOP Protection Trip.

## LOP versus Supply Timeout Example

Consider a situation where the following settings are applied:

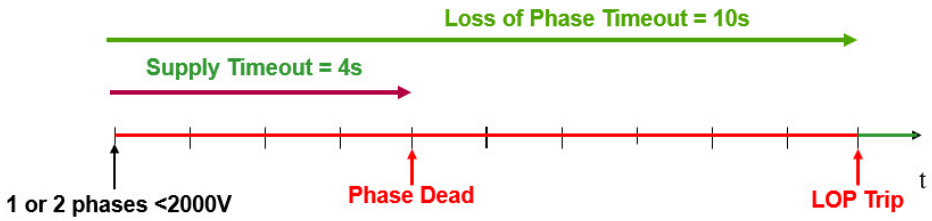
- LOP Protection – Trip
- LOP Voltage – 2000 V
- LOP Timeout – 10.0 s
- Live Line Threshold – 2000 V
- Supply Timeout – 4.0 s

And on a feeder energized at 6300 V per phase to earth, A phase goes dead at 00:00:00.00

The following events would be logged:

| Time | Event | Cause |
|---|---|---|
| 00:00:04.00 | A1 Dead | A phase bushings recorded as dead when Supply Timeout expires after 4s. |
| 00:00:04.00 | A2 Dead | |
| 00:00:10.00 | A Phase LOST | LOP protection operates 6 s later when the LOP Timeout expires. |
| 00:00:10.00 | Protection Trip Request | LOP issues a trip request to the switchgear. |

The same sequence of events are shown in the timing diagram below.




## LOP Protection Summary

- LOP protection operates on the loss of one or two phases but not three.
- LOP Protection requires two settings:
  - LOP Voltage (2000...15,000 V)
  - LOP Timeout (0.1...100.0 s)
- LOP protection can be set for:
  - Off
  - Trip
  - Alarm

**Table 59 LOP Protection Settings/Specifications**

| LOP Protection Settings/Specifications | |
|---|---|
| LOP Voltage range | 2...15 kV Default 10 kV |
| LOP Voltage setting resolution | 1 V |

**Table 59 LOP Protection Settings/Specifications (Continued)**

| LOP Protection Settings/Specifications | |
|---|---|
| LOP Voltage accuracy(1) | 2.5% ± 25 V |
| LOP Timeout range | 0.1...100.0 s Default 10.0 s |
| LOP Timeout resolution | 0.1 s |
| LOP Time accuracy | ± 50 ms |
| (1) Includes accuracy of VTs in the switchgear. | |

# UOV Close Block

Close Blocking allows an enabled and suitably configured protection element to preemptively apply a constraint to any switchgear CLOSE operation.

UOV protection is an Element Close Blocking (ECB) capable protection element.

switchgear will not be able to be closed by any means when a fault condition that would cause an Under Voltage trip exists.

If Under Voltage protection is enabled (Trip mode), and UOV Close Blocking is selected, the Similarly, if Over Voltage protection is enabled (Trip mode), and UOV Close Blocking is selected, the switchgear will not be able to be closed by any means when a fault condition that would cause an Over Voltage trip exists.

Close Blocking applies regardless of the reason for the most recent TRIP request.

Close Blocking also applies to all types of Close requests that is SCADA, HMI, IOEX etc.

## UOV Close Blocking Configuration

For UOV Close Blocking to be used it must be made available.

It can only be made available through Feature Selection in WSOS:

**Display** > **Configuration** > **Feature Selection**

Once UOV Close Blocking has been made available it can be selected in WSOS on the UOV Protection page in the Protection Group settings.

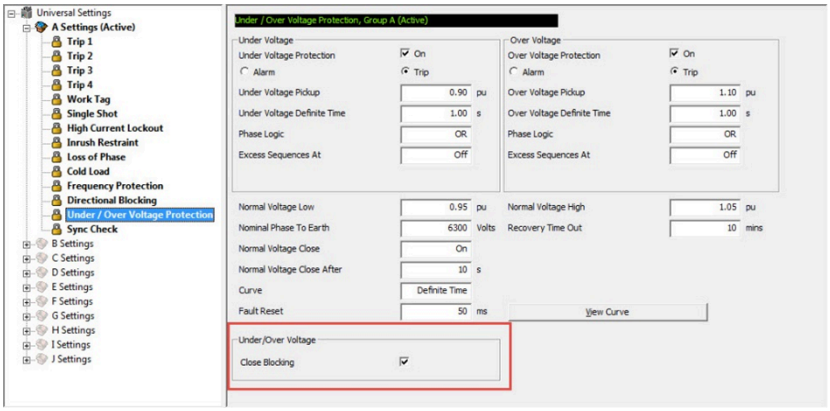



**Figure 173**
WSOS UOV Close Blocking setting

> **NOTE:** Selecting UOV Close Blocking will only affect the Close Blocking capability of that element. It will not impinge upon any other functionality that can effect a Close Block such as Loop Automation, Auto Reclose Block or Voltage Blocked Auto Reclose

Changes to the UOV Close Blocking On/Off status are recorded in the Event Log.

## UOV Close Blocking Operation

UOV Close Blocking is only operationally effective when either UOV protection is enabled and configured to TRIP for the active protection group.

For an UOV element to apply a Close Block, all of the following must be true:

- Protection On
- UOV Protection Available
- Close Blocking Available
- UOV Close Blocking On
- The element is in a faulted state that is in pickup
- The element is configured to TRIP

An UOV element will remove its Close Block if:

- Protection is turned Off
- The element is disabled
- Close Blocking is Not Available
- The UOV Close Block is Off (for the active group)
- The element is not configured to Trip
- The element is un-faulted that is not in a pickup state.

It is important to note that UOV Close Blocking differentiates between Under and Over Voltage. If Under Voltage Trip is enabled but Over Voltage is either Off or set for Alarm.

# Frequency Protection

## UOF Protection

UOF protection is an optional protection element that can be configured to trip the switchgear if the measured frequency deviates above or below acceptable levels for user-set times.

UOF protection can also be configured to automatically reclose the switchgear after an UOF protection trip if the system frequency has returned to within a normal frequency band.

UOF elements have separate On/Off controls so that either or both can be operational at any one time.

## UOF Protection Applications

Under Frequency protection can be used in a Load Shedding scheme to help restore system frequency when it has dropped due to an overload of the system. By configuring different U/F trip settings for each ACR in the scheme they can be made to progressively trip to shed load as the system frequency falls. Using Normal Frequency Close with different Under Frequency Normal settings the load can be progressively restored as the frequency recovers.

Over Frequency protection can be used as a type of Over-speed protection for generating plant.

## UOF Protection Configuration

If UOF protection is required for service it must first be made available.

It can be made available in WSOS on the Feature Selection page.

**Display** > **Configuration** > **Feature Selection** > **Protection**

or on the operator interface, page 697.

Once it has been made available, **UOF** protection can be configured in WSOS on the **Frequency Protection** page in the Protection Group settings.

The resolution of frequency protection for the UOF elements has been enhanced to 0.01 Hz as shown in the below figure. Previous versions allowed configuration with a resolution of 0.1 Hz.

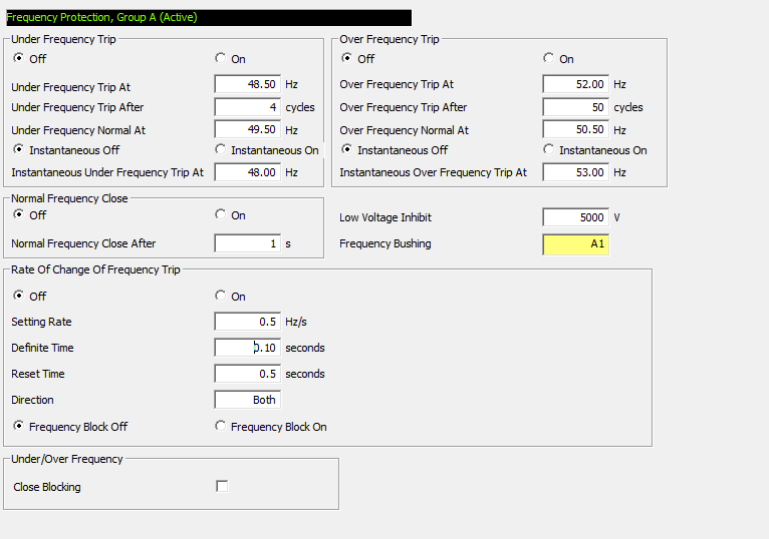



**Figure 174**
Under or Over Frequency protection frequency settings

**Under and Over Frequency** can also be configured on the operator interface.

The allowed setting range for **Under/Over Frequency protection** is 45...65 Hz so it can be configured for use with system frequencies of 50 or 60 Hz.

The settings used to configure Under and Over Frequency protection are described in the table below:

**Table 60 Under/Over Frequency Protection settings**

| Setting | Description |
|---|---|
| Under Frequency Trip On/Off | This setting allows the Under Frequency protection to be enabled (On) or disabled (Off). Under Frequency tripping will not occur whilst set to Off.<br><br>Range: Off – On Default: Off |
| Under Frequency Trip At (Hz) | The frequency value at and below which an Under Frequency pickup will occur.<br><br>Range: 45.0 – (Under Frequency Normal setting – dead-band) Default: 49.0 |
| Under Frequency Trip After (cycles) | The number of continuous cycles at and below the Under Frequency threshold required before an Under Frequency trip will occur.<br><br>Range: 2...1000 Default: 4 |
| Under Frequency Normal At (Hz) | The frequency at or above which the frequency is deemed to be Normal.<br><br>Range: (Under Frequency Trip At setting + dead-band) – (OF Trip At setting – dead-band) Default: 49.5 |
| Instantaneous under frequency At (Hz) | If a frequency measurement is below the instantaneous under frequency trip value in the setting trip value in the setting, an instantaneous trip will occur.<br><br>Range: Instantaneous Off/On Default: Off |

**Table 60 Under/Over Frequency Protection settings (Continued)**

| Setting | Description |
|---|---|
| Over Frequency Trip On/Off | This setting allows the Over Frequency protection to be enabled (On) or disabled (Off). Over Frequency tripping will not occur whilst set to Off.<br><br>Range: Off – On Default: Off |
| Over Frequency Trip At (Hz) | The frequency value at and above which an Over Frequency pickup will occur.<br><br>Range: (Over Frequency Normal setting + dead-band) – 65.0 Default: 52.0 |
| Instantaneous over frequency At (Hz) | If a frequency measurement is above the instantaneous over frequency trip value in the setting, an instantaneous trip will occur.<br><br>Range: Instantaneous Off/On Default: Off |
| Over Frequency Trip After (cycles) | The number of continuous cycles at and above the Over Frequency threshold required before an Over Frequency trip will occur.<br><br>Range: 2...1000 Default: 50 |
| Over Frequency Normal At (Hz) | The frequency at or below which the frequency is deemed to be Normal.<br><br>Range: (UF Trip At setting + dead-band) – (Over Frequency Trip At setting – dead-band)<br><br>Default: 50.5 |
| Low Voltage Inhibit (V) | The voltage at or below which the Under/Over Frequency protection will be disabled.<br><br>Range: 4000...23000 Default: 5000 |
| Normal Frequency Close On/Off | This setting determines whether a Normal Frequency Close can occur after a UOF protection trip.<br><br>Range: On – Off<br><br>Default: Off |
| Normal Frequency Close After (seconds) | The time that the frequency of the voltage on the frequency bushing must have returned to normal before auto closing takes place. |

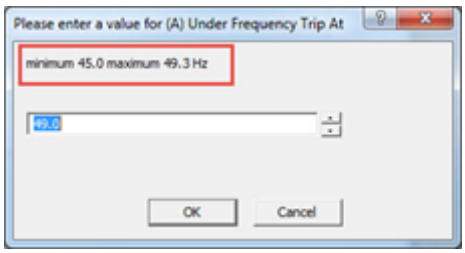
A dead-band of 0.2 Hz is imposed to provide hysteresis and helps to prevent a frequency value that is fluctuating around a pickup threshold setting from causing excessive pickup/reset events.

The setting range for the Trip At and Frequency Normal settings are partly determined by the dead-band.

For example, if the **Under Frequency Trip At** setting is 48.0 Hz, the **Under Frequency Normal At** setting must be at least 48.2 Hz. The **Under Frequency Trip At** setting must also be at least 0.2 Hz lower than the **Over Frequency Trip At** setting.

Illegal settings cannot be entered either via the O.I. or WSOS. When entering these settings via WSOS the setting dialogue will display the legal range for that setting.

See example below:




## Frequency Measurement

Frequency is measured on each available switchgear terminal. The frequency displayed and used for frequency protection is that of the first available terminal with voltage measurement, selected in the order:

- PMSet U Series: Ai, Bi, Ci, and if external CVT's are fitted, then Ax, Bx, Cx

The selected terminal is displayed as the Frequency Bushing in a read-only field. The frequency value is updated every 0.5 s and averaged over 2.0 s.

The frequency displayed in Measurements is the measured frequency and is valid whenever the voltage on the selected terminal is equal to or above the Low Voltage Inhibit threshold.

## Under Frequency Protection Operation

When the measured frequency drops below the **Under Frequency Trip At** setting an UF Pickup occurs and a Trip Delay Counter (TDC) is started.

The TDC will reset if the frequency rises back above the **Under Frequency Trip At** threshold plus the 0.2 Hz dead-band before the number of cycles configured for **Under Frequency Trip After** have occurred.

Otherwise Under Frequency protection will send a trip request to the switchgear after the configured **Under Frequency Trip After** number of cycles.

## Over Frequency Protection Operation

When the measured frequency rises above the **Over Frequency Trip At** setting an OF Pickup occurs and a TDC is started.

The TDC will reset if the frequency drops back above the Over Frequency Trip At threshold minus the 0.2 Hz dead-band before the number of cycles configured for **Over Frequency Trip After** have occurred.

Otherwise Over Frequency protection will send a trip request to the switchgear after the configured Over Frequency Trip After number of cycles.

When Normal Frequency Close is Off, the ACR will go immediately to Lockout following an Under or Over Frequency trip.

## Normal Frequency Close

The **Normal Frequency Close** function can close the switchgear automatically after an Under or Over Frequency trip when the frequency has returned to normal. Normal frequency is defined as being within a band between the **Under Frequency Normal At** and the **Over Frequency Normal At** setting values.

An automatic close occurs when:

- The switchgear tripped due to the Under or Over Frequency protection.

- Normal Frequency Close was On before the trip and is still On when the **Normal Frequency Close After** time expires.
- The measured frequency has returned to within the normal frequency band ± the dead-band.
- The voltage on the Frequency Bushing has remained above the **Live Voltage Inhibit** threshold for the Normal Frequency Close After time.

The Normal Frequency Close timing is aborted if the measured frequency goes outside the normal frequency band ± the dead-band or the voltage on the Frequency Bushing falls below or equal to the Low Voltage Inhibit threshold.

When Normal Frequency Close is On, the ACR will not go to Lockout following an Under or Over Frequency trip.

Instead, in the case of the ***set*VUE** O.I., it will display a flashing message at the top line of the screen which reads:

**ACR will auto-close when frequency normal**

When the frequency returns to normal, the Normal Frequency Close After timer will start to count down and the flashing message will change to:

**Frequency Normal – ACR will close in xxxx secs**

Where **xxxx** denotes the period of time remaining before closing occurs.

If the controller is fitted with a ***flex*VUE** O.I., the first message above will be displayed in the Alerts menu.

When the frequency returns to normal, the Normal Frequency Close After countdown timer causes a critical alert which circumvents the display until either the timer expires which closes the switchgear or it aborts due to one of two reasons mentioned above.

The ACR will go to Lockout if any of the following events occur whilst the PowerLogic ADVC Controller is waiting for the frequency to return to normal following a UOF trip.

- Normal Frequency Close is turned Off.
- Under Frequency Normal setting is changed.
- Over Frequency Normal setting is changed.
- Normal Frequency Close After setting is changed.
- Low Voltage Inhibit setting is changed.

## Under Frequency Protection Sequence Example

An Under Frequency protection sequence would be an Under Frequency trip followed by a Normal Frequency Close as depicted in the figure below.

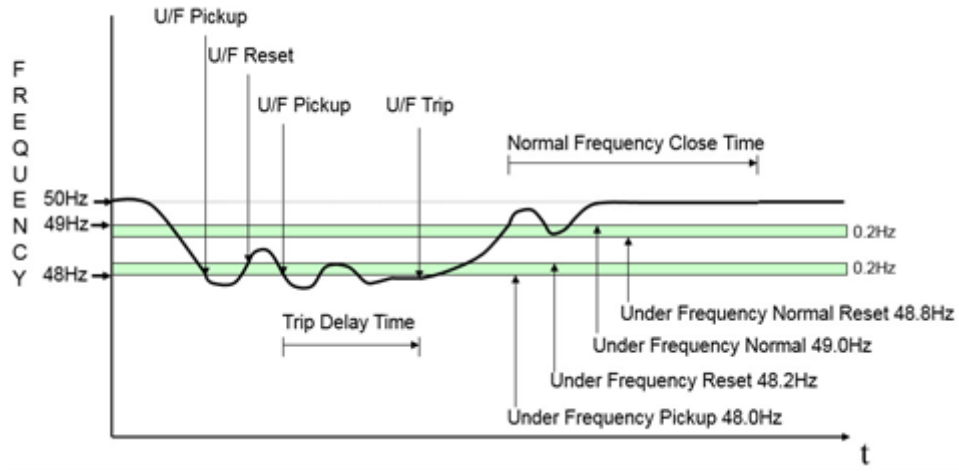



**Figure 175**
Under Frequency Protection Sequence Frequency/Time diagram

This sequence occurred with the following settings:

- System Frequency = 50.0 Hz
- Under Frequency Trip at = 48.0 Hz
- Under Frequency Normal at = 49.0 Hz
- And Dead-band = 0.2 Hz

Therefore: Under Frequency Reset = 48.0 + 0.2 = 48.2 Hz
Under Frequency Normal Reset = 49.0 – 0.2 = 48.8 Hz

## Sequence of Events

The first time the frequency went below the Under Frequency Pickup (48.0 Hz) it caused a pickup, but it went back up above the Under Frequency Reset (48.2 Hz) and reset before the Under Frequency Trip After number of cycles had completed.

The next time the frequency went below 48.0 Hz it caused another pickup and this time stayed below 48.2 Hz long enough to cause an Under Frequency trip.

Sometime later the frequency went back up above the Under Frequency Normal At setting (49.0 Hz) which started the Normal Frequency Close After timer. Because the frequency then stayed above the Under Frequency Normal Reset value (48.8 Hz) until the Normal Frequency Close After time out expired, the switchgear would have closed.

# UOF Protection Summary

- UOF can be configured to trip the switchgear if the measured frequency goes outside of a designated normal band for an unacceptable period of time.
- UOF protection elements can be enabled/disabled individually.
- Settings can be configured within the range 45 Hz to 65 Hz but individual settings must be chosen with respect to other settings and the dead-bands.
- The ACR will not auto reclose after a UOF protection trip but can be configured to close automatically when the frequency returns to normal.

**Table 61 Under/Over Frequency Protection Settings/Specifications**

| UOF Protection Settings/Specifications | |
|---|---|
| Frequency setting range(1) | 45...65 Hz |
| Frequency setting resolution | 0.1 Hz |
| Accuracy (for sinusoidal input) | ± 0.05 Hz |

**Table 61 Under/Over Frequency Protection Settings/Specifications (Continued)**

| UOF Protection Settings/Specifications | |
|---|---|
| Frequency dead-band (hysteresis) | 0.2 Hz |
| Number of under or over frequency cycles before tripping | 2...1000 |
| Frequency calculation | Once per cycle averaged over 2 cycles |
| Low Voltage Inhibit range | 4...23 kV |
| Low Voltage Inhibit setting resolution | 1 V |
| Normal Frequency Close Time | 1...1000 s |
| (1) Under/Over tripping frequencies and normal frequencies are interlocked by software so that only viable settings are possible. | |

# Rate of Change of Frequency

Rate of Change of Frequency (ROCOF) is a separate protection element on the PowerLogic ADVC Controller and operates independently of UOF protection elements. It does however utilize some UOF protection settings for Blocking, Frequency Normal, and Minimum Voltage functions.

When a large imbalance occurs between the generated power and the load demand it can cause the system frequency to change rapidly. A ROCOF function can be used to detect a loss of grid associated with the appreciable loss of load. It can also be used for fast load shedding by speeding up operational time in UOF situations.

ROCOF operation is based on the calculation of the frequency variation (df/dt).

## ROCOF Protection Configuration

ROCOF protection can be made available by making **UOF** protection available.

This can be done in WSOS on the Feature Selection page.

**Display** > **Configuration** > **Feature Selection**

Or on the operator interface.

Once **UOF** has been made available, ROCOF can be configured in WSOS on the same page in the Protection Group settings.

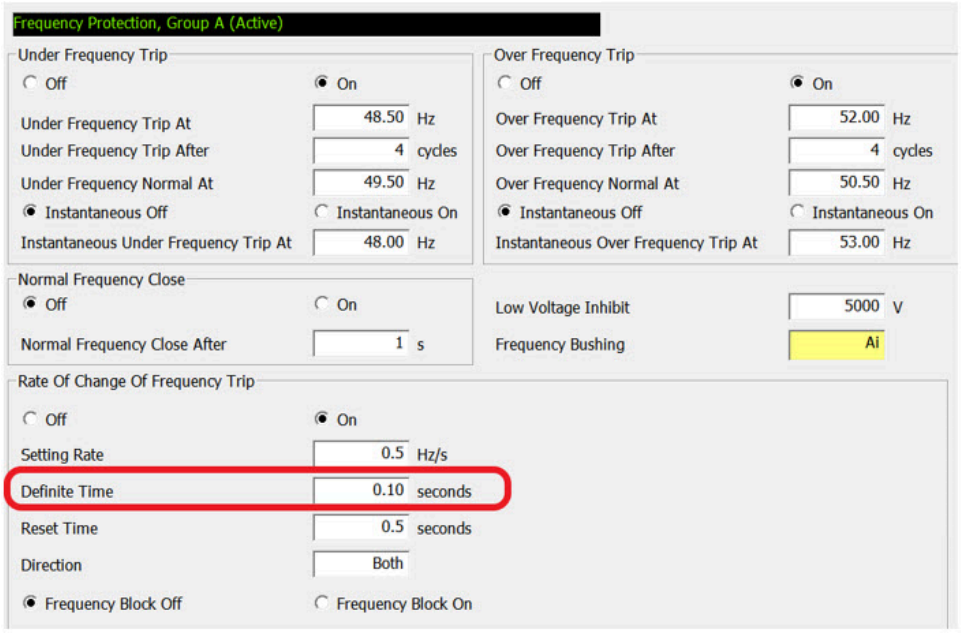



**Figure 176**
ROCOF Definite Time Protection settings

ROCOF can also be configured on the operator interface.

ROCOF can be configured using the settings described in the following table:

**Table 62 ROCOF Protection settings**

| Setting | Description |
|---|---|
| ROCOF Trip | Must be On in the active protection group for ROCOF to cause a protection trip. |
| Setting Rate | The minimum ROCOF (df/dt) in Hertz per second that will cause ROCOF to pick up and start the protection timing. |
| Definite Time | The time ROCOF must be in the pickup state before a protection trip will occur. |
| Reset Time | The time it takes the protection timing to reset if the measured df/dt falls below the Setting Rate when a pickup is active. |
| Direction | Determines whether the element will react to just rising of falling frequency conditions or both. |
| Frequency Block | Can be helps to prevent ROCOF protection tripping unless the measured frequency is outside of normal limits.<br><br>Make sure that the Under Frequency Normal at setting is lower than the Over Frequency Normal At setting for ROCOF Blocking to operate correctly. |

## ROCOF Protection Operation

The ROCOF in terms of Hertz per second (Hz/s) is continually calculated and monitored by the PowerLogic ADVC Controller. If the calculated rate goes above a user set value the protection will start timing out to trip the switchgear.

> **NOTE:** Due to the nature of the filtering that is performed to produce the ROCOF value from frequency measurements, there is a delay of approximately 200 ms between any step change in the network ROCOF and the value of ROCOF used by the PowerLogic ADVC Controller.

### Timing

Trip timing will start when the calculated ROCOF (df/dt) value is greater than the Setting Rate. A Pickup event will be logged when this occurs.

## Reset Timing

Reset timing will start when the df/dt value falls back below the Setting Rate. When the Reset Time has expired, the trip timing will be reset. If the df/dt becomes greater than the Setting Rate again before the Reset time expires, the trip timing will resume.

## Lockout

When ROCOF protection causes a protection trip the controller will always go to Lockout regardless of the Auto Reclose setting.

## Blocking

There is an option to block tripping by ROCOF protection when the measured frequency is within the normal frequency range.

A block, that is no operation, will occur if the measured frequency is inside the normal frequency range and Frequency Block is enabled. Blocking can also occur if the frequency moves into the normal frequency range while a pickup that occurred outside that range is active.

The normal frequency range is determined by the UOF Normal At settings.

The frequency is deemed to be normal when the measure frequency is:

≤ Over Frequency Normal At

And ≥ Under Frequency Normal At

UOF protection is not required to be On for these settings to be applied.

A frequency block will cause any pickup and trip timing that is running to reset.

## Direction

Tripping can be restricted to a ROCOF in a designated direction either increasing (Positive) or decreasing (Negative) if required.

## Minimum Voltage

The minimum voltage at which ROCOF protection will operate is determined by UOF Low Voltage Inhibit setting.

**Table 63 ROCOF Protection Settings/Specifications**

| ROCOF Setting Details and Specifications | | | | | |
|---|---|---|---|---|---|
| **Item** | **Default** | **Range** | | **Step Size** | **Units** |
| | | **Min** | **Max** | | |
| Trip | OFF | OFF | ON | N/A | N/A |
| Setting Rate | 0.5 | 0.1 | 5.0 | 0.1 | Hz/s |
| Definite Time | 0.50 | 0.10 | 100.0 | 0.01 | s |
| Reset Time | 0.5 | 0.0 | 100.0 | 0.1 | s |
| Direction | Both | Negative – Positive – Both | | N/A | N/A |
| Frequency Block | OFF | OFF | ON | N/A | N/A |

# UOF Close Blocking

Close Blocking allows an enabled and suitably configured protection element to pre-emptively apply a constraint to any switchgear CLOSE operation.

UOF protection is an ECB capable protection element.

If Under Frequency protection is On, and UOF Close Blocking is selected, the switchgear will not be able to be closed by any means when a fault condition that would cause an Under Frequency trip exists.

Similarly, if Over Frequency protection is On, and UOF Close Blocking is selected, the switchgear will not be able to be closed by any means when a fault condition that would cause an Over Frequency trip exists.

Close Blocking applies regardless of the reason for the most recent TRIP request. Close Blocking also applies to all types of Close requests that is SCADA, HMI, IOEX etc.

## UOF Close Blocking Configuration

For UOF Close Blocking to be used it must be made available. It can only be made available through Feature Selection in WSOS:

**Display** > **Configuration** > **Feature Selection**

Once UOF Close Blocking has been made available it can be selected in WSOS on the Under/Over Frequency Protection page in the Protection Group settings.

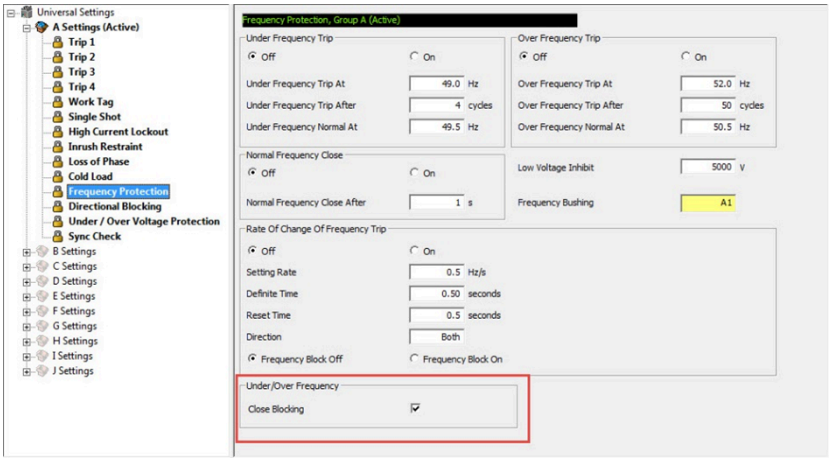



**Figure 177**
WSOS UOF Close Blocking setting

**NOTE:** Selecting UOF Close Blocking will only affect the Close Blocking capability of that element. It will not impinge upon any other functionality that can effect a Close Block such as Loop Automation, Auto Reclose Block or Voltage Blocked Auto Reclose.

Changes to the UOF Close Blocking On/Off status are recorded in the Event Log.

## UOF Close Block Operation

UOF Close Blocking is only operationally effective when either UOF protection is enabled for the active protection group.

For an UOF element to apply a Close Block, all of the following must be true:

- Protection On
- UOF Protection Available
- Close Blocking Available
- UOF Close Blocking On
- The element is in a faulted state that is in pickup
- The element is enabled

An UOF element will remove its Close Block if:

- Protection is turned Off
- The element is disabled
- Close Blocking is Not Available
- The UOF Close Block is Off (for the active group)
- The element is Off
- The element is un-faulted that is not in a pickup state.

It is important to note that UOF Close Blocking differentiates between UOF. If Under Frequency is enabled but Over Frequency is Off, UOF Close Blocking will only block if an Under Frequency element pickup is active.

# Automatic Sectionalising

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# Fault Detection and Automatic Sectionalising

## Introduction to Automatic Sectionalising

Sectionalising is the act of disconnecting a section of feeder that has a permanent fault.

The AS is normally used in conjunction with an upstream ACR.

The AS can be programmed to open if the fault is still present after the ACR has performed a pre configured number of automatic reclose sequences. This then allows the ACR to reclose successfully as the faulted section of feeder has been isolated.

Since the AS opens while the upstream ACR remains open during the dead time, the switchgear does not need to be capable of breaking fault current. The switchgear most commonly used by AS is the RL Series LBS. PMSet U and PMSet UR circuit breakers can also be used.

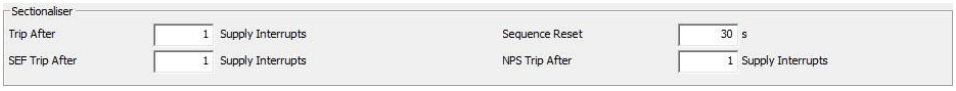
## Supply Interrupts

The Supply Interrupt count is a measure of how many times the upstream ACR has tripped during an auto reclose sequence, page 160.

There are separate counters for:

- Phase and EFs
- SEFs
- Negative Phase Protection Faults (if Sequence Components are available)

These settings can be found in WSOS under Sectionaliser on the Global Settings page for each Detection group.




They are also displayed on the operator interface.

The Supply Interrupt count for each fault type increments when the AS detects the following conditions in the correct sequence:

1. Fault Detected
   - Indicates a fault downstream of the AS
2. Zero Current
   - indicates that the upstream ACR has tripped
3. Loss of Source side voltage
   - Confirmation that the upstream ACR has tripped

A Supply Interrupt indicates to the AS that a downstream fault has caused the upstream ACR to trip.

So the Supply Interrupt count is a measure of how many times the upstream ACR has tripped during an auto reclose sequence.

## Automatic Sectionalising Coordination

Correct operation of an AS requires it to be coordinated with the upstream ACR. The AS must wait long enough to allow the fault to clear during the auto reclose sequence of the ACR, but must trip before the ACR goes to Lockout.

The figure below shows an AS downstream from an ACR configured for 4 Trips to Lockout.




**Figure 178**
AS and Upstream ACR

The AS could be configured for trip after 1, 2, 3, or 4 Supply Interrupts with the following considerations:

1. Trip after 1 supply interrupt does not give the fault a chance to clear. This would result in unnecessary loss of supply if the fault was temporary. It would however mean that the ACR closed successfully first time every time.
2. Trip after 2 supply interrupts might be an acceptable setting but may still result in an unnecessary loss of supply if the fault needed longer to clear.
3. Trip after 3 supply interrupts would be the optimum setting in this case. It could be assumed that the fault was permanent after it caused the ACR to trip three times.
4. Trip after 4 supply interrupts wouldn't allow the ACR to restore supply as it would have already gone to lockout.

The figure below shows timing diagrams of the ACR with 4 trips to lockout and the AS configured to trip after 3 supply interrupts when a permanent fault occurs downstream.

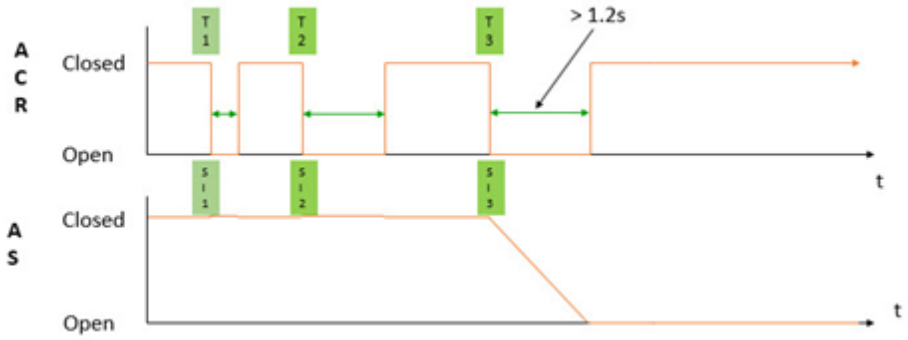



**Figure 179**
ACR and AS Timing Diagrams

**NOTE:** Each time the ACR trips, the AS logs a Supply Interrupt. When the ACR trips for the third time, the Supply Interrupt count reaches 3 and the AS trips. When the ACR recloses the third time it stays closed because the fault has been isolated by the AS.

The figure above represents a situation where an RL Series LBS is being used for the AS switchgear. The Trip 3 Reclose Time setting on the ACR needs to be long enough to allow the RL Series switchgear to fully open before the ACR recloses. In the case of an RL Series LBS, allow at least 1.2 s for the contacts to open as indicated in the above figure.

## System Configuration

Multiple ASs can coordinate with a single ACR. The basic rules to be observed are:

- The AS directly downstream from the ACR must trip before the ACR goes to Lockout.
- ASs in series must be configured with decreasing **Trip After Supply Interrupts** settings as shown in the figure below.

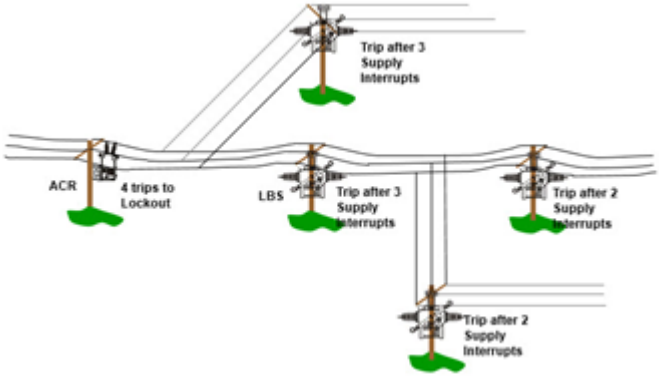



**Figure 180**
AS Coordination

## Fault Detection

The correct operation of an AS is dependent on its ability to detect a downstream overcurrent or broken conductor fault.

Fault detection is a two part process.

It starts with a protection pickup which occurs when the measured quantity for a particular detection element exceeds the Fault Detect setting x Pickup Multiplier for that element.

When a pickup occurs it generates an event in the Event Log and starts a Fault Detect timer.

If the fault persists until the timer expires a fault detection occurs which is also recorded in the Event Log.

Fault Detection is the first step in the sequence of events required for a Supply Interrupt to be logged.

The Fault Detection elements available are:

- Phase Overcurrent
- Earth Overcurrent
- SEF (Available by default)
- NPS (if Sequence Components are available)
- Broken Conductor (If Broken Conductor is available)

Each element can be configured for a pickup value and either a time delay or instantaneous operation.

Multiple elements can be in pickup at the same time but only the first element to go into pickup will generate a pickup event.

The first element to time out will log a Fault Detect event.

## Fault Reset

A fault that causes a detection element to pick up will reset if the fault current falls below a configurable reset threshold for a configurable reset time.

Fault reset can occur when the element is in pickup that is during the timing stage, or after a fault has been detected.

## Sectionaliser Trip

A Sectionaliser Trip occurs when the AS reaches its **Trip After Supply Interrupts** setting for the faulted element. When an AS trips it goes directly to Lockout.

It is not able to reclose automatically.

## Sequence Reset

The Sequence Reset timer is used to reset the supply interrupt counters to zero after a sequence ends with a sectionaliser trip. This helps to ensure that the supply interrupt count for each element starts at zero for the next sequence.

# AS Operation

Fault detection relies on the accurate measurement and processing of quantities monitored by the fault detection elements.

All switchgear used with the PowerLogic ADVC Controller as an AS are fitted with 2000:1 CTs on each phase. The CT secondary currents are continually sampled by the controller to detect overcurrent faults on the system.

- The **Phase Overcurrent** element deals with the actual CT secondary values.
- The **EF** element deals with the vector sum of the phase currents.
- The **SEF** element deals with analogue measurement of the spill current < 80 A primary and uses a low pass frequency filter to remove harmonic content.
- The **NPS** element deals with a value calculated in real time using the Fortescue formula for sequence components.
  - $I_2 = (I_a + I_b$ phase shifted 240° + $I_c$ phase shifted 120°)/3
- The **Broken Conductor** element deals with a ratio of the NPS current to the PPS current $I_{NPS}/I_{PPS}$.

## Fault Detect and Pickup Multiplier Settings

The Phase, Earth, SEF, and NPS elements each have Fault Detect and Pickup Multiplier settings as shown:




For the settings shown above, the pickup values for the individual detection elements would be:

| | | |
|---|---|---|
| Phase Fault | = 200 A x 1.0 | = 200 A |
| EF | = 40 A x 1.2 | = 48 A |
| SEF | = 4 A x 1.5 | = 6 A |
| NPS | = 40 A x 2.0 | = 80 A |

## Fault Detection Reset

A fault detection that leads to a supply interrupt that in turn leads to a sectionaliser trip will reset when the AS switchgear trips as the current would have dropped to zero.

A Protection Resetting event would be recorded in the Event Log followed by a Max Current event that is the maximum current value sampled between fault pickup and reset.

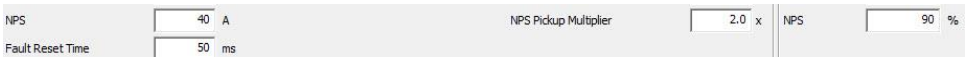
Not all pickups result in a supply interrupt or even a fault detection. They may reset earlier if the fault current falls to a value determined by the Reset Threshold Multiplier for the Fault Reset Time.

There are separate Reset Threshold Multiplier settings for each overcurrent element and a common Fault Reset Time setting.

In the example shown below for the NPS element, pickup would occur when the NPS current reached 80 A (40 A x 2.0).

If the fault current then dropped to below 90% of 80 A = 72 A, the Event Log would record a Protection Resetting event and start the Fault Reset timer.

If the NPS current stayed below 72 A for 50 ms the fault would reset and the Event Log would record a Max Current event.




A 90 Amp NPS fault that caused a pickup before the NPS current fell to 70 A 10 s later would record the following events.

| Time | Event |
|---|---|
| 00:00:00.00 | Pickup NPS |
| 00:00:10.00 | All Resetting |
| 00:00:10.05 | NPS Max 90 Amp |

## Fault Reset and Definite Time

If the picked up element has a Definite Time setting, the Definite Time timer will start at pickup and continue to run even if the fault current drops below the Reset Threshold providing the fault doesn't reset.

If the fault current rises back above the pickup value before the Definite Time timer expires, a fault detection will occur when the timer expires.

If the fault current is above the Reset Threshold but below the pickup value when the Definite Time timer expires, no fault detection will occur.

A fault detection will occur immediately if the fault current rises above the pickup level anytime later without the fault resetting.

## Sequence Reset Operation

The Sequence Reset timer is used to reset the supply interrupt counters to zero so that the next supply interrupt will cause the count to start from one.

Some important points to note regarding the operation of the Sequence Reset timer:

- The timer starts when the supply interrupt count is incremented.
- If fault detection pickup occurs while the Sequence Reset timer is running, it will be reset to zero and held there until the next supply interrupt occurs.
- When the Sequence Reset timer expires, a Sequence Reset event is recorded in the Event Log.

Ideally the sequence reset timer in the AS must be coordinated with the sequence reset timer in the upstream ACR. In practice this is difficult to always achieve because it can't be know when a fault that started a sequence will clear and the ACR is likely to have different Reclose Times configured for each trip.

## Detection Groups

There are up to 10 groups of detection settings (referred to as Detection Groups A, B, C, D, E, F, G, H, I, and J). Each Detection Group can have different settings. Users can nominate which one of the 10 detection groups is active.

Normally only one detection group can be active at one time. The exception is when Directional Detection is on. Directional detection uses two detection groups, one for forward faults and one for reverse faults. If Directional Detection is on, the user must choose between five pairs, A/B, C/D etc. where the first group in the pair is the forward group and the second group is the reverse group.

If less than ten detection groups are required, the controller can be configured for a lower number. The only way to change the number of configured detection groups in a controller is to change the setting in the WSOS off-line file and do a Write Switchgear Settings to the Switchgear with the Detection tick box selected.

The Write Switchgear Settings command will replace all the detection settings in the controller with those in the off-line file.

***NOTICE***

**HAZARD OF INCORRECT CONFIGURATION AND UNDESIRED BEHAVIOR**

It is strongly recommended to do a Read Switchgear Settings from the Controller first.

**Failure to follow these instructions can result in equipment damage.**

## Fault Flags

Fault flags indicate which elements detected a fault during the most recent fault sequence.

Fault flags for the elements described in the table below are displayed:

**Table 64 AS Fault Flags**

| Flag | Element | Description |
|---|---|---|
| O/C | Phase Fault | Includes letters displayed to the right indicating the faulted phase or phases. |
| E/F | EF | Indicates an EF was detected. |
| SEF | SEF | Only displayed if SEF is available. |
| NPS | NPS | Only displayed when Sequence Components are available. |

The fault flags can be viewed in WSOS by going to

**Display** > **Fault Flags**.

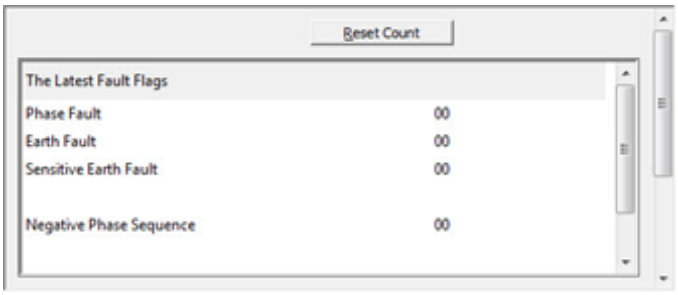



**Figure 181**
AS Fault Flags Display

Fault Flags are also displayed on the operator interface, page 704.

**Fault Flags Example**

An example of how the fault flags might be displayed by the AS in service is shown in the figure below.

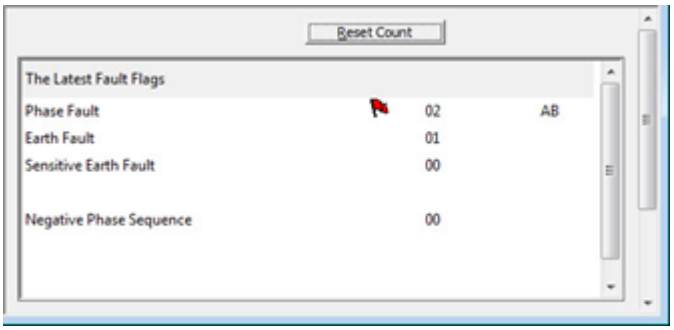



**Figure 182**
AS Fault Flags Example

The fault flags as shown indicate:

- The Phase Fault element was the only element to detect a fault during the last fault sequence. There have been two phase faults since this counter was last reset. They may not have both occurred during the last sequence. The last phase fault detected was between A and B phases.
- The EF element has detected one fault since the last time this counter was reset. This fault did not occur during the most recent fault sequence.
- There have been no SEF or NPS faults detected since the counters were last reset.

**Resetting the Fault Flags**

The Fault Flags will be reset by:

- Any manual close by a local or remote operator
- The start of a new sequence

The Fault Flags and counters can be manually reset by selecting the Reset Count button on the WSOS Fault Flags page.

There are a couple of options for resetting the Fault Flags and counters on the ***flex*VUE** and ***set*VUE** O.I.'s.

***flex*VUE**

- Navigate to the Fault Flags display, page 621 and press **SELECT** twice within a 10 s period.
- Press a Quick Action Key configured as Reset Flags twice within a 10 s period.

***set*VUE**

- Press the **SELECT** key twice within a 10 s period while the Fault Flags page is displayed.
- Press a Quick Key configured as Reset Flags twice within a 10 s period.

## Detection Off

When Detection is Off, the Fault Flags are replaced by Pickup Flags. Pickups occur as normal when Detection is Off but do not trigger fault detect timing so cannot lead to a fault being recorded.

# Fault Detection Enhancements

There are some detection enhancement features that can fundamentally change the operation of the detection function from the way it has already been described.

All of these enhancements are either off or unavailable by default and will not change the way the detection operates unless evoked by the user.

Each of these functions listed below can be either turned on or made available in WSOS in the Detection group in Feature Selection.

- Sequence Reset Clears Fault Flags
- Extended Standard Detection
- Extended Maximum Time per Curve
- Per Element Detection
- Close on Fault Trip

Feature Selection/Detection can be found in WSOS by navigating to:

**Display** > **Configuration** > **Feature Selection** > **Detection**

With the exception of Per Element Detection and Close on Fault Trip, these features can also be evoked on the O.I..

Sequence Reset Clears Fault Flags, page 699

Extended Standard Detection, page 699

Extended Maximum Time per Curve, page 699

## Sequence Reset Clears Fault Flags

There is an option to clear the fault flags on a sequence reset.

If fault flags are set during a sequence that doesn't lead to a sectionaliser trip, those flags will clear when the sequence resets.

This helps to ensure that after a sectionaliser trip, only the flags that were set during the sequence that lead to the trip are displayed.

## Extended Standard Detection

This feature is used when it is required to have different Detection Control settings associated with each configured detection group.

Detection Control settings include:

- Detection On/Off
- Sectionaliser On/Off
- NPS Detection Sectionalise/Alarm/Off
- EF Detection On/Off
- SEF Detection On/Off
- SEF Alarm On/Off
- Single Shot Mode On/Off

In normal operation that is with Extended Standard Detection Off, these settings are global. That means that once they have been configured on the WSOS Control page they become operational regardless of which detection group is active.

Extended Standard Detection functionality allows the On/Off status for these settings to be determined by the active detection group.

Selecting Extended Standard Detection On, immediately adds Detection Control settings to each configured detection group.

The Control page always displays the operational Detection Control settings that is the settings that are in service at the time.

Another set of Detection Control settings now appears on the Global Settings page for each configured detection group. See figure below.

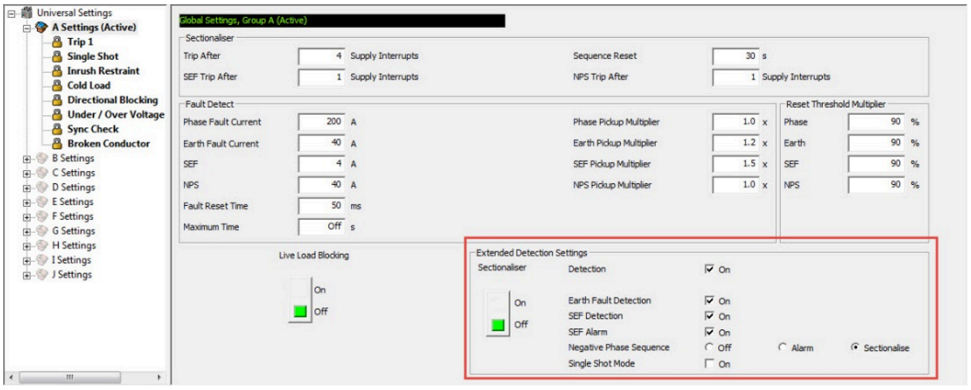



**Figure 183**
Extended Standard Detection settings

The settings in the figure above labelled Extended Detection Settings are the **DEFAULT** detection Control settings for that group. These default settings can be configured differently for each detection group.

When the active detection group is changed, the **default** Detection Control settings for the group that becomes active become the operational Detection Control settings and appear on the Control page.

So if Group A is active and the operational Detection Control settings are:

- Detection On
- Sectionalise Off
- NPS Detection Off
- EF Detection Off
- SEF Detection Off
- SEF Alarm Off
- Single Shot Mode Off

Then Group B is made active and the Group B Default Detection Control settings are:

- Detection On
- Auto Reclose On
- NPS Detection Trip
- EF Detection On
- SEF Detection On
- SEF Alarm On
- Single Shot Mode On

The appearance of the Control page will change as shown in the figure below:

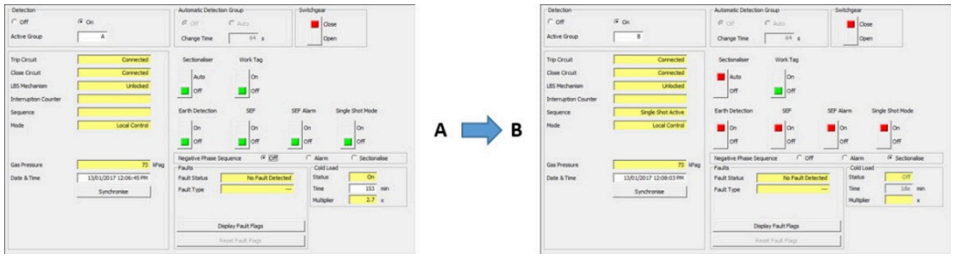



**Figure 184**
Control Page changes with Extended Standard Detection

It can be seen from the above figure that when the active detection group was changed from A to B, the Group B **default** Detection Control settings became the operational settings shown on the Control page.

These default settings are referred to as **non-volatile** as they will be retained in the detection group settings despite changes to the operational settings when their group is active.

## QAK/Quick Keys

If changes are made to any of the operational Detection Control settings using the QAK/Quick Keys, the changed setting will stay in force until either:

- The detection group is changed, or
- It is changed by the operator again.

# Extended Maximum Time per Curve

Extended Maximum Time per Curve changes the way the Maximum Time setting can be used.

Instead of the global Maximum Time setting, it allows a Maximum Time setting to be applied to the Trip1 settings for each element that uses an inverse curve for its fault detect timing.

## Operation

Normally there is only one Maximum Time setting for each detection group. It is a global setting which means that it applies to the fault detect timing for all elements that use an inverse curve for timing.

When the Extended Maximum Time per curve feature is on, there is a separate Maximum Time setting for each inverse curve that has been applied (Maximum 4) This feature also reduces the minimum value for Maximum Time settings from 2.0 s to 0.2 s. The maximum setting remains at 180.0 s.

The figure below shows the Global Settings and Trip 1 pages with Extended Maximum Time per Curve Off. In this configuration, Maximum Time is a global setting. One setting per group appears on the Global Settings page.

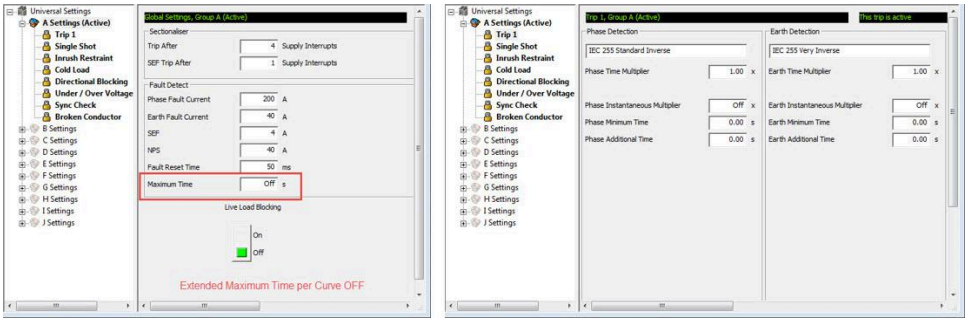



**Figure 185**
Extended Maximum Time per Curve OFF

In the next figure with Extended Maximum Time per Curve On, the Maximum Time setting no longer appears on the Global Settings page. Instead, a separate Maximum Time setting is included in the settings for the Phase and Earth fault detect elements which are both configured to use an inverse curve.

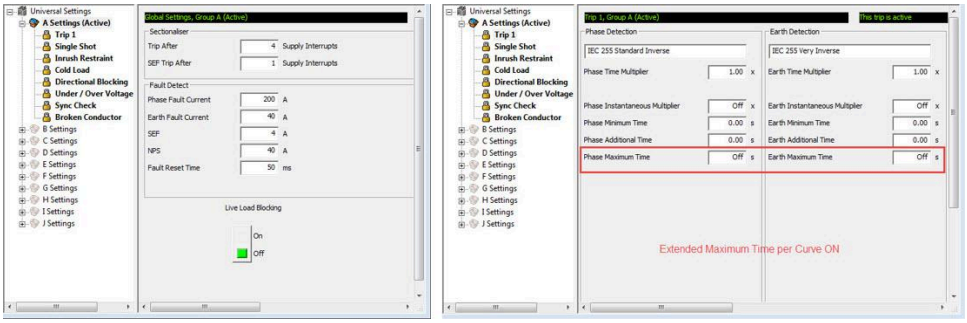



**Figure 186**
Extended Maximum Time per Curve ON

## Per Element Detection

This feature provides the operator with the option of selecting to generate an alarm or sectionalise on a per element basis.

The detection elements for Phase Fault, EF, SEF, and NPS detection can each be individually configured for:

- Sectionalise
- Alarm Only
- Off

### Sectionalise

An element configured to Sectionalise will pick up when it sees a fault and log a fault detection when it times out. If that fault detection leads to a supply interrupt it will increment the Supply Interrupt count.

## Alarm

An element that is configured to alarm only will still pick up if it sees a fault but will only generate an alarm when it times out and not cause a fault detection.

It may still lead to a supply interrupt being logged for each faulted element but they will not increment the Supply Interrupt count and therefore will not cause the AS to sectionalise.

## OFF

An element that is configured Off will not cause a pickup. Consequently that element cannot cause a fault detection, supply interrupt or sectionaliser trip.

When Extended Standard Detection, page 315 is also enabled, it provides the operator the option to configure different Sectionalise and Alarm settings on a per group basis.

## Making the feature available

In order to use this feature, Per Element Detection must be made available by the operator via the WSOS Feature Selection menu.

The Feature Selection menu can be found by navigating through:

**Display** > **Configuration** > **Feature Selection**.

## Configuration

Once this feature has been enabled, the operator will be able to configure the actions required for each detection element, either Off, Alarm or Sectionalise.

These options are available for the following detection elements:

- Phase Fault
- EF
- SEF
- NPS

SEF Alarm and Single Shot Mode On/Off settings are also included.

The additional settings are displayed on the WSOS Control page shown in the figure below.

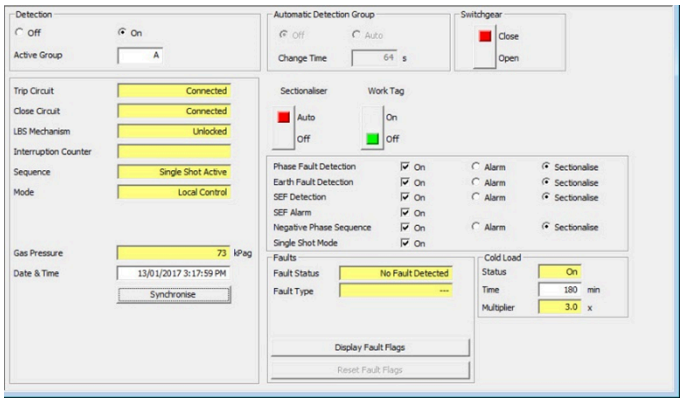



**Figure 187**
Per Element Detection settings

Per Element Detection adds 8 pages to the ***flex*VUE** operator interface.

And are displayed on two page on the ***set*VUE** operator interface.

The table below describes the changes that occur with the detection elements affected when Per Element Detection is enabled. It assumes that Detection is On,

SEF Detection is available, Sequence Components are available and NPS Off is allowed.

**Table 65 Per Element Detection On/Off**

| Element | Per Element Protection Not Available | Per Element Protection Available |
|---|---|---|
| Phase | Phase Fault detection is always On (when Detection is On). | Phase Fault detection can be On (Sectionalise), Off or Alarm. |
| Earth | EF detection can be On (Sectionalise) or Off. | EF detection can be On (Sectionalise), Off or Alarm. |
| SEF | SEF detection can be On (Sectionalise) or Off. | SEF detection can be On (Sectionalise), Off or Alarm. |
| SEF Alarm | SEF Alarm can be On or Off. | SEF Alarm can be On or Off. (no change) |
| NPS | NPS detection can be On (Sectionalise), Off or Alarm. | NPS protection can be On (Sectionalise), Off or Alarm. (no change) |

## Supply Interrupt Flags

When Per Element Detection is available, Supply Interrupt Flags are displayed by WSOS and the O.I. on the controller.

If a fault resets and the upstream device trips within the **Supply Fail Time**, a **Supply Interrupt Flag** for the faulted element/phase will be set.

The Supply Interrupt Flag is an indication that the fault was downstream of the AS that is it performs the function of a fault passage indicator.

The Supply Fail Time is 3.0 s by default and configurable between 1.0 and 60.0 s in 0.1 s steps.

This setting is available in WSOS on the Universal Settings page.

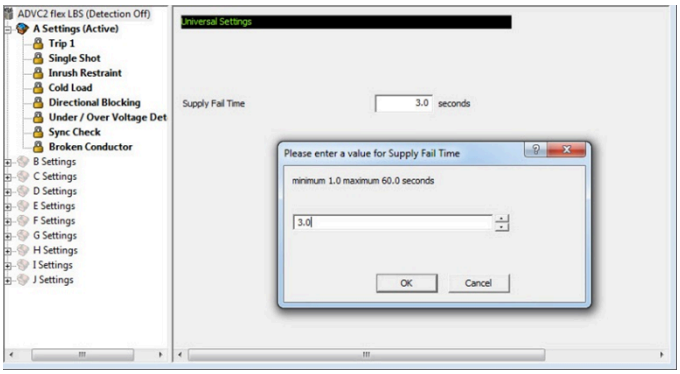



**Figure 188**
Supply Fail Time setting

The Supply Fail Time setting can also be configured on the operator interface.

Supply Interrupt Flags are displayed for the following elements providing they are available:

- A Phase Overcurrent
- B Phase Overcurrent
- C Phase Overcurrent
- EF
- SEF
- NPS

The conditions required to activate a Supply Interrupt Flag are:

1. Fault detection.
2. Fault reset.
3. Source supply goes to zero volts within the Supply Fail Time following step 2.

Once a Supply Interrupt Flag has been set, it can be cleared by any of the following:

- Any switchgear close.
- Any phase current above 2 amps.
- Any phase to Earth voltage above the Live Line Threshold on both sides.

Alarms generated by this feature are available for transmission via SCADA.

In addition to the SCADA alarm point, the Supply Interrupt Flags are available on the WSOS Fault Flags page in the Display menu.

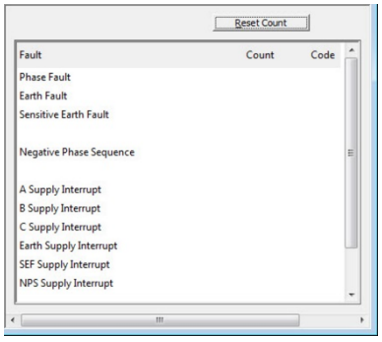



**Figure 189**
Automatic Sectionalise Supply Interrupt Flags

And also on the operator interface, page 704.

The Supply Interrupt Flags will operate whether Detection is On or Off.

## Close on Fault Trip

The **Close on Fault** Trip is a feature helps to ensure that a single shot trip occurs if the switchgear is closed onto a fault when the detection is in the alarm mode.

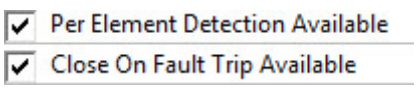
It applies whenever a downstream fault is cleared by an upstream device within the **Maximum Fault Period** of the switchgear being closed by an operator.

The required conditions for a Close on Fault Trip to occur are:

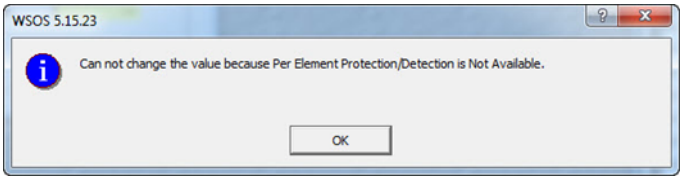
- The Close on Fault Trip feature enabled.
- Switchgear close by a local or remote operator.
- At least one bushing is live at the time of the close request.
- Switchgear has to have closed onto a fault (A fault alarm is raised after the close).
- Supply is lost within the **Maximum Fault Period** from the close.

### Close on Fault Trip Configuration

Close on Fault Trip can be made available in WSOS Feature Selection only if Per Element Detection is already available.




Attempts to make Close on Fault Trip available when Per Element Detection is not available will cause WSOS to display the message below.




Similarly an attempt to disable the Pre Element Detection feature when the Close on Fault Trip feature is enabled will also be rejected.

### Maximum Fault Period

The configuration parameter required for the **Close on Fault Trip** feature is the **Maximum Fault Period**.

When the Close on Fault Trip feature is enabled, a configuration page by that name is added to the settings for each detection group displayed by WSOS.

The Maximum Fault Period is 10 s by default and can be configured from 1 s to 180 s in 1 s steps.

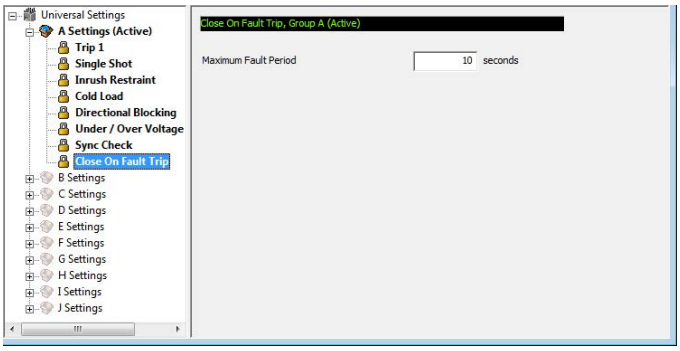



**Figure 190**
AS Maximum Fault Period setting

The Maximum Fault Period can also be set via the operator interface.

> **NOTE:** When **Close on Fault** is enabled, the switchgear will only open within the dead time of the upstream device if the fault is Phase, Earth or NPS and will not open if the fault is SEF.

## Fault Detection Timing Options

### Definite Time

A detection element configured for a Definite TimeMcharacteristic will log a fault detection at a fixed time after the element has picked up.

The current must be above the Fault Detect setting throughout the configured Definite Time.

Definite Time can be configured between 0.01 s and 100.00 s and may be modified by an instantaneous setting. No other curve modifiers can be applied to a Definite Time curve.

**Table 66 Definite Time Settings/Specifications**

| **Definite Time Detection Settings/Specifications** | |
|---|---|
| Definite Time range | 0.01...100 s |
| Definite Time resolution | 0.01 s |
| Timing Accuracy | ± 50 ms |

## Instantaneous Only

The Instantaneous Only characteristic causes the detection element to operate without any intended delay when the current is above the Fault Detect setting.

In practice, the detection algorithms take a certain minimum time to calculate the current, so the minimum operating time will be greater than zero.

Instantaneous characteristics can be modified by an Instantaneous Multiplier and a Minimum Time setting where the trip needs to be delayed by a set time.

Available as an additional element on inverse or definite time protection curves or as an alternative without inverse or definite time. Instantaneous protection can be applied to Phase, Earth, SEF, and NPS protection.

**Table 67 Instantaneous Settings/Specifications**

| **Instantaneous Only Settings/Specifications** | |
|---|---|
| Multiplier of Trip Current Setting (applies to both phase and earth) | 1...30 |
| Resolution of Multiplier Setting | 0.1 |
| Maximum Effective Setting | 12.5 kA |
| Trip Current Setting Accuracy(1) | ± 10% |
| Transient Overreach for X/R < 10 | < 5% |
| Transient Overreach for X/R > 10 | < 10% |
| (1) Current accuracy applies to detection relay function only and excludes accuracy of CTs. | |

## Inverse Current/Time

The Inverse Current Time characteristic causes the fault detection element to operate in a time inversely proportional to the magnitude of the current.

There are many different inverse time characteristics. Some have been standardized by organizations such as IEC and IEEE.

The PowerLogic ADVC Controller supports the following standard IDMT curves:

- IEC 255 – Appendix D, page 564.
  - Standard Inverse
  - Very Inverse
  - Extremely Inverse
- IEEE – Appendix E, page 566
  - Standard Moderately Inverse
  - Standard Very Inverse
  - Standard Extremely Inverse

There are also 42 non-standard (TCC) curves available for coordinating with older style ACRs and ASs.Appendix F, page 568

The basic characteristics of the Inverse Time curves can be modified by the use of time multipliers, instantaneous multipliers, additional times, minimum times and maximum times.

### User Defined Curves

User defined curves can be created using the User Defined Curve Editing tool which is part of the WSOS software package.

The tool can be used to create curves with up to 60 time/current points. Up to five user defined curves may be written to each controller.

## Plotting IDMT Curves

Inverse Time Curves are normally represented on a time/current graph with current on the x axis and time on the y axis.

The graph is normally drawn using log – log scales.

The current axis can be graduated in amps or in multiples of the Fault Detect setting current.

The figure below shows an IEC 255 Standard Inverse curve plotted on a log – log scale with the current axis graduated in amps.

To determine the fault detect time for a 400 A fault (2 x Fault Detect setting), draw a vertical line from 400 A on the current axis up until it hits the curve and then draw a horizontal line to the left until it hits the time axis. The fault detect time for a 400 A fault read off the time axis is just over 10 s (Actual 10.029 s).

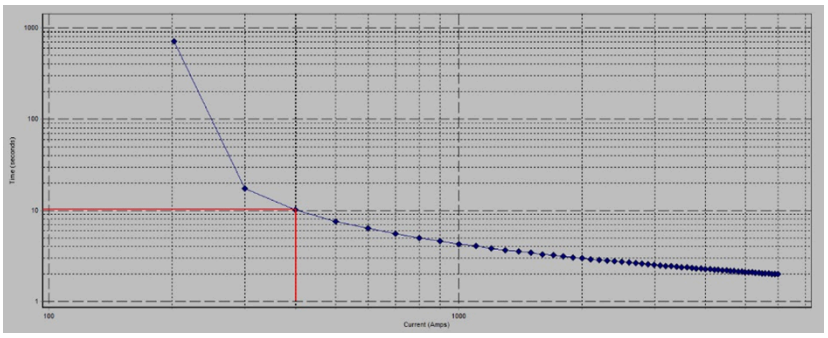


**Figure 191**
Reading the Fault Detect time from an IDMT Curve

Formulas for the standard inverse curves can be found in Appendix D, page 564 (IEC) and Appendix E, page 566 (IEEE).

Fault Detect times are calculated for the fault current as a multiple of the Fault Detect setting Current.

> **NOTE:** The Pickup Multiplier changes the pickup current but doesn't change the curve for fault currents higher than the pickup current. This is illustrated in the figures below.

The first figure below shows an IEC 255 Standard Inverse curve where the Fault Detect current and the pickup current are both 200 A. (Pickup Multiplier = x 1.0)

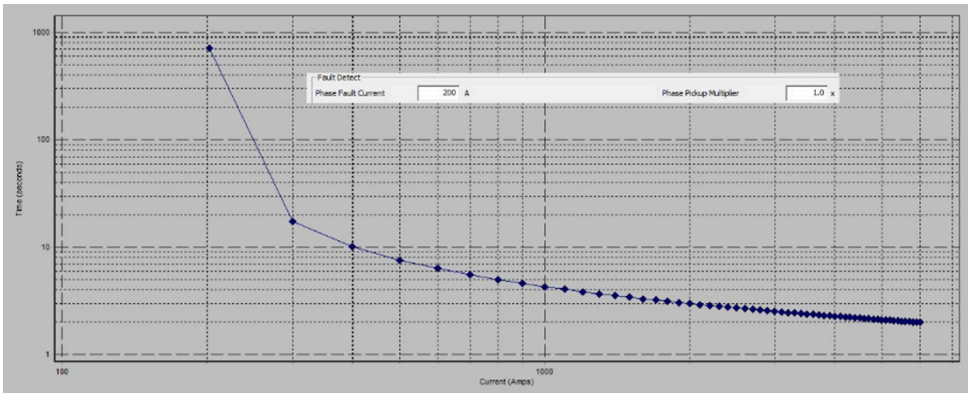



**Figure 192**
IEC 255 Standard Inverse Curve with default settings

The second figure shows the same curve but with a Pickup Multiplier of 1.5. This raises the pickup current from 200 A to 300 A but note that the fault detect times for fault currents >300 A don't change.

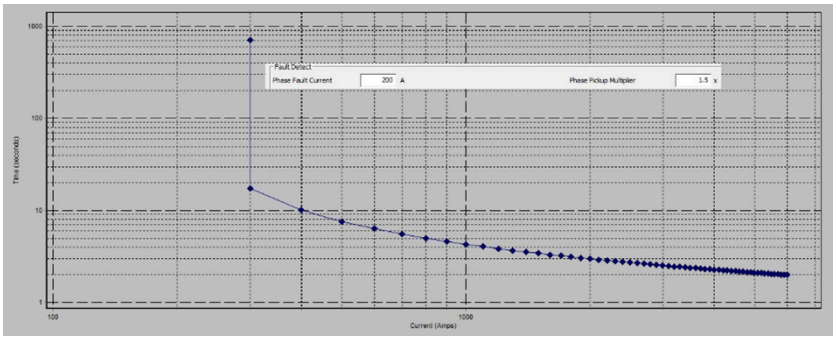



**Figure 193**
IEC 255 Standard Inverse Curve with a Pickup Multiplier x 1.5

The fault detect time for a 400 A (x2) fault in both of the above cases is 10.029 s.

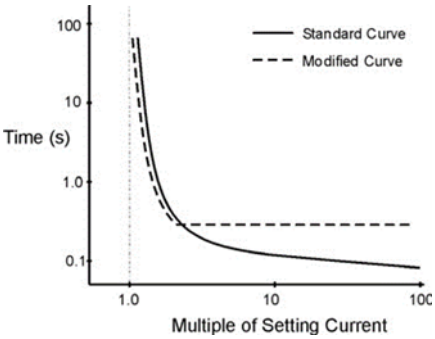
## Curve Modifiers

Inverse Current/Time characteristics can be changed with the following curve modifiers.

- Minimum Time
- Maximum Time
- Additional Time
- Time Multiple
- Pickup Multiplier
- Instantaneous Multiplier

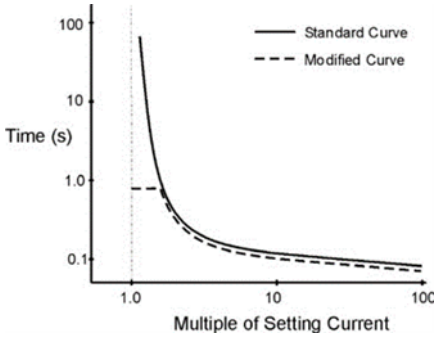
### Minimum Time

This setting modifies the time current characteristic so that the operating time is not less than the Minimum Time regardless of the current magnitude. See figure below.



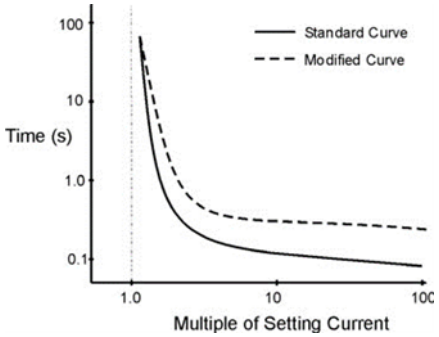

### Maximum Time

This setting modifies the time current characteristic so that the operating time is not more than the Maximum Time regardless of the current magnitude. This helps to ensure fault detection when the current is only slightly above the pickup setting. See figure below.



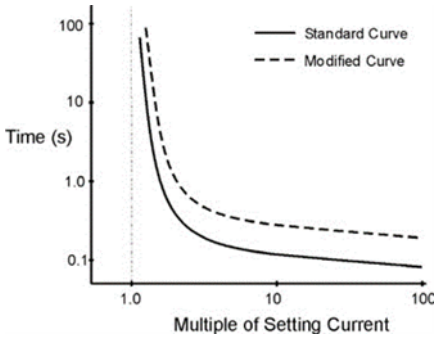

## Additional Time

This setting modifies the time current characteristic so that the operating time is greater than the standard time specified by the time current characteristics by a fixed additional amount. See figure below.



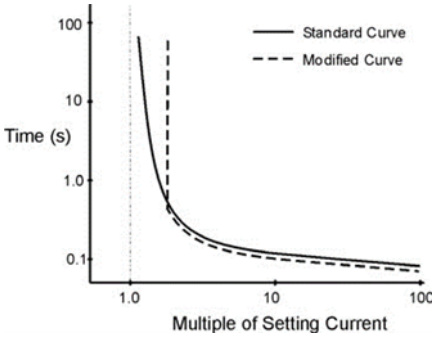

## Time Multiplier

This setting modifies the time current characteristic so that the operating time is a multiple of the standard time specified by the time current characteristics. See figure below.




## Pickup Multiplier

This setting modifies the time current characteristic so that the detection will not pick up unless the current exceeds the Fault Detect Setting X the Pickup Multiplier. This can be used to provide grading when the other devices have a different time/current characteristic. See figure below:




## Instantaneous Multiplier

An Instantaneous Multiplier can be applied to an Inverse Time characteristic. This setting forces an instantaneous trip if the current exceeds the Pickup Setting X Instantaneous Multiplier. This can be used to provide faster fault detection for high current faults.

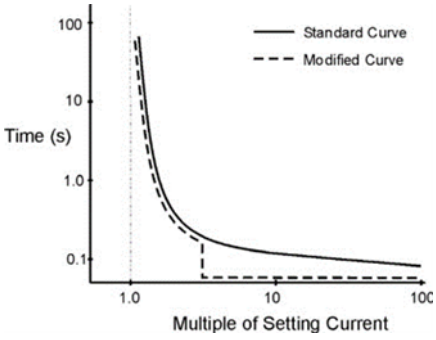



**Table 68 Inverse Time Detection Settings/Specifications**

| Inverse Time Detection Settings/Specifications | |
|---|---|
| Inverse Time Curves available | Refer App. D, E, F |
| Phase Setting Current Range | 10...1260 Amplitude |
| Earth Setting Current Range | 10...1260 Amplitude |
| Setting Current Resolution | 1 Amp |
| Setting Current Accuracy(1) | 5% |
| Maximum Current for which curve applies | 12.5 kA |
| Maximum Setting Current Multiple for which curve applies | × 30 |
| Time Multiplier | 0.01...25.0 |
| Time Multiplier Resolution | 0.01 |
| Maximum Time to Trip(2) | 2...180 s |
| Extended Maximum Time to Trip(30) | 0.2...180 s |
| Maximum Time to Trip Setting Resolution | 0.1 s |
| Minimum Time to Trip(4) | 0...2 s |
| Minimum Time to Trip Setting Resolution | 0.01 s |
| Additional Time to Trip(4) | 0.0...30.0 s |
| Additional Time to Trip Setting Resolution | 0.01 s |
| Phase Threshold Multiplier(4)(5) | 1...10 |
| Resolution of Phase Threshold Multiplier Setting | 0.1 |
| Earth Threshold Multiplier(4)(6) | 1...10 |
| Resolution of Earth Threshold Multiplier | 0.1 |

**Table 68 Inverse Time Detection Settings/Specifications (Continued)**

| | |
|---|---|
| Reset Threshold Multiplier Range (Phase, Ground/Earth and NPS) | 90%...100%(6)<br>10%...100%(7) |
| Resolution of Reset Threshold Multiplier Setting | 0.1% |
| Timing Accuracy(8) | 5%, ±20 ms |
| NPS Trip Current Setting Range | 1...1260 Amplitude |
| NPS Trip Current Setting Resolution | 1 Amplitude |
| NPS Trip Current Setting Accuracy | ±10% |
| NPS Trips in sequence to Lockout | 1...4 |

(1) Current accuracy applies to detection relay function only and excludes accuracy of CTs.

(2) Applies to inverse time and instantaneous protection only.

(3) Available when Extended Maximum Timer per Curve is On.

(4) Applies to inverse time protection only.

(5) A trip is inhibited when the line current < setting current x threshold multiplier.

(6) Valid if Reset Curves is turned off.

(7) Valid if Reset Curves is turned on.

(8) Timing refers to time to initiate operation of circuit breaker (opening and closing times are in addition).

# Current Operated Detection Elements

## Phase Overcurrent

Phase overcurrent detection monitors the RMS current in each phase in order to detect single phase, phase to phase or three phase faults.

A phase detection pickup occurs when the measured current ≥ the Phase Fault Detect current x the Phase Pickup Multiplier.

The fault detect time is calculated based on the magnitude of the fault current as a multiple of the Phase Fault Detect setting.

The phase current values are updated every 5 ms and the fault detect time is continually being recalculated while the pickup is active.

Unless the fault resets, page 310, a fault detection will ensue.

Configuration options for Phase Overcurrent fault detection and reset are listed in the table below.

**Table 69 Phase Overcurrent Fault Detect and Reset settings**

| Phase Overcurrent Fault Detect Settings | Range/Options | Resolution | Default |
|---|---|---|---|
| Fault Current | 10...1260 A | 1.0 A | 200 A |
| Pickup Multiplier | 1.0...10.0 | 0.1 | 1.0 |
| Reset Threshold Multiplier | 90...100% | 1.0% | 90% |
| Fault Reset Time | 0...10000 ms | 1 ms | 50 ms |

## EF

The EF element is driven by the residual current that is the real-time vector sum of the three phase currents.

The residual or earth current is calculated by digitally summing the phase currents sampled every 5 ms.

Residual current = A phase current + B phase current + C phase current or $I_e = I_a + I_b + I_c$

> **NOTE:** The Zero Sequence Current ($I_o$) is defined as $I_o = (I_a + I_b + I_c) / 3$. Therefore the Zero Sequence Current ($I_o$) is one third of the residual or earth current.

An EF pickup occurs when the measured current ≥ the EF Detect current x the Earth Pickup Multiplier.

The fault detect time is calculated based on the magnitude of the fault current as a multiple of the EF Detect setting.

The earth current values are updated every 5 ms and the EF detect time is continually being recalculated while the pickup is active.

Unless the fault resets, page 310, a fault detection will ensue.

Configuration options for EF detection and reset are listed in the table below.

**Table 70 EF Detect and Reset settings**

| EF Detect Settings | Range/Options | Resolution | Default |
|---|---|---|---|
| Fault Current | 10...1260 A | 1.0 A | 40 A |
| Pickup Multiplier | 1.0...10.0 | 0.1 | 1.0 |
| Reset Threshold Multiplier | 90...100% | 1.0% | 90% |
| Fault Reset Time | 0...10000 ms | 1 ms | 50 ms |

# Sensitive EF (SEF)

The Sensitive EF elements are driven by measured residual current.

The residual current used for the SEF element is determined by measuring the current in the common connection between the three CT secondary currents on the PCOM board.

Residual current = A phase current + B phase current + C phase current or $I_e = I_a + I_b + I_c$

> **NOTE:** The Zero Sequence Current ($I_o$) is defined as $I_o = (I_a + I_b + I_c) / 3$. Therefore the Zero Sequence Current ($I_o$) is one third of the residual or earth current.

A sensitive EF pickup occurs when the measured current ≥ the SEF Fault Detect current x the SEF Pickup Multiplier.

The fault detect time is calculated based on the magnitude of the fault current as a multiple of the SEF Fault Detect setting.

The SEF current values are updated every 5 ms and the SEF fault detect time is continually being recalculated while the pickup is active.

Unless the fault resets, page 310, a fault detection will ensue.

Configuration options for SEF detection and reset are listed in the table below.

**Table 71 SEF Detect and Reset settings**

| EF Detect Settings | Range/Options | Resolution | Default |
|---|---|---|---|
| Fault Current | 1...80 A | 1.0 A | 4 A |
| Pickup Multiplier | 1.0...10.0 | 0.1 | 1.0 |
| Reset Threshold Multiplier | 90...100% | 1.0% | 90% |
| Fault Reset Time | 0...10000 ms | 1 ms | 50 ms |

# NPS

The NPS elements are driven by the NPS current ($I_2$) which is calculated in real time by digitally summing the phase currents sampled every 5 ms and applying the Fortescue formula for sequence components.

$I_2 = (I_a + I_b$ phase shifted 240° + $I_c$ phase shifted 120°) / 3

An NPS pickup occurs when the measured current ≥ the NPS Fault Detect current x the NPS Pickup Multiplier. The fault detect time is calculated based on the magnitude of the fault current as a multiple of the NPS Fault Detect setting.

The NPS current values are updated every 5 ms and the NPS fault detect time is continually being recalculated while the pickup is active.

Unless the fault resets, page 310, a fault detection will ensue.

Configuration options for NPS fault detection and reset are listed in the table below.

**Table 72 NPS Detect and Reset settings**

| NPS Detect Settings | Range/Options | Resolution | Default |
|---|---|---|---|
| Fault Current | 10...1260 A | 1.0 A | 40 A |
| Pickup Multiplier | 1.0...10.0 | 0.1 | 1.0 |
| Reset Threshold Multiplier | 90...100% | 1.0% | 90% |
| Fault Reset Time | 0...10000 ms | 1 ms | 50 ms |

## Fault Detect and Reset Configuration

The **Fault Detect** and Reset settings for Phase, **Earth**, **SEF**, and **NPS** detection elements can be configured in WSOS on the Global Settings page.

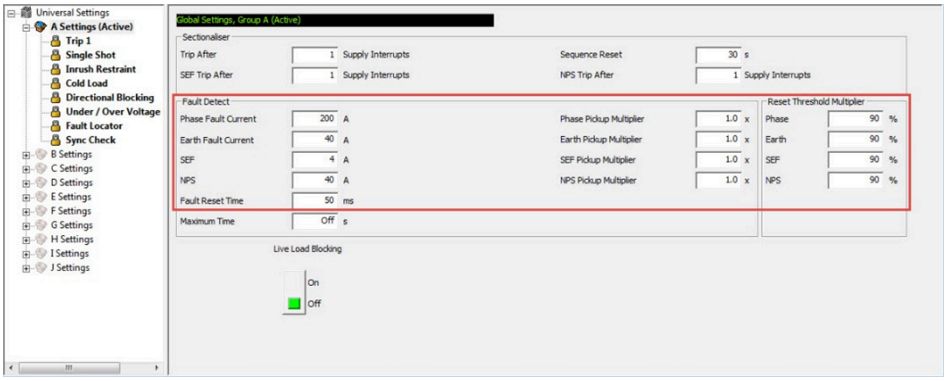



**Figure 194**
Fault Detection and Reset settings for Phase, Earth, SEF, and NPS elements

## Broken Conductor

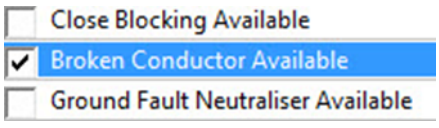
Open circuit faults due to broken conductors or mal operation of switchgear will not cause an increase in current and are not detected by standard over current protection.

This type of fault will cause an unbalance and produce NPS current.

The broken conductor algorithm is based on monitoring the relationship between NPS and PPS currents and is independent of load fluctuations.

Broken Conductor can only be used if it has been made available either through WSOS in Feature Selection.

**Display** > **Configuration** > **Feature Selection** > **Detection**




Or it can be made available on the operator interface, page 699.

If available it can be configured on the **Broken Conductor** page in the WSOS Protection menu.

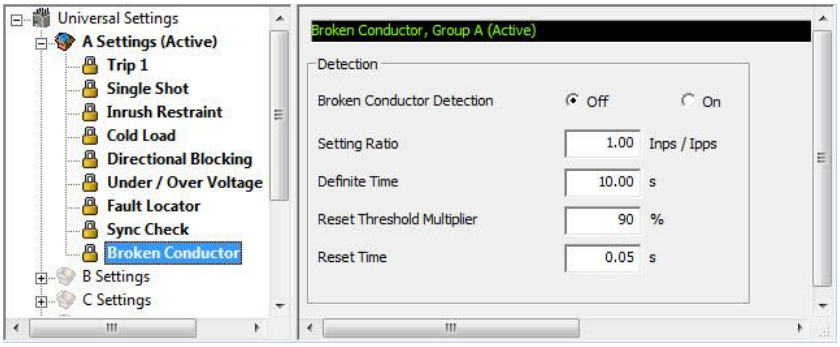



**Figure 195**
AS Broken Conductor settings

or on the operator interface, page 702.

A description of these settings are shown in the table below:

**Table 73 AS Broken Conductor settings**

| **Broken Conductor Detection Settings** | |
|---|---|
| **Setting** | **Description** |
| Off/On | Turns the Broken Conductor Detection off or on. |
| Setting Ratio | The threshold at which the Broken Conductor detection element will pick up |
| Definite Time | The time after a pickup for a Fault Detection to be logged. |
| Reset Threshold Multiplier | This is the percentage of the Broken Conductor pickup value at which reset timing begins. |
| Reset Time | Reset time will start when the $I_{nps}/I_{pps}$ ratio drops below the Reset Threshold.<br><br>When the Reset Time expires, the fault will be reset. |

Broken Conductor fault detection pickup will occur when the following conditions are present:

- Broken Conductor is Available.
- Broken Conductor Protection is On.
- The real time $I_{nps}/I_{pps}$ ratio exceeds the configured $I_{nps}/I_{pps}$ Setting Ratio.

A Broken Conductor pickup will be recorded in the Event Log.

A pickup will start the fault detect timer and if the pickup persists for the Definite Time setting, a Broken Conductor fault detection will occur.

**Fault Reset**

A Broken Conductor pickup will reset if the $I_{nps}/I_{pps}$ ratio drops to the Reset Threshold for the Reset Time. The Reset Threshold is 90% of the $I_{nps}/I_{pps}$ ratio by default.

A Broken Conductor reset event will be recorded in the Event Log.

Configuration options for Broken Conductor fault detection and reset are listed in the table below.

**Table 74 Broken Conductor Fault Detect and Reset settings**

| **Broken Conductor Detect Settings** | **Range/Options** | **Resolution** | **Default** |
|---|---|---|---|
| Setting Ratio | 0.10...1.00 $I_{NPS}/I_{PPS}$ | 0.01 $I_{NPS}/I_{PPS}$ | 1.00 $I_{NPS}/I_{PPS}$ |
| Reset Threshold Multiplier | 90...100% | 1.0% | 90% |
| Reset Time | 0.00...100.00 s | 0.01 s | 0.05 s |

# AS Detection Features

## Single Shot

In Single Shot mode, an AS will ignore the Trip After x Supply Interrupt settings for the active detection group and sectionalise after one supply interrupt.

## Single Shot Configuration

To use this feature, Single Shot must be turned On and the Single Shot Reset Time setting which is 0 s by default must be configured for a non-zero value, that is 1...180 s.

Single Shot can be turned On in WSOS on the Control page.

**Display** > **Control**

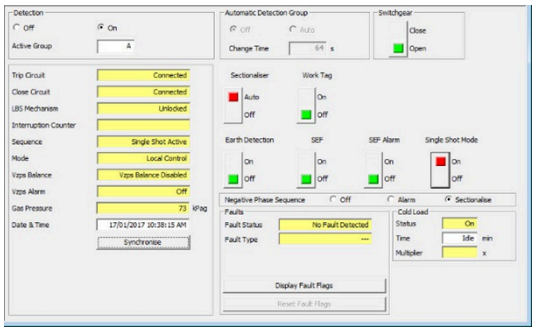



**Figure 196**
WSOS Single Shot On

And the Single Shot Reset Time setting can be found on the Single Shot setting page in the Detection settings.

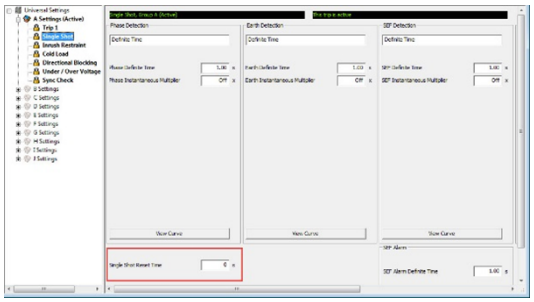


**Figure 197**
WSOS Single Shot Reset Time setting

Single Shot On/Off, page 702 and Single Shot Reset Time settings can also be configured on the O.I.

An AS can only be in Single Shot mode when Sectionaliser is in Auto.

So if Sectionaliser is Off when Single Shot mode is selected, Sectionaliser will be automatically set to Auto. Similarly, if Sectionaliser is turned Off when the AS is in Single Shot mode, Single Shot will be automatically set to Off also.

## Single Shot Fault Detect Timing

When an AS is configured for Single Shot mode, it requires appropriate curves to be selected for Single Shot fault detection timing.

Curves for Phase, Earth, SEF, and NPS detection if available can be configured in WSOS on the Single Shot page in the Detection settings for each Detection Group. See Figure above.

Single Shot fault detect timing can also be configured on the operator interface.

## Single Shot Operation

If an AS with Single Shot On is closed manually, it will be in Single Shot mode for the Single Shot Reset Time.

While it is in Single Shot mode, the AS will use the active group Single Shot detection curves for fault timing.

If a fault is detected which then leads to a supply interrupt, the device will immediately sectionalise (trip).

If the Single Shot Reset Time expires without a supply interrupt, the AS will revert to using the Trip 1 settings for fault detection timing and the global Trip After x Supply Interrupts settings will become active.

# Work Tag

## Introduction

An important feature of the PowerLogic ADVC Controller is that it is always in one of two modes, either local or remote, and can have a work tag applied by local or remote operators.

The mode and the tag specify the circumstances under which the switchgear can be closed which helps to ensure operational safety.

The Work Tag is applied to protect operators working on live lines.

Work Tag and the configuration are introduced in the these sections. Refer to see Work Tag/Hot Line Tag, page 56.

## Work Tag Configuration

Work Tag can be selected On/Off in WSOS on the WSOS Control page or on the operator interface

**Display** > **Control**

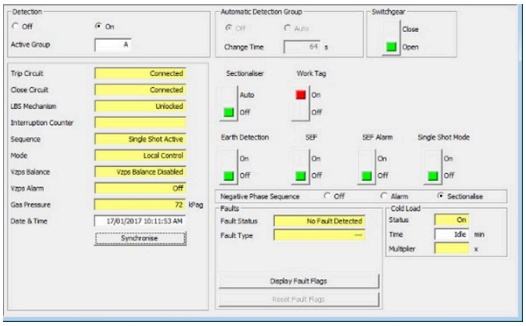



**Figure 198**
WSOS Work Tag Applied

## Applying the Work Tag to an AS

Applying the Work Tag to an AS helps ensure that the switchgear cannot be closed either by a local or remote operator.

When the work tag is applied, the operator interface will display the message:

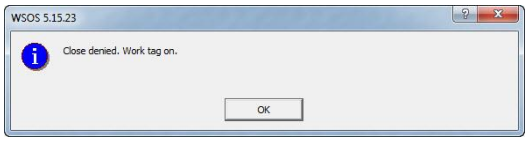
**Warning – Work Tag Applied**

On the ***flex*VUE** O.I., this message will be displayed in the Alerts menu.

On the ***set*VUE** O.I. the message will alternate with the heading normally displayed for the current page.

Only a local operator can apply/remove the work tag when the controller is in Local Mode and only a remote operator can apply/remove the work tag when the controller is in the RM. This means that a local user can remove the work tag that was applied by a remote user but they must first put the controller in Local Mode.

If a local operator is denied a close operation via WSOS due to the work tag being applied, WSOS will display a message:




If a local operator attempts to close the switchgear via the ***flex*VUE** O.I. when the work tag is applied, an Operation Denied event will be recorded in the Event Log.

If an attempt is made to close the switchgear via the ***set*VUE** O.I. with the work tag applied, the message:

**Not Allowed – Change to LOCAL mode**

**and/or remove Work Tag**

**Press the MENU/ENTER key to continue**

Will be displayed on the O.I. LCD display.

## Work Tag Restrictions

The work tag is normally applied to an AS when the switchgear is open. However this will not be allowed if either of the following conditions exist:

- Battery voltage is not normal that is Low or Off.
- Switchgear Data is Invalid.

The work tag can be applied to an AS when the switchgear is closed providing none of the following conditions exist:

- Battery voltage is not normal that is Low or Off.
- Switchgear Data is Invalid.
- Automatic Detection Group Selection (ADGS) is in Auto.
- Detection and Sectionaliser are Off.
- The switchgear is not able to trip (for example Trip Isolate).
- Phase protection is disabled or in the Alarm mode.

When the work tag is applied, as well as closing, the following actions will not be allowed:

- Enabling ADGS.
- Changing the Detection group.
- Disabling either Phase, Earth, SEF, or NPS detection.
- Switching Phase, Earth, SEF, or NPS from Sectionalise to Alarm mode.
- Writing of the switchgear settings via WSOS.
- Enabling/Disabling Directional Detection/Blocking from Feature Selection.

# ADGS

ADGS can be used to automatically change the active detection group to suit the network configuration without the need for operator intervention.

ADGS works by automatically changing between detection groups depending on the direction of power flow through the switchgear.

## The Selection Rules

- Each pair of detection groups (A), (C), (E), (G), (I) contains one primary and one alternate detection group.
- The number of pairs that are available depends on how many detection groups have been configured (minimum 2 required).
- When the power is in the positive direction (source to load), primary detection group A, C, E, G, or I is used.
- When the power is in the negative direction (load to source), alternate detection group B, D, F, H, or J is used.
- For ADGS to generate a change from primary to alternate protection group, the power flow must be > 50 kW in the negative direction for longer than the set period.
- To revert to the primary detection group the power must be > 50 kW in the positive direction for longer than the set period.

## ADGS Applications

Sometimes an AS is used at a location in a supply network where the power flow can be in either direction depending on the configuration of the network.

One example of this is a network tie point where the operator may have to select a different group of detection settings to compensate for a change in power flow when changing the network configuration. Emergency switching configurations may also require more than one detection group.

## ADGS Configuration

ADGS is an additional protection feature that must be made available before it can be configured and enabled.

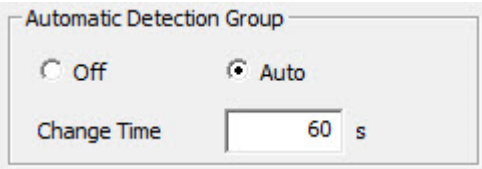
ADGS can be made available through Feature Selection in WSOS:

**Display** > **Configuration** > **Feature Selection** > **Detection**

It can also be made available on the operator interface.

Once ADGS is available it can be configured for a Change Time between 10 s and 180 s (default 60 s) and set to Auto.

In WSOS this is done on the Control page.




The ADGS Change Time and ADGS Auto/Off settings can also be configured on the O.I.

## Disabling ADGS

Certain operator actions will cause ADGS to be disabled.

- A change to the Power Direction setting.
- Selection of an active detection group other than Detection Auto.
- Setting ADGS to Not Available.

**Table 75 ADGS Settings/Specifications**

| ADGS Settings/Specifications | |
|---|---|
| Auto Change Time | 10...180 s |
| Auto Change Time Resolution | 1 s |

# SEF Alarm

The SEF Alarm is a facility whereby a SEF will trigger an alarm without causing a fault detection.

An SEF Alarm Definite Time delay can be configured which is independent of the SEF fault detect timing. This allows the SEF Fault Detect and Alarm functions to be operational at the same time.

## SEF Alarm Configuration

SEF Protection must be available for the SEF Alarm to be used.

The SEF Alarm On/Off control is displayed in WSOS on the Control page as well as on the operator interface.

## SEF Alarm Timing

There are separate SEF Alarm Definite Time settings for Trip 1 and Single Shot within each detection group.

Both settings default to 1.00 s and are configurable between 0.10 s and 999.00 s in steps of 0.01 s.

## SEF Alarm settings in WSOS

In WSOS there is an SEF Alarm Definite Time setting below the SEF Detection settings on the Trip 1 and Single Shot pages. As shown below for Trip 1.

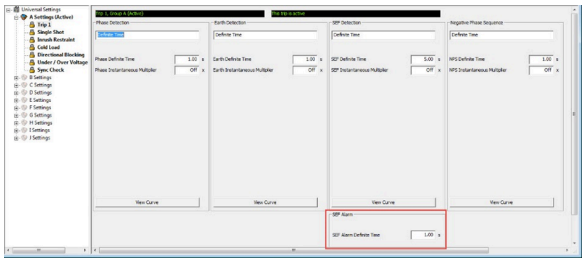


**Figure 199**
SEF Alarm Definite Time setting for Trip 1

The SEF Alarm Definite Time settings can also be configured on the operator interface.

When activated, the SEF Alarm will log an event in the Event Log.

SEF Alarm On/Off events are also recorded.

The SEF Alarm can be mapped to a Status Lamp or Quick Action Key lamp on the ***flex*VUE** O.I.

The SEF Alarm is also available for mapping through the Configurable Protocol Tool for reporting via SCADA.

# NPS Alarm

Providing Sequence Components are available, NPS can be configured for either Alarm or Trip regardless of whether Per Element Protection, page 174 is available.

## NPS Alarm Configuration

In WSOS this setting can be configured on the Control page or it can be configured on the operator interface




## NPS Alarm Operation

When NPS Alarm is selected, an NPS fault will still cause an NPS pickup but it will not time out to become a fault detection.

Instead, when the fault detection timing expires it will log an NPS alarm.

Consequently an NPS fault in Alarm mode will not lead to a supply interrupt.

Other events normally associated with a detection pickup:

- Pickup NPS
- Detection Group Active

Will still be logged.

And when the fault is removed:

- Detection Elements Resetting
- NPS Max Current

Will be logged.

NPS Mode Alarm is also logged when NPS Alarm is selected.

The NPS Alarm can be mapped to a Status Lamp or Quick Action Key lamp on the ***flex*VUE** O.I.

The NPS Alarm is also available for mapping through the Configurable Protocol Tool for reporting via SCADA.

# Detection Off

**Detection** is **On** by default but can be turned **Off** if **Detection Off** is allowed.

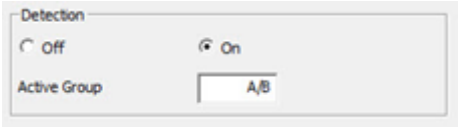
Detection Off Allowed can be selected in WSOS on the Feature Selection page:

**Display** > **Configuration** > **Feature Selection** > **Detection**

or on the operator interface.

**Detection On/Off**

If allowed, Detection can be turned off in WSOS on the Control page:




Detection On/Off can also be configured on the operator interface.

On the ***flex*VUE** and ***set*VUE** O.I.'s this setting has three options:

- Detection Off
- Sectionaliser Off
- Sectionaliser Auto

If Detection is Off, it can be turned On by selecting either Sectionaliser Off or Sectionaliser Auto.

> **NOTE:** Detection Off will deactivate all of the fault detection facilities and only pickup events will occur. AS operation will not be possible when Detection is Off. Only local/remote user trips and closes will be possible.

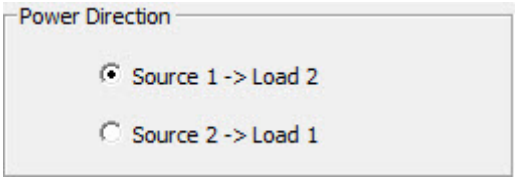
If Detection is On, each individual element can be programmed to log a fault detection depending on its detection configuration.

# Live Load Blocking

Live Load Blocking is used where there is a possibility of the AS switchgear being inadvertently closed when the **load side** is **energized** with an incompatible supply.

## Critical Settings

The **load side** is as defined by the Power Direction, page 155 setting:




and *energized* is as defined by the Live Line Threshold setting:




Which is configurable between 2000 V and 15000 V in 1 Volt steps

Both of these critical settings can be configured in WSOS on the Measurement page:

**Display** > **Measurement**

The Power Direction, page 155 and Live Line Threshold settings can also be configured on the .

## Live Load Blocking Operation

If Live Load Blocking is On, all close requests, manual or automatic, will be disregarded if any load side bushing is live.

A operator close request that is denied by Live Load Blocking will generate the following events:

- Panel Close Request
- Live Load Blocking
- Operation Denied

## Live Load Blocking Configuration

Live Load Blocking is Off by default but can be turned On in WSOS on the Detection Global Settings page or on the operator interface.

Live Load Blocking is configured per detection group.

| **Live Load Blocking Settings/Specifications** | |
|---|---|
| Live Load Threshold Voltage | 2...15 kV |

# Inrush Restraint

When closing onto typical loads, there may be an initial surge in current caused by phenomena such as:

- Transformer magnetizing currents
- Motor starting currents
- Start-up current of incandescent and arc lights

These surges are transient and referred to as Inrush Current. Depending on the active detection settings at the time, this inrush current may cause fault detection to operate unnecessarily.

The purpose of Inrush Restraint is to inhibit fault detection due to inrush current.

The PowerLogic ADVC Controller supports two modes of operation for Inrush Restraint, Zero Detect, and SOHIR. This section describes the Zero Detect mode. SOHIR, page 341, or SOHIR is described in the next section.

## Inrush Restraint Configuration

Inrush Restraint can be enabled and configured in WSOS on the

**Detection** > **Inrush Restraint** page shown below.

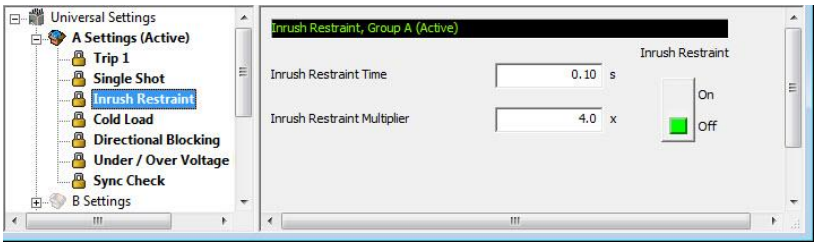



**Figure 200**
Zero Detect Inrush Restraint settings for an AS

Inrush Restraint can also be configured on the operator interface.

Inrush Restraint is configured per protection group.

## Inrush Restraint Operation

Inrush Restraint works by raising the Phase, Earth and NPS threshold current settings for a short period of time to allow the inrush current to subside.

**NOTE:** Inrush Restraint does not affect SEF thresholds or settings configured for Definite Time.

Apart from the On/Off control there are two settings that determine how Inrush Restraint operates.

| Setting | Default | Description |
|---|---|---|
| Inrush Restraint Time | 0.10 s | The time Inrush Restraint will remain active when triggered. |
| Inrush Restraint Multiplier | X4 | The Fault Detect current multiplier while Inrush Restraint is active |

- Inrush Restraint is armed for operation whenever the load current goes to zero.
- When the load current goes from zero to non-zero, the Inrush Restraint is activated and the Inrush Restraint Multiplier is applied to the Phase, Earth, and NPS Fault Detect thresholds for the Inrush Restraint Time.

## Inrush Restraint Operation during a Sequence

Inrush Restraint needs to be disabled if it is know that current is about to go from zero to non-zero due to a fault that has already tripped the upstream ACR.

If this is the case, the supply interrupt count would be greater than zero.

Therefore Inrush Restraint is disabled if the supply interrupt count is greater than zero.

In other words, if the current is zero due to the protection trip of an upstream ACR, the AS must have seen the fault and its supply interrupt count would have incremented.

In this case, as shown in the figure below, the inrush restraint will be disabled and the multiplier will not apply if the current goes to non-zero when the upstream ACR recloses.

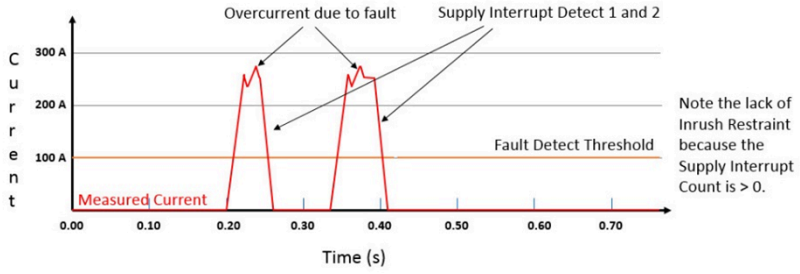



**Figure 201**
No Inrush Restraint Operation when Supply Interrupt Count > 0

## Example

In the example below, the Inrush Restraint multiplier (2) was applied to the trip setting (100 A) from when the current went from zero to non-zero. This could have been caused by the switchgear being closed and taking load or the switchgear could have been already closed and the load could have been caused by either an upstream or downstream device closing.

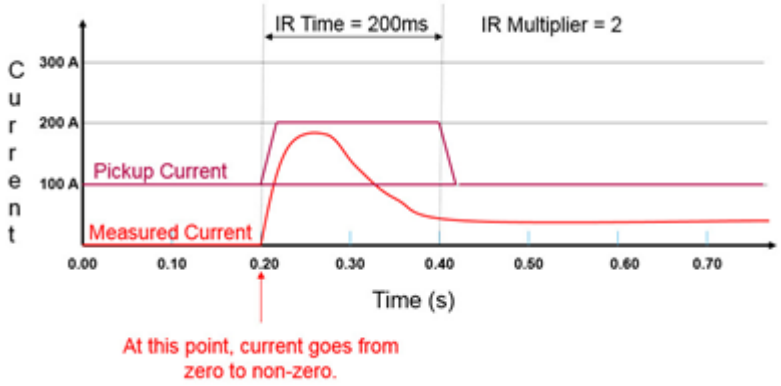



**Figure 202**
Inrush Restraint Time/Current diagram

The Inrush Restraint Multiplier of 2 caused the trip setting to go from 100 A to 200 A for the duration of the Inrush Restraint Time setting (200 ms). This effectively masked the inrush current which had returned to a steady state level before the Inrush Restraint Time expired and the configured setting was restored.

In this case a pickup event would have been logged when the measured current exceeded the pickup threshold that is 100 A, but the protection timing would not have started.

If the measured current had been higher than the pickup threshold when the inrush restraint timer expired, the protection timing for that element would have started. If the current remained above the pickup threshold for the protection trip time the ACR would trip.

## Inrush Restraint Summary

- Inrush Restraint helps to prevent an AS from sectionalising unnecessarily due to short lived inrush current such as magnetizing current associated with energizing a transformer.
- Pickup and Max Current events are still logged according to the Fault Detect setting for each element even though the Inrush Multiplier is being applied.
- Inrush Restraint affects Phase, Earth, and NPS detection but does not apply to Definite Time or SEF detection.
- Inrush Restraint is triggered by currents going from zero to non-zero. So if normal load currents are expected to drop below 2.5 A Inrush cannot be used and must be left off.

**Table 76 Zero Detect Inrush Restraint Settings/Specifications**

| **Inrush Restraint Settings/Specifications** | |
|---|---|
| Inrush Restraint Multiplier Range | 1...30 |
| Inrush Restraint Multiplier Resolution | 0.1 |
| Inrush Restraint Time Range | 0.05...30 s |
| Inrush Restraint Time Resolution | 0.01 |
| Timing Accuracy | ± 20 ms |

## SOHIR

SOHIR offers an alternative to the traditional Zero-Detect method of Inrush Restraint explained in Inrush Restraint Operation, page 210.

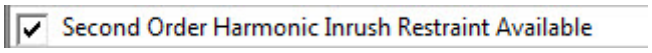
High inrush current is often due to magnetizing current when a transformer is energized.

Magnetizing currents are distinguished by their high second order harmonic content. SOHIR provides rapid harmonic detection of inrush current based on harmonic content.

## Making SOHIR Available

SOHIR is an optional feature and can be enabled on the Feature Selection page in WSOS.

**Display** > **Configuration** > **Feature Selection** > **Detection**




Or on the operator interface.

## SOHIR Configuration

When **SOHIR** has been made available, an additional field, Inrush Restraint Type, is added to the Inrush Restraint settings. The setting options for this field are:

- Zero Detect
- SOHIR

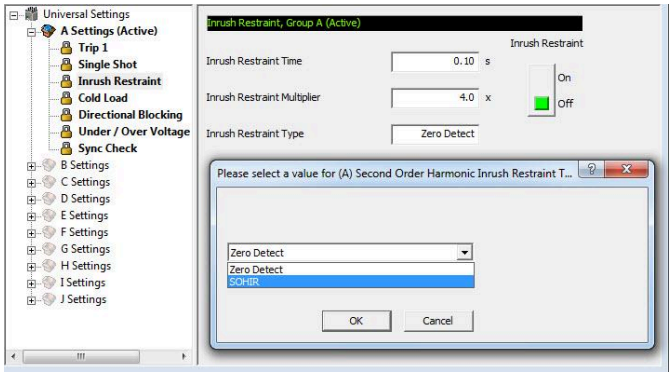



**Figure 203**
Inrush Restraint Type Selection

Two more settings are added if SOHIR is selected as the Inrush Restraint type.

- Inrush Restraint Threshold
- Inrush Restraint Algorithm

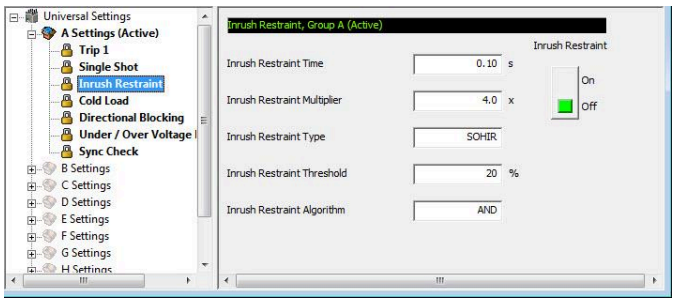



**Figure 204**
SOHIR Inrush Restraint settings

SOHIR can also be selected and configured on the operator interface.

The parameters used to configure SOHIR Inrush Restraint are described in the table below:

**Table 77 Inrush Restraint Settings**

| Setting | Default | Description |
|---|---|---|
| Inrush Restraint Time | 0.10 s | The time Inrush Restraint will remain active when triggered. |
| Inrush Restraint Multiplier | X4 | Setting current multiplier while Inrush Restraint is active. |
| Inrush Restraint Threshold | 20% | The 2nd harmonic component of current on the line (expressed as a percentage of the fundamental component) required for SOHIR to activate. |
| Inrush Restraint Algorithm | AND | Configured for either **AND** or **OR**. In the case of **AND** logic, all phases must have harmonics above the threshold setting, in order for SOHIR to become active. In the case of **OR** logic, only the phase with the highest current needs to have harmonics above the threshold setting. |

SOHIR is configured per detection group.

## SOHIR Operation

SOHIR monitors pickups by either Phase, Earth or NPS protection elements.

- Once a pickup is detected, SOHIR restrains all overcurrent protection trips from the Phase, Earth or NPS elements (except those using Definite Time curves) for 30 ms.
- During this 30 ms time period, SOHIR calculates the harmonics on the faulted phases as a percentage of the fundamental component.
- If one or more phases has a second harmonic component above the Inrush Restraint Threshold setting, a decision is made on whether to become active based on the Inrush Restraint Algorithm.
- If SOHIR does become active it will restrain all overcurrent trips from the Phase, Earth and NPS element for the configured Inrush Restraint Time.

SOHIR will be deactivated if either:

- Harmonics measured during the 30 ms period are below the threshold.
- The Inrush Restraint timer has expired.

Once SOHIR has been deactivated it cannot reactivate until all relevant protection elements have reset.

## CLP

When a typical load has been without supply for a period of time (hours) it loses its diversity.

When power is restored the load is initially higher than usual because many or all of the thermostat controlled devices such as heaters, refrigeration, air conditioners etc will turn on.

The longer the period without supply the greater the loss of diversity and the higher the load current will be when supply is restored.

If the supply is off long enough the load will eventually lose diversity altogether and any further extension of the outage will not cause any further increase in the load current when supply is restored.

The increase in load current after a prolonged outage could cause overcurrent detection to operate unnecessarily.

The purpose of the CLP feature is to automatically compensate for the loss of diversity by adjusting the overcurrent pickup thresholds until the load regains its diversity and steady state load conditions return.

It works by measuring the time that supply is lost and then temporarily raising the Fault Detect Current for the selected elements for a time according to the time the supply was lost.

## CLP Configuration

CLP can be selected On or Off for the Phase overcurrent, Earth Fault, SEF, and NPS elements independently. It is configured by setting two parameters:

- Cold Load Time – default 120 minutes
- Cold Load Multiplier – default x 2.0

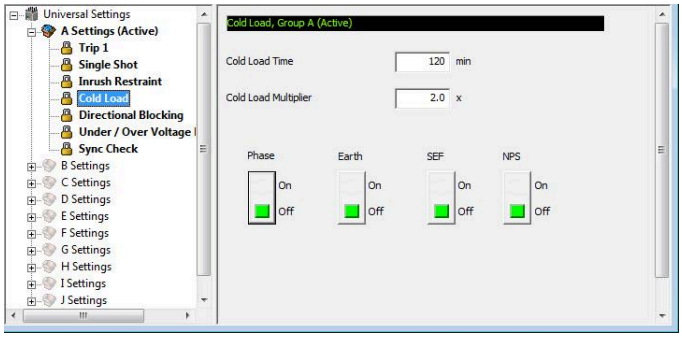



**Figure 205**
AS Cold Load settings

The default settings effectively say that the load is expected to completely lose its diversity when it's been without supply for 120 minutes after which time the Fault Detect threshold currents for the selected elements would need to be raised x 2 that is doubled.

CLP can be configured in WSOS on the

**Protection** > **Cold Load** page or on the operator interface.

CLP is configured per detection group.

## CLP Operation

The Cold Load Multiplier setting is the maximum value for the multiplier applied to the Fault Detect current setting for the selected detection elements.

Whenever the Cold Load timer is running, the actual multiplier being applied is known as the **Operational Cold Load Multiplier**.

The Operational Cold Load Multiplier is calculated using the following formula:

$$\text{Operational Cold Load Multiplier} = 1 + \frac{\text{Operational Cold Load Time}}{\text{User Set Cold Load Time}} \times (\text{User Set Cold Load Multiplier} - 1)$$

Where the Operational Cold Load Time is the time the supply has been lost minus any time it's been back on.

So when the supply is off, the Operational Cold Load Time is increasing and when the supply is on, the Operational Cold Load Time is decreasing.

This means the Operational Cold Load Multiplier will have a minimum value of 1, and a maximum value equal to the User Set Cold Load Multiplier setting.

Consider a situation where the supply has been off for 60 minutes.

If the controller was configured with the default CLP settings, the Operational Cold Load Multiplier would be:

$$\text{Operational Cold Load Multiplier} = 1 + \frac{60}{120} \times (2 - 1)$$

=1.5.

Therefore after the supply had been off for 60 minutes, a multiplier of 1.5 would be applied to the Fault Detect current settings.

So the Operational Cold Load Multiplier would increase linearly from x1 to x2 over a 120 minute period while the supply was off.

When the supply is restored, the Operational Cold Load Multiplier would start at x2 and decrease linearly to x1 over the next 120 minutes if the supply stays on.

While the Cold Load timer is running the controller recalculates the Operational Cold Load Multiplier every minute.

## CLP Example

The situation described above is depicted graphically in the figure below.

The Fault Detect setting is 100 A.

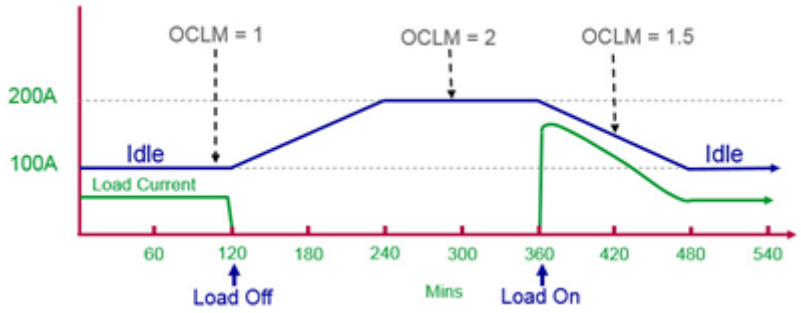



**Figure 206**
Cold Load Time/Current diagram

In this example the supply goes off for four hours. Over the first two hours, the Operational Cold Load Multiplier (OCLM) increases from x1 to x2.

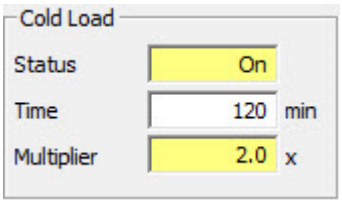
The supply stays off for another two hours but the Operational Cold Load Multiplier doesn't increase any further because it's reached its maximum setting.

When the supply comes back on, the load current is significantly higher than usual but doesn't cause a detection pickup because it doesn't exceed the Setting Current x the Operational Cold Load Multiplier.

Over the next two hours the Operational Cold Load Multiplier ramps down from x2 to x1 and is always above the load current which also tapers off over that time.

## CLP Status

The current status of the CLP is displayed by WSOS on the Control page.




The **Status** is read-only and can be either Off, On or Idle.

**Off** – means that the feature is off and will have no effect on the detection settings.

**On** – means that at least one of the CLP detection elements is on and the displayed Multiplier is being applied to the Fault Detect setting for that element.

**Idle** – means that the feature is on but not currently affecting the detection settings.

**Time** – is the Operational Cold Load Time. Note this field is configurable.

**Multiplier** – is the current Operational Cold Load Multiplier and is read-only.

The CLP Status is also displayed on the operator interface.

CLP cannot be turned On or Off via the Status display. That can only be done by selecting/deselecting one of the detection elements in the CLP detection settings.

## Cold Load Status on Power Up

The CLP status can be changed from the status display by changing the time.

Consider a situation where the load has been off and the controller powered down for some hours due to module replacement/maintenance etc.

The controller was powered down during the outage so when it is powered up again it assumes the load to be diverse that is the Operational Cold Load Time is zero and the CLP status will be Idle.

Because the CLP status time is an operator setting it can be manually adjusted to reflect the duration of the outage and thus allow for the load that might occur when the device goes back into service.

## Example

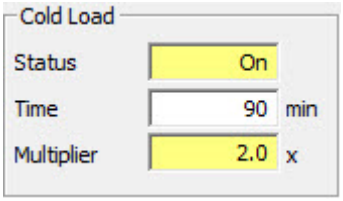
If the CLP settings are:

Cold Load Time 180 minutes

Cold Load Multiplier x3

And it is expected that the Setting Currents need to be doubled for the anticipated increase in load.

That can be achieved by setting the Cold Load Operational Time to 90 minutes as shown below.




Changing the Operational Cold Load Time automatically changes the Operational Cold Load Multiplier according to the active Cold Load settings.

## CLP Summary

- The user-set Cold Load time and Cold Load Multiplier are protection settings, only the Cold Load Status/Time is an operator setting.
- Only the protection elements that are selected, Phase, Earth, SEF, and NPS, are affected by the Cold Load Multiplier.
- Definite Time settings are not affected.
- CLP cannot be used if normal load currents are expected to drop below 2.5 A.

  **NOTE:** It is possible for Cold Load and Inrush Restraint to be applying multipliers at the same time.

In this situation, Inrush will use the Operational Cold Load Multiplier if it is the higher.

**Table 78 CLP Settings/Specifications**

| CLP Settings/Specifications | |
|---|---|
| Cold Load Multiplier Range | 1...5 |
| Cold Load Multiplier Resolution | 0.1 |
| Cold Load Time Constant Range | 1...480 min |
| Cold Load Time Constant Resolution | 1 min |
| Timing Accuracy | ± 1 min |

# Directional Detection and Block

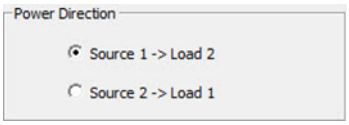
## Directional Blocking

### Overview

AS are sometimes installed in network configurations where power flow could be in either direction through the switchgear.

Directional Blocking can be used when the ACR is only required to trip for faults on either the load or source side. When power flows from Source to Load, the power flow is deemed to be forward. Reverse power flows from Load to Source.

The Source and Load sides of the switchgear are configurable through the Power Direction setting.




The Power Direction setting can be found on the WSOS Measurements page, page 148 or on the operator interface.

Directional Blocking is an optional protection feature that will only allow a fault to cause a protection trip when power flow is in the designated directions for the faulted element.

Each overcurrent element, Phase, Earth, SEF, and NPS if configured can be set for a Fault Detection Direction of:

- Forward Fault
- Reverse Fault
- Forward and Reverse Fault (non-directional)

Directional Blocking uses only one active detection group that determines the pickup and detection timing for faults detected in the designated fault detection direction for each element.

If a fault is determined to be in the designated fault detection direction, detection will be armed.

If a fault is determined to not be in the designated fault detection direction, detection will be blocked.

Directional Blocking can only be turned on from the WSOS Feature Selection page.

It can’t be turned on from the Options pages on the ***set*VUE** O.I. or the Feature Selection pages on the ***flex*VUE** O.I.

## Determining Direction

The user must set a **Characteristic Fault Angle** for each element.

The Characteristic Angle is essentially a prediction of the expected fault angle when a forward fault occurs.

The fault angle is defined according to the polarising method for each element and is effectively the phasor relationship between the fault current and the polarising voltage.

A forward fault is one where the fault angle is within ± 90° of the Characteristic Angle(8).

For any given fault, the actual fault angle will be determined by network characteristics such as line resistance and reactance as well as fault characteristics such as the nature of the short circuit, solid or arcing etc.

It is not necessary that the fault angle matches the Characteristic Angle precisely. There are only two possibilities for direction, forward and reverse. As long as the fault angle is at the Characteristic Angle +/- 90° it will be recognized as a forward fault. Otherwise it is a reverse fault.

Each element takes 20 ms to determine the direction of a fault once it has been detected. This delay occurs prior to the fault detection timing and adds to the actual fault detect time.

The figure below demonstrates a Characteristic Angle of +45° with phasors representing possible fault angles on either side. Both of these fault angles represent forward faults as they are well within the forward fault region (135° to -45°)

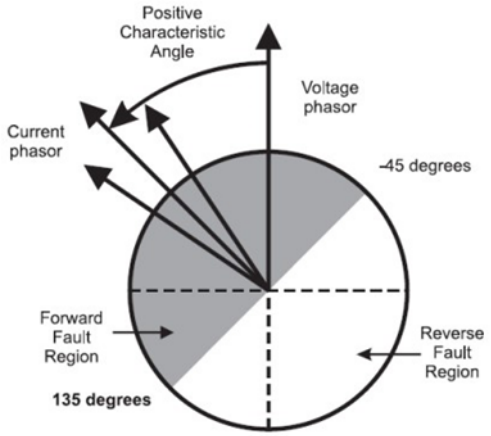



**Figure 207**
Directional Blocking Forward and Reverse Sectors

## Low V Block

In order to determine the direction of a fault that caused a pickup, the controller requires a Polarizing Voltage. If there is a bolted phase fault on the terminals of the switchgear there may not be sufficient voltage to determine the direction of the fault. Directional Blocking includes two settings per element to deal with low polarising voltage.

- Low Block
- Low Threshold

If the polarising voltage is below the Low Threshold setting for the faulted element, the Low Block setting will determine what action must be taken.

If Low Block is **Off**, the fault is assumed to be in the Fault Detection direction and fault detection will be armed.

(8) 90° is the default Sector Width setting and is configurable.

If Low Block is **On**, Polarising voltage below the Low Threshold setting will cause fault detection to be blocked.

## Sector Width

Each element will have either a **Forward Sector Width** setting if the Tripping Direction is Trip Forward, or a **Reverse Sector Width** setting if the Tripping Direction is Trip Reverse.

If the Fault Detection Direction is set for Forward and Reverse, Sector Width is meaningless and the setting is not displayed.

The **Forward Sector Width** setting is the angle that the deviation of the calculated fault angle from the Characteristic Angle needs to be equal to or less than to be deemed a forward fault.

The **Reverse Sector Width** setting is the angle that the deviation of the calculated fault angle from the Characteristic Angle plus 180° needs to be equal to or less than to be deemed a reverse fault.

## $V_{zps}$ Balance

ZPS Voltage ($V_{zps}$) is the polarising voltage for many of the polarising methods used by Directional Blocking.

Even in un-faulted networks the ZPS voltage is not likely to be zero because the three phase voltages are not going to be perfectly balanced.

This could lead to problems in high impedance fault conditions because the $V_{zps}$ due to an earth fault might be dominated by the $V_{zps}$ due to out of balance phase voltages, and this could lead to an incorrect determination of direction.

$V_{zps}$ Balancing is provided to overcome this by continuously balancing the phase voltages under normal conditions and compensating for imbalance between the three phase voltage measurements.

$V_{zps}$ Balance can be turned On in WSOS on the Directional Blocking page or on the operator interface.

When balancing is enabled, the zero sequence voltage is continually balanced at the rate of 0.6% of phase to earth voltage per second until zero $V_{zps}$ has been achieved.

Balancing is paused when any of the following conditions occur:

- Detection pickup
- The SCEM data is not valid
- The switchgear is open
- Any of the bushings are dead

$V_{zps}$ Balance status is displayed in WSOS under Controller Status on the Control page.

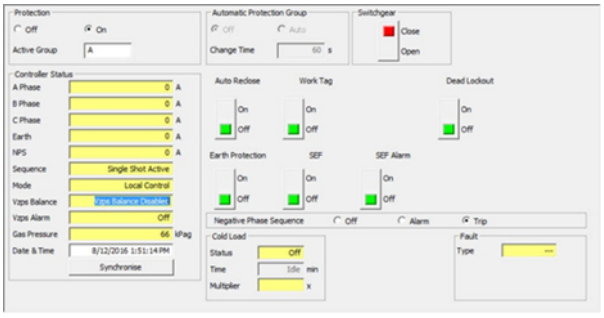



**Figure 208**
WSOS $V_{ZPS}$ Balance Status

When balancing is enabled the status displays **$V_{zps}$ Balancing** while the system is continually adjusting for balance, and **$V_{zps}$ Paused** when the balancing is suspended for one of the reasons above.

When balancing is disabled the display shows **$V_{zps}$ Balance Disabled**.

## High $V_{zps}$ Alarm

The Directional Blocking facility includes a High ZPS Voltage alarm.

This indication can be useful in unearthed neutral networks for earth fault detection.

The high $V_{zps}$ alarm is asserted whenever the Alarm Set-point is exceeded for the Alarm Timeout period. Regardless of whether SEF protection is picked up or not.

The alarm is cleared when $V_{zps}$ falls below the Alarm Set-point again.

The High $V_{zps}$ Alarm can be turned on and configured via WSOS on the Directional Blocking page.

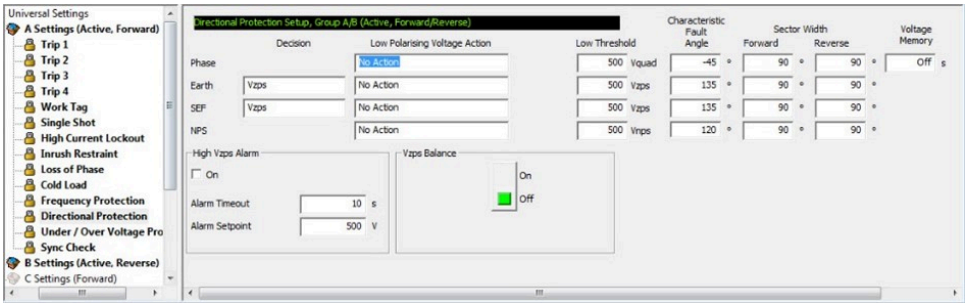



**Figure 209**
Directional Blocking High $V_{ZPS}$ Alarm

Or on the operator interface, page 703

The alarm status is displayed by WSOS on the Control page as well as on the operator interface.

The High $V_{ZPS}$ alarm is available for transmission by telemetry protocols.

# Phase Overcurrent Directional Blocking

The direction of a phase overcurrent fault can be determined by the phase relationship of the phase current to the phase voltage in the faulted phase(s).

The fault detection direction for phase faults may be:

- Forward Fault
- Reverse Fault
- Forward and Reverse Fault (that is non directional)

In order to minimize the effect of reduced voltage in faulted phases, phase detection uses quadrature voltage for polarization.

However the quadrature voltage angle is compensated by 90° to offset the inherent 90° phase shift. This gives a fault angle that relates to the phase angle between the phase current and the phase voltage.

## Example

Consider a single A phase fault where the A phase current lags the A phase – earth voltage by 45°,

The fault current would be IA and the polarising voltage would be the quadrature voltage $V_{B-C}$ + 90°

The fault angle would be ($V_{B-C}$ + 90°) ≥ $I_A$

Assuming balanced voltages and ABC rotation with A phase at 0°, $V_{B-C}$ would be at 270°

Compensated $V_{B-C}$ would be 360° or 0°.

Therefore the fault angle would be (360 ≥ -45) = 315° = - 45°.

## Phase Characteristic Fault Angle

The default Characteristic Angle is -45° for Phase faults. So an A phase fault where the current lagged the voltage by 45° would be a forward fault in the centre of the forward sector.

If Sectionaliser is set to Auto, the Angle at Fault reported in the Event Log would be -45°.

When this fault was cleared by an upstream ACR the Event Log will also record:

**Fault On**

- Forward Pickup Phase A
- Phase A Fault
- Phase Directional Armed

**ACR Tripped**

- Supply Interrupt
- Phase A Angle at Fault -45°

Phase fault currents and their associated quadrature voltages are shown in the table below.

| Fault Current | $I_A$ | $I_B$ | $I_C$ |
|---|---|---|---|
| Quadrature Voltage | $V_{B-C}$ | $V_{C-A}$ | $V_{A-B}$ |

## Phase Sector Width

The default Forward and Reverse Sector Width settings for phase protection are both 90°. These are ± settings and equate to actual sector widths of 180°.

> **NOTE:** The forward sector is centred on the Characteristic Angle and the reverse sector is centered on the Characteristic Angle –180°.

The likelihood of a fault angle causing an incorrect direction determination may be lessened by either increasing or decreasing the Sector Width setting. The range of these settings is 45° to 135° which equate to actual sector widths of 90° and 270° respectively.

## Phase Low Voltage Block

When the Phase Low Block setting is On, tripping is blocked if the polarising voltage is below the Low Threshold setting.

A phase fault with low polarising voltage will record the following events if Low Block is On:

- Pickup
- Phase Directional Low $V_{Blocked}$
- Polarizing Voltage Low $V_{QUAD}$

When the Phase Low Block setting is Off, the polarising voltage is disregarded and the action is entirely based on the calculated fault angle relative to the Phase Characteristic Fault Angle. So if the polarising voltage is below the Low Threshold setting, a protection trip will occur but no fault angle will be logged.

If the fault causes an upstream ACR to trip the Event Log will record:

**Fault On**

- Pickup
- Phase Fault
- Phase Directional Low $V_{Armed}$
- Polarizing Voltage Low $V_{QUAD}$

**ACR Tripped**

- Polarizing Voltage at the maximum $V_{QUAD}$

The default Phase Low Threshold setting is 500 $V_{QUAD}$ configurable over the range 150...15,000 $V_{QUAD}$.

## Phase Low Voltage Reset

Once the polarising voltage for phase faults has been deemed to be Low, it will not return to Normal until either the fault resets or the measured polarising voltage exceeds the Low Threshold setting by 10%. So if the Low Threshold setting is 500 $V_{QUAD}$ and a Low Voltage condition exists, $V_{QUAD}$ will have to rise to 550 $V_{QUAD}$ before the Low V condition is cancelled.

## Phase Voltage Memory

Three phase faults are the most likely to cause a low voltage condition. In this case a memorized voltage can be used for polarization.

Voltage Memory is Off by default so if this feature is required to be used it must be enabled and configured for a time period between 0.01 s and 10.00 s.

When Voltage Memory is enabled, the controller maintains a memory of the polarising voltage $V_{QUAD}$ updated every 4 ms. If a 3 phase fault causes all three phase voltages to drop sharply, the last value of $V_{QUAD}$ sampled before it fell below the Low Threshold setting is frozen in memory. That value is maintained in memory and used for polarization for the configured Voltage Memory time.

When a memorized voltage has been used for polarization, the values are identified in the Event Log by an asterisk '*'. For example,

- Angle at Fault* -45°

After the Voltage Memory time expires, the memorized polarising voltage is set to zero.

However if the controller is in pickup when the Voltage Memory time expires, the direction that was determined using the memorized voltage will be maintained as long as the pickup is active.

If a pickup occurs after the memorized polarising voltage has been set to zero, the Low V Block action will be used.

# EF Directional Blocking

The fault detection direction for EFs may be:

- Forward Fault
- Reverse Fault
- Forward and Reverse Fault (that is non directional)

When EF Directional Blocking is used, one of three methods can be used to determine the direction of an EF.

- $V_{ZPS}$
- Wattmetric
- Ir Cos (Ø)

$V_{ZPS}$ is the default option. The **Decision** setting determines the method used. Operating Quantities, Fault Angles, and default Characteristic Angles for each method are shown in the table below.

**Table 79 Directional Blocking EF Polarizing Methods**

| Polarizing Method (Decision) | Operating Quantity | Fault Angle | Angle logged on Trip | Default Characteristic Angle |
|---|---|---|---|---|
| $V_{ZPS}$ | Earth Current Ir ($I_{ZPS}$x3) | $V_{ZPS} \rightarrow I_{ZPS}$ | $V_{ZPS} \rightarrow I_{ZPS}$ | 135° Configurable |
| Wattmetric | Residual Power<br>($V_{ZPS}$x3) x ($I_{ZPS}$x3) x Cos (FA) | $V_{ZPS} \rightarrow I_{ZPS}$ | ($V_{ZPS} \rightarrow I_{ZPS}$) – CA (180°) | 180° Fixed |
| Ir Cos (Ø) | Active Earth Current<br>($I_{ZPS}$x3) x Cos (FA) | $V_{ZPS} \rightarrow I_{ZPS}$ | $-V_{ZPS} \rightarrow I_{ZPS}$ – CA (180°) | 180° Fixed |

## Earth $V_{ZPS}$ Polarising

With $V_{ZPS}$ polarization, the operating quantity is earth current (3 x $I_{ZPS}$) and the fault angle is the zero sequence current angle with respect to the zero sequence voltage angle ($V_{ZPS} \rightarrow I_{ZPS}$).

For demonstration purposes, the figure below substitute's residual current and voltage for zero sequence current and voltage. Although they have different magnitudes, the angles are the same.

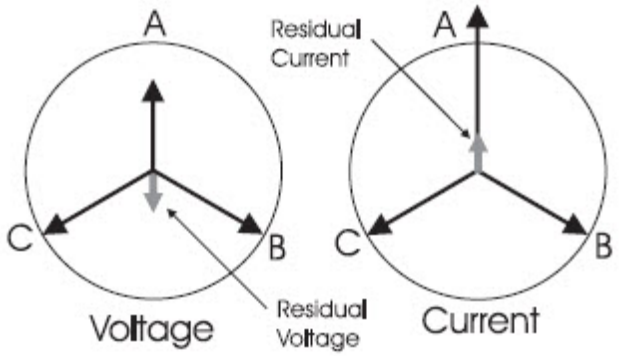



**Figure 210**
EF Current and Voltage Phasors

This figure shows phasor diagrams for voltage and current during a hypothetical resistive A phase to EF on an earthed neutral system.

The fault causes A phase voltage to reduce and the residual voltage phasor is 180° out of phase as shown. The current in A phase is increased and the residual current phasor is in phase with A phase current.

The fault angle for this fault is 180° that is the residual current is 180° out of phase with the residual voltage

The actual fault angle for an EF is determined by the network characteristics (line resistance and reactance, neutral earthing arrangement) and the fault characteristic (such as the nature of the short-circuit – solid or arcing, fault impedance and earth resistance).

## Earth $V_{ZPS}$ Characteristic Fault Angle

The Characteristic Angle setting for Earth $V_{ZPS}$ polarising is configurable between -179° and 180°.

A typical Characteristic Angle for systems with solidly or impedance earthed transformer neutrals would be approximately +135°.

The default Characteristic Angle +135° is for Earth Directional Blocking with $V_{ZPS}$ polarization. So an A phase to EF where the residual current led the residual voltage by 135° would be a forward fault in the centre of the forward sector.

For this fault the Event Log would record:

- Forward Pickup Earth
- Earth Directional Armed
- EF
- Earth Angle at Fault 135°

### Earth $V_{ZPS}$ Sector Width

The default Forward and Reverse Sector Width settings for earth protection are both 90°. These are ± settings and equate to actual sector widths of 180°.

> **NOTE:** The forward sector is centred on the Characteristic Angle and the reverse sector is centred on the Characteristic Angle - 180°.

The likelihood of a fault angle causing an incorrect direction determination may be lessened by either increasing or decreasing the Sector Width setting. The range of these settings is 45° to 135° which equate to actual sector widths of 90° and 270° respectively.

### Earth $V_{ZPS}$ Low Voltage Block

When the Earth Low Block setting is **On**, tripping is blocked if the polarising voltage is below the Low Threshold setting.

In this case the Event Log will record the following events:

- Pickup Earth
- Earth Directional Low $V_{Blocked}$
- Polarizing Voltage Low $V_{ZPS}$

When the Low Block setting is **Off**, the polarising voltage is disregarded and the action is entirely based on the calculated fault angle in relative to the Earth Characteristic Fault Angle. So if the polarising voltage is below the Earth Low Threshold setting, a protection trip will occur but no fault angle will be logged.

In this case the Event Log will record:

- Pickup Earth
- Earth Directional Low $V_{Armed}$
- Polarising Voltage Low $V_{ZPS}$
- EF
- Earth Low $V_{ZPS}$

The default Earth Low Threshold setting is 500 $V_{ZPS}$ configurable over the range 150...15,000 $V_{ZPS}$.

### Earth $V_{ZPS}$ Low Voltage Reset

Once the polarising voltage has been deemed to be Low, it will not return to Normal until either the fault resets or the measured polarising voltage exceeds the Low Threshold setting by 10%. So if the Low Threshold setting is 500 $V_{ZPS}$ and a Low Voltage condition exists, $V_{ZPS}$ will have to rise to 550 $V_{ZPS}$ before the Low V condition is cancelled.

## Earth Wattmetric Polarizing

Wattmetric is the method normally recommended to be used with a compensated or resistance earthed system. The Wattmetric method for EF detection may be

applied in all types of distribution systems having low earth-fault values. This includes isolated-neutral high-impedance earthed and compensated systems.

The Wattmetric value is in Watts and is defined as the in-phase residual power given by:

$$\text{Residual Power} = \text{Residual Voltage x Residual Current x Cos } (Ø)$$
$$= (V_{ZPS} \text{ x } 3) \text{ x } (I_{ZPS} \text{ x } 3) \text{ x Cos } (Ø)$$

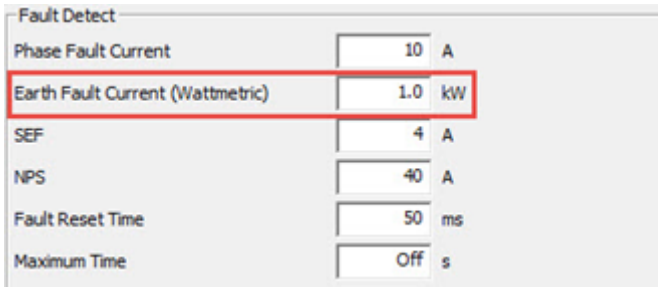
Where Ø is the Fault Angle that is the angle between $V_{ZPS}$ and $I_{ZPS}$.

$V_{ZPS}$ is the polarising voltage.

When Wattmetric is selected as the Earth Directional Blocking Decision WSOS displays this message:




This is because the EF Detect setting is now in kW as shown.




The Wattmetric Earth pickup threshold is 1.0 kW by default and can be set between 0.1 kW and 500.0 kW.

## Earth Wattmetric Characteristic Fault Angle

When a forward EF occurs on a compensated earthing system, $V_{ZPS}$ and $I_{ZPS}$ are assumed to be 180° out of phase.

Therefore the Characteristic Angle for Wattmetric is fixed at 180°.

> **NOTE:** When the directional EF decision is Wattmetric, the Characteristic Angle is fixed and **not displayed**.

The Wattmetric Fault Angle for a given fault is the Zero Sequence Current angle relative to the Zero Sequence Voltage angle $V_{ZPS} > I_{ZPS}$.

The **Angle at Fault** recorded in the Event Log is the fault angle relative to the Characteristic Angle which is fixed at 180°.

So a fault with a Fault Angle ($V_{ZPS} > I_{ZPS}$) = 135° would log an Angle at Trip of -45° (135°...180°) which indicates that the fault angle is lagging the Characteristic Angle by 45°.

When the EF Detection Direction is Forward Fault, and the above fault causes an upstream ACR to trip, the following events will be logged:

- **Fault On**
  - Forward Pickup Earth
  - Earth Directional Armed
  - EF

- **ACR Tripped**
  - Quantity at the maximum Earth/SEF – Maximum Wattmetric - xx.xx kW
  - Polarising Voltage at the maximum $V_{ZPS}$ xxxx Volt
  - Supply Interrupt
  - Earth Angle at Fault -45°

  **NOTE:** The sign of the residual power logged indicates the direction of the fault. A '-' indicates a forward fault and '+' indicates a reverse fault.

## Earth Wattmetric Sector Width

The default Forward and Reverse Sector Width settings for earth protection when the Decision is Wattmetric are both 90°. These are ± settings and equate to actual sector widths of 180°.

**NOTE:** The forward sector is centred on the Characteristic Angle $V_{ZPS} \rightarrow I_{ZPS}$ = 180° and the reverse sector is centred on $V_{ZPS} \rightarrow I_{ZPS}$ = 0°.

The likelihood of a fault angle causing an incorrect direction determination may be lessened by either increasing or decreasing the Sector Width setting. The range of these settings is 45° to 135° which equate to actual sector widths of 90° and 270° respectively.

## Earth Wattmetric Low Voltage Block

When the Earth Low Block setting is **On**, tripping is blocked if the polarising voltage is below the Low Threshold setting.

In this situation the ACR will still record fault resetting events when the apparent fault goes away the AS will record fault resetting events as shown:

**Fault On**

- Pickup Earth
- Earth Directional Low $V_{Blocked}$
- Polarising Voltage Low $V_{ZPS}$

**Fault Off**

- Quantity at the maximum Earth/SEF – Maximum Wattmetric - xx.xx kW
- Polarising Voltage at the maximum $V_{ZPS}$ xxxx Volt

When the Low Block setting is **Off**, the polarising voltage is disregarded and the action is entirely based on the calculated fault angle in relative to the Earth Characteristic Fault Angle. So if the polarising voltage is below the Earth Low Threshold setting, a protection trip will occur but no fault angle will be logged.

If this fault causes an upstream ACR to trip the Event Log will record the following events:

**Fault On**

- Pickup Earth
- Earth Directional Low $V_{Armed}$
- Polarising Voltage Low $V_{ZPS}$ xxxx Volt

**ACR Tripped**

- Quantity at the maximum Earth/SEF – Wattmetric - xx.xx kW
- Polarising Voltage at the maximum $V_{ZPS}$ xxxx Volt
- Supply Interrupt

The default Earth Low Threshold setting is 500 $V_{ZPS}$ configurable over the range 150...15,000 $V_{ZPS}$.

## Earth Wattmetric Voltage Memory

When Wattmetric is selected as the Decision for directional EFs, a Voltage Memory time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

Consider a reverse EF where $V_{ZPS}$ and $I_{ZPS}$ are in phase and $V_{ZPS}$ is above the Low Threshold setting.

If the EF Tripping Direction is Trip Reverse, and the Voltage Memory setting is 2.00 s, this fault will cause a reverse pickup and Earth Directional Armed will be logged.

If $V_{ZPS}$ then drops below the Low Threshold setting before the switchgear trips, this will not cause a Low V condition as the controller will continue to use the last sampled value of $V_{ZPS}$ that was above the threshold as the polarising voltage while the pickup is active.

If the fault persists long enough to cause a trip, the memorized voltage and corresponding fault angle recorded in the Event Log will be identified by an asterisk '*'.

If the fault reset was due to an upsteam ACR trip, the Event Log will report the following events:

**Fault On**

- Reverse Pickup Earth
- Earth Directional Armed

**Low $V_{ZPS}$**

- EF

**ACR Tripped**

- Quantity at trip maximum Earth/SEF Maximum Wattmetric xx.xx kW
- Polarising Voltage at the maximum $V_{ZPS}$ xxxx Volt
- Supply Interrupt
- EF Angle at Fault* 180°

  **NOTE:**

  - The Angle at Fault event above is identified as a memorized value because it was calculated using a memorized voltage.
  - The Polarising Voltage at the maximum is not a memorized value as $V_{ZPS}$ was above the Low Threshold setting when the fault first appeared.
  - Low $V_{ZPS}$ did not cause a *Polarising Voltage Low* event due to the effect of the Voltage Memory setting.

## Earth Wattmetric Fault Hold Time

When Wattmetric is selected as the Decision for directional EFs, a Fault Hold Time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

The effect of the Fault Hold Time is to pause the protection timing for a set period after a fault that caused a pickup has gone away.

When the fault hold time is 2.00 s, a forward EF with a tripping time of 3.0 s that goes away after 1.5 s for 1.0 s and then returns will cause a trip after another 1.5 s.

Because the hold time, that is the time that the fault went away for (1.0 s), is a shorter duration than the Fault Hold Time (2.0 s), the pickup will remain active while protection timing is paused and the tripping time will be extended by the Fault Hold Time setting.

The Event Log will record a Paused event to mark the start of the hold time.

The events recorded from pickup to after the upstream ACR trips with relevant time stamps would be:

| Event | Time Stamp |
|---|---|
| **Fault On** | |
| Forward Pickup Earth | 00:00:00.00 |
| Earth Directional Armed | 00:00:00.00 |
| All detection elements resetting | 00:00:01.50 |
| All detection elements paused | 00:00:01.50 |
| Detection element timing | 00:00:02.50 |
| EF | 00:00:04.00 |
| **ACR Tripped** | |
| Quantity at the maximum Earth/SEF Maximum Wattmetric -xx.xx kW | |
| Polarising Voltage at the maximum $V_{ZPS}$ xxxx Volt | |
| Supply Interrupt | |
| EF Angle at Fault - 45° | |

The fault was paused during the 1.0 s hold time so never reset. When the fault returned a Protection Element Timing event was logged.

**NOTE:** This was not a pickup as a pickup was already active.

The time between pickup and trip would be 4.0 s that is 3.0 s tripping time plus 1.0 s hold time.

## Earth Ir Cos (Ø) Polarising

The Ir Cos (Ø) operating characteristic is used in similar situations to Wattmetric. The operating value is defined as the active component of the residual current given by:

$$\text{Active Earth Current} = \text{Residual Current x Cos } (Ø)$$
$$= (I_{ZPS} \text{ x } 3) \text{ x Cos } (Ø)$$

Where Ø is the Fault Angle that is the angle between the $V_{ZPS}$ and $I_{ZPS}$ phasors.

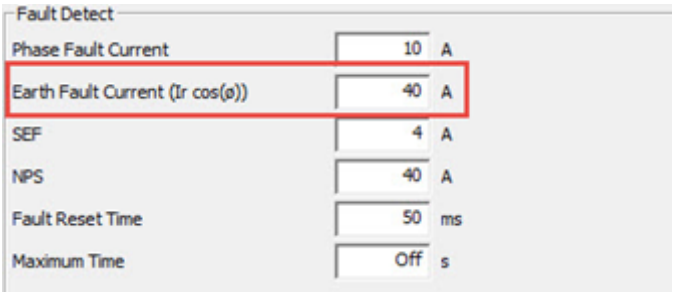
This feature works in a similar manner to Wattmetric with the following differences.

- The Active Current threshold is adjustable in the range 10 to 1260 A in steps of 1 A with a default value of 40 A.
- Ir Cos (Ø) is the value used to determine whether a fault is present, that is the pickup value.

When Ir cos (Ø) is selected as the polarising decision for directional EFs, WSOS displays this message:




This is because the Earth Pickup Threshold (Setting Current) is now set in Ir Cos (Ø) units as shown.




## Earth Ir Cos (Ø) Characteristic Fault Angle

When a forward EF occurs on a compensated earthing system, $V_{ZPS}$ and $I_{ZPS}$ are assumed to be 180° out of phase.

Therefore the Characteristic Angle for Ir Cos (Ø) is fixed at 180°.

**NOTE:** When the directional EF decision is Ir Cos (Ø), the Characteristic Angle is fixed and **not displayed**.

The Ir Cos (Ø) Fault Angle for a given fault is the Zero Sequence Current angle relative to the Zero Sequence Voltage angle $V_{ZPS} \rightarrow I_{ZPS}$

The Angle at Fault recorded in the Event Log is the fault angle relative to the Characteristic Angle which is fixed at 180°.

So a fault with a Fault Angle ($V_{ZPS} \rightarrow I_{ZPS}$) = 135° would log an Angle at Trip of -45° (135°...180°) which indicates that the fault angle is lagging the Characteristic Angle by 45°.

When the EF Detection Direction is Forward Fault and the above fault causes an upstream ACR to trip, the Event Log will record the following:

**Fault On**

- Forward Pickup Earth
- Earth Directional Armed
- EF

**ACR Tripped**

- Quantity at the maximum Earth/SEF – Maximum $I_R$ CosØ - xx.xx A
- Polarizing Voltage at the maximum $V_{ZPS}$
- Supply Interrupt
- Earth Angle at Fault -45°

**NOTE:** The sign of the active earth current logged indicates the direction of the fault. '-' indicates a forward fault and '+' indicates a reverse fault.

## Earth Ir Cos (Ø) Sector Width

The default Forward and Reverse Sector Width settings for earth protection when the Decision is Ir Cos (Ø) are both 90°. These are ± settings and equate to actual sector widths of 180°.

**NOTE:** The forward sector is centred on the Characteristic Angle $V_{ZPS} \rightarrow I_{ZPS}$ = 180° and the reverse sector is centred on $V_{ZPS} \rightarrow I_{ZPS}$ = 0°.

The likelihood of a fault angle causing an incorrect direction determination may be lessened by either increasing or decreasing the Sector Width setting.

The configurable range of these settings is 45° to 135° which equate to actual sector widths of 90° and 270° respectively.

## Earth Ir Cos (Ø) Low Voltage Block

When the Earth Low Block setting is **On**, fault detection is blocked if the polarising voltage is below the Low Threshold setting.

In this situation the upstream ACR must also block and not trip. When the apparent fault goes away the AS will record fault resetting events as shown

**Fault On**

- Pickup Earth
- Earth Directional Low V Blocked.
- Polarising Voltage Low $V_{ZPS}$

**Fault Off**

- Quantity at the maximum Earth/SEF – Maximum Ir Cos Ø xx.xx A
- Polarising Voltage at the maximum $V_{ZPS}$ xxxx Volt

When the Low Block setting is **Off**, the polarising voltage is disregarded and the action is entirely based on the calculated fault angle relative to the Earth Characteristic Fault Angle. So if the polarising voltage is below the Earth Low Threshold setting, a fault detection will occur but no fault angle will be logged.

In this situation the upstream ACR must trip and the Event Log will record:

**Fault On**

- Pickup Earth
- Earth Directional Low $V_{Armed}$
- Polarising Voltage Low $V_{ZPS}$ xxxx V
- EF

**ACR Tripped**

- Quantity at the maximum Earth/SEF Ir CosØ xx.xx kW
- Polarising Voltage at the maximum $V_{ZPS}$ xxxx V
- Supply Interrupt

The default Earth Low Threshold setting is 500 $V_{ZPS}$ configurable over the range 150...15,000 $V_{ZPS}$.

## Earth Ir Cos (Ø) Voltage Memory

When Ir Cos (Ø) is selected as the Decision for directional EFs, a Voltage Memory time between 0.01 s and 10.00 s or OFF can be configured.

The default setting is 2.00 s.

Consider a reverse EF where $V_{ZPS}$ and $I_{ZPS}$ are in phase and $V_{ZPS}$ is above the Low Threshold setting.

If the EF Tripping Direction is Trip Reverse, and the Voltage Memory setting is 2.00 s, this fault will cause a reverse pickup and Earth Directional Armed will be logged. If $V_{ZPS}$ then drops below the Low Threshold setting before the switchgear trips, this will not cause a Low V condition as the controller will continue to use the last sampled value of $V_{ZPS}$ that was above the threshold as the polarising voltage while the pickup is active.

If the pickup persists long enough it will cause a fault detection. The fault angle displayed in the Event Log after the upstream ACR trips will be identified by an asterisk '*' as a memorized value.

The Event Log will report the following events:

**Fault On**

- Reverse Pickup Earth
- Earth Directional Armed

**Low $V_{ZPS}$**

- EF

**ACR Tripped**

- Quantity at the maximum Earth/SEF Maximum Ir CosØ xx.xx A

- Polarising Voltage at the maximum $V_{ZPS}$ xxxx Volt
- Supply Interrupt
- EF Angle at Fault* 180

**NOTE:**

- The Angle at Fault event above is identified as a memorized value because it was calculated using a memorized voltage.
- The Polarising Voltage at the maximum is not a memorized value as $V_{ZPS}$ was above the Low Threshold setting when the fault first appeared.
- Low $V_{ZPS}$ did not cause a *Polarising Voltage Low* event due to the effect of the Voltage Memory setting.

## Earth Ir Cos (Ø) Fault Hold Time

When Ir Cos (Ø) is selected as the Decision for directional EFs, a Fault Hold Time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

The effect of the Fault Hold Time is to pause the protection timing for a set period after a fault that caused a pickup has gone away.

When the fault hold time is 2.00 s, a forward EF with a tripping time of 3.0 s that goes away after 1.5 s for 1.0 s and then returns will cause a trip after another 1.5 s. Because the hold time, that is the time that the fault went away for (1.0 s), is a shorter duration than the Fault Hold Time (2.0 s), the pickup will remain active while protection timing is paused and the tripping time will be extended by the Fault Hold Time setting.

The Event Log will record a Paused event during the hold time.

The events recorded from pickup through to when the upstream ACR tripped with relevant time stamps would be:

| Event | Time Stamp |
|---|---|
| **Fault On** | |
| Forward Pickup Earth | 00:00:00.00 |
| Earth Directional Armed | 00:00:00.00 |
| All protection elements resetting | 00:00:01.50 |
| All protection elements paused | 00:00:01.50 |
| Detection element timing | 00:00:02.50 |
| EF | 00:00:04.00 |
| **ACR Tripped** | |
| Quantity at the maximum Earth/SEF Maximum Ir Cos (Ø) -xx.xx A | |
| Polarising Voltage at the maximum $V_{ZPS}$ xxxx Volt | |
| Supply Interrupt | |
| EF Angle at Fault - 45° | |

The fault was paused during the 1.0 s hold time so never reset. When the fault returned a Protection Element Timing event was logged.

**NOTE:** this was not a pickup as a pickup was already active.

The time between pickup and trip would be 4.0 s that is 3.0 s tripping time plus 1.0 s hold time.

# SEF Directional Block

SEF Directional Blocking works the same way as EF and can use the same three methods to determine the direction of a SEF.

- $V_{ZPS}$
- Wattmetric
- Ir Cos (Ø)

$V_{ZPS}$ is the default option. The Decision setting determines the method used. Operating Quantities, Fault Angles, and default Characteristic Angles for each method are shown in the table below.

**Table 80 Directional Blocking SEF Polarizing Methods**

| Polarizing Method (Decision) | Operating Quantity | Fault Angle | Angle logged on Trip | Default Characteristic Angle |
|---|---|---|---|---|
| $V_{ZPS}$ | Earth Current (Ir) | $V_{ZPS} \rightarrow I_{ZPS}$ | $V_{ZPS} \rightarrow I_{ZPS}$ | 135° Configurable |
| Wattmetric | Residual Power<br>$V_{ZPS}$ x $I_{ZPS}$ x Cos (FA) | $V_{ZPS} \rightarrow I_{ZPS}$ | ($V_{ZPS} \rightarrow I_{ZPS}$) – CA (180°) | 180° Fixed |
| Ir Cos (Ø) | Active Earth Current<br>$I_{ZPS}$ x Cos (FA) | $V_{ZPS} \rightarrow I_{ZPS}$ | $-V_{ZPS} \rightarrow I_{ZPS}$ – CA (180°) | 180° Fixed |

Tripping direction options for SEFs regardless of the polarising method are:

- Trip Forward
- Trip Reverse
- Trip Forward and Reverse (that is non directional)

SEF has a default setting current of 4 A and can be configured for between 1 A and 80 A.

## SEF $V_{ZPS}$ Polarising

With $V_{ZPS}$ polarization, the fault angle is the zero sequence current angle with respect to the zero sequence voltage angle ($V_{ZPS} \rightarrow I_{ZPS}$).

For demonstration purposes, the figure below substitute's residual current and voltage for zero sequence current and voltage. Although they have different magnitudes, the angles are the same.

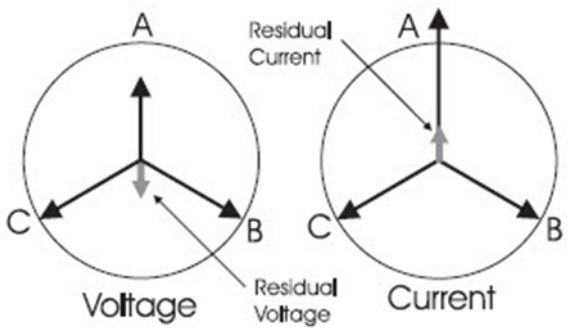



**Figure 211**
SEF Voltage and Current Phasors

This figure shows phasor diagrams for voltage and current during a hypothetical purely resistive A phase to earth fault on an earthed neutral system.

The fault causes A phase voltage to reduce and the residual voltage phasor is 180° out of phase as shown. The current in A phase is increased and the residual current phasor is in phase with A phase current.

The fault angle for this fault is 180° that is the residual current is 180° out of phase with the residual voltage.

The actual fault angle for an earth fault is determined by the network characteristics (line resistance and reactance, neutral earthing arrangement) and the fault characteristic (such as the nature of the short-circuit – solid or arcing, fault impedance and earth resistance).

## SEF $V_{ZPS}$ Characteristic Fault Angle

The Characteristic Angle setting for SEF $V_{ZPS}$ polarising is configurable between -179° and 180°.

A typical Characteristic Angle for systems with solidly or impedance earthed transformer neutrals would be approximately +135°.

+135° is the default Characteristic Angle for SEF Directional Blocking. So an A phase to earth fault where the residual current led the residual voltage by 135° would be a forward fault in the centre of the forward sector.

For this fault the Event Log would record:

- Forward Pickup SEF
- SEF Directional Armed
- SEF
- SEF at Fault 135°

## SEF $V_{ZPS}$ Sector Width

The default Forward and Reverse Sector Width settings for SEF protection are both 90°. These are ± settings and equate to actual sector widths of 180°.

> **NOTE:** The forward sector is centred on the Characteristic Angle and the reverse sector is centred on the Characteristic Angle - 180°.

The likelihood of a fault angle causing an incorrect direction determination may be lessened by either increasing or decreasing the Sector Width setting. The range of these settings is 45° to 135° which equate to actual sector widths of 90° and 270° respectively.

## SEF $V_{ZPS}$ Low Voltage Block

When the SEF Low Block setting is **On**, tripping is blocked if the polarising voltage is below the Low Threshold setting.

A SEF will low polarising voltage would record the following events:

- Pickup SEF
- SEF Directional Low $V_{Blocked}$
- Polarizing Voltage Low $V_{ZPS}$

When the Low Block setting is **Off**, the polarising voltage is disregarded and the action is entirely based on the calculated fault angle in relative to the SEF Characteristic Fault Angle. So if the polarising voltage is below the Earth Low Threshold setting, a protection trip will occur but no fault angle will be logged.

Instead the Event Log will record:

- Pickup SEF
- SEF Directional Low $V_{Armed}$
- Polarising Voltage Low $V_{ZPS}$
- SEF

- SEF Low $V_{ZPS}$

### SEF $V_{ZPS}$ Low Voltage Reset

Once the polarising voltage has been deemed to be Low, it will not return to Normal until either the fault resets or the measured polarising voltage exceeds the Low Threshold setting by 10%. So if the Low Threshold setting is 500 $V_{ZPS}$ and a Low Voltage condition exists, $V_{ZPS}$ will have to rise to 550 $V_{ZPS}$ before the Low V condition is cancelled.

## SEF Wattmetric Polarizing

The Wattmetric method for SEF detection may be applied in all types of distribution systems having low EF values. This includes isolated-neutral high-impedance earthed and compensated systems.

The Wattmetric value is in Watts and is defined as the in-phase residual power given by:

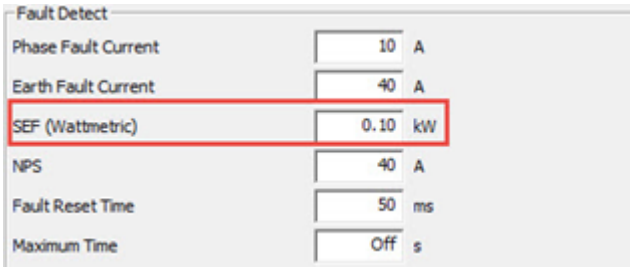
$$\text{Residual Power} = \text{Residual Voltage} \times \text{Residual Current} \times \cos(\text{Ø})$$
$$= (V_{ZPS} \times 3) \times (I_{ZPS} \times 3) \times \cos(\text{Ø})$$

Where Ø is the Fault Angle that is the angle between $V_{ZPS}$ and $I_{ZPS}$. $V_{ZPS}$ is the polarising voltage.

When Wattmetric is selected as the SEF Directional Blocking Decision WSOS displays this message:




This is because the SEF Pickup Threshold (Setting Current) is now in kilo Watts (kW) as shown.




The Wattmetric SEF pickup threshold can be set between 0.01 kw and 10.0 kW.

### SEF Wattmetric Characteristic Fault Angle

When a forward SEF occurs on a compensated earthing system, $V_{ZPS}$ and $I_{ZPS}$ are assumed to be 180° out of phase.

Therefore the Characteristic Angle for Wattmetric is fixed at 180°.

> **NOTE:** When the directional SEF decision is Wattmetric, the Characteristic Angle is fixed and **not displayed**.

The Wattmetric Fault Angle for a given fault is the Zero Sequence Current angle relative to the Zero Sequence Voltage angle $V_{ZPS} \rightarrow I_{ZPS}$.

The Angle at Fault recorded in the Event Log following a fault is the fault angle relative to the Characteristic Angle which is fixed at 180°.

So a fault with a Fault Angle ($V_{ZPS} \rightarrow I_{ZPS}$) = 135° would log an Angle at Trip of -45° (135°-180°). Which indicates that the Fault Angle is lagging the Characteristic Angle by 45°.

When the SEF Detection Direction is Forward Fault, the above fault that causes an upstream ACR to trip would log the following events:

**Fault On**

- Forward Pickup SEF
- SEF Directional Armed
- SEF

**ACR Tripped**

- Quantity at the maximum Earth/SEF – Maximum Wattmetric - xx.xx kW
- Polarising Voltage at the maximum $V_{ZPS}$ xxxx Volt
- Supply Interrupt
- SEF Angle at Fault -45°

**NOTE:** The sign of the residual power logged indicates the direction of the fault. '-' indicates a forward fault and '+' indicates a reverse fault.

## SEF Wattmetric Sector Width

The default Forward and Reverse Sector Width settings for SEF protection when the Decision is Wattmetric are both 90°. These are ± settings and equate to actual sector widths of 180°.

**NOTE:** The forward sector is centred on the Characteristic Angle $V_{ZPS} \rightarrow I_{ZPS}$ = 180° and the reverse sector is centred on $V_{ZPS} \rightarrow I_{ZPS}$ = 0°.

The likelihood of a fault angle causing an incorrect direction determination may be lessened by either increasing or decreasing the Sector Width setting.

The range of these settings is 45° to 135° which equate to actual sector widths of 90° and 270° respectively.

## SEF Wattmetric Low Voltage Block

When the SEF Low Block setting is On, tripping is blocked if the polarising voltage is below the Low Threshold setting.

In this situation the ACR will still record fault resetting events when the apparent fault goes away as shown:

**Fault On**

- Pickup SEF
- SEF Directional Low $V_{Blocked}$
- Polarizing Voltage Low $V_{ZPS}$

**Fault Off**

- Quantity at the maximum Earth/SEF – Maximum Wattmetric xx.xx kW
- Polarizing Voltage at the maximum $V_{ZPS}$ xxxx Volt

When the Low Block setting is **Off**, the polarising voltage is disregarded and the action is entirely based on the calculated fault angle relative to the Earth Characteristic Fault Angle. So if the polarising voltage is below the SEF Low Threshold setting, a fault detection will occur but no fault angle will be logged.

If the fault causes an upstream ACR to trip the Event Log will record:

**Fault On**

- Pickup SEF
- SEF Directional Low $V_{Armed}$
- Polarising Voltage Low $V_{ZPS}$ xxxx Volt

- SEF

**ACR Tripped**

- Quantity at the maximum Earth/SEF – Maximum Wattmetric - xx.xx kW
- Polarising Voltage at the maximum $V_{ZPS}$ xxxx Volt
- Supply Interrupt

The default SEF Low Threshold setting is 500 $V_{ZPS}$ configurable over the range 150...15,000 $V_{ZPS}$.

## SEF Wattmetric Voltage Memory

When Wattmetric is selected as the Decision for directional SEFs, a Voltage Memory time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

Consider a reverse SEF where $V_{ZPS}$ and $I_{ZPS}$ are in phase and $V_{ZPS}$ is above the SEF Low Threshold setting.

If the SEF Tripping Direction is Trip Reverse, and the SEF Voltage Memory setting is 2.00 s, this fault will cause a reverse pickup and SEF Directional Armed will be logged.

If $V_{ZPS}$ then drops below the SEF Low Threshold setting before the switchgear trips, this will not cause a Low V condition as the controller will continue to use the last sampled value of $V_{ZPS}$ that was above the threshold as the polarising voltage while the pickup is active.

If the fault persists long enough to cause a trip, the memorized voltage and corresponding fault angle will be identified by an asterisk '*'.

The Event Log will report the following events:

**Fault On**

- Reverse Pickup SEF
- SEF Directional Armed

**Low $V_{ZPS}$**

- SEF

**ACR Tripped**

- Quantity at the maximum Earth/SEF – Maximum Wattmetric xx.xx kW
- Polarising Voltage at the maximum $V_{ZPS}$ xxxx Volt
- Supply Interrupt
- SEF Angle at Fault* 180°

  **NOTE:**

  - The Angle at Fault event above is identified as a memorized value because it was calculated using a memorized voltage.
  - The Polarising Voltage at the maximum is not a memorized value as $V_{ZPS}$ was above the Low Threshold setting when the fault first appeared.
  - Low $V_{ZPS}$ did not cause a Polarising Voltage Low event due to the effect of the Voltage Memory setting.

## SEF Wattmetric Fault Hold Time

When Wattmetric is selected as the Decision for directional SEFs, a Fault Hold Time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

The effect of the Fault Hold Time is to pause the detection timing for a set period after a fault that caused a pickup has gone away.

When the fault hold time is 2.00 s, a forward SEF with a fault detect time of 3.0 s that goes away after 1.5 s for 1.0 s and then returns will cause a fault detection

after another 1.5 s. Because the hold time, i.e. the time that the fault went away for (1.0 s), is a shorter duration than the Fault Hold Time (2.0 s), the pickup will remain active while detection timing is paused and the fault detect time will be extended by the Fault Hold Time setting.

The Event Log will record a Paused event to mark the start of the hold time.

The events recorded from pickup through to an upstream ACR trip with relevant time stamps would be:

| Event | Time Stamp |
|---|---|
| **Fault On** | |
| Forward Pickup SEF | 00:00:00.00 |
| SEF Directional Armed | 00:00:00.00 |
| All detection elements resetting | 00:00:01.50 |
| All detection elements paused | 00:00:01.50 |
| Detection element timing | 00:00:02.50 |
| SEF | 00:00:04.00 |
| **ACR Tripped** | |
| Quantity at the maximum Earth/SEF Maximum Wattmetric - xx.xx kW | |
| Polarising Voltage at the maximum $V_{ZPS}$ xxxx Volt | |
| Supply Interrupt | |
| SEF Angle at Fault - 45° | |

The fault was paused during the 1.0 s hold time so never reset. When the fault returned a *Detection Element Timing* event was logged. Note that this was not a pickup as a pickup was already active.

The time between pickup and trip would be 4.0 s that is 3.0 s tripping time plus 1.0 s hold time.

## SEF Ir Cos (Ø) Polarising

The Ir Cos (Ø) operating characteristic is used in similar situations to Wattmetric.

The operating value is defined as the active current component of the zero sequence current with respect to the zero sequence voltage given by:

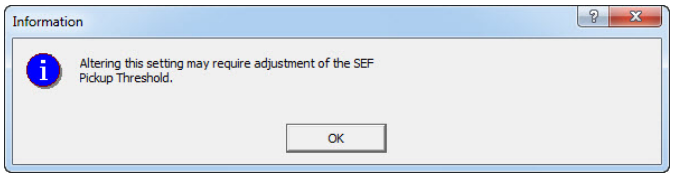
$$\text{Active Earth Current} = \text{Residual Current x Cos } (Ø)$$
$$= (I_{ZPS} \text{ x } 3) \text{ x Cos } (Ø)$$

Where Ø is the Fault Angle i.e. the angle between the $V_{zps}$ and $I_{zps}$ phasors.

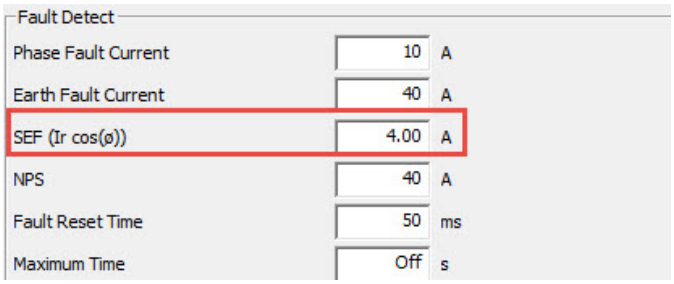
This feature works in a similar manner to Wattmetric with the following differences.

- The Active Current threshold is adjustable in the range 0.05 to 20 A in steps of 0.01 A with a default value of 4 A.
- Ir Cos (Ø) is the value used to determine whether a fault is present, i.e. the pickup value.

When Ir Cos (Ø) is selected as the polarising decision for directional SEFs, WSOS displays this message:




This is because the SEF Detect setting is now set in Ir Cos (Ø) units as shown.




## SEF Ir Cos (Ø) Characteristic Fault Angle

When a forward SEF occurs on a compensated earthing system, $V_{ZPS}$ and $I_{ZPS}$ are assumed to be 180° out of phase.

Therefore the Characteristic Angle for Ir Cos (Ø) is fixed at 180°.

> **NOTE:** When the directional SEF decision is Ir Cos (Ø), the Characteristic Angle is fixed and **not displayed**.

The Ir Cos (Ø) Fault Angle for a given fault is the Zero Sequence Current angle relative to the Zero Sequence Voltage angle $V_{ZPS} \rightarrow I_{ZPS}$.

The *Angle at Fault* recorded in the Event Log is the fault angle relative to the Characteristic Angle which is fixed at 180°.

So a fault with a Fault Angle ($V_{ZPS} \rightarrow I_{ZPS}$) = 135°.

would log an Angle at Trip of -45° (135°-180°) which indicates that the fault angle is lagging the Characteristic Angle by 45°.

When the SEF Tripping Direction is Trip Forward, the above fault which causes an upstream ACR to trip would log the following events:

**Fault On**

- Forward Pickup SEF
- SEF Directional Armed
- SEF

**ACR Tripped**

- Quantity at the maximum Earth/SEF – Maximum $I_R$CosØ - xx.xx A
- Polarising Voltage at the maximum $V_{ZPS}$ xxxx Volt
- Supply Interrupt
- SEF Angle at Fault -45°

> **NOTE:** The sign of the active earth current logged indicates the direction of the fault. '-' indicates a forward fault and '+' indicates a reverse fault.

## SEF Ir Cos (Ø) Sector Width

The default Forward and Reverse Sector Width settings for SEF protection when the Decision is Ir Cos (Ø) are both 90°. These are ± settings and equate to actual sector widths of 180°.

> **NOTE:** The forward sector is centred on the Characteristic Angle $V_{ZPS} \rightarrow I_{ZPS}$ = 180° and the reverse sector is centred on $V_{ZPS} \rightarrow I_{ZPS}$ = 0°.

The likelihood of a fault angle causing an incorrect direction determination may be lessened by either increasing or decreasing the Sector Width setting. The range of these settings is 45° to 135° which equate to actual sector widths of 90° and 270° respectively.

## SEF Ir Cos (Ø) Low Voltage Block

When the SEF Low Block setting is **On**, fault detection is blocked if the polarising voltage is below the Low Threshold setting.

In this situation the upstream ACR must also block and not trip. When the *apparent* fault goes away the AS will record fault resetting events as shown:

**Fault On**

- Pickup SEF.
- SEF Directional Low V Blocked.
- Polarising Voltage Low $V_{ZPS}$.

**ACR Tripped**

- Quantity at the maximum Earth/SEF – Maximum Ir CosØ xx.xx A
- Polarising Voltage at the maximum $V_{ZPS}$ xxxx Volt

When the Low Block setting is **Off**, the polarising voltage is disregarded and the action is entirely based on the calculated fault angle relative to the Earth Characteristic Fault Angle. So if the polarising voltage is below the SEF Low Threshold setting, a fault detection will occur but no fault angle will be logged.

In this situation an upstream ACR must trip and the AS Event Log will record:

**Fault On**

- Pickup SEF
- SEF Directional Low V Armed
- Polarising Voltage Low $V_{ZPS}$ xxxx Volt
- SEF

**ACR Tripped**

- Quantity at the maximum Earth/SEF Ir CosØ xx.xx kW
- Polarising Voltage at the maximum $V_{ZPS}$ xxxx Volt
- Supply Interrupt

The default SEF Low Threshold setting is 500 $V_{ZPS}$ configurable over the range 150 – 15 000 $V_{ZPS}$.

## SEF Ir Cos (Ø) Voltage Memory

When Ir Cos(Ø) is selected as the Decision for directional SEFs, a Voltage Memory time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

Consider a forward SEF at the characteristic angle with $V_{ZPS}$ above the SEF Low Threshold setting and an expected fault detect time of 3.5 s. If this fault is applied for 2.0 s and then $V_{ZPS}$ drops below the Low Threshold setting, the controller will retain the last $V_{ZPS}$ value that was sampled above the threshold for the Voltage Memory time.

This means that the low voltage condition is effectively ignored and the fault detection will still occur in the expected time of 3.5 s.

The fault angle logged after an upstream ACR trips will be identified by an asterisk '*'.

The Event Log will report the following events:

**Fault On**

- Forward Pickup SEF

**Low $V_{ZPS}$**

- Forward SEF

**ACR Tripped**

- Quantity at the maximum Earth/SEF – Maximum Ir Cos Ø xx.xx A
- Polarising Voltage at the maximum $V_{ZPS}$ xxxx Volt
- Supply Interrupt
- Earth Angle at Fault* 0°

**NOTE:**

- The Angle at Fault event above is identified as a memorized value.
- The Polarising Voltage at the maximum is not a memorized value as $V_{ZPS}$ was above the Low Threshold setting when the fault first appeared.
- Low $V_{ZPS}$ did not cause a Polarising Voltage Low event due to the effect of the Voltage Memory setting.

## SEF Ir Cos (Ø) Fault Hold Time

When Ir Cos (Ø) is selected as the Decision for directional SEFs, a Fault Hold Time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

The effect of the Fault Hold Time is to pause the detection timing for a set period after a fault that caused a pickup has gone away.

When the fault hold time is 2.00 s, a forward SEF with a fault detect time of 3.0 s that goes away after 1.5 s for 1.0 s and then returns will cause a fault detection after another 1.5 s.

Because the hold time, i.e. the time that the fault went away for (1.0 s), is a shorter duration than the Fault Hold Time (2.0 s), the pickup will remain active while detection timing is paused and the tripping time will be extended by the Fault Hold Time setting.

The Event Log will record a Paused event to mark the start of the hold time.

The events recorded from pickup through to an upstream ACR trip with relevant time stamps would be:

| Event | Time Stamp |
|---|---|
| **Fault On** | |
| Forward Pickup SEF | 00:00:00.00 |
| SEF Directional Armed | 00:00:00.00 |
| All detection elements resetting | 00:00:01.50 |
| All detection elements paused | 00:00:01.50 |
| Detection element timing | 00:00:02.50 |
| SEF | 00:00:04.00 |
| **ACR Tripped** | |
| Quantity at the maximum Earth/SEF Maximum Ir Cos (Ø) - xx.xx A | |
| Polarising Voltage at the maximum $V_{ZPS}$ xxxx Volt | |
| Supply Interrupt | |
| SEF Angle at Fault -45° | |

The fault was paused during the 1.0 s hold time so never reset. When the fault returned a Detection Element Timing event was logged.

**NOTE:** This was not a pickup as a pickup was already active.

The time between pickup and trip would be 4.0 s that is 3.0 s tripping time plus 1.0 s hold time.

# NPS Directional Blocking

**NOTE:** NPS protection is not available by default. Sequence Components must be made available before it can be used.

The direction of NPS overcurrent faults can be determined by their Fault Angle.

The Fault Angle is the relationship between the NPS current $I_{NPS}$ and the NPS voltage $V_{NPS}$. that is $V_{NPS} \rightarrow I_{NPS}$.

For example, $V_{NPS}$ = 60°, $I_{NPS}$ = 180°. Therefore NPS Fault Angle = 120°.

$V_{NPS}$ is used as the polarising voltage and a Low Block setting is used to determine the action taken when $V_{NPS}$ is below the Low Threshold setting.

The fault detection direction for NPS faults may be:

- Forward Fault
- Reverse Fault
- Forward and Reverse Fault (that is non directional)

Operational values for directional NPS are shown below:

| Polarizing Method | Fault Angle | Characteris-tic Fault Angle (default) | Low Threshold (default) | Range |
|---|---|---|---|---|
| $V_{NPS}$ | $V_{NPS} \rightarrow I_{NPS}$ | 120° | $V_{NPS}$= 500 V | Adjustable $V_{NPS}$ 300 to 2,000 V |

## NPS Characteristic Fault Angle

The Characteristic Fault Angle is the expected fault angle for a forward NPS overcurrent fault.

For NPS detection, the Characteristic Angle can be configured for a value between -179° and 180°.

The default Characteristic Angle for NPS faults is 120°. So an NPS fault where the NPS current $I_{NPS}$ leads the NPS voltage $V_{NPS}$ by 120° would be a forward fault in the centre of the forward sector.

When the Fault Detection Direction is Forward Fault and the Forward Sector Width is the default 90°, NPS faults with fault angles between 30° and 210° (-150°) would cause NPS Directional Detection to Arm and potentially lead to an NPS fault detection.

The Angle at Fault reported in the Event Log following an upstream ACR trip would be 120°.

The Event Log will also record:

**Fault On**

- Forward Pickup NPS
- NPS Directional Armed
- NPS fault

**ACR Tripped**

- Current at maximum NPS maximum xx A
- Polarising Voltage at the maximum $V_{nps}$ xxx Volt
- Supply Interrupt
- NPS Angle at Fault 120°

## NPS Sector Width

The default Forward and Reverse Sector Width settings for NPS protection are both 90°. These are ± settings and equate to actual sector widths of 180°.

**NOTE:** The forward sector is centred on the Characteristic Angle and the reverse sector is centred on the Characteristic Angle - 180°.

The likelihood of a fault angle causing an incorrect direction determination may be lessened by either increasing or decreasing the Sector Width setting.

The range of these settings is 45° to 135° which equate to actual sector widths of 90° and 270° respectively.

## NPS Low Voltage Block

When the NPS Low Block setting is On, fault detection is blocked if the polarising voltage is below the Low Threshold setting.

The Event Log will record the following events:

- Pickup NPS
- NPS Directional Low $V_{Blocked}$
- Polarising Voltage Low $V_{NPS}$ xxx Volt

When the Phase Low Block setting is Off, the polarising voltage is disregarded and the action is entirely based on the calculated fault angle relative to the NPS Characteristic Fault Angle. So if the polarising voltage is below the Low Threshold setting, a fault detection will occur but no fault angle will be logged when the upstream ACR trips.

The Event Log will record:

**Fault On**

- Pickup NPS
- NPS Directional Low $V_{Armed}$
- Polarising Voltage Low $V_{NPS}$ xxx Volt
- NPS fault

**ACR Tripped**

- Current at maximum NPS maximum xx A
- Polarising Voltage at the maximum $V_{nps}$ xxx Volt
- Supply Interrupt

The default Phase Low Threshold setting is 500 $V_{QUAD}$ configurable over the range 150...15,000 $V_{QUAD}$.

## NPS Low Voltage Reset

Once the polarising voltage for NPS faults has been deemed to be Low, it will not return to Normal until either the fault resets or the measured polarising voltage exceeds the Low Threshold setting by 10%. So if the Low Threshold setting is 500 $V_{NPS}$ and a Low Voltage condition exists, $V_{NPS}$ will have to rise to 550 $V_{NPS}$ before the Low V condition is cancelled.

**Table 81 Directional Blocking Settings/Specifications for AS**

| **Directional Protection Settings/Specifications** | |
|---|---|
| System Phase/Earth Nominal Voltage for correct operation | 2...25 kV |
| **Phase Directional Protection** | |
| Phase Characteristic Angle setting range | ± 180 ° |
| Phase Characteristic Angle setting resolution | 1 ° |
| Phase Characteristic Angle accuracy | ± 10 ° |
| Time to determine direction for phase faults | 20 ms |
| Minimum Quadrature Polarising Voltage for Phase Directional Protection to operate | 150 V |
| **Earth/SEF Directional Protection** | |

**Table 81 Directional Blocking Settings/Specifications for AS (Continued)**

| **Directional Protection Settings/Specifications** | |
|---|---|
| Earth/SEF Characteristic Angle setting range | ± 180 ° |
| Earth/SEF Characteristic Angle setting resolution | 1 ° |
| Characteristic Angle accuracy from 2...5 A earth current | ± 30 ° |
| Characteristic Angle accuracy from 5...20 A earth current | ± 20 ° |
| Characteristic Angle accuracy above 20 A earth current | ± 20 ° |
| Time to determine direction for Earth faults | 20 ms |
| Time to determine fault direction for SEF faults | 500 ms |
| Minimum Zero Sequence Polarising Voltage $V_{ZPS}$ for Earth<br>Directional Protection to operate | 15 V |
| Minimum Zero Sequence Polarising Voltage $V_{ZPS}$ for SEF<br>Directional Protection to operate | 15 V |
| Minimum SEF Definite time when Directional Protection is ON | 0.1 s |
| **NPS Directional Protection** | |
| NPS Characteristic Angle Setting range | ±180° |
| NPS Characteristic Angle Setting resolution | 1° |
| NPS Characteristic Angle Accuracy | ±10° |
| Time to determine fault direction for NPS faults | 20 ms |
| Minimum Negative Sequence Polarising Voltage $V_{NPS}$ for NPS Directional Protection to operate | 300 V |
| **Control** | |
| Low Polarising Voltage Action | No Action, Use Forward, Use Reverse |
| Forward Sector Width | 45°...135° |
| Reverse Sector Width | 45°...135° |
| Phase Low Threshold | 150...15,000 $V_{QUAD}$ |
| Phase Voltage Memory | Off,<br>0.01...10.00 s |
| Earth Decision | $V_{ZPS}$, Wattmetric, Ir Cos (Ø) |
| Earth Low Threshold | 15...15,000 $V_{ZPS}$ |
| Earth Wattmetric Characteristic Angle | 180° Fixed |
| Earth Ir Cos (Ø) Characteristic Angle | 180° Fixed |
| Earth Voltage Memory | Off<br>0.01...10.00 s |
| Earth Fault Hold Time | Off<br>0.01...10.00 s |
| SEF Decision | $V_{ZPS}$, Wattmetric,<br>Ir Cos (Ø) |
| SEF Low Threshold | 15...15,000 $V_{ZPS}$ |
| SEF Wattmetric Characteristic Angle | 180° Fixed |
| SEF Ir Cos (Ø) Characteristic Angle | 180° Fixed |

**Table 81 Directional Blocking Settings/Specifications for AS (Continued)**

| **Directional Protection Settings/Specifications** | |
|---|---|
| SEF Voltage Memory | Off<br>0.01...10.00 s |
| SEF Fault Hold Time | Off<br>0.01...10.00 s |
| NPS Low Threshold | 200...3000 $V_{NPS}$ |
| **$V_{ZPS}$ Balance** | |
| Residual Earth Voltage dynamic balance limit | 0 % |
| Residual Earth Voltage dynamic balance rate | 0.6% per second |
| | |
| High $V_{ZPS}$ Alarm Timeout | 1...180 s |
| High $V_{ZPS}$ Alarm Set point | 15...15,000 V |
| **Wattmetric and Ir Cos (Ø) Pickup Settings** | |
| Earth Wattmetric Pickup Setting | 0.1...500.0 kW |
| Earth Ir Cos (Ø) Pickup Setting | 10...1260 A |
| SEF Wattmetric Pickup Setting | 0.01...10.00 kW |
| SEF Ir Cos (Ø) Pickup Setting | 0.05...20.00 A |

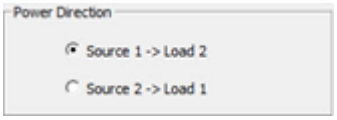
# Directional Detection

## Overview

ASs are sometimes installed in network configurations where power flow could be in either direction through the switchgear. Directional Detection can be used when the AS is required to coordinate with different fault detection or protection devices depending on which side of the switchgear the fault is detected that is whether the power flow during a fault is forward or reverse.

When power flows from Source to Load, the power flow is deemed to be forward. Reverse power flows from Load to Source.

The Source and Load sides of the switchgear are configurable through the Power Direction setting.




The Power Direction setting can be found on the WSOS Measurements page, page 148.

Or on the operator interface.

Directional Detection is an optional detection feature that uses separate detection groups to determine pickup thresholds and fault detection timing depending on which side of the switchgear the fault has been detected.

> **NOTE:** Because the direction of the fault needs to be determined before the correct detection settings can be applied, there is a minimum delay of approximately 20 ms that applies to all types of directional overcurrent detection that is Phase, Earth, SEF, and NPS.

When Directional Detection is On, there are always two detection groups active. One group is for forward faults and the other is for reverse faults. If the controller is configured for ten detection groups, five pairs will be available as shown in the table below.

**Table 82 Directional Detection Active Detection Group Pairs**

| Forward | Reverse |
|---|---|
| Group A | Group B |
| Group C | Group D |
| Group E | Group F |
| Group G | Group H |
| Group I | Group J |

Which pair becomes active when Directional Detection is turned On depends on which group was active at the time. If Group A was active, Groups A and B will become active. If Group D was active, Groups C and D will become active.

The active detection groups can be changed to another pair once Directional Detection is On.

WSOS will display a warning message to advise which detection groups will become active when Directional Detection is turned On.




Note that if an odd number of detection groups have been configured, not all will be available for Directional Detection for example, if five groups have been configured only two pairs (A+B and C+D) can be selected.

Directional Detection can only be turned on from the WSOS Feature Selection page. It can't be turned on from the Options pages on the ***set*VUE** O.I. or the Feature Selection pages on the ***flex*VUE** O.I.

## Directional Fault Detection

Directional fault detection operates in basically the same way as non-directional fault detection with a couple of differences:

- The real time measured/calculated current amplitudes are compared to the Fault Detect settings in the two active detection groups, forward and reverse.
- Once a pickup has been detected there is a 20 ms delay to determine if the group containing the threshold that was exceeded matches the direction of the fault. If it does then either a Forward Pickup or Reverse Pickup will be logged and fault detect timing will start.

## Directional Detection Configuration

When Directional Detection is On, the active detection groups have duplicate Directional Detection settings. Changing a setting in one group, either forward or reverse, automatically changes the same setting in the other group.

Some differences exist in the Global Settings for the two active groups. There are two settings that are common to both groups when Directional Detection is On.

- Live Load Blocking
- Sequence Reset Time

These settings are only displayed in the Global Settings for the forward detection group.

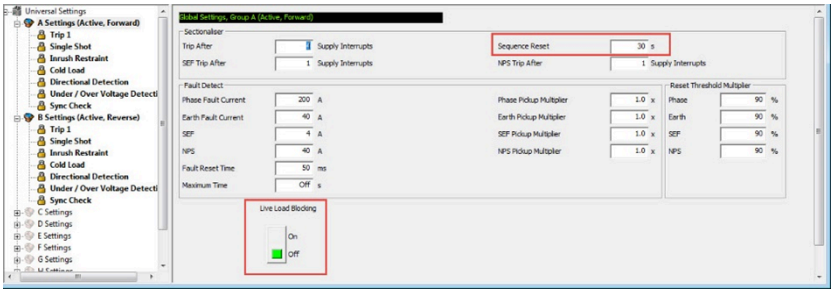



**Figure 212**
Directional Detection Global settings for the Forward Detection Group

## Sequence Reset Time

There is a single Sequence Reset Timer setting for both the forward and reverse detection groups. Whenever any of the Supply Interrupt counters is incremented, the sequence reset timer will start.

When the timer expires, both the forward and reverse sequence counters will be reset to zero.

If fault detection pickup occurs before the sequence reset timer has expired, the timer will be reset to zero and held there until the next supply interrupt occurs.

# Auto Sectionalise

When Directional Detection is on, there are two active detection groups.

Each group has its own Sectionaliser settings which can be configured differently as shown below.

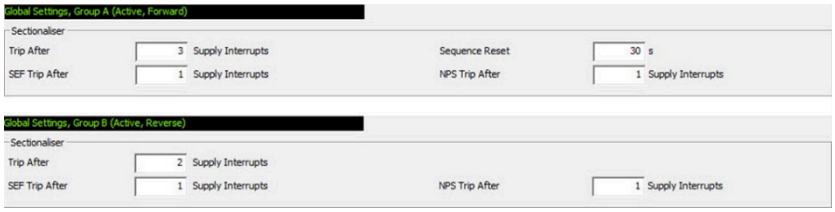



**Figure 213**
Forward and Reverse Sectionaliser settings

When the settings in the figure above are applied, a permanent forward phase fault will cause the AS to sectionalise after 3 supply interrupts. And a permanent reverse phase fault will cause the AS to sectionalise after 2 supply interrupts.

There are only three Supply Interrupt counters.

1. Global (Phase and EFs)
2. SEF
3. NPS

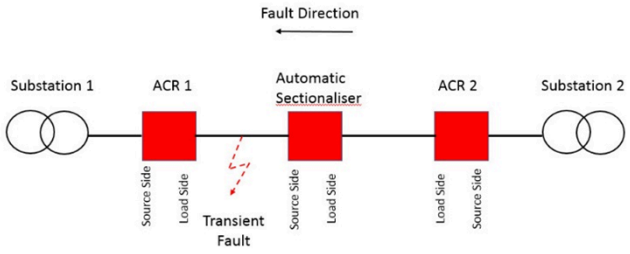
So if forward and reverse faults occur during the same sequence, each supply interrupt counter will count the total number of supply interrupts caused by that element regardless of direction.

This helps to ensure that the AS will sectionalise before ACR's on both sides go to lockout.

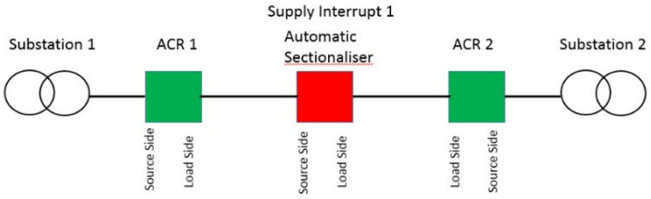
## Example

Consider the diagram below where ACR1 and ACR2 initially see a transient forward phase fault and have their forward phase trips to lockout set to 4 and 3 respectively.

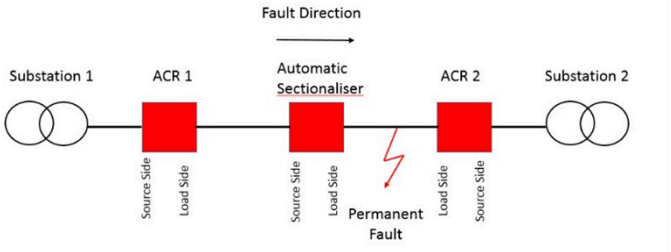
The AS has the supply interrupt settings for phase fault set to 3 forward and 2 reverse in order to coordinate with the ACR's.



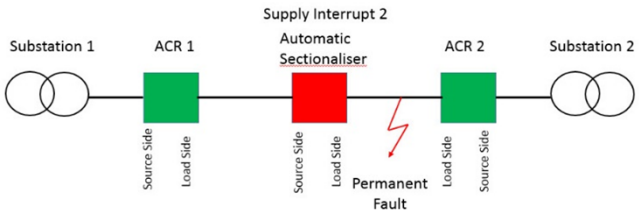

The transient fault will cause both ACR's to trip 1 which clears the fault. The AS will detect a reverse fault and log Supply Interrupt 1 when the ACR's trip.



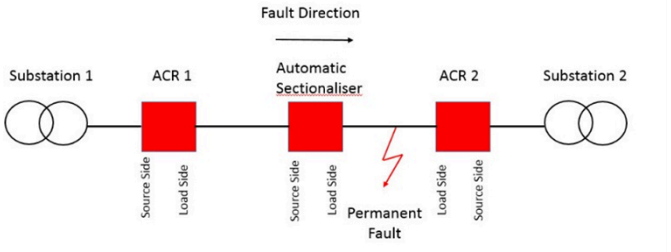

Both ACR's then reclose onto a permanent phase fault on the other side of the AS.



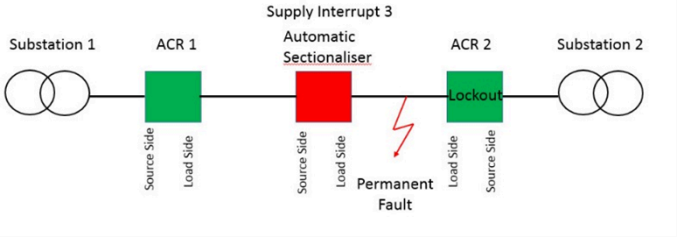

Both ACR's trip 2 because of the permanent fault. The AS will detect a forward fault and log Supply Interrupt 2.



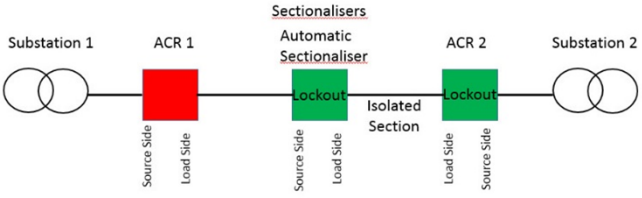

Both ACR's reclose again onto the permanent fault.




Both ACR's trip 3 and ACR2 goes to lockout. The AS detected a forward fault and logged Supply Interrupt 3.




The AS trips and goes to lockout and ACR1 recloses. The faulted section is isolated and supply restored to un-faulted sections of the feeder.




**NOTE:** The AS tripped after the second forward phase fault even though its forward Trip After x Supply Interrupt setting was 3.

This is because the accumulated forward and reverse supply interrupt count was 3 which matched the setting for the direction of the fault that is forward.

**NOTE:** There is only one Sectionaliser Auto/Off control, so it is not possible to configure the device to sectionalise on only forward or only reverse faults.

## Operation

Direction Detection is continuously monitoring the line voltage and current in order to determine the direction of power flow through the switchgear. It is also monitoring the Fault Detect thresholds for each configured element for each of the active detection groups.

When any Fault Detect setting in either of the active groups is exceeded, the power flow direction is checked to determine if the fault has occurred on the Source or Load side of the switchgear.

This direction determination takes 20 ms and no fault detect timing can start until it has been resolved.

If the fault is discovered to be on the Load side and a forward detection group Fault Detect setting has been exceeded, a Pickup Forward event is logged and the detection calculates the fault detect time according to the forward detection group settings for the faulted element. If the active detection groups are A and B, then Group A is used.

If the fault is discovered to be on the Source side and a reverse detection group Fault Detect setting has been exceeded, a Pickup Reverse event is logged and the detection calculates the fault detect time according to the reverse detection group settings. In this case, Group B.

## Determining Direction

The user must set a **Characteristic Fault Angle** for each element. The Characteristic Fault Angle is essentially a prediction of the expected fault angle when a forward fault occurs that is on the load side of the switchgear.

The fault angle is defined according to the polarising method for each element and is effectively the phasor relationship between the fault current and the polarising voltage.

A forward fault is one where the fault angle is within ± 90° of the Characteristic Angle by default.

Each element takes 20 ms to determine the direction of a fault once it has been detected. This delay occurs prior to the fault detect timing and adds to the actual fault detect time.

For any given fault, the actual fault angle will be determined by network characteristics such as line resistance and reactance as well as fault characteristics such as the nature of the short circuit, solid or arcing etc.

It is not necessary that the fault angle matches the Characteristic Angle precisely. There are only two possibilities for direction, forward and reverse. As long as the fault angle is at the Characteristic Angle ± 90° it will be recognized as a forward fault. Otherwise it is a reverse fault.

The figure below demonstrates a Characteristic Angle of +45° with phasors representing possible fault angles on either side. Both of these fault angles represent forward faults as they are well within the forward fault region (135° to -45°).

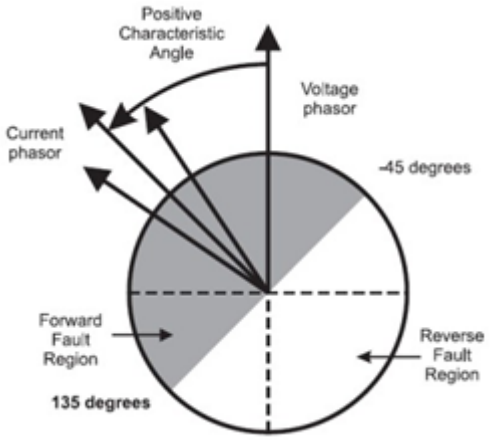



**Figure 214**
Directional Detection Forward and Reverse Sectors

## Low Polarising Voltage Action

In order to determine the direction of a fault that caused a pickup, the controller requires a Polarising Voltage. If there is a bolted phase fault on the terminals of the switchgear there may not be sufficient voltage to determine the direction of the fault.

Directional Protection includes two settings per element to deal with low polarising voltage.

- Low Polarising Voltage Action
- Low Threshold

If the polarising voltage is below the Low Threshold setting for the faulted element, the Low Polarising Voltage Action setting will determine what action must be taken.

The options are:

- Use Forward
- Use Reverse
- No Action (default setting)

**No Action** means that the Low Threshold setting determines if the fault detect must be considered valid.

The following points must be noted if the No Action option is being selected:

- An overcurrent fault will not cause a trip if the polarising voltage is below the Low Threshold setting and the No Action option is selected that is A low V condition will operate as an inhibit to a trip.
- A Pickup is still logged for an overcurrent fault when the polarising voltage is below the Low Threshold setting and the No Action option is selected.
- A Pickup that occurs when the polarising voltage is low and the No Action option is selected will only reset when the current has dropped below the reset threshold for the fault reset time.

## Sector Width

Directional Detection uses separate Sector Width settings for Forward and Reverse.

The likelihood of a fault angle causing an incorrect direction determination may be lessened by either increasing or decreasing one or both of the Sector Width settings.

Both settings are ± 90° by default and can be configured over a range of 45 to 135 which equate to actual sector widths of 90° and 270° respectively. However they cannot be configured to cause the sectors to overlap.

## Example

If say the Forward Sector Width is configured for 130°, the maximum setting available for the Reverse Sector Width is 50°.

The minimum setting is always 45° so the Forward and Reverse Sector Width settings can be configured such that not all fault angles will fall into either sector. If this happens, the detection will not pick up or time out. Instead if it happens for an A Phase fault for example, the Event Log will record the following events:

- Forward Out of Sector Phase A
- Reverse Out of Sector Phase A

**NOTE:** The forward sector is centred on the Characteristic Angle and the reverse sector is centred on the Characteristic Angle - 180°.

The **Forward Sector Width** setting is the angle that the deviation of the calculated fault angle from the Characteristic Angle needs to be equal to or less than to be deemed a forward fault.

The **Reverse Sector Width** setting is the angle that the deviation of the calculated fault angle from the Characteristic Angle plus 180° needs to be equal to or less than to be deemed a reverse fault.

# $V_{zps}$ Balancing

$V_{zps}$ is the polarising voltage for many of the polarising methods used by Directional Detection.

Even in un-faulted networks the zps voltage is not likely to be zero because the three phase voltages are not going to be perfectly balanced.

This could lead to problems in high impedance fault conditions because the $V_{zps}$ due to an EF might be dominated by the $V_{zps}$ due to out of balance phase voltages, and this could lead to an incorrect determination of direction.

$V_{zps}$ Balancing is provided to overcome this by continuously balancing the phase voltages under normal conditions and compensating for imbalance between the three phase voltage measurements.

$V_{zps}$ Balance can be turned **On** in WSOS on the Directional Detection page for each Detection Group.

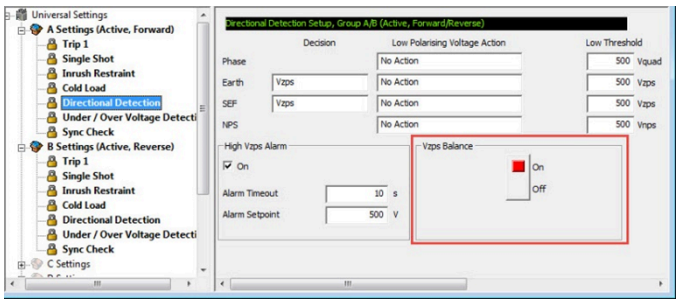



**Figure 215**
DIRD $V_{zps}$ Balance Control

It can also be turned on using the operator interface.

When balancing is enabled, the zero sequence voltage is continually balanced at the rate of 0.6% per second until zero $V_{zps}$ has been achieved.

Balancing is paused when any of the following conditions occur:

- Detection pickup
- The SCEM data is not valid

- The switchgear is open
- Any of the bushings are dead

$V_{zps}$ Balance status is displayed in WSOS under Controller Status on the Control page.

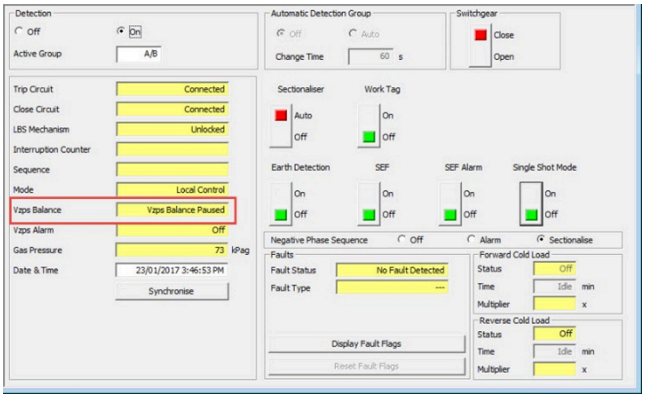



**Figure 216**
Directional Detection $V_{zps}$ Balance Status Display

## High $V_{zps}$ Alarm

The Directional Detection facility includes a High ZPS Voltage alarm.

This indication can be useful in unearthed neutral networks for EF detection.

The high $V_{zps}$ alarm is asserted whenever the Alarm Set-point is exceeded for the Alarm Timeout period, regardless of whether SEF detection is picked up or not.

The alarm is cleared when $V_{zps}$ falls below the Alarm Set-point again.

The High $V_{zps}$ Alarm can be turned on and configured via WSOS on the Directional Detection page.

The High $V_{zps}$ Alarm can be configured for each Detection Group.

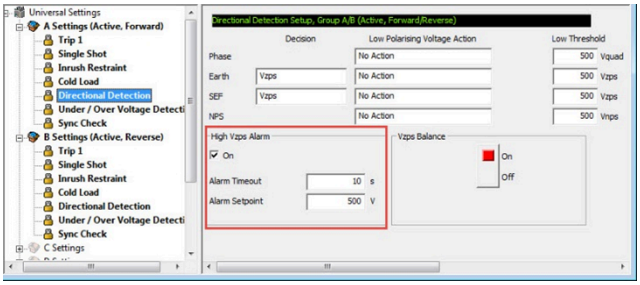



**Figure 218**
Directional Detection High $V_{ZPS}$ Alarm settings

# Phase Overcurrent Directional Detection

The direction of a phase overcurrent fault can be determined by the relationship between the phase current and phase voltage in the faulted phases.

In order to minimize the effect of reduced voltage in faulted phases, phase detection uses quadrature voltage for polarization.

However, the quadrature voltage angle is compensated by 90° to offset the inherent 90° phase shift. This gives a fault angle that relates to the phase angle between the phase current and the phase voltage.

**Example**

Consider a single A phase fault where the A phase current lags the A phase – earth voltage by 45°,

The fault current would be $I_A$ and the polarising voltage would be the quadrature voltage $V_{B-C}$ + 90°.

The fault angle would be ($V_{B-C}$ + 90°) → $I_A$

Assuming balanced voltages and ABC rotation with A phase at 0°, $V_{B-C}$ would be at 270°

Compensated $V_{B-C}$ would be 360° or 0°.

Therefore the fault angle would be (360 → -45) = 315° = - 45°.

## Phase Characteristic Fault Angle

The Characteristic Angle defines the forward and reverse fault regions for the network.

When a phase fault is detected, its fault angle is calculated and compared to the Phase Characteristic Angle to determine if the fault is forward or reverse.

If the fault angle is within ± 90°(9) of the Characteristic Angle the fault is forward, otherwise it's a reverse fault.

The Phase Characteristic Angle is configurable over the range -179° to 180°

-45° is the default Characteristic Angle for Phase faults. So an A phase fault where the fault current lagged the polarising voltage by 45° would be a forward fault in the centre of the forward sector. The Angle at Fault reported in the Event Log would be -45°.

When Detection Groups A and B are active, an A phase fault with a fault angle -45° that caused the upstream ACR to trip would log the following events:

**Fault On**

- Forward Pickup Phase A
- Detection Group A Active
- Forward Phase A Fault

**ACR Tripped**

- Polarising Voltage at the Maximum $V_{QUAD}$
- Supply Interrupt
- Phase A Angle at Fault -45°

The same fault on the opposite side of the AS switchgear would be a reverse fault with a fault angle of +135°. If that fault also caused an upstream ACR to trip the AS would log the following events:

**Fault On**

- Reverse Pickup Phase A
- Detection Group B Active
- Reverse Phase A Fault

**ACR Tripped**

- Polarising Voltage at the Maximum $V_{QUAD}$
- Supply Interrupt
- Phase A Angle at Fault 135°

Phase fault currents and their associated quadrature voltages are shown in the table below.

(9) Assumes default settings for Forward and Reverse Sector Widths that is 90°.

| | | | |
|---|---|---|---|
| Fault Current | $I_A$ | $I_B$ | $I_C$ |
| Quadrature Voltage | $V_{B-C}$ | $V_{C-A}$ | $V_{A-B}$ |

## Phase Sector Width

The default Forward and Reverse Sector Width settings for phase detection are both 90°. These are +/- settings and equate to actual sector widths of 180°.

Sector Width settings are identical for all elements and Decision settings. For more information, refer to Sector Width, page 253.

## Phase Low Polarising Voltage Action

In order to determine the direction of a phase fault that caused a pickup, the controller requires sufficient quadrature voltage, page 256 for each faulted phase.

If there is a bolted phase fault on the terminals of the switchgear there may not be sufficient polarising voltage for the controller to determine the direction of the fault.

Directional Phase Protection includes two settings that deal with low polarising voltage.

- Low Polarising Voltage Action
- Low Threshold

If the polarising voltage is below the Low Threshold setting for phase faults, the Low Polarising Voltage Action setting will determine what action must be taken.

The options are:

- Use Forward
- Use Reverse
- No Action (default setting)

More information on the No Action option can be found here.

The Phase Low Threshold setting can be configured for between 150 and 15000 $V_{QUAD}$. The default value is 500 $V_{QUAD}$.

When Use Forward or Use Reverse actions are selected, a fault with low polarising voltage will cause a fault detect as though it was a normal fault in the selected direction.

The only indication that the polarising voltage was low would be the Polarising Voltage Low $V_{QUAD}$ event which would record a value lower than the Phase Low Threshold setting.

When No Action is selected, a fault with low polarising voltage will cause a pickup followed by a *Polarising Voltage Low* $V_{QUAD}$event reporting the low value of polarising voltage. It will not cause a fault detection. The pickup condition will remain active until the fault resets.

## Phase Low Voltage Reset

Once the polarising voltage for phase faults has been deemed to be Low, it will not return to Normal until either the fault resets or the measured polarising voltage exceeds the Low Threshold setting by 10%. So if the Low Threshold setting is 500 $V_{QUAD}$ and a Low Voltage condition exists, $V_{QUAD}$ will have to rise to 550 $V_{QUAD}$ before the Low V condition is cancelled.

## Phase Voltage Memory

Three phase faults are the most likely to cause a low voltage condition. In this case a memorized voltage can be used for polarization.

Voltage Memory is Off by default so if this feature is required to be used it must be enabled and configured for a time period between 0.01 s and 10.00 s.

When Voltage Memory is enabled, the controller maintains a memory of the polarising voltage $V_{QUAD}$ updated every 4 ms. If a 3 phase fault causes all three phase voltages to drop sharply, the last value of $V_{QUAD}$ sampled before it fell below the Phase Low Threshold setting is frozen in memory. That value is maintained in memory and used for polarization for the configured Voltage Memory time.

When a memorized voltage has been used for polarization, the values can be identified in the Event Log by an asterisk '*'. For example,

- Angle at Fault* -45°

After the Voltage Memory time expires, the memorized polarising voltage is set to zero.

However if the controller is in pickup when the Voltage Memory time expires, the direction that was determined using the memorized voltage will be maintained as long as the pickup is active.

If a pickup occurs after the memorized polarising voltage has been set to zero, the Phase Low Polarising Voltage Action will be used.

# EF Directional Detection

When EF Directional Detection is enabled, it can use one of three methods to determine the direction of an EF.

- $V_{ZPS}$
- Wattmetric
- Ir Cos (Ø)

$V_{ZPS}$ is the default option. The Decision setting determines the method used.

Operating Quantities, Fault Angles and default Characteristic Angles for each method are shown in the table below.

**Table 83 Directional Detection EF Polarization Methods**

| Polarising Method (Decision) | Operating Quantity | Fault Angle | Angle logged on Trip | Default Characteristic Angle |
|---|---|---|---|---|
| $V_{ZPS}$ | Earth Current Ir ($I_{ZPS}$x3) | $V_{ZPS} \rightarrow I_{ZPS}$ | $V_{ZPS} \rightarrow I_{ZPS}$ | 135° Configurable |
| Wattmetric | Residual Power<br>($V_{ZPS}$x3) x ($I_{ZPS}$x3) x Cos (FA) | $V_{ZPS} \rightarrow I_{ZPS}$ | ($V_{ZPS} \rightarrow I_{ZPS}$) – CA (180°) | 180° Fixed |
| Ir Cos (Ø) | Active Earth Current<br>($I_{ZPS}$x3) x Cos (FA) | $V_{ZPS} \rightarrow I_{ZPS}$ | ($V_{ZPS} \rightarrow I_{ZPS}$) – CA (180°) | 180° Fixed |

## Earth $V_{ZPS}$ Polarizing

With $V_{ZPS}$ polarization, the operating quantity is earth current (3 x $I_{ZPS}$) and the fault angle is the zero sequence current angle with respect to the zero sequence voltage angle ($V_{ZPS} \rightarrow I_{ZPS}$).

For demonstration purposes, the figure below substitute's residual current and voltage for zero sequence current and voltage. Although they have different magnitudes, the angles are the same.

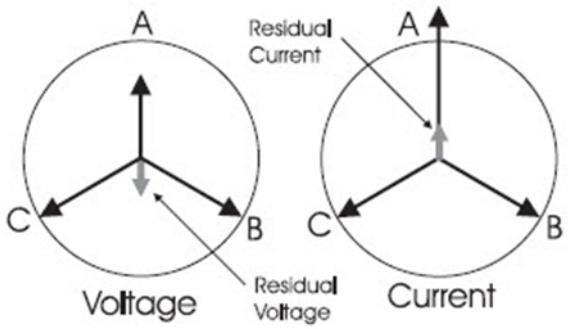



**Figure 218**
Earth Fault Voltage and Current Phasors

This figure shows phasor diagrams for voltage and current during a hypothetical purely resistive A phase to earth fault on an earthed neutral system.

The fault causes A phase voltage to reduce and the residual voltage phasor is 180° out of phase as shown.

The current in A phase is increased and the residual current phasor is in phase with A phase current.

The fault angle for this fault is 180° that is the residual current is 180° out of phase with the residual voltage.

The actual fault angle for an earth fault is determined by the network characteristics (line resistance and reactance, neutral earthing arrangement) and the fault characteristic (such as the nature of the short-circuit – solid or arcing, fault impedance and earth resistance).

## Earth $V_{ZPS}$ Characteristic Fault Angle

The default Characteristic Angle for Earth Directional Detectionis +135° . So an A phase to earth fault where the residual current led the residual voltage by 135° would be a forward fault in the centre of the forward sector.

The Characteristic Angle setting for Earth $V_{ZPS}$ polarising is configurable between -179° and 180°.

A typical Characteristic Angle for systems with solidly or impedance earthed transformer neutrals would be approximately +135°.

If this fault causes an upstream ACR to trip and Detection Groups A and B are active, the Event Log would record:

**Fault On**

- Forward Pickup Earth
- Detection Group A Active
- Forward Earth Fault

**ACR Tripped**

- Polarising Voltage at the maximum $V_{ZPS}$
- Supply Interrupt
- Earth Fault Angle at Fault 135°

The same fault in the opposite direction that caused its upstream ACR to trip would record:

**Fault On**

- Reverse Pickup Earth
- Protection Group B Active

- Reverse Earth Fault

**ACR Tripped**

- Polarising Voltage at the maximum $V_{ZPS}$
- Supply Interrupt
- Angle at Fault -45°

## Earth $V_{ZPS}$ Sector Width

The default Forward and Reverse Sector Width settings for earth protection are both 90°. These are ± settings and equate to actual sector widths of 180°.

Sector Width settings are identical for all elements and Decision settings. For more information, refer to Sector Width, page 253.

## Earth $V_{ZPS}$ Low Polarising Voltage Action

In order to determine the direction of an earth fault that caused a pickup when $V_{ZPS}$ polarization is used, the controller expects Zero Sequence Voltage to be above the Earth Low Threshold setting.

The Low Threshold is one of two settings that deal with low polarising voltages. The other is the Low Polarising Voltage Action.

If the polarising voltage is below the Low Threshold setting for earth faults, the Low Polarising Voltage Action setting will determine what action must be taken.

The options are:

- Use Forward
- Use Reverse
- No Action (default setting)

More information on the No Action option can be found here.

The Earth Low Threshold setting can be configured for between 15 and 15,000 V.

When Use Forward or Use Reverse actions are selected, a fault with low polarising voltage will cause a trip as though it was a normal fault in the selected direction. The only indication that the polarising voltage was low would be the Polarising Voltage at trip $V_{ZPS}$ event which would record a value lower than the Earth Low Threshold setting.

When No Action is selected, an earth fault with low polarising voltage will cause a pickup followed by a Polarising Voltage Low $V_{ZPS}$ event reporting the low value of polarising voltage. It will not cause a protection trip. The pickup condition will remain active until the fault resets.

## Earth $V_{ZPS}$ Low Voltage Reset

Once the polarising voltage has been deemed to be Low, it will not return to Normal until either the fault resets or the measured polarising voltage exceeds the Low Threshold setting by 10%. So if the Low Threshold setting is 500 $V_{ZPS}$ and a Low Voltage condition exists, $V_{ZPS}$ will have to rise to 550 $V_{ZPS}$ before the Low V condition is cancelled.

# Earth Wattmetric Polarising

Wattmetric is the method normally recommended to be used with a compensated or resistance earthed system. The Wattmetric method for EF protection may be applied in all types of distribution systems having low earth-fault values. This includes isolated-neutral high-impedance earthed and compensated systems.

The Wattmetric value is in Watts and is defined as the in-phase residual power given by:

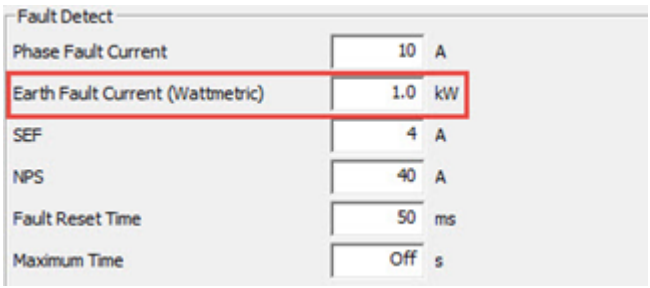
$$\text{Residual Power} = \text{Residual Voltage} \times \text{Residual Current} \times \text{Cos}(Ø)$$
$$= (V_{ZPS} \times 3) \times (I_{ZPS} \times 3) \times \text{Cos}(Ø)$$

Where Ø is the Fault Angle that is the angle between $V_{ZPS}$ and $I_{ZPS}$. $V_{ZPS}$ is the polarising voltage.

When Wattmetric is selected as the Earth Directional Protection Decision WSOS displays this message:




This is because the Earth Pickup Threshold (Setting Current) is now in kilo Watts (kW) as shown.




## Earth Wattmetric Characteristic Fault Angle

When a forward EF occurs on a compensated earthing system, $V_{ZPS}$ and $I_{ZPS}$ are assumed to be 180° out of phase.

Therefore the Characteristic Angle for Wattmetric is fixed at 180°.

> **NOTE:** When the directional EF decision is Wattmetric, the Characteristic Angle is fixed and **not displayed**.

The Wattmetric Fault Angle for a given fault is the Zero Sequence Current angle relative to the Zero Sequence Voltage angle $V_{ZPS} \rightarrow I_{ZPS}$

The Angle at Fault recorded in the Event Log following a fault is the fault angle relative to the Characteristic Angle which is fixed at 180°.

So a fault with a Fault Angle ($V_{ZPS} \rightarrow I_{ZPS}$) = 135° would log an Angle at Trip of -45° (135°...180°). Which indicates that the Fault Angle is lagging the Characteristic Angle by 45°.

A forward EF with a fault angle of 135° that tripped an upstream ACR will log the following events:

**Fault On**

- Forward Pickup Earth
- Protection Group A Active
- Forward EF

**ACR Tripped**

- Quantity at the maximum Earth/SEF – Maximum Wattmetric - xx.xx kW
- Polarising Voltage at the maximum $V_{ZPS}$
- Supply Interrupt
- EF Angle at Fault -45°

> **NOTE:** The sign of the residual power logged indicates the direction of the fault. '-' indicates a forward fault and '+' indicates a reverse fault.

## Earth $V_{ZPS}$ Sector Width

The default Forward and Reverse Sector Width settings for earth protection are both 90°. These are ± settings and equate to actual sector widths of 180°.

Sector Width settings are identical for all elements and Decision settings. For more information, refer to Sector Width, page 253.

## Earth Wattmetric Low Polarising Voltage Action

In order to determine the direction of an EF that caused a pickup when Wattmetric polarization is used, the controller requires Zero Sequence Voltage to be above the Earth Low Threshold setting.

The Earth Low Threshold is one of two settings that deal with low polarising voltages. The other is the Low Polarising Voltage Action.

If the polarising voltage is below the Low Threshold setting for EFs, the Low Polarising Voltage Action setting will determine what action must be taken.

The options are:

- Use Forward
- Use Reverse
- No Action (default setting)

More information on the No Action option can be found here.

The Earth Low Threshold setting can be configured for between 15 and 15 000 Volts. The default value is 500 $V_{ZPS}$.

When Use Forward or Use Reverse actions are selected, a fault with low polarising voltage will cause a fault detection as though it was a normal fault in the selected direction.

The only indication that the polarising voltage was low would be the Polarising Voltage Low $V_{ZPS}$ event which would record a value lower than the Earth Low Threshold setting.

When No Action is selected, an EF with low polarising voltage will cause a pickup followed by a Polarising Voltage Low $V_{ZPS}$ event reporting the low value of polarising voltage. It will not cause a fault detection. The pickup condition will remain active until the fault resets.

## Earth Wattmetric Low Voltage Reset

Once the polarising voltage for EFs has been deemed to be Low, it will not return to Normal until either the fault resets or the measured polarising voltage exceeds the Low Threshold setting by 10%. So if the Low Threshold setting is 500 $V_{ZPS}$ and a Low Voltage condition exists, $V_{ZPS}$ will have to rise to 550 $V_{ZPS}$ before the Low V condition is cancelled.

## Earth Wattmetric Voltage Memory

When Wattmetric is selected as the Decision for directional EFs, a Voltage Memory time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

Consider a reverse EF with $V_{ZPS}$ above the Earth Low Threshold setting and an expected fault detect time of 3.5 s.

If this fault is applied for 2.0 s and then $V_{ZPS}$ drops below the Low Threshold setting, the controller will retain the last $V_{ZPS}$ value that was sampled above the threshold for the Voltage Memory time.

This means that the low voltage condition is effectively ignored and the fault detection will still occur in the expected time of 3.5 s.

The memorized voltage and corresponding fault angle logged following the trip will be identified by an asterisk '*'.

If the fault causes an upstream ACR to trip the AS will log the following events:

**Fault On**

- Reverse Pickup Earth
- Detection Group B Active

**Low VZPS**

- Reverse EF

**ACR Tripped**

- Quantity at the maximum Earth/SEF – Maximum Wattmetric xxx kW
- Polarising Voltage at the maximum $V_{ZPS}$ xxx Volt
- Supply Interrupt
- Earth Angle at Fault* 180°

  **NOTE:**

  - The Angle at Fault event above is identified as a memorized value.
  - The Polarising Voltage at the maximum is not a memorized value as $V_{ZPS}$ was above the Low Threshold setting when the fault first appeared.
  - Low $V_{ZPS}$ did not cause a Polarising Voltage Low event due to the effect of the Voltage Memory setting.

## Earth Wattmetric Fault Hold Time

When Wattmetric is selected as the Decision for directional EFs, a Fault Hold Time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

The effect of the Fault Hold Time is to pause the detection timing for a set period after a fault that caused a pickup has gone away.

When the fault hold time is 2.00 s, a forward EF with a fault detect time of 3.0 s that goes away after 1.5 s for 1.0 s and then returns will cause a fault detection after another 1.5 s. Because the hold time, that is the time that the fault went away for (1.0 s), is a shorter duration than the Fault Hold Time (2.0 s), the pickup will remain active while detection timing is paused and the fault detection time will be extended by the Fault Hold Time setting.

The Event Log will record a Paused event to mark the start of the hold time.

The events recorded from pickup with relevant time stamps would be:

| **Event** | **Time Stamp** |
|---|---|
| Forward Pickup Earth | 00:00:00.00 |
| Polarising Voltage Low $V_{ZPS}$ xxx Volt | 00:00:00.00 |
| All detection elements resetting | 00:00:01.50 |
| All detection elements paused | 00:00:01.50 |
| Detection element timing | 00:00:02.50 |
| Forward EF | 00:00:04.00 |
| **ACR Tripped** | |
| Quantity at the maximum Earth/SEF – Maximum Wattmetric xxx kW | |
| Polarizing Voltage at the maximum trip $V_{ZPS}$ xxx Volt | |
| Supply Interrupt | |
| Earth Angle at Fault 0° | |

The pickup was paused during the 1.0 s hold time so never reset. When the fault returned a Detection Element Timing event was logged.

**NOTE:** This was not a pickup as a pickup was already active.

The time between pickup and trip would be 4.0 s that is 3.0 s tripping time plus 1.0 s hold time.

## Earth Ir Cos (Ø) Polarising

The Ir Cos (Ø) operating characteristic is used in similar situations to Wattmetric. The operating value is defined as the active component of the residual current given by:

$$\text{Active Earth Current} = \text{Residual Current x Cos } (Ø)$$
$$= (I_{ZPS} \text{ x } 3) \text{ x Cos } (Ø)$$

Where Ø is the Fault Angle that is the angle between the $V_{ZPS}$ and $I_{ZPS}$ phasors.

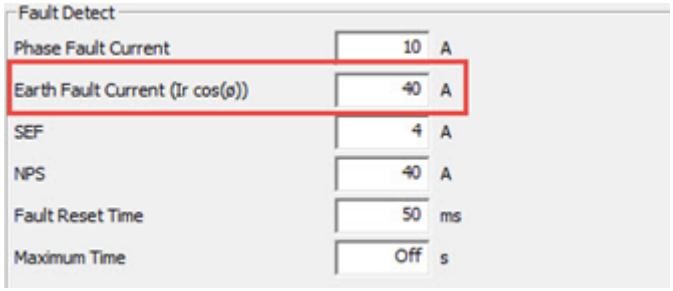
This feature works in a similar manner to Wattmetric with the following differences.

- The Active Current threshold is adjustable in the range 10 to 1260 A in steps of 1 A with a default value of 40 A.
- Ir Cos (Ø) is the value used to determine whether a fault is present, that is the pickup value.

When Ir Cos (Ø) is selected as the polarising decision for directional EFs, WSOS displays this message:




This is because the Earth Pickup Threshold (Setting Current) is now set in Ir Cos (Ø) units as shown.




## Earth Ir Cos (Ø) Characteristic Fault Angle

When a forward EF occurs on a compensated earthing system, $V_{ZPS}$ and $I_{ZPS}$ are assumed to be 180° out of phase.

Therefore the Characteristic Angle for Ir Cos (Ø) is fixed at 180°.

**NOTE:** When the directional EF decision is Ir Cos (Ø), the Characteristic Angle is fixed and **not displayed**.

The Ir Cos (Ø) Fault Angle for a given fault is the Zero Sequence Current angle relative to the Zero Sequence Voltage angle $V_{ZPS} \rightarrow I_{ZPS}$

The Angle at Fault recorded in the Event Log is the fault angle relative to the Characteristic Angle which is fixed at 180°.

So a fault with a Fault Angle ($V_{ZPS} \rightarrow I_{ZPS}$) = 135° would log an Angle at Fault of -45° (135°...180°) which indicates that the fault angle is lagging the Characteristic Angle by 45°.

A forward EF with a fault angle of 135° will log the following events:

**Fault On**

- Forward Pickup Earth
- Protection Group A Active
- Forward EF

**ACR Tripped**

- Quantity at the maximum Earth/SEF – Maximum $I_R$ Cos Ø - xx.xx A
- Polarising Voltage at the maximum $V_{ZPS}$ xxx Volt
- Supply Interrupt
- EF Angle at Fault -45°

  **NOTE:** The sign of the active earth current logged indicates the direction of the fault. '-' indicates a forward fault and '+' indicates a reverse fault.

## Earth Ir Cos (Ø) Sector Width

The default Forward and Reverse Sector Width settings for earth protection when the Decision is Ir Cos (Ø) are both 90°. These are ± settings and equate to actual sector widths of 180°.

**NOTE:** The forward sector is centred on the Characteristic Angle $V_{ZPS} \rightarrow I_{ZPS}$ = 180° and the reverse sector is centred on $V_{ZPS} \rightarrow I_{ZPS}$ = 0°.

The likelihood of a fault angle causing an incorrect direction determination may be lessened by either increasing or decreasing the Sector Width setting. The range of these settings is 45° to 135° which equate to actual sector widths of 90° and 270° respectively.

## Earth Ir Cos (Ø) Low Polarising Voltage Action

In order to determine the direction of an EF that caused a pickup when Ir Cos (Ø) polarization is used, the controller expects Zero Sequence Voltage to be above the Earth Low Threshold setting.

The Earth Low Threshold is one of two settings that deal with low polarising voltages. The other is the Low Polarising Voltage Action.

If the polarising voltage is below the Low Threshold setting for EFs, the Low Polarising Voltage Action setting will determine what action must be taken.

The options are:

- Use Forward
- Use Reverse
- No Action (default setting)

More information on the No Action option can be found here.

The Earth Low Threshold setting can be configured for between 15 and 15,000 V.

When Use Forward or Use Reverse actions are selected, a fault with low polarising voltage will cause a trip as though it was a normal fault in the selected direction. The only indication that the polarising voltage was low would be the Polarising Voltage at trip $V_{ZPS}$ event which would record a value lower than the Earth Low Threshold setting.

When No Action is selected, an EF with low polarising voltage will cause a pickup followed by a Polarising Voltage Low $V_{ZPS}$ event reporting the low value of polarising voltage. It will not cause a protection trip. The pickup condition will remain active until the fault resets.

## Earth Ir Cos (Ø) Low Voltage Reset

Once the polarising voltage for EFs has been deemed to be Low, it will not return to Normal until either the fault resets or the measured polarising voltage exceeds the Low Threshold setting by 10%. So if the Low Threshold setting is 500 $V_{ZPS}$ and a Low Voltage condition exists, $V_{ZPS}$ will have to rise to 550 $V_{ZPS}$ before the Low V condition is cancelled.

## Earth Ir Cos (Ø) Voltage Memory

When Ir Cos (Ø) is selected as the Decision for directional EFs, a Voltage Memory time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

Consider a forward EF at the Characteristic Angle with $V_{ZPS}$ above the Earth Low Threshold setting and an expected tripping time of 3.5 s. If this fault is applied for 2.0 s and then $V_{ZPS}$ drops below the Low Threshold setting, the controller will retain the last $V_{ZPS}$ value that was sampled above the threshold for the Voltage Memory time.

This means that the low voltage condition is effectively ignored and the protection trip will still occur in the expected tripping time of 3.5 s.

The memorized voltage and corresponding fault angle will be identified by an asterisk '*'.

The Event Log will report the following events:

**Fault On**

- Forward Pickup Earth

**Low VZPS**

- Forward EF

**ACR Tripped**

- Quantity at the maximum Earth/SEF – Maximum Ir Cos Ø –xxx A
- Polarising Voltage at the maximum $V_{ZPS}$ xxx Volt
- Supply Interrupt
- Earth Angle at Fault* 0°

  **NOTE:**

  - The Angle at Fault event above is identified as a memorized value.
  - The *Polarising Voltage at the maximum* is not a memorized value as $V_{ZPS}$ was above the Low Threshold setting when the fault first appeared.
  - Low $V_{ZPS}$ did not cause a *Polarising Voltage Low* event due to the effect of the Voltage Memory setting.

## Earth Ir Cos (Ø) Fault Hold Time

When Ir Cos (Ø) is selected as the Decision for directional EFs, a Fault Hold Time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

The effect of the Fault Hold Time is to pause the detection timing for a set period after a fault that caused a pickup has gone away.

When the fault hold time is 2.00 s, a forward EF with a fault detect time of 3.0 s that goes away after 1.5 s for 1.0 s and then returns will cause a fault detection 1.5 s later. Because the hold time, that is the time that the fault went away for (1.0 s), is a shorter duration than the Fault Hold Time (2.0 s), the pickup will remain active while detection timing is paused and the fault detection time will be extended by the Fault Hold Time setting.

The Event Log will record a Paused event to mark the start of the hold time.

The events recorded from pickup through to when the upstream ACR trips with relevant time stamps would be:

| Event | Time Stamp |
|---|---|
| **Fault On** | |
| Forward Pickup Earth | 00:00:00.00 |
| Polarising Voltage Low $V_{ZPS}$ xxx Volt | 00:00:01.50 |
| All detection elements resetting | 00:00:01.50 |
| All detection elements paused | 00:00:01.50 |
| Detection element timing | 00:00:02.50 |
| Forward EF | 00:00:04.00 |
| **ACR Tripped** | |
| Quantity at the maximum Earth/SEF Maximum Ir CosØ -xx.xx A | |
| Polarising Voltage at the maximum $V_{ZPS}$ xxxx Volt | |
| Supply Interrupt | |
| EF Angle at Fault 0° | |

The pickup was paused during the 1.0 s hold time so never reset. When the fault returned a Detection element timing event was logged.

**NOTE:** This was not a pickup as a pickup was already active.

The time between pickup and fault detection would be 4.0 s that is 3.0 s fault detect time plus 1.0 s hold time.

# SEF Directional Detection

When SEF Directional Detection is enabled, it can use one of three methods to determine the direction of a SEF.

- $V_{ZPS}$
- Wattmetric
- Ir Cos (Ø)

$V_{ZPS}$ is the default option. The Decision setting determines the method used. Operating Quantities, Fault Angles, and default Characteristic Angles for each method are shown in the table below.

**Table 84 Directional Detection SEF Polarization Methods**

| Polarising Method (Decision) | Operating Quantity | Fault Angle | Angle logged on Trip | Default Characteristic Angle |
|---|---|---|---|---|
| $V_{ZPS}$ | Earth Current (Ir) | $V_{ZPS} \rightarrow I_{ZPS}$ | $V_{ZPS} \rightarrow I_{ZPS}$ | 135° Configurable |
| Wattmetric | Residual Power<br>$V_{ZPS}$ x $I_{ZPS}$ x Cos (FA) | $V_{ZPS} \rightarrow I_{ZPS}$ | ($V_{ZPS} \rightarrow I_{ZPS}$) – CA (180°) | 180° Fixed |
| Ir Cos (Ø) | Active Earth Current<br>$I_{ZPS}$ x Cos (FA) | $V_{ZPS} \rightarrow I_{ZPS}$ | ($V_{ZPS} \rightarrow I_{ZPS}$) – CA (180°) | 180° Fixed |

## SEF $V_{ZPS}$ Polarising

With SEF $V_{ZPS}$ polarization, the fault angle is the zero sequence current angle with respect to the zero sequence voltage angle ($V_{ZPS} \rightarrow I_{ZPS}$).

For demonstration purposes, the figure below substitute's residual current and voltage for zero sequence current and voltage. Although they have different magnitudes, the angles are the same.

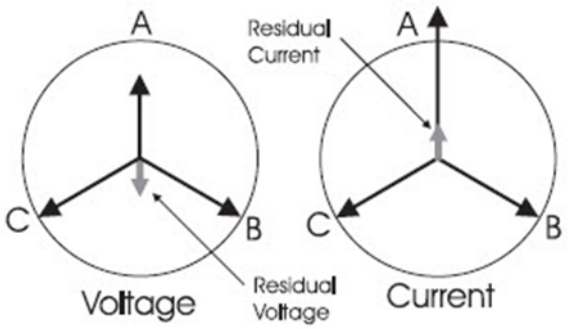



**Figure 219**
EF Voltage and Current Phasors

This figure shows phasor diagrams for voltage and current during a hypothetical purely resistive A phase to EF on an earthed neutral system.

The fault causes A phase voltage to reduce and the residual voltage phasor is 180° out of phase as shown. The current in A phase is increased and the residual current phasor is in phase with A phase current.

The fault angle for this fault is 180° that is the residual current is 180° out of phase with the residual voltage.

The actual fault angle for an EF is determined by the network characteristics (line resistance and reactance, neutral earthing arrangement) and the fault characteristic (such as the nature of the short-circuit – solid or arcing, fault impedance and earth resistance).

## SEF $V_{ZPS}$ Characteristic Fault Angle

The default Characteristic Angle for SEF Directional Protection is +135°. So an A phase to EF where the residual current led the residual voltage by 135° would be a forward fault in the centre of the forward sector.

The Characteristic Angle setting for SEF $V_{ZPS}$ polarising is configurable between -179° and 180°.

A typical Characteristic Angle for systems with solidly or impedance earthed transformer neutrals would be approximately +135°.

If this fault occurs when Protection Groups A and B are active the Event Log would record:

**Fault On**

- Forward Pickup SEF
- Detection Group A Active
- Forward SEF

**ACR Tripped**

- Polarising Voltage at the maximum $V_{ZPS}$
- Supply Interrupt
- EF Angle at Fault 135°

The same fault in the opposite direction would record:

**Fault On**

- Reverse Pickup SEF
- Protection Group B Active
- Reverse SEF

**ACR Tripped**

- Polarising Voltage at the maximum $V_{ZPS}$
- Supply Interrupt
- Angle at Fault -45°

## SEF $V_{ZPS}$ Sector Width

The default Forward and Reverse Sector Width settings for SEF protection are both 90°. These are ± settings and equate to actual sector widths of 180°.

Sector Width settings are identical for all elements and Decision settings. For more information, refer to Sector Width, page 253.

## SEF $V_{ZPS}$ Low Polarising Voltage Action

In order to determine the direction of a SEF that caused a pickup when VZPS polarization is used, the controller expects Zero Sequence Voltage to be above the SEF Low Threshold setting.

The Low Threshold is one of two settings that deal with low polarising voltages. The other is the Low Polarising Voltage Action.

If the polarising voltage is below the Low Threshold setting for SEFs, the Low Polarising Voltage Action setting will determine what action must be taken.

The options are:

- Use Forward
- Use Reverse
- No Action (default setting)

More information on the No Action option can be found here.

The SEF Low Threshold setting can be configured for between 15 and 15,000 $V_{ZPS}$. The default value is 500 $V_{ZPS}$.

When Use Forward or Use Reverse actions are selected, a fault with low polarising voltage will cause a trip as though it was a normal fault in the selected direction. The only indication that the polarising voltage was low would be the Polarising Voltage at trip $V_{ZPS}$ event which would record a value lower than the Earth Low Threshold setting.

When No Action is selected, a SEF with low polarising voltage will cause a pickup followed by a Polarising Voltage Low $V_{ZPS}$ event reporting the low value of polarising voltage. It will not cause a protection trip. The pickup condition will remain active until the fault resets.

## SEF $V_{ZPS}$ Low Voltage Reset

Once the polarising voltage has been deemed to be Low, it will not return to Normal until either the fault resets or the measured polarising voltage exceeds the Low Threshold setting by 10%. So if the Low Threshold setting is 500 $V_{ZPS}$ and a Low Voltage condition exists, $V_{ZPS}$ will have to rise to 550 $V_{ZPS}$ before the Low V condition is cancelled.

# SEF Wattmetric Polarizing

The Wattmetric method for SEF detection may be applied in all types of distribution systems having low EF values. This includes isolated-neutral high-impedance earthed and compensated systems.

The Wattmetric value is in Watts and is defined as the in-phase residual power given by:

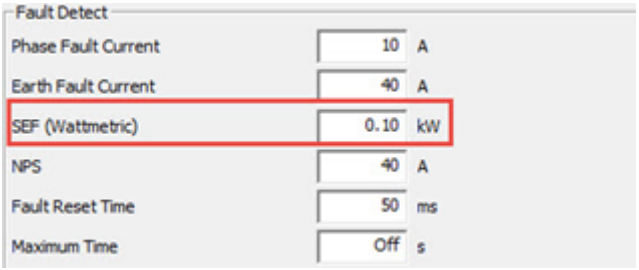
Residual Power = Residual Voltage x Residual Current x Cos (Ø)
= ($V_{ZPS}$ x 3) x ($I_{ZPS}$ x 3) x Cos (Ø)

Where Ø is the Fault Angle that is the angle between $V_{ZPS}$ and $I_{ZPS}$. $V_{ZPS}$ is the polarising voltage.

When Wattmetric is selected as the SEF Directional Blocking Decision WSOS displays this message:




This is because the SEF Pickup Threshold (Setting Current) is now in kilo Watts (kW) as shown.




## SEF Wattmetric Characteristic Fault Angle

When a forward SEF occurs on a compensated earthing system, $V_{ZPS}$ and $I_{ZPS}$ are assumed to be 180° out of phase.

Therefore the Characteristic Angle for Wattmetric is fixed at 180°.

**NOTE:** When the directional SEF decision is Wattmetric, the Characteristic Angle is fixed and **not displayed**.

The Wattmetric Fault Angle for a given fault is the Zero Sequence Current angle relative to the Zero Sequence Voltage angle $V_{ZPS} \rightarrow I_{ZPS}$.

The Angle at Fault recorded in the Event Log following a fault is the fault angle relative to the Characteristic Angle which is fixed at 180°.

So a fault with a Fault Angle ($V_{ZPS} \rightarrow I_{ZPS}$) = 135° would log an Angle at Trip of -45° (135°-180°). Which indicates that the Fault Angle is lagging the Characteristic Angle by 45°.

A forward EF with a fault angle of 135° that causes an upstream ACR to trip will log the following events:

**Fault On**

- Forward Pickup SEF
- Protection Group A Active
- Forward SEF

**ACR Tripped**

- Quantity at the maximum Earth/SEF – Maximum Wattmetric - xx.xx kW
- Polarising Voltage at the maximum $V_{ZPS}$
- Supply Interrupt
- EF Angle at Fault -45°

**NOTE:** The sign of the residual power logged indicates the direction of the fault. '-' indicates a forward fault and '+' indicates a reverse fault.

## SEF Wattmetric Sector Width

The default Forward and Reverse Sector Width settings for SEF protection are both 90°. These are ± settings and equate to actual sector widths of 180°.

Sector Width settings are identical for all elements and Decision settings. For more information, refer to Sector Width, page 253.

## SEF Wattmetric Low Polarising Voltage Action

In order to determine the direction of a SEF that caused a pickup when Wattmetric polarization is used, the controller expects Zero Sequence Voltage to be above the SEF Low Threshold setting.

The SEF Low Threshold is one of two settings that deal with low polarising voltages. The other is the Low Polarising Voltage Action.

If the polarising voltage is below the Low Threshold setting for SEFs, the Low Polarising Voltage Action setting will determine what action must be taken.

The options are:

- Use Forward
- Use Reverse
- No Action (default setting)

More information on the No Action option can be found here.

The SEF Low Threshold setting can be configured for between 15 and 15 000 $V_{ZPS}$. The default setting is 500 $V_{ZPS}$

When Use Forward or Use Reverse actions are selected, a fault with low polarising voltage will cause a trip as though it was a normal fault in the selected direction. The only indication that the polarising voltage was low would be the Polarising Voltage at trip $V_{ZPS}$ event which would record a value lower than the SEF Low Threshold setting.

When No Action is selected, a SEF with low polarising voltage will cause a pickup followed by a Polarising Voltage Low $V_{ZPS}$ event reporting the low value of polarising voltage. It will not cause a protection trip. The pickup condition will remain active until the fault resets.

## SEF Wattmetric Low Voltage Reset

Once the polarising voltage for SEFs has been deemed to be Low, it will not return to Normal until either the fault resets or the measured polarising voltage exceeds the Low Threshold setting by 10%. So if the Low Threshold setting is 500 $V_{ZPS}$ and a Low Voltage condition exists, $V_{ZPS}$ will have to rise to 550 $V_{ZPS}$ before the Low V condition is cancelled.

## SEF Wattmetric Voltage Memory

When Wattmetric is selected as the Decision for directional SEF, a Voltage Memory time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

Consider a forward SEF at the Characteristic Angle with $V_{ZPS}$ above the SEF Low Threshold setting and an expected tripping time of 3.5 s. If this fault is applied for 2.0 s and then $V_{ZPS}$ drops below the Low Threshold setting, the controller will retain the last $V_{ZPS}$ value that was sampled above the threshold for the Voltage Memory time.

This means that the low voltage condition is effectively ignored and the protection trip will still occur in the expected tripping time of 3.5 s.

The Earth Angle at Fault that's logged after an upstream ACR trips will be identified by an asterisk '*'.

The Event Log will report the following events:

**Fault On**

- Reverse Pickup SEF

**Low VZPS**

- Reverse SEF

**ACR Tripped**

- Quantity at the maximum Earth/SEF – Maximum Wattmetric xxx kW
- Polarising Voltage at the maximum $V_{ZPS}$ xxx Volt
- Supply Interrupt
- Earth Angle at Fault* 180°

  **NOTE:**

  - The Angle at Fault event above is identified as a memorized value.
  - The Polarising Voltage at the maximum is not a memorized value as $V_{ZPS}$ was above the Low Threshold setting when the fault first appeared.
  - Low $V_{ZPS}$ did not cause a *Polarising Voltage Low* event due to the effect of the Voltage Memory setting.

## SEF Wattmetric Fault Hold Time

When Wattmetric is selected as the Decision for directional SEFs, a Fault Hold Time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

The effect of the Fault Hold Time is to pause the protection timing for a set period after a fault that caused a pickup has gone away.

When the fault hold time is 2.00 s, a forward SEF with a tripping time of 3.0 s that goes away after 1.5 s for 1.0 s and then returns will cause a trip after another 1.5 s. Because the hold time, that is the time that the fault went away for (1.0 s), is a shorter duration than the Fault Hold Time (2.0 s), the pickup will remain active while protection timing is paused and the tripping time will be extended by the Fault Hold Time setting.

The Event Log will record a Paused event during the hold time.

The events recorded from pickup with relevant time stamps would be:

| Event | Time Stamp |
|---|---|
| **Fault On** | |
| Forward Pickup SEF | 00:00:00.00 |
| Polarising Voltage Low $V_{ZPS}$ xxx Volt | 00:00:01.50 |
| All detection elements resetting | 00:00:01.50 |
| All detection elements paused | 00:00:01.50 |
| Detection element timing | 00:00:02.50 |
| Forward SEF | 00:00:04.00 |
| **ACR Tripped** | |
| Quantity at the maximum Earth/SEF Maximum Wattmetric -xx.xx kW | |
| Polarising Voltage at the maximum $V_{ZPS}$ xxxx Volt | |
| Supply Interrupt | |
| EF Angle at Fault - 45° | |

The pickup was paused during the 1.0 s hold time so never reset. When the fault returned a Detection Element Timing event was logged.

**NOTE:** This was not a pickup as a pickup was already active.

The time between pickup and trip would be 4.0 s that is 3.0 s tripping time plus 1.0 s hold time.

## SEF Ir Cos (Ø) Polarising

The Ir Cos (Ø) operating characteristic is used in similar situations to Wattmetric. The operating value is defined as the active current component of the zero sequence current with respect to the zero sequence voltage given by:

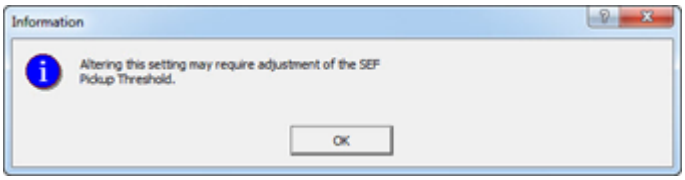
$$\text{Active Earth Current} = \text{Residual Current x Cos } (Ø)$$
$$= (I_{ZPS} \text{ x } 3) \text{ x Cos } (Ø)$$

Where Ø is the Fault Angle that is the angle between the $V_{zps}$ and $I_{zps}$ phasors.

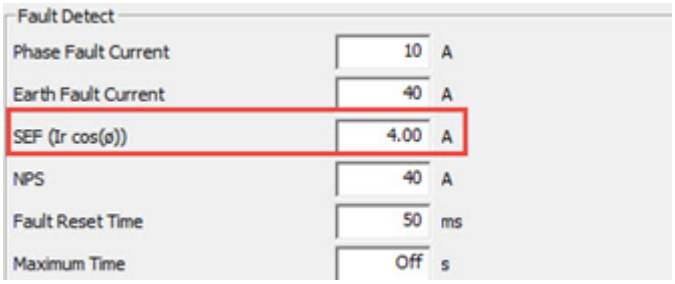
This feature works in a similar manner to Wattmetric with the following differences.

- The Active Current threshold is adjustable in the range 0.05 to 20 A in steps of 0.01 A with a default value of 4 A.
- Ir Cos (Ø) is the value used to determine whether a fault is present, that is the pickup value.

When Ir Cos (Ø) is selected as the polarising decision for directional SEFs, WSOS displays this message:




This is because the SEF Pickup Threshold (Setting Current) is now set in Ir Cos (Ø) units as shown.




## SEF Ir Cos (Ø) Characteristic Fault Angle

When a forward SEF occurs on a compensated earthing system, $V_{ZPS}$ and $I_{ZPS}$ are assumed to be 180° out of phase.

Therefore the Characteristic Angle for Ir Cos (Ø) is fixed at 180°.

> **NOTE:** When the directional SEF decision is Ir Cos (Ø), the Characteristic Angle is fixed and **not displayed**.

The Ir Cos(Ø) Fault Angle for a given fault is the Zero Sequence Current angle relative to the Zero Sequence Voltage angle $V_{ZPS} \rightarrow I_{ZPS}$.

The *Angle at Fault* recorded in the Event Log is the fault angle relative to the Characteristic Angle which is fixed at 180°.

So a fault with a Fault Angle ($V_{ZPS} \rightarrow I_{ZPS}$) = 135°.

would log an Angle at Trip of -45° (135°-180°) which indicates that the fault angle is lagging the Characteristic Angle by 45°.

When the SEF Tripping Direction is Trip Forward, the above fault which causes an upstream ACR to trip would log the following events:

**Fault On**

- Forward Pickup SEF
- SEF Directional Armed
- SEF

**ACR Tripped**

- Quantity at the maximum Earth/SEF – Maximum Ir Cos Ø - xx.xx A
- Polarising Voltage at the maximum $V_{ZPS}$ xxxx Volt
- Supply Interrupt
- SEF Angle at Fault -45°

**NOTE:** The sign of the active earth current logged indicates the direction of the fault. '-' indicates a forward fault and '+' indicates a reverse fault.

## SEF Ir Cos (Ø) Sector Width

The default Forward and Reverse Sector Width settings for SEF protection when the Decision is Ir Cos (Ø) are both 90°. These are ± settings and equate to actual sector widths of 180°.

**NOTE:** The forward sector is centred on the Characteristic Angle $V_{ZPS} \rightarrow I_{ZPS}$ = 180° and the reverse sector is centred on $V_{ZPS} \rightarrow I_{ZPS}$ = 0°.

The likelihood of a fault angle causing an incorrect direction determination may be lessened by either increasing or decreasing the Sector Width setting. The range of these settings is 45° to 135° which equate to actual sector widths of 90° and 270° respectively.

## SEF Ir Cos (Ø) Low Polarising Voltage Action

In order to reliably determine the direction of a SEF that caused a pickup when Ir Cos (Ø) polarization is used, the controller requires Zero Sequence Voltage to be above the SEF Low Threshold setting.

The SEF Low Threshold is one of two settings that deal with low polarising voltages. The other is the Low Polarising Voltage Action.

If the polarising voltage is below the Low Threshold setting for SEFs, the Low Polarising Voltage Action setting will determine what action must be taken.

The options are:

- Use Forward
- Use Reverse
- No Action (default setting)

More information on the No Action option can be found here.

The SEF Low Threshold setting can be configured for between 15 and 15 000 $V_{ZPS}$. The default value is 500 $V_{ZPS}$.

When Use Forward or Use Reverse actions are selected, a fault with low polarising voltage will cause a fault detection as though it was a normal fault in the selected direction. The only indication that the polarising voltage was low would be the Polarising Voltage Low $V_{ZPS}$ event which would record a value lower than the SEF Low Threshold setting.

When No Action is selected, a SEF with low polarising voltage will cause a pickup followed by a Polarising Voltage Low $V_{ZPS}$ event reporting the low value of polarising voltage. It will not cause a fault detection. The pickup condition will remain active until the fault resets.

## SEF Ir Cos (Ø) Low Voltage Reset

Once the polarising voltage for SEFs has been deemed to be Low, it will not return to Normal until either the fault resets or the measured polarising voltage exceeds

the Low Threshold setting by 10%. So if the Low Threshold setting is 500 $V_{ZPS}$ and a Low Voltage condition exists, $V_{ZPS}$ will have to rise to 550 $V_{ZPS}$ before the Low V condition is cancelled.

## SEF Ir Cos (Ø) Voltage Memory

When Ir Cos (Ø) is selected as the Decision for directional SEFs, a Voltage Memory time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

Consider a forward SEF at the characteristic angle with $V_{ZPS}$ above the SEF Low Threshold setting and an expected fault detect time of 3.5 s. If this fault is applied for 2.0 s and then $V_{ZPS}$ drops below the Low Threshold setting, the controller will retain the last $V_{ZPS}$ value that was sampled above the threshold for the Voltage Memory time.

This means that the low voltage condition is effectively ignored and the fault detection will still occur in the expected time of 3.5 s.

The fault angle logged after an upstream ACR trips will be identified by an asterisk '*'.

The Event Log will report the following events:

**Fault On**

- Forward Pickup SEF

**Low $V_{ZPS}$**

- Forward SEF

**ACR Tripped**

- Quantity at the maximum Earth/SEF – Maximum Ir Cos Ø xx.xx A
- Polarising Voltage at the maximum $V_{ZPS}$ xxxx Volt
- Supply Interrupt
- Earth Angle at Fault* 0°

  **NOTE:**

  - The Angle at Fault event above is identified as a memorized value.
  - The Polarising Voltage at the maximum is not a memorized value as $V_{ZPS}$ was above the Low Threshold setting when the fault first appeared.
  - Low $V_{ZPS}$ did not cause a Polarising Voltage Low event due to the effect of the Voltage Memory setting.

## SEF Ir Cos (Ø) Fault Hold Time

When Ir Cos (Ø) is selected as the Decision for directional SEFs, a Fault Hold Time between 0.01 s and 10.00 s or OFF can be configured. The default setting is 2.00 s.

The effect of the Fault Hold Time is to pause the detection timing for a set period after a fault that caused a pickup has gone away.

When the fault hold time is 2.00 s, a forward SEF with a fault detect time of 3.0 s that goes away after 1.5 s for 1.0 s and then returns will cause a fault detection after another 1.5 s. Because the hold time, that is the time that the fault went away for (1.0 s), is a shorter duration than the Fault Hold Time (2.0 s), the pickup will remain active while detection timing is paused and the fault detection time will be extended by the Fault Hold Time setting.

The Event Log will record a Paused event to mark the start of the hold time.

The events recorded from pickup with relevant time stamps would be:

| Event | Time Stamp |
|---|---|
| **Fault On** | |
| Forward Pickup SEF | 00:00:00.00 |
| Polarising Voltage Low $V_{ZPS}$ xxx Volt | 00:00:01.50 |
| All detection elements resetting | 00:00:01.50 |
| All detection elements paused | 00:00:01.50 |
| Detection element timing | 00:00:02.50 |
| Forward SEF | 00:00:04.00 |
| **ACR Tripped** | |
| Quantity at the maximum Earth/SEF Maximum Ir Cos (Ø) -xx.xx A | |
| Polarising Voltage at the maximum $V_{ZPS}$ xxxx Volt | |
| Supply Interrupt | |
| SEF Angle at Fault 0° | |

The pickup was paused during the 1.0 s hold time so never reset. When the fault returned a Detection element timing event was logged.

**NOTE:** This was not a pickup as a pickup was already active.

The time between pickup and fault detection would be 4.0 s that is 3.0 s fault detect time plus 1.0 s hold time.

# NPS Directional Detection

**NOTE:** NPS detection is not available by default. Sequence Components must be made available before it can be used The direction of NPS overcurrent faults can be determined by their Fault Angle.

The Fault Angle is the relationship between the NPS current $I_{NPS}$ and the NPS voltage $V_{NPS}$. that is $V_{NPS} \rightarrow I_{NPS}$

for example, $V_{NPS}$ = 60°, INPS = 180° Therefore NPS Fault Angle = 120°

NPS Voltage ($V_{NPS}$) is used as the polarising voltage for NPS faults.

Operational values for directional NPS are shown below:

| Polarising Method | Fault Angle | Characteristic Fault Angle (default) | Low Threshold (default) | Range |
|---|---|---|---|---|
| $V_{NPS}$ | $V_{NPS} \rightarrow I_{NPS}$ | 120° | $V_{NPS}$= 500 V | Adjustable $V_{NPS}$ 300 to 2,000 V |

## NPS Characteristic Fault Angle

The Characteristic Angle defines the forward and reverse fault regions for the network.

When a NPS fault is detected, its fault angle is calculated and compared to the NPS Characteristic Fault Angle to determine if the fault is forward or reverse.

If the fault angle is within ± 90°(10) of the Characteristic Fault Angle the fault is forward, otherwise it's a reverse fault.

The NPS Characteristic Angle is configurable over the range -179° to 180°.

(10) Assumes default settings for Forward and Reverse Sector Widths that is 90°.

The default Characteristic Angle for NPS faults is 120°. So an NPS fault where the fault current led the polarising voltage by 120° would be a forward fault in the center of the forward sector.

When the Fault Detection Direction is Forward Fault and the Forward Sector Width is the default 90°, NPS faults with fault angles between 30° and 210° (-150°) would cause NPS Directional Detection to Arm and potentially lead to an NPS fault detection.

The Angle at Fault reported in the Event Log would be 120°.

When Detection Groups A and B are active, the Event Log will also record:

**Fault On**

- Forward Pickup NPS
- Detection Group A Active
- Forward NPS fault

**ACR Tripped**

- Current at maximum NPS maximum xxx A
- Polarising Voltage at the Maximum $V_{NPS}$
- Supply Interrupt
- NPS Angle at Fault 120°

A reverse fault where the fault current lags the polarising voltage by 60° would log the events below.

**Fault On**

- Reverse Pickup NPS
- Detection Group B Active
- Reverse NPS fault

**ACR Tripped**

- Current at maximum NPS maximum xxx A
- Polarising Voltage at the Maximum $V_{NPS}$
- Supply Interrupt
- NPS Angle at Fault -60°

## NPS Sector Width

The default Forward and Reverse Sector Width settings for NPS protection are both 90°. These are ± settings and equate to actual sector widths of 180°.

> **NOTE:** The forward sector is centred on the Characteristic Angle and the reverse sector is centred on the Characteristic Angle - 180°.

The likelihood of a fault angle causing an incorrect direction determination may be lessened by either increasing or decreasing the Sector Width setting. The range of these settings is 45° to 135° which equate to actual sector widths of 90° and 270° respectively.

## NPS Low Polarising Voltage Action

In order to determine the direction of an NPS fault that caused a pickup, the controller requires sufficient polarising voltage $V_{NPS}$.

Directional NPS Protection includes two settings that deal with low polarising voltage.

- Low Polarising Voltage Action
- Low Threshold

If the polarising voltage is below the Low Threshold setting for NPS faults, the Low Polarising Voltage Action setting will determine what action must be taken.

The options are:

- Use Forward
- Use Reverse
- No Action (default setting)

More information on the No Action option can be found here.

The NPS Low Threshold setting can be configured for between 300 and 2 000 Volts.

When Use Forward or Use Reverse actions are selected, a fault with low polarising voltage will cause a trip as though it was a normal fault in the selected direction. The only indication that the polarising voltage was low would be the Polarising Voltage at trip $V_{NPS}$ event which would record a value lower than the NPS Low Threshold setting.

When No Action is selected, a fault with low polarising voltage will cause a pickup followed by a Polarising Voltage Low $V_{NPS}$ event reporting the low value of polarising voltage. It will not cause a protection trip. The pickup condition will remain active until the fault resets.

## NPS Low Voltage Reset

Once the polarising voltage for NPS faults has been deemed to be Low, it will not return to Normal until either the fault resets or the measured polarising voltage exceeds the Low Threshold setting by 10%. So if the Low Threshold setting is 500 $V_{NPS}$ and a Low Voltage condition exists, $V_{NPS}$ will have to rise to 550 $V_{NPS}$ before the Low V condition is cancelled.

**Table 85 Directional Detection Settings/Specifications**

| **Directional Detection Settings/Specifications** | |
|---|---|
| System Phase/Earth Nominal Voltage for correct operation | 2...25 kV |
| **Phase Directional Detection** | |
| Phase Characteristic Angle setting range | ± 180 ° |
| Phase Characteristic Angle setting resolution | 1 ° |
| Phase Characteristic Angle accuracy | ± 10 ° |
| Time to determine direction for phase faults | 20 ms |
| Minimum Quadrature Polarising Voltage for Phase Directional Detection to operate | 150 V |
| **Earth/SEF Directional Detection** | |
| Earth/SEF Characteristic Angle setting range | ± 180 ° |
| Earth/SEF Characteristic Angle setting resolution | 1 ° |
| Characteristic Angle accuracy from 2...5 A earth current | ± 30 ° |
| Characteristic Angle accuracy from 5...20 A earth current | ± 20 ° |
| Characteristic Angle accuracy above 20 A earth current | ± 20 ° |
| Time to determine direction for EFs | 20 ms |
| Time to determine fault direction for SEF faults | 500 ms |
| Minimum Zero Sequence Polarising Voltage $V_{ZPS}$ for Earth<br><br>Directional Detection to operate | 15 V |

**Table 85 Directional Detection Settings/Specifications (Continued)**

| **Directional Detection Settings/Specifications** | |
|---|---|
| Minimum Zero Sequence Polarising Voltage $V_{ZPS}$ for SEF<br><br>Directional Detection to operate | 15 V |
| Minimum SEF Definite time when Directional Detection is ON | 0.1 s |
| **NPS Directional Detection** | |
| NPS Characteristic Angle Setting range | ±180° |
| NPS Characteristic Angle Setting resolution | 1° |
| NPS Characteristic Angle Accuracy | ±10° |
| Time to determine fault direction for NPS faults | 20 ms |
| Minimum Negative Sequence Polarising Voltage $V_{NPS}$ for NPS Directional Detection to operate | 300 V |
| **Control** | |
| Low Polarising Voltage Action | No Action, Use Forward, Use Reverse |
| Forward Sector Width | 45°...135° |
| Reverse Sector Width | 45°...135° |
| Phase Low Threshold | 150...15,000 $V_{QUAD}$ |
| Phase Voltage Memory | Off,<br><br>0.01...10.00 s |
| Earth Decision | $V_{ZPS}$, Wattmetric, Ir Cos (Ø) |
| Earth Low Threshold | 15...15,000 $V_{ZPS}$ |
| Earth Wattmetric Characteristic Angle | 180° Fixed |
| Earth Ir Cos (Ø) Characteristic Angle | 180° Fixed |
| Earth Voltage Memory | Off<br><br>0.01...10.00 s |
| EF Hold Time | Off<br><br>0.01...10.00 s |
| SEF Decision | $V_{ZPS}$, Wattmetric,<br><br>Ir Cos (Ø) |
| SEF Low Threshold | 15...15,000 $V_{ZPS}$ |
| SEF Wattmetric Characteristic Angle | 180° Fixed |
| SEF Ir Cos (Ø) Characteristic Angle | 180° Fixed |
| SEF Voltage Memory | Off<br><br>0.01...10.00 s |
| SEF Fault Hold Time | Off<br><br>0.01...10.00 s |
| NPS Low Threshold | 200...3000 $V_{NPS}$ |
| **$V_{ZPS}$ Balance** | |
| Residual Earth Voltage dynamic balance limit | 0 % |
| Residual Earth Voltage dynamic balance rate | 0.6% per second |
| | |
| High $V_{ZPS}$ Alarm Timeout | 1...180 s |
| High $V_{ZPS}$ Alarm Set point | 15...15,000 V |
| **Wattmetric and Ir Cos (Ø) Pickup Settings** | |

**Table 85 Directional Detection Settings/Specifications (Continued)**

| Directional Detection Settings/Specifications | |
|---|---|
| Earth Wattmetric Pickup Setting | 0.1...500.0 kW |
| Earth Ir Cos (Ø) Pickup Setting | 10...1260 A |
| SEF Wattmetric Pickup Setting | 0.01...10.00 kW |
| SEF Ir Cos (Ø) Pickup Setting | 0.05...20.00 A |

# Voltage Operated Detection Elements

## UOV

UOV detection continuously compares real time voltage measurements with thresholds derived from the Nominal Phase to Earth Voltage setting and, in conjunction with the Phase Logic setting, determines if the measured voltage(s) is within or outside of the normal voltage band limits.

If the measured voltage is deemed to be outside the normal voltage band, an UOV pickup will be logged and if that condition persists, UOV detection will generate an alarm.

If the voltage later returns to normal, the alarm will reset and normal voltage events will be logged along with minimum or maximum voltage events to record the lowest or highest voltage level sampled between the pickup and reset events.

### UOV Detection Configuration

In order for **UOV Detection** to be enabled and configured it must be available. The feature can be made available in WSOS on the Feature Selection page by going to:

**Display** > **Configuration** > **Feature Selection** > **Detection** > **UOV Detection**

Or on the operator interface.

Once UOV Detection has been made available, UOV Detection can be configured **On** or **Off** individually.

UOV Detection can be configured in WSOS on the UOV page in the Detection menu.

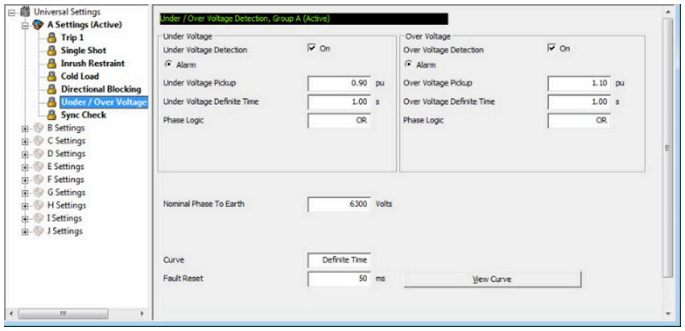



**Figure 220**
AS UOV Detection settings

Or on the operator interface.

> **NOTE:** UOV Detection threshold settings are configured in per unit values based on the Nominal Phase to Earth voltage setting.

## Dead-bands

A voltage dead-band of 0.02 pu is used to provide hysteresis and helps to prevent a voltage value that is fluctuating around a pickup threshold from causing excessive pickup/reset events.

The normal voltage band is centred on 1.0 pu.

Therefore the maximum value for the Under Voltage Pickup is 0.98 pu.

The minimum value for the Over Voltage Pickup is 1.02 pu.

With the default Normal Phase to Earth setting of 6300 V the dead band would be 0.02 x 6300 = 126 V.

UOV Detection can be configured with the following settings:

**Table 86 UOV Detection settings**

| **Under Voltage Detection** | |
|---|---|
| **Setting** | **Description** |
| Under Voltage Detection | On or Off |
| Under Voltage Mode | Trip or Alarm (Only applicable when Under Voltage Detection is On). |
| Under Voltage Pickup | The voltage expressed as a per unit value at which an Under Voltage pickup will occur.<br>Range: 0.50 per unit – (Normal Voltage Low setting -0.02 per unit).<br>Default: 0.9 per unit |
| Under Voltage Definite Time | The time that an under voltage condition will take to cause an alarm or trip depending on the UV mode setting. (Only applicable when the Curve setting is Definite Time).<br>Range: 0.01...300.00 s. Default: 1.0 s |
| Under Voltage Phase Logic | The phase logic that applies to Under Voltage Detection.<br>Range: AND/OR/Average. Default: AND |
| **Over Voltage Detection** | |
| Over Voltage Detection | On or Off |
| Over Voltage Mode | Always in Alarm mode if Over Voltage Detection is On. |
| Over Voltage Pickup | The voltage expressed as a per unit value at which an Over Voltage pickup will occur.<br>Range 1.02...2.00 pu<br>Default 1.1 pu |
| Over Voltage Definite Time | The time that an over voltage condition will take to cause an alarm. (Only applicable when the *Curve* setting is Definite Time).<br>Range: 0.01...300.00 s. Default: 1.0 s |
| Over Voltage Phase Logic | The phase logic that applies to Over Voltage detection.<br>Range: AND/OR/Average. Default: AND |
| **UOV Detection** | |
| Nominal Phase to Earth | Defines the nominal phase to earth system voltage. This is a critical setting as it is used to derive the per unit values configured for other settings.<br>This setting is linked to the *Nominal Phase to Earth* setting displayed in Measurements.<br>Range: 2,000...25,000 V<br>Default: 6,300 V |

**Table 86 UOV Detection settings (Continued)**

| Under Voltage Detection | |
|---|---|
| **Setting** | **Description** |
| Curve | This setting is used to select the Voltage – Time curve.<br>Range: Definite Time, User Curve 1 to 5.<br>Default: Definite Time. |
| Fault Reset | The time it takes for a fault to reset after the voltage returns to normal (+/- the dead-band) following a UOV pickup.<br>Range: 0...10,000 ms<br>Default: 50 ms |

## UOV Detection Curves

UOV Detection uses a form of voltage/time curve to provide an envelope beyond which Detection trips or alarms will occur. The curves available are:

- Definite Time – This option is always available and if selected requires UOV to be configured with individual times between 0.01 and 300.00 s.
- User Defined – If a customized curve is required it can be configured using the curve editor in WSOS. Up to 5 user defined curves can be loaded into an PowerLogic ADVC Controller and are then available for selection.

## Phase Logic

The individual UOV Phase Logic settings control the method by which measured voltages are evaluated against their respective Pickup and Normal thresholds.

This setting determines the conditions required to generate UOV detection pickup or reset events.

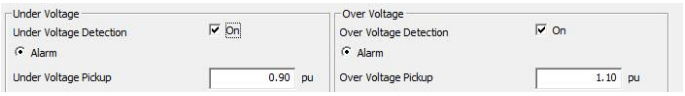
- **AND** – When ALL the measured phase voltages deviate beyond the UOV thresholds.
- **OR** – When ANY measured phase voltage deviates beyond the UOV thresholds.
- **Average** – When the numerical average of all three measured phase voltages deviates beyond the UOV thresholds.

## Normal Voltage Band

For the correct operation of the UOV detection, a Normal Voltage band which defines the range within which the voltage is considered normal needs to be defined.

With the default pickup settings shown below, the normal voltage band would be:

**0.92 pu–1.08 pu** that is (0.9 + 0.02)–(1.1 – 0.02)




Low Voltage and High Voltage events would be logged if the measured voltage went below 0.92 pu or above 1.08 pu respectively.

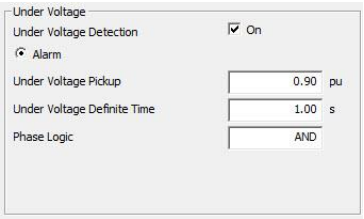
Pickup events will only occur if the UOV.Pickup settings are exceeded.

A pickup will not reset until the voltage has gone back within the normal voltage band for the Fault Reset time.

## Under Voltage Detection Operation

Under Voltage detection can be configured to generate an alarm if the measured system voltage goes below the pre-set limits for a certain time.

Consider the Under Voltage Detection configured to alarm with the default settings shown below and a Nominal Phase to Earth 6300 V:




Each phase to earth voltage will cause a Low Voltage condition if it falls below 5796 V (0.92 x 6300). These events would be recorded in the Event Log.

The Phase Logic is set to **AND** which means that all three phase to earth voltages would need to fall further to below 5670 V (0.9 x 6300) to cause an Under Voltage pickup.

Suppose they all fall to 5544 V (0.88 x 6300) 10 s after the low voltage condition and each voltage remains below the normal voltage band until the 1.0 s definite time setting expires.

This will generate an Under Voltage Alarm.

If say 10 s after that, the voltage for each phase rose back above 5796 V (0.92 per unit) which would put them back in the normal voltage band. This would cause the Under Voltage fault to reset. Voltage Normal and Minimum Voltage events would then be logged.

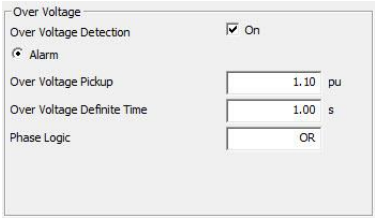
The following events would be logged:

| Time | Event |
|---|---|
| 00:00:00.00 | A Voltage Low |
| 00:00:00.00 | B Voltage Low |
| 00:00:00.00 | C Voltage Low |
| 00:00:10.00 | Under Voltage Pickup |
| 00:00:11.00 | Under Voltage Alarm |
| 00:00:21.00 | Under Voltage Reset |
| 00:00:21.00 | A Voltage Normal |
| 00:00:21.00 | B Voltage Normal |
| 00:00:21.00 | C Voltage Normal |
| 00:00:21.00 | A Min 0.88 per unit |
| 00:00:21.00 | B Min 0.88 per unit |
| 00:00:21.00 | C Min 0.88 per unit |

## Over Voltage Detection Operation

Over Voltage Detection can be configured to either trip the switchgear or generate an alarm if the measured system voltage goes above the pre-set limits for a pre-set time.

Consider the Over Voltage Detection configured to alarm with the settings shown below and a Nominal Phase to Earth 6300 V:




The Phase Logic is set to OR which means that only one or more of the phase to earth voltages need to rise above the Over Voltage Pickup setting to cause an Over Voltage pickup.

Consider a case where only A phase voltage initially goes just above the Normal Voltage band upper limit of 6804 V (1.08 x 6300) and records a Voltage High event.

Suppose then 10 s later the A phase voltage rises further to 7056 V (1.12 x 6300) and causes a pickup.

Providing the voltage remains above 6804 V (1.08 x 6300) for the 1.0 s definite time setting, it will generate an alarm.

If say 10 s after that, the A phase voltage dropped back below 6804 V (1.08 x 6300) which would put it back in the normal voltage band. This would cause the Over Voltage alarm to reset.

Immediately following the reset, the Event Log will record Voltage Normal and the maximum voltage sampled for the faulted phase in per unit values.

The following events would be logged:

| Time | Event |
|---|---|
| 00:00:00.00 | A Voltage High |
| 00:00:10.00 | Over Voltage Pickup |
| 00:00:11.00 | Over Voltage Alarm |
| 00:00:21.00 | Over Voltage Trip |
| 00:00:21.00 | A Voltage Normal |
| 00:00:21.00 | A Min 1.12 pu |

## Average Phase Logic Events

When the Phase Logic is set to Average, only one event is logged for Voltage High and Low events as well as Minimum and Maximum voltage events.

Examples are shown below:

- ABC Voltage High
- ABC Voltage Low
- ABC Min 0.84 pu
- ABC Max 1.16 pu

## Pickup Thresholds and Reset

The Pickup thresholds are expressed as per unit values based on the Nominal Phase to Earth Voltage setting.

A **Pickup** occurs when the measured voltage is:

- **Under Voltage**
  - Less than or equal to the Under Voltage Pickup setting.

- **Over Voltage**
  - Greater than or equal to the Over Voltage Pickup setting.

**Fault Reset** occurs following a pickup when the voltage then becomes:

- **Under Voltage**
  - Greater than the Under Voltage Pickup setting **plus** the dead-band for the Fault Reset time OR less than the Live/Dead threshold.
- **Over Voltage**
  - Less than the Over Voltage Pickup setting **minus** the dead-band for the Fault Reset Time.

## UOV Detection Summary

- UOV detection, when enabled, can be configured to generate alarms individually.
- Under Voltage detection will generate an alarm when the source side voltages fall below the Under Voltage Pickup setting for a time determined by the Curve selected.
- Over Voltage detection will generate an alarm when the source side voltages rise above the Over Voltage Pickup setting for a time determined by the Curve selected.
- Dead-bands helps to prevent a voltage value that is fluctuating from causing excessive pickup/reset events.
- UOV detection uses logic based on **AND**, **OR** or **Average** evaluation to determine if an under or over voltage condition exists.
- Alarm times can be configured for Definite Time or a user defined Time/Voltage curve.

**Table 87 UOV Detection Settings/Specifications**

| UOV Detection Settings/Specifications | |
|---|---|
| Voltage accuracy | 2.5% ± 25 V |
| Dead Band (hysteresis) | 2.0% of nominal system voltage |
| Voltage value updated | 31.25 ms |
| Measured voltage evaluation | Once/1.125 s |
| Measured voltage averaged over | 0.25 s |
| Nominal Phase to Earth Voltage | 2.0...25.0 kV |
| Nominal Phase to Earth Voltage resolution | 1 V |
| Nominal Voltage range | 2.0...25.0 kV |
| Under Voltage Pickup | 0.5–0.98 per unit |
| Over Voltage Pickup | 1.02...2.00 per unit |
| Under/Over Voltage Fault Reset Time | 0...10 s |
| Under/Over Voltage Fault Reset Time resolution | 1 ms |
| Under/Over Voltage Definite Time | 10 ms...300 s |
| Under/Over Voltage Definite Time resolution | 10 ms |

# Distance to Fault Location

## What's in This Chapter

Fault Locator..... 415

# Fault Locator

## Introduction

### Product Perspective

Medium voltage overhead distribution lines are subject to many types of faults due to the exposed nature of their conductors. Accurate and robust fault location techniques are an important requirement when dealing with both permanent and transient faults.

The use of fault location systems on distribution networks are advantageous in that they can expedite location and repair of faults thereby reducing restoration times. This can lead to an improvement in system availability and performance as well as a reduction in operating costs and losses.

### Product Functions

The fault locator module in the PowerLogic ADVC Controller provides information on:

- The fault type
- The faulted phases
- The distance to the fault from the controller
- The fault impedance for single phase faults.

This information can be monitored via WSOS or a SCADA system.

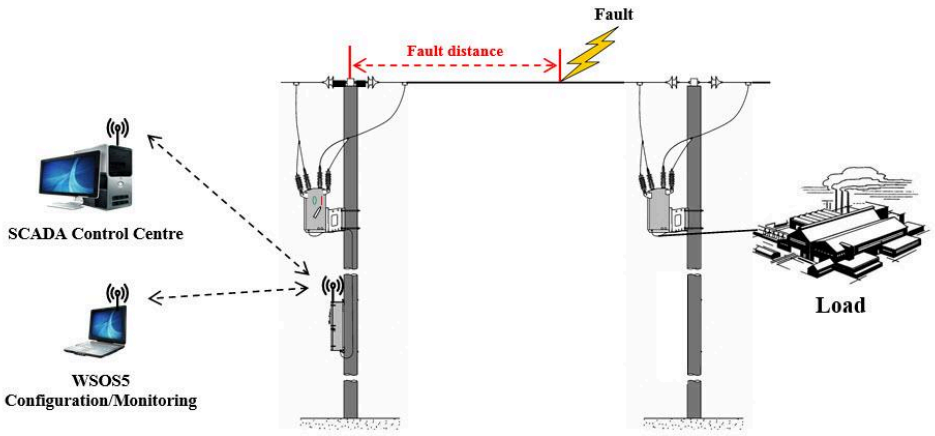



**Figure 221**
Fault Locator System Diagram

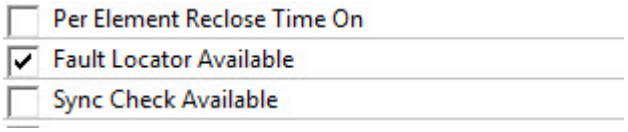
## Fault Locator Feature Selection

If the Fault Locator is required to be used it must be made available.

This can be done in WSOS on the Feature Selection page:

**Display** > **Configuration** > **Feature Selection** > **Protection**. (ACR)

**Display** > **Configuration** > **Feature Selection** > **Detection**. (AS)



The Fault Locator can also be made available for on ACR, page 697 and AS, page 699 the O.I.

# Fault Locator Settings Pages

Once the **Fault Locator** has been made available for an ACR, a Fault Locator settings page is added to the protection settings for each protection group in WSOS.

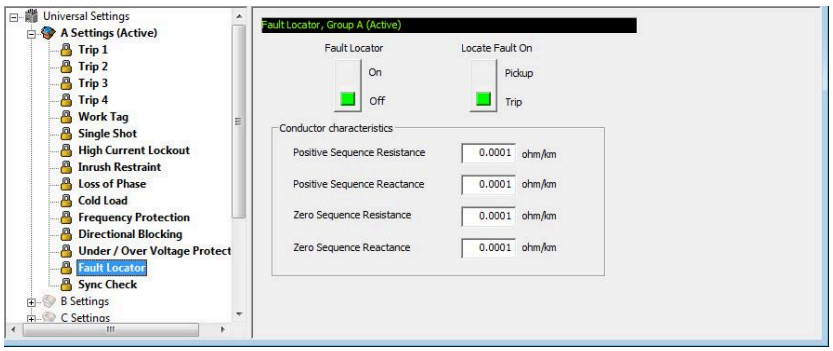



**Figure 222**
WSOS Fault Locator setting for an ACR

Making the **Fault Locator** available for an AS adds a Fault Locator setting page for each detection group.

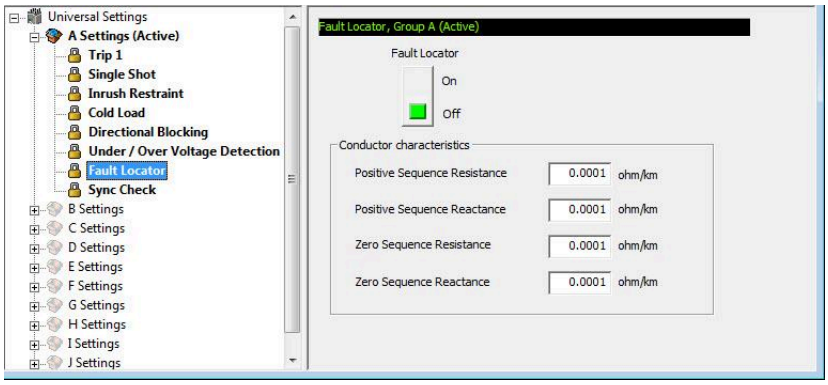



**Figure 223**
WSOS Fault Locator settings for an AS

Making the Fault Locator available also adds a Fault Locator sub-menu on the ***flex*VUE** O.I. for both ACR and AS.

On the ***set*VUE** O.I., two Fault Locator setting pages are added to the Protection Menu for an ACR and to the Detection Menu for an AS.

# Fault Information Display

When the **Fault Locator** is made available on either an ACR or AS, addition fault information fields for **Distance** and **Impedance** are added to their WSOS Control pages.

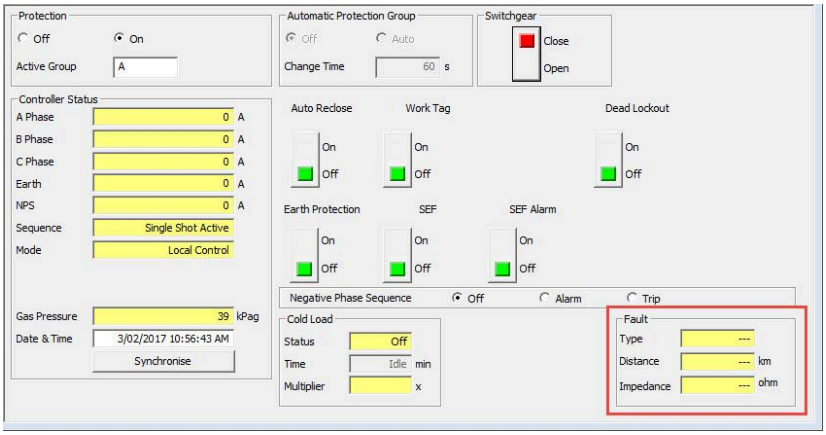



**Figure 224**
Fault Locator Information for an ACR displayed in WSOS

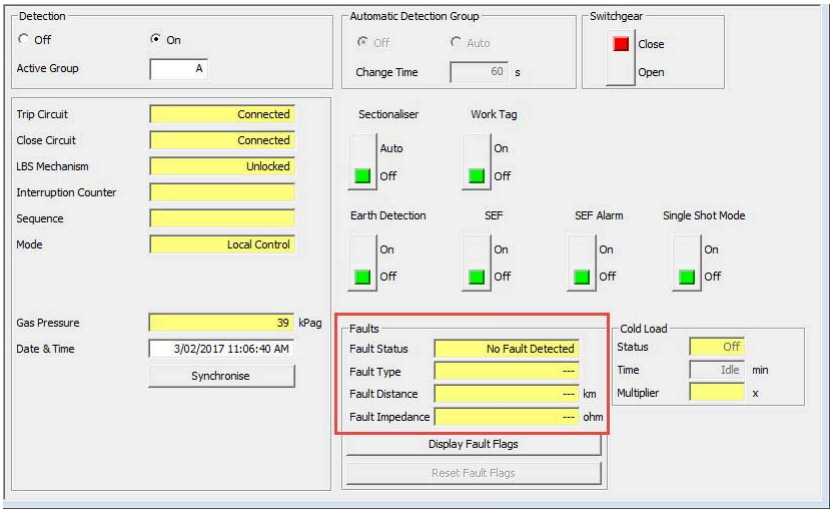



**Figure 225**
Fault Locator Information for an AS displayed in WSOS

When the Fault Locator operates, distance and impedance measurements are added to the Fault Information display on the operator interface.

> **NOTE:** The Distance measurement provided by the Fault Locator may be in either kilometres (km) or miles (mi) depending on whether the Display setting is Metric or Imperial.

The Display setting can be found in WSOS at:

**Display** > **Configuration** > **Configuration**.

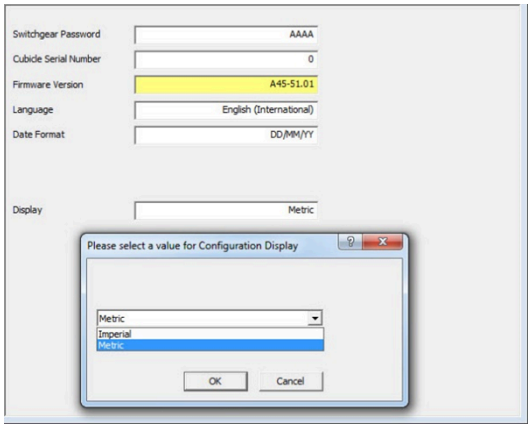



**Figure 226**
Display setting on WSOS Configuration page

The displayed distance units can be changed on the operator interface.

# Principles of Operation

The fault location is calculated using symmetrical components. These are calculated using the values of the three phase currents and the three phase-to-earth voltages under the following conditions:

- During normal operation.
- During steady state fault conditions.

The main assumption of this calculation relies on simplification of the feeder diagram.

The single line tree diagram comprising a variety of conductors and loads is replaced by an equivalent simplified diagram, which consists of one type of conductor and one load connected at the end of the line.

The function determines the type of fault and phases affected by the fault and then calculates the fault location using a patented algorithm.

When the protection function is non-directional, fault calculations are performed for faults downstream from the device.

When directional protection is enabled, fault calculations are also performed for faults upstream from the device.

## Fault Location for ACR

On ACR devices the fault distance and impedance calculations are triggered by either a pickup or trip (configurable) caused by the following protection elements whether directional or non-directional.

- Phase Overcurrent
- Earth Overcurrent
- SEF

When a protection pickup or trip occurs, the fault locator initially determines the type of fault and the faulted phases. The type of fault needs to be identified before the distance to fault can be calculated.

Possible fault types are:

- Phase to Earth (A-E, B-E, C-E)
- Phase to Phase (A-B, A-C, B-C)
- Phase to Phase to Earth (A-B-E, A-C-E, B-C-E)
- Phase to Phase to Phase (A-B-C)

- Phase to Phase to Phase to Earth (A-B-C-E)

In order to analyze the fault information, the fault locator needs to process at least 50 ms of sampled data. In some cases this might not be possible, for instance:

- When Fault Locate On is set to Trip and less than 50 ms elapses between the pickup and trip request. This could be caused by:
  - An instantaneous trip
  - A definite time trip set for less than 50 ms
  - A trip according to a very steep IDMT curve
- When Fault Locate On is set to Pickup and a fleeting fault causes a pickup then resets less than 50 ms later.

## Fault Location on AS

Fault location on AS works similarly to fault location on ACRs explained above. The main difference is that the fault locator calculations are triggered on each supply interrupt.

In order to analyze the faulted phase signal, the fault locator has to process at least 50 ms of sampled data.

In a situation where a supply interrupt was initiated by a fault that was cleared by the upstream ACR in less than 50 ms, the controller for the sectionaliser would not be able to calculate the fault type and consequently not the distance or impedance.

# Fault Locator Settings and Status

The fault locator settings are configured for each protection/detection group.

## Fault Locator ON/OFF

This setting enables or disables the Fault Locator functionality.

- **Type**: Configurable (Binary)
- **Range**: Fault Locator ON or Fault Locator OFF
- **Default**: Fault Locator OFF

## Fault Locate On (ACR only)

This setting determines how the fault locator for an ACR is triggered.

- **Type**: Configurable (Binary)
- **Range**: Pickup or Trip
- **Default**: Trip

## Conductor Characteristics

## Positive Sequence Resistance

- **Type**: Configurable
- **Range**: 0.0001 to 10.0000 ohm/km (Metric),
  0.0001 to 16.0930 ohm/mi (Imperial)
- **Default**: 0.0001 ohm/km

## Positive Sequence Reactance

- **Type**: Configurable
- **Range**: 0.0001 to 10.0000 ohm/km (Metric), 0.0001 to 16.0930 ohm/mi (Imperial)
- **Default**: 0.0001 ohm/km

## Zero Sequence Resistance

- **Type**: Configurable
- **Range**: 0.0001 to 10.0000 ohm/km (Metric), 0.0001 to 16.0930 ohm/mi (Imperial)
- **Default**: 0.0001 ohm/km

## Zero Sequence Reactance

- **Type**: Configurable
- **Range**: 0.0001 to 10.0000 ohm/km (Metric), 0.0001 to 16.0930 ohm/mi (Imperial)
- **Default**: 0.0001 ohm/km

## Fault Locator Status

**Fault Type**

Reports the type of detected fault. See possible fault types.

**Fault Distance**

Reports the distance to fault in either km (kilometers) or mi (miles)

- **Type**: Status (read-only)
- **Range**: displayed when the distance cannot be calculated.

**Fault Impedance**

Reports the fault resistance in ohms to the fault.

- **Type**: Status (read-only)
- **Range**: displayed when the distance cannot be calculated.

All displayed measurements (fault distance, fault impedance, fault type etc.) are reset after any CLOSE operation or after a Reset Fault Flags command sent via WSOW or a SCADA protocol.

> **NOTE:** The accuracy of the calculations are sensitive to the type of earthing. The best results are given with purely resistive earthing.

The fault locator will give out of bounds results for the following types of earthing:

- Isolated earthing
- Impedance earthing 40 ohm
- Petersen Coil

More information on the Fault Locator feature for the PowerLogic ADVC Controller can be found in the PowerLogic ADVC Controller Range Fault Locator Technical Manual.

# Synchronization

## What's in This Chapter

Sync Check ..... 422

# Sync Check

## Introduction

In order to help prevent possible equipment damage in medium voltage distribution systems, it is crucial that voltages on both sides of a circuit breaker are in sync before the CB is closed.

Sync Check is an optional feature on the PowerLogic ADVC Controller that helps to prevent an operator close command being sent to the switchgear unless the supplies on either side of the switch are synchronized according to the Sync Check configuration.

Sync Check, when enabled, monitors three different aspects of the voltage across the switch to determine if a close must be allowed:

- Amplitude
- Frequency
- Phase

The following close operations are inhibited by Sync Check unless the necessary criteria is met:

- Control panel close request
- WSOS close request
- Communications protocol close command
- IOEX initiated close command
- Customized Logic Tool close command
- ACO close command(11)

Automatic reclose requests are not affected by the Sync Check functionality.

When a close operation is denied, visual indication of the element causing the constraint is provided on the O.I. and through WSOS.

Sync Check is a check function only and no interface to external speed or voltage controllers is provided.

Close retries can be configured to occur automatically if synchronization is achieved following the initial close request being denied.

Sync Check can be used with ACRs or ASs with PMSet E Series, PMSet U Series or PMSet UR Series switchgears.

RL and V/C Series switchgear are not supported.

## Sync Check Feature Selection

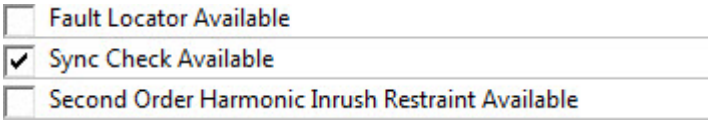
If the Sync Check function is required to be used it must firstly be made available.

This can be done in WSOS on the Feature Selection page:

**Display** > **Configuration** > **Feature Selection** > **Protection**. (ACR)

**Display** > **Configuration** > **Feature Selection** > **Detection**. (AS)

(11) When the ACO selected algorithm is One-Way, Both-Ways or Break Before Make, the ACO scheme operation is not affected by the Sync Check feature. When the ACO selected algorithm is Make Before Break: if Sync Check is enabled and the supplying source is the backup supply, then when the preferred supply is back live, and it detects that the supplies are out of sync ACO will report that the master station is Not Ready To operate and will abort unless the self-healing option Device Not Ready is enabled. In this case the scheme will wait for the supplies to become synchronized to switch to Device Ready. If Sync Check is enabled and ACO wants to perform a changeover from the backup to the preferred supply, and it detects that the supplies are out of sync, then the close operation on the preferred supply will be denied by Sync Check and the ACO status will report Out Of Sync.




Sync Check can also be made available for an ACR or AS on the O.I.

# Sync Check Settings Displays

Once Sync Check has been made available for an ACR, a Sync Check settings page is added to the protection settings for each protection group in WSOS.

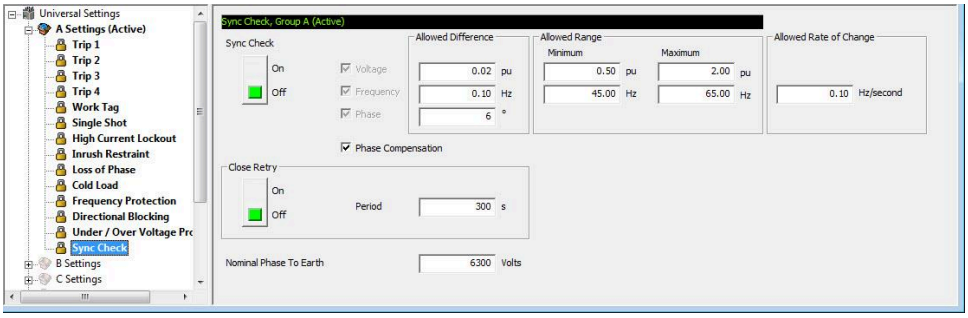



**Figure 227**
WSOS Sync Check settings for an ACR

Making Sync Check available for an AS adds a Sync Check setting page for each detection group.

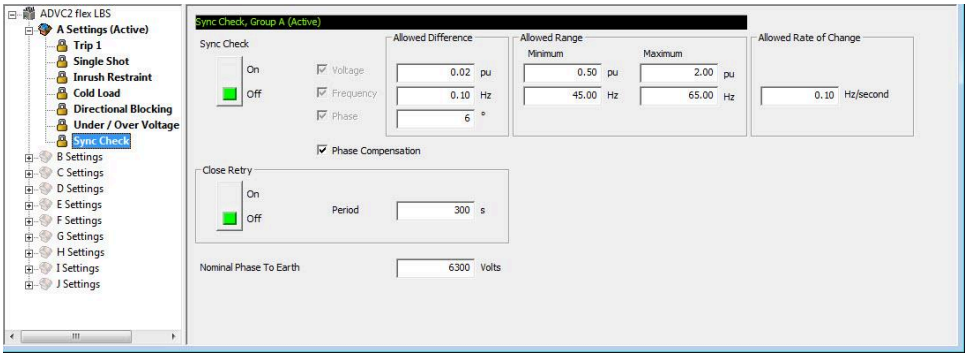



**Figure 228**
Sync Check settings for an AS

Making Sync Check available also adds a Sync Check sub-menu on the ***flex*VUE** O.I. for an ACR and AS.

Four Sync Check setting pages are added to the ***set*VUE** O.I. for both ACR and AS.

# Principles of Operation

In order to check that the voltage supplies on either side of a switchgear are synchronized, three aspects of those supplies need to be checked: amplitude, frequency and phase.

## Voltage Amplitude Synchronization

If the voltage amplitudes across the switchgear are not closely matched when it is closed, a sudden rise in kVAR flow will occur.

## Voltage Frequency Synchronization

If the frequencies on each side of an open switch are not matched prior to closing, a sudden change in MW flow through the switchgear will occur as the system seeks to establish a common frequency of operation. The allowable difference is system specific, however a general guideline would be for the frequencies to be within 0.1 Hz of each other prior to closing.

Sync Check will only allow a manual close request if the rate of frequency change has been below the configured threshold for at least 500 ms.

## Phase Angle Synchronization

The third synchronizing variable – and probably the most important of the three – is the voltage phase angle difference. The phase difference between the voltages on each side of the open switchgear needs to be reduced to a small value prior to closing.

Otherwise a large MW flow increase will suddenly occur through the switchgear. Ideally, the voltage phase angle difference must be as close to 0° as possible before manually closing the switchgear.

## Phase Compensation

The Phase Compensation option allows the time to close the switchgear to be taken into account when the system issues the close request. Depending on the frequency difference and phase difference between the two sides, Sync Check will determine when the close request needs to be issued in order for the actual closing of the switchgear contacts to occur when the two supplies are perfectly synchronized.

## Close Retry

The Close Retry option enables Sync Check to issue a subsequent close request automatically when synchronism occurs sometime after an operator close was denied due to an out of sync condition. It helps to prevent the need for an operator to closely monitor the synchronization status of the system and issue another close request manually.

The Close Retry Period setting determines how long Close Retry will wait for the two sides to be synchronized after the initial close request.

While an automatic close request is pending, an alert message is displayed on the O.I.s showing the time remaining before the automatic close operation is aborted.

An operator may cancel a pending automatic close request by issuing a trip request or by changing any Sync Check setting.



## Operation Diagram

Consider the following phase synchronism diagram:

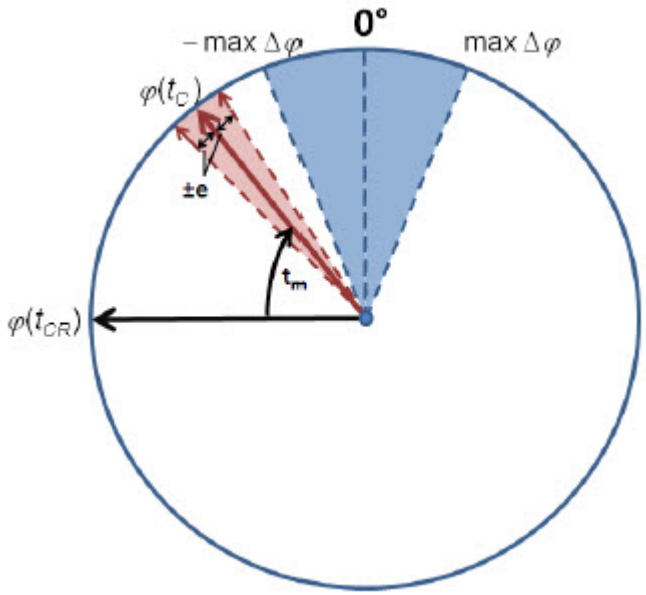



**Figure 229**
Phase Synchronism Diagram

Where:

- 0° is the reference phase measurement on bushing Ai, Bi or Ci.
- $\Phi(t_{CR})$ is the phase difference measurement between bushings Ax, Bx or Cx and their reference bushings at the time of the close request.
- $\Phi(t_C)$ is the phase difference measurement between bushings Ax, Bx, or Cx and their reference bushings at the time of the actual close.
- $t_m$ is the switchgear mechanism time. This is the time between the close coil energization and the moment the interrupter contacts touch (the actual close). This time is inherent to each switchgear series and is not configurable.
- e is the maximum phase error when the close contacts meet. This error is due to mechanical, environmental and software components, which can cause the actual time to close the switchgear to vary slightly. The phase error is directly proportional to the measured frequency difference: the bigger the frequency difference, the bigger the rate of phase change and consequently, the bigger the phase error when the contacts close.
- Max$\Delta$ φ is the maximum allowed phase measurement difference between bushings Ax, Bx or Cx and its corresponding reference bushing. It is the Maximum Allowed Phase Difference setting available in WSOS and in the PowerLogic ADVC Controller.

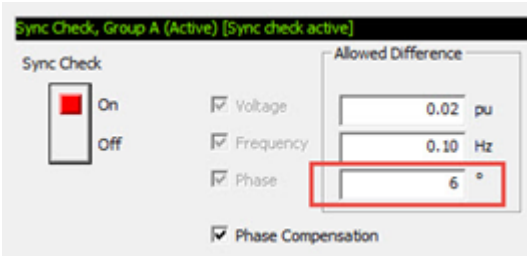



**Figure 230**
Maximum allowed Phase Difference setting in WSOS

With Phase Compensation OFF, Sync Check will allow a close operation if:

$$-\max\Delta\varphi \leq \varphi(t_{CR}) \leq \max\Delta\varphi$$

Due to the switchgear mechanism time, the actual close will occur at:

$$\Phi(t_{C)} = \varphi(t_{CR}) + \varphi(t_m, \Delta f) \pm e$$

The phase difference at the actual close is a function of the phase difference at the time of the close request, the frequency difference between source and load (the bigger the frequency difference, the bigger the phase difference from close request to actual close) and the mechanism time. This phase difference may cause the actual close to occur on out-of-phase conditions. The Phase Compensation functionality is provided to mitigate this risk.

When Phase Compensation is ON, the Sync Check functionality will allow or reject a close operation based on the predicted phase measurement at the time of the actual close, calculated using the measured frequency difference and the (known) switchgear mechanism time. When Phase Compensation is ON, Sync Check will allow a close operation of:

$$-\max\Delta\varphi \leq \varphi(t_C) \leq \max\Delta\varphi$$

For an automatic close retry, the actual close will occur when the phase difference between the bushings is:

$$\Phi(t_C) = 0° \pm e$$

**⚠⚠DANGER**

**HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH**

Do not touch the network phase even though the Live/Dead indication shows that a phase is dead.

**Failure to follow these instructions will result in death or serious injury.**

When one or two phases is/are dead on either side, Sync Check will reject a close request and report an out of sync situation. When all of the phases are dead on either side, Sync Check will allow a close operation regardless of measurements and ranges. When all phases are dead on both sides, Sync Check will allow a close operation.
The PowerLogic ADVC Controller uses the Live Line Threshold setting to determine whether a phasor is dead.There may be a significant voltage level still present on the line.

## Sync Check Configuration

Once the Sync Check feature has been enabled, its settings are configured independently for each protection/detection group. However, the Voltage, Frequency and Phase ON settings are read-only and cannot be configured independently. Additionally, the Sync Check settings in the forward group are copied to the reverse group when Directional Protection/Detection is enabled.

**⚠DANGER**

**HAZARD OF UNSYNCHRONIZED NETWORK**

Perform Sync Check when there are several sources in the network and they need to be interconnect with each other.

**Failure to follow these instructions will result in death or serious injury.**

# Sync Check Settings

## Sync Check Available/Not Available

This setting makes Sync Check available or not available for configuration and operation. When this setting is set to Available, Sync Check may be configured and per unitt into service on WSOS or the O.I. If set to Not Available, Sync Check is not available for configuration or operation.

- **Type**: Configurable
- **Range**: Sync Check Available or Sync Check Not Available
- **Default**: Sync Check Not Available
- If enabled, the sync check feature will helps to prevent IEC 61850 close commands where the sources do not meet the configured Sync Check parameters
- WSOS5 incorporates Sync Check Close Retry notification.

## Sync Check ON/OFF

Setting this option to OFF means that no synchronism verification will occur before a Close operation. When Protection is ON and the Sync Check ON/OFF setting is ON, every operator close operation will be validated by the Sync Check function.

- **Type**: Configurable
- **Range**: Sync Check ON or Sync Check OFF
- **Default**: Sync Check OFF

## Sync Check Active/Inactive

This setting is only displayed on the O.I.s to indicate if the Sync Check functionality is operational.

- **Type**: Read only

## Phase Compensation ON/OFF

Setting this option to OFF means that the Sync Check function will not take into account the closing time of the switchgear and if there is a difference between frequencies it is possible that the phase angles can be out of sync when the switchgear contacts close. Setting this option to ON means that Sync Check will compensate for the time it takes for the switchgear to close and the phase drifting due to the frequency difference between the two sides when a manual close is issued. It is usually recommended that Phase Compensation be enabled.

- **Type**: Configurable
- **Range**: Phase Compensation ON or Phase Compensation OFF
- **Default**: Phase Compensation ON

## Automatic Close Retry ON/OFF

When this option is set to OFF, the Sync Check function will not retry the close operation if the original request is denied. When this option is set to ON the Sync Check will close the switchgear if the source and load become synchronized within the retry period.

- **Type**: Configurable
- **Range**: Retry ON or Retry OFF
- **Default**: Retry OFF

## Automatic Close Retry Period

When Automatic Close Retry is ON, this setting provides the time period after a rejected close operation by Sync Check within which the close operation is performed if voltage, frequency and phase become synchronized. The Retry Period setting defines the time period after a close request was issued on unsynchronized conditions during which the Automatic Close Retry functionality may close if synchronism is detected.

- **Type**: Configurable
- **Range**: 1 to 600 s
- **Default**: 300 s

When PMSet U Series switchgear is used with external CVT's there exist an error of up to approximately 3% between the voltage measured by the internal CVT's and the external CVT's. This error is due to the temperature difference that can exist between the different CVT's. It is recommended that an allowed voltage amplitude difference of at least 0.05 per unit be selected.

## Allowed Voltage Difference

This setting provides the voltage difference in per unit(12) values within which a close operation is allowed.

- **Type**: Configurable
- **Range**: 0.02 per unit to 0.50 per unit
- **Default**: 0.02 per unit

## Allowed Voltage Minimum

This setting provides the minimum voltage limit in per unit values above which a close operation is allowed.

- **Type**: Configurable
- **Range**: 0.50 per unit to (Allowed Voltage Max – Allowed Voltage Difference)
- **Default**: 0.50 per unit

## Allowed Voltage Maximum

This setting provides the maximum voltage limit in per unit values below which a close operation is allowed.

- **Type**: Configurable
- **Range**: (Allowed Voltage Minimum + Allowed Voltage Difference) to 2.00 per unit
- **Default**: 2.00 per unit

## Allowed Frequency Difference

This setting provides the maximum allowed frequency difference in Hz within which a close operation is allowed. The allowed frequency difference is constrained by the allowed phase difference.

- **Type**: Configurable
- **Range**: 0.04 Hz to 2.20 Hz
- **Default**: 0.10 Hz

(12) Per unit of the nominal voltage setting.

## Allowed Frequency Minimum

This setting provides the minimum frequency limit in Hz above which a close operation is allowed.

- **Type**: Configurable
- **Range**: 45 Hz to (Allowed Frequency Max – Allowed Frequency Difference)
- **Default**: 45 Hz

## Allowed Frequency Maximum

This setting provides the maximum frequency limit in Hz below which a close operation is allowed.

- **Type**: Configurable
- **Range**: (Allowed Frequency Min + Allowed Frequency Difference) to 65Hz
- **Default**: 65 Hz

## Allowed Frequency Rate of Change

This setting provides the maximum allowed frequency rate of change in Hz/s below which a close operation is allowed.

- **Type**: Configurable (WSOS only)
- **Range**: 0.05 Hz/s to 0.50 Hz/s
- **Default**: 0.10 Hz/s

## Allowed Phase Difference

This setting provides the maximum allowed phase angle difference in degrees within which a close operation is allowed. The allowed phase difference is constrained by the allowed frequency difference. Note that the effective allowed phase difference is smaller to compensate for measurement errors.

- **Type**: Configurable
- **Range**: 2° to 90°
- **Default**: 6°

**⚠WARNING**

**HAZARD OF UNEXPECTED EQUIPMENT OPERATION**

- Generator must not connect to a grid with a large phase angle differences.
- Person must stay away from the generator.

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

## Nominal Phase to Earth Voltage

This setting is a duplicate of the Nominal Phase to Earth setting displayed on the measurement pages. Changing either setting changes the other.

- **Type**: Configurable
- **Range**: 2000 V to 25000 V
- **Default**: 6300 V

# Status Indication

**Synchronization** indicators on the Measurement page in WSOS provide a quick visual check of the current synchronization status of the load and source voltages.

Status is displayed using four indicators for **Global**, **Voltage**, **Frequency**, and **Phase**.

When the indicators for all three components are green the source and load side supplies are synchronized. In this case the Global indicator will also be Green.

A component is synchronized when it is within the configured limits.

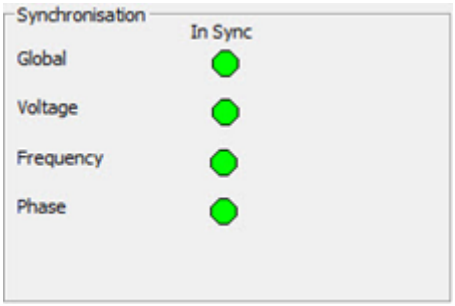



**Figure 231**
Synchronization Status displayed by WSOS

One or more components out of sync will cause the Global indication to appear out of sync as well as shown in the figure below.

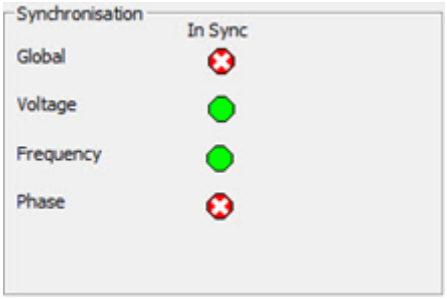



**Figure 232**
Out of Sync indications displayed by WSOS

Synchronization status indicators can also be viewed on the ***flex*VUE** O.I. at:

**Engineer Menu** > **Measurement Menu** > Synchronisation.

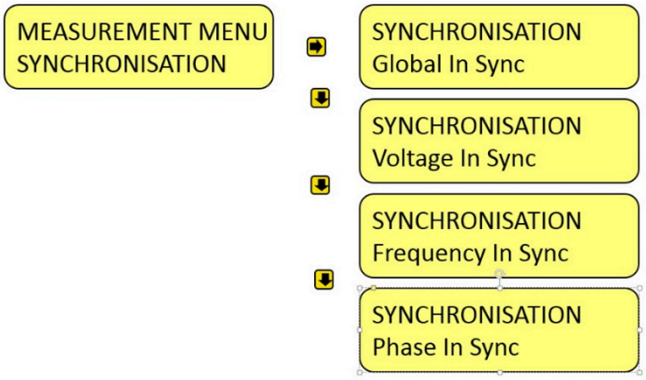



**Figure 233**
Synchronization Status Indications on the ***flex*VUE** O.I.

Synchronization status indications appear on the ***set*VUE** O.I. in the Measurement menu.

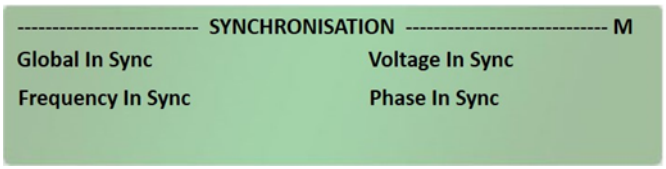



**Figure 234**
Synchronization Status Indications on the ***set*VUE** O.I.

## Synchronization Status Indicators

### Global In Sync

Indicates when voltage, frequency and phase elements are all in sync.

- **Type**: Status
- **Range**: True/False (green/red)

### Voltage In Sync

Indicates when source and load voltage amplitudes are in sync.

- **Type**: Status
- **Range**: True/False (green/red)

### Frequency In Sync

Indicates when source and load frequencies are in sync.

- **Type**: Status
- **Range**: True/False (green/red)

### Phase In Sync

Indicates when source and load phases are in sync.

- **Type**: Status
- **Range**: True/False (green/red)

# Standards and Guidelines

The Sync Check functionality it the PowerLogic ADVC Controller Range complies with the requirements of IEEE 1547-2003 standard section 5.1.2 A – Synchronous interconnection to a EPS, or an energized local EPS to an energized Area EPS.

**Table 88 IEEE 1547 – 2003 EPS/DR Interconnection Requirements**

| Aggregate rating of DR units (kVA) | Frequency difference (Δf,Hz) | Voltage difference (ΔV, %) | Phase angle difference (ΔØ, °) |
|---|---|---|---|
| 0–500 | 0.3 | 10 | 20 |
| 500–1500 | 0.2 | 5 | 15 |
| 1500-10000 | 0.1 | 3 | 10 |

It also complies with the requirements of major diesel generation device vendors:

**Table 89 Diesel generator vendor guidelines for synchronous interconnection**

| Frequency difference (∆f,Hz) | ROCOF (Hz/s) | Voltage difference (∆V, %) | Phase angle difference (∆Ø, °) |
|---|---|---|---|
| 0.1 Hz | 0.1 Hz/s | 3% Generator-Mains | 5° Daily Interconnections(13) |
| | | 0.5% Generator - Generator | 10° Infrequent Interconnections |
| | | | 15° Gas Engine Interconnection |

More information on the Sync Check feature for the PowerLogic ADVC Controller can be found in the Sync Check Technical Manual.

(13) To achieve this phase angle difference requirement, the allowed frequency difference on the PowerLogic ADVC Controller Range Sync Check needs to be set to 0.09 Hz.

# Automation

## What's in This Chapter

Loop Automation ..... 434
LA Configuration ..... 456
Auto Changeover (ACO) ..... 462

# Loop Automation

## Introduction

Loop Automation (LA) is Schneider Electrics fault detection, isolation and restoration (FDIR) system for overhead ACR and AS.

## Loop Automation Logic

LA can automatically reconfigure a network to return supply to fault free sections that have lost supply due to a fault in another part of the network. It achieves this through the following steps:

- Isolate the faulted section.
- Reconfigure the network so that the un-faulted sections receive supply.
- Automatically restore the normal configuration when the fault has been removed.

LA can be configured to operate according to either Classic or Intelligent logic.

## Classic LA

Classic LA s the original implementation. In a Classic LA scheme each ACR or AS is configured as a particular device type and operates independently according to the rules for that type. Classic LA does not require communications between devices and utilities with or without SCADA can easily introduce Classic LA into most ring networks without having to add any additional equipment. Classic LA is a software feature. The distributed intelligence embedded in each device operates the scheme using built-in voltage detection.

## Intelligent LA

Intelligent LA represents an evolution of the Classic LA algorithm. Intelligent LA also requires each device to be assigned a device type but in addition utilizes peer-to-peer communications between devices to help prevent the possibility of a device closing onto a detected fault while the network is being reconfigured. The implementation of Intelligent LA may require that additional communications equipment is installed in each device.

## Device Types

Both Classic and Intelligent LA schemes require that each device be assigned a particular device type depending on its position in the network. Each device, whether an ACR or AS needs to be configured as one of the following:

- **Feeder** – This device is positioned closest to the substation or source of supply. A LA scheme would have at least two Feeder type devices, one for each source.
- **Tie** – This device is used where two feeders meet and is normally the open point in the network.
- **Mid-Point** – A device positioned anywhere on the network between a Feeder and a Tie is a Mid-Point device. A LA scheme can have multiple Mid-Point devices.

An example of a LA scheme with two Feeder ACR’s, three Mid-Point ACR’s and one Tie ACR is shown in the figure below.

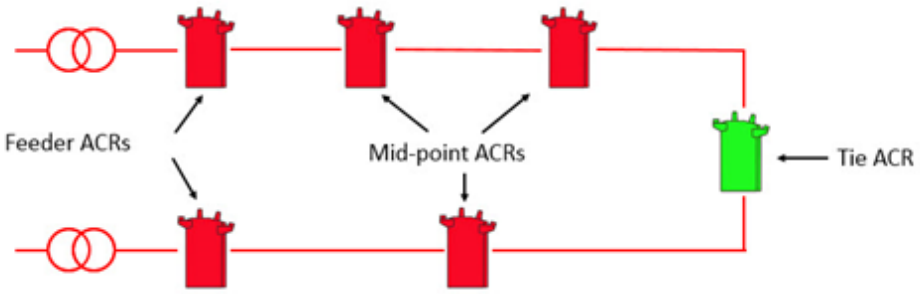


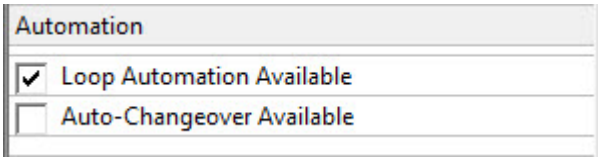

**Figure 235**
LA scheme example with device types shown

# LA Feature Selection

If LA is required to be used it must firstly be made available.

This can be done in WSOS on the Feature Selection page:

**Display** > **Configuration** > **Feature Selection** > **Automation**.




LA can also be made available for ACR or AS on the O.I.

**NOTE:** LA cannot be made available if another automation feature that is ACO is already available.

# LA Display

Once LA has been made available it can be configured in WSOS by going to:

**Display** > **LA** > **Display**.

The LA display page opens with Classic logic and Tie device type selected by default.

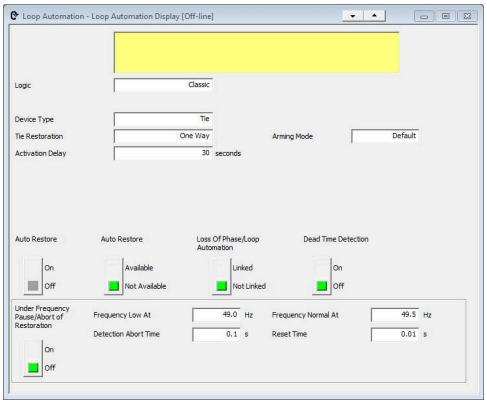



**Figure 236**
Default Classic LA WSOS display page

Changing the Logic setting to Intelligent changes the display page as shown below.

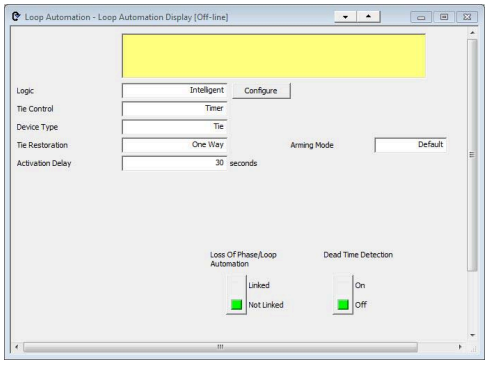



**Figure 237**
Default Intelligent LA WSOS display page

LA can also be configured on the operator interface.

# Intelligent LA Communications

When LA is configured for Intelligent logic, each device requires its communications parameters to be configured.

In WSOS the LA Communications page can be opened by going to:

**Display** > **LA** > **Communications**.

The parameters to be configured will depend on the device type and tie control. Communications parameters for Feeder and Mid-Point devices will also differ according to the downstream device type.

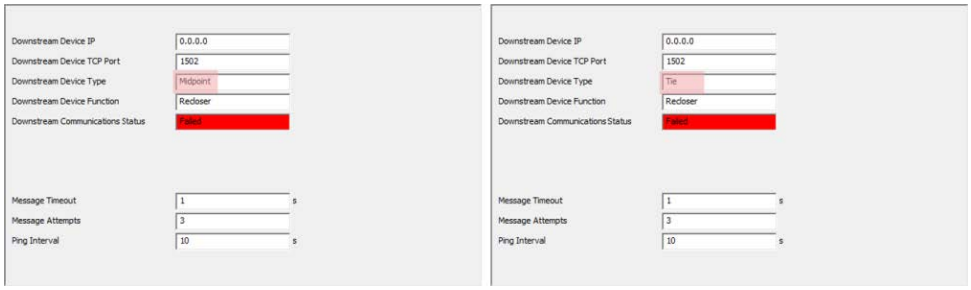



**Figure 238**
Intelligent LA Communications for a Feeder with Mid-Point and Tie downstream devices and Message Tie Control

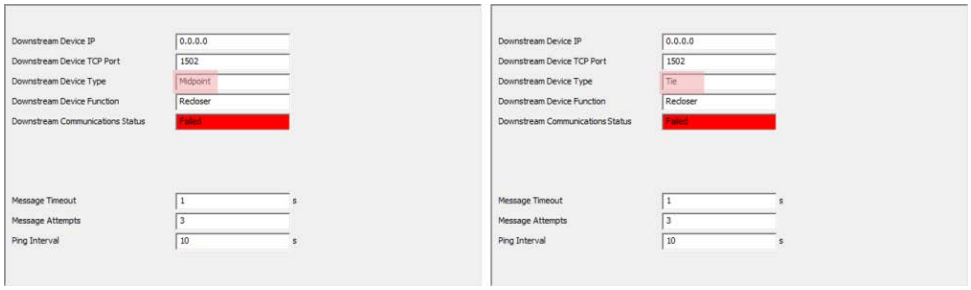



**Figure 239**
Intelligent LA Communications for a Feeder with Mid-Point and Tie downstream devices and Timer Tie Control

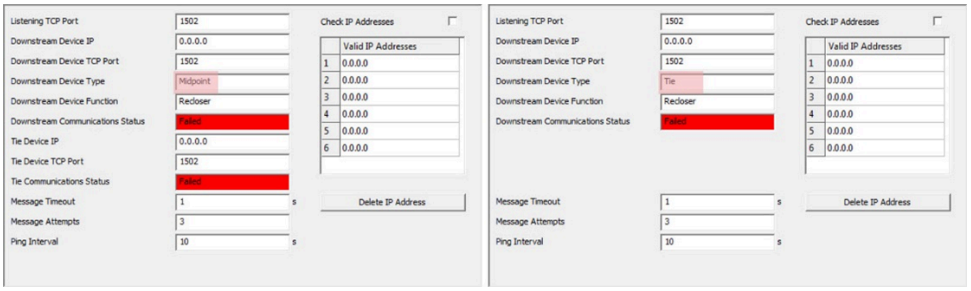



**Figure 240**
Intelligent LA Communications for a Mid-Point with Mid-Point and Tie downstream devices and Message Tie Control

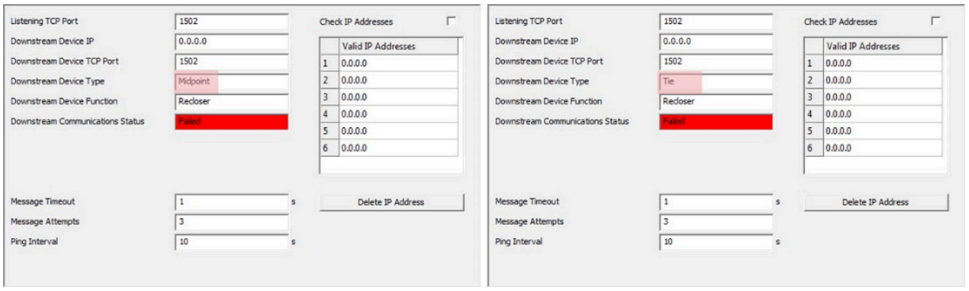



**Figure 241**
Intelligent LA Communications for a Mid-Point with Mid-Point and Tie downstream devices and Timer Tie Control

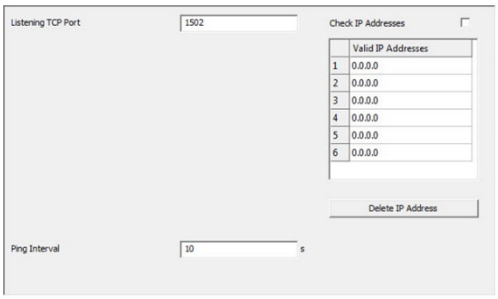



**Figure 242**
Intelligent LA Communications for a Tie with Message or Timer Tie Control

Intelligent LA communications parameters can also be configured on the operator interface.

For a description of the settings on these pages, see Intelligent LA Communications Parameters, page 461.

# LA Basics

## Purpose of the Feeder Device

The Feeder device is always the one closest to the source of supply and must never feed power in the reverse direction. This is the purpose of Item A.RULE A, page 445 to isolate the source when it is not available so that LA does not try to feed power back into it. Conversely, a Mid-Point device can feed power in both directions. Therefore, there is no need for a network to have a Mid-Point device but must always have a Feeder device for each source of supply. Ideally, the Feeder device is also the substation circuit breaker as this allows maximum coverage of the network by the scheme.

## Asymmetric Tie Operation

It may not be desirable to reconfigure the network on both sides of the Tie point in some networks. For this reason, the Tie device has the option to close automatically only if the Load Side Supply is not available. This is called the Tie Restoration setting which can be either One Way or Both Ways.

## Loss of Substation Supply

This can happen due to a transformer fault of a fault on the transmission line feeding the substation. In this case when both feeders in a LA scheme originate from the same de-energised substation, the Feeder devices trip according to Item A.RULE A, page 445. The Tie device will not close as it has lost supply to both sides. When the substation is reenergized, supply will initially only return to the open Feeder devices. However, if Auto Restore is On, the Feeder devices will close according to restoration Item F. RULE F, page 445 and energize both feeders up to the Tie device.

## A Note about Protection Groups

**⚠⚠WARNING**

**HAZARD OF INCORRECT SETTING IN TIE ACR**

Correct setting groups must be set up in Tie ACR for correct coordination when the network is fed in reverse direction.

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

After the isolation and reconfiguration process, the Mid-Point ACR is running on the alternate or reverse setting group. These settings must have been set up for correct coordination for when the network is fed in this *reverse* direction. Ensuring that the Tie device has the correct settings depends on which side is detected as having lost supply. If supply is lost on the Load side, the forward group must be active when it closes. If supply is lost on the Source side, the reverse group must be active when it closes.

## A Note about the LA Activation Delay

LA is normally triggered in a device by supply voltage being lost or restored to the terminals of that device. Loss and restoration of supply also occurs during a normal Auto-Reclose sequence. Therefore, to help prevent LA from being triggered during the normal Auto-Reclose sequence, there is a time delay which must elapse before the LA algorithms start. This time delay is called the LA Activation Delay and must be set to a greater duration than the longest Auto-Reclose sequence that could occur.

When supply is lost, the Feeder and Mid-Point devices must operate according to RULES Item A.RULE A, page 445 and Item B.RULE B, page 445 before the Tie closes according to Item C.RULE C, page 445. To achieve this coordination, the LA Activation Delay must be set for a longer period for the Tie than for the other devices.

The LA Activation Delay may typically be set for 30 s in the Feeder and Mid-Point devices and 40 s in the Tie device.

# Classic LA Operation

## The Classic Re-configuration Rules

The basic rules of LA, The Classic Rules, which cause isolation and reconfiguration are as follows:

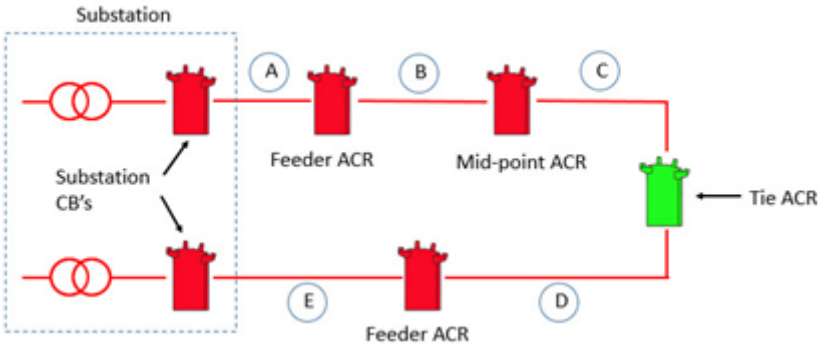
1. A Feeder device trips when there is no supply.
2. A Mid-Point device changes to the alternate Protection Group and changes to single-shot mode for a short time if there is no supply.
3. A Tie device closes when it detects that supply to one side of the network is not available providing supply is available on the other side.

These simple rules can isolate and reconfigure the network for all possible faults detected.

**NOTE:** The rules above are a simplification. For all the rules in detail, refer to Appendix L.1 Loop Automation Operating Rules, page 688. For more information on LA with AS rules, refer to Appendix L.3 Network Configuration Example, page 692.

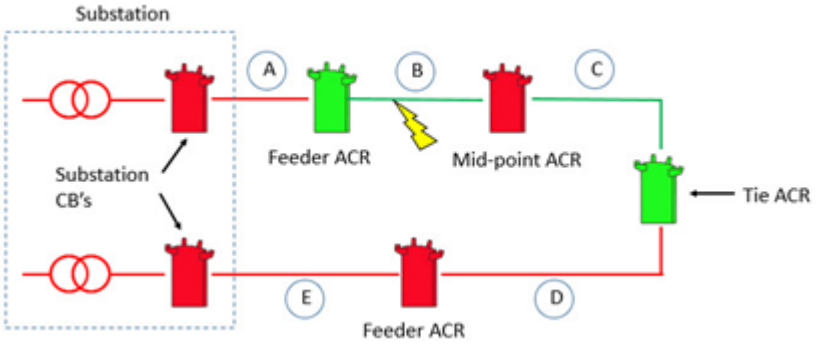
## Classic Isolation and Re-Configuration Example

Consider the basic LA scheme depicted below that consists of two Feeder devices, One Mid-Point and one Tie device creating five sections of feeder A – E.

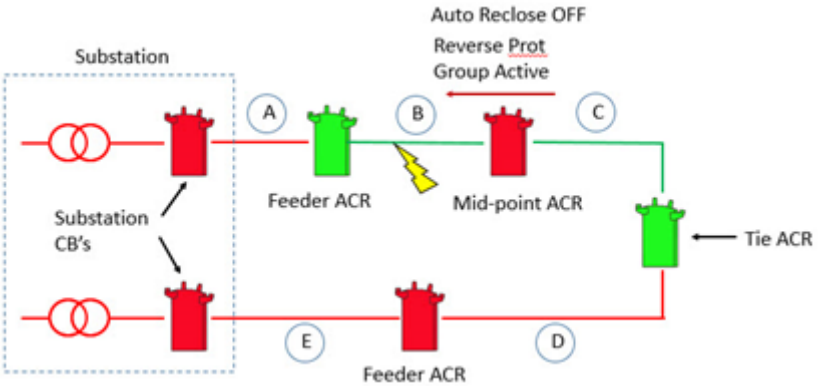



With Classic LA enabled, a fault in Section B would initiate the following sequence.

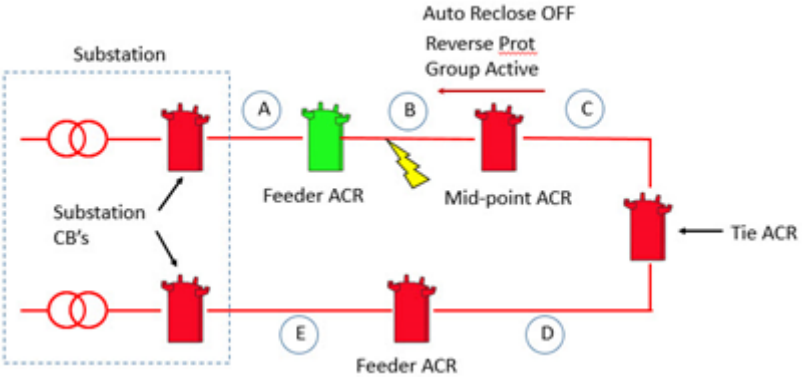
- Overcurrent protection trips the Feeder ACR upstream from the fault. Note that this just a normal protection operation, not a LA function.



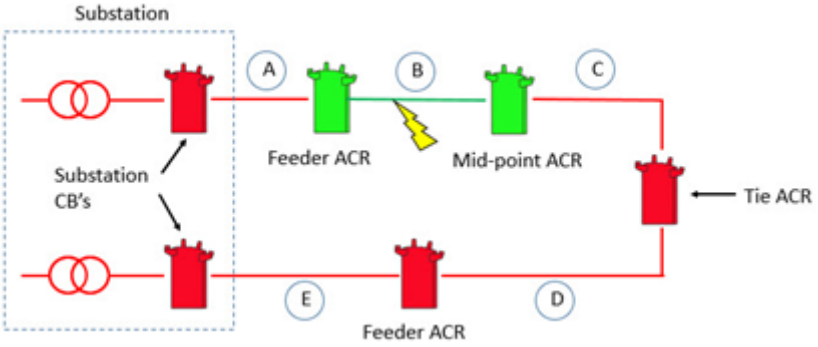
- The feeder ACR may trip and auto reclose a number of times in anticipation of the fault clearing. When the auto reclose sequence has finished and the ACR has gone to lockout, section B (faulted) and section C (un-faulted) are both without supply. LA then changes the Mid-Point ACR to the alternate (reverse) protection group and turns Auto Reclose Off temporarily according to Item B.RULE B, page 445.




- LA then closes the Tie ACR according to Item C.RULE C, page 445.




- The Mid-Point ACR trips due to protection when the fault in section B is reenergized and goes directly to Lockout.




- This action isolates section B and reconfigures the network to provide supply to section C.

## Fault Detected in Section A – Classic LA

In this scenario, the circuit breaker at the substation trips and source supply is lost to the Feeder ACR between sections A and B which then trips according to Item A.RULE A, page 445. The Mid-Point ACR between sections B and C also loses supply on its source side causing it to change to the alternate protection group and go to single shot mode according to Item B.RULE B, page 445.

Similarly, supply is also lost to one side of the Tie ACR which now closes according to Item C.RULE C, page 445, and restores supply to the un-faulted B and C sections.

**NOTE:** In this example, the Tie ACR did not close onto a detected fault. After a short delay the Mid-Point ACR will come out of Single Shot mode and be ready to auto reclose if a new fault is detected on section B.

## Fault Detected in Section C – Classic LA

A fault in section C would cause the Mid-Point ACR closest to the Tie to trip. This would cause a loss of supply on one side of the Tie which would then close onto the fault according to RULE C. The Tie ACR would have set single shot mode before it closed so would have gone to lockout when it tripped.

**NOTE:** Since the fault is located in the last section of line before the open point, there is no section that can be restored by LA.

## Faults Detected in Sections D and E

These are similar to faults in sections A and C and are isolated and reconfigured in a similar manner.

## The Classic Restoration Rules

The process of isolating the detected fault and reconfiguring the network to bring supply back to the fault free section is the primary function of LA.

In addition, LA can Auto-Restore the original network configuration when the detected fault on section B in the example above is removed. The basic rules for restoration are:

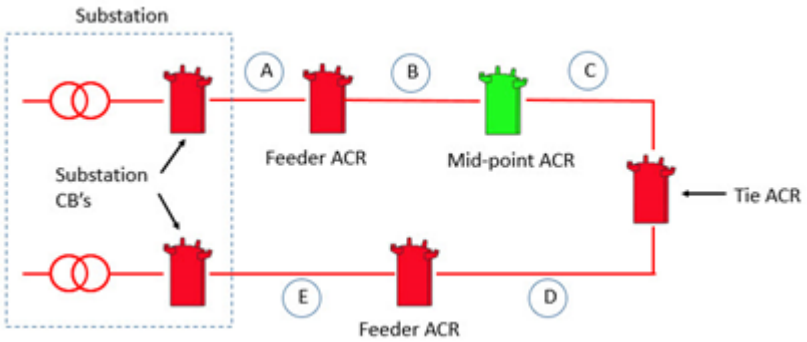
**D**. A Mid-Point ACR closes when supply is restored to both sides.

**E**. The Tie ACR trips when power flow reduces by 50% or power flow direction through the switchgear reverses.

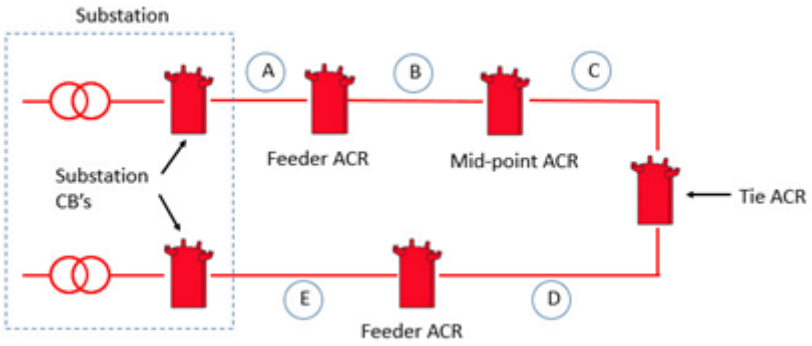
**F**. The Feeder ACR closes when its source supply is restored, providing it was tripped by LA, or when supply is restored on both sides.

## Classic Auto Restore Example

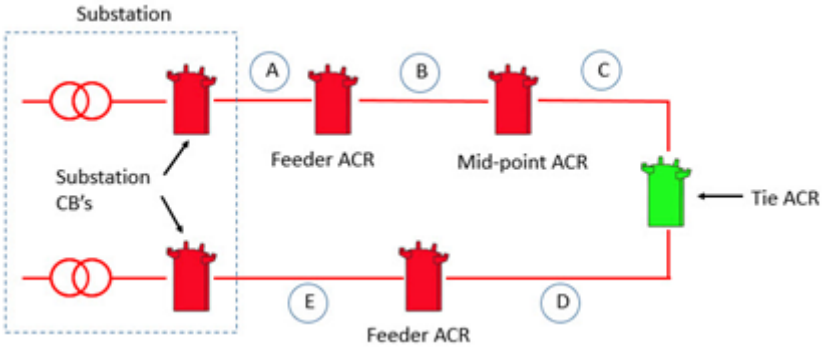
The restoration process starts when the fault is removed and one of the open ACRs is manually closed. In this example the Feeder ACR is manually closed.



- The Mid-Point ACR detects that supply is present on both sides and closes according to Item D.RULE D, page 445.




- Section C is now fed through the Mid-Point as well as the Tie ACR which causes the Tie ACR to open according to Item E.RULE E, page 445.




**NOTE:** Auto Restore is an option. Manual restoration may be preferred in some situations. If the network cannot run as a closed loop, then Auto Restore cannot be used and must be turned OFF.

**NOTE:** Auto Restore is only available for the Classic LA application.

# ACO using Classic LA

## Overview

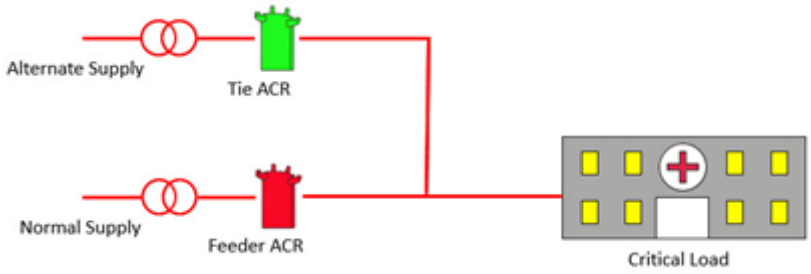
Classic LA can help ensure that supply is provided to a vital load (for example, a hospital) by implementing an ACO scheme with Make before Break restoration that does not rely on communications between devices. This scheme helps to ensure that the vital load maintains supply providing either the normal or alternate supply is available.

## ACO Configuration

The scheme must be set up as shown in the figure below.

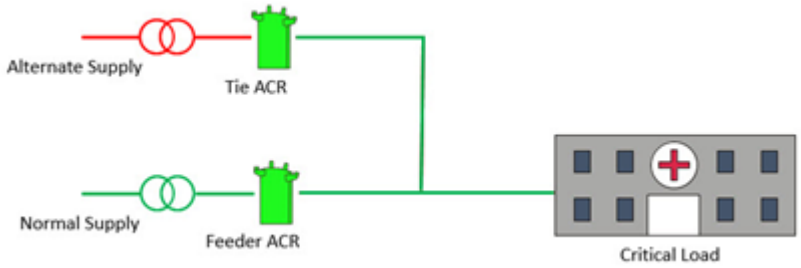
The ACR on the normal or preferred supply must be configured as a Feeder type and the ACR on the alternate supply must be configured as a Tie.

The Tie ACR must be configured to *Tie Restore One Way*. This helps to ensure that the Tie ACR does not close to back-feed the alternate supply if it is not available.

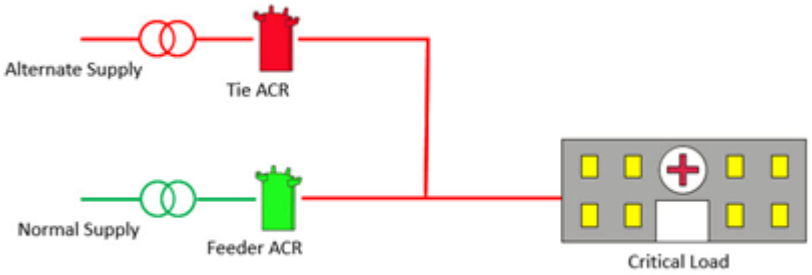



## ACO Operation

- If the normal supply is lost, the Feeder ACR will detect loss of supply on its source side and trip according to Item A.RULE A, page 445. The critical load will experience a temporary loss of supply.



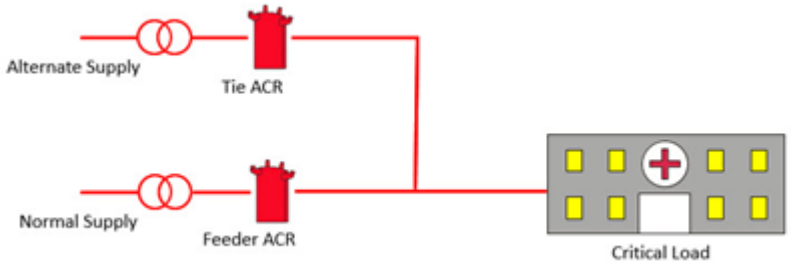

- The Tie ACR will now detect a loss of supply on its load side and close according to Item C.RULE C, page 445. This restores the supply to the critical load from the alternate supply.



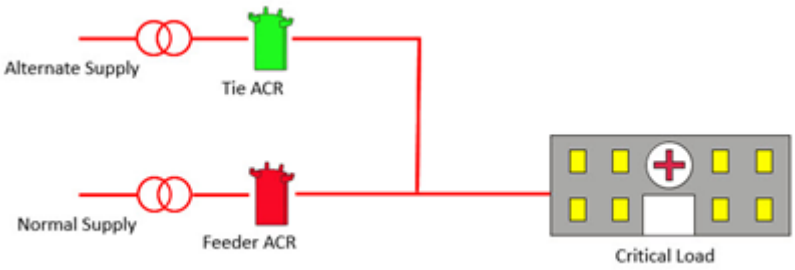

## ACO Restoration

Make before Break restoration can be achieved using Classic LA functionality.

- If the normal supply returns, supply will be restored to the sources side of the Feeder ACR and it will close according to Item F. RULE F, page 445.



- Once the normal supply takes up its share of the load, the Tie ACR will trip according to Item E.RULE E, page 445.




**⚠WARNING**

**HAZARD OF UNEXPECTED EQUIPMENT OPERATION**

- Generator must not connect to a grid with a large phase angle differences.
- Person must stay away from the generator.

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

## Pros and Cons of using LA for ACO

There are some points to be considered when using LA in an ACO scheme:

- **Advantage**: No communications between ACR's is required.
- **Disadvantage**: Only Make before Break restoration is available.

# Intelligent LA Operation

## Intelligent LA Enhancements

The Intelligent LA feature has been enhanced to allow users helps to prevent a feeder device from tripping or a mid-point device from selecting its alternate protection group, after its LA Timer has expired following a loss of supply, if the supply has been lost to both sides of the corresponding Tie device in the network. This setting may be useful where the Tie device is supplied from a common source.

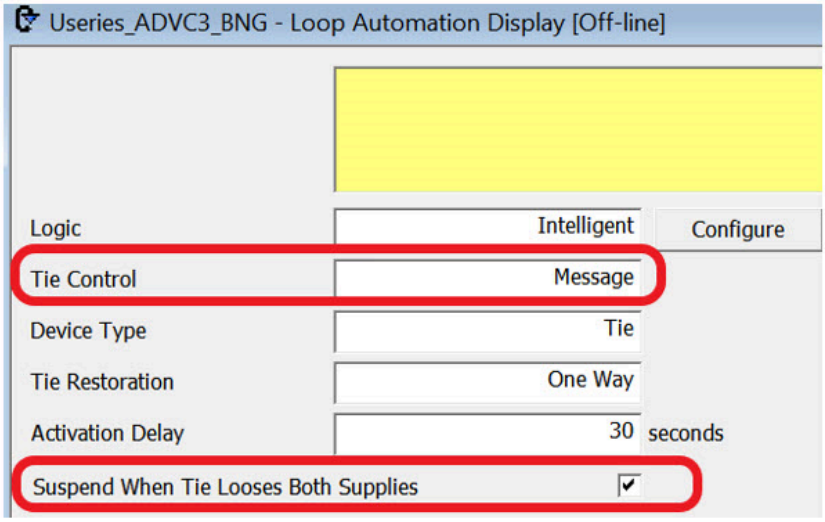



**Figure 243**
Intelligent LA configuration for suspend when Tie loses both supplies

The Suspend When Tie Looses Both Supplies setting can only be enabled if Tie control is selected as Message. To help prevent a feeder device tripping or a mid-point from selecting its alternate group when supply has been lost on both sides of the Tie, the Suspend When Tie Loses Both Supplies setting must be configured at the Tie and all other devices in the scheme. This is verified as part of the iLA scheme validation tool. If enabled, and if the Tie loses supply to both sides, the Tie will send a Suspend message to all upstream devices in the scheme.

Range: On/Off

Default: Off

The Feeder and Midpoint devices suspend operation when this setting is enabled after they lose supply and receive a Suspend message from the Tie.

If the supplies are restored to both sides, the LA goes back to normal on all devices.

If the supply is restored to one side only of the Tie, a message is sent by the Tie to the upstream devices (Feeder and Midpoints) on the side where supplies remain off, confirming supply can be restored from the Tie. On receipt of this message the feeder which has lost supply will trip open, Midpoint devices which have lost supply will change protection group and send a close request to the Tie. The Tie will close to restore the supply to that section of network. If there is loss of communication either when the iLA timers are timing or after receipt of the Suspend Loop Auto message from Tie, the scheme defaults to the original behavior. That would mean that in case of loss of communication when Feeder detects a loss of communications while suspended, it would then trip and turn LA OFF, and similarly a Midpoint will select its alternate protection group and disable iLA.

- Firmware (A50-15.04) and above must be used on all the devices in the scheme.
- The PING interval must be less than the Activation Delay.

## Intelligent Re-Configuration Rules

Intelligent LA can operate in a more informed fashion than Classic due to communications between devices.

It complements the basic Classic LA operation rules with the following rules for Intelligent LA.

A. When either a Feeder or Mid-Point device goes to lockout due to a protection operation, it sends a trip request to its downstream device if that device is a Mid-Point.

B. A Feeder device also sends a trip request to its downstream device if that device is a Mid-Point when it trips to lockout after losing its source supply (Classic LA Rule A).

C. If the device downstream from the locked out Feeder or Mid-Point is a Tie, the locked out device sends a close inhibit request message to the Tie. This helps to prevent it from closing onto a detected fault.

D. If Tie control mode is Message, and the device downstream from the locked out device is a Mid-Point, the locked out device also sends a close request to the Tie in the scheme. A close request is sent upon confirmation of the successful operation of its downstream Mid-Point device. If this confirmation is not received, the locked out device does not send a close request to the Tie.

E. If Tie control mode is Timer, a Tie operates as per its basic Classic LA Rule C, regardless of receiving a close request or not. This mode maintains the availability of the scheme and enables an automatic attempt to restore supply regardless of the availability of the peer-to-peer communications.

F. If Tie control mode is Message, a Tie operates only if it receives a LA close request.

**NOTE:** The rules above are a simplification. For all the rules in detail, refer to Appendix L.1 Loop Automation Operating Rules, page 688. For more information on LA with AS rules, refer to Appendix L.3 Network Configuration Example, page 692.

## Timer Tie Control

The Timer Tie Control option is based on a single message sent by a Feeder or Mid-Point device which goes to lockout on a protection trip.

The message is received either by a downstream Mid-Point or Tie.

When a downstream Mid-Point receives the message, it trips once to lockout to isolate an upstream detected fault.

When a Tie receives the message, it turns LA OFF helps to prevent closing onto a detected fault.

To help prevent a Tie from closing onto a detected fault, the message needs to be sent before the Tie LA timer expires.

The LA timer starts when the device has no supply available on the first trip of the protection sequence.

The window for the message to be sent is: Tie LA delay minus protection sequence time.

Typically this is in the order of 5 s.

The sending of the message can be attempted multiple times. The attempt count and time out are configurable.

## Message Tie Control

In the Message Tie Control mode, the Tie switchgear device closing is controlled by a message.

When the Feeder or Mid-Point device goes to a protection lockout, it initially sends the same message to the downstream device as described above in Timer Tie Control.

The downstream device also reacts to the message as described in the Timer Tie Control. If the downstream device is not a Tie, an additional close message is sent to the Tie.

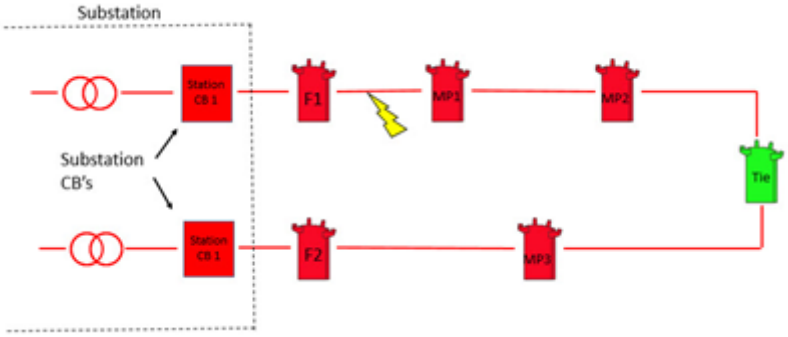
If the Tie does not receive a close message, it does not close the switchgear when it has no supply available and the Loop Automation Activation Delay, page 450 expires.

If the **close** message is not received before the LA delay expires, it turns LA OFF.

This also means that the total message retry period must be shorter than the LA Activation Delay.

# Intelligent Isolation and Re-Configuration Examples

The following examples describe the operation of Intelligent LA with Timer and Message Tie Control when a fault occurs between a Feeder (F1) and a Mid-Point ACR (MP1) on the network configuration shown below.



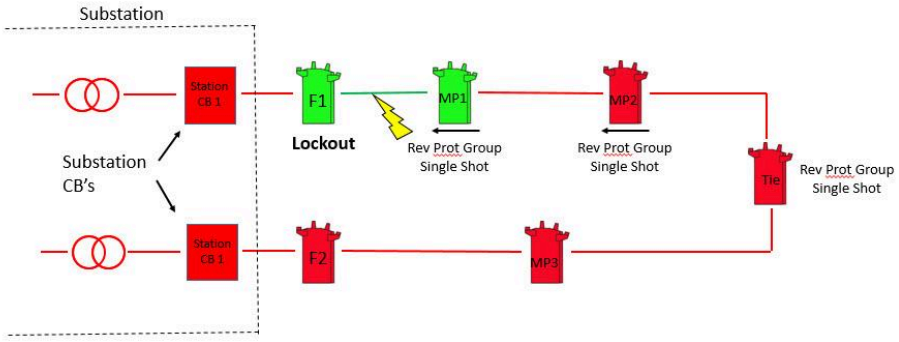

The configuration as shown consists of two feeders connected by a normally open Tie device.

The feeder from substation CB1 has one Feeder and two Mid-Point devices.

The feeder from substation CB2 has one Feeder and one Mid-Point device.

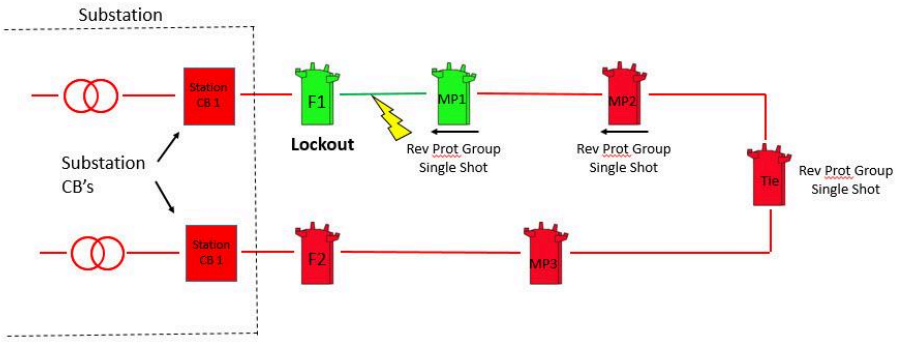
## Intelligent LA Example with Timer Tie Control

- The fault between F1 and MP1 causes the Feeder ACR overcurrent protection to trip F1. This may initiate an auto reclose sequence but because the fault is a permanent one, F1 will eventually go to lockout.
- When F1 goes to lockout it will send a trip request to its downstream device (MP1) according to ILA Item A.RULE A, page 445. At the same time, LA Activation Timers will start to run in the controllers for MP1, MP2 and the Tie device due to a loss of supply.




- Mid-Point device MP1 will change to its reverse protection group, turn Auto Reclose Off when its LA activation delay timer expires according to Classic LA Item B.RULE B, page 445 and trip providing it has received a trip request from F1.
- Mid-Point device MP2 will also change to its reverse protection group and go to single shot mode that is Auto Reclose Off when its LA activation delay timer expires according to Classic LA Item B.RULE B, page 445.

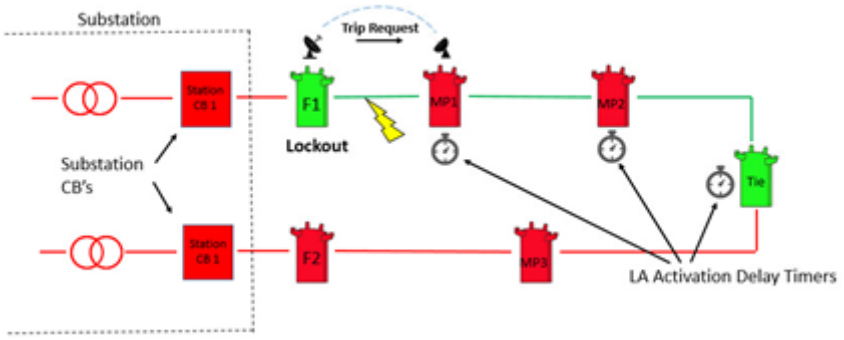
- The Tie may also change its Protection Groups, page 170 depending on which side the supply was lost (source or load) and goes to single shot mode when its LA activation delay timer expires then closes according to Classic LA Item C.RULE C, page 445 regardless of whether it received a close signal or not. Refer to ILA Item E.RULE E, page 445.




- The faulted section of feeder between F1 and MP1 has been isolated. All healthy sections of the feeder now have supply.
- Intelligent LA was able to achieve isolation of the fault and re-configuration of the network without any device closing onto a fault as is necessary in the same scenario when Classic LA is used.

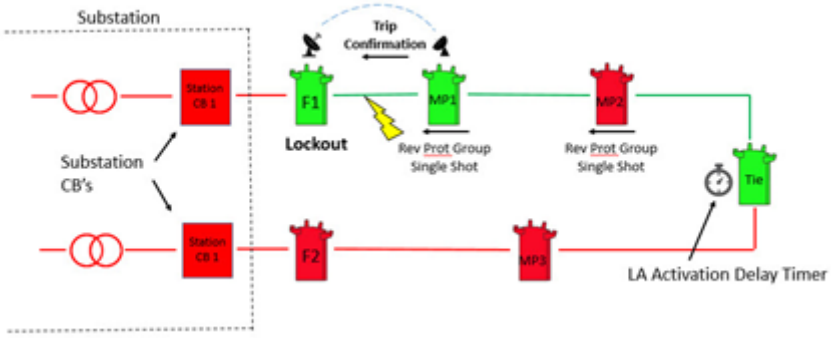
## Intelligent LA Example with Message Tie Control

- The fault between F1 and MP1 causes the Feeder ACR overcurrent protection to trip F1. This may initiate an auto reclose sequence but because the fault is a permanent one, F1 will eventually go to lockout.
- When F1 goes to lockout it will send a trip request to its downstream device (MP1) according to ILA Item A.RULE A, page 445. At the same time, LA Activation Timers will start to run in the controllers for MP1 and MP2 as well as the Tie due to a loss of supply.

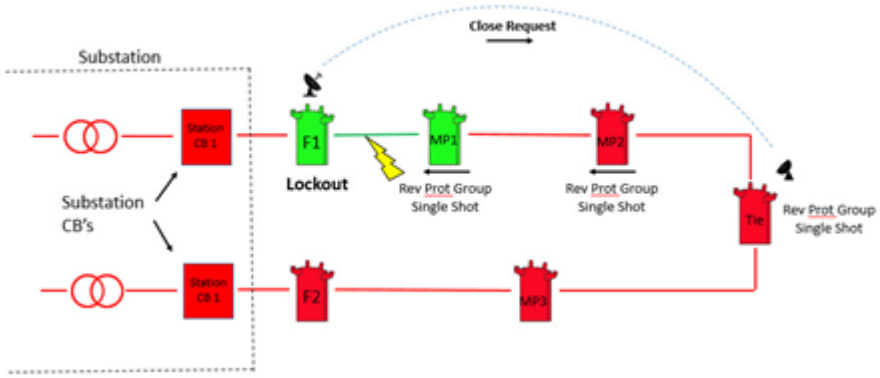



- Mid-Point device MP1 will change its active protection group and go to single shot mode when its LA activation delay timer expires and also trip providing it has received a trip signal from F1. It will then send a message back to Feeder device F1 to confirm that it has tripped.

- Mid-Point device MP2 will also change its active protection group and go to single shot mode when its LA activation delay timer expires.




- When F1 receives confirmation from MP1 that it has tripped it sends a close message to the Tie according to ILA Item D.RULE D, page 445. The Tie LA activation delay timer must be still running when the close message is received. When the timer expires, the Tie device may change its active protection group, depending on which side the supply was lost (source or load), go to single shot mode and close.




- The faulted section of feeder between F1 and MP1 has been isolated. All healthy sections of the feeder now have supply.
- Intelligent LA was able to achieve isolation of the fault and re-configuration of the network without any device closing onto a fault as is necessary in the same scenario when Classic LA is used.

## Fault between CB1 and F1 – Intelligent LA

If the Tie Control is Timer, Intelligent LA will isolate the detected fault and restore supply in the same way as Classic LA.

If the Tie Control is Message, the Feeder ACR F1 will send a close request to the Tie after its LA Activation Delay timer expires. The Tie will only close after its LA Activation Delay timer expires if it has already received a close request.

## Fault between MP1 and MP2 – Intelligent LA

If the Tie Control is Timer, MP1 will trip due to protection and send a Trip Request message to MP2. Having received the Trip Request message, MP2 will trip when its LA Activation Delay timer expires. The Tie ACR will close according to Item C. RULE C, page 445 but will not close onto the detected fault because the fault has been isolated by MP2.

The fault is isolated and supply restored to the section between MP2 and the Tie.

If the Tie Control is Message, when MP1 goes to lockout it will send a Trip Request to its downstream device MP2 and a Close Request to the Tie.

MP2 changes protection groups, sets single shot and trips. The Tie changes protection groups if required, sets single shot mode and closes to energize the non-faulted section between it and MP2.

# LA LBS Support

## Firmware and Software Support

PowerLogic ADVC Controllers with firmware version A45-19.02+ support ASs with LBS switchgear in LA schemes.

LA support for ASs is available in WSOS versions 5.13.24.

## Supported Switchgear

ASs may be used in a LA scheme with the following switchgear types.

- RL Series LBS.
- PMSet U Series, PMSet UR Series and PMSet E Series (circuit breaker) switchgears.

## AS as a Feeder Device

An AS Feeder functions similarly to an ACR Feeder for an upstream fault.

Consider the LA scheme in the figure below where a fault occurs in section A.

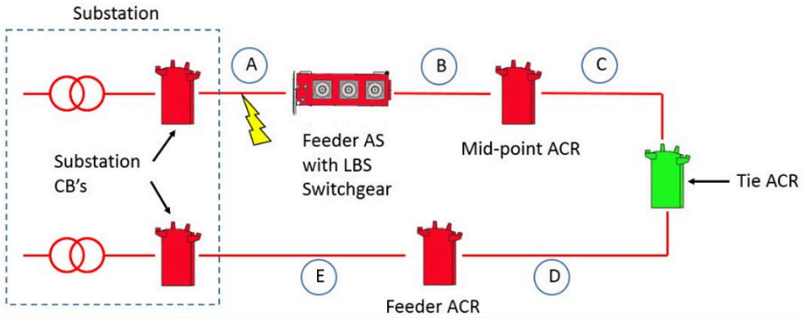



**Figure 244**
AS Feeder Device with LBS Switchgear and upstream fault

In this case, the Feeder device behaves the same as if it were an ACR.

Isolation and re-configuration events would occur in the following order:

1. The fault in section A causes overcurrent protection to trip the substation circuit breaker.
2. The Feeder AS detects a loss of source supply and will trip after the LA delay time.
3. The Tie ACR will also detect a loss of supply when the substation circuit breaker trips and do a LA close when its delay time expires.

Consider the same LA scheme in the figure below where a fault occurs downstream of the AS in section B.

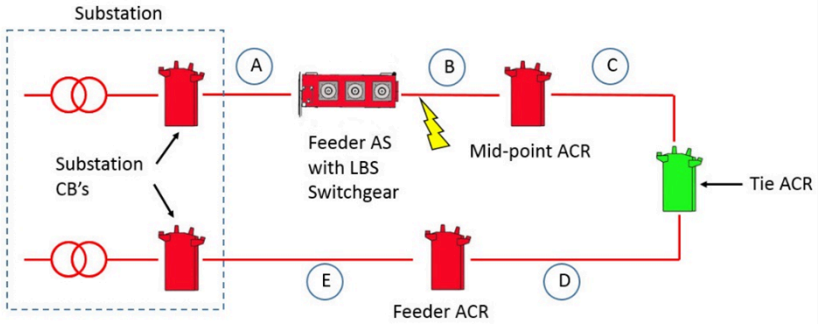



**Figure 245**
AS Feeder Device with LBS Switchgear and downstream fault

In this case the Feeder device behaves differently because its switchgear is LBS and it can't trip to break fault current. So it's still up to the substation CB to clear the fault.

However if the substation CB has reclosing capabilities and is graded with the Feeder AS, the AS will automatically sectionalise after the configured number of supply interrupts and the end result will be the same. That is, at the end of the sequence, the substation CB will be closed and the Feeder AS will be open.

If the substation CB does not have reclosing capabilities, it will trip and stay open which will remove the supply from the Feeder AS. The Feeder AS will then do a LA trip when its activation delay time expires.

The end result will be that both the substation CB and the Feeder AS will both be open and the LA algorithm will proceed.

## AS as a Tie Device

A LA scheme using an AS as the Tie device requires a trigger which, unlike the trigger for standard LA, utilizes the dead time set for the upstream ACR (its *signature*) to identify which recloser has tripped.

The Tie sectionaliser logic rules use the identification of the upstream ACR to reduce the possibility that the Tie sectionaliser will close onto a fault.

> **NOTE:** The Auto-Restoration option is not available if LA with Dead Time is in use.

A variation of Item C.RULE C, page 445 mentioned previously is introduced to cater for AS Tie devices.

**G —** A Tie ACR or AS closes when supply is lost and it has detected an *Allow Loop Auto* dead time of an upstream ACR.

## Dead Time Detection

Dead time is the duration voltage is lost at the downstream devices and is measured from when the voltages on all three phases fall below the Live Line Threshold until the voltage on one or more phases rises above the Live Line Threshold.

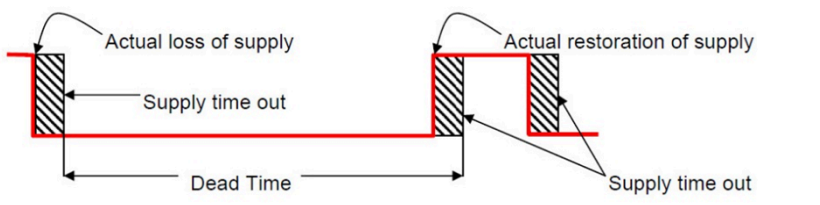



**Figure 246**
Tie Sectionaliser Dead Time Diagram

## Dead Time Trigger

The trigger is called Allow Dead Time in this document. This LA feature is capable of recognizing an Allow condition in the network.

This is done by measuring the duration of the final dead time of upstream switchgear. For instances where this dead time equals a user configurable time, the switchgear will *Allow* LA actions to take place.

Conversely, if the final dead time does not equal the allow dead time value, the Tie will take no action.

Power lost for the duration of the LA time in the Tie will cause LA to abort.

It is therefore necessary to set the normal *Loop Auto time* and also set the *Allow* dead time for the Tie ACR/AS.

- LA Activation Delay time is the delay after LA was triggered before LA actions are taken (for example, the Feeder device opens or closes). This delay helps to ensure that all the protection sequences are finished before LA reconfigures the network and the value is set as a time for example 40 s. In the Tie ACR/AS this time is also used to determine a prolonged outage and will turn LA off must power be lost for longer than the LA Activation Delay time. Loop Auto Activation Delay time must therefore be greater than the Allow Dead Time setting.
- The Allow dead time is the duration of the final upstream reclose interval that will allow LA actions to take place. This value is set as a time with a margin, for example, 25 s ± 3 s. When a value of zero (0 s) is entered, LA will ignore all dead time durations. Examples:
- Allow Dead Time = 25 s ± 3 s will describe the reclose profile in scenario A that will allow the Tie ACR/AS to close after the LA Activation Delay time.
- The Tie device can be used to restore power in both directions. Due to the possible different characteristics of Feeder 1 and Feeder 2, it is necessary to set the Allow dead time for both sides (Source and Load) of the Tie device.
- When the reclose sequence has successfully restored power after a temporary fault occurred, a LA sequence reset timer will be used in the Tie device to reset the LA sequence. This LA sequence reset timer is equal to the LA Activation Delay time plus the Forward or Reverse Margin. Forward is used when the dead time was detected on the Load side terminals. And when the Tie device is configured to restore both ways, the Reverse Margin is used for a dead time detected on the Source side terminals.

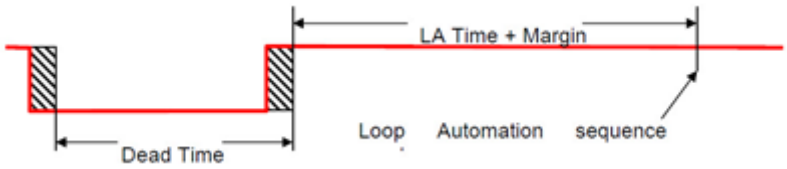



**Figure 247**
Dead Time Detection Diagram

# Understanding Isolation and Reconfiguration with Dead Time

Standard LA with ACR's uses the loss of voltage at the switchgear to trigger the specific actions taken by each device. A specific time delay (LA Activation Delay) for each device is set to help ensure that the actions taken by LA to reconfigure the network occur in the correct sequence.

For example if the power is lost at one of the substations, the Feeder device opens first, then the Mid-Point device changes direction for protection and finally the Tie device closes to restore supply. LA with dead time identifies a specific dead time and uses it to trigger the same LA reconfigurations as in the standard scheme but this can be used to reduce the possibility that the Tie ACR/AS will close onto a fault.

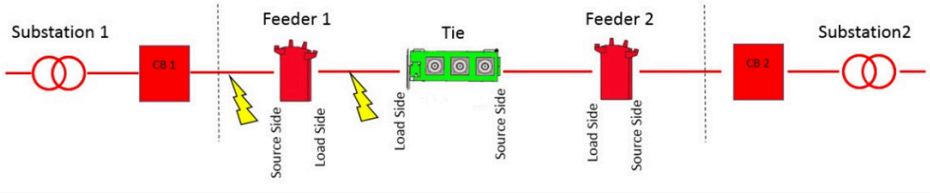
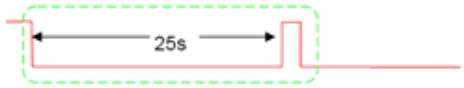
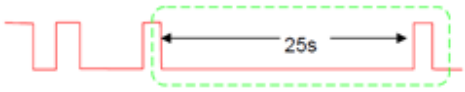
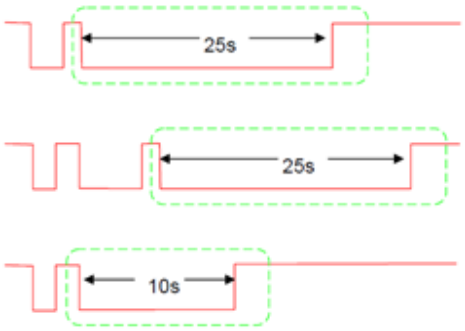
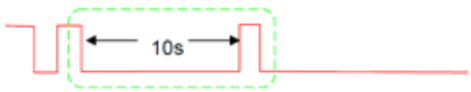



**Figure 248**
Example Scenario with a potential Tie close onto fault

The following table describes a few different reclose possibilities that could be detected by the Tie sectionaliser. In this example the Tie sectionaliser is configured with an Allow Dead Time = 25 s ± 3 s.

**Table 90 Tie ACR/AS Voltage Profiles**

| Voltage profile at Tie ACR/AS | Action | Comment |
|---|---|---|
|  | Allow | Only one reclose interval equals the Allow Dead Time |
|  | Allow | Second (last) reclose interval equals the Allow Dead Time |
|  | Allow | Third (last) reclose interval equals the Allow Dead Time |
|  | Ignore | Power is restored on the final reclose attempt<br><br>Power restored by any auto reclose action will cause LA to take no action. LA will reset if the power remains on for the duration of the LA time. |
|  | Ignore | Third (last) reclose interval does not equal the Allow Dead Time |
|  | Ignore | Second (last) reclose interval does not equal the Allow Dead Time |

## Under Frequency Pause/Abort of Tie Restoration

PowerLogic ADVC Controller firmware A45-40.00+ supports this feature on the Tie device only when the Loop Automation Logic is Classic.

## Overview

When enabled, this feature will either:

- Pause the Loop Automation Activation Delay timer

or

- Abort Tie restoration by setting Loop Automation to Off

If an under frequency condition is detected on the LIVE side of an OPEN switch during a Tie restoration.

## Description

If Loop Automation is On and the supply is lost on one side of a Tie device which still has healthy voltage on the other side, the Loop Automation Activation Delay timer will start running. If the frequency on the live side of the Tie device falls to at or below the *Frequency Low At* setting, the Loop Automation Tie restoration is constrained by holding the Loop Automation Activation Delay timer in a paused state or aborting Loop Automation by turning it Off.

- If the Loop Automation Activation Delay timer is paused for a longer time than the Detection Abort Time setting, Tie restoration is aborted by turning Loop Automation Off.
- Should the Frequency Low At condition abate during the Detection Abort Time, the detection timer is reset and the Reset Time period starts again.
- If the frequency remains at or above the Frequency Normal At threshold for the Reset Time period, the Loop Automation Activation Delay timer is resumed.

This feature can be configured in WSOS on the Loop Automation page when LA Logic is Classic and the Device Type is Tie.

**Display** > **Loop Automation** > **Display**

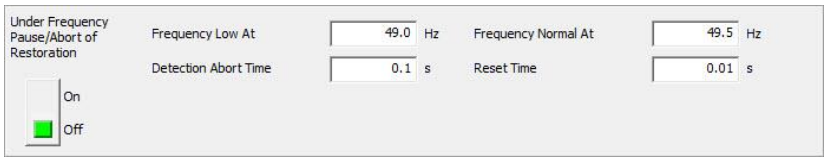



**Figure 249**
Under Frequency Pause/Abort of Restoration settings in WSOS

They can also be found on the operator interface.

# LA Software Modifications

Two modifications have been made to the LA software which can be used to change some basic functions by selecting non-default settings. These settings are:

- **Arming Mode** – for a Tie
- **Pickup** – for Feeder and Mid-Point devices

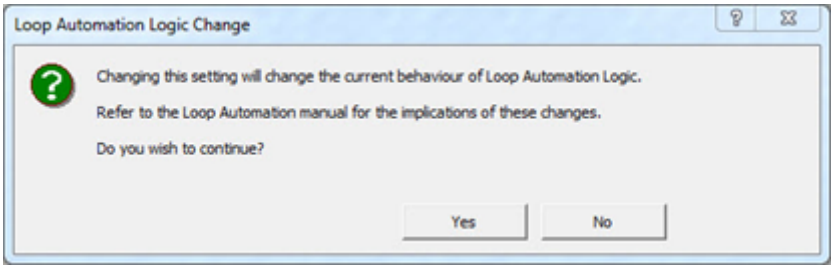
These settings can only be changed via WSOS on the LA Display page when the Protection password is active.

**Display** > **LA** > **Display**




**Figure 250**
Arming Mode and Pickup settings in WSOS

To guard against either of these settings being changed accidently, WSOS displays the message below if they are selected:




These settings also appear on the operator interface but cannot be changed, that is they are read-only.

The **Arming Mode** setting for Tie devices defaults to *Default* which is the setting required for normal LA operation.

The alternate setting is Alternate which modifies the operation of the Tie device when selected.

The Tie normally requires the voltage on its source and load terminals to be either both Dead or both Live before it will respond to a loss of supply.

Selecting Alternate for the Arming Mode will effectively ARM LA at the time it is turned on, without waiting for the conditional state of Live-Live or Dead-Dead on the Tie terminals.

The Pickup setting for Feeder and Mid-Point devices defaults to Blocks Trigger which is the setting required for normal LA operation.

The alternate setting is **Allows Trigger** which modifies the operation of the Feeder and Mid-Point devices when selected.

In normal operation, LA is suspended when a protection pickup occurs.

Setting **Allows Trigger** for the Pickup setting helps to ensure that fault protection and voltage sensing for LA remain independent and each will continue to operate regardless of the operation of the other. In other words, LA will continue to operate even when a protection pickup is active.

# LA Configuration

## Introduction

LA configuration involves assigning each device type, either Feeder, Mid-Point or Tie, setting the LA Activation Delay timers and configuring Auto-Restore if required.

It must be understood that LA relies on the basic protection being configured correctly for each device included in a LA scheme. If the protection doesn't work correctly, LA cannot be expected to work correctly either.

## LA Timing

ACRs in a LA scheme are primarily protection devices. Their purpose is to detect faults on the system and trip to disconnect that fault from the source of supply. They are normally configured to automatically reclose a number of times in an attempt to restore supply if the fault is not permanent.

If the fault does clear during the auto reclose sequence, supply will be restored and LA is not required. LA only comes into effect when the fault fails to clear during the auto reclose sequence. So the ACR must be allowed to go through its configured auto reclose sequence uninterrupted.

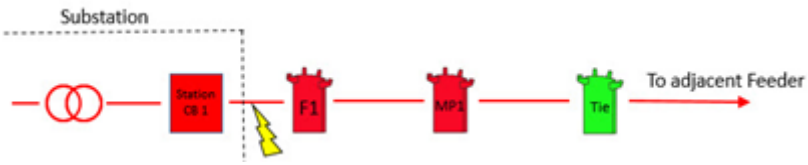
Make sure that the LA Activation Delay is set for a period greater than the longest auto reclose time, plus a safety margin of several seconds.

The LA Activation Delay for the Tie device must be set for a longer duration than the same setting in the Feeder or Mid-Point devices. This is to allow the Feeder device to open and the Mid-Point device to change setting groups and turn auto reclose off if required before the Tie closes.

Common practice is to decide on a coordination time between the various stages of the isolation and reconfiguration sequence.

## LA Timing Example

This example describes the timing that occurs for the LA scheme shown below when a permanent fault is detected between the substation circuit breaker CB1 and the Feeder ACR F1.




In this scenario the Station circuit breaker CB1 trips due to the fault, recloses once and then trips again to lockout. LA operation is described below through to when the Tie ACR closes.

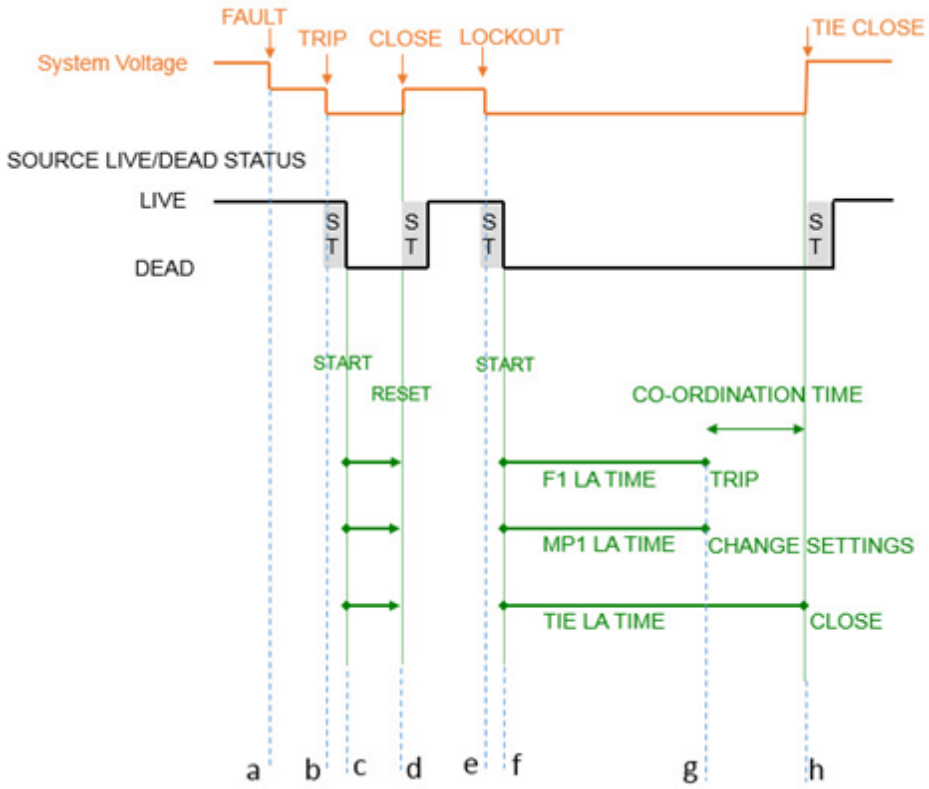



**Figure 251**
LA Timing Diagram

A. When the fault is first detected the protection timing starts and the fault causes the system voltage on the feeder to drop but remain above the Live Line Threshold setting. So the Live/Dead status doesn't change.

B. When CB1 trips the system voltage drops to zero and the Supply Timeout timer starts to run. The reclose timer also starts.

C. The Supply Timeout timer expires and the Live/Dead status changes to Dead. This starts the LA Activation Delay timers in F1, MP1, and the Tie.

D. The reclose time for CB1 expires and it closes back onto the fault which restarts the protection timing. This immediately resets the LA Activation Delay timers running in each device which were all set for a longer time than the reclose time for CB1. The Supply Timeout timer also starts to run and the Live/Dead status goes back to Live when it expires.

E. Circuit breaker CB1 trips to lockout which drops the voltage back to zero and starts the Supply Timeout timer running.

F. When the Supply Timeout expires, the LA Activation Delay timers for F1, MP1, and the Tie restart.

G. At this point, the LA Activation Delay timers for F1 and MP1 expire. This causes F1 to trip and MP1 to change its protection setting group and go into single shot mode.

H. The Tie LA Activation Delay timer expires and the Tie closes. This also starts the Supply Timeout timers running and the Live/Dead status goes back to Live when that expires.

## Points to Note:

Live/Dead status changes follow the actual voltage change on the bushings by the Supply Timeout setting value which is 4.0 s by default.

In most cases, LA Activation Delay timer activation occurs when the Live/Dead status on one side of a device changes from Live to Dead.

LA Activation Delay timer reset occurs when the device closes and does not wait for the status to return to Live.

LA timers must not be allowed to expire during a normal auto reclose sequence that is they must be set longer than the longest auto reclose time minus the Supply Timeout setting plus a safety margin.

LA times for the different types of devices need to be coordinated. The Tie needs to have a longer time than the Feeder and Mid-Point devices. In the example above the Tie LA time was longer than the Feeder and Mid-Point by an appropriate coordination time. This is to help ensure that the LA events occur in the required order.

# Classic LA Parameters

## Overview

LA incorporates a number of parameters that must be correctly configured which helps to ensure the correct operation. These parameters may be set using WSOS or the O.I. except where noted.

## Description of Parameters

Some of the following parameters are LA specific. Others are parameters that impact on LA and some are referenced in the LA Settings Record in Appendix L.3 Network Configuration Example, page 692.

**Table 91 Description of Parameters – Classic LA**

| Parameter | Description |
|---|---|
| Live Line Threshold<br>2000...15,000 V<br>Default 2000 V | Determines the voltage level at which a terminal is considered to be *live*. This value is used to generate Load/Source On/Off events that trigger LA. It must be the same value for all devices in a LA scheme.<br>Typical value is 2000 V<br>***set*VUE**: System Status Menu → Phase Voltage and Power Flow<br>***flex*VUE**: **Engineer Menu** > **Configuration Menu** > **System Settings** > **Network Parameters**. |
| Supply Timeout<br>0.1...100 s<br>Default 4 s | Determines the time between detecting a change of terminal live/dead status and generating the *Supply On/Off* event. It is this event that triggers the start of the LA timer and must be set to the same value in all devices in a LA scheme. The value of this parameter is set by utility practices. A value of 0.5 to 5.0 s is typical.<br>***set*VUE**: **System Status Menu** > **Phase Voltage and Power Flow**<br>***flex*VUE**: **Engineer Menu** > **Configuration Menu** > **System Settings** > **Network Parameters**. |
| Coordination Time (T1) | There has to be a delay between the actions of each of the LA devices. For example: the Mid-Point device must change its protection group before the Tie device closes. This is known as the coordination time. A typical time is 10 s. Minimum recommended time is 5 s. |
| Single Shot Reset Time (2 x T1) | The single shot facility is used by LA to force one shot to lockout in the Mid-Point and Tie devices prior to the Tie closing onto a faulted feeder. The Single Shot timer must be set longer than the LA coordination time (T1), twice as long is recommended.<br>***set*VUE**: **Protection Menu** > **Protection Setting 2**<br>***flex*VUE**:**Engineer Menu** > **Protection Menu** > **Protection Trip Settings** > **Single Shot** > **Reset**. |
| Maximum Sequence Time (T2) | LA must only take control after there is no possibility of the supply being restored by an auto reclose from a device. Therefore the LA Time must be longer than the maximum time the device will take to trip to lockout. This is called the Maximum Sequence Time.<br>Maximum Sequence time is determined by the protection settings and the expected fault levels. It must include the Time to Trip and the Reclose time for each reclose in a sequence. To limit the Time to Trip it may be desirable to set a maximum time to trip.<br>For example: a typical reclose sequence has an instantaneous trip, a 1 s dead time followed by a second inverse time trip with a max time of 5 s. This sets the Maximum Sequence Time to be approximately 6 s. |

**Table 91 Description of Parameters – Classic LA (Continued)**

| Parameter | Description |
|---|---|
| | If there is a possibility of low level faults with long trip time (perhaps on fused spur lines) then these can take longer than the Maximum Sequence Time provided that they do not reduce the system voltage to a level where Loss of Supply events occur. |
| ACO Time (T1 + T2) | Determines the period of time that power (greater than 50 kW) must flow in the reversed direction before an automatic change of protection groups takes place.<br>Used in the Mid-Point device to change protection settings when restoring the normal configuration, it is also used when power flows to the alternate source in a closed Tie device and LA is turned off.<br>In a LA scheme this must be long enough to allow an auto reclose sequence to finish. Therefore it must be longer than the Maximum Sequence Time (T2).<br>A time of T2 plus the Coordination Time is recommended. |
| Live Load Blocking On/Off | This setting takes priority over LA closing and must be turned Off when LA is used.<br>Factory default: OFF |
| LA Available | Enables or disables the entire LA facility.<br>This must be set to Available in all devices used in the LA scheme.<br>Factory default is Not Available. |
| Dead Time Detection On/Off<br>(This mode is only for Tie switchgear). | Turns the LA Dead Time function ON or OFF.<br>By default, Dead Time is On for a Tie on an AS and Off or a Tie on an ACR. |
| Forward Dead Time<br>Reverse Dead Time | This value is used to determine the allowable upstream device dead time for forward or reverse Tie reconfiguration. This is a value for example 25 s ± a margin (see below).<br>Factor default: 25.0 s |
| Forward Margin ±<br>Reverse Margin ± | The margin is used with the Dead Time values above. This value is typically not more than the trip time of the upstream devices.<br>Factory default: 2.0 s |
| Device Type | Determines whether the device operates as a Feeder, Mid-Point or Tie ACR device or a Tie or Feeder sectionaliser device.<br>Range: Feeder, Mid-Point, Tie<br>Factory default: Tie |
| Power Direction | Designates which terminals of the switchgear are the source and load sides in normal configuration.<br>For the Feeder device this in only important if auto restore is used.<br>For the Mid-Point device this affects the selection of the protection group. Which is set automatically by the direction of the power flow when the Tie device is closed. Therefore if the direction parameter is not right the wrong protection group will be active.<br>For the Tie device this affects the protection group selection as for the Mid-Point device and, in addition will affect the Tie Restore One Way direction. If wrongly set, then the Tie will operate for loss of supply on the wrong side.<br>This parameter can only be set after field installation when the switchgear orientation is known.<br>Range: Source 1 – Load 2 or Source 2 – Load 1 on the N Series and<br>Source I – Load X or Source X – Load I on the PMSet U, PMSet UR and RL Series<br>Factory defaults are: Source 1 – Load 2 for the N Series<br>Source I – Load X for the PMSet U, PMSet UR and RL Series. |
| Loop Auto Time (Activation Delay) (LA) | Determines the delay after a Supply On/Off event before the LA program takes action. The same time out value is used both when supply is lost and during an Auto Restore operation.<br>Range: 3 to 1800 s<br>Factory default: 30 s |
| Auto Restore Available | Enables or disables the Auto Restore facility. This is a security feature that helps to ensure the Auto Restore features cannot be turned on unless this field is first set to Auto Restore Available.<br>The network must be able to operate closed if Auto Restore is used.<br>Range: Available, Not Available |

**Table 91 Description of Parameters – Classic LA (Continued)**

| Parameter | Description |
|---|---|
| | Factory default: Auto Restore Not Available |
| Tie Restore | Only applies to a Tie device.<br>This field is only displayed if Device Type is set to Tie ACR. This field sets whether a Tie ACR reconfigures supply in both directions, or just from Source to Load.<br>Set Tie Restore Both Ways if you want to restore symmetrically across the Tie device.<br>Range: One Way, Both Ways<br>Factory default: Tie Restore One Way |
| LA On/Off | Turns the LA function On or Off.<br>Range: LA On, LA Off<br>Factory default: LA Off |
| Arming Mode<br>(configurable via WSOS only) | **Default** mode causes LA to operate only when a loss of voltage occurs after there has been Live voltage whilst LA is active.<br>**Alternate** mode can be used by a Tie device to allow LA to respond to logic conditions that exist when LA is turned on. For example, if LA is turned On while the Tie device is live on the source and dead on the load, the LA timer would start.<br>Alternate mode may avoid the problem of manually closing a Tie while an upstream device is mid sequence. A Tie device with Live/Dead condition is closed while the upstream device is in the middle of a reclose sequence, causing potentially 2 out of phase networks to be connected.<br>(Using the Alternate mode resolves this as the LA time of the Tie is always configured to be greater than the sequence time T2 of the upstream devices sequences).<br>**Warning:** alternate mode may cause turning LA on to close the switch before any loss of supply events are generated. |
| Pickup<br>(configurable via WSOS only) | Set to Blocks Trigger by default. This causes LA to ignore any loss of supply events while still in pickup.<br>The default is changed to Allows Trigger. This causes LA to ignore any loss of supply events while still in pickup (also dependent on fault reset time, see below).<br>Changing Pickup to Allows Trigger will allow LA to process loss of supply events during pickup. This would helps to ensure protection operations can complete a protection sequence with auto recloses at the same time as allowing LA to operate on Loss of Supply triggers i.e. without restoring power in a temporary fault situation.<br>This mode is selectable only for Feeder and Mid-Point devices. |
| LOP/LA Linked/Not Linked | If set to Linked, turning LOP Off will turn LA Off and vice versa. (Only available for Classic LA) |
| Under Frequency Pause/Abort of Restoration (Tie only) | When enabled, this feature will either:<br>• Pause the LA Activation Delay timer<br>or<br>• Abort Tie restoration by setting LA to Off<br>If an under frequency condition is detected on the LIVE side of an OPEN switch during a Tie restoration. |
| Frequency Low At (Tie only) | The frequency at which the LA Activation Delay timer is paused. If the frequency is less than or equal to Frequency Low At contiguously for the Detection Abort Time period then restoration is aborted by setting LA Off. |
| Frequency Normal At (Tie only) | The tie live side frequency threshold at which the paused LA Activation Delay is resumed after the live side frequency has been greater than or equal to the Frequency Normal At threshold and the Reset time period has elapsed. |
| Detection Abort Time (Tie only) | If a contiguous Frequency Low At condition exceeds the Detection Abort Time period, then restoration is aborted by setting LA to Off. |
| Reset Time (Tie only) | Subsequent to a Frequency Low At condition, if the live side frequency reverts to being greater than or equal to the Frequency Normal At threshold for the Reset Time period then the paused LA Activation Delay time is resumed.<br>If the live side frequency *falls* to less than or equal to Frequency Low At threshold during the Reset Time period, then the reset timer is cleared to zero, and the Detection Abort timer is started. |

# Intelligent LA Parameters

## Overview

Some LA parameters are only applicable when the Logic is Intelligent.

These parameters may be set using WSOS or the O.I. except where noted.

## Description of Parameters

The following parameters are specific to Intelligent LA. They don't include the LA Communications parameters which are covered in the next section.

**Table 92 Description of Parameters – Intelligent LA**

| Parameter | Description |
|---|---|
| Tie Control | When set to **Timer**, the Tie will close when the activation delay timer has expired.<br><br>When set to **Message**, the Tie acts according to either a Close or *Close Inhibit* message received via communications from another device before its LA activation delay timer expires. |
| Overload Control (only valid when Tie Control is Message) | Turns the LA Overload Control function On or Off. |
| Capacity Percentage (only valid when Overload Control is On) | This value is used to determine whether to close the Tie or not. The phase trip pickup current is multiplied by this value and compared to the current that was flowing before the fault. |
| Upstream Devices (only valid when Overload Control is On) | This is used by the Tie to determine whether there is a source (Side A), Load (Side B) or source and load (Side A and B) upstream devices. |
| Load Shedding (only valid when Overload Control is On) | This is used by the Tie to determine which Mid-Point to open so the load before the fault can be handled when the Tie closes. The Tie can open either of the Mid-Points depending on the load. Also the Tie may not close if the load is too high. |

# Intelligent LA Communications Parameters

When LA Logic is Intelligent, the communications parameters for each device can be configured in WSOS by going to:

**Display** > **LA** > **Communications**

They can also be configured on the operator interface.

The following table lists and describes the LA communications parameters associated with Intelligent logic.

**Table 93 Description of Parameters – LA Communications**

| Parameter | Description |
|---|---|
| Listening TCP Port | TCP/IP Port to listen for poll or control messages. |
| Downstream Device IP | This is the IP address of the downstream controller. |
| Downstream Device TCP Port | This is the TCP port the controller uses when communicating with the downstream device. |
| Downstream Device Type | For a Feeder or Mid-Point, the downstream device type can be a Mid-Point or a Tie. |
| Downstream Device Function | Can be either a Recloser (ACR) or LBS (AS). |

**Table 93 Description of Parameters – LA Communications (Continued)**

| Parameter | Description |
|---|---|
| Downstream Communications Status | This is the status of the IP communications to the downstream Mid-Point or Tie device. |
| Tie Device IP | This is the IP address of the Tie device. |
| Tie Device TCP Port | This is the TCP port the controller uses when communicating with the Tie. |
| Tie Communications Status | This is the status of the IP communications to the Tie controller from either a Mid-Point or Feeder. |
| Message Timeout | This is the number of seconds for the controller to wait before resending a control message if no response is received. |
| Message Attempts | This is the number of times for the controller to send a control message. |
| Ping Interval | This is the number of seconds between sending poll messages to determine the communications status of downstream devices. |
| Check IP Addresses | If selected then only the IP addresses in the list that appears below will be used. Any poll or control message from an unknown IP address will be ignored. If not selected, then any IP address can poll and send control messages. |
| Valid IP Address | The list of valid IP addresses that will be used for poll and control messages. |

For more information on LA refer to the LA Technical Manual.

# Auto Changeover (ACO)

## Introduction

An Auto changeover (ACO) scheme provides reliability in power supply by ensuring there is continuous supply to a critical loads (for example, a hospital or manufacturing plant etc.) to allow an alternate supply to be available in the event of a power failure.

A typical ACO scheme is depicted in the figure below.

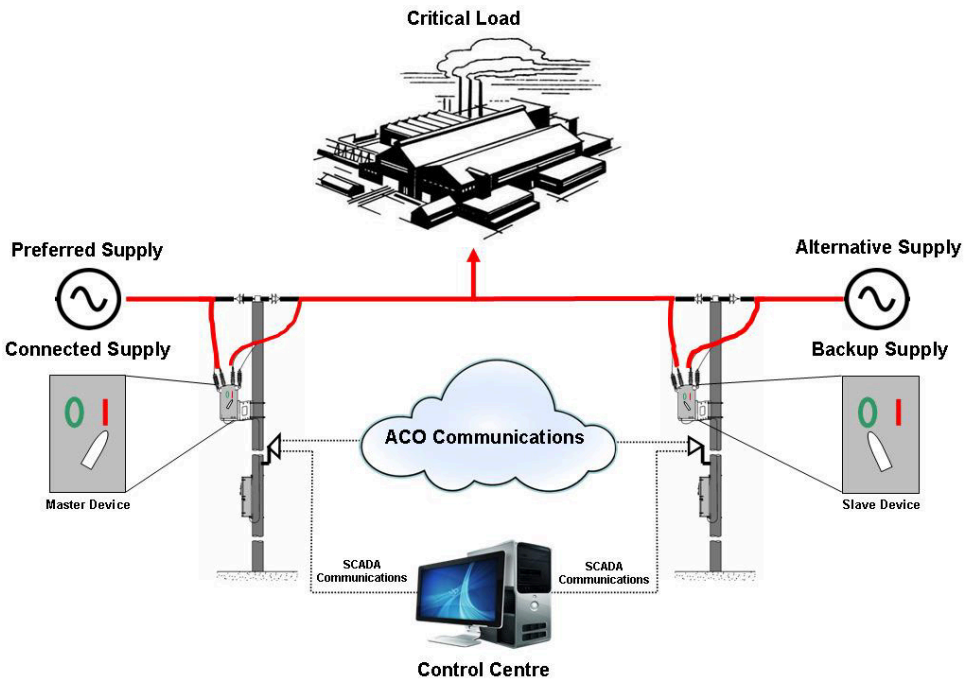


**Figure 252**
ACO Scheme

The ACR or sectionaliser that connects the Preferred Supply to the load is designated the primary device and the ACR or sectionaliser that connects the Alternate Supply to the load is designated the secondary device.

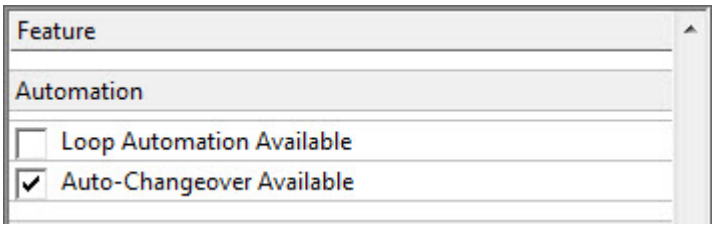
Communications between the two devices is performed by using a proprietary ACO protocol through a communications channel that may be shared with SCADA communications to a Control Centre.

# ACO Feature Selection

If the ACO function is required to be used it must firstly be made available.

This can be done in WSOS on the Feature Selection page:

**Display** > **Configuration** > **Feature Selection** > **Automation**




ACO can also be made available for the ACR or AS on the O.I.

**NOTE:** ACO cannot be made available if another automation feature that is LA is already available.

# ACO Settings Displays

Once ACO has been made available, an ACO configuration page is added to the Display menu.

**Display** > **ACO** > **ACO Configuration**

When this page is first opened it is displayed with a Rank of secondary by default as shown in the figure below.

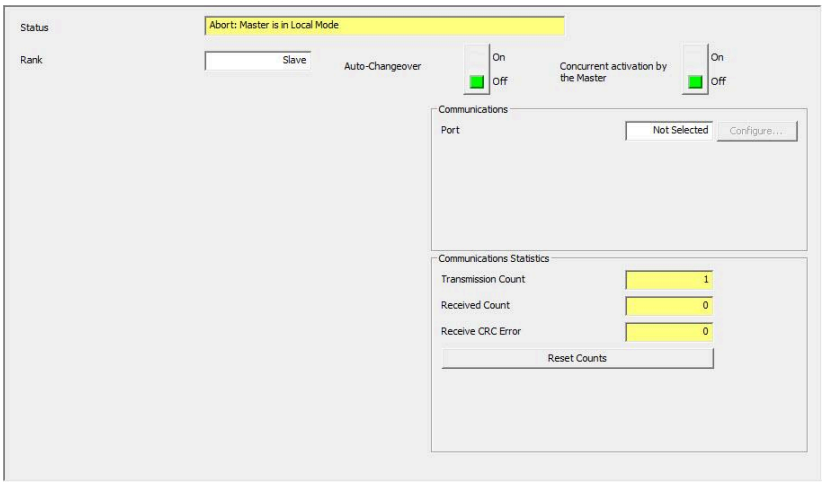



**Figure 253**
WSOS ACO Configuration secondary settings

Additional settings are required to be configured when the Rank of the device is primary.

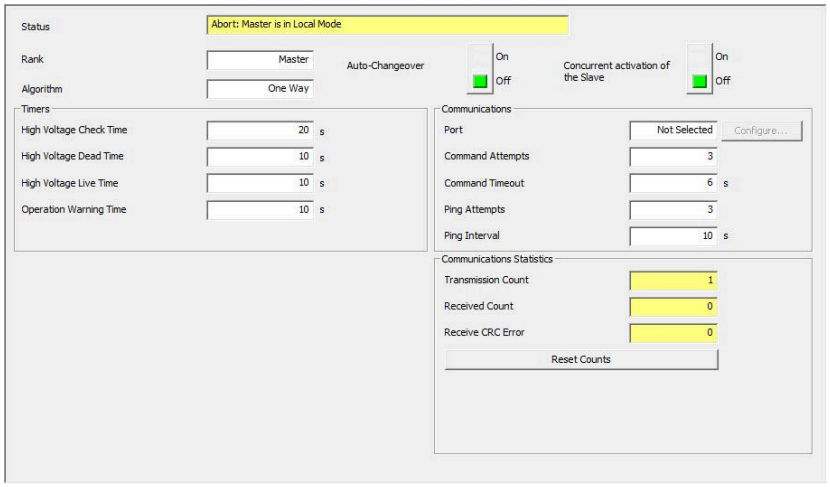



**Figure 254**
WSOS ACO Configuration primary settings

If ACO is available it can also be configured on the operator interface.

# Principles of Operation

## Normal Network Configuration

The normal network configuration would have the primary device switchgear **CLOSED** and the secondary device switchgear **OPEN**. The primary device with the preferred supply connected would be supplying the load and all source/load terminal voltages on both switchgear would be above the Live Line Threshold. ACO would be correctly configured and enabled, all self-healing, page 467 conditions are cleared on both devices and a communications link is established.

At this stage, ACO Status displays *Running: primary is supplying the load on all interfaces*.

# Automatic-Changeover Sequence

## No Supply Available on the Preferred Supply

When the preferred supply is lost, perhaps due to an upstream fault on the feeder, the primary device controller checks the operational and network conditions on both primary and secondary controllers before initiating an Automatic-Changeover sequence.

This sequence automatically connects the load to the alternate supply. Depending on the selected algorithm, the primary device will interrupt the changeover scheme after a changeover, or wait for restoration/changeover conditions while ACO Status displays .

*Running: secondary is supplying the load.*

A typical changeover sequence is shown in the figure below.

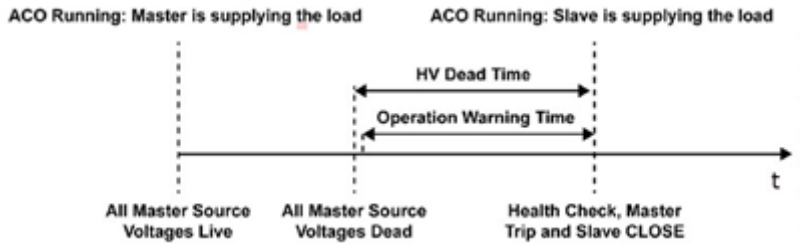



**Figure 255**
Typical ACO Sequence

## Restoration Algorithms

An ACO restoration, changeover from the alternate to preferred supply, may happen in different ways depending on which algorithm is selected.

1. **One Way**

   If One Way is the selected algorithm, ACO will be aborted after a changeover to the alternate supply, and no restoration will be performed when the preferred supply is restored. At this stage, ACO Status displays *Aborted: One Way changeover executed on all interfaces*.

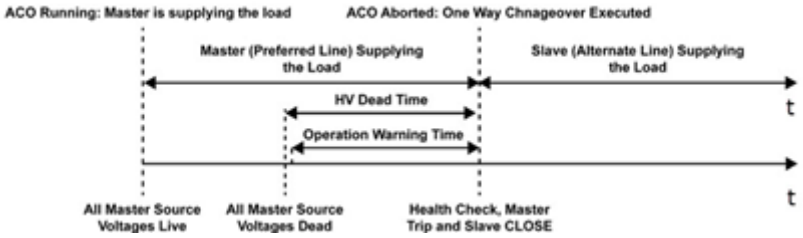



**Figure 256**
Auto Changeover Sequence with One Way Restoration

2. **Break Before Make**

   This option must be used when the preferred and alternate supplies are incompatible and must never be connected to the load at the same time. If the preferred supply is lost while the primary device is closed to supply the load, the primary device will trip and the secondary will close to supply the load from the alternate supply as described in the figure above – Typical ACO Sequence.

   If the Algorithm is *Break before Make* and the preferred supply voltage is restored, the primary device commands the secondary device to trip and verifies that the load side bushings on the secondary switchgear are dead before the HV Check Time expires. If the load side bushings are not dead restoration is aborted.

   A short interruption of supply is experienced by the load during the HV Check Time confirmation period. The primary device then closes its switchgear to reconnect the preferred supply to the load.

   When using Break before Make, the Live Load Blocking functionality is automatically turned On on both primary and secondary devices. This stops an operator inadvertently closing the primary onto an energized load, and cannot be changed while Auto Changeover is enabled.

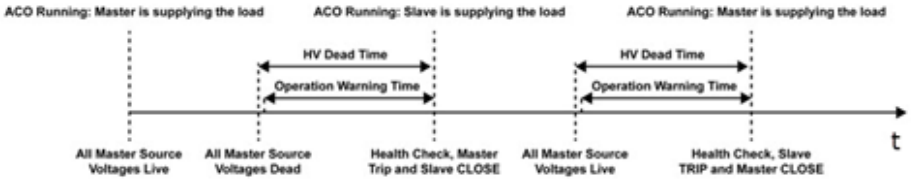



**Figure 257**
Auto Changeover Sequence with Break Before Make Restoration

3. **Make Before Break**

   This option may be used when the preferred and alternate supplies are compatible and may be connected to the load at the same time. If the preferred supply is lost while the primary device is closed to supply the load, the primary device will trip and the secondary will close to supply the load from the alternate supply as described in the figure above – Typical ACO Sequence.

   If the Algorithm is Make before Break and the preferred supply is restored, the primary device will close thus interconnecting the preferred and alternate supplies. The primary device then commands the secondary device to trip, disconnecting the alternate supply from the load.

   When using Make before Break, the Live Load Blocking functionality is automatically turned Off on both primary and secondary devices. This allows an operator to have both devices closed and energized at the same time, and cannot be changed while Auto Changeover is enabled.

   When using Make before Break, the primary uses the Sync Check functionality if it is turned On. This mean Sync Check may reject a close operation of the primary if the primary source and load side voltages are not synchronized.

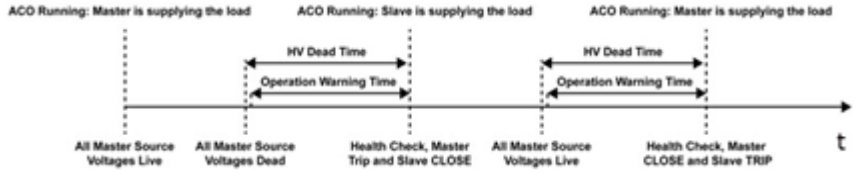



**Figure 258**
Auto Changeover Sequence with Make Before Break Restoration

4. **Both Ways**

   Also known as the Voltage Follower method, this option has the potential to minimize the number of operations, thus reducing the number of supply interruptions, by changing back to the preferred supply only when it is the only supply available.

   If the preferred supply is lost while the primary device is closed to supply the load, the primary device will trip and the secondary will close to supply the load from the alternate supply as described in the figure above – Typical ACO Sequence.

   If the Algorithm is Both Ways, automatic restoration will not occur when the preferred supply returns as long as the load is being supplied from the alternate supply.

   If the alternate supply is lost, Both Ways will perform a Break before Make restoration to connect the preferred supply to the load.

   When using Both Ways, the Live Load Blocking functionality is automatically turned Off and cannot be changed while Auto Changeover is enabled on both primary and secondary devices. This allows an operator to have both devices closed and energized at the same time when the option *Manually Close Backup Device* is selected.

# Self-Healing Options

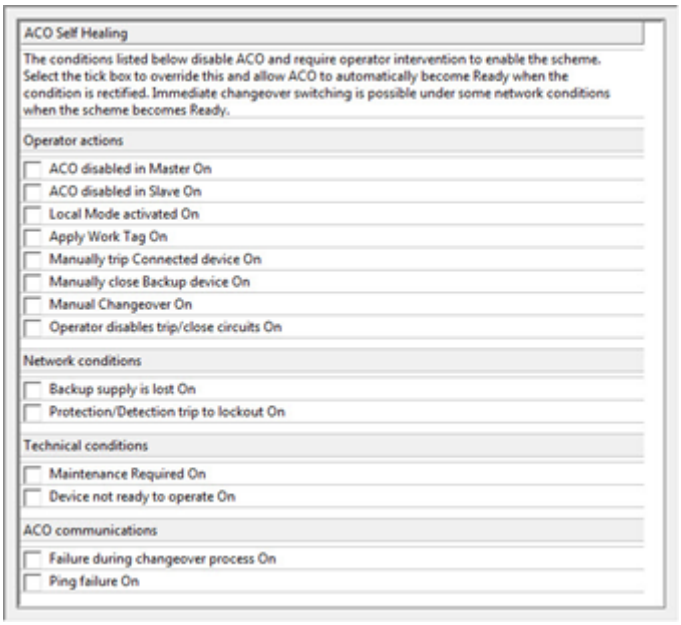
## Overview

There are a number of conditions that disable ACO and require operator intervention before ACO is re-enabled. The ACO Self-Healing facility lists these conditions, and allows each one to be selected individually. This allows the ACO scheme to become ready automatically when the selected item has been rectified. When the operator enables Auto Changeover in the primary after completing unrelated actions, Auto Changeover becomes *Ready* and will perform changeover actions if required.

Self-Healing options can only be selected in WSOS. The ACO Self-Healing dialogue box can be opened by going to:

**Display** > **ACO** > **ACO Self Healing**

When ACO is available and ACO Rank is Master.




A description of the Self-Healing options appear below:

# Operator Actions

## ACO disabled in Primary On

When selected, this option changes ACO Status to Aborted/Not Ready/Waiting if the primary Device is disabled (turned OFF). In this scenario, ACO Status reads:

| WSOS5 | O.I.s |
|---|---|
| Status: Primary is not enabled | Status: Primary is not enabled |

## ACO disabled in Secondary On

When selected, this option changes ACO Status to Aborted/Not Ready/Waiting if the secondary device is disabled (turned OFF). In this scenario, ACO Status reads:

| WSOS5 | O.I.s |
|---|---|
| Status: Secondary is not enabled | Status: Secondary is not enabled |

## Local Mode activated On

When selected, this option changes ACO Status to Aborted/Not Ready/Waiting if the controller mode is changed from Remote to Local. In this scenario, ACO Status reads:

| WSOS5 | O.I.s |
|---|---|
| Status: DEVICE is in Local mode | Status: DEVICE in local mode |

## Apply Work Tag On

When selected, this option changes ACO Status to Aborted/Not Ready/Waiting if Work Tag is applied. In this scenario, ACO Status reads:

| WSOS5 | O.I.s |
|---|---|
| Status: DEVICE Work Tag applied | Status: DEVICE Work Tag applied |

### Manually trip Connected device On

When selected, this option changes ACO Status to Aborted/Not Ready/Waiting if the Connected (closed) device is tripped from any source other than ACO. In this scenario, ACO Status reads:

| WSOS5 | O.I.s |
|---|---|
| Status: DEVICE Work Tag applied | Status: DEVICE Work Tag applied |

### Manually close Backup device On

When selected, this option changes ACO Status to Aborted/Not Ready/Waiting if the Backup (tripped) device is closed from any source other than ACO. In this scenario, ACO Status reads:

| WSOS5 | O.I.s |
|---|---|
| Status: DEVICE was closed from a different source | Status: DEVICE closed from diff src |

### Manual Changeover On

When unselected, this option changes ACO Status to Aborted if a Manual Changeover (connected device is manually tripped and Backup device is manually closed, in any order) is performed. In this scenario, ACO Status reads:

| WSOS5 | O.I.s |
|---|---|
| Status: Manual CO executed | Status: Manual CO executed |

If the Manual Changeover On option is selected, ACO Status will display which source is supplying the load.

> **NOTE:** If a Manual Changeover is performed and the selected algorithm is Break before Make or Make before Break, a restoration procedure will take place if the preferred supply is live. In order to help prevent this from happening, the selected algorithm needs to be Both Ways. This way, the new supplying source remains connected until the other source is not available.

Activating the Manual Changeover On option will automatically activate both *Manually trip Connected device* and *Manually close Backup device* options.

### Operator disables trip/close circuits On

Selecting this option changes ACO Status to Aborted/Not Ready/Waiting if the Trip or the Close circuit is isolated via the CAPE switches or a Fast Trip Input Module (FTIM) Trip/Close block is in place. In this scenario, ACO Status reads:

| WSOS5 | O.I.s |
|---|---|
| Status: DEVICE Trip or Close circuit is isolated | Status: DEVICE Trip or Close Isolated |

## Network Conditions

### Backup Supply is lost On

Selecting this option changes ACO Status to Aborted/Not Ready/Waiting if the preferred supply is connected and any phase on the source side of the switchgear for the alternate supply is not available. In this scenario, ACO Status reads:

| WSOS5 | O.I.s |
|---|---|
| Status: Secondary has no supply voltage | Status: Secondary has no supply voltage |

If both preferred and alternate supplies are not available while the alternate supply is connected, ACO status reads:

| WSOS5 | O.I.s |
|---|---|
| Not Ready: Both Preferred and Backup supplies are dead | Not Ready: Pref and Backup supplies dead |

### Protection/Detection trip to lockout On

Selecting this option will change ACO Status to Aborted/Not Ready/Waiting if the connected device goes to lockout after a protection/detection sequence is performed on fault detection. In this scenario, ACO Status reads:

| WSOS5 | O.I.s |
|---|---|
| Status: DEVICE is in a protection lockout | Status: DEVICE is in a prot lockout |

## Technical Conditions

### Maintenance Required On

Selecting this option changes ACO Status to Aborted/Not Ready/Waiting if maintenance is required on either the primary of the secondary device. In this scenario, ACO Status reads:

| WSOS5 | O.I.s |
|---|---|
| Status: DEVICE Maintenance Required | Status: DEVICE maintenance required |

### Device not ready to operate On

Selecting this option changes ACO Status to Aborted/Not Ready/Waiting if either the primary or the secondary device may not operate (see list of conditions below). In this scenario, ACO Status reads:

| WSOS5 | O.I.s |
|---|---|
| Status: DEVICE is not ready to operate | Status: DEVICE not ready to operate |

The device does not operate if any of the following conditions are met:

- Switchgear not supported
- Switchgear is mechanically interlocked
- Current measurement is above maximum interruption trip limit
- Excessive Trip operations
- Excessive Close operations
- Any capacitor is disconnected
- Capacitor charge failed
- Sync Check is On and Source and Load sides are not synchronized.

# ACO Communications

## Failure during changeover process On

Selecting this option changes ACO Status to Aborted/Not Ready/Waiting if the primary device does not send the trip or close request during a changeover or restoration sequence. In this scenario, ACO Status reads:

| WSOS5 | O.I.s |
|---|---|
| Status: DEVICE has failed to Trip or Close | Status: DEVICE failed to Trip or Close |

## Ping failure On

Selecting this option changes ACO Status to Aborted/Not Ready/Waiting if the primary device does not receive a ping response from the secondary device or the secondary device does not receive a keep-alive signal from the primary device. In this scenario, ACO Status reads:

| WSOS5 | O.I.s |
|---|---|
| Status: DEVICE is not responding to communications | Status: DEVICE comms not responding |

# ACO using LBS

An ACO scheme may be configured with ASs using LBS switchgear as either the primary or secondary device.

Operation is similar to an ACO scheme with ACRs with the differences listed below.

## Detection Sequence

- If an overcurrent pickup occurs on the closed device, ACO Status will change to Not Ready: primary/secondary Detection Sequence in Progress. This state is reset when the fault has been cleared and the *Supply Interrupt* count is zero. If the maximum number of supply interruptions is reached and a sectionalizing trip is performed, ACO Status will change to primary/secondary is in a detection lockout and will abort/wait depending on the Protection/Detection trip to lockout On self-healing option.
- If a device performs a sectionalizing trip, it will stay in that state until an operator close operation is performed. Re-starting ACO will not reset the detection sequence, which will remain as Sectionalise, with ACO Status still indicating that a detection sequence is in progress.

## Upstream Recloser Lockout

A lockout on the upstream ACR is detected if the Sequence Reset Timer expires during a detection sequence. In this case, ACO Status will change to primary/secondary upstream device is in lockout and will abort/wait depending on the *Protection/Detection trip to lockout On* self-healing option. If this option is selected, ACO will change to *Running* after the voltage supply on the respective device is normalized.

# ACO Controls and Status

## ACO ON/OFF

This setting enables or disables the ACO functionality.

- **Type**: Configurable (Binary)
- **Range**: ACO ON or ACO OFF
- **Default**: ACO OFF

## Rank

This setting defines the rank of the device.

- **Type**: Configurable
- **Range**: primary or secondary
- **Default**: secondary

## Algorithm

This setting defines the restoration algorithm used by ACO.

- **Type**: Configurable
- **Range**: One Way, Make before Break, Break before Make or Both Ways
- **Default**: One Way

## Concurrent Activation

The Concurrent Activation setting behavior is explained in the Table below:

**Table 94 Concurrent Activation Logic**

| **Primary Setting** | | |
|---|---|---|
| **Secondary Setting** | **ON** | **OFF** |
| | When ACO is enabled on the primary, it is automatically enabled on the secondary. If the user then disables ACO on the secondary, the scheme is disabled (temporarily or permanently, depending on the self-healing option *ACO Disabled in secondary*). | When ACO is enabled on the primary, the secondary ACO ON/OFF status does not change. |
| | When ACO is enabled on the primary, the secondary ACO ON/OFF status does not change. | When ACO is enabled on the primary, the secondary ACO ON/OFF status does not change. |

- **Type**: Configurable
- **Range**: Concurrent Activation On/Off
- **Default**: Off

## ACO Status

Displays the current execution status of ACO.

- **Type**: Read only
- **Range**: Refer to Appendix L.5 Auto-Changeover Status Codes, page 693
- **Default**: ACO Off

# ACO Timers

## High Voltage Check Time

The period of time that the primary device will wait for its load side terminals to go dead before connecting to preferred supply to the load.

- **Type**: Configurable
- **Range**: 0...999 s
- **Default**: 20 s

It is possible to use ACO when there are no external CVT's on the units for load side voltage measurement. For this purpose, ACO allows the user to set the High Voltage Check Time to zero. In this case, the primary device will not check that its load side is dead when performing a restoration from the alternate supply when using Both Ways and Break before Make algorithms.

When High Voltage Check Time is set to a non-zero value, the user is not able to turn ACO On if there are no external CVT's on the load side and either the Break before Make or Both Ways algorithm is selected. Similarly, the user is not able to change High Voltage Check Time to a non-zero value if there are no external CVT's on the load side and either Break before Make or Both Ways algorithm is selected. Furthermore, the user is not able to change the algorithm to *Break before Make* or Both Ways when High Voltage Check Time is set to a non-zero value if there are no external CVT's on the load side.

**⚠⚠WARNING**

**HAZARD OF ELECTRIC SHOCK OR ARC FLASH**

It is the responsibility of the user helps to ensure that correct safety procedures are in place to avoid misbehavior of ACO in this particular configuration.

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

## High Voltage Dead Time

The period of time that the primary device will wait after the source voltage drops below the *Live Line Threshold* setting before deciding that a loss of supply has occurred.

- **Type**: Configurable
- **Range**: 1...999 s
- **Default**: 10 s

The *High Voltage Dead Time* value cannot be smaller than the *Supply Timeout* setting. If *Supply Timeout* is changed to a value higher than any of the ACO timers, *High Voltage Dead Time* is changed automatically to the *Supply Timeout* value rounded up to the next integer.

### High Voltage Live Time

The period of time that the primary device will wait after the source voltage rises above or is equal to the *Live Line Threshold* setting before deciding that a restoration of supply has occurred.

- **Type**: Configurable
- **Range**: 1...999 s
- **Default**: 10 s

The *High Voltage Live Time* value cannot be smaller than the Supply Timeout setting. If Supply Timeout is changed to a value higher than any of the two ACO timers, High Voltage Live Time is changed automatically to the Supply Timeout value, rounded up to the next integer.

### Operator Warning Time

The period of time that the device will display a countdown alert before performing an ACO Trip or an ACO Close operation.

- **Type**: Configurable
- **Range**: 0...120 s
- **Default**: 10 s

The Operation Warning Time cannot be greater than the High Voltage Dead/Live Times. Reciprocally, the High Voltage Dead/Live Times cannot be lower than the Operation Warning Time. When a self-healing condition is restored from *Waiting/ Not Ready to Running*, the Operation Warning Time is started immediately after the normal operation is established. This helps to ensure that the changeover will be performed with a delay, even if the High Voltage Dead/Live timers have expired. If the state of any of the two devices changes to *Waiting or Not Ready*, the Operation Warning Timer stops and resets.

## Communications Settings

### Port

The communications port on the CAPE to be used by ACO.

- **Type**: Configurable
- **Range**: PowerLogic ADVC: NONE/LAN 1/LAN 2/USB-1/USB-2/Modem
- **Default**: NONE

## Ping Interval

The time between the transmission of two ping requests from the primary device to the secondary device. The communications port on the CAPE to be used by ACO.

- **Type**: Configurable
- **Range**: 1...7200 s
- **Default**: 10 s

## Ping Attempts

The number of times that the primary device will re-send a ping request before it detects a failure in the communications channel.

- **Type**: Configurable
- **Range**: 1...999 s
- **Default**: 3 s

## Command Timeout

The period of time that the primary device will wait for an acknowledge response after sending a protocol command to the secondary device.

- **Type**: Configurable
- **Range**: 1...999 s
- **Default**: 6 s

## Command Attempts

The number of times that the primary device will transmit a protocol command before it detects a failure in the communications channel, if the last command was unacknowledged.

- **Type**: Configurable
- **Range**: 1...999 s
- **Default**: 3 s

## Secondary IP Address

This setting contains the IP Address of the secondary device to which the primary device will establish a connection. Only applicable if the ACO Communications Port is an Ethernet port.

- **Type**: Configurable
- **Range**: Any valid IP Address
- **Default**: 127.0.0.1

## Secondary Port Number

This setting contains the TCP port number on the Slave device used by ACO. Only applicable if the ACO Communications Port is an Ethernet port.

- **Type**: Configurable
- **Range**: 1...65535
- **Default**: 3108

## Check Primary IP Address

This option is used if a verification of the incoming primary Device IP address needs to be done by the secondary device before accepting an ACO connection. Only applicable for the secondary device when the ACO Communications Port is an Ethernet port.

- **Type**: Configurable (Binary)
- **Range**: On/Off
- **Default**: Off

## Primary IP Address

This setting contains the only primary device IP Address accepted by the secondary device if the option Check primary IP is selected.

- **Type**: Configurable
- **Range**: Any valid IP Address
- **Default**: 127.0.0.1

## Log Invalid IP

If selected, this option registers a new entry on the event log for every unauthorized primary device IP address that attempts to establish a connection with the secondary device.

- **Type**: Tick box
- **Range**: On/Off
- **Default**: Off

## Transmission Count

The number of transmitted ACO messages.

- **Type**: Read only
- **Range**: 0...99999 s
- **Default**: 0 s

## Received Count

The number of received ACO messages.

- **Type**: Read only
- **Range**: 0...99999 s
- **Default**: 0 s

## Receive CRC Error

The number of received ACO messages with a CRC error.

- **Type**: Read only
- **Range**: 0...99999 s
- **Default**: 0 s

## Last Invalid IP Address

Displays the last unauthorized primary device IP address that attempted to connect to the secondary device if Check primary IP Address is On. If a new unauthorized connection is attempted from a different source, Last Invalid IP Address is updated and the count is reset to 1.

If the option Log Invalid IP is On, each connection attempt shall have its IP address recorded in the Event Log.

The Invalid IP Packet Count rolls over to 1 after 99999 is reached.

- **Type**: Read only
- **Range**: A valid IP address or NONE
- **Default**: NONE

## Invalid IP Packet Count

The number of invalid packets received from an invalid primary device IP address if Check primary IP Address is On.

- **Type**: Read only
- **Range**: 0...99999 s
- **Default**: 0 s

# Communications

The ACO scheme and the DNP3 protocol can share the same communications port on the PowerLogic ADVC Controller to allow the usage of communications devices (radios, modems etc.) at both the Slave and Master devices to:

- Provide communications between the devices;
- Provide communications to a SCADA Master Station via the DNP3 protocol.

When the ACO Master device communicates with the Slave device it uses a proprietary ACO protocol format which is separate from any other protocol used by the PowerLogic ADVC Controller. This proprietary protocol wraps ACO data in a packet and, when this packet is transmitted, the ACO partner controller recognizes the ACO content in the packet and processes only the ACO data.

# Interaction with other Functionality

## Protection Sequences and Lockouts

The lockout flag on the tripped ACO device is cleared when the ACO scheme starts. If the Manually trip Connected device On self-healing option is selected and *Manual Changeover On*is not selected, any manual (non-ACO) trip request will take the tripped controller to a lockout. This lockout is cleared if the manually tripped switchgear is closed, bringing ACO back to its Running state. If Manual Changeover On is selected, manually tripping a connected supply will not take it to a lockout. If ACO is aborted or turned Off, the tripped ACO device will go to lockout regardless of the selected self-healing options.

If an Overcurrent protection sequence starts on a connected device, ACO will change its state to Not Ready/Waiting until the protection sequence is over (pickup cleared or protection trip to lockout). If the pickup is cleared, ACO will go back to its Running state. If the device trips to lockout, ACO will either abort or go to a Not Ready/Running state depending on the Protection trip to lockout On self-healing option.

## Live Load Blocking

Live Load Blocking is automatically **enabled** when ACO is enabled and the selected Algorithm is either One Way or Break before Make. It is automatically **disabled** when ACO is enabled and the selected Algorithm is Make before Break or Both Ways.

## LOP Protection

LOP Protection cannot be turned **ON** if ACO is **ON** and vice-versa, but can still be set to **ALARM** in this case.

## Other Protection Features

ACO cannot be **Available** if Loop Automation, Under/Over Frequency Protection, Under/Over Voltage Protection, Directional Blocking and Directional Protection are **Available** and vice-versa.

# ACO – Important Points

- ACO cannot be made available if Loop Automation or other automation features are available.
- ACO can only be used when DNP3 or another suitable communications protocol is available.
- The Make before Break algorithm can only be used for restoration when the preferred and alternate supplies are compatible.
- Initial setup of an ACO scheme requires the secondary device to be installed, configured and checked prior to the primary device being configured.

For more information on the ACO feature, refer to the ACO Technical Manual.

# History

## What's in This Chapter

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# Event Log

## Introduction

The PowerLogic ADVC Controller maintains a log of up to 30,000 events that record changes to the status of the switchgear, protection/detection operation, configuration logic and other relevant events. The Event Log also records protection setting changes.

The events can be viewed on the ***flex*VUE** and ***set*VUE** O.I.s in their Event Log display group. The event log display will update automatically with new events as they occur. The most recent event appears on the bottom line of the display and previous events can be viewed by scrolling upwards. When the event log is full, the oldest events are deleted to make way for new events as they occur.

All events displayed on the O.I. are date and time stamped to a 10 ms resolution and displayed in the order that they occurred. The source of each event is also recorded.

Event category filters can be applied so that only selected categories are displayed.

The event log can be uploaded and displayed by WSOS. In addition to time stamp, source identification and filter category features, WSOS can be used for text searches and to go to a particular date/time. Events uploaded by WSOS are displayed with a date/time stamp resolution of 1 ms. The event log uploaded by WSOS can be saved as a text file or as a csv file.

## Reading the Event Log on the O.I.

The ***flex*VUE** O.I. has a dedicated **EVENT LOG** key. Pressing this key is the only way the Event Log can be displayed on the ***flex*VUE** O.I.

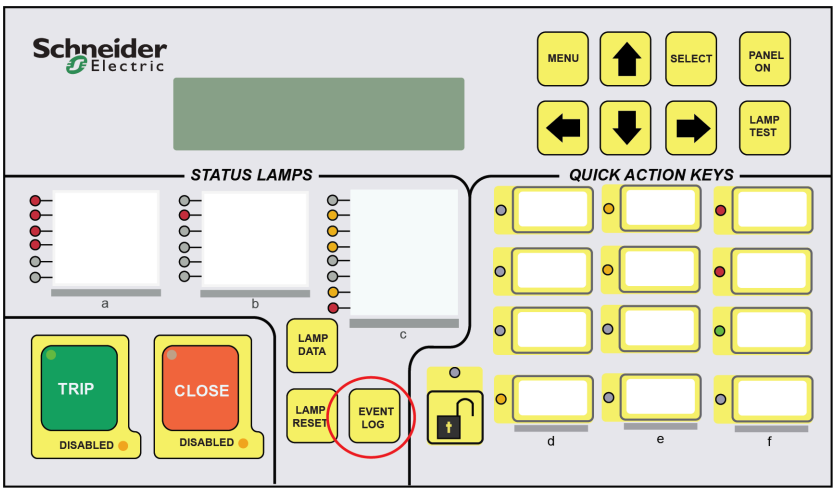



**Figure 259**
EVENT LOG key on the flexVUE O.I.

On the ***set*VUE** O.I., the Event Log is one of the main display groups as shown in Appendix K.1 setVUE ACR Menu Structure, page 636.

The Event Log navigation differs depending on the O.I. being used. The following table indicates the differences between the ***flex*VUE** and ***set*VUE** Event Log navigation.

**Table 95 *flex*VUE and *set*VUE Event Log Navigation**

| Description | *set*VUE | *flex*VUE |
|---|---|---|
| Number of events displayed | 4 | 2 |
| Key to scroll to OLDER events | ⬅ | ⬆ |
| Key to scroll to NEWER events | ➡ | ⬇ |
| Show the CHANGE EVENT FILTER screen | SELECT | SELECT |
| Return to EVENT LOG from FILTER screen | MENU | EVENT LOG |
| View additional information about event (if available) | ALT | EVENT LOG |
| Switch between DATE/TIME, TIME/EVENT AND EVENT DESCRIPTION | - | ⬅ and ➡ |

# Typical Event Log Trip Sequence Display

The following is an example of the event log display recording the events logged by a three phase fault that caused a trip sequence with two trips to lockout.

| EVENT LOG (E) | | |
|---|---|---|
| **Date/Time Stamp** | **Event** | **Comment** |
| 08/06/16 09:27:37.35 | Lockout | Lockout |
| 08/06/16 09:27:37.35 | Current at Max Phase C –300 A | Max C Phase current during fault |
| 08/06/16 09:27:37.35 | Current at Max Phase B – 300 A | Max B Phase current during fault |
| 08/06/16 09:27:37.35 | Current at Max Phase A – 300 A | Max A Phase current during fault |
| 08/06/16 09:27:37.35 | Current at Trip C Phase – 300 A | C Phase current at time of trip |
| 08/06/16 09:27:37.35 | Current at Trip B Phase – 300 A | B Phase current at time of trip |
| 08/06/16 09:27:37.35 | Current at Trip A Phase – 300 A | A Phase current at time of trip |
| 08/06/16 09:27:37.34 | Protection Trip 2 | 2nd Protection Trip in sequence |
| 08/06/16 09:27:37.34 | Phase Protection Trip | Trip caused by Phase Protection |
| 08/06/16 09:27:37.34 | Protection Group A Active | Protection Group A was active |
| 08/06/16 09:27:37.34 | Protection Trip Request | Trip signal sent to switchgear |
| 08/06/16 09:27:37.34 | Fault Type A-B-C | Fault type that caused trip |
| 08/06/16 09:27:20.17 | Pickup Phase C | C Phase pickup |
| 08/06/16 09:27:20.17 | Pickup Phase B | B Phase pickup |
| 08/06/16 09:27:20.17 | Pickup Phase A | A Phase pickup |
| 08/06/16 09:27:20.17 | Protection Group A Active | Protection Group A was active |
| 08/06/16 09:27:20.17 | Pickup | 2nd Protection pickup |

| EVENT LOG (E) | | |
|---|---|---|
| **Date/Time Stamp** | **Event** | **Comment** |
| 08/06/16 09:27:20.16 | Automatic Reclose | Reclose No 1 |
| 08/06/16 09:27:19.25 | Protection Disk Reset | Fault Reset timer expired |
| 08/06/16 09:27:19.21 | All Protection Elements Resetting | Fault Reset timer started |
| 08/06/16 09:27:19.17 | Current at Max Phase C – 300 A | Max C Phase current during fault |
| 08/06/16 09:27:19.17 | Current at Max Phase B – 300 A | Max B Phase current during fault |
| 08/06/16 09:27:19.17 | Current at Max Phase A – 300 A | Max A Phase current during fault |
| 08/06/16 09:27:19.17 | Current at Trip C Phase – 300 A | C Phase current at time of trip |
| 08/06/16 09:27:19.17 | Current at Trip B Phase – 300 A | C Phase current at time of trip |
| 08/06/16 09:27:19.17 | Current at Trip A Phase – 300 A | A Phase current at time of trip |
| 08/06/16 09:27:19.16 | Protection Trip 1 | 1st Protection Trip in sequence |
| 08/06/16 09:27:19.16 | Phase Protection Trip | Trip caused by Phase Protection |
| 08/06/16 09:27:19.16 | Protection Group A Active | Protection Group A was active |
| 08/06/16 09:27:19.16 | Protection Trip Request | Trip signal sent to switchgear |
| 08/06/16 09:27:19.16 | Fault Type A-B-C | Fault type that caused trip |
| 08/06/16 09:27:18.19 | Pickup Phase C | C Phase pickup |
| 08/06/16 09:27:18.19 | Pickup Phase B | B Phase pickup |
| 08/06/16 09:27:18.16 | Pickup Phase A | A Phase pickup |
| 08/06/16 09:27:18.16 | Protection Group A Active | Protection Group A was active |
| 08/06/16 09:27:18.16 | Pickup | 1st Protection pickup |

The following is an example of the event log display recording the events logged by a three phase fault that cleared during the Trip 1 Reclose Time and lead to a sequence reset following an automatic reclose.

| EVENT LOG (E) | | |
|---|---|---|
| **Date/Time Stamp** | **Event** | **Comment** |
| 08/06/16 14:38:57.56 | Sequence Reset | End of Sequence |
| 08/06/16 14:38:47.56 | Automatic Reclose | Reclose after Trip 1 |
| 08/06/16 14:38:42.65 | Protection Disk Reset | Fault Reset timer expired |
| 08/06/16 14:38:42.60 | All protection elements resetting | Fault Reset timer started |
| 08/06/16 14:38:42.57 | Current at Max Phase C – 300 A | Max C Phase current during fault |
| 08/06/16 14:38:42.57 | Current at Max Phase B – 300 A | Max B Phase current during fault |
| 08/06/16 14:38:42.57 | Current at Max Phase A – 300 A | Max A Phase current during fault |
| 08/06/16 14:38:42.57 | Current at Trip C Phase – 300 A | C Phase current at time of trip |
| 08/06/16 14:38:42.57 | Current at Trip B Phase – 300 A | B Phase current at time of trip |

| EVENT LOG (E) | | |
|---|---|---|
| **Date/Time Stamp** | **Event** | **Comment** |
| 08/06/16 14:38:42.57 | Current at Trip A Phase – 300 A | A Phase current at time of trip |
| 08/06/16 14:38:42.56 | Protection Trip 1 | 1st Protection Trip in sequence |
| 08/06/16 14:38:42.56 | Phase Protection Trip | Trip caused by Phase Protection |
| 08/06/16 14:38:42.56 | Protection Group A Active | Protection Group A was active |
| 08/06/16 14:38:42.56 | Protection Trip Request | Trip signal sent to switchgear |
| 08/06/16 14:38:42.56 | Fault Type A-B-C | Fault type that caused trip |
| 08/06/16 14:38:42.56 | Pickup Phase C | C Phase pickup |
| 08/06/16 14:38:42.56 | Pickup Phase B | B Phase pickup |
| 08/06/16 14:38:42.56 | Pickup Phase A | A Phase pickup |
| 08/06/16 14:38:42.56 | Protection Group A Active | Protection Group A was active |
| 08/06/16 14:38:42.56 | Pickup | 1st Protection pickup |

More information on reading the Event Log on the ***flex*VUE** and ***set*VUE** O.I.'s can be found in the Event Log, page 60 section of the Operator Functions, page 49 chapter.

# The Event Log in WSOS

To upload and view the Event Log in WSOS when it is on-line, the History page must be opened by going to:

**Display** > **History** > **Display**

And select Event Log in the top left hand corner.

In WSOS has not uploaded the Event Log from the connected device previously, the Event Text field will be blank.

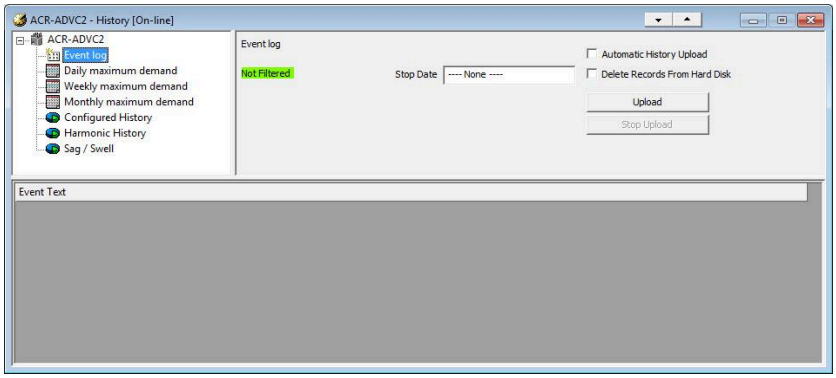



**Figure 260**
WSOS Blank Event Log Display

# Uploading History Files

The Event Log can be uploaded by selecting the *Upload* button on the Event Log History page shown above. The most recent event is uploaded first followed by earlier events in chronological order.

Once an upload has started, WSOS will show the progress by displaying the time elapsed, the number of events uploaded so far and the date/time stamp of the most recently uploaded (earliest) event.

The upload can be left to run until all events stored in the controller have been retrieved, at which time the upload will stop.

If required, the upload can be stopped at any time by selecting the Stop Upload button.

The other option is to enter an historical date and time in the Stop Date field. In this case the upload will automatically stop when it gets to an event at or earlier than the date/time entered. Clicking in the Stop Date field will launch a calendar dialogue box.

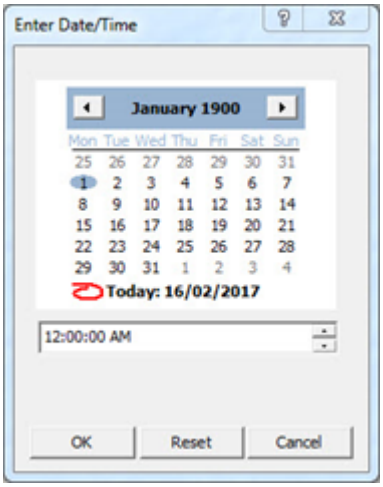
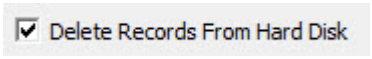



**Figure 261**
Calendar dialogue box for selecting a Stop Date in WSOS

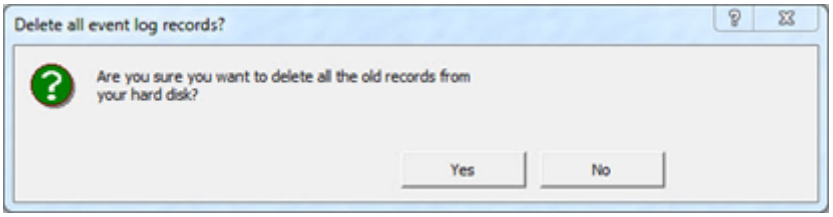
Select the **Today: dd/mm/yyyy** link to bring the display to the current date.

## Delete Records from Hard Disk



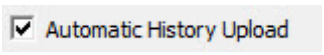

Selecting this option prior to an upload will delete any events that were previously uploaded from the connected device.

WSOS displays a message requiring confirmation before deleting any records and starting the upload.




**NOTE:** This option does not delete any records stored in the controller. It only deletes records stored on the WSOS PC that were uploaded previously. Records that were uploaded previously and are still in the controller can up uploaded again.

## Automatic History Upload




This option will cause an Event Log upload to be performed every time WSOS polls the connected device.

This is a useful feature for keeping the uploaded Event Log up to date during testing or when monitoring events.

Before using this option it is recommended that the entire Event Log is uploaded manually. Otherwise a complete upload will occur the next time WSOS polls the controller.

## Saving Uploaded Event Log Files

Once event log files have been uploaded, they appear in the Event Text field in chronological order with the most recent event at the top.

A right mouse click anywhere on the Event Text display will open the context menu that includes options for saving the uploaded events in a file on the PC.

The options are:

- Save as a Text File
- Save as a CSV File

These options appear at the top of the context menu as shown in the figure below.

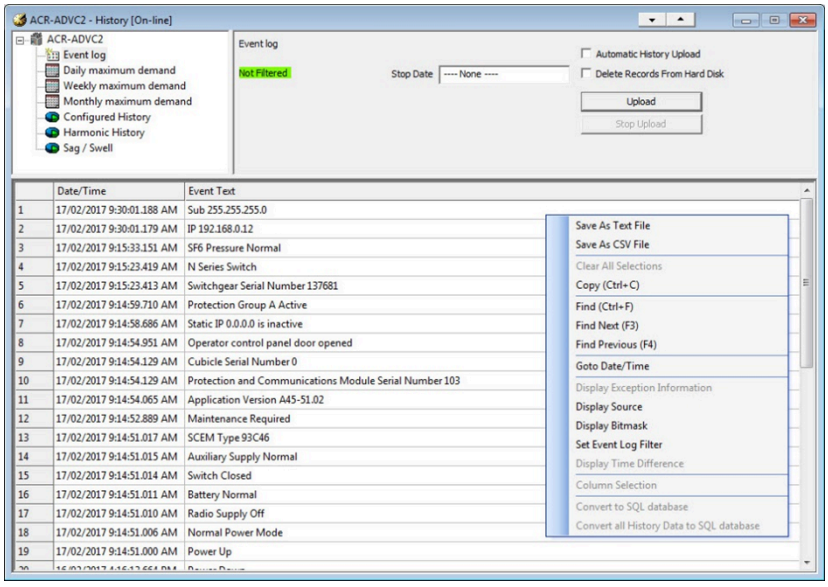



**Figure 262**
Uploaded Event Log records and context menu

## Other Context Menu Options

Other context menu options include Copy, Find and Go to Date/Time which can assist in finding particular events.

Display Source adds an extra column to the display that includes the source of individual events.

Selecting the **Event Log Filter** will open the Event Log Filter dialogue box shown below.

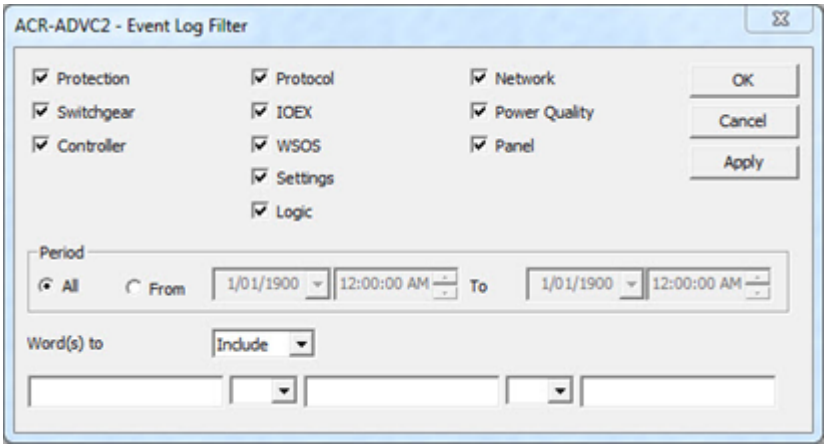



**Figure 263**
Event Log Filter

Using this dialogue, filters can be applied according to the Sources of the events, the time period the events occurred or any words to include or exclude. **AND** and/or **OR** logic can be applied to entered words.

When two events have been selected by holding down the **Ctrl** key on the keyboard, the Display Time Difference option can be used to measure the elapsed time between events. This can be useful for measuring protection trip timing.

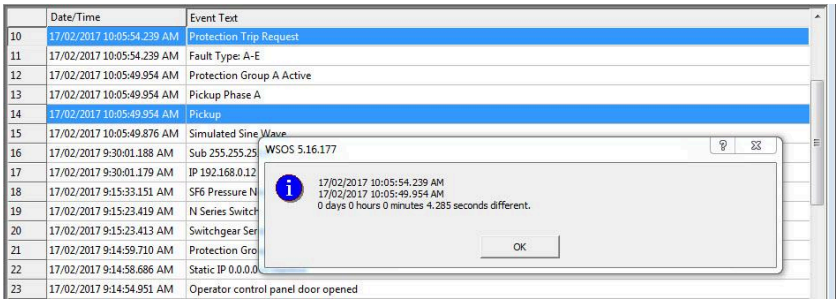



**Figure 264**
Display Time Difference

# Maximum Demand Records

The PowerLogic ADVC Controller maintains a log of three sets of maximum demand records that show total energy (kWh) for the previous period, either day, week or month. Each demand record also logs the peak real power and power factor for the demand period.

Approximately six years of daily, weekly and monthly data can be stored in memory by the controller.

When a log is full, the oldest records are deleted as new records are added.

# Maximum Demand Records on the O.I.

Maximum Demand records that have been logged can be viewed on the PowerLogic ADVC Controller operator interface.

On the ***flex*VUE** O.I. the most recent record appears when the max demand pages are displayed.

Press the **SELECT** key to enter the **HISTORY** mode and view earlier records.

Press **SELECT** again to exit the **HISTORY** mode and return to the most recent record.

On the ***set*VUE** O.I., the most recent record appears when the max demand pages are displayed.

Press the **SELECT** key to enter the **HISTORY** mode and view earlier records.

Press **MENU/ENTER** to exit the **HISTORY** mode and return to the most recent record.

## Maximum Demand Records in WSOS

Maximum demand records can be uploaded and displayed in WSOS through the History page.

**Display** > **History** > **Display**

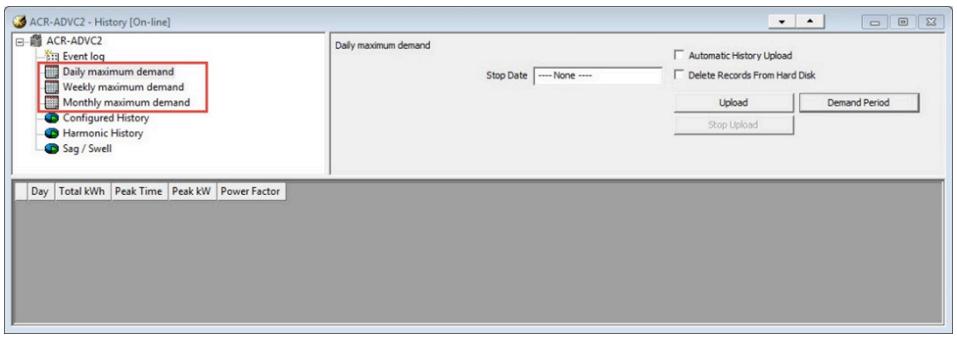



**Figure 265**
WSOS History page for uploading Maximum Demand records

Maximum demand records are uploaded in the same way as the Event Log explained in Uploading History Files, page 484.

## Demand Period on the O.I.

The demand period for the three maximum demand logs can be configured for 5, 15, 30 or 60 minutes. All values are averaged over the set period.

The demand period is 15 minutes by default and can be set on the operator interface.

Logging begins on the hour, or on intervals past the hour. For example, if a 15 minute demand period is selected at 12 minutes past the hour then averaging begins at 15 minutes past the hour and data is stored at 30 minutes past the hour.

If the demand period is changed then the new demand period data will be added to any existing data for that demand period.

When the maximum demand record is stored it will consequently look at all data for that period irrespective of demand period.

## Demand Period in WSOS

The demand period can be configured in WSOS on the History page by selecting the Demand Period button.

That will launch the dialogue box shown below that can be used to configure the Demand Period for either 5, 15, 30 or 60 minutes.

This dialogue box can be launched from the Daily, Weekly or Monthly Maximum Demand pages but the same setting is common to all three.

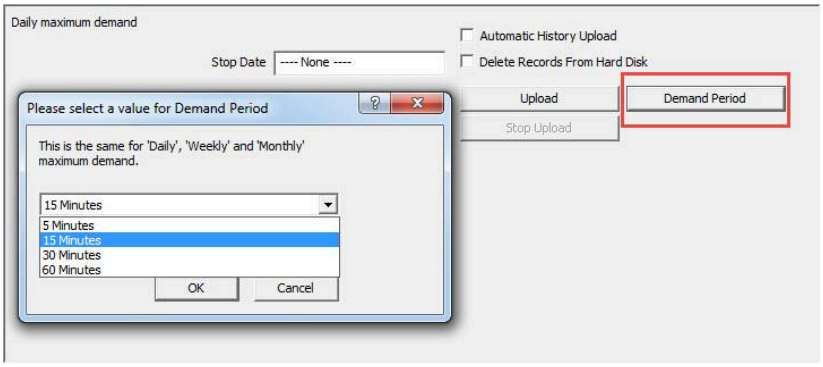



**Figure 266**
Setting the Demand Period on the WSOS History page

# Daily Maximum Demand

A new daily maximum demand record is logged every time the controller's clock passes through midnight and records the following data:

**Day** – Identifies the day and date for which this record was generated.

**Total kWh** – Records the total energy through the device on that day.

**Peak Time** – Identifies the period during the day that the maximum demand occurred.

**Peak kW** – Records the maximum real power averaged over the maximum demand period.

**Power Factor** – Records the Power Factor averaged over the maximum demand period.

| | Day | Total kWH | Peak Time | Peak kW | Power Factor |
|---|---|---|---|---|---|
| 1 | Monday 29/10/2007 | 0 | 29/10/2007 11:59:59 PM | 0 | 0.00 |
| 2 | Sunday 28/10/2007 | 0 | 28/10/2007 11:59:59 PM | 0 | 0.00 |
| 3 | Saturday 27/10/2007 | 0 | 27/10/2007 11:59:59 PM | 0 | 0.00 |
| 4 | Friday 26/10/2007 | 132687 | 26/10/2007 1:59:59 PM | 22649 | 1.00 |
| 5 | Thursday 25/10/2007 | 81 | 25/10/2007 4:44:59 PM | 326 | 0.17 |

**Figure 267**
Daily Maximum Demand records displayed by WSOS




**Figure 268**
Daily Maximum Demand record displayed on the ***flex*VUE** O.I.

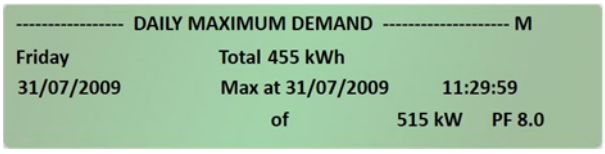



**Figure 269**
Daily Maximum Demand record displayed on the ***set*VUE** O.I.

# Weekly Maximum Demand

A new weekly maximum demand record is logged every time the controller's clock pass through midnight on a Sunday and records the following data:

**Week Ending** – Identifies the week for which this record was generated.

**Total kWh** – Records the total energy through the device during that week.

**Peak Time** – Identifies the period during the week that the maximum demand occurred.

**Peak kW** – Records the maximum real power averaged over the maximum demand period.

**Power Factor** – Records the Power Factor averaged over the maximum demand period.

| | Week Ending | Total kWH | Peak Time | Peak kW | Power Factor |
|---|---|---|---|---|---|
| 1 | 27/10/2007 | 132768 | 26/10/2007 1:59:59 PM | 22649 | 1.00 |
| 2 | 20/10/2007 | 0 | 20/10/2007 11:59:59 PM | 0 | 0.00 |
| 3 | 13/10/2007 | 0 | 13/10/2007 11:59:59 PM | 0 | 0.00 |

**Figure 270**
Weekly Maximum Demand records displayed by WSOS

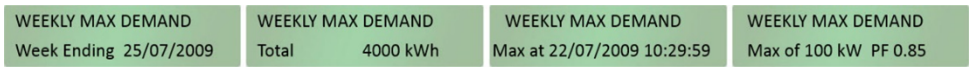



**Figure 271**
Weekly Maximum Demand record displayed on the ***flex*VUE** O.I.

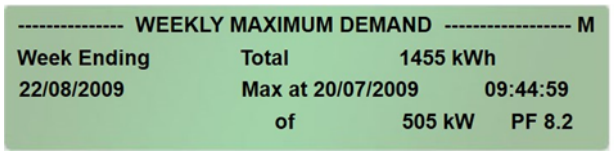



**Figure 272**
Weekly Maximum Demand record displayed on the ***set*VUE** O.I.

# Monthly Maximum Demand

A new monthly maximum demand record is logged every time the controller's clock passes through midnight on the last day of each month and records the following data:

**Month** – Identifies the month for which this record was generated.

**Total kWh**– Records the total energy through the device during that month.

**Peak Time** – Identifies the period during the month that the maximum demand occurred.

**Peak kW** – Records the maximum real power averaged over the maximum demand period.

**Power Factor** – Records the Power Factor averaged over the maximum demand period.

| | Log Month | Total kWH | Peak Time | Peak kW | Power Factor |
|---|---|---|---|---|---|
| 1 | September 2007 | 17303717 | 30/09/2007 11:59:59 PM | -16435 | 0.96 |

**Figure 273**
Monthly Maximum Demand record displayed by WSOS




**Figure 274**
Monthly Maximum Demand record displayed on the ***flex*VUE** O.I.

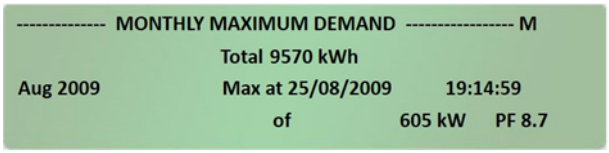



**Figure 275**
Monthly Maximum Demand record displayed on the ***set*VUE** O.I.

## Signed and Unsigned Power

When power flow can be in either direction through the switch, the total energy recorded will depend on whether power measurement is signed or unsigned. See Power Measurement, page 155. If power is signed, the total power flow (kWh) logged for the demand period will be the net value, that is zero if equal energy has flowed both ways, or total power flow irrespective of the direction if power flow is unsigned.

# History Configuration

The PowerLogic ADVC Controller maintains a history log of user selectable data through History Configuration. This is a WSOS only feature and cannot be configured or viewed on the Operator Interface.

The number of data types collected and the sample log period can be selected on the History Configuration page which can be opened in WSOS at:

**Display** > **History** > **History Configuration**

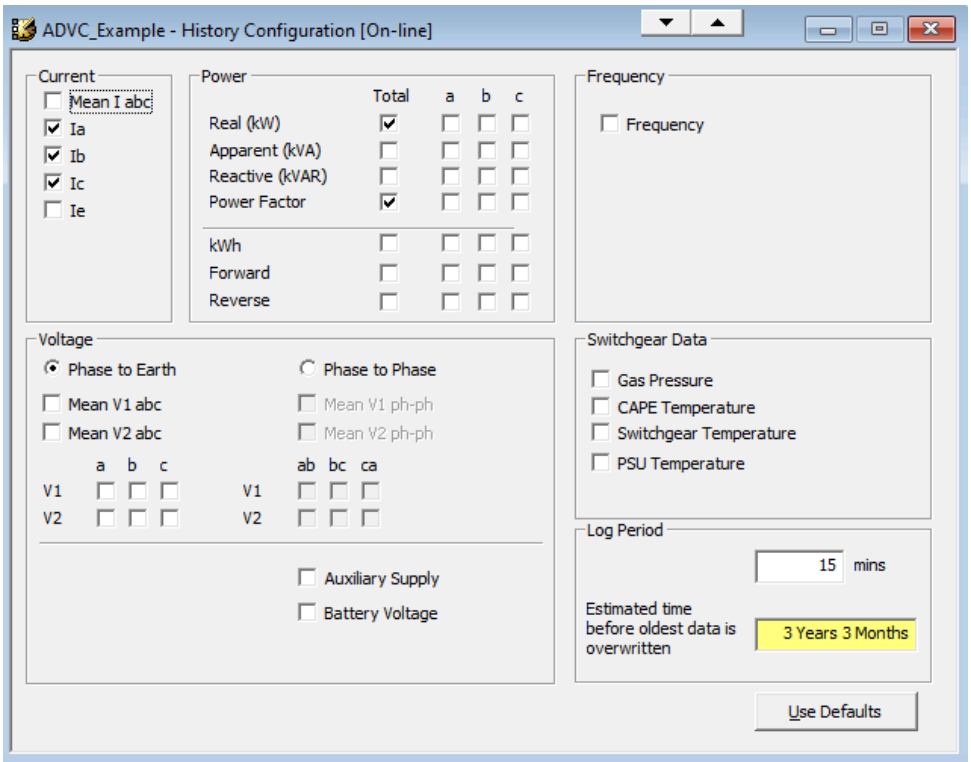



**Figure 276**
WSOS History Configuration page

The default data types are:

- A Phase current
- B Phase current
- C Phase current
- Real Power (kW)
- Power Factor

With a Log Period of 15 minutes.

The Log Period can be set to:

1, 5, 10, 15, 30, 60, 120, 360, 480, 720 or 1440 minutes.

History Configuration records stored in the controller can be uploaded via WSOS by selecting the Upload button on the History page with Configured History selected.

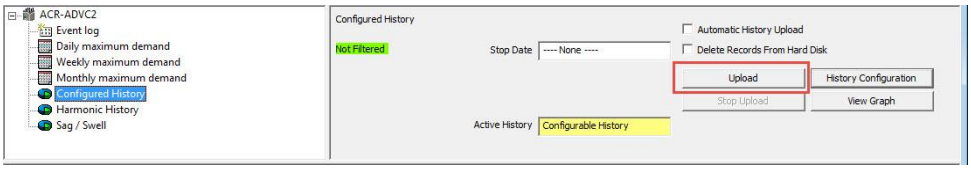



**Figure 277**
Configured History Upload via WSOS

For more information on uploading history files, refer to Uploading History Files, page 484.

A typical upload with default data types selected and a 1 minute log period is shown below:

| | Date/Time | Ia | Ib | Ic | kW | Power Factor |
|---|---|---|---|---|---|---|
| 4 | 17/02/2017 4:56:59 PM | 29 | 27 | 28 | 843 | 0.76 |
| 5 | 17/02/2017 4:55:59 PM | 40 | 38 | 39 | 1148 | 0.97 |
| 6 | 17/02/2017 4:54:59 PM | 46 | 45 | 45 | 1284 | 0.95 |
| 7 | 17/02/2017 4:53:59 PM | 46 | 45 | 45 | 1284 | 0.95 |
| 8 | 17/02/2017 4:52:59 PM | 40 | 40 | 40 | 1049 | 0.87 |
| 9 | 17/02/2017 4:51:59 PM | 40 | 40 | 40 | 1039 | 0.87 |
| 10 | 17/02/2017 4:50:59 PM | 40 | 40 | 40 | 1039 | 0.87 |
| 11 | 17/02/2017 4:49:59 PM | 40 | 40 | 40 | 1039 | 0.87 |
| 12 | 17/02/2017 4:48:59 PM | 40 | 40 | 40 | 1039 | 0.87 |

**Figure 278**
Uploaded Configured History records

Upload log files can be saved as either Text or CSV files from the context menu launched by right clicking on the uploaded display.

The History Configuration page can also be launched from the History page by selecting the History Configuration button.

History Configuration log files will be stored in the controller according to the History Configuration settings. When the allocated memory is full, the oldest records are overwritten by the new records. The time a record will remain in memory before being overwritten depends on the number of data types and log period selected. An estimate of this time is displayed in the read-only field in the bottom right hand corner of the WSOS History Configuration page.

The formula used to calculate this time is shown below:

$$\text{Estimated Time (in days)} = \frac{\text{Log Period (in minutes) x 360448}}{9 + \text{number of data selections}}$$

History Configuration settings can be restored to the defaults by selecting the *Use Defaults* button on the WSOS History Configuration page.

# Configurable History Graph

Once configurable history data has been uploaded from the controller it can be displayed graphically in WSOS. Selecting the View Graph button on the History page with Configured History selected will launch the Configurable History Graph page. When this page opens, choose the data to plot and the time period and select Plot Now. Data to be displayed can be selected/deselected from the tick boxes on the right hand side.

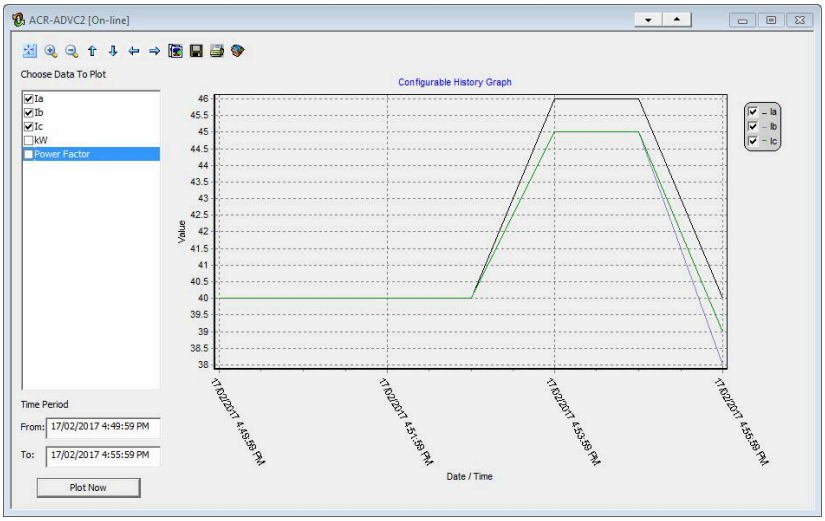



**Figure 279**
Configurable History Graph

# Harmonic History

In order to log harmonics history, Harmonics Analysis, page 511 must be running.

Harmonic History can then be configured in WSOS at:

**Display** > **History** > **Harmonic Configuration**

Selecting this option will launch the Harmonic Configuration dialogue box shown below.

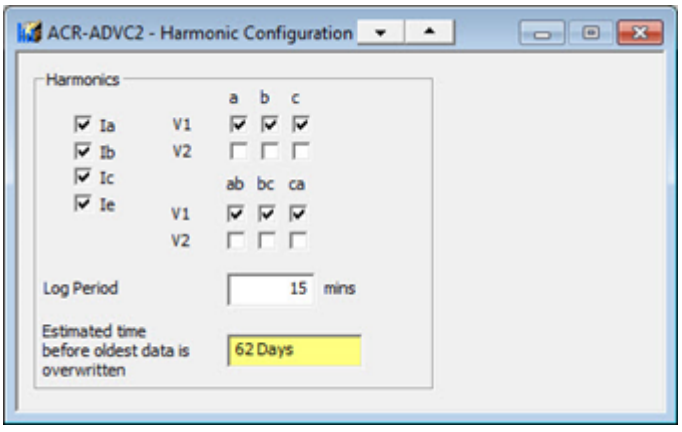



**Figure 280**
Harmonic Configuration Dialogue

The harmonic values to be logged and the log period can be configured on the Harmonic Configuration page.

The Log Period options are: 1, 5, 10, 15, 30, 60, 120, 360, 480, 720 and 1440 minutes.

Depending on what options were selected, WSOS will estimate how long a record will be retained by the controller before it has to be overwritten to make way for the logging of a new record. The estimated time is displayed in a read-only field at the bottom of the Harmonic Configuration dialogue box.

WSOS will display a warning message if the estimated time is less than one week.

Harmonic values as configured will be logged by the controller and can be uploaded by selecting the Upload button on the History page with Harmonic History selected as shown below:

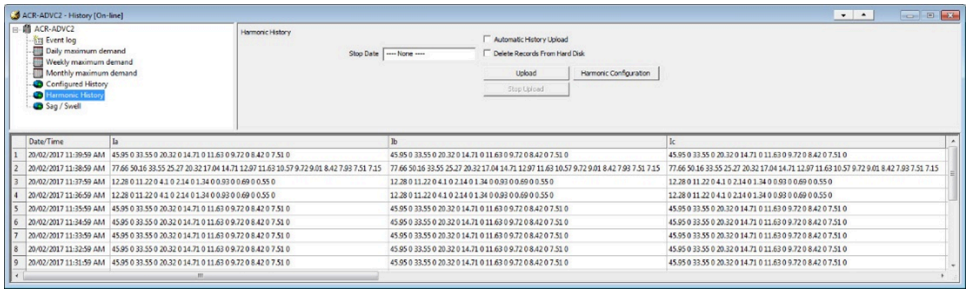


**Figure 281**
Harmonics History

For more information on uploading history files, refer to Uploading History Files, page 484.

Uploaded log files can be saved as either Text or CSV files from the context menu launched by right clicking on the uploaded display.

The Harmonic Configuration dialogue can also be launched from the Harmonic Configuration button on the History page with Harmonic History selected.

# Sag and Swell History

Sag and Swell history can be used to record any Sag and/or Swell events that have occurred according to the way Sag/Swell , page 516 has been configured.

Once Sag/Swell has been made available it can be configured in WSOS on the Sag/Swell configuration dialogue box shown below that can be opened from:

**Display** > **Power Quality** > **Sag/Swell**.

Either Sag and/or Swell must be enabled for events to be recorded.

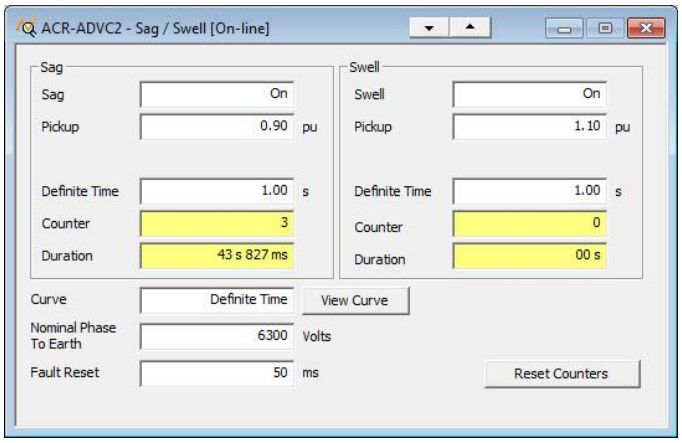



**Figure 282**
Sag/Swell Configuration

Any Sag/Swell events that have been recorded by the controller can be retrieved via WSOS by clicking the Upload button on the History page with Sag/Swell selected.

For more information on uploading history files, refer to Uploading History Files, page 484.

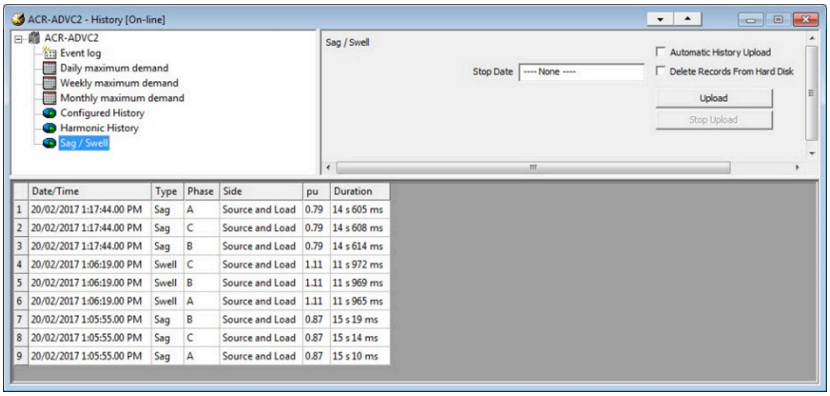



**Figure 283**
Sag/Swell History

Uploaded log files can be saved as either Text or CSV files from the context menu launched by right clicking on the uploaded display.

# Power Quality

## What's in This Chapter

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# Power Quality Tool Kit

Utilities are coming under increasing pressure from both customers and regulatory bodies alike to review the quality of power they are providing. This requires monitoring of the networks for various indices such as number of and duration of outages, sag/surge voltages and system harmonics.

The PowerLogic ADVC Controller takes advantage of the switchgear's built in current and voltage sensors to provide power-monitoring abilities to meet the benchmark needs without the need for highly priced specialized monitoring instruments that require expensive additional current and voltage transformers.

# Supply Outages

## Introduction

Many utilities analyse their network outages to measure the supply reliability to their customers. The average duration and frequency of outages are key indicators in this process and they are commonly defined as:

- System Average Interruption Duration Index (SAIDI). This is the average minutes lost per customer per year. Each utility has its own definition of lost customer minutes. For example, it may not include outages of less than one minute or outages resulting from transmission grid failure or extreme weather events.
- System Average Interruption Frequency Index (SAIFI). This is the average number of interruptions per customer per year. Each utility may define an outage in a different way.

The Supply Outage Measurement feature can be used to record the number and duration of outages. These statistics are recorded by the PowerLogic ADVC Controller and are available to the utility to help calculate SAIDI and SAIFI. The number of consumers on the source and load sides of the device also needs to be known. If data for the timer and duration of individual outages is required it can be obtained from the Event Log.

## Determination of Supply Outages

The PowerLogic ADVC Controller monitors the ACR or AS switchgear terminal voltages to determine when there is an outage. A loss of supply voltage on one or more phases for a user-set time is defined as the start of the outage and when voltage is restored to all three phases for the same user-set time, the outage has ended. The reported outage duration is the actual time without voltage. The PowerLogic ADVC Controller logs:

- The number of outages
- The total outage duration
- The start and finish times for each outage in the Event Log.

Number of outages and total outage duration are recorded separately for the Source and Load sides of the switchgear.

If the switchgear is disconnected from the PowerLogic ADVC Controller or the PowerLogic ADVC Controller is powered down during an outage, then it cannot determine the outage duration. In such cases the duration data for that specific outage is discarded but the outage counter is maintained.

# Supply Outage Configuration

Supply Outage Measurement is an optional feature and must be made available through Feature Selection before it can be used.

It can be made available through WSOS at:

**Display** > **Configuration** > **Feature Selection** > **Power Quality**

Or on the operator interface for an ACR or AS.

Once available, Supply Outage Measurement settings can be configured in WSOS on the Supply Outage page.

**Display** > **Power Quality** > **Supply Outage**

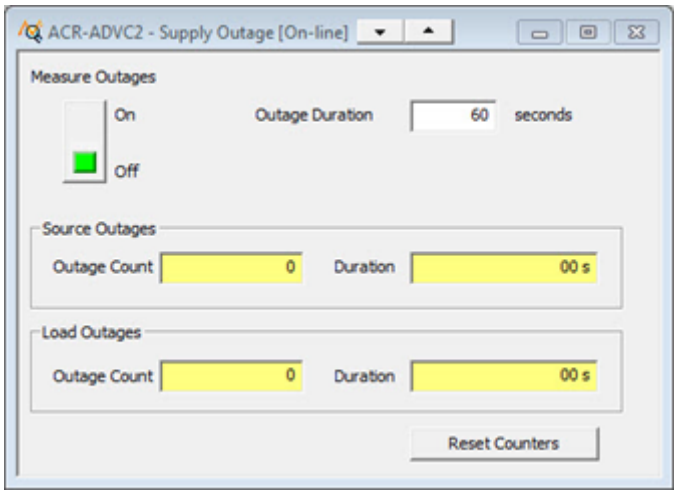



**Figure 284**
Supply Outage settings in WSOS

The table below lists and describes the configurable and read-only settings associated with Supply Outage measurement.

**Table 96 Supply Outage Configuration settings**

| Setting | Description |
|---|---|
| Measure Outages On/Off | Enables or Disables supply outage monitoring. This is a configurable password protected setting.<br><br>Options: Off, On. Factory default is Off |
| Outage Duration | The minimum time for loss of voltage to be recorded as a supply outage. Also used as the minimum time for restored voltage before an outage ends. This is a configurable password protected setting.<br><br>Range: 1 to 3600 s. Factory default is 60 s |
| Source Outages | The number of supply outages on the source side of the switchgear.<br><br>Read-only |
| Load Outages | The number of supply outages on the load side of the switchgear.<br><br>Read-only |

**Table 96 Supply Outage Configuration settings (Continued)**

| Setting | Description |
|---|---|
| Source Duration | The total duration for supply outages on the source side of the switchgear in hours, minutes and seconds.<br><br>Range: 0 h 0 m 0 s to 9999 h 59 m 59 s<br><br>Read-only |
| Load Duration | The total duration for supply outages on the load side of the switchgear in hours, minutes and seconds.<br><br>Range: 0 h 0 m 0 s to 9999 h 59 m 59 s<br><br>Read-only |

**NOTE:** Only the first two settings in the table above are configurable. They are used to turn Supply Outage Measurement on and to set the duration that defines an outage. The other four fields are read-only. These fields display the cumulative number and duration of outages recorded on the load and source sides of the switchgear.

# Supply Outage Operation

## Measuring the Outage Duration

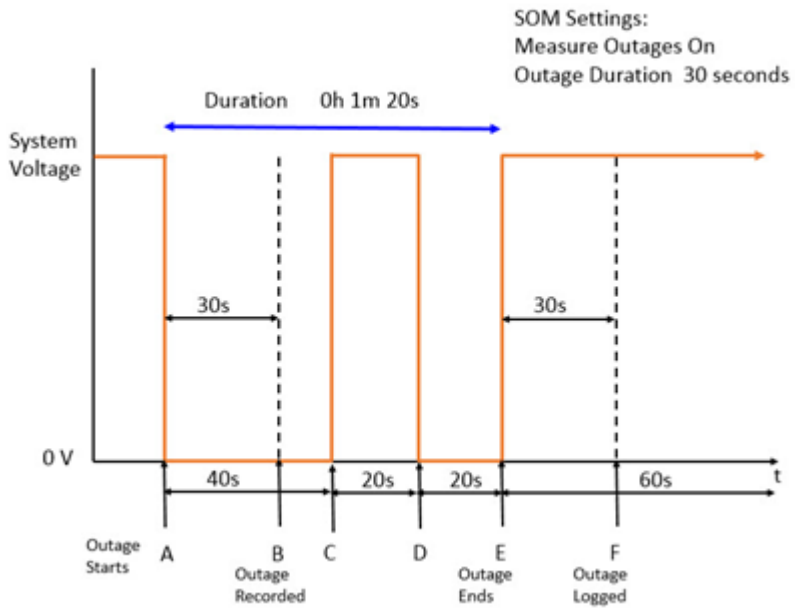



**Figure 285**
Measuring the Outage Duration

The figure above represents the voltage on either side of an ACR or AS switchgear which is alternating between the normal system voltage and zero volts. The Supply Outage Measurement settings are shown.

- The voltage drops to zero at point A which starts the Outage Duration timer and begins to measure the duration of a possible outage.
- At point B, the Outage Duration timer expires which means that an outage has occurred.
- At point C, the system voltage is restored which starts the Outage Duration timer again in order to determine if the outage has reset.
- The voltage goes to zero again at Point D before the Outage Duration timer expired so the outage has not ended and the outage duration measurement continues.

- At point E, system voltage returns which starts the Outage Duration timer to determine if the outage has ended.
- At point F, the Outage Duration timer expires which means that the outage has ended.

  **NOTE:** The outage began at point A but wasn't recorded as an outage until point B. The end of the outage was recorded at point F but it actually ended at point E. The duration of the outage is the time between points A and E which is 1 minute 20 s.

## Measuring Supply Reliability

The following examples calculate SAIDI and SAIFI from the data in the table below that includes Supply Outage Measurement readings over a three month period.

**Table 97 Three monthly SOM readings**

| | |
|---|---|
| No of Source Outages | 5 |
| Source Outage Duration | 0 h 14 m 29 s |
| No of Load Outages | 9 |
| Load Outage Duration | 0 h 45 m 10 s |
| No of Source side consumers | 100 |
| No of Load side consumers | 120 |

### SAIDI – System Average Interruption Duration Index

SAIDI measures the average minutes lost per customer per year.

SAIDI can be calculated using the formula:

SAIDI = ((source outage duration x No of source side consumers) + (load outage duration x No of load side consumers) / total number of customers) x 4

= ((14.29 x 100) + (45.10 x 120) / (100 + 120)) x 4 minutes

= 124.86 minutes

### SAIFI – System Average Interruption Frequency Index

SAIFI measures the average number of outages per customer per year.

SAIFI can be calculated using the formula:

SAIDI = ((number of source outages x number of source side consumers) + (number of load outages x number of load side consumers) / total number of consumers) x 4

= 28.73 outages

## Supply Outage Measurement – Summary

- The Outage Duration setting determines how long one or more terminals need to be dead to constitute an outage, and for how long all terminals must be live for the outage to have ended.
- Outages are only logged after they have ended.
- Outage Counts and Durations are recorded for both Source and Load sides.
- Additional information regarding can be obtained from the Event Log.

# Waveform Capture

## Introduction

The ability to capture and view system current and voltage waveform data of an electrical network system in oscilloscope format is an integral part of any power quality analysis. The power quality tool kit in the PowerLogic ADVC Controller has a feature the enables capture of the raw input data (3200 samples per second) as presented to the electronics by the A-D converters. The scaled raw data includes the three phase currents, earth current, six phase – earth/ground voltages and six phase – phase voltages.

The total recording time, the proportioning of the total recording to pre-trigger or post-trigger recording and the events that trigger the recording are user configurable from both WSOS and the operator interface.

The captured data can be retrieved later in COMTRADE (IEEE Std C37.111-1999) format using WSOS. WSOS can be used to display the data in waveform and vector formats.

## Waveform Capture Configuration

Waveform Capture is an optional feature and must be made available through Feature Selection before it can be used.

It can be made available through WSOS at:

**Display** > **Configuration** > **Feature Selection** > **Power Quality**

Or on the operator interface for an ACR, page 697 or AS, page 699.

Once available, Waveform Capture settings can be configured in WSOS on the Waveform Capture page.

**Display** > **Power Quality** > **Waveform Capture**

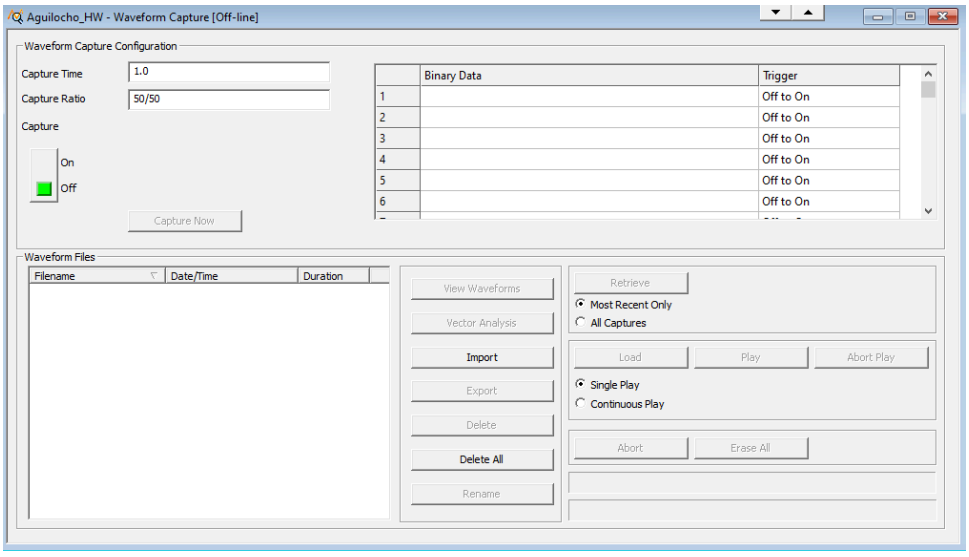



**Figure 286**
Waveform Capture configuration settings

Settings provided for the configuration of Waveform Capture are listed and described in the table below.

**Table 98 Configurable Waveform Capture settings**

| Setting | Description |
|---|---|
| Wave Capture | Enables or Disables Waveform Capture triggering. This is a configurable password protected setting.<br><br>Options: On, Off Factory default is Off |
| Waveform Capture Window | The total time window during which data is recorded per waveform capture.<br><br>The number of capture events that the controller can capture is directly related to the size of the capture window:<br>• 0.5 s allows 32 capture events<br>• 1.0 s allows 16 capture events<br>• 2.0 s allows 8 capture events<br>When the capture event buffer is full, a new capture will overwrite the oldest capture event. This is a configurable password protected setting.<br><br>Options: 0.5 s, 1.0 s, 2.0 s Factory default is 1.0 s |
| Waveform Capture Ratio | The portion of the waveform capture prior to and post a trigger event. This is a configurable password protection setting.<br><br>Options: 10/90, 20/80, 30/70, 40/60, 50/50, 60/40, 70/30, 80/20, 90/10 Factory default is 50/50 |
| Capture Now | To manually trigger a waveform capture.<br><br>When set to Capture Now ON, the controller performs a waveform capture and sets the setting to Waveform Captured. Requires Wave Capture On to be active.<br><br>Options: On/Off Factory default is Off |

If Waveform Capture is On, it can be triggered automatically from one or more selected triggers. Available triggers are listed and described in the table below.

**Table 99 Waveform Capture Trigger options**

| Trigger | Event that triggers a waveform capture |
|---|---|
| Protection Trip | Any protection trip |
| Manual Close | Manual close (includes IOEX, WSOS and protocol closes) |
| Manual Trip | Manual trip (includes IOEX, WSOS and protocol trips) |
| Auto Close | Automatic close (includes automatic reclose, loop automation and auto changeover closes) |
| Harmonics | Harmonics outside their configured alarm limits |
| Pickup | Protection pickup |

## Extended Waveform Capture

With release A50-11.xx installed, it is now possible to capture a waveform in the controller for up to 40 s.

> **NOTE:** Versions A50.15.04 and later the maximum capture time is 10 s. Waveform capture can be enabled via the Feature Selection window in WSOS5.

With WSOS5 5.16.19, there is a noticeable difference in the configuration option for the Capture. When configuring the ADVC3 for firmware version A50-11.xx, the user will be presented with:

- An option to configure the duration of the capture, as shown in below figure.
- An option to automatically extend the capture, for up to 40 s, in the event of a continued capture trigger, beyond the configured Capture time For example, let’s assume that the Capture Time is configured to 5 s, and a capture on Pick-up is enabled.

The controller will start recording the waveform as soon as a Pick-up is flagged. If the controller remains in this Picked-up state for longer than 5 s, then the duration for the capture is automatically extended, if the Extend on Continued Trigger is enabled.

The controller will start recording the waveform as soon as a Pick-up is flagged.

If the controller remains in this Picked-up state for longer than 5 s, then the duration for the capture is automatically extended, if the Extend on Continued Trigger is enabled.

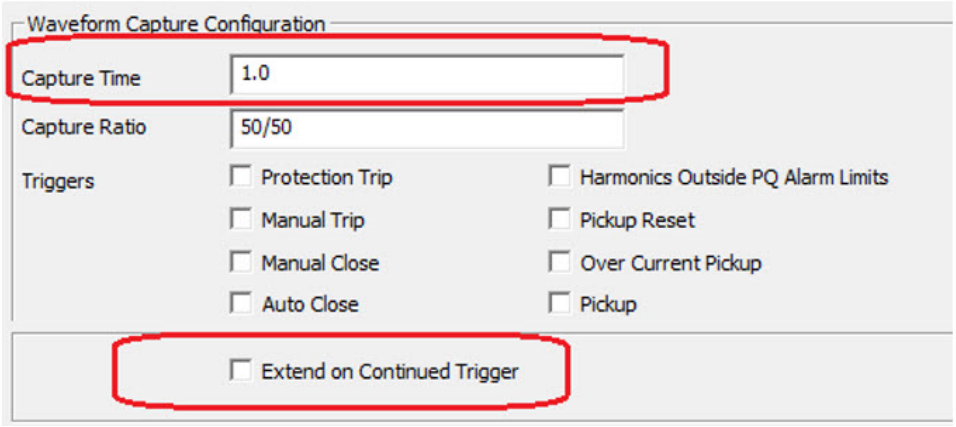



**Figure 287**
Capture options with A50-11.xx

The configuration for the Capture Duration has a minimum setting of 0.5 s and a maximum of 40 s, as shown in below figure.

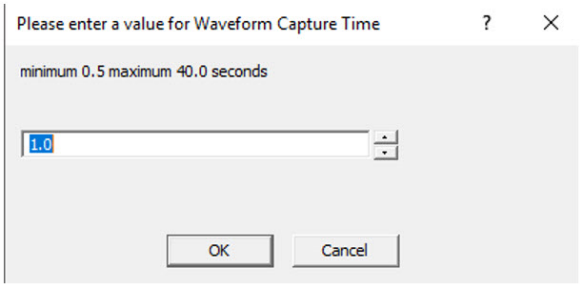



**Figure 288**
Capture duration configuration

**NOTE:**

1. This version obsoletes the previous Capture Options configuration, which was based on the number of events recorded, as shown in below figure. When upgrading to ADVC3 to version A50-11.xx, this configuration will be set to 0.5 s as default and will need to be re-configured suitably.

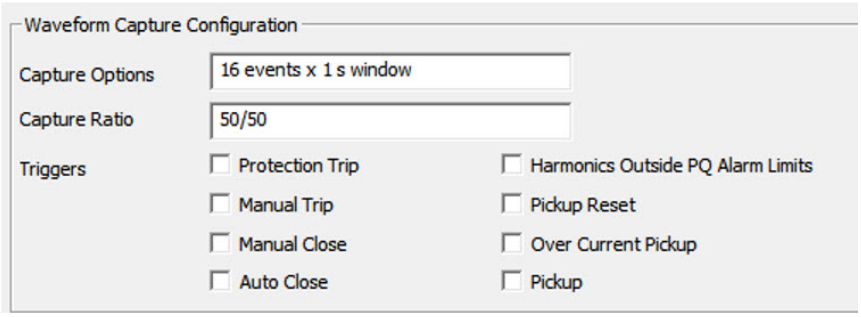



**Figure 289**
Capture options prior to A50-11.xx

2. The format of the captured waveform, which is stored in the controller, is no longer backwards compatible with the previously captured waveforms that may exist in the in the controller's storage area.

   As a part of the installation process, the older captures in the controller will be upgraded to the newer format.

   It is advisable to retrieve any older captures, prior to upgrading the firmware on the PowerLogic ADVC Controllers.

# Waveform Capture Operation

## Triggering

A waveform capture can be triggered manually from the operator interface or from WSOS on-line to the PowerLogic ADVC Controller. A waveform capture can also occur automatically if triggered by an event associated with one of the triggers that have been selected.

The timing of an automatic trigger is from the internal controller request signal. For example, if Manual Trip is selected as a trigger and the switchgear is tripped from the trip key on the operator interface, the beginning of the waveform capture will coincide with the time stamp for the Panel Trip Request recorded in the Event Log.

The accuracy of the pre and post trigger ratio is therefore subject to minor software variances, plus in this case, the operating time of the switchgear.

Any number of automatic triggers can be selected. If a waveform capture is triggered, and a second trigger occurs while the initial waveform capture is being processed, the second trigger will be ignored.

When a waveform capture occurs, the captured data for all ten waveforms is processed by the PowerLogic ADVC Controller and stored in its memory.

## Protocol Digital Points as Waveform Capture Triggers

The digital input points from the SCADA protocol can now be used as triggers to capture waveforms. A digital point can be configured to trigger a waveform capture when it transitions from off to on or vice versa. The digital point configuration opens by double clicking the list of triggers on the right side of the window on below Figure.

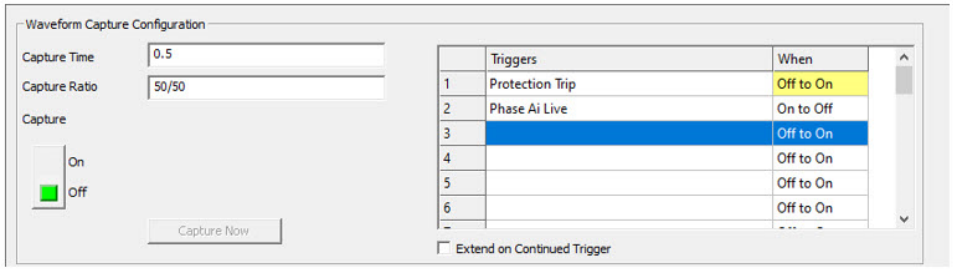



**Figure 290**
Waveform Capture window

The capture triggers that were available prior to this release are listed under the Fixed Points section and the new digital trigger points are listed under the Data Points section as shown in Figure.

**NOTE:** The Fixed Points can only trigger by an Off to On transition. Therefore, the When column is shown in yellow as read-only fields.

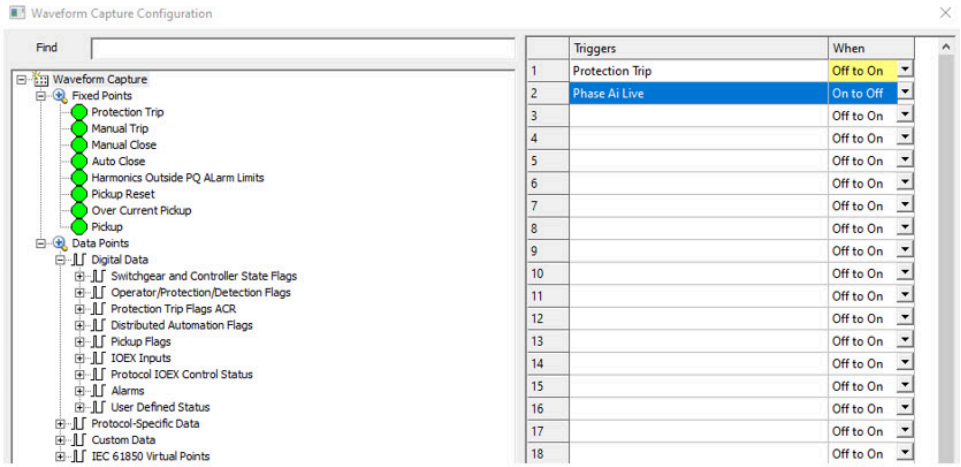



**Figure 291**
Waveform capture trigger configuration for digital points

## Retrieval

Waveforms stored in the controller can be read by WSOS and saved in the WSOS PC's memory. The operator can choose to retrieve the most recent capture or all captures stored in the controller by selecting the required option.




All waveform captures retrieved from the PowerLogic ADVC Controller are identified by the date/time they occurred and displayed in the Waveform Files field on the WSOS Waveform Capture window.

## View Waveforms for Waveforms Display

Selecting one of the retrieved files allows it to be viewed by selecting the View Waveforms button.

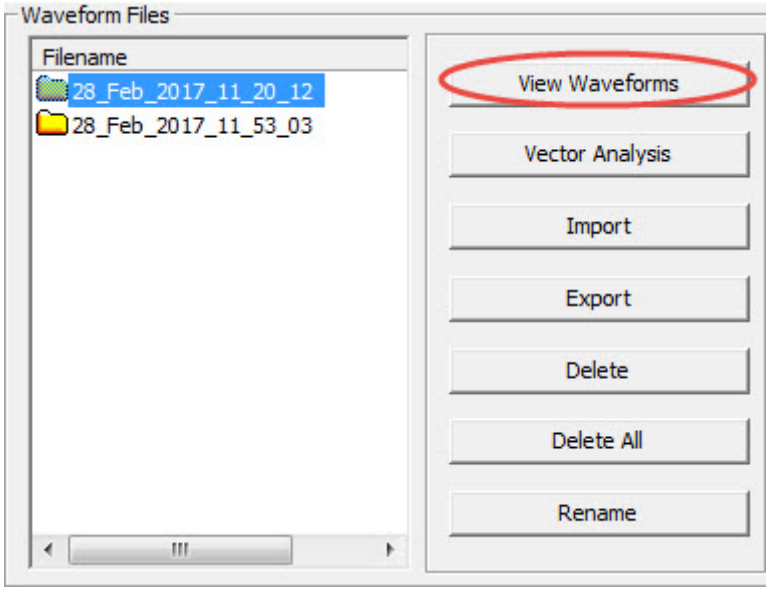



**Figure 292**
List of Waveform Capture files retrieved from the PowerLogic ADVC Controller

View Waveforms causes the selected waveform capture to be displayed in oscilloscope format.

The figure below is an example of a waveform capture that was triggered by a protection trip caused by a single phase overcurrent fault.

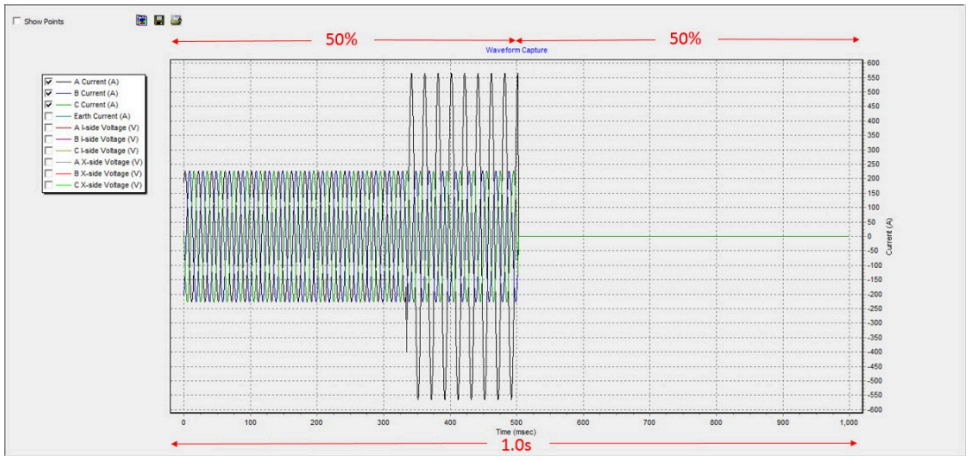



**Figure 293**
Waveform Capture example

A tick box in the top left hand corner can be used to display the points on which the displayed waveforms have been plotted.

Copy, Print and Save options are also made available via icons near the top of the window.

From the figure above it can be seen that:

- The Waveform Capture Window setting was 1.0 s
- The Capture Ratio setting was 50/50
- Although every waveform capture captures all ten waveforms only A, B, and C phase currents were selected for display in this case.

### Zoom

The viewed waveform can be zoomed into by clicking and dragging left to right to select the area of interest.

An example of a zoomed waveform is shown in the figure below.

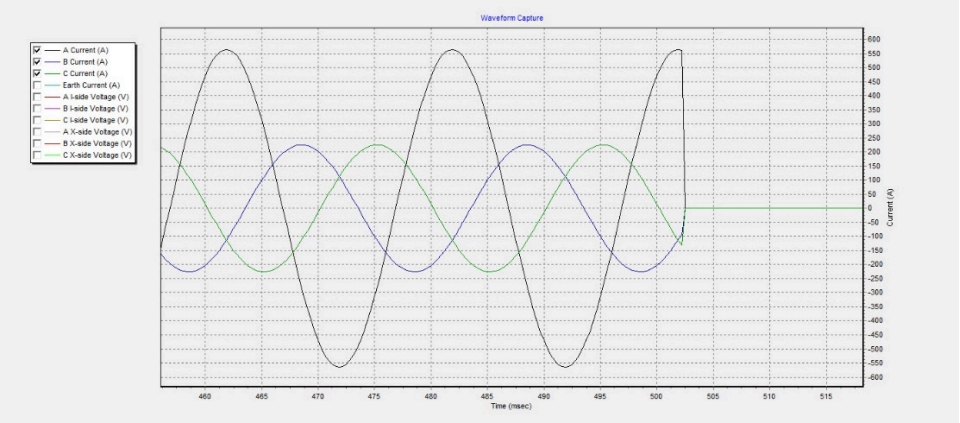



**Figure 294**
Waveform Capture viewed in Zoom format

The original display can be restored by clicking and dragging right to left anywhere on the captured waveform display.

### Waveform Capture Display

The Waveform Capture View display (A50-15.06) has been as modified shown in the image below. The window now displays the Currents, Voltages, and digital statuses (ADVC3 only) as separate sections.

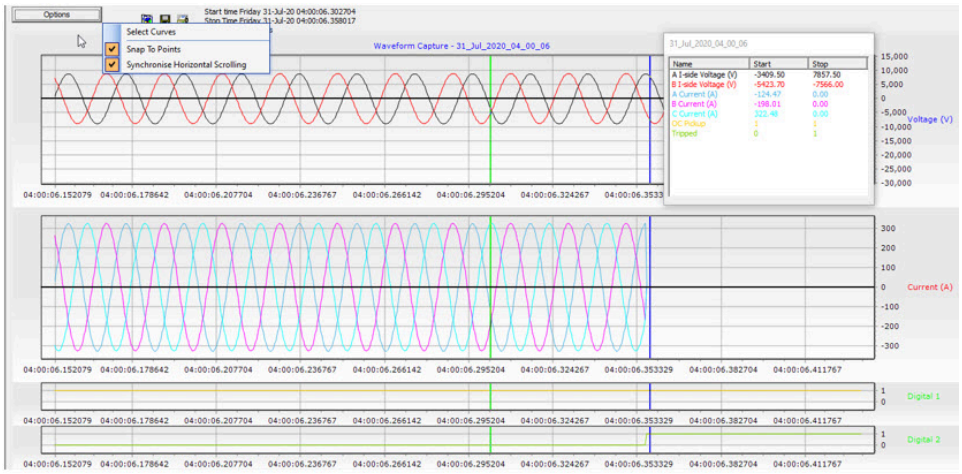



**Figure 295**
Waveform Capture Display page

The Select Curve option can be used to select the phase specific Voltage and Currents channels, and the Digital data to view.

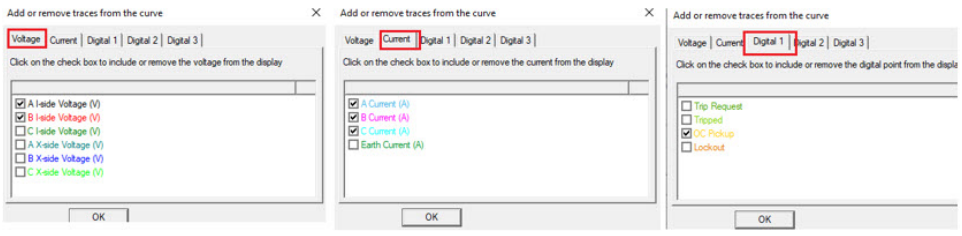



**Figure 296**
Waveform Capture Cursor page

## Waveform Capture Display

The Waveform Capture View display has been as modified shown in the image below. The window now displays the Currents, Voltages, and digital statuses (ADVC3 only) as separate sections.

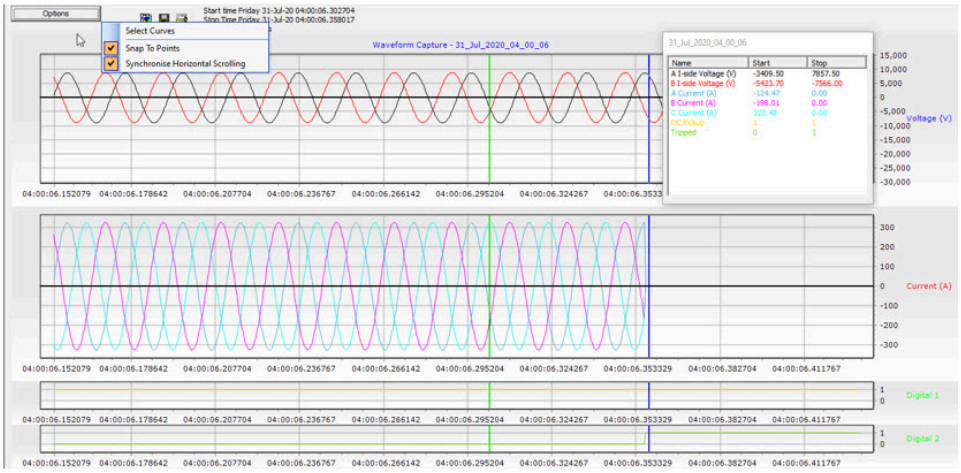



**Figure 297**
Waveform Capture Display page

The Select Curve option can be used to select the phase specific Voltage and Currents channels, and the Digital data to view.

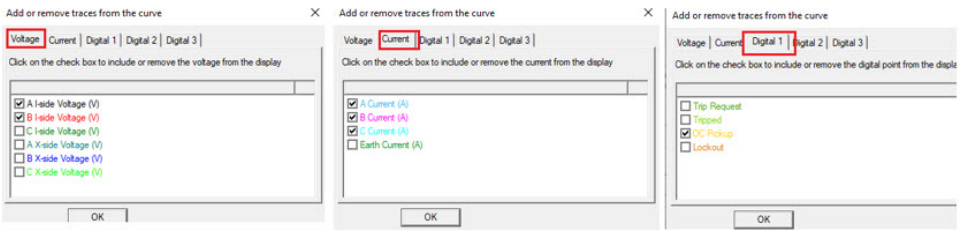



**Figure 298**
Waveform Capture Cursor page

## Vector Analysis

Vector analysis and polar charts of the selected waveform can be viewed by selecting the Vector Analysis button to the right of the Waveform Files display.

The waveform capture vector analysis display as shown in the figure below will appear.

The vector analysis display can be repositioned in order to assist viewing by right mouse button clicking and dragging the image to achieve the orientation required.

The point on the vector analysis time axis relating to the polar chart is indicated by a vertical line. This line can be moved by clicking and dragging it with the left mouse button or alternatively, left and right arrows above the vector display are provided for this purpose.

Separate Copy, Print and Save icons are provided for the Vector Analysis and Polar Chart displays.

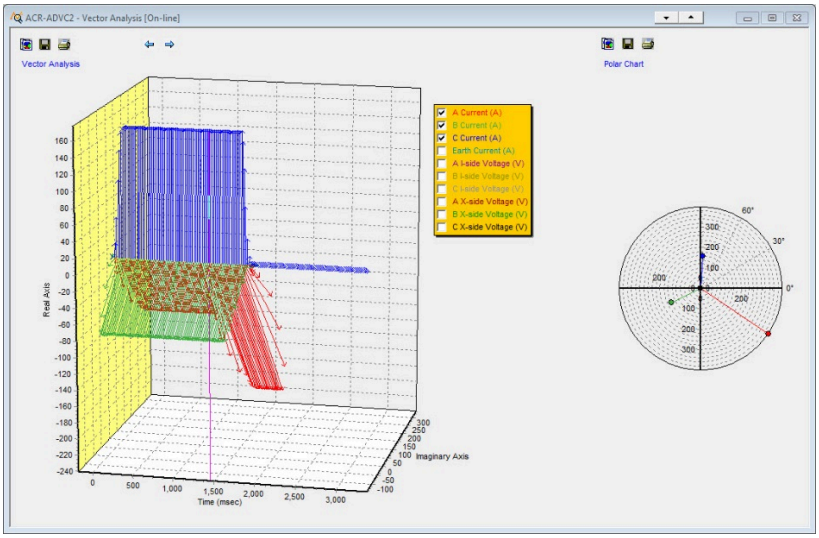



**Figure 299**
Waveform Capture Vector Analysis and Polar Chart Display

## Waveform Replay

A waveform capture that has been retrieved by WSOS can be loaded back into the PowerLogic ADVC Controller for the purpose of simulating the conditions that were present when the waveform capture occurred.

The procedure is to select the required waveform capture from the list of retrieved waveform files and select the Load button.

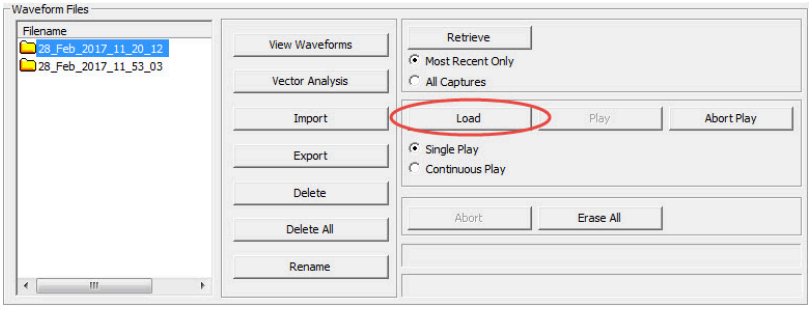


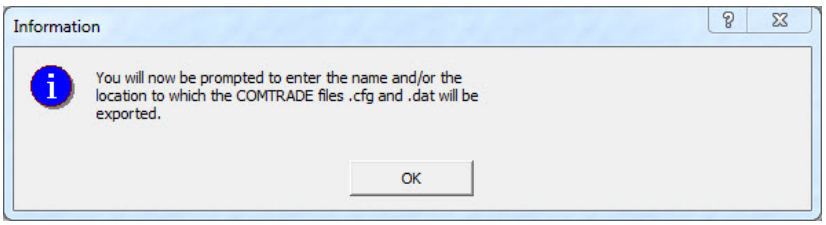

**Figure 300**
Loading a Waveform Capture back into the PowerLogic ADVC Controller

Once the load is complete the Play button will become active which can be used to replay the waveforms in either Single Play or Continuous Play mode.

The Abort Play button can be used to stop the replay at any time.

## File Handling

Waveform captures that were retrieve from the PowerLogic ADVC Controller can be saved as COMTRADE files. Selecting the Export button will cause WSOS to display the message below:




Clicking **OK** in the message above will open the MS Windows Save As dialogue box allowing a location and if necessary a new name for the files to be saved as.

Two files with *.cfg* and *.dat* extensions as per the COMTRADE format are saved.




Waveform capture files saved in the COMTRADE format can be transferred to another PC and imported into WSOS running on that PC.

Retrieved or Imported waveform files can also be deleted and/or renamed as required.

# Waveform Capture Summary

- The total recording time, the proportioning of the total recording to pre-trigger or post-trigger recording and the events that trigger the recording are user configurable from both the operator interface and WSOS.
- The captured data can be later retrieved and saved in COMTRADE (IEEE Std D37.111.1999) format using WSOS.
- Waveform captures can be displayed by WSOS in waveform or vector formats.
- There is 2 Mb available in the PowerLogic ADVC for waveform capture files which equates to 16 s of recordings.
- Once the available memory is full, subsequent captures will overwrite the oldest captures already in memory. Captures will not be lost if they are retrieved by WSOS before they’re overwritten.
- Each second takes approximately 128 kb.
  - (3200 samples * 10 channels * 4 bytes)

## Sample Rate Enhancements and Implications

With this release, the Digital Signal Processor sample rate has been increased from 3200 samples per second to 8000 samples per second. This is required for Transient Earth Fault protection. This change impacts waveform capture which will also use the increased sample rate of 8000 samples per second.

**NOTE:** Before upgrading a control unit to this firmware version any stored waveform captures must first be retrieved from the control unit.

To facilitate with this increased sample rate change, user must take into account the following considerations:

- **DESIGN ADAPTATION**:

  **NOTE:** If a user chooses to play back older version waveforms captured at the slower rates to the PowerLogic ADVC, they are automatically up scaled by the controller as required to 8000 sample per seconds.

  Waveforms can be played back to an ADVC while online with WSOS by choosing the Display menu and Selecting Power Quality and then selecting the Waveform Capture feature to open the Waveform Capture dialogue box. The user must first select and load the required waveform and then choose play.

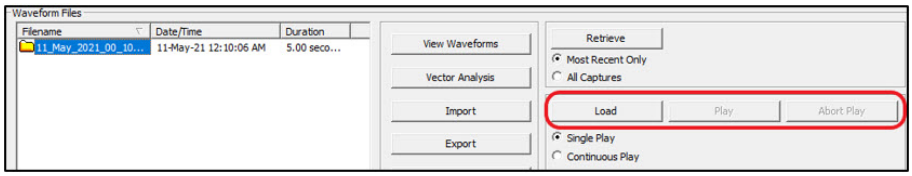



**Figure 301**
Waveform Capture replay function using WSOS5

- **DESIGN LIMITATIONS**:

  **NOTE:** The maximum capture time of all the new waveform is limited to 10 s.

  **NOTE:** Due to change in the format of the waveform capture and retrieve mechanism, old waveform captures (already present in the Controller) captured at the previous lower sample rate cannot be retrieved. It is recommended to recover all stored waveforms before proceeding with a Firmware Upgrade to 50.15.04 or later. Waveforms that have not been recovered before a firmware upgrade cannot be retrieved after the firmware Upgrade Process is complete.

Waveforms can be from an ADVC while online with WSOS by choosing the display menu, selecting Power Quality and then select the Waveform Capture Configuration feature to open the Waveform Capture dialogue box. Use the Retrieve option to retrieve all or the most recent capture.

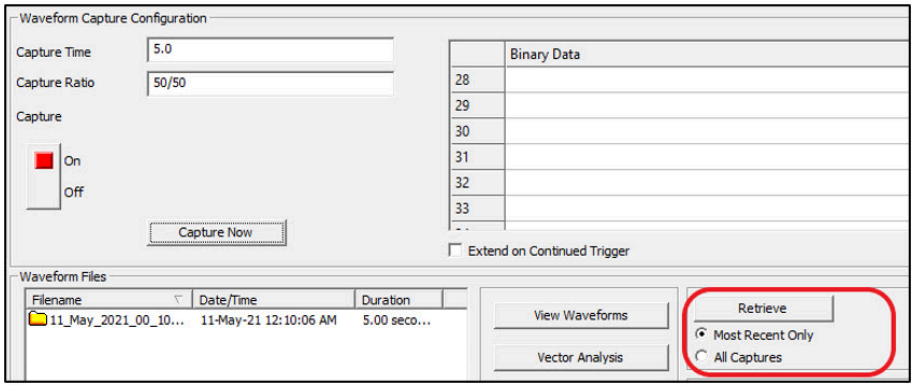



**Figure 302**
Waveform Capture retrieve option using WSOS5

# Harmonic Analysis

## Introduction

Many utilities are finding that the nature of their electricity network load is changing as an increasing number of distorting devices are attached to it. Typical sources of waveform distortion include variable speed drives, personal computer power supplies, uninterruptible power supplies, fluorescent lamp ballasts and transformer excitation currents.

Simultaneously with the increased level of waveform distorting sources there is also an increasing quantity of advanced electronic equipment that is sensitive to the waveform purity of the power it receives. Examples of such equipment include personal computers, modern home electronic equipment such as televisions, audio and visual entertainment devices, dishwashers, washing machines, microwaves etc, and sensitive industrial control and instrumentation equipment.

To complicate things further, high levels of distortion can also lead to increased line loses and transmission equipment burn out which means increased utility equipment costs.

Utilities are therefore finding it necessary to analyze their network currents and voltages to detect the level of waveform distortion. The index for distortion most commonly used is harmonics. In addition to monitoring the harmonics themselves, a Total Harmonic Distortion (THD) value can be calculated. THD is a relative value of all harmonics with respect to the fundamental that is expressed as a percentage.

The PowerLogic ADVC Controller calculates 2$^{nd}$ to 16$^{th}$ harmonics and THD over a 80 ms period for 4 currents (3 x phase + earth/ground), 6 x phase – phase voltages and 6 x phase – earth/ground voltages. Each harmonic and the THD is averaged over a moving 2 s window, updated every 500 ms.

# Harmonic Analysis Configuration

Harmonic Analysis is an optional feature and must be made available through Feature Selection before it can be used.

It can be made available through WSOS at:

**Display** > **Configuration** > **Feature Selection** > **Power Quality**.

Or on the operator interface for an ACR or AS.

Once available, Harmonic Analysis settings can be configured in WSOS on the Harmonic page.

Display → Power Quality → Harmonics

Harmonic Analysis can only be configured using WSOS. There is no facility to configure Harmonic Analysis via the Operator Interface.

When Harmonics has been made available, it can be configured on the WSOS Harmonics page which is shown in the figure below.

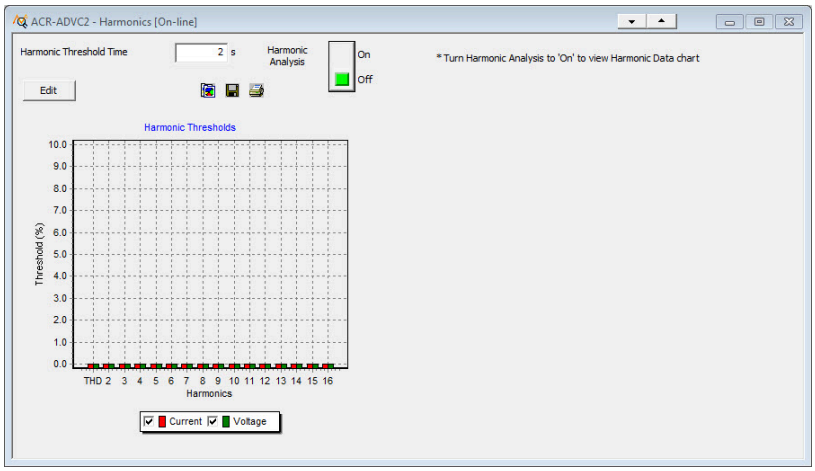



**Figure 303**
Harmonics configuration page in WSOS

The harmonics configuration page in WSOS can be used to:

- Enable Harmonic Analysis by selecting Harmonic Analysis On.
  - When Harmonic Analysis is On, a Harmonic Data display appears to show the value of harmonics being measured in a bar chart format.
- Set the Harmonic Threshold Time for between 2 and 60 s.
  - This is the time that a harmonic must exceed its threshold for before an alarm is recorded in the Event Log.
  - The Harmonic Threshold Time is also used when the harmonic value returns to below its threshold before an alarm Off event is logged.
- Edit the thresholds for 2nd to 16th harmonics plus THD for Current and Voltage.

# Harmonics Display

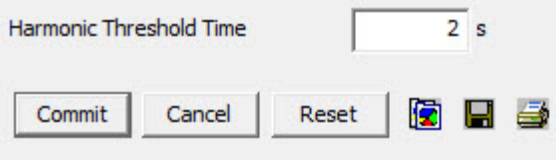
The Harmonics configuration page has been modified (A50-15.06) to include a grid to view/edit the threshold values.

The thresholds for the 2nd to 16th harmonics plus THD can be set in the table directly in the Edit mode.

# Editing Harmonics Alarm Thresholds

Selecting the **Edit** button on the Harmonics configuration page will put Harmonics Analysis in Edit mode.

This mode can be identified by the Cancel and Reset buttons that appear.




In Edit mode, the threshold values for each of the harmonics between 2nd and 16th as well as THD for both current (red) and voltage (green) can be configured.

Individual alarm thresholds are set by clicking and dragging each of the 32 bars provided as required.

When all thresholds have been set correctly, selecting the Commit button will save the settings and exit the Edit mode.

In the Harmonics Thresholds display in the figure below, the alarm thresholds have been set as shown for both voltage and current:

| Harmonic | Alarm Threshold |
|---|---|
| THD | 5% |
| 2nd | 4% |
| 3rd | 4% |
| 4th | zero |
| 5th | zero |
| 6th | 3% |
| 7th | 3% |
| 8th | zero |
| 9th | zero |
| 10th | 2% |
| 11th | 2% |
| 12th | zero |
| 13th | zero |
| 14th | 1% |
| 15th | 1% |
| 16th | zero |

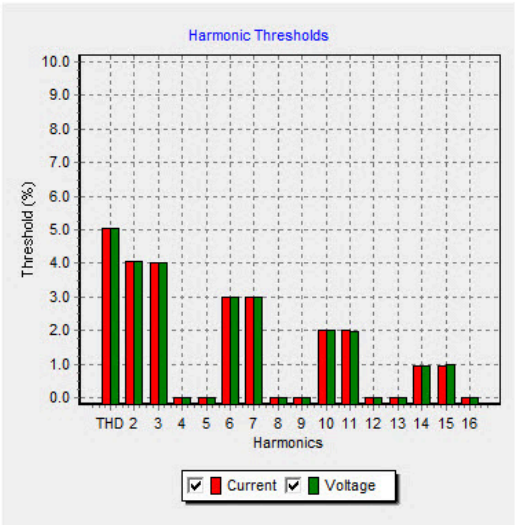



**Figure 304**
Harmonics Alarm Thresholds settings and configuration

**NOTE:** Harmonics that are set to zero, that is not configured, will never cause an alarm.

# Harmonics Display

The Harmonics configuration page has been modified to include a grid to view/edit the threshold values.

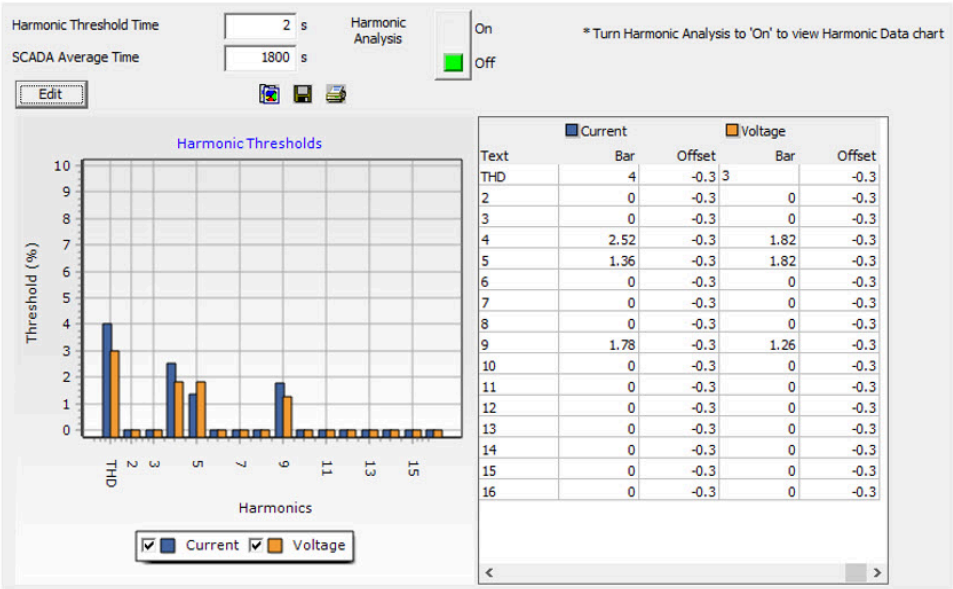



**Figure 305**
Harmonic display page

The thresholds for the 2nd to 16th harmonics plus THD can be set in the table directly in the Edit mode.

# Harmonic Analysis Data

When Harmonic Analysis is enabled, WSOS displays the measured harmonic data on the Harmonics page in a bar chart format as shown in the figure below.

Six quantities as selected by the tick boxes on the right of the Harmonic Data chart are displayed.

This display represents voltage and current waveforms rich in odd harmonics.

No alarm thresholds were configured for odd harmonics 5, 9 and 13 which are displayed in green to indicate that they are not in an alarm state.

The 3rd harmonics for the three selected voltages are also displayed in green because they have not exceeded their configured alarm threshold setting of 4%.

All other 3rd, 7th, 13th and 15th harmonics as well as THD have exceeded their alarm thresholds and are in an alarm state. The bars representing these harmonics are displayed in the color associated with their particular quantity as indicated next to their tick boxes.

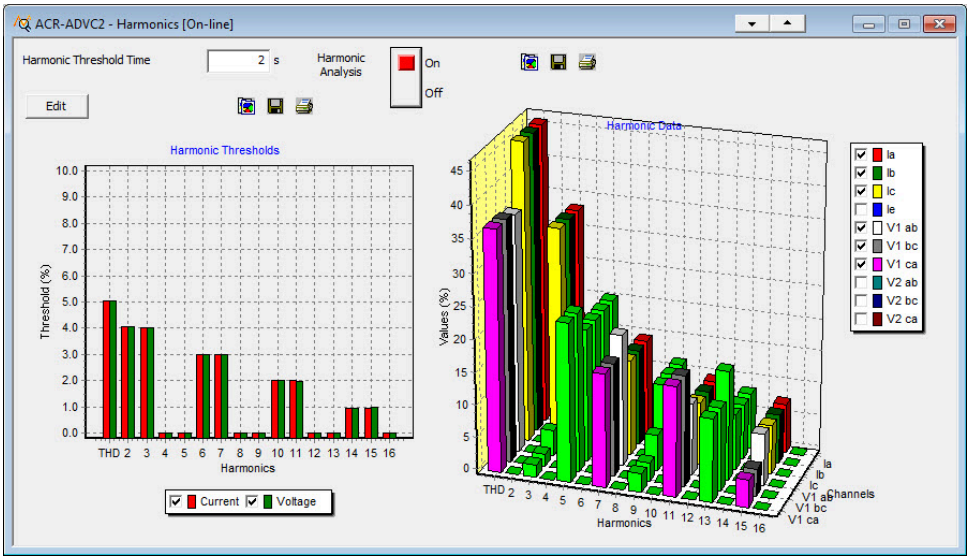



**Figure 306**
Harmonic Data displayed according to the alarm threshold configuration

## Harmonic Analysis Events

Alarm events are logged whenever any quantity exceeds its harmonic alarm threshold setting for the set Harmonic Threshold Time. A reset event is logged when a quantity that was in an alarm state, drops back below its harmonic alarm threshold value and stays there for the set Harmonic Threshold Time.

An extract from the Event Log below shows the events recorded when the V1 c-a voltage exceeds the 3rd harmonic voltage alarm threshold at 5:16:18.176 and then resets 5 s later. The reset event is followed almost immediately by another event recording the maximum 3rd harmonic sampled while the alarm state was active.

| | | |
|---|---|---|
| 28/02/2017 5:16:23.179 PM | | Harmonic V1ca:3H 35.1% Maximum |
| 28/02/2017 5:16:23.176 PM | | Harmonic V1ca:3H Reset |
| 28/02/2017 5:16:18.176 PM | | Harmonic V1ca:3H 35.1% |

## Harmonic Analysis History

A harmonics history is also available through WSOS and can be configured by launching the harmonics history configuration page.

For more information on this feature, refer to Harmonic History, page 493 in the History chapter.

## Harmonic Analysis Summary

- The PowerLogic ADVC Controller calculates 2nd to 16th harmonics and Total Harmonic Distortion over 80 ms periods for:
- 4 currents (three phase currents + earth/ground)
- 6 phase to phase voltages
- 6 phase to earth voltages
- Each value is averaged over a moving 2 s window updated every 500 ms.
- The magnitude of each harmonic is represented as a percentage of the RMS value of the fundamental, not the total RMS of the distorted waveform.

Total Harmonic Distortion (THD) equals the RMS value of all harmonics divided by the RMS value of the fundamental expressed as a percentage.

# Sag and Swell

## Introduction

This feature enables sags and swells in the voltage of any of the available bushings to be recorded in the Event Log, and in historical data for later examination.

Monitoring occurs regardless of whether the switchgear is closed or tripped.

For the Sag and Swell Monitoring feature to operate correctly, an accurate Nominal Phase to Earth operating voltage must be specified. All deviations in voltage are referenced to this setting in per unit values.

Sag and Swell Monitoring uses a form of voltage/time curve to provide an envelope beyond which Sag/Swell events occur. The curves available are:

- Definite time
- User defined custom curve

The default curve is Definite Time but if customized Sag and Swell curves are required they can be configured using the curve editor in WSOS and written to the PowerLogic ADVC Controller.

## Sag and Swell Monitoring Configuration

Sag and Swell Monitoring is an optional feature and must be made available through Feature Selection before it can be used.

It can be made available through WSOS at:

**Display** > **Configuration** > **Feature Selection** > **Power Quality**

Or on the operator interface for an ACR or AS.

Once available, Sag and Swell Monitoring can be configured and monitored in WSOS on the Sag/Swell page.

**Display** > **Power Quality** > **Sag/Swell**

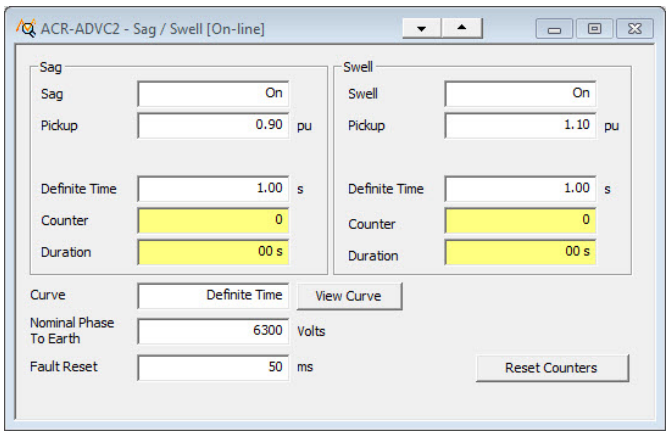



**Figure 307**
Sag and Swell Configuration and Monitoring page

Settings provided for the configuration of Sag and Swell Monitoring are listed and described in the table below.

**Table 100 Sag and Swell Monitoring configuration settings**

| Setting | Description |
|---|---|
| Sag Monitoring | Allows Sag monitoring to be enabled independently of Swell monitoring. Options: On, Off. Factory default is Off. |
| Sag Pickup threshold | Designates the voltage level in pu values at or below which a Sag pickup occurs.<br><br>Range: 0.50 to 0.98 in 0.01 steps. Factory default is 0.9. |
| Sag Definite Time | The time that the voltage must be at or below the Sag Pickup level before a Sag event is logged. This setting is only available when the selected Curve is Definite Time.<br><br>Range: 0.01 to 100.00 s in 0.01 s steps. Factory default is 1.00 s. |
| Swell Monitoring | Allows Swell monitoring to be enabled independently of Sag monitoring. Options: On, Off. Factory default is Off. |
| Swell Pickup threshold | Designates the voltage level in pu values at or above which a Swell pickup occurs.<br><br>Range: 1.02 to 2.00 in 0.01 steps. Factory default is 1.1. |
| Swell Definite Time | The time that the voltage must be at or above the Swell Pickup level before a Swell event is logged. This setting is only available when the selected Curve is Definite Time.<br><br>Range: 0.01 to 100.00 s in 0.01 s steps. Factory default is 1.00 s. |
| Curve | The Voltage/Time curve used for the determination of Sag/Swell events. Options: Definite Time, User Defined Curves 1 to 5.<br><br>Factory default is Definite Time. |
| Nominal Phase to Earth Voltage | The nominal phase to earth system voltage. This value allows the ratio, in pu values, of actual to expected voltages to be calculated.<br><br>This setting is a duplication of the setting used by Under/Over Voltage Protection, Directional Protection and Directional Protection.<br><br>Range: 2000 V to 25,000 V. Factory Default is 6,300 Volts |
| Fault Reset | The time after a Sag pickup that the voltage must be greater than or equal to the Sag Pickup level plus the dead band before a Sag reset occurs. This is the time at which the Sag event is logged if the voltage was such that it passed through the selected curve during the Sag.<br><br>Or<br><br>The time after a Swell pickup that the voltage must be less than or equal to the Swell Pickup level minus the dead band[53] before a Swell reset occurs. This is the time at which the Swell event is logged if the voltage was such that it passed through the selected curve during the Swell.<br><br>Range: 0 to 10,000 ms. Factory default is 50 ms. |

# Sag and Swell Monitoring Operation

Every excursion of the voltage of any phase below the Sag curve or above the Swell curve causes a Sag/Swell event to be logged at the conclusion of the excursion.

## Excursion Conclusion and Event Duration

The conclusion of the excursion is defined as the voltage returned to Normal for the Fault Reset time. The Fault Reset time is user configurable. If the voltage is picked up again before the reset time expires, the timer is reset.

The duration of the Sag/Swell event is defined as the time from the instant that the voltage goes outside any point on the curve in use (that is the pickup threshold) until the voltage returns to normal for that type of excursion.

## Pickup Threshold

The Pickup Thresholds are expressed as per unit values based on the nominal system voltage. The default values are 1.1 pu (Swell) and 0.9 pu (Sag). The curves in use are normalized to these values. A voltage is in pickup if it is:

- Sag; Less than or equal to the Sag Pickup Threshold.
- Swell; Greater than or equal to the Swell Pickup Threshold.

## Pickup Reset

Pickup Reset occurs when the voltage has been in pickup and then becomes:

- Sag; > Pickup Threshold plus the Dead band for the Fault Reset time.
- Swell; < Pickup Threshold minus the Dead band for the Fault Reset time.

The figure below depicts an example of a Sag event where Sag monitoring is using a custom curve plotted according to the Time/Voltage data shown on the left.

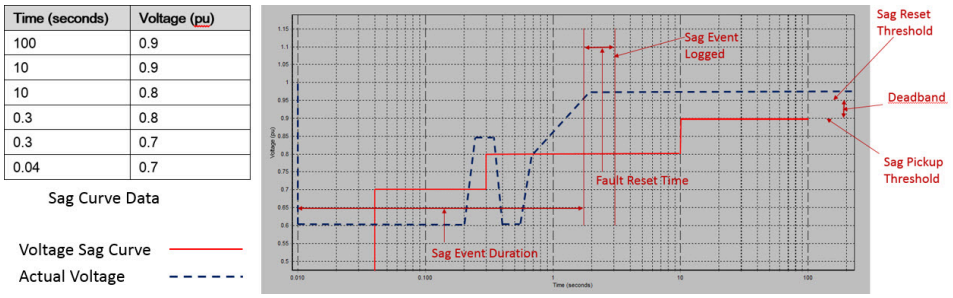



**Figure 308**
Sag Example

## Events

Every Sag or Swell event generates two records in the Event Log.

Each record identifies the phase and whether it was a Sag or a Swell event.

One record logs the duration of the event.

The second record logs the lowest sampled voltage in pu values in the case of a Sag event, or the highest sampled voltage in pu values in the case of a Swell event.

| | | |
|---|---|---|
| 1/03/2017 3:52:28.987 PM | | C Phase Swell for 19.995 seconds |
| 1/03/2017 3:52:28.987 PM | | C Phase Swell to 1.19 pu |
| 1/03/2017 3:51:13.537 PM | | A Phase Sag for 81.835 seconds |
| 1/03/2017 3:51:13.537 PM | | A Phase Sag to 0.82 pu |

If the switchgear is open when an excursion occurs, the side, either source or load, is also identified in the recorded event.

There is one event per phase that experiences the Sag/Swell.

If the switchgear is closed then only the source side voltages are monitored.

## Historical Data

To enable the use of Sag/Swell data logged, it can be exported from WSOS in the normal manner for event logs. Sag/Swell events are in the Power Quality category. A filter on Power Quality events provides just those events on interest that can then be saved as text or CSV files. See Saving Uploaded Event Log Files, page 486.

Any Sag/Swell events that have been recorded by the controller can be retrieved via WSOS by clicking the Upload button on the History page with Sag/Swell selected.

For more information, refer to Sag and Swell History, page 494.

## Sag and Swell Monitoring Summary

- Sag and Swell Monitoring is a means of recording occurrences of voltage fluctuations outside of acceptable limits.
- Sag Monitoring and Swell Monitoring can be set to On or Off independently.
- Monitoring will occur regardless of whether the switchgear is closed or open.
- Every excursion of the voltage of any phase below the Sag curve or above the Swell curve will cause a Sag/Swell event to be logged.
- The event will only be logged at the conclusion of the excursion.
- Sag and Swell behavior have been modified for 60 Hz systems. Earlier versions could, under certain circumstances, report an incorrect number of Sag and Swell incidents.

# Diagnostics and Fault Finding

## What's in This Chapter

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Waveform Generation....525

# Introduction

The PowerLogic ADVC Controller in conjunction with WSOS can perform certain functions to check the operational condition of an ACR or AS.

The functions described in this chapter are:

- Battery testing
- Communications diagnostics
- Waveform generation

A healthy battery supply is essential to the correct operation of an ACR or AS. This is mainly due to the demand placed on the batteries when the trip and close capacitors need to be recharged quickly.

The life of the batteries can be expected to be influenced by operational and environmental factors. It is recommended that the batteries are checked on a regular basis and replaced at least every five years.

The Battery Testing feature allows operators to check the battery supply in order to determine the current condition of the batteries. Battery testing can be configured to run automatically according to a predetermined schedule or activated manually from either the O.I. or WSOS.

The ADVC controller can be fitted with either 7.2Ah or 12Ah Lead Acid batteries or with 10Ah LiFePO4 batteries.

> **NOTE:** It is important that the Battery Test for Lead-Acid is configured for the correct Rated Battery Capacity in order to help ensure the accuracy of the results.

# Battery Testing

## Battery Test Configuration

The battery test function is available for operation by the PowerLogic ADVC Controller by default. Otherwise it can be made available through Feature Selection in WSOS at:

**Display** > **Configuration** > **Feature Selection** > **General**

Or it can be made available on the operator interface for an ACR or AS.

Battery test can be configured and activated from WSOS on-line to the controller on the Battery Health Test page:

**Display** > **Maintenance** > **Battery Health Test**

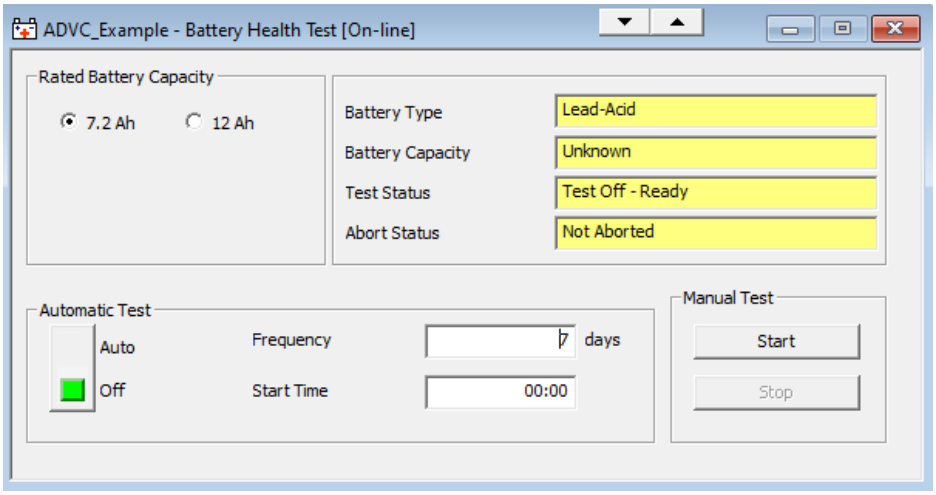



**Figure 309**

Battery Health Test page

Configurable settings and controls for the Battery Health Test feature in WSOS are listed and described in the table below.

**Table 101 WSOS Battery Test configuration settings**

| Setting | Description |
|---|---|
| Automatic Test | This setting controls the pre-configured automatic battery testing. When set to Off, the scheduled battery test will not run. When set to Auto, the battery test will run according to the Frequency and Start Time settings.<br><br>Options: Auto and Off. Factory default is Off. |
| Frequency | This is the interval in days between automatic tests when Automatic Test is set to Auto.<br><br>Range: 1 to 31 days. Factory default is 7 days. |
| Start Time | This is the desired time of day of day that automatic tests will run according to the Frequency setting when Automatic Test is set to Auto.<br><br>A scheduled test may be delayed due to conditions not suited to running the battery test for example, protection pickup, auxiliary supply off.<br><br>Range: 00:00 to 23:30 in 30 minute steps. Factory default is 00:00. |
| Manual Test<br><br>Start/Stop | This is the manual battery test control. Selecting the Start button will start the test providing a test is allowed at that time.<br><br>Normally the Start button is active and the Stop button is inactive.<br><br>While the test is running the Start button becomes inactive and the Stop button becomes active allowing the test to be aborted if required. |
| Rated Battery Capacity | Used to set the Amp hour capacity of the battery installed in the control cubicle.<br><br>Options for Lead-Acid batteries (7.2 Ah or 12 Ah): Factory default is set to correspond to the battery installed at the factory.<br><br>Options for LiFePO4 batteries (10 Ah): The option is blocked since there is only one possible capacity for this battery type. |
| Battery Type | This is a read-only field that displays the battery type which is configured.<br><br>Range: Lead-Acid, LiFePO4, Unknown. |
| Battery Capacity | This read-only field displays the battery condition as determined by the result of the most recent battery test. Battery Capacity is set to *Unknown* until the first battery test is run.<br><br>Range: Unknown, OK, Not OK. Factory default is Unknown. |
| Test Status | This is a read-only field that displays the status of the battery test. The status could be:<br><br>Test Off – Ready - The battery test is able to be run<br><br>Test Off – Wait - The battery test is not able to be run at this time<br><br>Testing - The battery test is running |
| Abort Status | This read-only field will display *Not aborted* if the most recent test ran to completion.<br><br>If the most recent test was manually stopped by an operator it will display:<br><br>Abort Status: External Request<br><br>A battery test may also be terminated by an unexpected condition such as a protection pickup. If this is the case, the reason for the test being aborted is displayed. For example,<br><br>Abort Status: Protection Request<br><br>Factory default is Not aborted |

Some of the battery test settings and displays are identified differently on the operator interface compared to WSOS. The differences are described in the table below.

**Table 102 Comparison of settings between WSOS and the Operator Interfaces**

| WSOS | Operator Interface |
|---|---|
| Automatic Test (Off/Auto) | Test Status (Off/Auto) |
| Frequency | Auto Test |
| Start Time | Test Time |
| Manual Test | These fields are combined on the ***flex*VUE** and ***set*VUE** O.I. They can be used to start a test manually and also display if the test is ready or in the Wait state. |
| Test Status (read-only) | |
| Rated Battery Capacity | 7.2/12 Ah Battery |
| Battery Capacity | These fields are combined on the ***flex*VUE** and ***set*VUE** O.I. They display the result of the most recent test if it was successful or the reason it was aborted. |
| Abort Status (read-only) | |

# Battery Test Operation

A successful battery test will run for 20 s during which time the battery voltage is measured three times. These three voltage readings are known as the Beginning, Middle and End readings. They are recorded in the Event Log at the completion of the test as **Beg**, **Mid** and **End**. The PowerLogic ADVC Controller uses these three voltages to determine the capacity of the batteries, OK or Not OK.



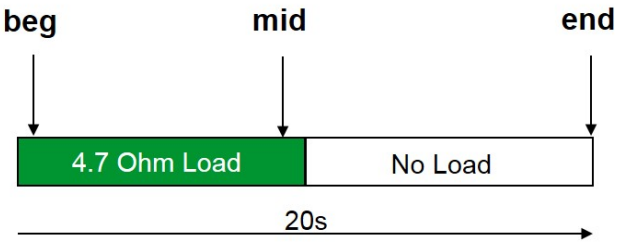

**Figure 310**
Battery Test Voltage readings in the Event Log

A Battery Test can be initiated in response to either of the following:

- An operator request
- An automatic time out

The PowerLogic ADVC Controller turns off the battery charger and applies a 4.7 Ohm load resistor across the battery.

- The battery voltage (Beg) is measured after 100 ms.
- The load test continues for a further 9.8 s and the battery voltage (Mid) is measured again.
- The load resistor is removed after another 100 ms
- The battery is allowed to recover for 10.0 s after which the battery voltage (End) is measured.



The PowerLogic ADVC Controller calculates the capacity of the batteries using the temperature compensated Beginning, Middle and End voltages measured during the test.

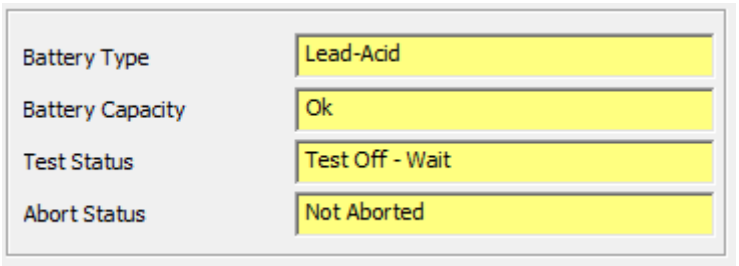
If the voltage drops excessively during the on-load time, or fails to recover sufficiently after the load is removed according to the algorithm employed, the result of the test will be: Capacity Not OK.

Normal operation of the CAPE is suspended for the 20 s duration of the battery test unless the battery test has been stopped. If the battery test is stopped, the CAPE will revert to its pre-battery test state.

**NOTE:** Battery charging will be Off during a test. The battery status and voltage will not be updated during a battery test.

## Wait State

Following a battery test, automatic or manual, another test will not be allowed for fifteen minutes. The displayed Test Status will show that the battery test is in a Wait state.




This also means that if an automated test is scheduled to begin within 15 minutes of a manual test ending, it will not begin at the scheduled time. Instead it will begin 15 minutes after the conclusion of the manual test.

## Battery Test Status

The battery test can be in any one of five states described below.

1. Test Off – Ready
   - This is the normal state from which it can respond to either an operator or automatic request.
2. Test Off – Wait
   - This status indicates that the test is not running but will not respond to a manual or automatic test start command. This would normally be due to less than fifteen minutes having elapsed since the last test was run.
3. Test Off – (abnormal condition)
   - This status indicates that the test is not running but will not respond to a manual or automatic test start command due to some abnormal condition being present for example, auxiliary supply fail.
4. Test Requested
   - The battery test function enters this transient state when it accepts either an operator or automatic request.
   - Before proceeding with the actual test it first checks that there are no conditions present that must inhibit the test from taking place. If there are, the test procedure is aborted and it resumes the Test Off – Ready state.

5. Test Running
    - The battery test function normally runs for 20 s. However during this time it is constantly checking to make sure that no conditions have changed that must cause it to abort.
    - If a test is aborted, battery test will go to the Test Off – Wait state for fifteen minutes.
    - When a battery test has successfully completed the function will also go to the Test Off - Wait state.

## Request Denied

There are a number of abnormal conditions that can helps to prevent the battery test from proceeding from the Test Requested to the Test Running state. They are:

- Protection pickup
- Auxiliary Supply fail
- Protection sequence in progress
- Battery Off or voltage < 23 V for Lead-Acid batteries
- Battery Off or not detected for LiFePO4 batteries
- Database save pending
- Less than 15 minutes since the last test

When a battery test request is denied, the Event Log will record:

- Battery Test Start - Denied

## Test Aborted

Once a battery test has entered the Test Running state, there are a number of conditions that will cause it to abort and go into the Wait state. They are:

- Operator Abort request
- Protection pickup
- Auxiliary Supply failure
- Trip or Close request
- Battery Off

When a test is aborted, the Event Log will record:

- Battery Test START
- Battery Test Performing Test
- Battery Test abort
- Battery Test aborted: *Reason for example Prot Req*
- Battery Test Off

# Waveform Generation

## Introduction

Waveform Generation is a feature of the PowerLogic ADVC Controller that can be used to simulate three phase voltage and current waveforms without the need for primary or secondary injection.

This feature can be used to simulate live conditions with control of voltage, current and frequency and can be used for commissioning and checking SCADA analogues. It can also be used for limited protection testing.

The algorithm which runs in the PCOM can only be started, controlled and stopped through WSOS when it is on-line.

To select Waveform Generation in WSOS, go on-line and select:

**Display** > **Maintenance** > **Waveform Generation**

This will launch the Waveform Generation dialogue box shown in the figure below.

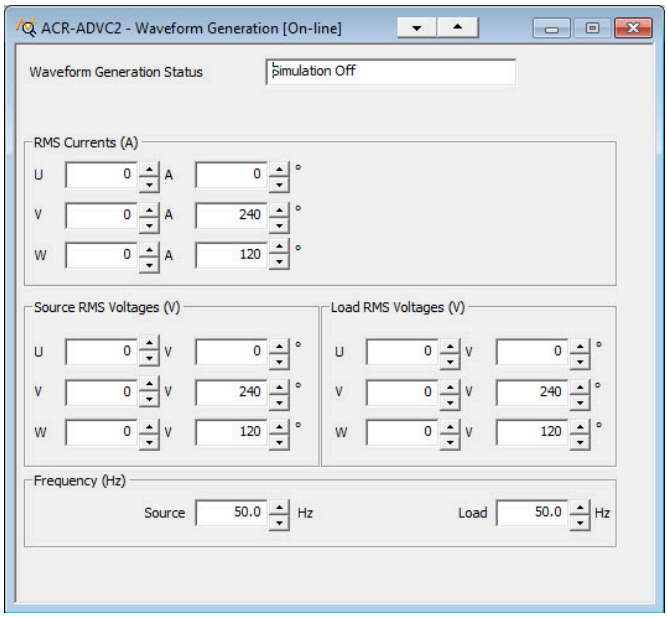



**Figure 311**
Waveform Generation Dialogue

# Waveform Generation Configuration

Currents and Voltages are configured in RMS values. All values can be changed using the thumb wheels provided or by selecting a field and entering a value. Once a field has been configured, the next field can be selected by pressing the Tab key on the WSOS PC keyboard.

## Current

Separate values for amplitude and phase angle can be configured for each of the three phases with a resolution of 1 A and 1°.

## Voltage

Separate values for amplitude and phase angle can be configured for each of the six bushings with a resolution of 1 V and 1°.

## Frequency

Source and Load side frequency can be configured separately between 45.0 Hz and 65.0 Hz in steps on 0.1 Hz.

All values can be pre configured in WSOS on-line while the status is the default Simulation Off. Once the status is changed to one of the waveform options listed below, the Waveform Generator will be activated and the configured values simulated.

# Waveform Generation Status

The Waveform Generator can simulate the following current and voltage waveforms:

- Sine Wave
- Square Wave
- Triangular Wave
- Sawtooth Wave

Examples of the available waveforms are shown in the figure below.

Note that the configured value is always the RMS value. Peak values will vary between waveforms according to their form factor.

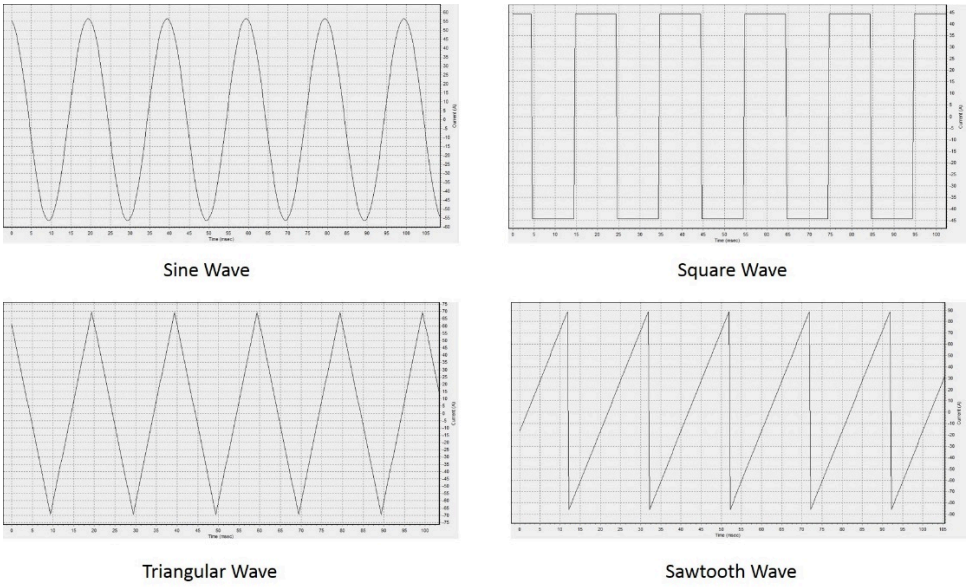
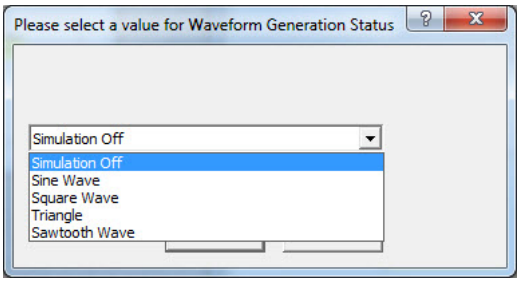



**Figure 312**
Waveform Generation Waveform Options

The required waveform can be selected by clicking in the Waveform Generation Status field and selecting one from the drop down list.




Once the waveform has been selected, selecting OK will start the Waveform Generator running.

> **NOTE:** Waveform Generation cannot be activated if the PowerLogic ADVC Controller detects that there is system current or voltage present. If this is the case, WSOS will display the message: *Command was rejected by the Switchgear – Invalid Mode*.

# Waveform Generator Active

When the Waveform Generator is active that is running, **Read** and **Write** buttons appear in the bottom right hand corner of the dialogue box and a red banner with the text **Simulation Data** flashes in the top left hand corner.

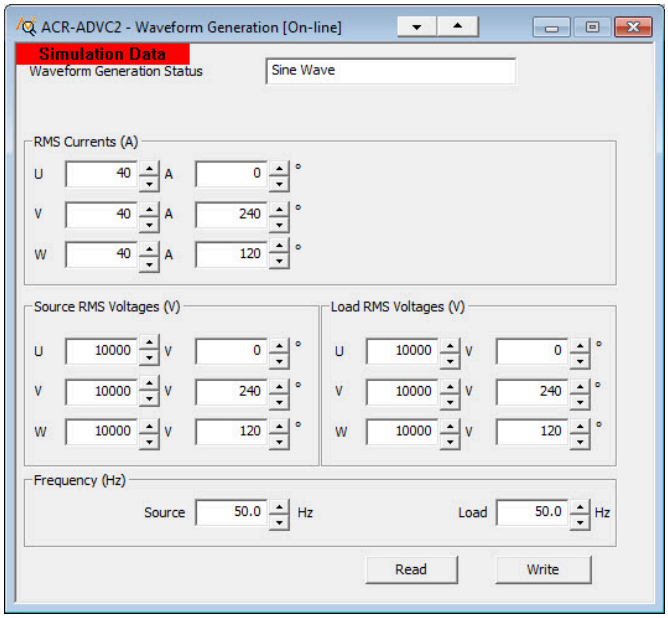



**Figure 313**
Waveform Generation Running Indications

The flashing red Simulation Data banner appears on all open WSOS windows while Waveform Generation is running.

The operator interface also displays a message to warn that the Waveform Generator is active.

On the ***set*VUE** O.I., the message Waveform Generator Active alternates with the heading for whichever page is being displayed every 2 s.

On the ***flex*VUE** O.I., an alert is generated when the Waveform Generator is running and the message (1) Alerts Active will flash at the top of the page. The message Waveform Generator Active is displayed in the Alerts menu.

A running Waveform Generator can be stopped by selecting Simulation Off for the status.

While the Waveform Generator is running, the simulated values can be read directly from the Measurement page in WSOS and are also displayed on the operator interface measurement pages.

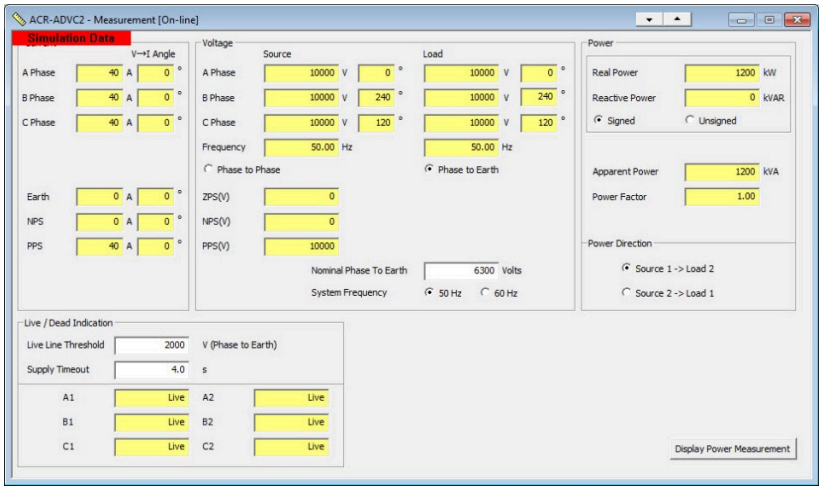



**Figure 314**
WSOS Measurement page with Waveform Generation active

Any of the configured values can be changed while Waveform Generation is running by editing the required field and either selecting the Write button or pressing the Enter key on the WSOS PC keyboard.

The status (waveform) can also be changed in this way without having to turn the Waveform Generator off.

Simply click in the Waveform Generation Status field, select a different waveform from the drop down list and click **OK**.

## Fault Simulation using Waveform Generation

The Waveform Generator can be used to simulate a fault by transitioning from load to fault conditions in one step change.

If only one value needs to change, its field can be edited and put into service by either clicking on the Write button or pressing the Enter key as described above.

However, in order to simulate the required fault conditions it may be necessary to edit several values and put them all into service at the same time.

This can be achieved by editing the required values by either clicking in each field requiring editing or moving between fields using the Tab button.

As long as the Enter key is not pressed, the new values will not go into service.

When all of the required fields have been edited, select the Write button to put all of the new values into service simultaneously.

If the values have been changed but not written, the running values can be restored by selecting the Read button.

## Waveform Generation with Waveform Capture

If Waveform Generation is activated when Waveform Capture is On, it will turn off automatically when the switchgear trips to interrupt the current simulation.

A message to this effect is displayed on the Waveform Generation dialogue box when this conditions exists.

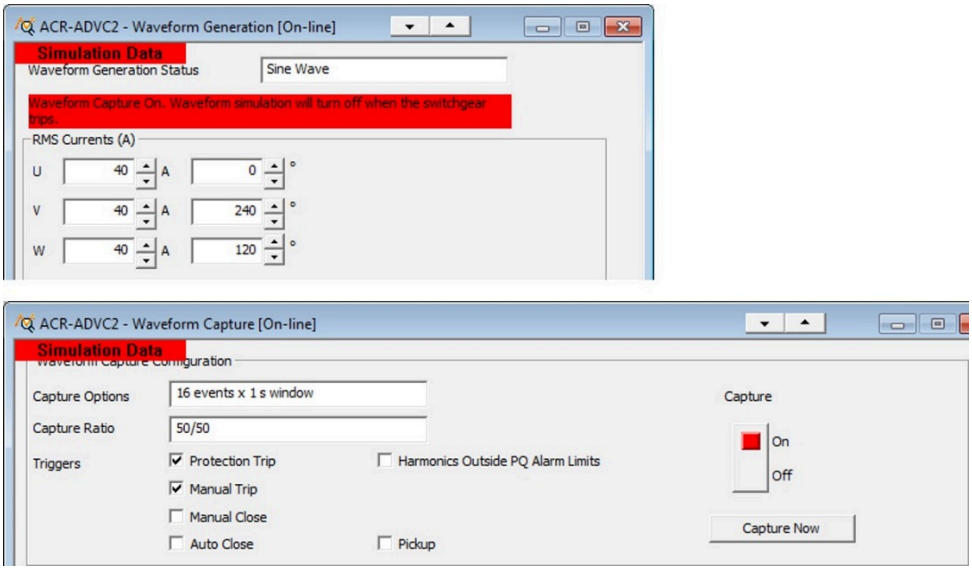



**Figure 315**
Waveform Generation used with Waveform Capture

The message reads: *Waveform Capture On, Waveform simulation will turn off when the switchgear trips*.

# Ancillary Equipment and Accessories

## What's in This Chapter

Input/Output Expander Card..... 531
Fast Trip Input Module ..... 540

# Input/Output Expander Card

## Introduction

The IOEX (Input Output Expander Module) is an PowerLogic ADVC Controller Range accessory that accepts external control signals from third party devices. It provides optically isolated inputs and voltage-free outputs. These allow connection to an external protection relay or RTU The electronic circuit is installed in a die case, sealed enclosure which is attached to the upper accessory mounting tray of an PowerLogic ADVC ULTRA controller cubicle.

An PowerLogic ADVC Controller can support two IOEX modules if required.

The main components of the IOEX are identified in the figure below.

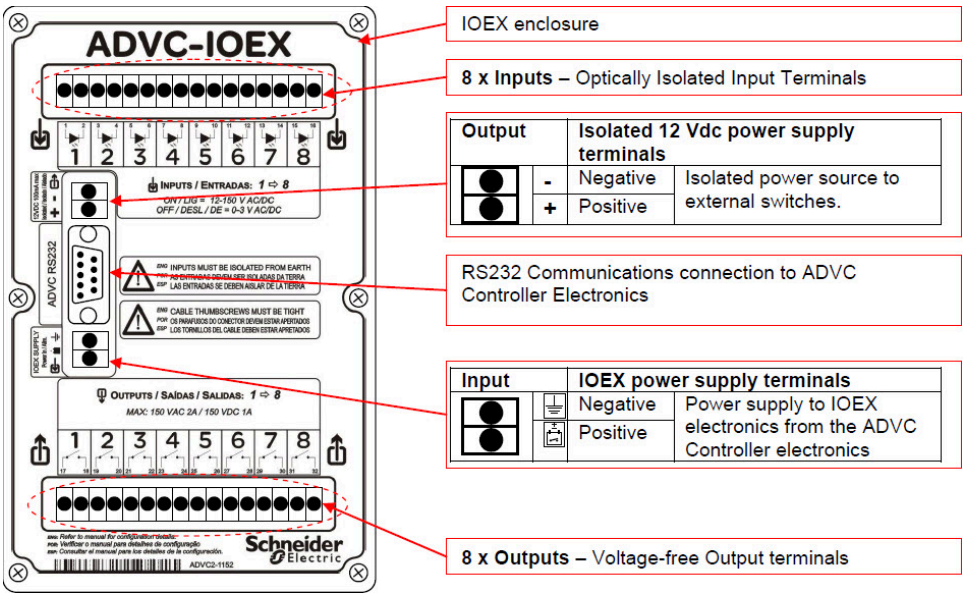



**Figure 316**
Input Output Expander Module (IOEX) main components

## Compatibility

The IOEX is compatible with the **ULTRA** model of the PowerLogic ADVC Controller Range where the upper accessory tray is used to mount the IOEX module. The controller electronics includes a regulated power supply for the IOEX modules. Connection to the power supply is via two terminals mounted on the side accessory tray.

RS232 communications is used to interface the IOEX modules to the control electronics.

The **ULTRA** model includes the following features to accommodate the IOEX modules.

- Upper accessory tray for up to two IOEX modules.
- Additional holes in the base of the cubicle for IOEX cable entry.
- Cable tie point on the cubicle side to attach the cables.

## Parts supplied with the IOEX

The following parts are supplied with each IOEX module.

- 1 x IOEX module
- 1 x RS232 cable
- 1 x Power cable

- 4 x M5 stainless steel screws and washers
- 1 x EMC cable gland

Shielded cables (not supplied) for external connections and the EMC gland are essential for reliable operation.

| NOTICE |
| --- |
| **HAZARD OF CONTROLLER DAMAGE**<br>If the IOEX is installed with cables drawn out of the cubicle, make sure to use the shielded cables along with the EMC glands.<br>**Failure to follow these instructions can result in equipment damage.** |

# Specifications

**Table 103 IOEX Specifications**

| Item | Description |
| --- | --- |
| Isolated power supply output | 12...15 Vdc, 100 ma max |
| IOEX power supply input | 18...36 Vdc, 200 ma max. supplied by controller electronics. |
| Optically isolated inputs | 8 inputs per IOEX module<br>ON = 12...150 Vdc, 12...150 Vac<br>OFF = 0...3 Vdc, 0...3 Vac |
| Voltage-free outputs | 8 outputs per IOEX module<br>150 Vdc at 1 A maximum or<br>150 Vac RMS at 2 A non-inductive maximum |
| Dimensions (mm) | 188 high, 119.5 wide, 37 deep. |
| Controller connection | RS232 – DB9 Male/Female cable (part number ADC-640) |

# Installation

The IOEX must be fitted to the upper accessory mounting tray.

## Removing and installing the mounting tray

The upper accessory tray can be easily removed in three steps:

1. Undo and remove the self-locking nuts and washers.
2. Rotate the accessory tray to the slide-out position by lifting the bottom of the tray away from the cubicle; and
3. Slide the tray to the left.

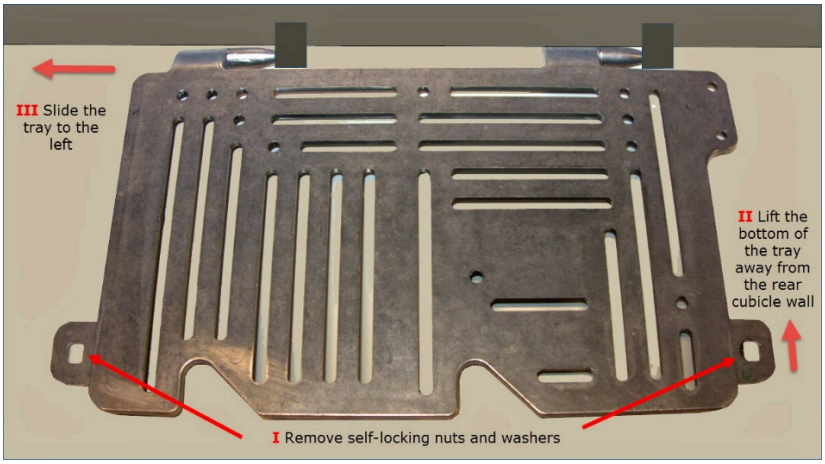



**Figure 317**
Upper accessory tray removal

To install the upper tray, locate the accessory tray hinges to the left of the brackets in the top corner of the cubicle. Use the corner as a guide and slide the tray to the right. The self-locking hinges will guide the tray into the brackets. Continue to slide the tray until the hinges are completely inside the brackets. Rotate the tray into the lock-down position and fasten the nuts.

# Attaching the IOEX

## Method

1. Remove the Upper Accessory Mounting Tray from the PowerLogic ADVC ULTRA cubicle as described above, page 541.
2. Multiple mounting options are provided on the tray for one or two IOEX modules. Select a convenient option;
3. Align the IOEX to convenient holes/slots and use the screws and washers provided to attach it to the tray. Tighten the screws to 4 Nm of torque; and
4. Fit the tray containing the IOEX to the Upper Accessory Mounting space using the existing mounting points.

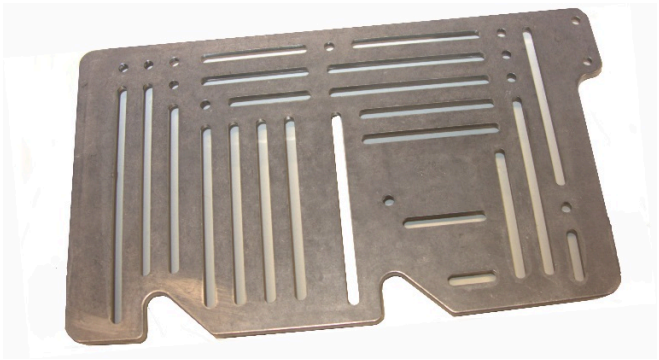


**Figure 318**
Accessory tray with multiple mounting options

# Connect the IOEX to the Controller

Connect the IOEX power supply lead to the terminals on the side accessory tray. The terminals are marked with the following symbols.



Ground terminal



IOEX Positive power terminal

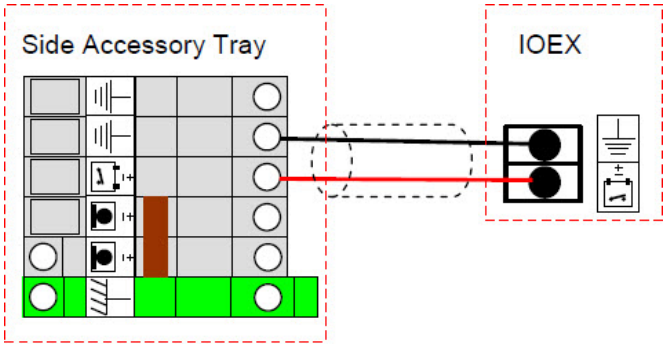



**Figure 319**
IOEX Power Supply connection

Using the RS232 cable (ADC-640), connect the IOEX to a RS232 port on the PowerLogic ADVC Controller.

The options are:

- PowerLogic ADVC
  - IOEX/WSOS port,
  - USB 1, 2, or 3 via a USB/RS232 converter.

Before the IOEX can be used it must be made available in the WSOS Feature Selection tool and assigned a communications port. It may also be necessary to configure and download a custom mapping file.

Please see: IOEX Configuration Tool, page 79.

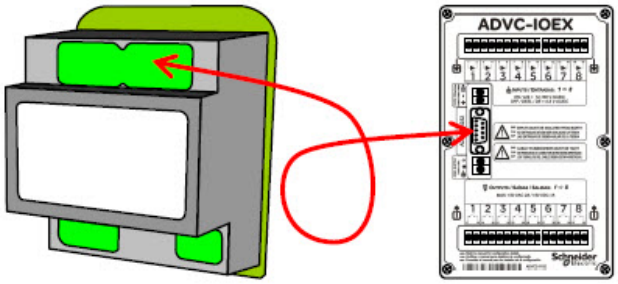



**Figure 320**
IOEX Communications connection

# Electrical Connections

## Inputs

### Using the built-in isolated supply

The IOEX has a built-in isolated power supply that can be used as field excitation voltage. The following connection diagram describes using this DC voltage as a source to supply the external contacts.

**NOTICE**

**HAZARD OF UNEXPECTED INPUT ACTIVATION**

- Field excitation must not be provided from the battery nor the radio power supply.
- Isolate the field excitation power supply from earth or use double pole switching for all inputs.

**Failure to follow these instructions can result in equipment damage.**

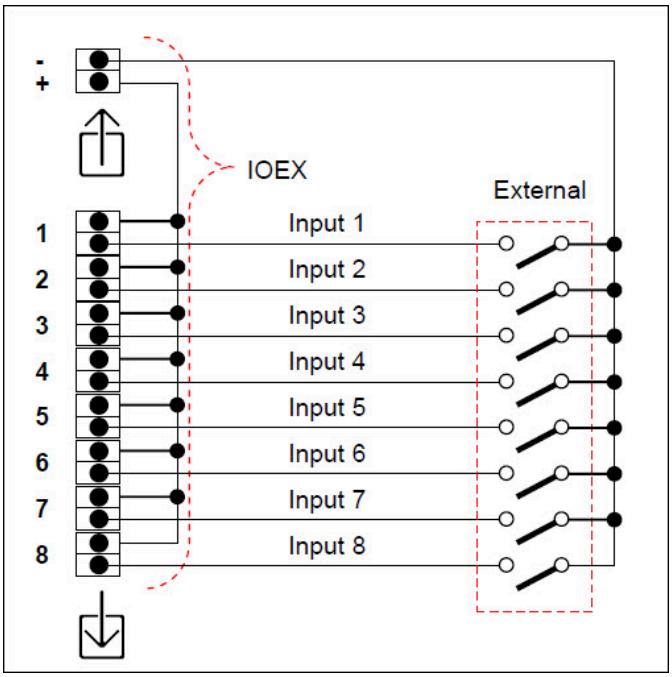



**Figure 321**
IOEX Inputs connected using the built-in isolated supply

### Using an External Source

It is also possible to use a custom AC or DC source for field excitation of the external contacts. This supply must be isolated from earth.

Field excitation voltage: 12 V AC/DC up to 150 V AC/DC

**NOTICE**

**HAZARD OF UNEXPECTED INPUT ACTIVATION**

Isolate the field excitation power supply from earth.

**Failure to follow these instructions can result in equipment damage.**

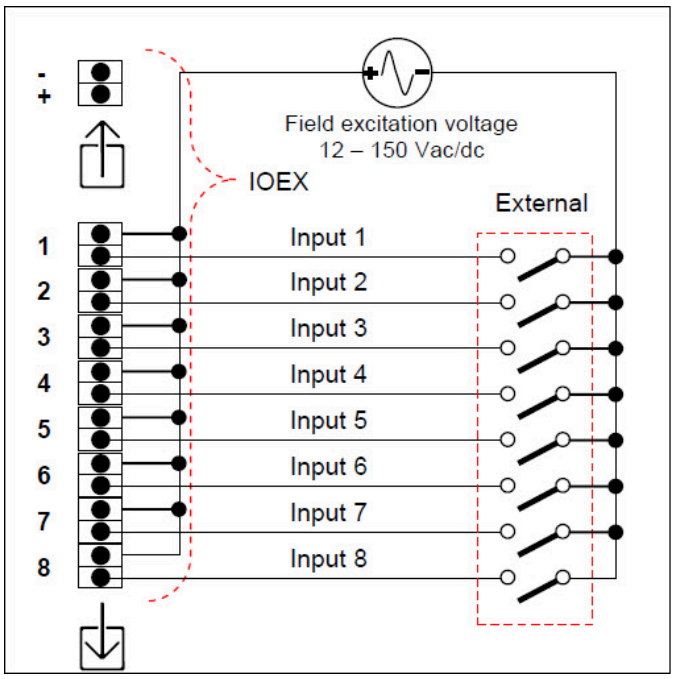



**Figure 322**
IOEX Inputs connected using an external source

## Voltage - Free Outputs

The voltage-free outputs require a field excitation voltage of between 12 and 150 Vac/dc.

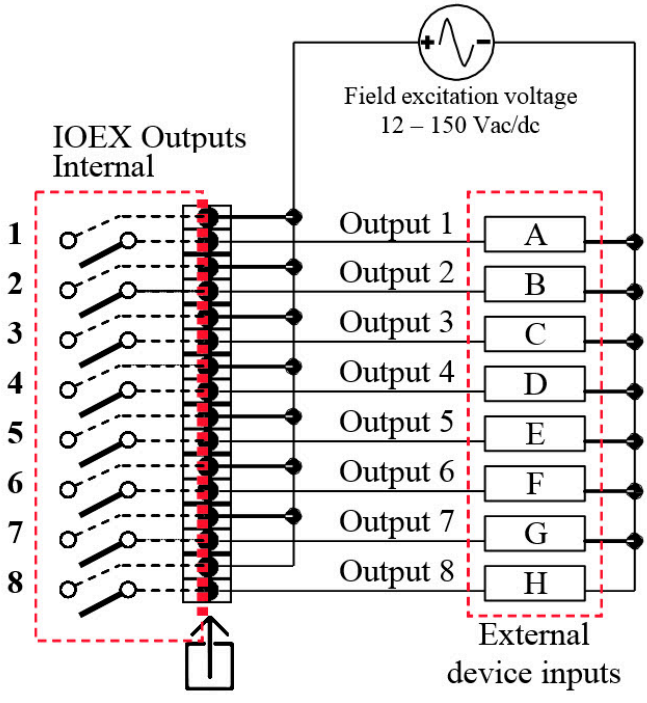



**Figure 323**
IOEX voltage-free output connected to a field excitation supply

# Shielded Cable

For the external connections, shielded cable with the following characteristics is recommended:

| | |
|---|---|
| Operating Temperature: | -55° C to +105° C |
| Voltage Rating: | 600 V |

Product Description:

| | |
|---|---|
| Conductor: | Stranded Tinned Copper |
| Area Conductor: | 0.22 $mm^2$ |
| External Diameter: | 6...12 mm |
| Screen Diameter: | 5 mm minimum |
| Insulation: | Color-Coded PVC |
| Shield: | Braided Tinned Copper (90% Coverage) |
| Jacket: | PVC |

An example of the shielded cable described is shown in the figure below.



**Figure 324**
Shielded Cable for IOEX Installation (not supplied)

# IOEX Cable Installation

## EMC Gland Specification

An M20 EMC cable gland with the following characteristics is required.

- Diameter, cable max: 12 mm
- Diameter, cable min: 6 mm
- Diameter, cable screen min: 5 mm
- Material: Brass
- Plating: Nickle
- Thread size: M20
- Length, thread: 8 mm
- IP Rating: IP68

## EMC Gland Installation

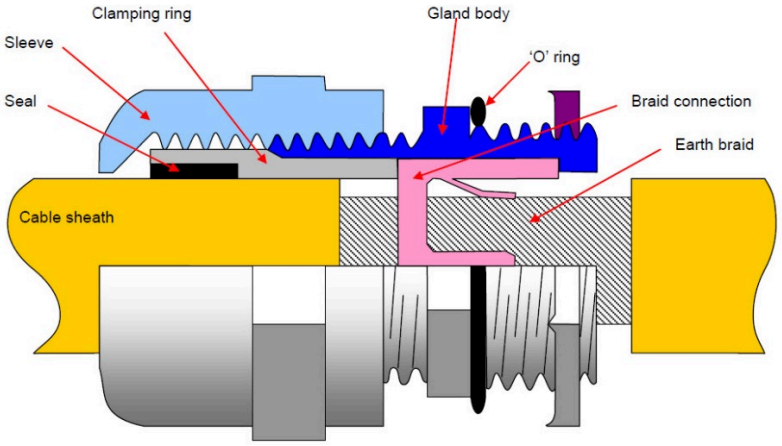



**Figure 325**
EMC Cable Gland

**⚠WARNING**

**HAZARD OF UNEXPECTED BEHAVIOR**

Correct installation of the EMC gland is essential for reliable operation.

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

**⚠CAUTION**

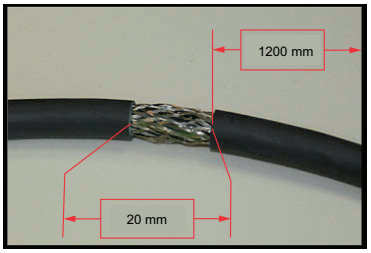
**HAZARD OF IMPACTED CRITICAL COMPONENT**

Do not push the cable in the opposite direction.

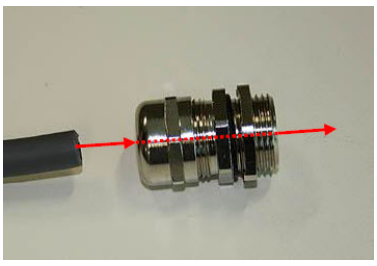
**Failure to follow these instructions can result in injury or equipment damage.**

## Method

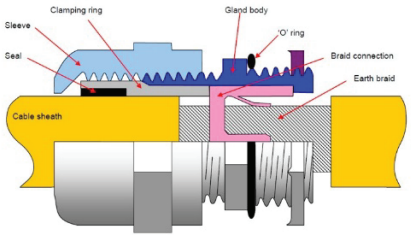
1. Remove 20 mm of the plastic sheath 1200 mm from the end of the cable that will be connected to the IOEX to expose the earth braid.

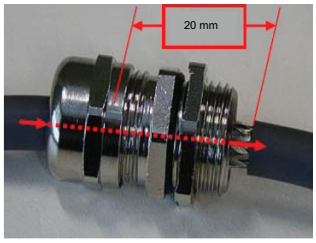



2. Push the end of the cable that will be connected to the IOEX through the cable gland in the direction as shown.



3. Continue bushing the cable through the gland, until the earth braid aligns with the gland.



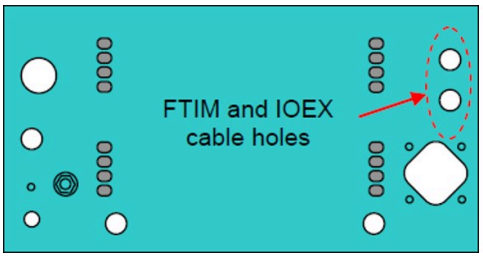

| NOTICE |
| --- |
| **HAZARD OF IMPROPER EARTHING**<br><br>Make sure that the earth braid is in contact with the braid connection ring in the gland.<br><br>**Failure to follow these instructions can result in equipment damage.** |



4. Make sure the seal and clamping mechanism is overlapping with the plastic sheath. Tighten the gland sleeve to firmly grip the cable in place.



5. Select a 20 mm hole in the base of the cubicle. The two holes on the right hand side are provided for this purpose. Remove the plug and fit the cable with gland.






## Cable Termination

1. Use cable ties to attach the cable to the cubicle wall.
2. Cut the cable to the appropriate length and terminate the cable at the IOEX connectors.

# Fast Trip Input Module

## Introduction

TheFast Trip Input Module (FTIM)is an PowerLogic ADVC Controller Range accessory that accepts external control signals from third party devices. It provides optically isolated inputs that allow connection of an external protection relay or RTU. The electronic circuit is installed in a die cast, sealed enclosure which is attached to the upper accessory mounting tray of an PowerLogic ADVC Controller ULTRA cubicle.

It is possible to interface external trip, close or close block signals to the PowerLogic ADVC Controller via the FTIM.

The main components of the Fast Trip Input Module are identified in the figure below.

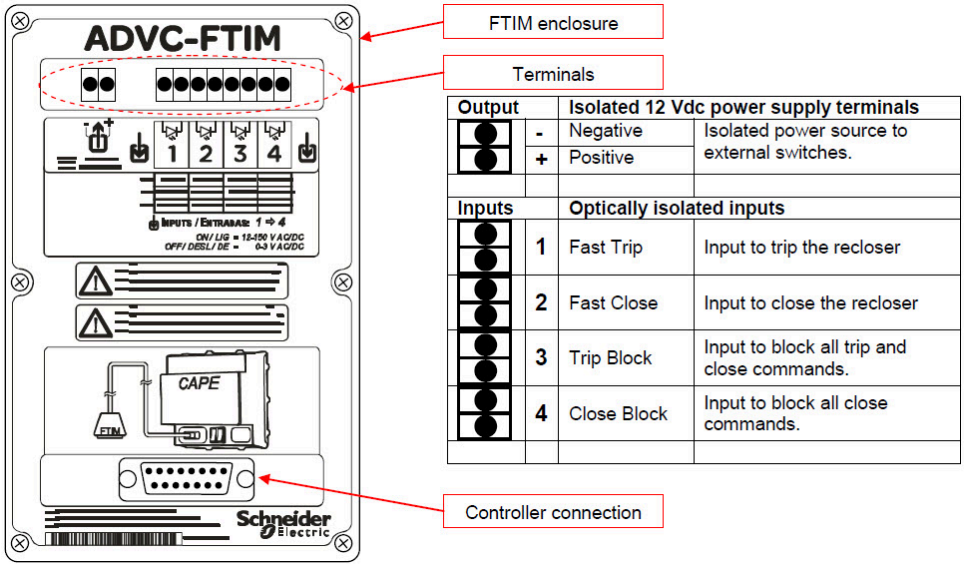



**Figure 326**
Fast Trip Input Module (FTIM) main components

## Compatibility

The FTIM is compatible with the PowerLogic ADVC Controller Range. If an PowerLogic ADVC Controller is to be used with an FTIM, a connection cable for the module has to be included during manufacturing. It is therefore necessary to specify the intended use of an FTIM when ordering the device. Note his connection cannot be retrofitted in the field.

An FTIM can be used with PowerLogic ADVC Controllers displaying one of the following part numbers on the rating plate:

| Part Number | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th | 10th |
|---|---|---|---|---|---|---|---|---|---|---|
| 88xxxx2-xxx | 8 | 8 | X | X | X | X | 2 | X | X | X |
| 88xxxx3-xxx | 8 | 8 | X | X | X | X | 3 | X | X | X |
| 88xxxx5-xxx | 8 | 8 | X | X | X | X | 5 | X | X | X |

The part number has to start with *88* and the 7th digit must be 2, 3, or 5.

## Parts Supplied with the FTIM

The following parts are supplied with each FTIM.

- 1 x FTIM module
- 4 x M5 stainless steel screws
- 4 x flat washers and 4 x spring washers
- 1 x EMC cable gland

# Specifications

| | |
|---|---|
| Isolated power supply output | 12–15 Vdc, 100 mA max. |
| Optically isolated inputs | ON = 12–150 Vdc, 12–150 Vac<br>OFF = 0–3 Vdc, 0–3 Vac |
| Dimensions (mm) | 188 high, 119.5 wide, 37 deep |
| Controller connection | Shielded cable with shielded 15 pin D-type connector |

# FTIM installation

The FTIM must be fitted to the upper accessory mounting tray which is only provided in the **ULTRA** cubicle.

## Removing and installing the mounting tray

The upper accessory tray can be easily removed in three steps:

1. Undo and remove the self-locking nuts and washers.
2. Rotate the accessory tray to the slide-out position by lifting the bottom of the tray away from the cubicle; and
3. Slide the tray to the left.



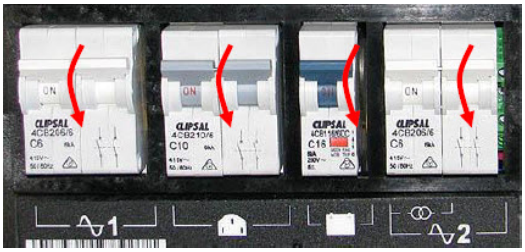

**Figure 327**
Upper Accessory Tray removal

## Attaching the FTIM

1. Remove the upper accessory mounting tray from the PowerLogic ADVC Controller **ULTRA** cubicle as described above.
2. There are number of mounting options available on the tray. Select a convenient option.
3. Align the FTIM to whichever holes/slots are convenient and use the screws and washers provided to attach it to the tray. Tighten the screws to 4 Nm of torque; and
4. Fit the tray containing the FTIM to the Upper Accessory Mounting space using the existing mounting points.

## Connect the FTIM to the controller

1. Before connecting the FTIM, turn off all power to the controller.




2. Connect the shielded 15 pin D connector to the FTIM.
3. Fasten the connector securely helps to ensure a reliable connection.
4. Turn all power to the controller ON when the installation is complete.



**Figure 328**
FTIM with 15 pin D connector fitted

**NOTE:** Failure to power OFF the controller when connecting the FTIM to the CAPE may cause unwanted trip/close operation.

# Electrical Connections

## Using the built-in isolated supply

The FTIM has a built-in isolated power supply that can be used as field excitation voltage.

The following connection diagram describes using this DC voltage as a source to supply the external contacts.

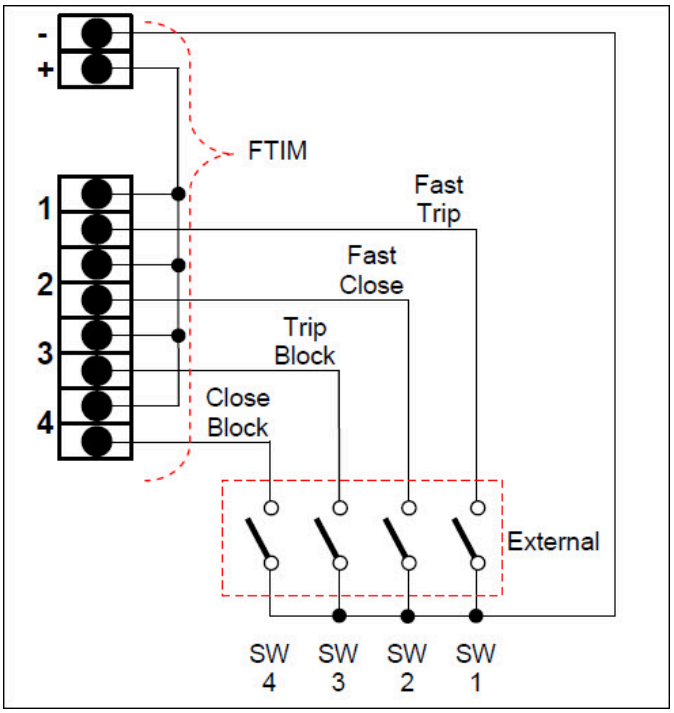



**Figure 329**
FTIM wired with the built-in isolated supply

| ***NOTICE*** |
| --- |
| **HAZARD OF ELECTROMAGNETIC INTERFERENCE**<br><br>Field excitation must not be provided from the battery nor the radio power supply.<br><br>**Failure to follow these instructions can result in equipment damage.** |

## Using an external source

It is also possible to use a custom AC or DC source for field excitation of the external contacts. This supply must be isolated from earth.

Field excitation voltage: 12 Vac/dc up to 150 Vac/dc

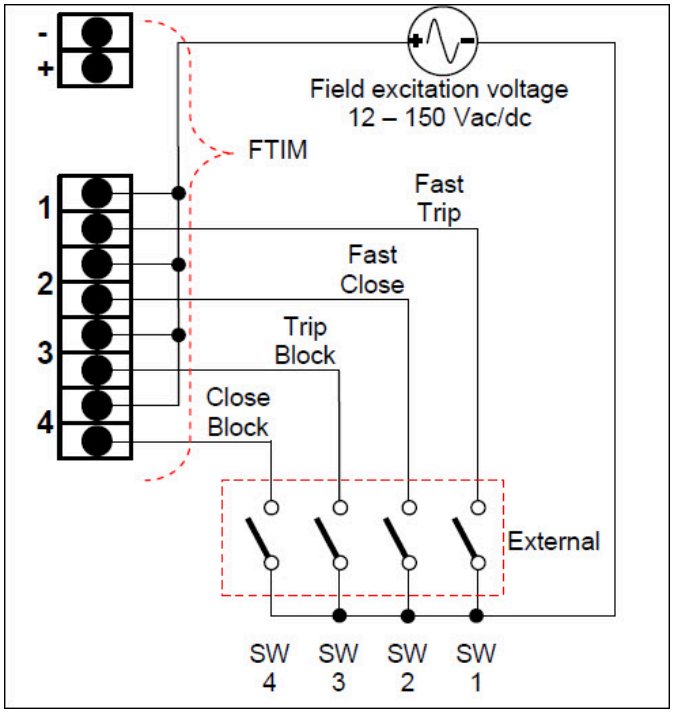



**Figure 330**
FTIM wired from an external voltage source

| ***NOTICE*** |
|---|
| **HAZARD OF UNEXPECTED INPUT ACTIVATION** |
| Isolate the field excitation power supply from earth. |
| **Failure to follow these instructions can result in equipment damage.** |

## Shielded Cable

For the external connections, shielded cable with the following characteristics is recommended:

| | |
|---|---|
| Operating Temperature: | -55° C to +105° C |
| Voltage Rating: | 600 V |

Product Description:

| | |
|---|---|
| Conductor: | Stranded Tinned Copper |
| Area Conductor: | 0.22 $mm^2$ |
| External Diameter: | 7.2 mm |
| Maximum Length: | 10 m |
| Insulation: | Color-Coded PVC |
| Shield: | Braided Tinned Copper (90% Coverage) |
| Jacket: | PVC |

An example of the shielded cable described is shown in the figure below.



**Figure 331**
Shielded cable for FTIM installation (not supplied)

**NOTE:** If more than 10 m of cable are needed, an optical fiber and an optical media converter are required.

## Cable Gland Specification

An M20 EMC cable gland with the following characteristics is required.

- Diameter, cable max: 12 mm
- Diameter, cable min: 6 mm
- Diameter, cable screen min: 5 mm
- Material: Brass
- Plating: Nickle
- Thread size: M20
- Length, thread: 8 mm
- IP Rating: IP68



**Figure 332**
EMC Cable Gland (supplied)

# FTIM Cable Installation

The installation of cabling for the FTIM is the same as the procedure described for the IOEX in the previous section.

See: IOEX Configuration Tool, page 79

# General Purpose Outlet

The GPO is designed to power small devices such as laptops while operating the PowerLogic ADVC Controller.

The equipment is powered through a 10A circuit breaker.

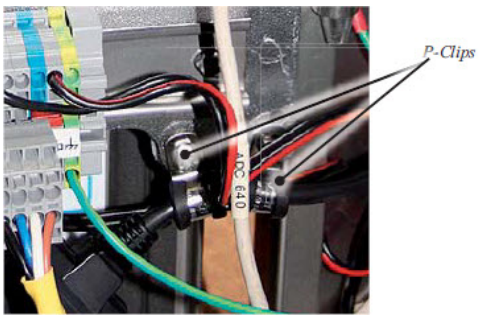
## Compatibility

| | |
|---|---|
| Controller: | PowerLogic ADVC ULTRA and COMPACT |
| Power Supply: | Power Supply: Models equipped with the IEC power outlet option. |

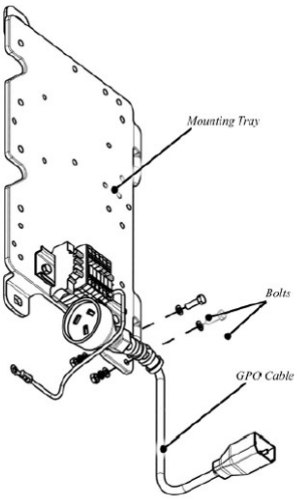
**NOTE:** Mains 1 is used to supply power to the GPO socket.

## GPO Cable Installation

1. Remove the side accessory mounting tray.
2. Fit the two P-clips around the GPO cable.




3. Using the bolts provided, to the cable to the accessory mounting tray.




4. Replace the side accessory mounting tray in its normal position.
5. Plug the IEC male cable end connected into the female connector on the side of the PSM.

The location of the IEC socket on the Power Supply Unit can be seen in the figure below.

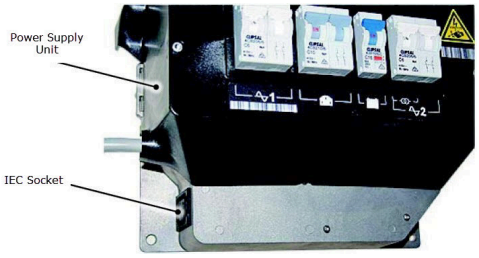



**Figure 333**
Power Supply Unit showing location of IEC Socket

**⚠⚠DANGER**

**HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH**

- The power transformer used to supply the PowerLogic ADVC Controller and the GPO must be correctly rated to supply the needed current.
- In the case of using a VT to power the PowerLogic ADVC Controller and the GPO, do not exceed the VT specified ratings.
- Do no connect any device, tool or equipment that does not comply with the power transformer or VT specifications.
- Use the proper input connector for connecting your device, tool or equipment to the GPO output connector.

**Failure to follow these instructions will result in death or serious injury.**

# Test and Training Set

## Introduction

The Test and Training Set (TTS) is an accessory available for use with the PowerLogic ADVC Controller Range to assist in field or workshop testing.

The TTS is a briefcase sized test set which connects to the PowerLogic ADVC Controller and in conjunction with a standard secondary injection test set can be used to inject single or multi-phase currents into the PowerLogic ADVC Controller to simulate primary current.

The TTS can also be used to simulate the ACR or AS switchgear to aid in fault finding and testing of the control electronics.

The TTS is highly suited to the training of maintenance and operations staff.




**Figure 334**
Test and Training Set (TTS)

## Construction

The TTS has six (3 x 2) terminals for three phase current injection and overcurrent cut-outs for each phase.

Two terminals connected to a set of dry contacts which emulate the switchgear open/close status are provided for timing purposes.

Internally the TTS is fitted with three 5:1 interposing current transformers (CT's) and a SCEM card similar to the one fitted to ACR and AS switchgear.

There is a 24 pin burndy plug for connection via either of the supplied cables to the PowerLogic ADVC Controller.

## Modes of Operation

The Test and Training Set can be used in two different modes.

- Stand Alone Mode
  - Where the TTS is connected to the control cubicle in place of the switchgear.
- Parallel Operation Mode
  - Where both the TTS and the switchgear are connected to the control cubicle.

### Stand Alone Mode

In the stand alone mode, the switchgear is disconnected from the controller and the TTS is connected via one of the supplied cables (N05-207) into the switchgear port at the bottom of the CAPE that is where the control cable to the switchgear normally connects. In this mode the TTS acts as a switchgear simulator and can be tripped/closed from the PowerLogic ADVC Controller.

Current can be injected through the TTS terminals to test the PowerLogic ADVC Controller measurement and protection functions.

When the switchgear simulator (TTS) is open, the injection current is interrupted.

The stand alone mode is typically used for training or workshop maintenance. In the field it can be used when the actual switchgear is not able to be tripped.

The figure below shows a TTS in stand alone mode being used for single phase current injection.

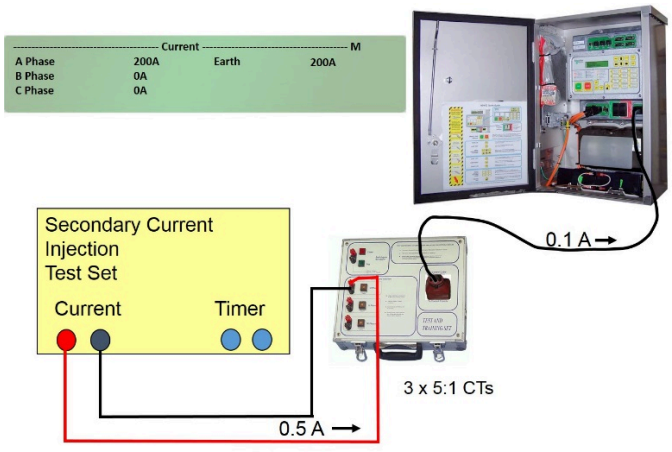



**Figure 335**
A Test and Training Set connected in Stand Alone mode

From the above figure it can be seen that:

- 0.5 A injected into the TTS A phase terminals results in 0.1 A injected into the PowerLogic ADVC Controller due to the 5:1 interposing CT in the TTS.
- 0.5 A injected into the TTS A phase terminals equates to primary A phase and earth currents of 200 A that is injected current x 400.
  - This 400:1 ratio is due to the combined effects of the 5:1 interposing CT's in the TTS and the 2000:1 scaling built into the PowerLogic ADVC Controller firmware.

When the TTS is used in the stand alone mode, the switchgear contacts change state according to the simulated status and can be used for protection timing. The operating time of the internal relay will add around 20 ms to the actual relay time.

## Parallel Mode

In the parallel mode, the switchgear remains connected to the PowerLogic ADVC Controller and the TTS is connected to the secondary current injection port, page 549 using one of the supplied cables (N05-208). In this mode the TTS is used solely as a means of secondary injection and not as a switchgear simulator.

The figure below shows a TTS in parallel mode being used for single phase current injection.

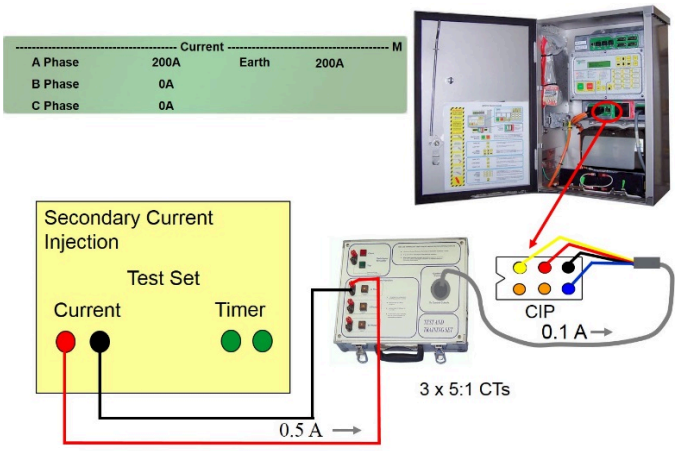



**Figure 336**
A Test and Training Set connected in Parallel mode (switchgear not shown)

From the above figure it can be seen that:

- 0.5 A injected into the TTS A phase terminals results in 0.1 A injected into the PowerLogic ADVC Controller due to the 5:1 interposing CT in the TTS.
- 0.5 A injected into the TTS A phase terminals equates to primary A phase and earth currents of 200 A that is injected current x 400.
    - This 400:1 ratio is due to the combined effects of the 5:1 interposing CT's in the TTS and the 2000:1 scaling built into the PowerLogic ADVC Controller firmware.

The main difference between the two modes is that in parallel mode the switchgear is still connected and will trip if current injection causes protection to operate.

## Secondary Current Injection Port

The PowerLogic ADVC Controller Range is fitted with a secondary current injection port (CIP) located on the bottom of the CAPE below the operator interface as shown in the figure below.

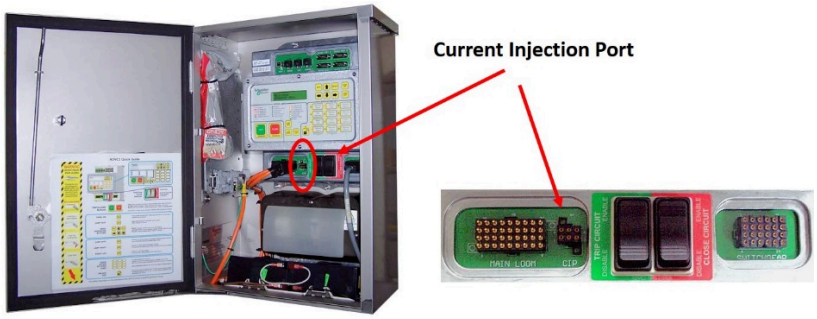



**Figure 337**
Location of Current Injection Port on the PowerLogic ADVC Controller

Secondary current can be injected directly into the CIP but it is highly recommended that a Test and Training Set which offers overcurrent cut-out protection is used.

### Current Injection Limitations

The maximum continuous current that can be injected into the PowerLogic ADVC Controller via a TTS is 2.0 A (equivalent to 800 A primary current).

The maximum current limit for 3 s is 10.0 A (equivalent to 4 000 A primary current).

| NOTICE |
| --- |
| **HAZARD OF ELECTROMAGNETIC INTERFERENCE**<br><br>Make sure that the maximum continuous value is 0.5 A continuous and 2.0 A for up to 3 s.<br><br>**Failure to follow these instructions can result in equipment damage.** |

## Multiple Switchgear Support

A TTS can simulate any of the Schneider Electric supported switchgear series. When connected to the switchgear port of an PowerLogic ADVC Controller, the TTS is recognized as the same switchgear series to which the controller was last connected. This functionality is only available for TTS units calibrated with the N24-150 s switch type (the factory default). TTS units containing a calibration file other than N24-150 s would need to be reloaded with the N24-150 s calibration file in order for this functionality to be available. Also note that the mechanical interlock functionality is not available when TTS is used.

**NOTE:** The Test and Training Set is purchased as a separate item. For further information, refer to Schneider Electric or your local distributor.

# Secondary Voltage Injection Interface Set

## Introduction

The Secondary Voltage Injection Interface Set (SVIIS) provides a means of injecting secondary voltage for the testing of protection/detection or automation functions for ACRs or ASs that use the PowerLogic ADVC Controller.

The SVIIS is supplied with a test cable Part No: N05-631

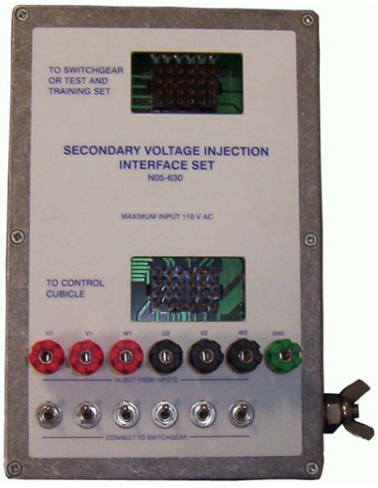



**Figure 338**
SVIIS

Secondary voltages can be injected between each of the six terminals corresponding to the six switchgear bushings and the earth terminal.

The terminals are marked as shown below to indicate which switchgear bushings they correspond to.

U1/I, V1/II, W1/III, U2/X, V2/XX, W2/XXX

The maximum voltage that can be applied between each terminal and earth is 110 Vac.

The equivalent primary voltage will depend on the voltage calibration for each bushing stored in the memory of the SCEM card in the switchgear (or switchgear simulator).

The switchgear voltage measurement is correctly calibrated at the factory during the final testing.

**⚠WARNING**

**HAZARD OF INCORRECT MEASUREMENTS REPORTED BY THE CONTROLLER**

Do not change the calibration of the switchgear voltage measurement.

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

**NOTE:** Due to varying calibration factors for different switchgear types and ratings, their PowerLogic ADVC Controllers will display different primary voltages when the same secondary voltage is applied.

The SVIIS has six toggle switches. One associated with each of the six input terminals.

The switch positions are marked:

- Inject from Inputs
- Connect to Switchgear

There are two 24 pin Burndy plugs which enable the SVIIS to be installed in series with the control cable. One plug connects to the PowerLogic ADVC Controller, and the other plug connects to the switchgear or a TTS as marked.

## Loss of Phase Testing

If the switchgear is energized, this configuration can be used to test Loss of Phase protection without the need for voltage injection equipment. The SVIIS will be transparent to the PowerLogic ADVC Controller when the toggle switches are all in the Connect to Switchgear position. Selecting the toggle switches for one phase to *Inject from Inputs* will simulate loss of voltage on that phase.

## SVIIS Voltage Injection Only

An SVIIS can be connected between the switchgear port on an PowerLogic ADVC Controller and the switchgear for voltage injection only if required. In this configuration the position of the toggle switches will determine if the individual bushing voltages reported by the controller are the injected voltages or the signals from their own CVT's if the switchgear is energized.

A connection diagram for this configuration is shown in the figure below.

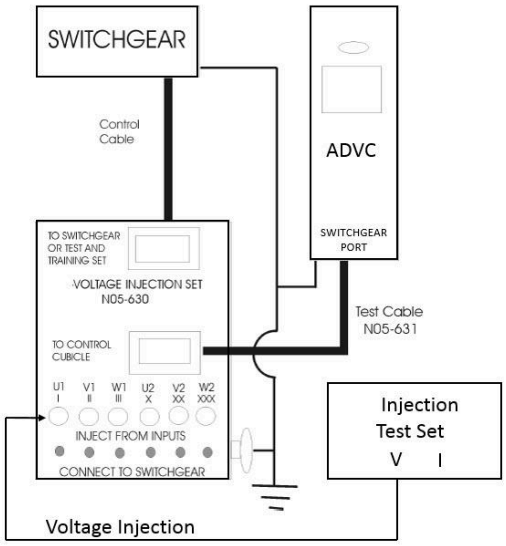



**Figure 339**
SVIIS connected for voltage injection

## SVIIS + TTS in Parallel Mode

If current injection is also required with the SVIIS connected as above, a TTS can be connected to the secondary current injection port, page 549 on the PowerLogic ADVC Controller that is in Parallel mode, page 549.

This configuration allows testing of the switchgear and PowerLogic ADVC Controller through secondary voltage and current injection.

Points to note when testing with this configuration:

- The switchgear is connected to the PowerLogic ADVC Controller and can be tripped by a protection operation.
- The TTS contacts can’t be used for timing purposes.

A connection diagram for this configuration is shown in the figure below.

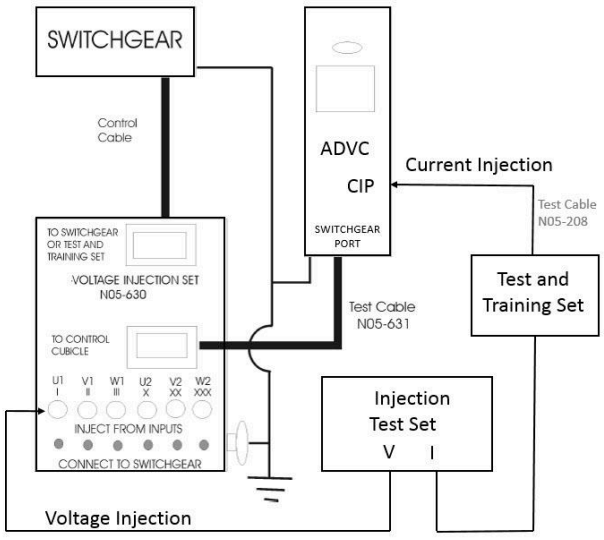



**Figure 340**
SVIIS and TTS connected in Parallel Mode

## SVIIS + TTS in Stand Alone Mode

The other option is to connect the SVIIS in series with the control cable between the switchgear port on the PowerLogic ADVC Controller and a TTS that is in stand alone mode, page 548. In this case the toggle switches would need to be in the Inject from Inputs position for voltage injection.

Points to note when testing with this configuration:

- The switchgear is disconnected and the TTS is acting as a switchgear simulator.
- The TTS contacts can be used for timing.

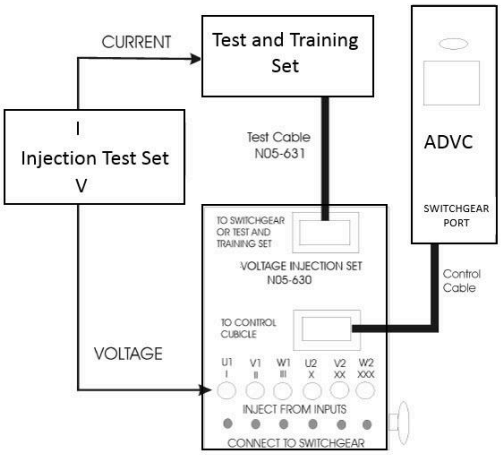



**Figure 341**
SVIIS and TTS connected in Stand Alone Mode

## Earthing the SVIIS

An earthing stud terminal, complete with wing nut, is provided at the side of the SVIIS.

Make sure that the SVIIS is correctly earthed before commencing test procedures involving hazardous voltages.

All earthing must be in accordance with the supply authorities authorized practices and procedures.



**Figure 342**
SVIIS Earth Stud

**NOTE:** The Secondary Voltage Injection Interface Set is purchased as a separate item. For further information, refer to Schneider Electric or your local distributor.

# Appendices

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# Appendix A - Switchgear Models

## PMSet U Series Circuit Breaker

The PMSet U Series three phase circuit breaker can be used as the switchgear component for an ACR using the PowerLogic ADVC Controller. It can also function as a load break switch when used as the switchgear component for an AS.

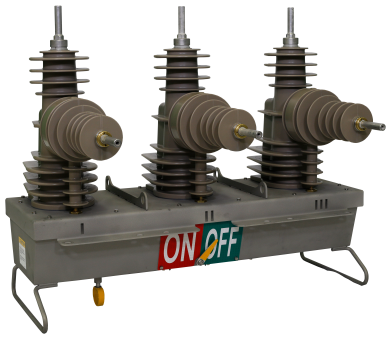



**Figure 343**
PMSet U Series Circuit Breaker

The PMSet U Series circuit breaker is operated by a magnetic actuator which produces a positive opening and closing action. Switching occurs when a controlled pulse is sent through the open/close actuator from a storage capacitor in the PowerLogic ADVC Controller. When closed, the switch is latched magnetically. Spring loaded push rods provide contact loading on the interrupters.

A Current Transformer (CT) and a Capacitive Voltage Transformer (CVT) are moulded into the CT-housing. These are monitored by the PowerLogic ADVC Controller for protection, remote monitoring and display.

One or two auxiliary voltage supplies (either 115 or 230 VAC) can be used to power the PowerLogic ADVC Controller which in turn supplies a DC line voltage to the SCEM in the switchgear. Another auxiliary supply option is to use an external (integral) voltage transformer with a 27.8 VAC secondary connected directly to terminals on the SCEM card adjacent to the plug where the control cable from the PowerLogic ADVC Controller is connected.

The ACR or AS with PMSet U Series switchgear is supplied with copper stems or optional cable clamp connectors. Mounting brackets for lightning arresters are optionally available.

The switchgear contact position is shown by a large, clearly visible external pointer.

A hook-stick can be used to engage the manual trip ring to trip and mechanically lockout the switchgear from the ground. The mechanical trip ring has two positions. In the *up* position normal operation can take place. In the *down* position the switchgear is tripped and both mechanically and electronically locked open. So if the switchgear is tripped by pulling the trip ring down, the trip ring must be pushed back up before the switchgear can be closed.

The PowerLogic ADVC interfaces to the switchgear via the control cable and connects to the Switchgear Cable Entry Module (SCEM) in the base of the tank. The SCEM uses non-volatile memory to store all relevant switchgear data such as calibration values, ratings and number of operations. The SCEM also provides electronic shorting of the CT's and CVT's in the event the control cable is disconnected while current is flowing through the switchgear.

# RL Series Load Break Switch

The RL Series three phase load break switch can be used as the switchgear component for an AS using the PowerLogic ADVC Controller. It can also operate independently of a controller as a manual load break switch or sectionaliser.

The RL Series cannot be used as the switchgear component for an ACR primarily because it is not designed to break fault current.

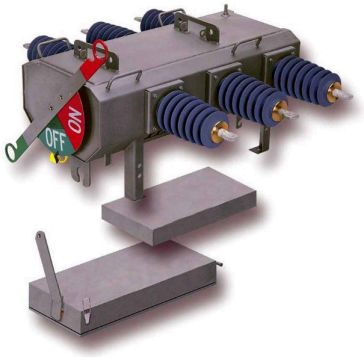



**Figure 345**
RL Series Load Break Switch with optional Motor Pack

The RL Series Load Break Switch is a pole or pylon mounted, gas insulated three phase Load Break Switch (LBS)/Sectionaliser optimized for remote control and automation schemes.

Using a puffer interruption system insulated by $SF_6$ gas and enclosed in a sealed-for-life 316 Marine Grade stainless steel tank helps to ensure a long, low-maintenance service life. A fully insulated cabling system and a simple pole hanging arrangement all contribute to a quick, low cost installation.

The actuation of the Load Break Switch can be achieved in two ways:

- Manually – by use of a hook-stick to pull on an external operating lever.
- Electronically – with the addition of a motor pack mounted on the switch and operated via the PowerLogic ADVC Controller.

The interrupters are ganged together and driven by an over-centring spring mechanism which is *operator independent* so that it does not matter how fast or slow the arm is moved by the operator.

Current transformer and voltage screens are embedded in the bushings. These send signals to the control electronics to monitor line current, earth current and phase to earth voltages. Combined with the additional Motor Pack the RL Series switchgear can integrate easily into a SCADA system.

Available in 15, 27 and 38 kV variations, the RL Series also has the option of attaching surge arresters and capabilities for monitoring internal $SF_6$ gas pressure through sensors and highly visible low pressure external indicator. There is also a high pressure release to help avoid explosions or detachment from the RL Series mountings.

The switchgear position is shown by a large, clearly visible indicator, which is attached to the external operating lever.

The PowerLogic ADVC interfaces to the switchgear via the control cable and connects to the Switchgear Cable Entry Module (SCEM) in the base of the tank. The SCEM uses non-volatile memory to store all relevant switchgear data such as calibration values, ratings and number of operations. The SCEM also provides electronic shorting of the CT's and CVT's in the event the control cable is disconnected while current is flowing through the switchgear.

# PMSet UR Series Circuit Breaker

The PMSet UR Series three phase circuit breaker can be used as the switchgear component for an ACR using the PowerLogic ADVC Controller. It can also function as a load break switch when used as the switchgear component for an AS. The PMSet UR Series switchgear is an evolution of the PMSet U Series switchgear, with higher current capacity and BIL, and is equipped with 6 internal CVTs for voltage measurement.




**Figure 346**
PMSet UR Series Circuit Breaker

The PMSet UR Series circuit breaker is operated by a magnetic actuator which produces a positive opening and closing action. Switching occurs when a controlled pulse is sent through the open/close actuator from a storage capacitor in the PowerLogic ADVC Controller. When closed, the switch is latched magnetically. Spring loaded push rods provide contact loading on the interrupters.

Three Current Transformers (CTs) (one per phase), and six Capacitive Voltage Transformers (CVTs) (one per bushing) are moulded into the pole. These are monitored by the PowerLogic ADVC Controller for protection, remote monitoring, and display.

The ACR or AS with PMSet UR Series switchgear is supplied with aluminum stems or optional cable clamp connectors. Mounting brackets for lightning arresters also are optionally available.

The switchgear contact position is indicated by a large, clearly visible external pointer.

A hook-stick can be used to engage the manual trip ring, allowing the switchgear to be tripped and mechanically locked out from the ground. The mechanical trip ring has two positions:

- Up position: Normal operation is enabled.
- Down position: The switchgear is tripped and locked open both mechanically and electronically.

If the switchgear is tripped by pulling the trip ring downward, the ring must be pushed back upward before the switchgear can be closed again.

The PowerLogic ADVC interfaces with the switchgear via a control cable, which connects to the SCEM located at the base of the tank. The SCEM uses non-volatile memory to store all relevant switchgear data, such as calibration values, ratings, and the number of operations. Additionally, the SCEM provides electronic shorting of the CTs and CVTs in the event that the control cable is disconnected while current is flowing through the switchgear.

# Appendix B Dimensions

## PowerLogic ADVC COMPACT Dimensions

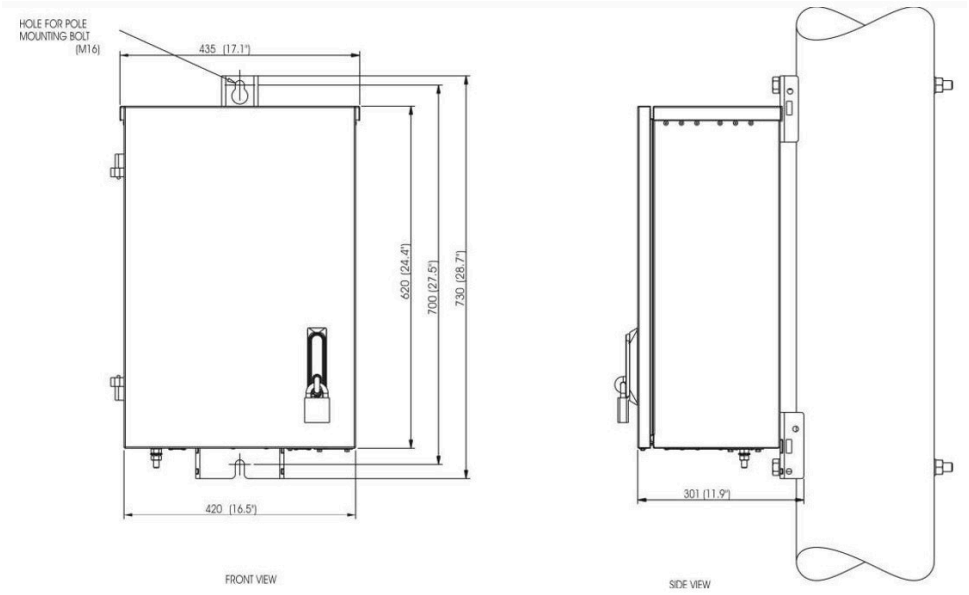



**Figure 347**
Front and Side view of PowerLogic ADVC Controller COMPACT cubicle with dimensions

## PowerLogic ADVC ULTRA Dimensions

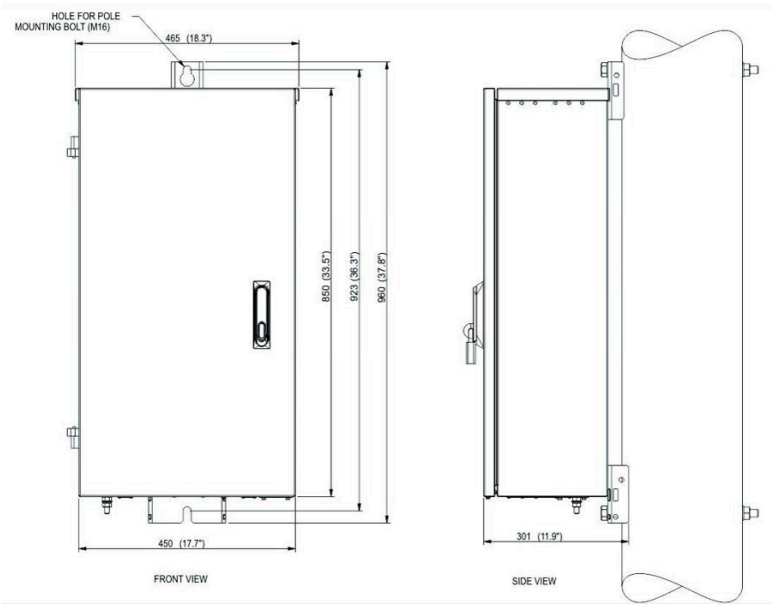



**Figure 348**
Front and Side view of the PowerLogic ADVC Controller ULTRA cubicle with dimensions

# IOEX Dimensions

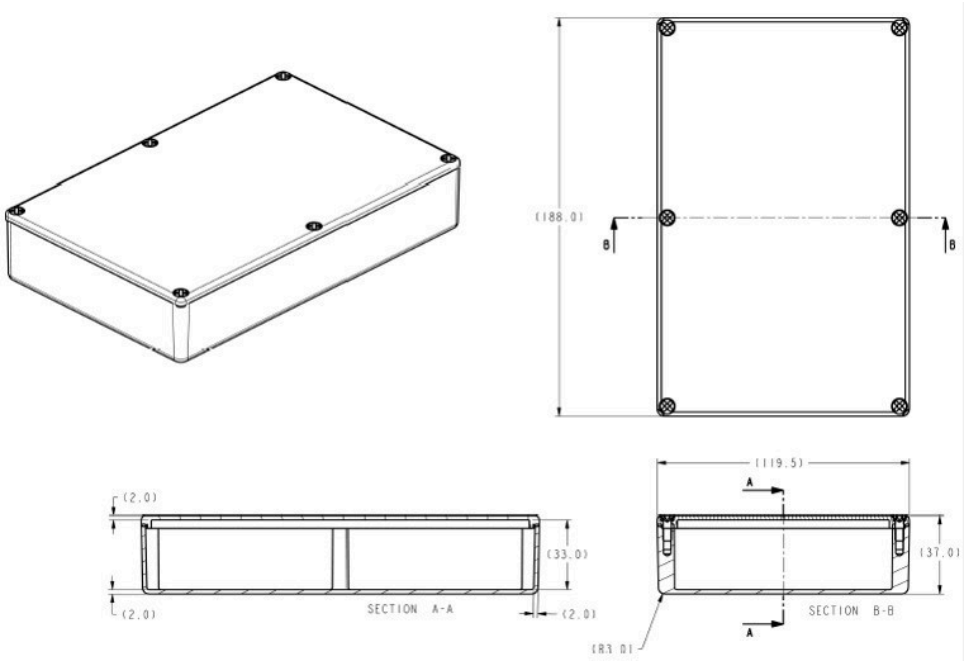



**Figure 349**
IOEX Dimensions

# PowerLogic ADVC Controller Customer Tray Dimensions

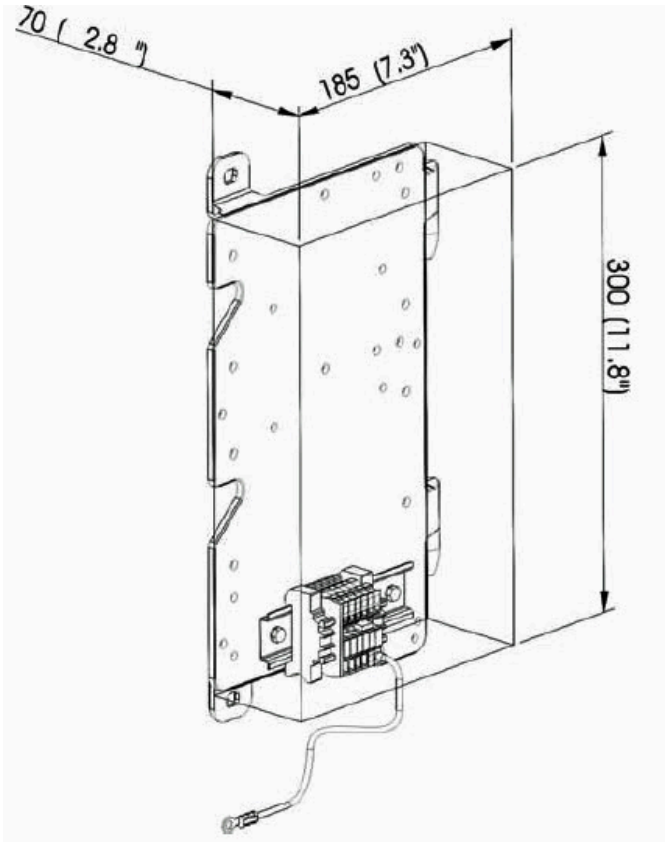



**Figure 350**
Side Customer Tray Dimensions (ULTRA and COMPACT cubicles)

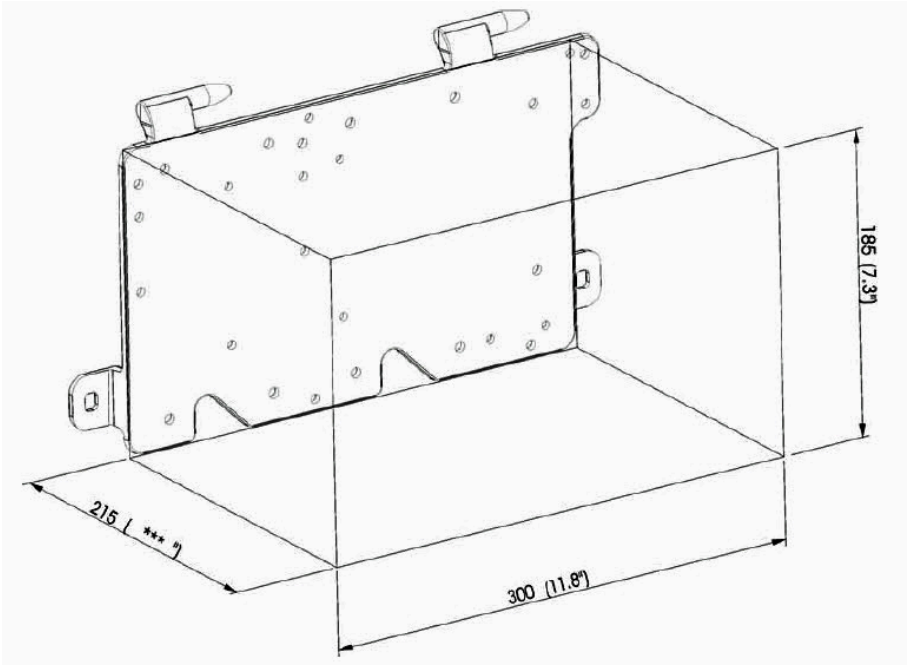



**Figure 351**
Top Customer Tray Dimensions (ULTRA cubicle only)

## PowerLogic ADVC Controller Base View

PowerLogic ADVC COMPACT

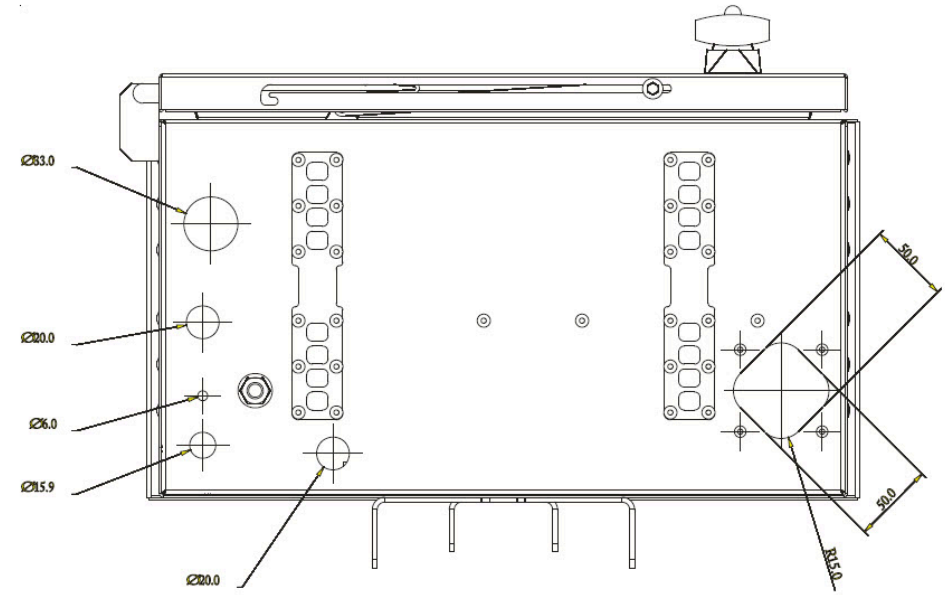



**Figure 352**
Base View of PowerLogic ADVC Controller COMPACT cubicle with cut-out dimensions

PowerLogic ADVC ULTRA

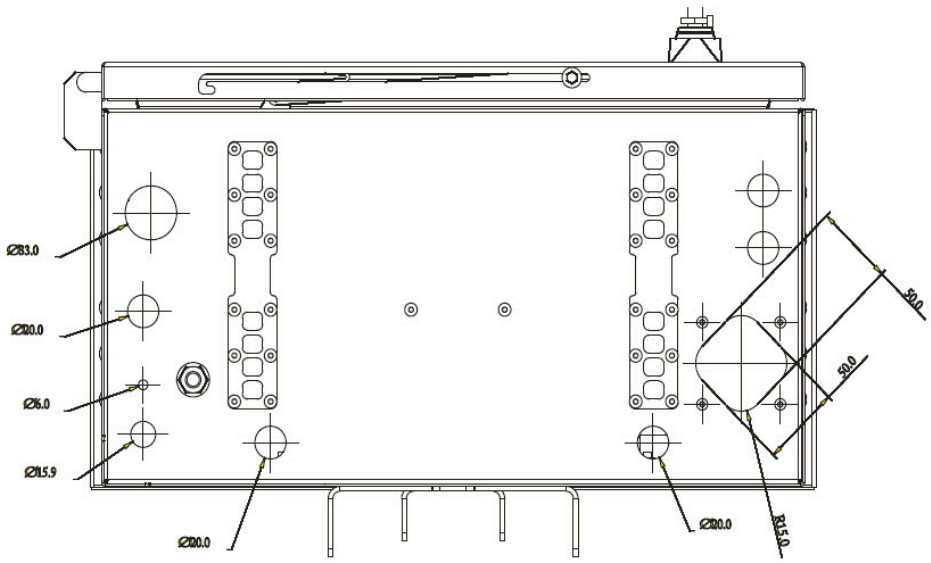



**Figure 353**
Base View of PowerLogic ADVC Controller ULTRA cubicle with cut-out dimensions

# Appendix C PowerLogic ADVC Schematics

## PowerLogic ADVC Controllers General Arrangement

PowerLogic ADVC Controller with***flex*VUE** O.I..

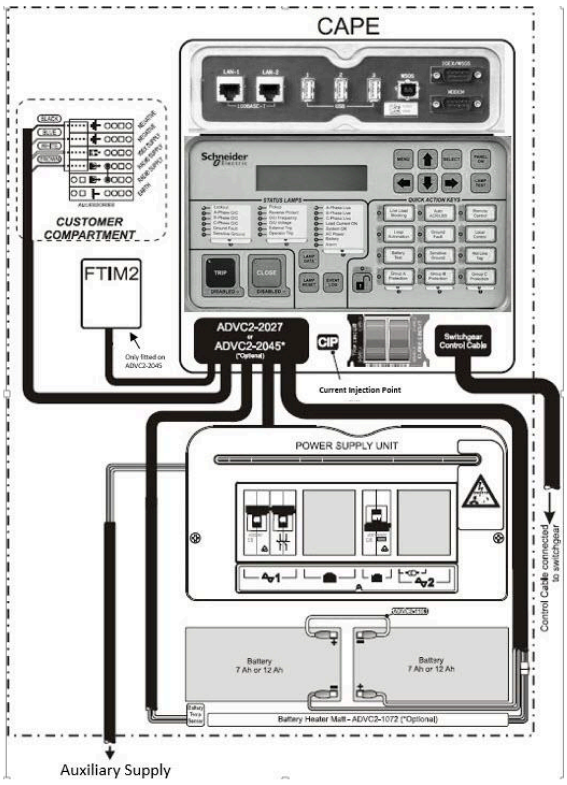



**Figure 354**
PowerLogic ADVC General Arrangements

The ***set*VUE** and ***flex*VUE** Operator Interfaces are available with PowerLogic ADVC.

**NOTE:** If the Fast Trip Input Module (FTIM) is required it must be specified at the time the device is ordered.

# Control Cable

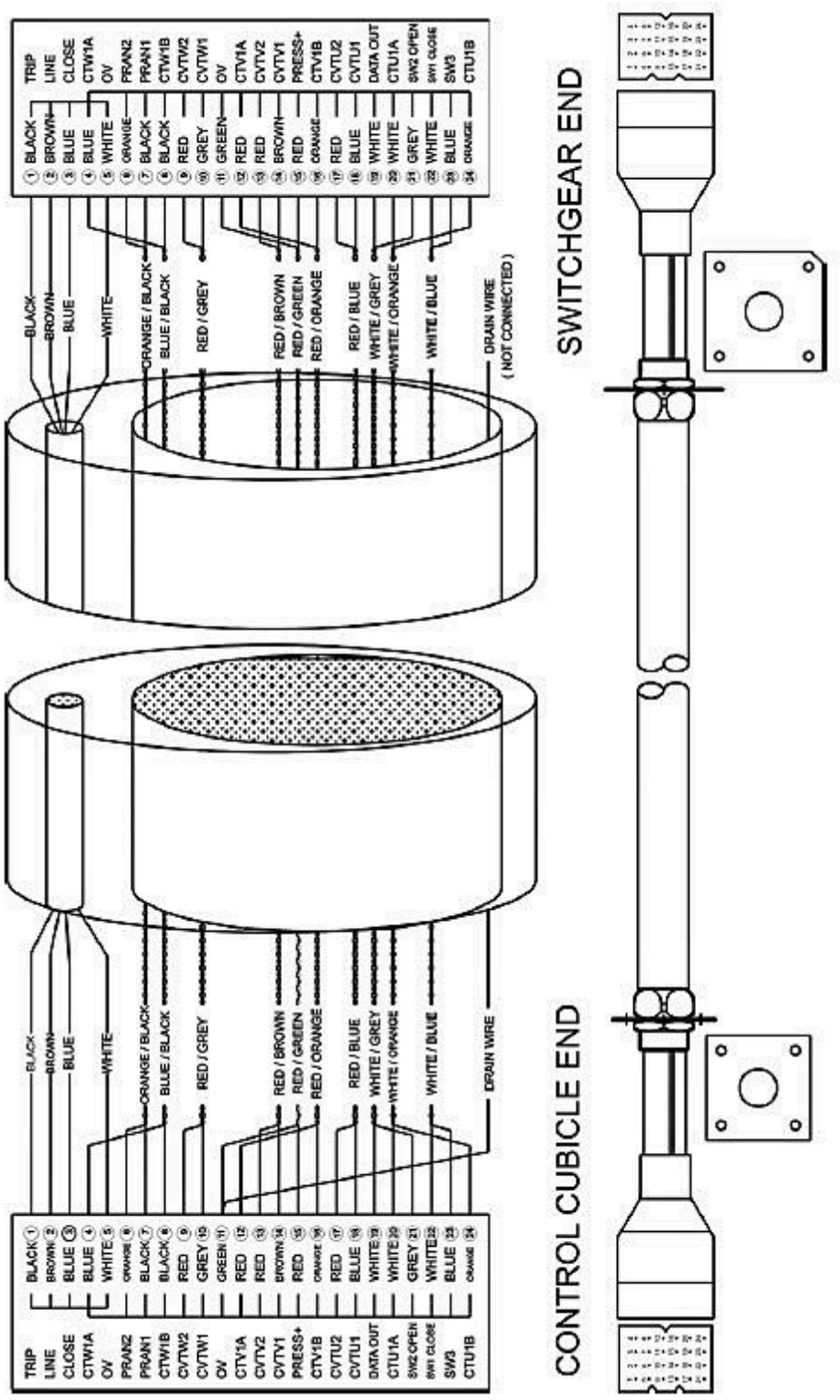



**Figure 355**
Control Cable Pinouts

# Appendix D IEC255 Inverse Time Tables

The times shown for the inverse time curves in this appendix are calculated according to the formulas defined in the IEC 255 Standard.

- Standard Inverse (SI) = 0.14 / (I^0.02-1)
- Very Inverse (VI) = 13.5 / (I-1)
- Extremely Inverse (EI) = 80 / (I^2-1)

Where I is the fault current expressed as a multiple of the setting current.

Each curve is defined in terms of a formula such as:

***Time = T / (IN – Q) + B***

Where:

T = time parameter specific to characteristic

I = ratio of fault current to setting current

N = parameter specific to characteristic

Q = parameter specific to characteristic

B = parameter specific to characteristic

Tables for the calculated times for each of the IEC255 curves are shown in the table below.

**Table 104 IEC 255 Inverse Curves Timing Table**

| Setting Current Multiple | Standard Inverse Time (s) | Very Inverse Time (s) | Extremely Inverse Time (s) |
|---|---|---|---|
| 1.10 | 73.37 | 135.00 | 380.95 |
| 1.50 | 17.19 | 27.00 | 64.00 |
| 2.00 | 10.03 | 13.50 | 26.67 |
| 2.50 | 7.57 | 9.00 | 15.24 |
| 3.00 | 6.30 | 6.75 | 10.00 |
| 3.50 | 5.52 | 5.40 | 7.11 |
| 4.00 | 4.98 | 4.50 | 5.33 |
| 4.50 | 4.58 | 3.86 | 4.16 |
| 5.00 | 4.28 | 3.38 | 3.33 |
| 5.50 | 4.04 | 3.00 | 2.74 |
| 6.00 | 3.84 | 2.70 | 2.29 |
| 6.50 | 3.67 | 2.45 | 1.94 |
| 7.00 | 3.53 | 2.25 | 1.67 |
| 7.50 | 3.40 | 2.08 | 1.45 |
| 8.00 | 3.30 | 1.93 | 1.27 |
| 8.50 | 3.20 | 1.80 | 1.12 |
| 9.00 | 3.12 | 1.69 | 1.00 |
| 9.50 | 3.04 | 1.59 | 0.90 |
| 10.00 | 2.97 | 1.50 | 0.81 |
| 10.50 | 2.91 | 1.42 | 0.73 |
| 11.00 | 2.85 | 1.35 | 0.67 |
| 11.50 | 2.80 | 1.29 | 0.61 |
| 12.00 | 2.75 | 1.23 | 0.56 |
| 12.50 | 2.70 | 1.17 | 0.52 |
| 13.00 | 2.66 | 1.13 | 0.48 |

**Table 104 IEC 255 Inverse Curves Timing Table (Continued)**

| Setting Current Multiple | Standard Inverse Time (s) | Very Inverse Time (s) | Extremely Inverse Time (s) |
|---|---|---|---|
| 13.50 | 2.62 | 1.08 | 0.44 |
| 14.00 | 2.58 | 1.04 | 0.41 |
| 14.50 | 2.55 | 1.00 | 0.38 |
| 15.00 | 2.52 | 0.96 | 0.36 |
| 15.50 | 2.48 | 0.93 | 0.33 |
| 16.00 | 2.46 | 0.90 | 0.31 |
| 16.50 | 2.43 | 0.87 | 0.29 |
| 17.00 | 2.40 | 0.84 | 0.28 |
| 17.50 | 2.38 | 0.82 | 0.26 |
| 18.00 | 2.35 | 0.79 | 0.25 |
| 18.50 | 2.33 | 0.77 | 0.23 |
| 19.00 | 2.31 | 0.75 | 0.22 |
| 19.50 | 2.29 | 0.73 | 0.21 |
| 20.00 | 2.27 | 0.71 | 0.20 |
| 20.50 | 2.25 | 0.69 | 0.19 |
| 21.00 | 2.23 | 0.68 | 0.18 |
| 21.50 | 2.21 | 0.66 | 0.17 |
| 22.00 | 2.20 | 0.64 | 0.17 |
| 22.50 | 2.18 | 0.63 | 0.16 |
| 23.00 | 2.16 | 0.61 | 0.15 |
| 23.50 | 2.15 | 0.60 | 0.15 |
| 24.00 | 2.13 | 0.59 | 0.14 |
| 24.50 | 2.12 | 0.57 | 0.13 |
| 25.00 | 2.11 | 0.56 | 0.13 |
| 25.50 | 2.09 | 0.55 | 0.12 |
| 26.00 | 2.08 | 0.54 | 0.12 |
| 26.50 | 2.07 | 0.53 | 0.11 |
| 27.00 | 2.05 | 0.52 | 0.11 |
| 27.50 | 2.04 | 0.51 | 0.11 |
| 28.00 | 2.03 | 0.50 | 0.10 |
| 28.50 | 2.02 | 0.49 | 0.10 |
| 29.00 | 2.01 | 0.48 | 0.10 |
| 29.50 | 2.00 | 0.47 | 0.09 |
| 30.00 | 1.99 | 0.47 | 0.09 |

# Appendix E IEEE Inverse Time Protection Tables

The times shown for the inverse time curves in this appendix are calculated according to the formulas defined in the IEEE Standard.

- Standard Moderately Inverse = (0.0515 / (I^0.02 - 1)) + 0.114
- Standard Very Inverse = (19.61 / (I^2-1)) + 0.491
- Standard Extremely Inverse = (28.2 / (I^2-1)) + 0.1217

Where I is the fault current expressed as a multiple of the setting current.

Each curve is defined in terms of a formula such as:

***Time = T / (IN – Q) + B***

Where:

T = time parameter specific to characteristic

I = ratio of fault current to setting current

N = parameter specific to characteristic

Q = parameter specific to characteristic

B = parameter specific to characteristic

Tables for the times to trip for each of these curves are shown in the table below.

**Table 105 IEEE Inverse Curves Timing Table**

| Setting Current Multiple | Standard Moderately Inverse Time (s) | Standard Very Inverse Time (s) | Standard Extremely Inverse Time (s) |
|---|---|---|---|
| 1.10 | 27.11 | 93.87 | 134.41 |
| 1.50 | 6.44 | 16.18 | 22.68 |
| 2.00 | 3.80 | 7.03 | 9.52 |
| 2.50 | 2.90 | 4.23 | 5.49 |
| 3.00 | 2.43 | 2.94 | 3.65 |
| 3.50 | 2.14 | 2.23 | 2.63 |
| 4.00 | 1.95 | 1.80 | 2.00 |
| 4.50 | 1.80 | 1.51 | 1.59 |
| 5.00 | 1.69 | 1.31 | 1.30 |
| 5.50 | 1.60 | 1.16 | 1.09 |
| 6.00 | 1.53 | 1.05 | 0.93 |
| 6.50 | 1.46 | 0.97 | 0.81 |
| 7.00 | 1.41 | 0.90 | 0.71 |
| 7.50 | 1.37 | 0.85 | 0.63 |
| 8.00 | 1.33 | 0.80 | 0.57 |
| 8.50 | 1.29 | 0.77 | 0.52 |
| 9.00 | 1.26 | 0.74 | 0.47 |
| 9.50 | 1.23 | 0.71 | 0.44 |
| 10.00 | 1.21 | 0.69 | 0.41 |
| 10.50 | 1.18 | 0.67 | 0.38 |
| 11.00 | 1.16 | 0.65 | 0.36 |
| 11.50 | 1.14 | 0.64 | 0.34 |
| 12.00 | 1.12 | 0.63 | 0.32 |
| 12.50 | 1.11 | 0.62 | 0.30 |
| 13.00 | 1.09 | 0.61 | 0.29 |
| 13.50 | 1.08 | 0.60 | 0.28 |

### Table 105 IEEE Inverse Curves Timing Table (Continued)

| Setting Current Multiple | Standard Moderately Inverse Time (s) | Standard Very Inverse Time (s) | Standard Extremely Inverse Time (s) |
|---|---|---|---|
| 14.00 | 1.06 | 0.59 | 0.27 |
| 14.50 | 1.05 | 0.58 | 0.26 |
| 15.00 | 1.04 | 0.58 | 0.25 |
| 15.50 | 1.03 | 0.57 | 0.24 |
| 16.00 | 1.02 | 0.57 | 0.23 |
| 16.50 | 1.01 | 0.56 | 0.23 |
| 17.00 | 1.00 | 0.56 | 0.22 |
| 17.50 | 0.99 | 0.56 | 0.21 |
| 18.00 | 0.98 | 0.55 | 0.21 |
| 18.50 | 0.97 | 0.55 | 0.20 |
| 19.00 | 0.96 | 0.55 | 0.20 |
| 19.50 | 0.96 | 0.54 | 0.20 |
| 20.00 | 0.95 | 0.54 | 0.19 |
| 20.50 | 0.94 | 0.54 | 0.19 |
| 21.00 | 0.93 | 0.54 | 0.19 |
| 21.50 | 0.93 | 0.53 | 0.18 |
| 22.00 | 0.92 | 0.53 | 0.18 |
| 22.50 | 0.92 | 0.53 | 0.18 |
| 23.00 | 0.91 | 0.53 | 0.18 |
| 23.50 | 0.90 | 0.53 | 0.17 |
| 24.00 | 0.90 | 0.53 | 0.17 |
| 24.50 | 0.89 | 0.52 | 0.17 |
| 25.00 | 0.89 | 0.52 | 0.17 |
| 25.50 | 0.88 | 0.52 | 0.17 |
| 26.00 | 0.88 | 0.52 | 0.16 |
| 26.50 | 0.87 | 0.52 | 0.16 |
| 27.00 | 0.87 | 0.52 | 0.16 |
| 27.50 | 0.87 | 0.52 | 0.16 |
| 28.00 | 0.86 | 0.52 | 0.16 |
| 28.50 | 0.86 | 0.52 | 0.16 |
| 29.00 | 0.85 | 0.51 | 0.16 |
| 29.50 | 0.85 | 0.51 | 0.15 |
| 30.00 | 0.85 | 0.51 | 0.15 |

# Appendix F Non Standard Inverse Time Tables

The 42 inverse time curves in this appendix are non-standard inverse curves.

Tables for the set times for each of these curves are given below.

**Table 106 Non Standard Inverse Curves TCC010 - TCC111 Timing Table**

| Setting Current Multiple | TCC010 | TCC101 | TCC102 | TCC103 | TCC104 | TCC105 | TCC106 | TCC107 | TCC111 |
|---|---|---|---|---|---|---|---|---|---|
| 1.10 | 0.145 | 0.100 | 0.214 | 0.301 | 0.445 | 0.705 | 1.015 | 1.218 | 2.589 |
| 1.50 | 0.100 | 0.036 | 0.065 | 0.128 | 0.252 | 0.351 | 0.396 | 0.597 | 1.121 |
| 2.00 | 0.080 | 0.022 | 0.028 | 0.075 | 0.155 | 0.232 | 0.203 | 0.291 | 0.651 |
| 2.50 | 0.069 | 0.019 | 0.022 | 0.052 | 0.107 | 0.171 | 0.117 | 0.159 | 0.443 |
| 3.00 | 0.060 | 0.017 | 0.019 | 0.04 | 0.067 | 0.137 | 0.073 | 0.095 | 0.325 |
| 3.50 | 0.056 | 0.016 | 0.017 | 0.033 | 0.04 | 0.113 | 0.046 | 0.055 | 0.25 |
| 4.00 | 0.053 | 0.016 | 0.016 | 0.029 | 0.028 | 0.097 | 0.03 | 0.034 | 0.201 |
| 4.50 | 0.050 | 0.015 | 0.016 | 0.025 | 0.022 | 0.085 | 0.022 | 0.024 | 0.169 |
| 5.00 | 0.048 | 0.015 | 0.016 | 0.022 | 0.019 | 0.076 | 0.019 | 0.02 | 0.146 |
| 5.50 | 0.046 | 0.015 | 0.016 | 0.02 | 0.017 | 0.068 | 0.016 | 0.017 | 0.127 |
| 6.00 | 0.045 | 0.015 | 0.016 | 0.019 | 0.016 | 0.059 | 0.015 | 0.016 | 0.113 |
| 6.50 | 0.044 | 0.015 | 0.016 | 0.018 | 0.015 | 0.053 | 0.013 | 0.015 | 0.101 |
| 7.00 | 0.043 | 0.015 | 0.016 | 0.017 | 0.014 | 0.048 | 0.013 | 0.014 | 0.091 |
| 7.50 | 0.042 | 0.015 | 0.016 | 0.016 | 0.013 | 0.043 | 0.012 | 0.013 | 0.083 |
| 8.00 | 0.041 | 0.015 | 0.016 | 0.016 | 0.012 | 0.038 | 0.011 | 0.013 | 0.076 |
| 8.50 | 0.041 | 0.015 | 0.016 | 0.015 | 0.012 | 0.033 | 0.011 | 0.013 | 0.069 |
| 9.00 | 0.040 | 0.015 | 0.016 | 0.015 | 0.011 | 0.03 | 0.011 | 0.012 | 0.063 |
| 9.50 | 0.040 | 0.015 | 0.016 | 0.015 | 0.011 | 0.027 | 0.011 | 0.012 | 0.057 |
| 10.00 | 0.039 | 0.015 | 0.016 | 0.015 | 0.011 | 0.025 | 0.011 | 0.012 | 0.053 |
| 10.50 | 0.039 | 0.015 | 0.016 | 0.014 | 0.011 | 0.024 | 0.011 | 0.012 | 0.049 |
| 11.00 | 0.039 | 0.015 | 0.016 | 0.014 | 0.011 | 0.022 | 0.011 | 0.011 | 0.045 |
| 11.50 | 0.039 | 0.015 | 0.016 | 0.014 | 0.011 | 0.021 | 0.011 | 0.011 | 0.041 |
| 12.00 | 0.038 | 0.015 | 0.016 | 0.014 | 0.011 | 0.02 | 0.011 | 0.011 | 0.038 |
| 12.50 | 0.038 | 0.015 | 0.016 | 0.014 | 0.011 | 0.019 | 0.011 | 0.011 | 0.036 |
| 13.00 | 0.038 | 0.015 | 0.016 | 0.014 | 0.011 | 0.018 | 0.011 | 0.011 | 0.033 |
| 13.50 | 0.037 | 0.015 | 0.016 | 0.014 | 0.011 | 0.017 | 0.011 | 0.011 | 0.031 |
| 14.00 | 0.037 | 0.015 | 0.016 | 0.014 | 0.011 | 0.016 | 0.011 | 0.011 | 0.03 |
| 14.50 | 0.037 | 0.015 | 0.016 | 0.014 | 0.011 | 0.016 | 0.011 | 0.011 | 0.029 |
| 15.00 | 0.037 | 0.015 | 0.016 | 0.014 | 0.011 | 0.015 | 0.011 | 0.011 | 0.027 |
| 15.50 | 0.037 | 0.015 | 0.016 | 0.014 | 0.011 | 0.015 | 0.011 | 0.011 | 0.026 |
| 16.00 | 0.036 | 0.015 | 0.016 | 0.014 | 0.011 | 0.014 | 0.011 | 0.011 | 0.025 |
| 16.50 | 0.036 | 0.015 | 0.016 | 0.014 | 0.011 | 0.014 | 0.011 | 0.011 | 0.024 |
| 17.00 | 0.036 | 0.015 | 0.016 | 0.014 | 0.011 | 0.014 | 0.011 | 0.011 | 0.023 |
| 17.50 | 0.036 | 0.015 | 0.016 | 0.014 | 0.011 | 0.014 | 0.011 | 0.011 | 0.023 |
| 18.00 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.013 | 0.011 | 0.011 | 0.022 |
| 18.50 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.013 | 0.011 | 0.011 | 0.022 |
| 19.00 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.013 | 0.011 | 0.011 | 0.021 |
| 19.50 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.013 | 0.011 | 0.011 | 0.021 |
| 20.00 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.012 | 0.011 | 0.011 | 0.02 |

### Table 106 Non Standard Inverse Curves TCC010 - TCC111 Timing Table (Continued)

| Setting Current Multiple | TCC010 | TCC101 | TCC102 | TCC103 | TCC104 | TCC105 | TCC106 | TCC107 | TCC111 |
|---|---|---|---|---|---|---|---|---|---|
| 20.50 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.012 | 0.011 | 0.011 | 0.02 |
| 21.00 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.012 | 0.011 | 0.011 | 0.019 |
| 21.50 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.012 | 0.011 | 0.011 | 0.019 |
| 22.00 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.012 | 0.011 | 0.011 | 0.019 |
| 22.50 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.012 | 0.011 | 0.011 | 0.018 |
| 23.00 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.012 | 0.011 | 0.011 | 0.018 |
| 23.50 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.012 | 0.011 | 0.011 | 0.018 |
| 24.00 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.012 | 0.011 | 0.011 | 0.017 |
| 24.50 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.012 | 0.011 | 0.011 | 0.017 |
| 25.00 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.012 | 0.011 | 0.011 | 0.017 |
| 25.50 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.011 | 0.011 | 0.011 | 0.017 |
| 26.00 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.011 | 0.011 | 0.011 | 0.016 |
| 26.50 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.011 | 0.011 | 0.011 | 0.016 |
| 27.00 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.011 | 0.011 | 0.011 | 0.016 |
| 27.50 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.011 | 0.011 | 0.011 | 0.016 |
| 28.00 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.011 | 0.011 | 0.011 | 0.016 |
| 28.50 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.011 | 0.011 | 0.011 | 0.016 |
| 29.00 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.011 | 0.011 | 0.011 | 0.016 |
| 29.50 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.011 | 0.011 | 0.011 | 0.016 |
| 30.00 | 0.035 | 0.015 | 0.016 | 0.014 | 0.011 | 0.011 | 0.011 | 0.011 | 0.016 |

### Table 107 Non Standard Inverse Curves TCC112 - TCC120 Timing Table

| Setting Current Multiple | TCC112 | TCC113 | TCC114 | TCC115 | TCC116 | TCC117 | TCC118 | TCC119 | TCC120 |
|---|---|---|---|---|---|---|---|---|---|
| 1.10 | 2.415 | 2.954 | 6.054 | 4.692 | 5.752 | 5.396 | 6.949 | 6.401 | 9.354 |
| 1.50 | 1.024 | 1.264 | 2.376 | 1.792 | 2.301 | 2.291 | 2.511 | 2.505 | 3.755 |
| 2.00 | 0.563 | 0.704 | 1.398 | 0.726 | 1.216 | 1.396 | 1.248 | 1.518 | 2.013 |
| 2.50 | 0.356 | 0.467 | 0.952 | 0.374 | 0.748 | 0.920 | 0.754 | 1.145 | 1.302 |
| 3.00 | 0.257 | 0.358 | 0.699 | 0.219 | 0.499 | 0.649 | 0.523 | 0.940 | 0.925 |
| 3.50 | 0.198 | 0.293 | 0.532 | 0.141 | 0.351 | 0.489 | 0.384 | 0.809 | 0.696 |
| 4.00 | 0.158 | 0.259 | 0.420 | 0.096 | 0.259 | 0.391 | 0.295 | 0.716 | 0.549 |
| 4.50 | 0.132 | 0.233 | 0.334 | 0.067 | 0.200 | 0.321 | 0.234 | 0.652 | 0.462 |
| 5.00 | 0.113 | 0.215 | 0.261 | 0.049 | 0.159 | 0.270 | 0.193 | 0.602 | 0.398 |
| 5.50 | 0.099 | 0.203 | 0.206 | 0.038 | 0.129 | 0.231 | 0.162 | 0.572 | 0.348 |
| 6.00 | 0.088 | 0.196 | 0.164 | 0.030 | 0.107 | 0.200 | 0.139 | 0.549 | 0.311 |
| 6.50 | 0.079 | 0.189 | 0.127 | 0.025 | 0.090 | 0.176 | 0.121 | 0.529 | 0.281 |
| 7.00 | 0.073 | 0.185 | 0.098 | 0.021 | 0.078 | 0.156 | 0.107 | 0.512 | 0.257 |
| 7.50 | 0.068 | 0.182 | 0.076 | 0.019 | 0.068 | 0.140 | 0.096 | 0.499 | 0.236 |
| 8.00 | 0.063 | 0.180 | 0.053 | 0.018 | 0.060 | 0.126 | 0.087 | 0.487 | 0.220 |
| 8.50 | 0.059 | 0.179 | 0.038 | 0.017 | 0.053 | 0.115 | 0.078 | 0.477 | 0.207 |
| 9.00 | 0.056 | 0.177 | 0.032 | 0.016 | 0.048 | 0.105 | 0.071 | 0.468 | 0.195 |
| 9.50 | 0.053 | 0.176 | 0.028 | 0.015 | 0.043 | 0.097 | 0.066 | 0.461 | 0.185 |
| 10.00 | 0.050 | 0.175 | 0.025 | 0.014 | 0.039 | 0.089 | 0.060 | 0.455 | 0.175 |
| 10.50 | 0.048 | 0.174 | 0.024 | 0.014 | 0.036 | 0.083 | 0.056 | 0.452 | 0.167 |

**Table 107 Non Standard Inverse Curves TCC112 - TCC120 Timing Table (Continued)**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 11.00 | 0.046 | 0.174 | 0.022 | 0.014 | 0.034 | 0.078 | 0.051 | 0.448 | 0.161 |
| 11.50 | 0.044 | 0.173 | 0.021 | 0.014 | 0.031 | 0.073 | 0.048 | 0.445 | 0.155 |
| 12.00 | 0.043 | 0.172 | 0.020 | 0.014 | 0.029 | 0.068 | 0.045 | 0.441 | 0.150 |
| 12.50 | 0.041 | 0.172 | 0.019 | 0.014 | 0.027 | 0.064 | 0.042 | 0.439 | 0.145 |
| 13.00 | 0.040 | 0.172 | 0.018 | 0.014 | 0.026 | 0.059 | 0.040 | 0.436 | 0.141 |
| 13.50 | 0.039 | 0.171 | 0.018 | 0.014 | 0.024 | 0.055 | 0.037 | 0.434 | 0.137 |
| 14.00 | 0.038 | 0.171 | 0.017 | 0.014 | 0.023 | 0.052 | 0.035 | 0.432 | 0.134 |
| 14.50 | 0.037 | 0.171 | 0.017 | 0.014 | 0.022 | 0.048 | 0.034 | 0.431 | 0.130 |
| 15.00 | 0.036 | 0.170 | 0.016 | 0.014 | 0.020 | 0.044 | 0.032 | 0.429 | 0.128 |
| 15.50 | 0.035 | 0.170 | 0.016 | 0.014 | 0.019 | 0.041 | 0.031 | 0.429 | 0.126 |
| 16.00 | 0.034 | 0.170 | 0.016 | 0.014 | 0.019 | 0.039 | 0.030 | 0.428 | 0.124 |
| 16.50 | 0.033 | 0.170 | 0.015 | 0.014 | 0.018 | 0.037 | 0.029 | 0.427 | 0.122 |
| 17.00 | 0.032 | 0.169 | 0.015 | 0.014 | 0.017 | 0.035 | 0.028 | 0.427 | 0.121 |
| 17.50 | 0.032 | 0.169 | 0.015 | 0.014 | 0.016 | 0.033 | 0.026 | 0.426 | 0.119 |
| 18.00 | 0.031 | 0.169 | 0.014 | 0.014 | 0.016 | 0.031 | 0.025 | 0.426 | 0.117 |
| 18.50 | 0.031 | 0.169 | 0.014 | 0.014 | 0.015 | 0.030 | 0.025 | 0.425 | 0.115 |
| 19.00 | 0.030 | 0.168 | 0.014 | 0.014 | 0.015 | 0.029 | 0.024 | 0.425 | 0.114 |
| 19.50 | 0.030 | 0.168 | 0.014 | 0.014 | 0.014 | 0.028 | 0.023 | 0.424 | 0.113 |
| 20.00 | 0.029 | 0.168 | 0.014 | 0.014 | 0.014 | 0.027 | 0.022 | 0.424 | 0.111 |
| 20.50 | 0.029 | 0.168 | 0.014 | 0.014 | 0.014 | 0.026 | 0.022 | 0.423 | 0.110 |
| 21.00 | 0.028 | 0.167 | 0.013 | 0.014 | 0.013 | 0.026 | 0.021 | 0.423 | 0.109 |
| 21.50 | 0.028 | 0.167 | 0.013 | 0.014 | 0.013 | 0.025 | 0.020 | 0.422 | 0.108 |
| 22.00 | 0.028 | 0.167 | 0.013 | 0.014 | 0.013 | 0.025 | 0.020 | 0.422 | 0.106 |
| 22.50 | 0.027 | 0.167 | 0.013 | 0.014 | 0.013 | 0.024 | 0.019 | 0.422 | 0.105 |
| 23.00 | 0.027 | 0.167 | 0.013 | 0.014 | 0.012 | 0.024 | 0.019 | 0.421 | 0.104 |
| 23.50 | 0.027 | 0.166 | 0.013 | 0.014 | 0.012 | 0.023 | 0.019 | 0.421 | 0.103 |
| 24.00 | 0.026 | 0.166 | 0.013 | 0.014 | 0.012 | 0.023 | 0.018 | 0.421 | 0.102 |
| 24.50 | 0.026 | 0.166 | 0.013 | 0.014 | 0.012 | 0.023 | 0.018 | 0.421 | 0.102 |
| 25.00 | 0.026 | 0.166 | 0.012 | 0.014 | 0.012 | 0.022 | 0.018 | 0.421 | 0.101 |
| 25.50 | 0.026 | 0.166 | 0.012 | 0.014 | 0.012 | 0.022 | 0.017 | 0.421 | 0.100 |
| 26.00 | 0.026 | 0.166 | 0.012 | 0.014 | 0.012 | 0.021 | 0.017 | 0.421 | 0.099 |
| 26.50 | 0.025 | 0.166 | 0.012 | 0.014 | 0.011 | 0.021 | 0.017 | 0.421 | 0.098 |
| 27.00 | 0.025 | 0.166 | 0.012 | 0.014 | 0.011 | 0.021 | 0.017 | 0.421 | 0.098 |
| 27.50 | 0.025 | 0.166 | 0.012 | 0.014 | 0.011 | 0.020 | 0.016 | 0.421 | 0.097 |
| 28.00 | 0.025 | 0.166 | 0.012 | 0.014 | 0.011 | 0.020 | 0.016 | 0.421 | 0.096 |
| 28.50 | 0.025 | 0.166 | 0.012 | 0.014 | 0.011 | 0.020 | 0.016 | 0.421 | 0.096 |
| 29.00 | 0.025 | 0.166 | 0.012 | 0.014 | 0.011 | 0.020 | 0.016 | 0.421 | 0.095 |
| 29.50 | 0.025 | 0.166 | 0.012 | 0.014 | 0.011 | 0.020 | 0.016 | 0.421 | 0.095 |
| 30.00 | 0.025 | 0.166 | 0.012 | 0.014 | 0.011 | 0.020 | 0.016 | 0.421 | 0.095 |

**Table 108 Non Standard Inverse Curves TCC121 – TCC137 Timing Table**

| Setting Current Multiple | TCC121 | TCC122 | TCC131 | TCC132 | TCC133 | TCC134 | TCC135 | TCC136 | TCC137 |
|---|---|---|---|---|---|---|---|---|---|
| 1.10 | 8.877 | 8.219 | 10.610 | 13.732 | 13.716 | 11.367 | 13.660 | 15.655 | 19.198 |
| 1.50 | 1.145 | 4.430 | 8.306 | 4.460 | 5.602 | 4.790 | 6.369 | 4.658 | 10.162 |
| 2.00 | 0.019 | 2.616 | 7.106 | 2.586 | 3.020 | 2.387 | 3.677 | 2.781 | 6.495 |

**Table 108 Non Standard Inverse Curves TCC121 – TCC137 Timing Table (Continued)**

| Setting Current Multiple | TCC121 | TCC122 | TCC131 | TCC132 | TCC133 | TCC134 | TCC135 | TCC136 | TCC137 |
|---|---|---|---|---|---|---|---|---|---|
| 2.50 | 0.014 | 1.689 | 6.425 | 1.571 | 1.920 | 1.507 | 2.566 | 1.884 | 4.756 |
| 3.00 | 0.012 | 1.102 | 6.101 | 1.002 | 1.329 | 1.079 | 1.969 | 1.339 | 3.667 |
| 3.50 | 0.011 | 0.653 | 5.901 | 0.722 | 0.973 | 0.847 | 1.616 | 1.024 | 2.933 |
| 4.00 | 0.011 | 0.347 | 5.730 | 0.552 | 0.754 | 0.698 | 1.367 | 0.833 | 2.416 |
| 4.50 | 0.011 | 0.114 | 5.624 | 0.438 | 0.613 | 0.617 | 1.197 | 0.686 | 2.006 |
| 5.00 | 0.011 | 0.037 | 5.537 | 0.353 | 0.511 | 0.553 | 1.072 | 0.550 | 1.694 |
| 5.50 | 0.011 | 0.022 | 5.460 | 0.287 | 0.432 | 0.508 | 0.974 | 0.448 | 1.464 |
| 6.00 | 0.011 | 0.019 | 5.398 | 0.236 | 0.371 | 0.484 | 0.900 | 0.367 | 1.287 |
| 6.50 | 0.011 | 0.017 | 5.359 | 0.198 | 0.323 | 0.463 | 0.849 | 0.304 | 1.155 |
| 7.00 | 0.011 | 0.016 | 5.334 | 0.169 | 0.284 | 0.446 | 0.805 | 0.252 | 1.062 |
| 7.50 | 0.011 | 0.015 | 5.312 | 0.146 | 0.253 | 0.436 | 0.767 | 0.210 | 0.990 |
| 8.00 | 0.011 | 0.014 | 5.290 | 0.127 | 0.227 | 0.432 | 0.735 | 0.172 | 0.928 |
| 8.50 | 0.011 | 0.013 | 5.269 | 0.110 | 0.205 | 0.427 | 0.711 | 0.142 | 0.873 |
| 9.00 | 0.011 | 0.013 | 5.251 | 0.097 | 0.186 | 0.423 | 0.689 | 0.116 | 0.824 |
| 9.50 | 0.011 | 0.012 | 5.233 | 0.086 | 0.170 | 0.419 | 0.670 | 0.087 | 0.786 |
| 10.00 | 0.011 | 0.012 | 5.216 | 0.077 | 0.157 | 0.416 | 0.651 | 0.064 | 0.753 |
| 10.50 | 0.011 | 0.012 | 5.210 | 0.070 | 0.146 | 0.415 | 0.635 | 0.049 | 0.730 |
| 11.00 | 0.011 | 0.011 | 5.208 | 0.064 | 0.137 | 0.415 | 0.619 | 0.038 | 0.714 |
| 11.50 | 0.011 | 0.011 | 5.208 | 0.058 | 0.128 | 0.415 | 0.607 | 0.032 | 0.699 |
| 12.00 | 0.011 | 0.011 | 5.208 | 0.053 | 0.121 | 0.415 | 0.599 | 0.029 | 0.685 |
| 12.50 | 0.011 | 0.011 | 5.208 | 0.049 | 0.115 | 0.415 | 0.591 | 0.026 | 0.671 |
| 13.00 | 0.011 | 0.011 | 5.208 | 0.046 | 0.109 | 0.415 | 0.584 | 0.024 | 0.662 |
| 13.50 | 0.011 | 0.011 | 5.208 | 0.043 | 0.103 | 0.415 | 0.577 | 0.022 | 0.653 |
| 14.00 | 0.011 | 0.011 | 5.208 | 0.040 | 0.098 | 0.415 | 0.571 | 0.021 | 0.645 |
| 14.50 | 0.011 | 0.011 | 5.207 | 0.037 | 0.093 | 0.415 | 0.566 | 0.020 | 0.640 |
| 15.00 | 0.011 | 0.011 | 5.207 | 0.035 | 0.089 | 0.415 | 0.561 | 0.019 | 0.635 |
| 15.50 | 0.011 | 0.011 | 5.207 | 0.033 | 0.085 | 0.415 | 0.556 | 0.018 | 0.629 |
| 16.00 | 0.011 | 0.011 | 5.207 | 0.032 | 0.082 | 0.415 | 0.553 | 0.017 | 0.626 |
| 16.50 | 0.011 | 0.011 | 5.207 | 0.030 | 0.078 | 0.415 | 0.551 | 0.017 | 0.622 |
| 17.00 | 0.011 | 0.011 | 5.207 | 0.029 | 0.076 | 0.415 | 0.549 | 0.017 | 0.619 |
| 17.50 | 0.011 | 0.011 | 5.207 | 0.027 | 0.074 | 0.415 | 0.548 | 0.016 | 0.616 |
| 18.00 | 0.011 | 0.011 | 5.207 | 0.026 | 0.072 | 0.415 | 0.546 | 0.016 | 0.614 |
| 18.50 | 0.011 | 0.011 | 5.207 | 0.025 | 0.070 | 0.415 | 0.544 | 0.015 | 0.612 |
| 19.00 | 0.011 | 0.011 | 5.207 | 0.023 | 0.068 | 0.415 | 0.543 | 0.015 | 0.610 |
| 19.50 | 0.011 | 0.011 | 5.207 | 0.023 | 0.066 | 0.415 | 0.541 | 0.015 | 0.608 |
| 20.00 | 0.011 | 0.011 | 5.207 | 0.022 | 0.065 | 0.415 | 0.539 | 0.015 | 0.606 |
| 20.50 | 0.011 | 0.011 | 5.207 | 0.022 | 0.063 | 0.415 | 0.538 | 0.015 | 0.605 |
| 21.00 | 0.011 | 0.011 | 5.207 | 0.021 | 0.061 | 0.415 | 0.537 | 0.015 | 0.603 |
| 21.50 | 0.011 | 0.011 | 5.207 | 0.021 | 0.060 | 0.415 | 0.535 | 0.015 | 0.602 |
| 22.00 | 0.011 | 0.011 | 5.207 | 0.020 | 0.058 | 0.415 | 0.534 | 0.015 | 0.602 |
| 22.50 | 0.011 | 0.011 | 5.207 | 0.020 | 0.057 | 0.415 | 0.533 | 0.015 | 0.602 |
| 23.00 | 0.011 | 0.011 | 5.207 | 0.019 | 0.056 | 0.415 | 0.531 | 0.015 | 0.602 |
| 23.50 | 0.011 | 0.011 | 5.207 | 0.019 | 0.054 | 0.415 | 0.530 | 0.015 | 0.602 |
| 24.00 | 0.011 | 0.011 | 5.207 | 0.018 | 0.054 | 0.415 | 0.529 | 0.015 | 0.602 |

**Table 108 Non Standard Inverse Curves TCC121 – TCC137 Timing Table (Continued)**

| Setting Current Multiple | TCC121 | TCC122 | TCC131 | TCC132 | TCC133 | TCC134 | TCC135 | TCC136 | TCC137 |
|---|---|---|---|---|---|---|---|---|---|
| 24.50 | 0.011 | 0.011 | 5.207 | 0.018 | 0.053 | 0.415 | 0.528 | 0.015 | 0.602 |
| 25.00 | 0.011 | 0.011 | 5.207 | 0.018 | 0.052 | 0.415 | 0.528 | 0.015 | 0.602 |
| 25.50 | 0.011 | 0.011 | 5.207 | 0.018 | 0.051 | 0.415 | 0.528 | 0.015 | 0.602 |
| 26.00 | 0.011 | 0.011 | 5.207 | 0.017 | 0.051 | 0.415 | 0.528 | 0.015 | 0.602 |
| 26.50 | 0.011 | 0.011 | 5.207 | 0.017 | 0.050 | 0.415 | 0.528 | 0.015 | 0.602 |
| 27.00 | 0.011 | 0.011 | 5.207 | 0.017 | 0.049 | 0.415 | 0.528 | 0.015 | 0.602 |
| 27.50 | 0.011 | 0.011 | 5.207 | 0.017 | 0.049 | 0.415 | 0.528 | 0.015 | 0.602 |
| 28.00 | 0.011 | 0.011 | 5.207 | 0.017 | 0.048 | 0.415 | 0.528 | 0.015 | 0.602 |
| 28.50 | 0.011 | 0.011 | 5.207 | 0.017 | 0.047 | 0.415 | 0.528 | 0.015 | 0.602 |
| 29.00 | 0.011 | 0.011 | 5.207 | 0.017 | 0.047 | 0.415 | 0.528 | 0.015 | 0.602 |
| 29.50 | 0.011 | 0.011 | 5.207 | 0.017 | 0.046 | 0.415 | 0.528 | 0.015 | 0.602 |
| 30.00 | 0.011 | 0.011 | 5.207 | 0.017 | 0.046 | 0.415 | 0.528 | 0.015 | 0.602 |

**Table 109 Non Standard Inverse Curves TCC138 - TCC162 Timing Table**

| Setting Current Multiple | TCC138 | TCC139 | TCC140 | TCC141 | TCC142 | TCC151 | TCC152 | TCC161 | TCC162 |
|---|---|---|---|---|---|---|---|---|---|
| 1.10 | 20.647 | 15.250 | 25.082 | 19.763 | 36.299 | 38.923 | 72.701 | 19.879 | 27.549 |
| 1.50 | 9.741 | 5.097 | 10.141 | 15.227 | 16.543 | 11.551 | 45.263 | 3.860 | 8.109 |
| 2.00 | 5.905 | 2.889 | 5.802 | 13.159 | 9.181 | 5.848 | 39.251 | 1.688 | 3.793 |
| 2.50 | 4.115 | 1.943 | 4.122 | 12.159 | 5.868 | 3.688 | 36.458 | 1.002 | 2.331 |
| 3.00 | 3.117 | 1.446 | 3.254 | 11.511 | 3.711 | 2.545 | 35.035 | 0.686 | 1.570 |
| 3.50 | 2.493 | 1.139 | 2.708 | 11.095 | 2.372 | 1.888 | 33.905 | 0.494 | 1.117 |
| 4.00 | 1.949 | 0.929 | 2.323 | 10.860 | 1.507 | 1.489 | 32.987 | 0.371 | 0.819 |
| 4.50 | 1.583 | 0.776 | 2.057 | 10.655 | 1.101 | 1.244 | 32.235 | 0.299 | 0.615 |
| 5.00 | 1.299 | 0.661 | 1.857 | 10.486 | 0.849 | 1.068 | 31.587 | 0.248 | 0.486 |
| 5.50 | 1.085 | 0.564 | 1.695 | 10.419 | 0.701 | 0.973 | 31.014 | 0.209 | 0.394 |
| 6.00 | 0.925 | 0.486 | 1.590 | 10.383 | 0.595 | 0.894 | 30.568 | 0.180 | 0.325 |
| 6.50 | 0.802 | 0.423 | 1.506 | 10.351 | 0.511 | 0.828 | 30.234 | 0.158 | 0.274 |
| 7.00 | 0.703 | 0.373 | 1.434 | 10.321 | 0.445 | 0.773 | 29.955 | 0.140 | 0.235 |
| 7.50 | 0.625 | 0.332 | 1.372 | 10.293 | 0.391 | 0.728 | 29.690 | 0.126 | 0.206 |
| 8.00 | 0.561 | 0.297 | 1.315 | 10.267 | 0.346 | 0.687 | 29.441 | 0.114 | 0.182 |
| 8.50 | 0.508 | 0.268 | 1.268 | 10.243 | 0.310 | 0.652 | 29.226 | 0.105 | 0.162 |
| 9.00 | 0.462 | 0.242 | 1.226 | 10.220 | 0.279 | 0.622 | 29.021 | 0.097 | 0.145 |
| 9.50 | 0.422 | 0.221 | 1.197 | 10.199 | 0.253 | 0.600 | 28.880 | 0.091 | 0.130 |
| 10.00 | 0.388 | 0.202 | 1.168 | 10.180 | 0.231 | 0.579 | 28.768 | 0.085 | 0.117 |
| 10.50 | 0.360 | 0.185 | 1.144 | 10.175 | 0.211 | 0.565 | 28.661 | 0.079 | 0.106 |
| 11.00 | 0.337 | 0.171 | 1.119 | 10.175 | 0.194 | 0.551 | 28.564 | 0.075 | 0.097 |
| 11.50 | 0.315 | 0.158 | 1.098 | 10.175 | 0.179 | 0.539 | 28.463 | 0.071 | 0.089 |
| 12.00 | 0.297 | 0.146 | 1.079 | 10.175 | 0.166 | 0.529 | 28.376 | 0.067 | 0.082 |
| 12.50 | 0.280 | 0.135 | 1.060 | 10.175 | 0.154 | 0.518 | 28.290 | 0.064 | 0.076 |
| 13.00 | 0.265 | 0.126 | 1.053 | 10.175 | 0.144 | 0.514 | 28.201 | 0.061 | 0.071 |
| 13.50 | 0.253 | 0.117 | 1.046 | 10.175 | 0.132 | 0.509 | 28.135 | 0.059 | 0.067 |
| 14.00 | 0.242 | 0.110 | 1.038 | 10.175 | 0.121 | 0.504 | 28.068 | 0.057 | 0.063 |
| 14.50 | 0.232 | 0.103 | 1.032 | 10.175 | 0.112 | 0.499 | 27.998 | 0.054 | 0.060 |

**Table 109 Non Standard Inverse Curves TCC138 - TCC162 Timing Table (Continued)**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 15.00 | 0.224 | 0.096 | 1.026 | 10.175 | 0.103 | 0.495 | 27.971 | 0.052 | 0.056 |
| 15.50 | 0.216 | 0.090 | 1.020 | 10.175 | 0.095 | 0.491 | 27.955 | 0.051 | 0.053 |
| 16.00 | 0.208 | 0.085 | 1.014 | 10.175 | 0.088 | 0.487 | 27.939 | 0.049 | 0.050 |
| 16.50 | 0.201 | 0.080 | 1.009 | 10.175 | 0.081 | 0.485 | 27.924 | 0.047 | 0.048 |
| 17.00 | 0.195 | 0.074 | 1.003 | 10.175 | 0.076 | 0.482 | 27.910 | 0.046 | 0.045 |
| 17.50 | 0.190 | 0.070 | 0.998 | 10.175 | 0.070 | 0.479 | 27.897 | 0.045 | 0.042 |
| 18.00 | 0.184 | 0.065 | 0.996 | 10.175 | 0.066 | 0.477 | 27.883 | 0.043 | 0.040 |
| 18.50 | 0.197 | 0.062 | 0.995 | 10.175 | 0.062 | 0.475 | 27.869 | 0.043 | 0.038 |
| 19.00 | 0.175 | 0.058 | 0.994 | 10.175 | 0.059 | 0.472 | 27.857 | 0.042 | 0.036 |
| 19.50 | 0.171 | 0.055 | 0.993 | 10.175 | 0.056 | 0.470 | 27.845 | 0.041 | 0.034 |
| 20.00 | 0.168 | 0.051 | 0.992 | 10.175 | 0.053 | 0.469 | 27.833 | 0.040 | 0.033 |
| 20.50 | 0.154 | 0.049 | 0.991 | 10.175 | 0.050 | 0.468 | 27.821 | 0.040 | 0.031 |
| 21.00 | 0.161 | 0.046 | 0.990 | 10.175 | 0.048 | 0.468 | 27.809 | 0.039 | 0.030 |
| 21.50 | 0.158 | 0.043 | 0.990 | 10.175 | 0.046 | 0.468 | 27.799 | 0.038 | 0.029 |
| 22.00 | 0.155 | 0.041 | 0.989 | 10.175 | 0.045 | 0.467 | 27.788 | 0.038 | 0.028 |
| 22.50 | 0.152 | 0.039 | 0.988 | 10.175 | 0.043 | 0.467 | 27.777 | 0.037 | 0.027 |
| 23.00 | 0.149 | 0.037 | 0.988 | 10.175 | 0.042 | 0.467 | 27.766 | 0.036 | 0.026 |
| 23.50 | 0.146 | 0.035 | 0.987 | 10.175 | 0.040 | 0.467 | 27.757 | 0.036 | 0.026 |
| 24.00 | 0.144 | 0.033 | 0.986 | 10.175 | 0.039 | 0.466 | 27.751 | 0.035 | 0.025 |
| 24.50 | 0.142 | 0.031 | 0.986 | 10.175 | 0.038 | 0.466 | 27.746 | 0.035 | 0.024 |
| 25.00 | 0.140 | 0.030 | 0.985 | 10.175 | 0.037 | 0.466 | 27.740 | 0.034 | 0.024 |
| 25.50 | 0.137 | 0.028 | 0.985 | 10.175 | 0.037 | 0.466 | 27.735 | 0.033 | 0.023 |
| 26.00 | 0.135 | 0.027 | 0.985 | 10.175 | 0.036 | 0.465 | 27.729 | 0.033 | 0.023 |
| 26.50 | 0.134 | 0.026 | 0.985 | 10.175 | 0.035 | 0.465 | 27.725 | 0.033 | 0.022 |
| 27.00 | 0.133 | 0.025 | 0.984 | 10.175 | 0.034 | 0.465 | 27.722 | 0.032 | 0.022 |
| 27.50 | 0.132 | 0.024 | 0.984 | 10.175 | 0.034 | 0.464 | 27.720 | 0.032 | 0.021 |
| 28.00 | 0.131 | 0.023 | 0.984 | 10.175 | 0.033 | 0.464 | 27.717 | 0.031 | 0.021 |
| 28.50 | 0.131 | 0.022 | 0.984 | 10.175 | 0.033 | 0.464 | 27.714 | 0.031 | 0.020 |
| 29.00 | 0.130 | 0.022 | 0.984 | 10.175 | 0.032 | 0.464 | 27.711 | 0.031 | 0.020 |
| 29.50 | 0.129 | 0.021 | 0.984 | 10.175 | 0.032 | 0.464 | 27.709 | 0.031 | 0.020 |
| 30.00 | 0.129 | 0.021 | 0.984 | 10.175 | 0.032 | 0.464 | 27.709 | 0.031 | 0.020 |

**Table 110 Non Standard Inverse Curves TCC163 - TCC202 Timing Table**

| | **TCC163** | **TCC164** | **TCC165** | **TCC200** | **TCC201** | **TCC202** |
|---|---|---|---|---|---|---|
| 1.10 | 33.228 | 53.091 | 84.512 | 74.687 | 122.300 | 125.060 |
| 1.50 | 3.747 | 18.503 | 31.451 | 17.354 | 27.161 | 64.047 |
| 2.00 | 1.356 | 7.916 | 12.916 | 10.039 | 13.506 | 26.654 |
| 2.50 | 0.720 | 4.318 | 5.994 | 7.583 | 9.012 | 15.234 |
| 3.00 | 0.482 | 2.596 | 3.199 | 6.323 | 6.770 | 10.004 |
| 3.50 | 0.356 | 1.715 | 2.051 | 5.530 | 5.410 | 7.109 |
| 4.00 | 0.276 | 1.162 | 1.463 | 4.985 | 4.505 | 5.335 |
| 4.50 | 0.222 | 0.787 | 1.102 | 4.588 | 3.860 | 4.154 |
| 5.00 | 0.187 | 0.556 | 0.866 | 4.286 | 3.380 | 3.333 |
| 5.50 | 0.161 | 0.420 | 0.714 | 4.044 | 3.006 | 2.735 |
| 6.00 | 0.140 | 0.333 | 0.602 | 3.844 | 2.705 | 2.286 |
| 6.50 | 0.123 | 0.272 | 0.515 | 3.671 | 2.456 | 1.940 |

**Table 110 Non Standard Inverse Curves TCC163 - TCC202 Timing Table (Continued)**

| | TCC163 | TCC164 | TCC165 | TCC200 | TCC201 | TCC202 |
|---|---|---|---|---|---|---|
| 7.00 | 0.109 | 0.228 | 0.450 | 3.533 | 2.254 | 1.667 |
| 7.50 | 0.097 | 0.197 | 0.397 | 3.409 | 2.081 | 1.448 |
| 8.00 | 0.087 | 0.174 | 0.352 | 3.300 | 1.931 | 1.270 |
| 8.50 | 0.078 | 0.155 | 0.317 | 3.206 | 1.804 | 1.123 |
| 9.00 | 0.070 | 0.140 | 0.287 | 3.119 | 1.690 | 1.000 |
| 9.50 | 0.064 | 0.127 | 0.262 | 3.044 | 1.591 | 0.897 |
| 10.00 | 0.058 | 0.116 | 0.240 | 2.974 | 1.502 | 0.808 |
| 10.50 | 0.054 | 0.106 | 0.221 | 2.910 | 1.422 | 0.732 |
| 11.00 | 0.049 | 0.098 | 0.205 | 2.854 | 1.353 | 0.667 |
| 11.50 | 0.046 | 0.090 | 0.190 | 2.797 | 1.286 | 0.610 |
| 12.00 | 0.042 | 0.085 | 0.178 | 2.751 | 1.229 | 0.560 |
| 12.50 | 0.040 | 0.080 | 0.166 | 2.705 | 1.176 | 0.516 |
| 13.00 | 0.037 | 0.075 | 0.156 | 2.660 | 1.125 | 0.476 |
| 13.50 | 0.035 | 0.071 | 0.145 | 2.623 | 1.082 | 0.441 |
| 14.00 | 0.033 | 0.068 | 0.135 | 2.586 | 1.040 | 0.410 |
| 14.50 | 0.031 | 0.065 | 0.126 | 2.549 | 1.001 | 0.382 |
| 15.00 | 0.030 | 0.062 | 0.117 | 2.518 | 0.966 | 0.357 |
| 15.50 | 0.028 | 0.059 | 0.110 | 2.488 | 0.933 | 0.335 |
| 16.00 | 0.027 | 0.057 | 0.103 | 2.458 | 0.901 | 0.314 |
| 16.50 | 0.026 | 0.055 | 0.096 | 2.429 | 0.871 | 0.295 |
| 17.00 | 0.025 | 0.053 | 0.091 | 2.404 | 0.845 | 0.278 |
| 17.50 | 0.023 | 0.051 | 0.086 | 2.380 | 0.820 | 0.262 |
| 18.00 | 0.022 | 0.049 | 0.081 | 2.355 | 0.795 | 0.248 |
| 18.50 | 0.022 | 0.048 | 0.077 | 2.330 | 0.772 | 0.234 |
| 19.00 | 0.021 | 0.047 | 0.072 | 2.310 | 0.751 | 0.222 |
| 19.50 | 0.020 | 0.045 | 0.069 | 2.290 | 0.731 | 0.211 |
| 20.00 | 0.019 | 0.044 | 0.065 | 2.270 | 0.712 | 0.200 |
| 20.50 | 0.019 | 0.043 | 0.062 | 2.249 | 0.693 | 0.191 |
| 21.00 | 0.018 | 0.042 | 0.059 | 2.231 | 0.676 | 0.182 |
| 21.50 | 0.018 | 0.040 | 0.057 | 2.214 | 0.660 | 0.173 |
| 22.00 | 0.018 | 0.039 | 0.055 | 2.198 | 0.644 | 0.166 |
| 22.50 | 0.017 | 0.038 | 0.053 | 2.181 | 0.629 | 0.159 |
| 23.00 | 0.017 | 0.037 | 0.051 | 2.164 | 0.614 | 0.152 |
| 23.50 | 0.017 | 0.036 | 0.049 | 2.149 | 0.601 | 0.145 |
| 24.00 | 0.017 | 0.036 | 0.047 | 2.135 | 0.588 | 0.139 |
| 24.50 | 0.016 | 0.035 | 0.046 | 2.122 | 0.576 | 0.134 |
| 25.00 | 0.016 | 0.034 | 0.044 | 2.108 | 0.564 | 0.129 |
| 25.50 | 0.016 | 0.033 | 0.043 | 2.094 | 0.552 | 0.124 |
| 26.00 | 0.016 | 0.033 | 0.042 | 2.080 | 0.541 | 0.119 |
| 26.50 | 0.015 | 0.032 | 0.041 | 2.068 | 0.530 | 0.114 |
| 27.00 | 0.015 | 0.031 | 0.040 | 2.056 | 0.520 | 0.110 |
| 27.50 | 0.015 | 0.031 | 0.040 | 2.045 | 0.510 | 0.106 |
| 28.00 | 0.014 | 0.030 | 0.039 | 2.034 | 0.501 | 0.103 |
| 28.50 | 0.014 | 0.030 | 0.039 | 2.022 | 0.492 | 0.099 |
| 29.00 | 0.014 | 0.029 | 0.038 | 2.011 | 0.482 | 0.096 |

**Table 110 Non Standard Inverse Curves TCC163 - TCC202 Timing Table (Continued)**

| | TCC163 | TCC164 | TCC165 | TCC200 | TCC201 | TCC202 |
|---|---|---|---|---|---|---|
| 29.50 | 0.014 | 0.029 | 0.038 | 2.001 | 0.475 | 0.093 |
| 30.00 | 0.014 | 0.029 | 0.038 | 2.001 | 0.475 | 0.093 |

# Appendix G Reset Curve Timing Tables

Reset times (T) for IEEE Reset Curves can be calculated using the following formula.

***IEEE Moderately Inverse***

T= 4.85* Time Multiplier / (M² - 1)

***IEEE Very Inverse***

T= 21.6* Time Multiplier / (M² - 1)

***IEEE Extremely Inverse***

T= 29.1* Time Multiplier / (M² - 1)

If the Reset Curve starting point is set to Reset Threshold,

M = (Measured Current) / (Reset Threshold x Pickup Current).

If the Reset Curve starting point is set to Pickup,

M = (Measured Current) / (Pickup Current).

Tables listing the reset times in seconds for IEEE Reset Curves are given below.

**Table 111 IEEE Reset Curves Timing Table**

| % of Setting Current | IEEE Inverse | IEEE Very Inverse | IEEE Extremely Inverse |
|---|---|---|---|
| 0% | 4.85 | 21.60 | 29.10 |
| 5% | 4.86 | 21.65 | 29.17 |
| 10% | 4.90 | 21.82 | 29.39 |
| 15% | 4.96 | 22.10 | 29.77 |
| 20% | 5.05 | 22.50 | 30.31 |
| 25% | 5.17 | 23.04 | 31.04 |
| 30% | 5.33 | 23.74 | 31.98 |
| 35% | 5.53 | 24.62 | 33.16 |
| 40% | 5.77 | 25.71 | 34.64 |
| 45% | 6.08 | 27.08 | 36.49 |
| 50& | 6.47 | 28.80 | 38.80 |
| 55% | 6.95 | 30.97 | 41.72 |
| 60% | 7.58 | 33.75 | 45.47 |
| 65% | 8.40 | 37.40 | 50.39 |
| 70% | 9.51 | 42.35 | 57.06 |
| 75% | 11.09 | 49.37 | 66.51 |
| 80% | 13.47 | 60.00 | 80.83 |
| 85% | 17.48 | 77.84 | 104.86 |
| 90% | 25.53 | 113.68 | 153.16 |
| 95% | 49.74 | 221.54 | 298.46 |
| 99% | 243.72 | 1085.43 | 1462.31 |

Reset times (I) for IEC 255 Reset Curves can be calculated using the following formula.

***IEC 255 Inverse***

T= 13.5* Time Multiplier / (M² - 1)

***IEC 255 Very Inverse***

T= 47.3* Time Multiplier / (M² - 1)

***IEC 255 Extremely Inverse***

T= 80* Time Multiplier / (M² - 1)

If the Reset Curve starting point is set to Reset Threshold,

M = (Measured Current) / (Reset Threshold x Pickup Current).

If the Reset Curve starting point is set to Pickup,

M = (Measured Current)/(Pickup Current)

Tables listing the reset times in seconds for IEC 255 Reset Curves are given below.

**Table 112 IEC 255 Reset Curves Timing Table**

| % of Setting Current | IEC 255 Inverse | IEC 255 Very Inverse | IEC 255 Extremely Inverse |
|---|---|---|---|
| 0% | 13.50 | 47.30 | 80.00 |
| 5% | 13.53 | 47.42 | 80.20 |
| 10% | 13.64 | 47.78 | 80.81 |
| 15% | 13.81 | 48.39 | 81.84 |
| 20% | 14.06 | 49.27 | 83.33 |
| 25% | 14.40 | 50.45 | 85.33 |
| 30% | 14.84 | 51.98 | 87.91 |
| 35% | 15.38 | 53.90 | 91.17 |
| 40% | 16.07 | 56.31 | 95.24 |
| 45% | 16.93 | 59.31 | 100.31 |
| 50& | 18.00 | 63.07 | 106.67 |
| 55% | 19.35 | 67.81 | 114.70 |
| 60% | 21.09 | 73.91 | 125.00 |
| 65% | 23.38 | 81.90 | 138.53 |
| 70% | 26.47 | 92.75 | 156.86 |
| 75% | 30.86 | 108.11 | 182.86 |
| 80% | 37.50 | 131.39 | 222.22 |
| 85% | 48.65 | 170.45 | 288.29 |
| 90% | 71.05 | 248.95 | 421.05 |
| 95% | 138.46 | 485.13 | 820.51 |
| 99% | 678.39 | 2376.88 | 4020.10 |

# Appendix H Communications Settings

## PowerLogic ADVC

### Modem Port Settings

**Table 113 PowerLogic ADVC Modem Communications Port Settings**

| Setting | Description |
|---|---|
| ENABLED IN USE | **Port Operation**<br>This setting indicates whether the port is ENABLED or ENABLED and IN USE by an application within the PowerLogic ADVC.<br>Range: ENABLED, IN USE<br>(Display only setting) |
| Driver | **Communication Driver**<br>Communication driver attached to port e.g. modem driver<br>Range: Hayes, RDI, SOS Multi, NONE<br>Factory default is NONE |
| Mode | **Mode State**<br>LOCAL/Remote mode of communication assigned to this port. Range: LOCAL, Remote<br>A port used by SCADA protocols must use Remote, WSOS or IOEX must be set to LOCAL or Remote depending upon requirements.<br>Refer to Local, Remote, Hit, and Run/Delayed Operation for more information about Remote/LOCAL modes.<br>Factory default is REMOTE |
| Baud | **Communications Baud Rate**<br>Range: 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600 or 115200 baud.<br>Factory default is 115200 Baud |
| Parity | **Parity**<br>Parity of the communications port<br>Range: NONE, EVEN, ODD<br>Factory default is NONE |
| Stop bits | **Number of Stop Bits**<br>Number of stop bits appended to transmitted byte Range: 1, 2<br>Factory default is 1 |
| RTS | **RTS Support**<br>When ENABLED, RTS is asserted for Pre-Tx period of time prior to transmission of data as well as Post-Tx period of time after transmission.<br>Pre and post transmission RTS is required on most radio modems.<br>Range: DISABLED, ENABLED<br>Factory default is ENABLED |
| CTS | **CTS Support**<br>If the modem does not support a Clear To Send (CTS) signal and/or the cabling has no CTS wiring, this setting must be set to CTS Ignore.<br>When set to CTS Ignore, the protocol asserts RTS as normal but does not check for a returned CTS input signal. If the modem supports a Clear To Send (CTS) signal, setting CTS Don't Ignore, allows data to be transmitted only when CTS is asserted.<br>Range: Ignore, Don't Ignore |

**Table 113 PowerLogic ADVC Modem Communications Port Settings (Continued)**

| Setting | Description |
|---|---|
| | Factory default is Ignore |
| DTR | **DTR Support**<br>When set to ENABLED, DTR is asserted whenever the port is in use.<br>Range: DISABLED, ENABLED<br>Factory default is ENABLED |
| Pre-Tx | **Pre-Transmission Period**<br>If RTS support is ENABLED, Pre-Tx is the time delay between asserting RTS and when the message starts.<br>Range: 0 to 3000 ms.<br>Factory default is 250 ms |
| Post-Tx | **Post-Transmission Period**<br>If RTS support is ENABLED, Post-Tx is the time after the last character is sent before RTS is negated.<br>Range: 0 to 3000 ms.<br>Factory default is 35 ms |
| DCD | **DCD Usage**<br>If the modem does not support a Data Carrier Detect (DCD) signal this setting must be set to DCD Ignore. Even if the modem does support a DCD signal this setting is usually set to DCD Ignore. This is because most point-point systems using conventional modems run as full duplex so that the DCD is always asserted during normal operation.<br>When set to DCD Ignore, the protocol uses any received data to build an incoming packet irrespective of DCD input signal. Also the protocol will transmit irrespective of the DCD input signal.<br>If the modem supports a Data Carrier Detect (DCD) signal this setting can be set to DCD Don't Ignore. When set to this mode, the protocol will only read data and build an incoming protocol packet when DCD is asserted. In addition, the protocol will not transmit when DCD is asserted. This is necessary for multi-dropped systems or ones shared with voice users or some radio-modems.<br>Range: DCD Ignore, DCD Don't Ignore<br>Factory default is DCD Ignore |
| CA Delay | **Collision Avoidance Delay**<br>On a multi-drop communications link this setting can be used to provide priority access.<br>If the controller prepares to transmit and finds the link busy (DCD asserted), it waits until it is no longer busy, then waits a back off time as follows:<br>Back off time = CA Delay + (random delay with range 0.0 to CA Delay) After the back off time the device tries again.<br>If still unsuccessful then the controller will continue in an indefinite loop until successful. If the DCD usage is configured to DCD Ignore, the CA Delay time is disabled.<br>Range: 0 to 180000 ms<br>Factory default is 1000 ms |
| Preamble | **Preamble Usage**<br>Determines whether the port transmits some preamble characters prior to transmitting a message. The message itself is not otherwise modified. Some modems require these characters to assist with message reception and synchronization at the master station. Start of frame filtering at the master station helps to ensure identification of the transmitted message.<br>ENABLED means that the preamble characters are transmitted prior to a message transmission. |

**Table 113 PowerLogic ADVC Modem Communications Port Settings (Continued)**

| Setting | Description |
|---|---|
| | DISABLED means that the message is transmitted without any preamble characters.<br>Range: ENABLED, DISABLED<br>Factory default is DISABLED |
| First Char | **Preamble First Character**<br>This is the first character to be transmitted as a preamble. The character is specified by entering its ASCII code in hexadecimal format.<br>Range: is 0 to FF hexadecimal.<br>Factory default is 0x55 |
| Repeat First | **Number of Preamble First Characters**<br>This is the number of times the first character will be repeated as part of the preamble.<br>For example, if all preamble settings are at default values then the preamble sent is 0x55, 0x55, 0x55, 0xFF<br>Range: 0 to 20.<br>Factory default is 3 |
| Last Char | **Last Preamble Character**<br>This is the last char that will be sent as part of the preamble. The character is specified by entering its ASCII code in hexadecimal format.<br>Range: is 0 to FF hexadecimal.<br>Factory default is 0xFF |

## IOEX/WSOS Port Settings

**Table 114 PowerLogic ADVC IOEX/WSOS Communications Port Settings**

| Setting | Description |
|---|---|
| ENABLED IN USE | **Port Operation**<br>This setting indicates whether the port is ENABLED or ENABLED and IN USE by an application within the PowerLogic ADVC.<br>Range: ENABLED, IN USE<br>(Display only setting) |
| Driver | **Communication Driver**<br>Communication driver attached to port e.g. modem driver<br>Range: Hayes, RDI, SOS Multi, NONE<br>Factory default is NONE |
| Mode | **Mode State**<br>LOCAL/Remote mode of communication assigned to this port.<br>Range: LOCAL, Remote<br>A port used by SCADA protocols must use Remote, WSOS or IOEX must be set to LOCAL or Remote depending upon requirements.<br>Refer to Local, Remote, Hit, and Run/Delayed Operation for more information about Remote/LOCAL modes.<br>Factory default is REMOTE |
| Baud | **Communications Baud Rate** |

**Table 114 PowerLogic ADVC IOEX/WSOS Communications Port Settings (Continued)**

| Setting | Description |
|---|---|
| | Range: 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600 or 115200 baud.<br>Factory default is 57600 Baud |
| Parity | **Parity**<br>Parity of the communications port<br>Range: NONE, EVEN, ODD<br>Factory default is NONE |
| Stop bits | **Number of Stop Bits**<br>Number of stop bits appended to transmitted byte<br>Range: 1, 2<br>Factory default is 1 |
| Preamble | **Preamble Usage**<br>Determines whether the port transmits some preamble characters prior to transmitting a message. The message itself is not otherwise modified. Some modems require these characters to assist with message reception and synchronization at the master station. Start of frame filtering at the master station helps to ensure identification of the transmitted message.<br>ENABLED means that the preamble characters are transmitted prior to a message transmission.<br>DISABLED means that the message is transmitted without any preamble characters.<br>Range: ENABLED, DISABLED<br>Factory default is DISABLED |
| First Char | **Preamble First Character**<br>This is the first character to be transmitted as a preamble. The character is specified by entering its ASCII code in hexadecimal format.<br>Range: is 0 to FF hexadecimal.<br>Factory default is 0x55 |
| Repeat First | **Number of Preamble First Characters**<br>This is the number of times the first character will be repeated as part of the preamble.<br>For example, if all preamble settings are at default values then the preamble sent is 0x55, 0x55, 0x55, 0xFF<br>Range: 0 to 20.<br>Factory default is 3 |
| Last Char | **Last Preamble Character**<br>This is the last char that will be sent as part of the preamble. The character is specified by entering its ASCII code in hexadecimal format.<br>Range: is 0 to FF hexadecimal.<br>Factory default is 0xFF |

# USB 1, 2, 3 Port Settings

### Table 115 PowerLogic ADVC USB 1, 2, 3 Port Type Settings

| Setting | Description |
|---|---|
| Type | **Type of Port**<br>USB ports 1, 2, 3 can be used with USB/RS232 and USB/RS485 converters. They can also be used with a USB storage device.<br>This setting determines the function for which this USB port will be used. The options are:<br>• Not Used<br>• Storage<br>• RS-232<br>• RS-485<br>Factory default is *Not Used* |

### USB 1, 2, 3 Storage Device Settings

### Table 116 PowerLogic ADVC USB 1, 2, 3 Storage Device Settings

| Setting | Description |
|---|---|
| History | History Files<br>This setting determines which historical files will be written to the storage device.<br>The options are:<br>• Event Log<br>• Daily Maximum Demand<br>• Weekly Maximum Demand<br>• Monthly Maximum Demand<br>• Configured History<br>• Harmonic History<br>• Sag/Swell<br>None of the above options are selected by default |
| Quality | Power Quality Captures<br>This setting determines which power quality capture files will be written to the storage device.<br>Waveform Capture is the only option and is not selected by default |

### USB 1, 2, 3 RS-232 Settings

**Table 117 PowerLogic ADVC USB 1, 2, 3 RS-232 Communications Settings**

| Setting | Description |
|---|---|
| ENABLED IN USE | **Port Operation**<br>This setting indicates whether the port is ENABLED or ENABLED and IN USE by an application within the PowerLogic ADVC.<br>Range: ENABLED, IN USE<br>(Display only setting) |
| Driver | **Communication Driver**<br>Communication driver attached to port e.g. modem driver.<br>Range: Hayes, RDI, SOS Multi, NONE<br>Factory default is NONE |
| Mode | **Mode State**<br>LOCAL/Remote mode of communication assigned to this port.<br>Range: LOCAL, Remote<br>A port used by SCADA protocols must use Remote, WSOS or IOEX must be set to LOCAL or Remote depending upon requirements.<br>Refer to Local, Remote, Hit and Run/Delayed Operation for more information about Remote/LOCAL modes.<br>Factory default is REMOTE |
| Baud | **Communications Baud Rate**<br>Range: 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600 or 115200 baud.<br>Factory default is 115200 Baud |
| Parity | **Parity**<br>Parity of the communications port.<br>Range: NONE, EVEN, ODD<br>Factory default is NONE |
| Stop bits | **Number of Stop Bits**<br>Number of stop bits appended to transmitted byte.<br>Range: 1, 2<br>Factory default is 1 |
| Preamble | **Preamble Usage**<br>Determines whether the port transmits some preamble characters prior to transmitting a message. The message itself is not otherwise modified. Some modems require these characters to assist with message reception and synchronisation at the master station. Start of frame filtering at the master station helps to ensure identification of the transmitted message.<br>ENABLED means that the preamble characters are transmitted prior to a message transmission.<br>DISABLED means that the message is transmitted without any preamble characters.<br>Range: ENABLED, DISABLED<br>Factory default is DISABLED |
| First Char | **Preamble First Character**<br>This is the first character to be transmitted as a preamble. The character is specified by entering its ASCII code in hexadecimal format.<br>Range: is 0 to FF hexadecimal. |

### Table 117 PowerLogic ADVC USB 1, 2, 3 RS-232 Communications Settings (Continued)

| Setting | Description |
|---|---|
| | Factory default is 0x55 |
| Repeat First | **Number of Preamble First Characters**<br>This is the number of times the first character will be repeated as part of the preamble.<br>For example, if all preamble settings are at default values then the preamble sent is 0x55, 0x55, 0x55, 0xFF.<br>Range: 0 to 20.<br>Factory default is 3 |
| Last Char | **Last Preamble Character**<br>This is the last char that will be sent as part of the preamble. The character is specified by entering its ASCII code in hexadecimal format.<br>Range: is 0 to FF hexadecimal.<br>Factory default is 0xFF |

## USB 1, 2, 3 RS-485 Settings

### Table 118 PowerLogic ADVC USB 1, 2, 3 RS-485 Communications Settings

| Setting | Description |
|---|---|
| ENABLED IN USE | **Port Operation**<br>This setting indicates whether the port is ENABLED or ENABLED and IN USE by an application with in the controller.<br>Range: ENABLED, IN USE<br>(Display only setting) |
| Baud | **Communications Baud Rate**<br>Range: 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, or 115200 baud.<br>Factory default is 115200 Baud |
| Parity | **Communication Parity**<br>Determines the parity of the communication port.<br>Range: NONE, EVEN, ODD<br>Factory default is NONE |
| Mode | **Mode State**<br>LOCAL/Remote mode of communication assigned to this port.<br>Range: LOCAL/Remote<br>A port used by SCADA protocols must use Remote. WSOS5 & IOEX must be set to LOCAL or Remote depending upon requirements.<br>Refer to Local, Remote, Hit and Run/Delayed Operation for more information about LOCAL/Remote modes.<br>Factory default is Remote |
| Driver | **Communication Driver**<br>Communication driver attached to port e.g. modem driver.<br>Range: Hayes, RDI, SOS Multi, NONE<br>Factory default is NONE |

# LAN-1, LAN-2 Port Settings

**Table 119 PowerLogic ADVC LAN-1 and LAN-2 Communications Port settings**

| Setting[1] | Description |
|---|---|
| ENABLED | **Port Operation**<br>Not configurable for 100Base-T<br>Range: ENABLED, IN USE |
| Remote | **LOCAL/Remote Status**<br>Not configurable for 100Base-T<br>Factory default is Remote |
| IP[2] | **Internet Protocol Address**<br>IP address of controller<br>Range: 0.0.0.0 to 255.255.255.255<br>Factory defaults: LAN-1: 10.176.1.2; LAN-2: 10.1.1.2 |
| Sub[3] | Subnet mask<br>Subnet mask is used when controller is not in DHCP mode.<br>Range: 0.0.0.0 to 255.255.255.255<br>Factory default is 255.255.0.0 |
| DHCP[3],[4] | DHCP Support<br>If ENABLED then IP address of controller is automatically determined from a DHCP server.<br>If DISABLED then IP address is determined via configuration of IP and Subnet mask settings.<br>Range: ENABLED, DISABLED<br>Factory default is DISABLED |
| [1] All of these settings are read only.<br>[2] If the IP address and Subnet mask settings are blank then the controller has failed to establish a connection with the DHCP server and therefore has no IP address nor subnet mask. The test for DHCP server is only done on power up. To retry the communications, check the 10Base-T connection and cycle the power to the controller.<br>[3] WSOS is required for configuration of 10Base-T settings. If DHCP mode is changed then WSOS prompts the operator that a controller reset is required.<br>[4] If the IP address and Subnet mask settings are blank then the controller has failed to establish a connection with the DHCP server and therefore has no IP address nor subnet mask. The test for DHCP server is only done on power up. To retry the communication, check the 10base-T connection and cycle the power to the controller. | |

# SOS Multi-Drop Support Settings

**Table 120 PowerLogic ADVC SOS Multi-drop Driver Support settings**

| Setting | Description |
|---|---|
| SOS Multi Available | **SOS Multi-drop Driver Availability**<br>This enables the use of the SOS Multi-drop driver.<br>Factory default is *Not Available*. |
| Address | **PowerLogic ADVC Controller Address**<br>Address of the PowerLogic ADVC.<br>This is used by every driver instance.<br>Range: 1 to 2147483647 Factory default is 1 |

**Table 120 PowerLogic ADVC SOS Multi-drop Driver Support settings (Continued)**

| Setting | Description |
|---|---|
| Max Frag Size | **Maximum Data Fragment Size**<br>Maximum data fragment size not including any header, address, or CRC bytes.<br>This is useful when very long messages are unlikely to succeed e.g. V23, Radio. It makes the driver fragment the long message to increase the chance of successful transmission.<br>Range: 10 to 1982 bytes.<br>Factory default is 1982 bytes |
| Fragment Timeout | **Fragment Retry Timeout**<br>Maximum time to wait for a confirm message from WSOS.<br>Do not set lower than the worst-case delay for transmission and reply time.<br>Range: 1 to 999 s.<br>Factory default is 10 s |
| Frag Retries | **Maximum Fragment Retry Count**<br>Maximum count for fragment retries per message to WSOS.<br>Range: 1 to 100<br>Factory default is 10 |
| Char Timeout | **Inter character Timeout Delay**<br>If no character is received within this time, an attempt is made to decode the packet.<br>Range: 20 to 999 ms.<br>Factory default is 20 ms |
| Tx Count | **Transmission Count**<br>The total number of packets transmitted by the PowerLogic ADVC, including retries of unacknowledged packets.<br>Read only |
| Rx Count | **Receive Count**<br>The total number of packets transmitted by the PowerLogic ADVC, including retries of unacknowledged packets.<br>Read only |
| Rx CRC Err | **Receive CRC Error**<br>The number of packets received by the PowerLogic ADVC that fail the CRC test.<br>Read only |
| Rx Length Err | **Receive Length Error**<br>The number of packets received by the PowerLogic ADVC that do not have the required amount of characters. Usually the result of an inter character time out.<br>Read only |

# Appendix I List of Events

## Event List

Each event falls into one or more categories as shown in the Category column of the main table below. The categories are described as follows:

**Table 121 Event Categories and Abbreviations**

| Category | Abbreviation | Description |
|---|---|---|
| Protection | PRTN | A general grouping of all protection related events. |
| Controller | CTRL | A general grouping of all controller hardware related events. |
| Switchgear | SWGR | All messages from Switchgear. |
| Network | NWRK | A general grouping of all electrical system events. |
| Power Quality | PQ | All quality of supply messages. |
| Windows Switchgear Operating System | WSOS | All setting changes with source WSOS5 are shown. |
| Operator Interface | O.I. | All setting changes with source O.I. are shown. |
| Protocol | PTCL | All setting changes and system status messages that are SCADA protocol related are shown. |
| Input/Output Expander 2 | IOEX | All setting changes and system status messages that are IOEX2 related are shown. |
| Settings | - | All setting changes with source WSOS, Panel, Protocol or IOEX are shown. |

**Table 122 List of Events**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| - blank - | Quick Key function or Waveform Capture Trigger Setting. See Waveform Capture, page 501. | C N E RL U UR V | CTRL PQ |
| ## Contact < 20% | Amount of Contact Life remaining is low. Less than 20%. | N E RLM2 U UR | SWGR |
| ## Dead | A terminal changed from live to dead. | C N E RL U UR V | NWRK |
| ## Live | A terminal changed from dead to live. | C N E RL U UR V | NWRK |
| ### Voltage High | The Voltage on this phase has exceeded the Normal Voltage High threshold. | N U UR E RL V C | PRTN |
| ### Voltage Low | The Voltage on this phase has gone below the Normal Voltage Low threshold. | N U UR E RL V C | PRTN |
| ### Voltage Normal | The Voltage on this phase has returned to the normal range. | N U UR E RL V C | PRTN |
| 101/4 Available/Not Available | IEC 60870-5-101/4 protocol available/not available. Please refer to manufacturer's technical manual for PowerLogic ADVC. Part No. PowerLogic ADVC01-DOC-246. | N U UR E RL V C | PTCL |
| 12 Ah Battery | Battery capacity was configured as 12 Amp Hour. | N U UR E RL V C | CTRL |
| 12 V Rail Failure | 12 V supply rail failed. | C N RL U UR V | CTRL SWGR |
| A Max #### pu | Phase A Maximum Voltage NN per unit | N U UR E RL V C | PRTN |
| A Min #### pu | Phase A Minimum Voltage NN per unit | N U UR E RL V C | PRTN |
| A/B/C ### Amp | The phase and current of the maximum demand. See Maximum demand Records, page 487. | N U UR E RL V C | PRTN |
| A/B/C dd/mm/yy hh:mm:ss | The time and phase of the maximum demand. See Maximum demand Records, page 487. | N U UR E RL V C | PRTN |
| A/B/C Max NN Amp | Following pickup of the overcurrent protection element on A, B or C phase, the maximum fault current recorded was NN Amps. This event was logged only after the current fell back below the phase setting current.<br><br>See Fault Reset Operation, page 163. | N U UR E RL V C | PRTN |

**Table 122 List of Events (Continued)**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| A/B/C Phase LOST | Loss of supply occurred on this phase. | N U UR E V C | PRTN |
| A/B/C/E/NPS ## Amp | Current measured at time of trip. See Typical Event Log Trip Sequence Display, page 482. | N U UR E RL V C | PRTN |
| ABC Max #### pu | Average Phase ABC Maximum Voltage NN per unit | N U UR E RL V C | PRTN |
| ABC Min #### pu | Average Phase ABC Minimum Voltage NN per unit | N U UR E RL V C | PRTN |
| ACK2 ON/OFF | On/Off for Radio Data Interface (RDI) acknowledgement at remote radio. | N U UR E RL V C | PTCL |
| ACR Function | Switchgear is setup to function as an ACR | N U UR E RL V C | CTRL |
| Additional #######s | Additional time to trip in seconds. Added to the associated protection curve. | N U UR E RL V C | PRTN |
| Addr Mode Extended | MITS protocol addressing mode is extended. Valid address range is 1 to 32767. | N U UR E RL V C | PTCL |
| Addr Mode Normal | MITS protocol addressing mode is normal. Valid address range is 1 to 126. | N U UR E RL V C | PTCL |
| Address ########## | SOS Multi-drop address of the PowerLogic was set. Valid range 1 to 2147483647. | N U UR E RL V C | PTCL |
| Advc load Reset | WSOS's PowerLogic Loader reset the controller. | N U UR E RL V C | CTRL |
| After ## sequences | Excess Voltage Trip/Close sequences will occur after this number of sequences. | N U UR E V C | PRTN |
| After #### O/F cyc | An over frequency protection trip would occur after this number of frequency cycles. See Under and Over Frequency (UOF) Protection, page 295. | N U UR E RL V C | PRTN |
| After #### U/F cyc | An under frequency protection trip would occur after this number of frequency cycles. See Under and Over Frequency (UOF) Protection, page 295. | N U UR E RL V C | PRTN |
| All Paused | All picked up protection elements were paused. See Fault Reset Operation, page 163. | N U UR E RL V C | PRTN |
| All Paused Fwd/Rev | All picked up protection elements in this direction had paused. See Directional Protection, page 249. | N U UR E RL V C | PRTN |
| All Resetting | All picked up protection elements were resetting. See Fault Reset Operation, page 163. | N U UR E RL V C | PRTN |
| All Resetting Fwd/Rev | All picked up protection elements in this direction were resetting. See Directional Protection, page 249. | N U UR E RL V C | PRTN |
| Analog Flag ON/OFF | For DNP3, determines whether or not a byte containing the status of the analog was included with the reported value. Please refer to the manufacturer's DNP3 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-146. | N U UR E RL V C | PTCL |
| Analog Size 16/32 bit | For DNP3, determines the size of the default analog objects. Please refer to the manufacturer's DNP3 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-146. | N U UR E RL V C | PTCL |
| Analog Time ON/OFF | For DNP3, determines whether or not a time tag was included with analog change of state events. Please refer to the manufacturer's DNP3 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-146. | N U UR E RL V C | PTCL |
| APGS Change ###s | Automatic protection group selection change time. See Automatic Protection Group Selection, page 201. | N U UR E RL V C | PRTN |
| APGS Not/Available | Automatic protection group selection feature not available or available. See Automatic Protection Group Selection, page 201. | N U UR E RL V C | PRTN |
| APGS ON/OFF | Automatic protection group selection ON or OFF. See Automatic Protection Group Selection, page 201. | N U UR E RL V C | PRTN |
| Apl Cf TO #######ms | For DNP3, determines the application confirm timeout. Please refer to the manufacturer's DNP3 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-146. | N U UR E RL V C | PTCL |
| Apl Frag Size #### | For DNP3, determines the maximum size of the application layer fragment that can be sent at any one time. Please refer to the manufacturer's DNP3 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-146. | N U UR E RL V C | PTCL |

**Table 122 List of Events (Continued)**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| App. Ver ######### | Controller firmware version number. See Firmware Identification System, page 18. | N U UR E RL V C | CTRL |
| Attempt Delay #####s | RS232 port's Hayes modem driver delay before next connection attempt. See Hayes compatible modem support, page 139. | N U UR E RL V C | PTCL |
| Auto Close | Waveform Capture Trigger On Auto Close. See Waveform Capture, page 501. | N U UR E RL V C | PQ |
| Auto Close OFF | Waveform Capture Trigger On Auto Close turned off. See Waveform Capture, page 501. | N U UR E RL V C | PQ |
| Auto ON/OFF | Automatic Reclose ON/OFF selected for a Quick Key. See Configuring the Quick Keys, page 47. | N U UR E RL V C | CTRL |
| Auto Reclose OFF | Auto Reclose was turned OFF by a local or remote operator. See Automatic Reclose, page 161. | N U UR E RL V C | PRTN |
| Auto Reclose ON | Auto Reclose was turned ON by a local or remote operator. See Automatic Reclose, page 161. | N U UR E RL V C | PRTN |
| Auto Restore ####s | Directional protection automatic restore time. See Directional Protection, page 249. | N U UR E RL V C | PRTN |
| Auto Test ## | Automatic battery test frequency. See Battery Test Configuration, page 521. | N U UR E RL V C | CTRL |
| Automatic Reclose | The circuit breaker was automatically re-closed following a protection trip. See Automatic Reclose, page 161. | N U UR E RL V C | PRTN |
| AutoRes. Not Avail | For loop automation, automatic restore feature not made an available option. See Description of Parameters, page 461. | N U UR E RL V C | PRTN |
| AutoRestore Avail | For loop automation, automatic restore feature made an available option. See Description of Parameters, page 461. | N U UR E RL V C | PRTN |
| AutoRestore ON/OFF | For loop automation or directional protection, automatic restoration of supply was ON or OFF. See Description of Parameters, page 461. | N U UR E RL V C | PRTN |
| Aux Fail | Battery Test Aborted because of Auxiliary Supply Fail | N U UR E RL V C | CTRL |
| Aux Supply Fail | The auxiliary power supply failed. See PSM - Options, page 25. | N U UR E RL V C | CTRL |
| Aux Supply Normal | The auxiliary power supply became normal. See PSM - Options, page 25. | N U UR E RL V C | CTRL |
| Aux Supply Overvolt | The auxiliary power supply exceeded its threshold voltage. See PSM - Options, page 25. | N U UR E RL V C | CTRL |
| B Max #### pu | Phase B Maximum Voltage NN per unit | N U UR E RL V C | PRTN |
| B Min #### pu | Phase B Minimum Voltage NN per unit | N U UR E RL V C | PRTN |
| Batt Test Not/Avail | Battery test feature not available or available. See Battery Test Configuration, page 521. | N U UR E RL V C | CTRL |
| Battery High | The battery voltage was too high. This could only occur if there was a battery charger hardware failure. If this event occurs the equipment may require maintenance. Contact the Manufacturer or Distributor for advice. See *18 Battery Testing (page 18-1)*. | N U UR E RL V C | CTRL |
| Battery Low | The battery voltage was below the low battery voltage setting. This can also be a reason for an operation denied. See Battery Test Configuration, page 521. | N U UR E RL V C | CTRL SWGR |
| Battery NA | Batt Test Aborted because of Batt N/A | N U UR E RL V C | CTRL |
| Battery Normal | The battery was in the normal range. See Battery Test Configuration, page 521. | N U UR E RL V C | CTRL |
| Battery OFF | The battery was not connected or not detected. See Battery Test Configuration, page 521. | N U UR E RL V C | CTRL |
| Battery Unavailable | Ignore. Invalid state. | N U UR E RL V C | CTRL SWGR |
| Baud ##### | Port baud rate changed. See Communications Port Configuration, page 105. | N U UR E RL V C | PTCL |
| Beg #####V | First (beginning) battery voltage measured during the most recent battery test. | N U UR E RL V C | CTRL SYS |

**Table 122 List of Events (Continued)**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| Binary Output ON/OFF | For DNP3, determines whether binary outputs are included in an integrity poll. Please refer to the manufacturer's DNP3 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-146. | N U UR E RL V C | PTCL |
| Binary Time ON/OFF | For DNP3, determines whether or not a time tag was included for change of state events. Please refer to the manufacturer's DNP3 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-146. | N U UR E RL V C | PTCL |
| C Max #### pu | Phase C Maximum Voltage NN per unit | N U UR E RL V C | PRTN |
| C Min #### pu | Phase C Minimum Voltage NN per unit | N U UR E RL V C | PRTN |
| C# Delay ####s | For DNP3, maximum class notification delay in seconds an event was held before an unsolicited response was triggered. Please refer to the manufacturer's DNP3 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-146. | N U UR E RL V C | PTCL |
| C# Max Count # | For DNP3, unsolicited response class notification maximum count that must have occurred before an unsolicited response message was triggered. Please refer to the manufacturer's DNP3 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-146. | N U UR E RL V C | PTCL |
| CA Delay #####ms | Port transmit collision avoidance delay. See Communications Port Configuration, page 105. | N U UR E RL V C | PTCL |
| Cap Charge status | Logged if a trip/close request was denied due to a capacitor inverter problem. Where status was the current status of the inverter, for example *Cap Charge Resting*. | N U UR E RL | CTRL SWGR |
| Cap Charging | Warning that the capacitor was charging. Unable to be used in an operation. | N U UR E RL | CTRL SWGR |
| Cap failure mode | Trip and/or close capacitors did not charge correctly. Where failure mode, was the cause of the failure. For example, *CAP Excess Closes*. | N U UR E RL | CTRL SWGR |
| Cap Resting | Warning that inverter was resting from capacitor charging. This can occur after an excessive number of operations. | N U UR E | CTRL |
| Capacity NOT/OK | The result of the battery test, whether or not the inferred capacity was satisfactory. | N U UR E RL V C | CTRL |
| Capacity Unknown | Battery test has not yet been performed so battery capacity is unknown. | N U UR E RL V C | CTRL |
| Capture Now ON/OFF | Waveform capture was set ON or OFF. See Waveform Capture, page 501. | N U UR E RL V C | PQ |
| CD DISABLED | Transmission on V23 not blocked when carrier was detected. See Communications Port Configuration, page 105. | N U UR E RL V C | PTCL |
| CD ENABLED | Transmission on V23 blocked when carrier was detected. See Communications Port Configuration, page 105. | N U UR E RL V C | PTCL |
| CD if input HIGH | When CD input was HIGH then the V23 carrier detect was asserted. See Communications Port Configuration, page 105. | N U UR E RL V C | PTCL |
| CD if input LOW | When CD input was LOW then the V23 carrier detect was asserted. See Communications Port Configuration, page 105. | N U UR E RL V C | PTCL |
| CFG Hist Time ## | Configurable history sample time. | N U UR E RL V C | CTRL |
| Char Angle #### Deg | Characteristic angle in degrees between voltage and current. See Directional Protection, page 249. | N U UR E RL V C | PRTN |
| Char Timeout ### ms | SOS Multi-drop inter character timeout in milliseconds. | N U UR E RL V C | PTCL |
| Close Block | Reason for a close operation being denied. | N U UR E RL V C | SWGR CTRL |
| Close Blocking OFF | Close blocking was disabled. The circuit breaker would now close when requested. See UOV Close Blocking, page 294 or UOF Close Blocking, page 294. | N U UR E RL V C | CTRL |
| Close Blocking ON | The circuit breaker was prevented from closing. See UOV Close Blocking, page 294 or UOF Close Blocking, page 294. | N U UR E RL V C | CTRL |
| Close Coil Connect | The close solenoid isolate switch on the Operator Interface was changed to Enable position. See Trip/Close Isolate, page 59. | N U UR E RL V C | SWGR |
| Close Coil Disconn | The Close solenoid isolate switch on the Operator Interface was changed to Isolate position. See Trip/Close Isolate, page 59. | N U UR E RL V C | CTRL SWGR |

**Table 122 List of Events (Continued)**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| Close Coil Failed | Close Coil supervision detected a fault. | N U UR E RL V C | SWGR |
| CLP Time ###min | User change to operational cold load time in minutes. See Cold Load Pickup (CLP), page 343. | N U UR E RL V C | PRTN |
| Cold Load | Quick Key configured for Cold Load option. | N U UR E RL V C | CTRL |
| Cold Load Mult x### | User cold load multiplier value. See Cold Load Pickup (CLP), page 343. | N U UR E RL V C | PRTN |
| Cold Load ON/OFF | Cold load pickup was enabled or disabled. See Cold Load Pickup (CLP), page 343. | N U UR E RL V C | PRTN |
| Cold Load Time ###m | User set cold load time in minutes. See Cold Load Pickup (CLP), page 343. | N U UR E RL V C | PRTN |
| Common Addr ### | IEC 60870-5-101/4 setting for the application layer's ASDU common address. Please refer to the manufacturer's IEC60870-5-101/4 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-246. | N U UR E RL V C | PTCL |
| Common Addr Size ## | IEC 60870-5-101/4 setting for the number of octets in the link layer address field of all messages on the communications link. Please refer to the manufacturer's IEC60870-5-101/4 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-246. | N U UR E RL V C | PTCL |
| Config QK Not/Avail | Configurable quick key maps are available or not available. | N U UR E RL V C | CTRL |
| COS Retries ### | MITS Protocol change of state (COS) retry setting. The maximum number of times a COS message will be tried. Please refer to the manufacturer's MITS Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-210. | N U UR E RL V C | PTCL |
| COS Scan On/Off | MITS protocol change of state (COS) reporting was turned on or off. Please refer to the manufacturer's MITS Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-210. | N U UR E RL V C | PTCL |
| COT Size # | IEC101 Cause Of Transmission field size in octets. Please refer to the manufacturer's IEC60870-5-101/4 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-246. | N U UR E RL V C | PTCL |
| CTS Don't/Ignore | For a port with handshaking lines, whether to ignore or use the clear to send signal. See Communications Port Configuration, page 105. | N U UR E RL V C | PTCL |
| Cubicle S/N ###### | Cubicle serial number. | N U UR E RL V C | CTRL |
| Custom Menu Not/Avail | Expand Custom Menu avail See Custom Menu, page 48. | N U UR E RL V C | CTRL |
| Cyclic Dly ###s | IEC 60870-5-101/4 setting for the maximum number of seconds between cyclic data transmissions. Please refer to the manufacturer's IEC60870-5-101/4 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-246. | N U UR E RL V C | PTCL |
| Data Type NORMAL | IEC 60870-5-101/4 setting for the type of information to be used by the protocol handler when ASDU's are transmitted to the master station to normalized values. Please refer to the manufacturer's IEC60870-5-101/4 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-246. | N U UR E RL V C | PTCL |
| Data Type SCALED | IEC 60870-5-101/4 setting for the type of information to be used by the protocol handler when ASDU's are transmitted to the master station to scaled values. Please refer to the manufacturer's IEC60870-5-101/4 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-246. | N U UR E RL V C | PTCL |
| Daylight Save #### hr | Amount of daylight saving to add or remove in hours. | N U UR E RL V C | PTCL |
| DCB OPEN/CLOSED | Dummy circuit break open or closed. Used for SCADA testing. | N U UR E RL V C | PTCL |
| DCD Don't/Ignore | Whether to ignore or use Data Carrier Detect signal. See Communications Port Configuration, page 105. | N U UR E RL V C | PTCL |
| DD/MM | Display format of Day/Month. See Date Format , page 99. | N U UR E RL V C | CTRL |
| Dead Lockout | Switchgear would not reclose unless one or more terminals were live. See Dead Lockout, page 206. | N U UR E RL V C | PRTN |
| Dead Lockout ON/OFF | Dead Lockout feature was enabled or disabled. See Dead Lockout, page 206. | N U UR E RL V C | PRTN |
| Definite ######s | Definite time in seconds. See Definite Time DT, page 321. | N U UR E RL V C | PQ PRTN |
| Delay Time ###s | Loop Automation action delay after supply ON-to-OFF in seconds. See Description of Parameters, page 461. | N U UR E RL V C | PRTN |

**Table 122 List of Events (Continued)**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| Demand Period ##min | Demand logging sample period value in minutes. See Maximum demand Records, page 487. | N U UR E RL V C | CTRL |
| Details Not/Avail | Plant details available or not available. See Plant Details, page 86. | N U UR E RL V C | CTRL |
| Detect Group | Quick Key to change the Detection Group. | RL | CTRL |
| Dial Command ATD/T/P | Expand dial command | N U UR E RL V C | PTCL |
| Dial Timeout ###s | RS232 port's Hayes modem driver timeout without DCD being asserted for phone number dialed. See Communications Port Configuration, page 105. | N U UR E RL V C | PTCL |
| Dir Blocking ON/OFF | Directional blocking feature enabled or disabled. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Dir Protection ON/OFF | Directional protection feature enabled or disabled. See Directional Protection, page 249. | N U UR E RL V C | PRTN |
| DirP Auto Restore | Directional protection automatic restoration of supply. See Directional Protection, page 249. | N U UR E RL V C | PRTN |
| DISABLED/ENABLED | Port was enabled or disabled. | N U UR E RL V C | PTCL |
| Display Imperial | Display configured for imperial measurements (e.g. psi). See Display Setting Units, page 99. | N U UR E RL V C | CTRL |
| Display Metric | Display configured for metric measurements (e.g. kPa). See Display Setting Units, page 99. | N U UR E RL V C | CTRL |
| Display Ph/Earth V | The voltage measurement page was set to display phase to earth voltages. | N U UR E RL V C | CTRL |
| Display Ph/Ph Volt | The voltage measurement page was set to display phase to phase voltages. | N U UR E RL V C | CTRL |
| DL Cf Rqd ### | For DNP3, whether datalink confirm was required never, sometimes or always. Please refer to the manufacturer's DNP3 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-146. | N U UR E RL V C | PTCL |
| DL Cf TO #####ms | For DNP3, datalink confirm timeout period. Please refer to the manufacturer's DNP3 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-146. | N U UR E RL V C | PTCL |
| DL Max Retries #### | For DNP3, datalink maximum retry count. Please refer to the manufacturer's DNP3 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-146. | N U UR E RL V C | PTCL |
| DNP Address ##### | DNP3 Protocol Station Address. Please refer to the manufacturer's DNP3 Protocol Technical Manual for Advanced Controller, Part No: ADC01- DOC-146. | N U UR E RL V C | PTCL |
| DNP3 Not/Avail | DNP3 protocol available or not available. Please refer to the manufacturer's DNP3 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-146. | N U UR E RL V C | PTCL |
| DNP3 Trip/Close Req | DNP3 protocol trip/close request. Please refer to the manufacturer's DNP3 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-146. | N U UR E RL V C | SWGR |
| Double Cmd ### | The base address for the double command objects. Please refer to the manufacturer's IEC60870-5-101/4 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-246. | N U UR E RL V C | PTCL |
| Double Pts ### | The base address for the double point objects. Please refer to the manufacturer's IEC60870-5-101/4 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-246. | N U UR E RL V C | PTCL |
| Driver ############ | Driver selected for a port. This refers to another communications layer outside the protocol. See Communications Port Configuration, page 105. | N U UR E RL V C | PTCL |
| DTR ENABLED/DISABLED | RS232 port Data Terminal Ready signal disabled/enabled. See Communications Port Configuration, page 105. | N U UR E RL V C | PTCL |
| E Max NN Amp | Following pickup of the overcurrent protection element on earth or SEF, the maximum fault current recorded was NN Amps. This event was logged only after the current fell back below the earth setting current. See Fault Reset Operation, page 163. | N U UR E RL V C | PRTN |

**Table 122 List of Events (Continued)**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| E/F OFF Not/Allowed | Whether earth fault protection was allowed to be turned OFF. See Basic Current Protection Elements, page 162. | N U UR E RL V C | PRTN |
| Earth Dir Arm | An earth protection pickup occurred and tripping was enabled in the faulted direction. The trip could take place as normal. This event can only occur with Directional Blocking ON. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Earth Dir Block | An earth protection pickup occurred but tripping was blocked in the faulted direction. The circuit breaker would not trip. This event can only occur with Directional Blocking ON. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Earth Low Vzps | An Earth overcurrent trip occurred with a low Vzps condition present. See Earth Fault Directional Protection, page 258. | N U UR E RL V C | PRTN |
| Earth Low Vzps Arm | An earth protection pickup occurred and tripping was enabled because the residual voltage (Vzps) was less than the user-specified level and Low Vzps blocking was OFF. The trip could take place as normal. This event can only occur with Directional Blocking ON. See Earth Fault Directional Protection, page 258. | N U UR E RL V C | PRTN |
| Earth Low Vzps Blk | An earth protection pickup occurred but tripping was blocked because the residual voltage (Vzps) was less than the user-specified level and Low Vzps blocking was ON. The circuit breaker would not trip. This event can only occur with Directional Blocking ON. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Earth Low Vzps Fwd/ Rev/No Action | Set the fault direction for an earth protection pickup or for No Action. See Earth Fault Directional Protection, page 258. | N U UR E RL V C | PRTN |
| Earth Pickup ###x | Protection earth setting current multiplier to give the pickup level. See Earth Fault (EF), page 192. | N U UR E RL V C | PRTN |
| Earth Prot | Quick Key configured for Earth Protection. | N U UR E RL V C | CTRL |
| Earth Prot OFF | Earth fault protection was turned OFF by a local or remote operator. | N U UR E RL V C | PRTN |
| Earth Prot ON | Earth fault Protection was turned ON by a local or remote operator. | N U UR E RL V C | PRTN |
| Earth Prot Trip | A protection trip was generated by the Earth overcurrent protection element. | N U UR E RL V C | PRTN |
| Earth Reset ##%% | Protection earth current multiplier to give the reset level. See Earth Fault (EF), page 192. | N U UR E RL V C | PRTN |
| Earth Set #### Amp | Protection earth setting current level. See Earth Fault (EF), page 192. | N U UR E RL V C | PRTN |
| End #####V | The last of three (end) battery voltage readings taken during a battery test. | N U UR E RL V C | CTRL SYS |
| End Day ## | Daylight saving's end day of the end month. | N U UR E RL V C | PTCL |
| End Month ## | Daylight saving's end month. | N U UR E RL V C | PTCL |
| End of Line CR | For a communications trace, an end of line was a carriage return character. | N U UR E RL V C | PTCL |
| End of Line CR/LF | For a communications trace, an end of line was a carriage return followed by a linefeed character. | N U UR E RL V C | PTCL |
| End of Line LF | For a communications trace, an end of line was a linefeed character. | N U UR E RL V C | PTCL |
| End of Line NONE | For a communications trace, there was no end of line. | N U UR E RL V C | PTCL |
| End of Sequence | The end of the protection sequence was reached. See Auto Restore, page 251. | N U UR E RL V C | PRTN |
| Excess Motor Ops | Excess operations of an RL Series motor pack | RL | SWGR CTRL |
| Excess Pickups Trip | Trip due to excessive number of pickups. | N U UR E RL V C | PRTN |
| ExSeq ## | Excess Voltage Trip/Close sequences will occur after this number of sequences. | N U UR E RL V C | PRTN |
| ExSeq OFF | Monitoring of excess Voltage Trip/Close sequences is Disabled. See Under and Over Frequency (UOF) Protection, page 295. | N U UR E RL V C | PRTN |
| Extern Req | Batt Test Aborted because of an external Request (one of the protocols) | N U UR E RL V C | CTRL |
| External Prot Trip | External protection trip. | N U UR E RL V C | PRTN |

**Table 122 List of Events (Continued)**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| Fault Reset #####ms | Protection element fault reset time. See Fault Reset Operation, page 163. | N U UR E RL V C | PQ PRTN |
| Feeder ACR | Feeder ACR type defined for loop automation. See Device Types, page 434. | N U UR E RL V C | PRTN |
| First Char ## | Preamble first character on this communications port. See Communications Port Configuration, page 105. | N U UR E RL V C | PTCL |
| Fmt ASCII-HEX | Communications trace format was ASCII of Hexadecimal. See Communications Port Configuration, page 105. | N U UR E RL V C | PTCL |
| Fmt ASCII-HEX VT100 | Communications trace format was ASCII of Hexadecimal with VT100 terminal display controls. See Communications Diagnostics. | N U UR E RL V C | PTCL |
| Fmt HEADER BINARY | Communications trace format configured to a header and binary data. See Communications Diagnostics. | N U UR E RL V C | PTCL |
| Fmt RAW BINARY | Communications trace format was unchanged. See Communications Diagnostics. | N U UR E RL V C | PTCL |
| Fmt RAW LOOPBACK | Communications trace format was replying with the characters received. See Communications Diagnostics. | N U UR E RL V C | PTCL |
| Frag Retries ### | SOS Multi-drop maximum amount of fragment retries See SOS Multi-drop Driver, page 143. | N U UR E RL V C | PTCL |
| Frag Retry Time ###s | SOS Multi-drop fragment retry time in seconds. The delay between retries. See SOS Multi-drop Driver, page 143. | N U UR E RL V C | PTCL |
| Frame TO ###ms | MITS protocol frame timeout in milliseconds. Please refer to the manufacturer's MITS Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-210. | N U UR E RL V C | PTCL |
| Fwd AutoReclose ON/ OFF | Forward directional protection automatic reclose enabled or disabled. See Directional Protection, page 249. | N U UR E RL V C | PRTN |
| Fwd AutoRestore OFF | Auto Restore was turned OFF for the forward protection group by a local or remote operator. See Auto Restore, page 251. | N U UR E RL V C | PRTN |
| Fwd AutoRestore ON | Auto Restore was turned ON for the forward protection group by a local or remote operator. See Auto Restore, page 251. | N U UR E RL V C | PRTN |
| Fwd Earth Blocked | Directional protection blocked on forward earth current. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Fwd Earth Prot Trip | Protection trip on forward flowing earth current. | N U UR E RL V C | PRTN |
| Fwd NPS Blocked | Directional protection blocked on forward negative phase sequence current. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Fwd NPS Prot Trip | Protection trip on forward flowing negative phase sequence current. See Directional Protection, page 249. | N U UR E RL V C | PRTN |
| Fwd Phase Blocked | Directional protection blocked on forward phase current. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Fwd Phase Prot Trip | Protection trip on forward flowing phase current. See Directional Protection, page 249. | N U UR E RL V C | PRTN |
| Fwd SEF Blocked | Directional protection blocked on forward sensitive earth fault current. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Fwd SEF Prot Trip | Protection trip on forward flowing sensitive earth fault current. See Directional Protection, page 249. | N U UR E RL V C | PRTN |
| Fwd Sequence Adv | Directional protection sequence advance in the forward direction. See Sequence Control, page 206. | N U UR E RL V C | PRTN |
| Gas Inhibit Not/Avail | Expand gas inhibit not avail | N RL | CTRL |
| Gas Inhibit Not/Avail | Low gas inhibit available or not available. | N RL | CTRL |
| Gas Inhibit ON/OFF | Gas low inhibit was set ON or OFF | N RL | CTRL |
| Gas Override OFF | Gas Override was set to OFF | N RL | CTRL |
| Gas Override ON | Gas Override was set to ON | N RL | CTRL |
| Gas Press Invalid | An operation was attempted with an invalid gas pressure. | N RL | SWGR CTRL |

**Table 122 List of Events (Continued)**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| Gas Press Low | This event was recorded after an operation was attempted with Sulphur hexafluoride ($SF_6$) gas pressure low and Gas Low Lockout ON. | N RL | SWGR CTRL |
| Group # Displayed | Panel protection group displayed. See Protection Groups, page 170. | N U UR E RL V C | CTRL |
| GW ### | Default Gateway IP address | N U UR E RL V C | CTRL |
| H/AAlm ON Time ##s | Harmonic analysis time to alarm ON. See Harmonic Analysis, page 511. | N U UR E RL V C | PQ |
| H/A Logging ## mins | Harmonic analysis logging period. See Harmonic Analysis, page 511. | N U UR E RL V C | PQ |
| Hardware Failure | Problem with controller hardware. | N U UR E RL V C | CTRL |
| Harmonics | Waveform capture to trigger on harmonics. See Waveform Capture, page 501. | N U UR E RL V C | PQ |
| Harmonics Not/Avail | Harmonic analysis available or not available. See Harmonic Analysis, page 511. | N U UR E RL V C | PQ |
| Harmonics OFF | Waveform capture to trigger on harmonics turned off. | N U UR E RL V C | PQ |
| Harmonics ON/OFF | Harmonic analysis ON or OFF. See Harmonic Analysis, page 511. | N U UR E RL V C | PQ |
| Hayes Not/Available | Hayes available. See Hayes compatible modem support, page 139. | N U UR E RL V C | PTCL |
| HCL Active Trip ### | High current lockout active after this trip. See High Current Lockout (HCL), page 208. | N U UR E RL V C | PRTN |
| Heater Connected | Heater power supply is connected. | N U UR E RL V C | CTRL |
| Heater Disconnected | Heater power supply is disconnected. | N U UR E RL V C | CTRL |
| Heater Shorted | Heater power supply is shorted. | N U UR E RL V C | CTRL |
| High Current | Operation denied because of High Current. | N U UR E RL V C | SWGR CTRL |
| High Lockout ####A | The circuit breaker tripped with a current above the High Current Lockout setting whilst the High Current Lockout was effective, the event shows the value of setting at the time the event occurred. See High Current Lockout (HCL), page 208. | N U UR E RL V C | PRTN |
| High Lockout ON/OFF | High current lockout ON/OFF. See High Current Lockout (HCL), page 208. | N U UR E RL V C | PRTN |
| High Vzps ###s | Directional Blocking High Vzps alarm time in seconds. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| High Vzps Alarm ON/ OFF | Directional Blocking high Vzps alarm ON/OFF. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| High Vzps DISABLED | Directional Blocking high Vzps was disabled. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Hit and Run OFF | End of Hit and Run request countdown, or timeout. See Hit and Run, page 55. | N U UR E RL V C | CTRL |
| Hit and Run ON | Start of Hit and Run period, or reason for an operation denial. See Hit and Run, page 55. | N U UR E RL V C | CTRL SWGR |
| Hit&Run Close ###s | Hit and Run close time in seconds. See Hit and Run, page 55. | N U UR E RL V C | CTRL |
| Hit&Run Close OFF | Hit and Run close is OFF. See Hit and Run, page 55. | N U UR E RL V C | CTRL |
| Hit&Run Not/Avail | Hit and Run feature available or not available. See Hit and Run, page 55. | N U UR E RL V C | CTRL |
| Hit&Run Trip ###s | Hit and Run trip time in seconds. See Hit and Run, page 55. | N U UR E RL V C | CTRL |
| Hit&Run Trip OFF | Hit and Run trip is OFF. See Hit and Run, page 55. | N U UR E RL V C | CTRL |
| Idioma Espanol | The Spanish language has been selected. | N U UR E RL V C | CTRL |
| IEC870 Close Req | A close request was issued by the IEC60870-5-101/4 communications protocol. | N U UR E RL V C | SWGR |
| IEC870 Trip Req | A trip request was issued by the IEC60870-5-101/4 communications protocol. | N U UR E RL V C | SWGR |
| in ####min | Excess Voltage Trip/Close sequences will occur in this time. | N U UR E RL V C | PRTN |

**Table 122 List of Events (Continued)**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| Inrush Mult x ##### | Inrush current restraint multiplier. See Inrush Restraint, page 209. | N U UR E RL V C | PRTN |
| Inrush ON/OFF | Inrush current restraint enabled or disabled. See *Inrush Restraint Settings/Specifications (page 9-4)*. | N U UR E RL V C | PRTN |
| Inrush Ready | The Inrush current timer has been reset ready for an inrush current. See Inrush Restraint, page 209. | N U UR E RL V C | PRTN |
| Inrush Time ######s | Inrush current restraint time in seconds. See Inrush Restraint, page 209. | N U UR E RL V C | PRTN |
| Inrush Timed Out | The Inrush current timer has been expired. See Inrush Restraint, page 209. | N U UR E RL V C | PRTN |
| Inrush Timing | Inrush current has been detected and the Inrush timer has started. See Inrush Restraint, page 209. | N U UR E RL V C | PRTN |
| Instant Mult x #### | Instantaneous Multiplier Value. See Instantaneous Multiplier. | N U UR E RL V C | PRTN |
| Integ Total ### | Determines if the integrated total object information is reported in the data transmitted to the master station. Please refer to the manufacturer's IEC60870-5-101/4 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-246. | N U UR E RL V C | PTCL |
| Integ Total Rep OFF | Integrated Totals have been disabled. | N U UR E RL V C | PTCL |
| Integ Total Rep ON | Integrated Totals have been enabled. | N U UR E RL V C | PTCL |
| Invalid Mapping | Invalid protocol mapping. | N U UR E RL V C | PTCL |
| Invalid Profile | Database profile was invalid. | N U UR E RL V C | CTRL |
| Invalid Switch ### | Invalid switch number detected. | N U UR E RL V C | SWGR |
| IOEX Close Req | Input/Output Expander operation close request. | N U UR E RL V C | SWGR |
| IOEX Input## OFF | IOEX Input XX changed from the ON state to the OFF state (where XX is from 01 to 08). | N U UR E RL V C | IOEX |
| IOEX Input## ON | IOEX Input XX changed from the OFF state to the ON state (where XX is from 01 to 08). | N U UR E RL V C | IOEX |
| IOEX Not/Available | IOEX feature was made available or not available. | N U UR E RL V C | IOEX |
| IOEX Oper Trip Req | Input/Output Expander operation trip request | N U UR E RL V C | SWGR |
| IOEX Output## OFF | IOEX Output XX changed from the ON state to the OFF state (where XX is from 01 to 08). | N U UR E RL V C | IOEX |
| IOEX Output## ON | IOEX Output XX changed from the OFF state to the ON state (where XX is from 01 to 08). | N U UR E RL V C | IOEX |
| IOEX Prot Trip Req | Input/Output Expander protection trip request. | N U UR E RL V C | SWGR |
| IP ### | Internet protocol address. | N U UR E RL V C | CTRL |
| Iso. fail, blocking | | N U UR E RL V C | SWGR |
| k:Max Uncnfm ### | Maximum number of unconfirmed I-Format APDU transmitted. Please refer to the manufacturer's IEC60870-5-101/4 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-246. | N U UR E RL V C | PTCL |
| Keep-alive #ms | DNP3 TCP/IP Keep-alive Timeout Period. Please refer to the manufacturer's DNP3 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-146. | N U UR E RL V C | PTCL |
| Lang English (Intl) | Language English (International) was selected for the display. | N U UR E RL V C | CTRL |
| Lang English (USA) | Language English (USA) was selected for the display. | N U UR E RL V C | CTRL |
| Last Char ## | Last preamble character for this communications port. See Communications Port Configuration, page 105. | N U UR E RL V C | PTCL |
| LBS Function | Switchgear is setup to function as an LBS | N U UR E RL V C | CTRL |
| Link Addr ### | The link layers service address of the controller on the communications link. | N U UR E RL V C | PTCL |
| Link Addr Size ## | The number of octets in the link layer address field of all IEC60870 -5-101 messages on the communications link. | N U UR E RL V C | PTCL |
| Link BALANCED | IEC60870-5-101 is configured to run in Balanced mode. | N U UR E RL V C | PTCL |

**Table 122 List of Events (Continued)**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| Link Reset EO.I. OFF | IEC60870-5-101/4 E.O.I. message transaction has been disabled. | N U UR E RL V C | PTCL |
| Link Reset EO.I. ON | IEC60870-5-101/4 E.O.I. message transaction has been enabled. | N U UR E RL V C | PTCL |
| Link UNBALANCED | IEC60870-5-101 is configured to run in Unbalanced mode. | N U UR E RL V C | PTCL |
| Live Block | Quick key configured to control live load blocking. | N U UR E RL V C | CTRL |
| LIVE if > ####V | Voltage configured to live if greater than ### volts. | N U UR E RL V C | CTRL PRTN |
| Live Load Block ON/ OFF | Live load blocking enabled or disabled. See Live Load Blocking, page 338. | N U UR E RL V C | PRTN |
| Live Load Blocking | A close request was disregarded due to a load side terminal being alive. See Live Load Blocking, page 338. | N U UR E RL V C | CTRL SWGR |
| Load Out... | The accumulated time the load side terminals have experienced an outage. | N U UR E RL V C | PQ |
| Load Profile | Saved database profile was loaded into current database. | N U UR E RL V C | CTRL |
| Load Supply ON/OFF | All configured load side voltages are ON or OFF. | N U UR E RL V C | NWRK PRTN |
| LOCAL CONTROL ON | A local operator put the controller in LOCAL mode. See *Definition of Local or Remote User (page 8-1)*. | N U UR E RL V C | CTRL |
| LOCAL/Remote | Quick key configured to change LOCAL/Remote mode. | N U UR E RL V C | CTRL |
| Lockout | The protection went to lockout and would not perform any more automatic recloses. See Automatic Reclose Sequence, page 160. | N U UR E RL V C | SWGR PRTN |
| Loop Auto | Quick key configured to control loop automation ON/OFF. | N U UR E RL V C | CTRL |
| Loop Auto Close Req | Close request from loop automation. See Loop Automation Basics, page 437. | N U UR E RL V C | SWGR |
| Loop Auto Not/Avail | Loop automation option was made available or not available. See Loop Automation Basics, page 437. | N U UR E RL V C | PRTN |
| Loop Auto ON/OFF | Loop automation was set ON or OFF. See Loop Automation Basics, page 437. | N U UR E RL V C | PRTN |
| Loop Auto Trip Req | Trip request from loop automation. See Loop Automation Basics, page 437. | N U UR E RL V C | SWGR |
| LOP Prot Trip | A protection trip was generated by Loss Of Phase protection. See Loss of Phase Protection, page 291. | N U UR E RL V C | PRTN |
| LOP/Loop Linked | Loss Of Phase and Loop Automation features are linked. | N U UR E RL V C | PRTN |
| LOP/Loop Unlinked | Loss Of Phase and Loop Automation features are not linked. | N U UR E RL V C | PRTN |
| Loss Phase Prot Alm | Loss of phase protection was set to alarm. See Loss of Phase Protection, page 291. | N U UR E RL V C | PRTN |
| Loss Phase Prot ON/ OFF | Loss of phase protection was set ON or OFF. See Loss of Phase Protection, page 291. | N U UR E RL V C | PRTN |
| Low Batt | Batt Test Aborted because of low battery voltage. | N U UR E RL V C | CTRL |
| Low Power Mode | If the power supply voltage drops below the threshold for a certain time, then the radio supply is turned off. The switchgear would operate, but would go to lockout if the capacitors cannot be charged quickly enough.<br>**NOTE:** Low Power Mode does not exist with LiFePO4 batteries. | N U UR E RL V C | CTRL |
| Low V Block OFF | For Low Phase to earth voltage, Directional Blocking OFF. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Low V Block ON | For Low Phase to earth voltage, Directional Blocking ON. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Low V Inhibit ####V | The voltage below which the Under/Over frequency protection was disabled. | N U UR E RL V C | PRTN |
| Low Vnps Block ON/ OFF | For Low negative phase sequence voltage, Directional Blocking was set ON or OFF. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Low Vzps Block ON/ OFF | For Low residual voltages, Directional Blocking was set ON or OFF. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |

**Table 122 List of Events (Continued)**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| Maint. Req. | A maintenance item requires attention. | N U UR E RL V C | CTRL |
| Manual Close | Waveform capture trigger on manual close. See Waveform Capture, page 501. | N U UR E RL V C | PQ |
| Manual Close OFF | Waveform capture trigger on manual close turned off. See Waveform Capture, page 501. | N U UR E RL V C | PQ |
| Manual Trip | Waveform capture trigger on manual trip. See Waveform Capture, page 501. | N U UR E RL V C | PQ |
| Manual Trip OFF | Waveform capture trigger on manual trip turned off. See Waveform Capture, page 501. | N U UR E RL V C | PQ |
| Map Already Used | Operation denied. Another protocol was already using this map. | N U UR E RL V C | SWGR CTRL |
| Master Addr ##### | DNP3 protocol master address. See Configure the DNP3 Settings, page 113. | N U UR E RL V C | PTCL |
| Master Port # | DNP3 TCP/IP Master port number. | N U UR E RL V C | PTCL |
| Max ASDU Size ### | IEC maximum size of ASDU (frame) in octets. | N U UR E RL V C | PTCL |
| Max Attempts ### | RS232 port's Hayes modem driver maximum connection attempts. See Hayes compatible modem support, page 139. | N U UR E RL V C | PTCL |
| Max Current >=... Amps | High current lockout measurement. See High Current Lockout (HCL), page 208. | N U UR E RL V C | PRTN |
| Max Frag Size #### | SOS Multi-drop maximum fragment size. No SOS Multi-drop message will exceed this size. | N U UR E RL V C | PTCL |
| Maximum Time #####s | Maximum time to trip in seconds. See Fault Reset Operation, page 163. | N U UR E RL V C | PRTN |
| MDI Reset | A reset was done on the Maximum Demand Indicator Meter Values. | N U UR E RL V C | PRTN |
| Meas Vals ### | Measured Values. If enabled, Cyclic data are periodic updates of Measured Values that are reported in Class 2 poll responses. Please refer to the manufacturer's IEC60870-5-101/4 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-246. | N U UR E RL V C | PTCL |
| Measured Time OFF | Time tags are not included with all Class 1 measured value information. Please refer to the manufacturer's IEC60870-5-101/4 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-246. | N U UR E RL V C | PTCL |
| Measured Time ON | Time tags are included with all Class 1 measured value information. Please refer to the manufacturer's IEC60870-5-101/4 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-246. | N U UR E RL V C | PTCL |
| Mech Interlocked | Switchgear was mechanically interlocked. | U UR E V C | SWGR CTRL |
| Mech Locked | Switchgear was mechanically locked. | U UR E V C | SWGR |
| Mech UnLocked | Switchgear was mechanically unlocked. | U UR E V C | SWGR |
| Mechanical Close | A mechanical close occurred. | N U UR E RL V C | SWGR |
| Mechanical Trip | A mechanical trip occurred. | N U UR E RL V C | SWGR |
| Mechanism Fail | Switchgear mechanism failed to operate after being requested by the controller. | N U UR E RL V C | SWGR |
| Mid #####V | The second of three (middle) battery voltages measured during a battery test. | N U UR E RL V C | CTRL SYS |
| MidPoint ACR | Loop automation switchgear device type was set to be a midpoint recloser. | N U UR E RL V C | PRTN |
| Min Earth Vzps #### | Minimum earth residual voltage as a percentage of phase to earth voltage. See Directional Protection and Blocking, page 222. | N U UR E RL V C | PRTN |
| Min NPS Vnps ####V | Minimum NPS residual voltage. See Directional Protection and Blocking, page 222. | N U UR E RL V C | PRTN |
| Min SEF Vzps #### | Minimum Sensitive Earth Fault Vo. See Directional Protection and Blocking, page 222 (page 9-1). | N U UR E RL V C | PRTN |
| Minimum #######s | Minimum Time to Trip (in seconds). See Protection Discrimination/ Timing, page 185. | N U UR E RL V C | PRTN |

**Table 122 List of Events (Continued)**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| MITS Close Req | MITS protocol close request. See *9 Recloser Protection Features (Page 9-1)*. | N U UR E RL V C | SWGR |
| MITS Not/Available | MITS protocol was made available or not available. Please refer to the manufacturer's MITS Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-210. | N U UR E RL V C | PTCL |
| MITS Trip Req | MITS protocol trip request. Please refer to the manufacturer's MITS Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-210. | N U UR E RL V C | SWGR |
| MM/DD | Display format of Month/Day. | N U UR E RL V C | CTRL |
| Mode LOCAL/Remote | Port mode was made LOCAL or Remote. See Local and Remote Control Modes, page 50. | N U UR E RL V C | PTCL |
| Modem Pwr Cyc ## hr | Time in hours to automatically cycle power of the radio power supply. It is a way of resetting problem modems. See Protocol Monitor, page 136. | N U UR E RL V C | PTCL |
| Modem Pwr Cyc OFF | Automatic power cycle of radio power supply is OFF. It is a way of resetting problem modems. See Protocol Monitor, page 136. | N U UR E RL V C | PTCL |
| Msg Attempts ## | RDI Number of attempts to transmit. See RDI Modem Support. | N U UR E RL V C | PTCL |
| N Series Switch | N Series Switch | N | CTRL |
| N/F Cls after ####s | Frequency protection close time after normal frequency reached. See Under and Over Frequency (UOF) Protection, page 295. | N U UR E RL V C | PRTN |
| Network End Point DATAGRAM | For DNP3, UDP End Point. | N U UR E RL V C | PTCL |
| Network End Point DUAL | For DNP3, Dual Point. | N U UR E RL V C | PTCL |
| Network End Point LISTENING | For DNP3, TCP Listening End Point. | N U UR E RL V C | PTCL |
| New IOEX Mapping | New IOEX Mapping loaded. See Connect the IOEX to the Controller, page 534. | N U UR E RL V C | IOEX |
| New SCEM Data | New SCEM data was written to the SCEM. | N U UR E RL V C | SWGR |
| No Data Timeout ###s | RS232 port's Hayes modem driver disconnect timeout without any data transmitted, or received. See Hayes compatible modem support, page 139. | N U UR E RL V C | PTCL |
| No PSU Detected | No power supply unit was detected. | N U UR E RL V C | CTRL |
| No SWGM Detected | No switchgear module detected. | N U UR E RL V C | CTRL |
| Nom P-E V #####kV | Nominal phase-earth voltage. | N U UR E RL V C | PRTN |
| Normal Freq Close | Under/Over frequency protection, the source frequency returned to normal and a close request was issued. See Under and Over Frequency (UOF) Protection, page 295. | N U UR E RL V C | PRTN |
| Normal Freq Close ON/ OFF | Under/Over frequency protection close was enabled or disabled. See Under and Over Frequency (UOF) Protection, page 295. | N U UR E RL V C | PRTN |
| Normal Power Mode | If the power supply voltage returns to normal then the power mode would return to normal after 15 minutes. | N U UR E RL V C | CTRL |
| NPS Alarm Mode ON | Negative phase sequence protection set to alarm. See Negative Phase Sequence (NPS), page 195. | N U UR E RL V C | PRTN |
| NPS Dir Arm | Directional Blocking NPS fault armed. See Negative Phase Sequence Directional Blocking, page 245. | N U UR E RL V C | PRTN |
| NPS Dir Block | Directional Blocking NPS fault blocking. See Negative Phase Sequence Directional Blocking, page 245. | N U UR E RL V C | PRTN |
| NPS Low Vnps | An NPS overcurrent trip occurred with a low Vnps condition present. See Negative Phase Sequence Directional Blocking, page 245. | N U UR E RL V C | PRTN |
| NPS Low Vnps Arm | Directional Blocking low Vnps fault armed. See Negative Phase Sequence Directional Blocking, page 245. | N U UR E RL V C | PRTN |
| NPS Low Vnps Block | Directional Blocking low Vnps fault blocking. See Negative Phase Sequence Directional Blocking, page 245. | N U UR E RL V C | PRTN |

**Table 122 List of Events (Continued)**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| NPS Low Vnps Fwd | Directional protection low Vnps was in forward fault region. See Negative Phase Sequence Directional Blocking, page 245. | N U UR E RL V C | PRTN |
| NPS Low Vnps Ignore | Directional protection low Vnps was disabled. See Negative Phase Sequence Directional Blocking, page 245. | N U UR E RL V C | PRTN |
| NPS Low Vnps Rev | Directional protection low Vnps was in reverse fault region. See Negative Phase Sequence Directional Blocking, page 245. | N U UR E RL V C | PRTN |
| NPS Max #### Amp | Following pickup of the NPS overcurrent protection, the maximum fault current recorded was ## Amps. This event was logged only after the current fell back below the NPS setting current. See Negative Phase Sequence (NPS), page 195. | N U UR E RL V C | PRTN |
| NPS OFF Not/Allowed | NPS protection OFF allowed or not allowed. See Negative Phase Sequence (NPS), page 195. | N U UR E RL V C | PRTN |
| NPS ON/OFF | Negative phase sequence protection was set ON or OFF. See Negative Phase Sequence (NPS), page 195. | N U UR E RL V C | PRTN |
| NPS Pickup ###x | Protection negative phase sequence setting current multiplier to give the pickup level. See Negative Phase Sequence (NPS), page 195. | N U UR E RL V C | PRTN |
| NPS Prot | Quick key configured to control negative phase sequence protection ON and OFF. See Negative Phase Sequence (NPS), page 195. | N U UR E RL V C | CTRL |
| NPS Prot Alarm | Negative phase sequence current exceeded the pickup setting for the user-specified time. See Negative Phase Sequence (NPS), page 195. | N U UR E RL V C | PRTN |
| NPS Prot Trip | Negative phase sequence protection trip. See Negative Phase Sequence (NPS), page 195. | N U UR E RL V C | PRTN |
| NPS Reset ##%% | Protection negative phase sequence current multiplier to give the reset level. See Negative Phase Sequence (NPS), page 195. | N U UR E RL V C | PRTN |
| NPS Set #### Amp | Negative phase sequence setting current level. See Negative Phase Sequence (NPS), page 195. | N U UR E RL V C | PRTN |
| NPS Trips Lockout # | Negative phase sequence trips to lockout. See Negative Phase Sequence (NPS), page 195. | N U UR E RL V C | PRTN |
| Null Resp Port # | DNP3 UDP Null response port number. | N U UR E RL V C | PTCL |
| NV Close | Under/Over voltage protection, the source voltage returned to normal and a close request was issued. | N U UR E RL V C | PRTN |
| NV Close ####s | Closing due to Normal Voltage will occur after the Voltage is Normal for this time. | N U UR E RL V C | PRTN |
| NV Close OFF | Closing due to Normal Voltage after an Under/Over Voltage Trip is NOT enabled. | N U UR E RL V C | PRTN |
| NV High ####pu | The High Voltage threshold for Voltage Normal. | N U UR E RL V C | PQ PRTN |
| NV Low ####pu | The Low Voltage threshold for Voltage Normal. | N U UR E RL V C | PQ PRTN |
| O/F Normal ####Hz | Over frequency protection's normal frequency in Hertz. See Under and Over Frequency (UOF) Protection, page 295. | N U UR E RL V C | PRTN |
| O/F Trip at ###Hz | Over frequency protection trip this frequency in Hertz. See Under and Over Frequency (UOF) Protection, page 295. | N U UR E RL V C | PRTN |
| O/F Trip ON/OFF | Over frequency protection trip was enabled or disabled. See Under and Over Frequency (UOF) Protection, page 295. | N U UR E RL V C | PRTN |
| Object Addr Size ## | IEC60870-5-101 only. The number of octets in the application layer information object address field of all messages on the comms link. Please refer to the manufacturer's IEC60870-5-101/4 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-246. | N U UR E RL V C | PTCL |
| O.I. Door Closed | Operator Interface door closed. | N U UR E RL V C | CTRL |
| O.I. Door Opened | Operator Interface door opened. | N U UR E RL V C | CTRL |
| One Octet Ack OFF | IEC60870-5-101 only. Single octet acknowledge responses to Send/ Confirm expected primary link functions are disabled. Please refer to the manufacturer's IEC60870-5-101/4 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-246. | N U UR E RL V C | PTCL |
| One Octet Ack ON | IEC60870-5-101 only. Single octet acknowledge responses to Send/ Confirm expected primary link functions are enabled. Please refer to the | N U UR E RL V C | PTCL |

**Table 122 List of Events (Continued)**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| | manufacturer's IEC60870-5-101/4 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-246. | | |
| One Octet Resp OFF | IEC60870-5-101 only. Single octet acknowledge responses to Send/ Confirm expected primary link functions are disabled. Please refer to the manufacturer's IEC60870-5-101/4 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-246. | N U UR E RL V C | PTCL |
| One Octet Resp ON | IEC60870-5-101 only. Single octet acknowledge responses to Send/ Confirm expected primary link functions are enabled. Please refer to the manufacturer's IEC60870-5-101/4 Protocol Technical Manual for Advanced Controller, Part No: ADC01-DOC-246. | N U UR E RL V C | PTCL |
| Operation Denied | Attempt to perform a change was denied. | N U UR E RL V C | SWGR CTRL |
| OPS #### | Number of switchgear close operations. | N U UR E RL V C | SWGR |
| Options Available | The panel pages displaying configurable options are accessible. See Systems Settings 2, page 643. | N U UR E RL V C | CTRL |
| Options Not Avail | The panel pages displaying configurable options are not accessible. See Systems Settings 2, page 643. | N U UR E RL V C | CTRL |
| Out. Duration ###s | Time in seconds, for terminals without voltage to be counted as a supply outage. See Supply Outages, page 657. | N U UR E RL V C | PQ |
| Outages ON/OFF | The supply outage measurement feature was enabled or disabled. See Supply Outages, page 657. | N U UR E RL V C | PQ |
| Outages Reset | All supply outage measurement counters have been reset to zero. See Supply Outages, page 657. | N U UR E RL V C | PQ |
| OV Excess Seq | Over Voltage Protection excess sequences. See Under and Over Frequency (UOF) Protection, page 295. | N U UR E RL V C | PRTN |
| OV Pickup | The measured voltage was equal to or above the over voltage threshold. See Under and Over Frequency (UOF) Protection, page 295. | N U UR E RL V C | PRTN |
| OV Protection OFF | Over Voltage protection is turned off. See Under and Over Voltage Protection (UOV), page 278. | N U UR E RL V C | PRTN |
| OV Protection ON | Over Voltage protection is turned on. See Under and Over Voltage Protection (UOV), page 278. | N U UR E RL V C | PRTN |
| OV Reset | The measured voltage dropped to equal or below the Over voltage trip threshold minus the dead band. See Under and Over Voltage Protection (UOV), page 278. | N U UR E RL V C | PRTN |
| OV Trip | The source voltage was equal to or above the Over Voltage threshold for the Trip Delay count and a trip request was issued. See Under and Over Voltage Protection (UOV), page 278. | N U UR E RL V C | PRTN |
| Over Freq Pickup | The measured frequency was equal to or above the Over Frequency trip threshold. See Under and Over Frequency (UOF) Protection, page 295. | N U UR E RL V C | PRTN |
| Over Freq Reset | The measured frequency fell to equal or above the Over Frequency trip threshold plus the dead band. See Under and Over Frequency (UOF) Protection, page 295. | N U UR E RL V C | PRTN |
| Over Freq Trip | The source frequency was equal to or above the Over Frequency threshold for the Trip Delay count and a trip request was issued. See Under and Over Frequency (UOF) Protection, page 295. | N U UR E RL V C | PRTN |
| Panel Close Req | Request to close made from the panel. | N U UR E RL V C | SWGR |
| Panel Trip Req | Request to trip made from the panel. | N U UR E RL V C | SWGR |
| Panel Trip Req | Request to trip made from the panel. | N U UR E RL V C | SWGR |
| Param Cmd ### | | N U UR E RL V C | PTCL |
| Parity EVEN | Communications port parity bit was even. See Communications Port Configuration, page 105. | N U UR E RL V C | PTCL |
| Parity NONE | Communications port parity bit was none. See Communications Port Configuration, page 105. | N U UR E RL V C | PTCL |
| Parity ODD | Communications port parity bit was set to odd. See Communications Port Configuration, page 105. | N U UR E RL V C | PTCL |

**Table 122 List of Events (Continued)**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| Password Changed | Either the panel password or the write access password was changed. | N U UR E RL V C | CTRL |
| PCOM S/N ###### | PCOM Serial Number. | N U UR E RL V C | CTRL |
| Performing Test... | Battery test in progress. | N U UR E RL V C | CTRL |
| Phase A/B/C LOST | Loss of supply occurred on this phase. See Loss of Phase Protection, page 291. | N U UR E RL V C | PRTN |
| Phase Dir Arm | Phase overcurrent pickup and trip enabled in faulted direction. The trip can take place as normal. This can only occur with Directional Blocking ON. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Phase Dir Block | Phase overcurrent pickup and trip blocked in faulted direction. The trip cannot take place. This can only occur with Directional Blocking ON. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Phase Logic AND | The logic used to combine the phase voltages for Voltage Protection is set to AND. | N U UR E RL V C | PRTN |
| Phase Logic AVG | The logic used to combine the phase voltages for Voltage Protection is set to AVERAGE. | N U UR E RL V C | PRTN |
| Phase Logic OR | The logic used to combine the phase voltages for Under or Over Voltage Protection is set to OR. | N U UR E RL V C | PRTN |
| Phase Lost #######s | Phase considered lost if below a voltage for this time. | N U UR E RL V C | PRTN |
| Phase Lost @ ####V | Phase considered lost below this voltage for a set time. | N U UR E RL V C | PRTN |
| Phase Low V | A phase overcurrent trip occurred with a low V condition present. | N U UR E RL V C | PRTN |
| Phase Low V Arm | A phase protection pickup occurred and tripping was enabled because the voltage on all three phases (V) was less than 500V and Low V blocking was OFF. The trip takes place as normal. This event can only occur with Directional Blocking ON. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Phase Low V Block | A phase protection pickup occurred and tripping was blocked because the voltage on all three phases (V) was less than 500 V and Low V blocking was ON. The circuit breaker does not trip. This event can only occur with Directional Blocking ON. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Phase Low V Fwd | Directional protection overcurrent pickup allowed if low voltage and power flowing in the forward direction. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Phase Low V Ignore | Directional protection overcurrent pickup allowed if low voltage. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Phase Low V Rev | Directional protection overcurrent pickup allowed if low voltage and power flowing in the reverse direction. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Phase Pickup ###x | Protection phase setting current multiplier to give the pickup level. | N U UR E RL V C | PRTN |
| Phase Prot Trip | A protection trip was generated by the Phase overcurrent protection element. See Phase Overcurrent, page 191. | N U UR E RL V C | PRTN |
| Phase Reset ##%% | Protection phase current multiplier to give the reset level. See Phase Overcurrent, page 191. | N U UR E RL V C | PRTN |
| Phase Set #### Amp | Protection phase setting current level. | N U UR E RL V C | PRTN |
| Phase Set OFF | Protection phase setting current OFF. | N U UR E RL V C | PRTN |
| Phase Set ON | Protection phase setting current ON. | N U UR E RL V C | PRTN |
| Phasing ABC | Phase Rotation was made A,B,C. | N U UR E RL V C | CTRL |
| Phasing ACB | Phase Rotation was made A,C,B. | N U UR E RL V C | CTRL |
| Pickup | One of the protection elements picked up (phase, earth, SEF or NPS). This event was generated by the first element to pick up, if more elements pick up subsequently then no more pickup events are generated until all the elements have reset. See Protection Pickup , page 160. | N U UR E RL V C | PRTN |
| Pickup Fwd | Protection overcurrent pickup in the forward direction. | N U UR E RL V C | PRTN |

**Table 122 List of Events (Continued)**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| Pickup Rev | Protection overcurrent pickup in the reverse direction. | N U UR E RL V C | PRTN |
| Pickup Volt ####pu | Voltage at which a Voltage pickup occurs. | N U UR E RL V C | PQ PRTN |
| Plant Detail: | Plant Detail. | N U UR E RL V C | CTRL |
| Plant Name: | Plant Name. | N U UR E RL V C | CTRL |
| PMSet U/UR/E Switch | Type of the Switch that is connected | U UR E | CTRL |
| Port ############## | A protocol was configured to use this RS232 port. See Communications Port Configuration, page 105. | N U UR E RL V C | PTCL |
| Port in REQ ON | Port number in request is ON. | N U UR E RL V C | PTCL |
| Port in REQ OFF | Protection phase setting current OFF. | N U UR E RL V C | PTCL |
| Post-Tx #####ms | Post-Transmission time in milliseconds. | N U UR E RL V C | PTCL |
| Power Down | Power supply to CAPE was removed. | N U UR E RL V C | CTRL |
| Power Signed | Power measurement displayed in a signed format. | N U UR E RL V C | CTRL |
| Power Unsigned | Power measurement displayed in an unsigned format. | N U UR E RL V C | CTRL |
| Power Up | Power supply to CAPE was restored. | N U UR E RL V C | CTRL |
| Pre-Tx #####ms | Pre-Transmission time in milliseconds. | N U UR E RL V C | PTCL |
| Preamble DISABLED | Sending of preamble characters out of this communications port was disabled. | N U UR E RL V C | PTCL |
| Preamble ENABLED | Sending of preamble characters out of this communications port was enabled. | N U UR E RL V C | PTCL |
| Prefix Data OFF | All RDI Data messages are as per the RDI specification. | N U UR E RL V C | PTCL |
| Prefix Data ON | All RDI Data messages are as per the RDI specification. | N U UR E RL V C | PTCL |
| Pressure Invalid | Sulphur hexafluoride ($SF_6$) gas pressure invalid. | N RL | SWGR |
| Program Fault | A program fault was detected. Contact the Manufacturer or Distributor for advice. | N U UR E RL V C | CTRL |
| Prot Group | Quick Key to change the protection group. | N U UR E RL V C | CTRL |
| Prot Group # Req | Change to active protection group requested. See Protection Groups, page 170. | N U UR E RL V C | PRTN |
| Prot Grp # Active | The protection group that was then active. See Protection Groups, page 170. | N U UR E RL V C | PRTN |
| Prot OFF Allowed | Protection can be turned OFF. | N U UR E RL V C | PRTN |
| Prot OFF Not Allow | Protection cannot be turned OFF. | N U UR E RL V C | PRTN |
| Prot Req | Batt Test Aborted because of Protection Request | N U UR E RL V C | CTRL |
| Prot Reset Fwd/Rev | All of the protection elements picked up (phase, earth, SEF or NPS) have reset. This is analogous to the induction disk returned to the stop position, but it also occurs for fault reset, definite time, and instantaneous. See Fault Reset Operation, page 163. | N U UR E RL V C | PRTN |
| Prot Trip | Waveform capture trigger on protection trip. See Waveform Capture, page 501. | N U UR E RL V C | PQ |
| Prot Trip 1/2/3/4 | Protection trip sequence number. | N U UR E RL V C | PRTN |
| Prot Trip OFF | Waveform capture trigger on protection trip turned off. See Waveform Capture, page 501. | N U UR E RL V C | PQ |
| Prot Trip Req | Protection trip request. | N U UR E RL V C | SWGR |
| Protection ON/OFF | All the Protection features are ON or OFF. | N U UR E RL V C | PRTN |
| Protocol Reset | | N U UR E RL V C | CTRL |
| PSU Unprogrammed | Power supply unit was un-programmed. | N U UR E RL V C | CTRL |
| Ptcl Map Updated | Protocol map was updated. | N U UR E RL V C | PTCL |
| Quick Key # Changed | Quick Key changed. | N U UR E RL V C | CTRL |

**Table 122 List of Events (Continued)**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| Radio Batt Charger | Radio Supply voltage reached the minimum voltage. | N U UR E RL V C | CTRL |
| Radio Hold #### min | Amount of time radio power supply was set to hold up after the loss of auxiliary power. | N U UR E RL V C | CTRL |
| Radio OFF Requested | Request to remove the power supply from the radio was made. | N U UR E RL V C | CTRL |
| Radio ON Requested | Request to restore the power supply to the radio was made. | N U UR E RL V C | CTRL |
| Radio Shutdown | The radio power supply was shutdown. | N U UR E RL V C | CTRL |
| Radio Supply ##V | The voltage to supply to the radio. | N U UR E RL V C | CTRL |
| Radio Supply FAILED | The radio power supply failed. | N U UR E RL V C | CTRL |
| Radio Supply OFF | The radio power supply was turned OFF. | N U UR E RL V C | CTRL |
| Radio Supply ON | The radio power supply was turned ON. | N U UR E RL V C | CTRL |
| RDI Not/Available | RS232 RDI interface driver was made available or not available. | N U UR E RL V C | PTCL |
| Reclose Time #####s | Time delay in seconds after a trip before reclosing. | N U UR E RL V C | PRTN |
| Recovery Tout ####s | The time period allocated for the recovery of the voltage to Normal after an Under/Over voltage trip. | N U UR E RL V C | PRTN |
| Recovery Tout OFF | Monitoring of the time for the recovery of the voltage to Normal after an Under/Over voltage trip is OFF. | N U UR E RL V C | PRTN |
| Remote Control ON | A local operator put the controller in RM. See Local and Remote Control Modes, page 50. | N U UR E RL V C | CTRL |
| Repeat First ##### | Number of preamble first characters to repeat on this communications port. | N U UR E RL V C | PTCL |
| Resend Wait ####ms | All RDI Data messages are as per the RDI specification. | N U UR E RL V C | PTCL |
| Reset Database | Indicates that the databases have been reset and a default database used. | N U UR E RL V C | CTRL |
| Reset Flags | The quick key was configured to reset the trip/protection flags. | N U UR E RL V C | CTRL |
| Retry Delay ###s | MITS Protocol retry delay between change of state (COS) attempts. | N U UR E RL V C | PTCL |
| Rev AutoReclose OFF | Reverse directional protection automatic reclose OFF. See Directional Protection, page 249. | N U UR E RL V C | PRTN |
| Rev AutoReclose ON | Reverse directional protection automatic reclose ON. See Directional Protection, page 249. | N U UR E RL V C | PRTN |
| Rev AutoRestore OFF | Auto Restore was turned OFF for the reverse protection group by a local or remote operator. See Auto Restore, page 251. | N U UR E RL V C | PRTN |
| Rev AutoRestore ON | Auto Restore was turned ON for the reverse protection group by a local or remote operator. See Auto Restore, page 251. | N U UR E RL V C | PRTN |
| Rev Cold Load | Quick key configured to operate the reverse direction cold load. | N U UR E RL V C | CTRL |
| Rev Earth Blocked | Directional protection blocked on reverse earth current. See Earth Fault Directional Blocking, page 228. | N U UR E RL V C | PRTN |
| Rev Earth Prot Trip | Protection trip on reverse flowing earth current. | N U UR E RL V C | PRTN |
| Rev NPS Blocked | Directional protection blocked on reverse negative phase sequence current. See Negative Phase Sequence Directional Blocking, page 245. | N U UR E RL V C | PRTN |
| Rev NPS Prot Trip | Protection trip on reverse flowing negative phase sequence current. | N U UR E RL V C | PRTN |
| Rev Phase Blocked | Directional protection blocked on reverse phase current. See Phase Overcurrent Directional Blocking, page 226. | N U UR E RL V C | PRTN |
| Rev Phase Prot Trip | Protection trip on reverse flowing phase current. | N U UR E RL V C | PRTN |
| Rev SEF Blocked | Directional protection blocked on reverse sensitive earth fault current. See Sensitive Earth Fault Directional Blocking, page 363. | N U UR E RL V C | PRTN |
| Rev SEF Prot Trip | Protection trip on reverse flowing sensitive earth fault current. See Sensitive Earth Fault Directional Blocking, page 363. | N U UR E RL V C | PRTN |
| Rev Sequence Adv | Directional protection sequence advance in the reverse direction. See Sequence Control, page 206. | N U UR E RL V C | PRTN |

**Table 122 List of Events (Continued)**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| RL2 Series Switch | RL Series Switch | N U UR E RL V C | CTRL |
| Rst Curve Available | The Reset Curves Feature is Available for use. | N U UR E RL V C | CTRL |
| Rst Curve Not Avail | The Reset Curves Feature is NOT Available for use. | N U UR E RL V C | CTRL |
| RTS ENABLED/ DISABLED | RS232 port Request to Send signal disabled/enabled. | N U UR E RL V C | PTCL |
| Rx Bytes ########## | Number of bytes received by trace utility. | N U UR E RL V C | PTCL |
| Rx Count ########## | For the communications trace utility, the number of byte groups received. Note this does not necessarily relate to packets. | N U UR E RL V C | PTCL |
| Rx Sync Err #### | The number of messages received with unrecognized frame type or a second octet that is not correct according to the FT1.2 format. | N U UR E RL V C | PTCL |
| Rx TO Err ######## | The number of times that the total receive time, Frame TO, for the frame is exceeded. | N U UR E RL V C | PTCL |
| Sag for ######s | A Sag event of this duration occurred. See Sag and Swell, page 516. | N U UR E RL V C | PQ |
| Sag Monitor OFF | Sag Monitoring is turned OFF. See Sag and Swell, page 516. | N U UR E RL V C | PQ |
| Sag Monitor ON | Sag Monitoring is turned ON. See Sag and Swell, page 516. | N U UR E RL V C | PQ |
| Sag to ####pu | A Sag event to this per unit level occurred. See Sag and Swell, page 516. | N U UR E RL V C | PQ |
| Sag/Swell Available | Sag/Swell Monitoring was made available. See Sag and Swell, page 516. | N U UR E RL V C | PQ |
| Sag/Swell Not Avail | Sag/Swell Monitoring was made Not available. See Sag and Swell, page 516. | N U UR E RL V C | PQ |
| Sag/Swell Reset | All Sag and Swell measurement counters have been reset to zero. See Sag and Swell, page 516. | N U UR E RL V C | PQ |
| Save Profile | The settings of the database are being saved as a profile. | N U UR E RL V C | CTRL |
| SCEM Corrupted | Data in the SCEM (switch cable entry module) was corrupted. | N U UR RL | SWGR |
| SCEM Memory Fail | SCEM memory failure. | N U UR RL | SWGR |
| SCEM Type 93C46 | SCEM was type 93C46. | N U UR | SWGR |
| SCEM Type SCEM11 | SCEM was type 11. | U UR | SWGR |
| SCEM Type SCEM11P | SCEM was type 11P. | N, RL | SWGR |
| SCEM Type SCEM9 | SCEM was type 9. | U UR | SWGR |
| SCEM Type Unknown | SCEM type was unknown. | N U UR E RL V C | SWGR |
| SCEM Write Fail | Controller was unable to write switchgear data to the SCEM. | N U UR E RL V C | SWGR |
| Section ON/OFF | For an AS, the Sectionaliser mode is either Auto or Off. | RL | CTRL |
| SEF Available | Sensitive earth fault protection was made available. See Sensitive Earth Fault (SEF), page 193. | N U UR E RL V C | PRTN |
| SEF Definite #####s | Sensitive earth fault protection after a definite time after pickup. Also applicable to work tag and single shot protection. See Sensitive Earth Fault (SEF), page 193. | N U UR E RL V C | PRTN |
| SEF Dir Arm | A SEF pickup occurred and tripping was enabled in the faulted direction. The trip could take place as normal. This event can only occur with Directional Blocking ON. See Sensitive Earth Fault Directional Protection, page 266. | N U UR E RL V C | PRTN |
| SEF Dir Block | A SEF pickup occurred but tripping was blocked in the faulted direction. The circuit breaker would not trip. This event can only occur with Directional Blocking ON. See Sensitive Earth Fault Directional Blocking, page 363. | N U UR E RL V C | PRTN |
| SEF Fault #### Amp | A Sensitive Earth Fault was detected. | RL | PRTN |
| SEF Low Vzps | An SEF overcurrent trip occurred with a low Vzps condition present. See Sensitive Earth Fault Directional Protection, page 266. | N U UR E RL V C | PRTN |
| SEF Low Vzps Arm | A SEF protection pickup occurred and tripping was enabled because the residual voltage (Vo) was less than the user-specified level and Low Vo | N U UR E RL V C | PRTN |

**Table 122 List of Events (Continued)**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| | blocking was OFF. The trip could take place as normal. This event can only occur with Directional Blocking ON. See Sensitive Earth Fault Directional Blocking, page 363. | | |
| SEF Low Vzps Block | A SEF protection pickup occurred and tripping was blocked because the residual voltage (Vo) was less than the user-specified level and Low Vo blocking was ON. The circuit breaker would not trip. This event can only occur with Directional Blocking ON. See Sensitive Earth Fault Directional Blocking, page 363. | N U UR E RL V C | PRTN |
| SEF Low Vzps Fwd | A SEF pickup would occur in the forward direction if there was a low Vzps. See Sensitive Earth Fault Directional Protection, page 266. | N U UR E RL V C | PRTN |
| SEF Low Vzps Rev | A SEF pickup would occur in the reverse direction if there was a low Vzps. See Sensitive Earth Fault Directional Protection, page 266. | N U UR E RL V C | PRTN |
| SEF Not Available | Sensitive earth fault protection was made not available. See Sensitive Earth Fault Directional Protection, page 266. | N U UR E RL V C | PRTN |
| SEF Prot OFF | Sensitive earth fault protection was set OFF. See Sensitive Earth Fault Directional Protection, page 266. | N U UR E RL V C | PRTN |
| SEF Prot ON | Sensitive earth fault protection was set ON. See Sensitive Earth Fault Directional Protection, page 266. | N U UR E RL V C | PRTN |
| SEF Prot Trip | A protection trip was generated by the SEF overcurrent protection element. See Sensitive Earth Fault Directional Protection, page 266 . | N U UR E RL V C | PRTN |
| SEF Trip #### Amp | Sensitive earth fault trip current in Amperes. See Sensitive Earth Fault Directional Protection, page 266. | N U UR E V C | PRTN |
| SEF Trips Lockout # | The number of sensitive earth fault trips to lockout. See Sensitive Earth Fault Directional Protection, page 266. | N U UR E RL V C | PRTN |
| SEF Vzps No Action | No action due to a Sensitive earth fault if Vzps was too low. See Sensitive Earth Fault Directional Protection, page 266. | N U UR E RL V C | PRTN |
| Select/Exec TO ###s | For IEC60870-5-101/4, the maximum time in seconds between the controller receiving a Select command and receiving an Execute command for the command to be valid. | N U UR E RL V C | PTCL |
| Select/Op #####ms | For DNP3, the maximum time permitted in milliseconds, between receiving a select command message and an operate command message from the master station for the control action to be deemed valid. | N U UR E RL V C | PTCL |
| Send Class ALL | For DNP3, unsolicited response class reporting. All available events, irrespective of class, would be included in the unsolicited message. | N U UR E RL V C | PTCL |
| Send Class PRIORITY | For DNP3, unsolicited response class reporting. Any events available of equal or higher priority are sent. | N U UR E RL V C | PTCL |
| Send Class READY | For DNP3, unsolicited response class reporting. Only the events of that class are reported. | N U UR E RL V C | PTCL |
| Seq Comp Available | Sequence components measurements are available. | N U UR E RL V C | CTRL |
| Seq Comp Not Avail | Sequence components measurements are not available. | N U UR E RL V C | CTRL |
| Seq Reset Time ###s | Auto reclose sequence reset time in seconds. | N U UR E RL V C | PRTN |
| Seq:Reset Flags OFF | Sequence Reset Flags are disabled. | N U UR E RL V C | CTRL |
| Seq:Reset Flags ON | Sequence Reset Flags are enabled. | N U UR E RL V C | CTRL |
| Sequence Advance | With sequence control ON, this event was generated when the sequence counter advanced due to a downstream fault which did not cause a protection trip. See Sequence Control, page 206. | N U UR E RL V C | PRTN |
| Sequence OFF | Automatic reclose sequence control was disabled. See Sequence Control, page 206. | N U UR E RL V C | PRTN |
| Sequence ON | Automatic reclose sequence control was enabled. See Sequence Control, page 206. | N U UR E RL V C | PRTN |
| Sequence Reset | The sequence reset timer expired. This causes the protection relay to reset to the start of the circuit breaker sequence for the next fault. See Sequence Control, page 206. | N U UR E RL V C | PRTN |
| Set PT Cmd ### | The base address for the Set Point Command objects. | N U UR E RL V C | PTCL |

**Table 122 List of Events (Continued)**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| $SF_6$ Pressure High | Sulphur hexafluoride ($SF_6$) gas pressure was high. | N RL | SWGR |
| $SF_6$ Pressure Low | Sulphur hexafluoride ($SF_6$) gas pressure low. | N RL | SWGR |
| $SF_6$ Pressure Normal | Sulphur hexafluoride ($SF_6$) gas pressure was normal. | N RL | SWGR |
| Sim Sawtooth Wave | Simulated data was set to a saw-tooth wave. | N U UR E RL V C | CTRL |
| Sim Sine Wave ON | Simulated data was set to a sine wave. | N U UR E RL V C | CTRL |
| Sim Square Wave ON | Simulated data was set to a square wave. | N U UR E RL V C | CTRL |
| Sim Triangle Wave | Simulated data was set to a triangle wave. | N U UR E RL V C | CTRL |
| Simulation OFF | Waveform simulation was set OFF. See Waveform Capture, page 501. | N U UR E RL V C | CTRL |
| Single Cmd ### | The base address of the Single Command objects. | N U UR E RL V C | PTCL |
| Single Pts ### | The base address of the Single Point Command objects. | N U UR E RL V C | PTCL |
| Single Shot | A trip occurred whilst in Single Shot Mode. See Active Trip, page 164. | N U UR E RL V C | PRTN |
| Single Shot Trip ## | Single shot active trip number. | N U UR E RL V C | PRTN |
| Slave Port # | DNP3 TCP/IP Slave port number. | N U UR E RL V C | PTCL |
| SOM Not/Available | Supply outage monitoring feature was made available or not available. | N U UR E RL V C | PQ |
| SOS Multi Not/Avail | SOS Multi-drop feature not available or available. | N U UR E RL V C | PTCL |
| Source... Load... | The operator (local or remote) changed the power flow direction. See Power Flow Direction, page 155. | N U UR E RL V C | CTRL |
| Source Out... | The accumulated time the source side terminals have experienced an outage. | N U UR E RL V C | PQ |
| Source Supply ON/OFF | All configured source side voltages are ON or OFF. See Voltage Measurement, page 153. | N U UR E RL V C | NWRK PRTN |
| SS Reset Time ####s | Single shot protection reset time in seconds. | N U UR E RL V C | PRTN |
| Start at Pickup | Reset curves start when the measured current drops below the Pickup value. | N U UR E RL V C | PRTN |
| Start at Rst Thresh | Reset curves start when the measured current drops below the reset threshold value. | N U UR E RL V C | PRTN |
| Start Day ## | Daylight saving's start day of the start month. | N U UR E RL V C | PTCL |
| Start Month ## | Daylight saving's start month. | N U UR E RL V C | PTCL |
| Station Addr ### | MITS Protocol station address number. | N U UR E RL V C | PTCL |
| Stop bits # | The number of RS232 stop bits for a communications port. | N U UR E RL V C | PTCL |
| Sub ### | The IP subnet mask address for the controller. | N U UR E RL V C | CTRL |
| Supply Timeout ###s | Time in seconds the lines must be live/dead before changing live/dead state. | N U UR E RL V C | CTRL PRTN |
| SW Inconsistent | Software installed in the CAPE and the PSU are inconsistent. New code should be installed via WSOS5's PowerLogic Loader. | N U UR E RL V C | CTRL |
| SW Load Aborted | Software load was aborted. | N U UR E RL V C | CTRL |
| SW Load Completed | Software load was completed. | N U UR E RL V C | CTRL |
| SW Load Flash Write | Software load flash write in progress. | N U UR E RL V C | CTRL |
| SW Load Starting | Software load process was started. | N U UR E RL V C | CTRL |
| Swell for ######s | A Swell event of this duration occurred. See Sag and Swell, page 516 . | N U UR E RL V C | PQ |
| Swell Monitor OFF | Swell Monitoring is turned OFF. See Sag and Swell, page 516 . | N U UR E RL V C | PQ |
| Swell Monitor ON | Swell Monitoring is turned ON. See Sag and Swell, page 516 . | N U UR E RL V C | PQ |
| Swell to ####pu | A Swell event to this per unit level occurred. See Sag and Swell, page 516 . | N U UR E RL V C | PQ |
| SWGM Unprogrammed | SWGM was un-programmed. | N U UR E RL V C | CTRL |

**Table 122 List of Events (Continued)**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| Switch Closed | On power up and switch re-connection the circuit breaker was measured as closed. | N U UR E RL V C | SWGR |
| Switch Connected | Switchgear was connected to the controller. | N U UR E RL V C | SWGR |
| Switch Disconnected | Switchgear was disconnected from the controller. | N U UR E RL V C | CTRL SWGR |
| Switch Open | On power up and switch re-connection the circuit breaker was measured as open. | N U UR E RL V C | SWGR |
| Switch S/N #### | Switchgear with serial number #### was connected. | N U UR E RL V C | SWGR |
| Switch Unsupported | Switchgear connected was unsupported. | N U UR E RL V C | CTRL SWGR |
| System Freq 50Hz | Nominal system frequency was 50Hz. | N U UR E RL V C | CTRL |
| System Freq 60Hz | Nominal system frequency was 60Hz. | N U UR E RL V C | CTRL |
| t0:Connect TO ###s | Seconds to try an *Active Open* before starting another Active Open | N U UR E RL V C | PTCL |
| t1:Confirm TO ###s | Seconds the controller will wait for an outstanding confirmation. | N U UR E RL V C | PTCL |
| t2:Ack TO ###s | Time the receiving station will hold-off sending an acknowledgement. | N U UR E RL V C | PTCL |
| t3:Idle TO ######s | Seconds before a test message is transmitted - zero means NO message. | N U UR E RL V C | PTCL |
| Target ############ | Communication trace target port. See Waveform Capture, page 501. | N U UR E RL V C | PTCL |
| TCP/IP Port ###### | The TCP/IP port number defined for IEC104 on this controller. | N U UR E RL V C | PTCL |
| TCP/IP Un/Available | TCP/IP communications available or not available. | N U UR E RL V C | PTCL |
| Terminals A/B/C | The phase designation that corresponds to terminals U (I), V (II), W (III) is A/B/C. | N U UR E RL V C | CTRL |
| Terminals A/C/B | The phase designation that corresponds to terminals U (I), V (II), W (III) is A/C/B. | N U UR E RL V C | CTRL |
| Terminals B/A/C | The phase designation that corresponds to terminals U (I), V (II), W (III) is B/A/C. | N U UR E RL V C | CTRL |
| Terminals B/C/A | The phase designation that corresponds to terminals U (I), V (II), W (III) is B/C/A. | N U UR E RL V C | CTRL |
| Terminals C/A/B | The phase designation that corresponds to terminals U (I), V (II), W (III) is C/A/B. | N U UR E RL V C | CTRL |
| Terminals C/B/A | The phase designation that corresponds to terminals U (I), V (II), W (III) is C/B/A. | N U UR E RL V C | CTRL |
| Test ABORT | Battery test aborted. See Battery Testing, page 521. | N U UR E RL V C | CTRL |
| Test Batt | Quick key configured to access the battery test. | N U UR E RL V C | CTRL |
| Test OFF | The battery test was turned OFF. See Battery Testing, page 521. | N U UR E RL V C | CTRL |
| Test START | The battery test started. See Battery Testing, page 521. | N U UR E RL V C | CTRL |
| Test Status AUTO | The battery test was set to operate automatically. See Battery Testing, page 521. | N U UR E RL V C | CTRL |
| Test Status OFF | The battery test was turned OFF. See Battery Testing, page 521. | N U UR E RL V C | CTRL |
| Test Time ##### | The time of day to operate the automatic battery test. See Battery Testing, page 521. | N U UR E RL V C | CTRL |
| Tie ACR | Tie ACR type defined for loop automation. | N U UR E RL V C | PRTN |
| TieRestore Both ways | Loop automation Tie restore supply for loss of load or source supply. See Asymmetric Tie Operation, page 438. | N U UR E RL V C | PRTN |
| TieRestore One way | Loop automation Tie restore supply for loss of load supply. See Asymmetric Tie Operation, page 438. | N U UR E RL V C | PRTN |
| Time Dly Rq ####min | The amount of time, in minutes, after the last master station time synchronisation message that the controller was set to wait before setting the *Time Synchronisation Required* internal indication bit (IIN1-4). This bit is sent to the master station in every controller DNP3 message. | N U UR E RL V C | PTCL |

### Table 122 List of Events (Continued)

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| Time Mult #### | Protection curve time multiplier. Multiplies the time to trip. | N U UR E RL V C | PRTN |
| Time size 24 | The time tags reported by IEC60870-5-101/4 are set for 24 bits. | N U UR E RL V C | PTCL |
| Time size 56 | The time tags reported by IEC60870-5-101/4 are set for 56 bits. | N U UR E RL V C | PTCL |
| Timeout #### Min | Communications trace timeout in minutes. This was the maximum duration of the trace. | N U UR E RL V C | PTCL |
| Timing | One or more protection elements were timing. | N U UR E RL V C | PRTN |
| Timing Fwd/Rev | One or more protection elements in this direction were timing. | N U UR E RL V C | PRTN |
| Trace Available | Communications trace was made available. | N U UR E RL V C | PTCL |
| Trace Not Available | Communications trace was not made available. | N U UR E RL V C | PTCL |
| Trip after # faults | The number of supply interrupts (faults) the AS must see before it performs a sectionaliser trip. | RL | PRTN |
| Trip Angle #### Deg | Directional protection trip angle (in degrees) between the voltage and current. | N U UR E RL V C | PRTN |
| Trip Blocking OFF | Trip blocking was disabled. The circuit breaker would now trip when requested. | N U UR E RL V C | CTRL |
| Trip Blocking ON | The circuit breaker was prevented from tripping. | N U UR E RL V C | CTRL SWGR |
| Trip Fwd | Directional Blocking would allow tripping in the forward direction. This could be applied to phase, earth, SEF, and NPS protection. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Trip Fwd & Rev | Directional Blocking would allow tripping in the either direction. This could be applied to phase, earth, SEF, and NPS protection. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Trip Rev | Directional Blocking would allow tripping in the reverse direction. This could be applied to phase, earth, SEF, and NPS protection. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Trips to Lockout ## | Number of protection trips to lockout. | N U UR E RL V C | PRTN |
| Tx Bytes ######### | Communications trace count of transmitted bytes. | N U UR E RL V C | PTCL |
| Tx Count ######### | For the communications trace utility, the number of byte groups transmitted. Note this does not necessarily relate to packets. | N U UR E RL V C | PTCL |
| Tx Delay #####ms | For DNP3, additional time in milliseconds, between receiving a request and sending a response. | N U UR E RL V C | PTCL |
| U/F Normal ###Hz | Under frequency protection's normal frequency in Hertz. See Under and Over Voltage Protection (UOV), page 278. | N U UR E RL V C | PRTN |
| U/F Trip at ###Hz | Under frequency protection trip this frequency in Hertz. See Under and Over Voltage Protection (UOV), page 278. | N U UR E RL V C | PRTN |
| U/F Trip ON/OFF | Under frequency protection trip was enabled or disabled. See Under and Over Voltage Protection (UOV), page 278. | N U UR E RL V C | PRTN |
| U/O Freq Available | Under/Over frequency protection was made available. See Under and Over Voltage Protection (UOV), page 278. | N U UR E RL V C | PRTN |
| U/O Freq Not Avail | Under/Over frequency protection was not made available. See Under and Over Voltage Protection (UOV), page 278. | N U UR E RL V C | PRTN |
| Under Freq Pickup | Measured frequency was equal to or below the under frequency threshold. See Under and Over Voltage Protection (UOV), page 278. | N U UR E RL V C | PRTN |
| Under Freq Reset | The measured frequency rose to equal or above the Under Frequency trip threshold plus the dead band. See Under and Over Voltage Protection (UOV), page 278. | N U UR E RL V C | PRTN |
| Under Freq Trip | The measured frequency was equal to or below the Under Frequency threshold for the Trip Delay count and a trip request was issued. See Under and Over Voltage Protection (UOV), page 278. | N U UR E RL V C | PRTN |
| Unknown | Batt Test Aborted because of an unknown reason | N U UR E RL V C | CTRL |
| Unsol Delay ######s | For DNP3, unsolicited response retry delay in seconds. | N U UR E RL V C | PTCL |

**Table 122 List of Events (Continued)**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| Unsol Retries ### | For DNP3, maximum number of attempts to re-transmit an unsolicited response without getting a confirmation from the master. | N U UR E RL V C | PTCL |
| Unsolicited FORCED | For DNP3, the controller would transmit unsolicited response change of state events immediately without waiting for the *Enable Unsolicited Messages* command from the master station. | N U UR E RL V C | PTCL |
| Unsolicited OFF | For DNP3, unsolicited messages from the controller are disabled. | N U UR E RL V C | PTCL |
| Unsolicited ON | For DNP3, unsolicited messages from the controller are enabled. | N U UR E RL V C | PTCL |
| UOV Available | Under/Over Voltage protection was made available. See Under and Over Voltage Protection (UOV), page 278. | N U UR E RL V C | PRTN |
| UOV Not Avail | Under/Over Voltage protection was made unavailable. See Under and Over Voltage Protection (UOV), page 278. | N U UR E RL V C | PRTN |
| UV Excess Seq | Under Voltage Protection excess sequences. | N U UR E RL V C | PRTN |
| UV Pickup | The measured voltage was equal to or below the under voltage threshold. | N U UR E RL V C | PRTN |
| UV Protection OFF | Under Voltage protection is turned off. See Under and Over Voltage Protection (UOV), page 278. | N U UR E RL V C | PRTN |
| UV Protection ON | Under Voltage protection is turned on. See Under and Over Voltage Protection (UOV), page 278. | N U UR E RL V C | PRTN |
| UV Reset | The measured voltage rose to equal or above the Under voltage trip threshold plus the dead band. | N U UR E RL V C | PRTN |
| UV Trip | The measured voltage was equal to or below the Under Voltage threshold for the Trip Delay count and a trip request was issued. | N U UR E RL V C | PRTN |
| V Series Switch | V Series switchgear connected. | V C | CTRL |
| V/I a/b/c/e: THD #.#% | Harmonic analysis alarm ON. Total harmonic distortion of #.#%. See Harmonic Analysis, page 511. | N U UR E RL V C | PQ |
| V/I a/b/c: THD OFF | Harmonic analysis alarm OFF. Below total harmonic distortion level. See Harmonic Analysis, page 511. | N U UR E RL V C | PQ |
| Very/Ext Inv IEC255, Definite Time, Instantaneous Only, Mod/Very/Ext Inv IEEE, TCC### | Different curve selected for Earth, NPS, Phase, Work Tag or Single Shot Protection. | N U UR E RL V C | PQ PRTN |
| Vnps ##### Volt | Directional Blocking measure of negative phase sequence volts. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| VWE/VWVE Emulator | SCEM type was VWE/VWVE Emulator. | N U UR E RL V C | SWGR |
| Vzps ##### Volt | Directional Blocking measure of zero phase sequence voltage at the time of maximum earth or SEF current. This event can only occur with Directional Blocking ON. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Vzps Bal DISABLED | Directional Blocking zero phase sequence voltage balancing disabled. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Vzps Bal ENABLED | Directional Blocking zero phase sequence voltage balancing enabled. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| w:Max Unack ### | Maximum number of unacknowledged I-Format APDU received. | N U UR E RL V C | PTCL |
| Wave Capt Avail | Waveform capture was made available. See Waveform Capture, page 501. | N U UR E RL V C | PQ |
| Wave Capt Not Avail | Waveform capture was not made available. See Waveform Capture, page 501. | N U UR E RL V C | PQ |
| Wave Capture OFF | Waveform capture was set OFF. See Waveform Capture, page 501. | N U UR E RL V C | PQ |
| Wave Capture ON | Waveform capture was set ON. See Waveform Capture, page 501. | N U UR E RL V C | PQ |
| Under Freq Reset | The measured frequency rose to equal or above the Under Frequency trip threshold plus the dead band. See Under and Over Voltage Protection (UOV), page 278. | N U UR E RL V C | PRTN |

**Table 122 List of Events (Continued)**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| Under Freq Trip | The measured frequency was equal to or below the Under Frequency threshold for the Trip Delay count and a trip request was issued. See Under and Over Voltage Protection (UOV), page 278. | N U UR E RL V C | PRTN |
| Unknown | Batt Test Aborted because of an unknown reason | N U UR E RL V C | CTRL |
| Unsol Delay ######s | For DNP3, unsolicited response retry delay in seconds. | N U UR E RL V C | PTCL |
| Unsol Retries ### | For DNP3, maximum number of attempts to re-transmit an unsolicited response without getting a confirmation from the master. | N U UR E RL V C | PTCL |
| Unsolicited FORCED | For DNP3, the controller would transmit unsolicited response change of state events immediately without waiting for the *Enable Unsolicited Messages* command from the master station. | N U UR E RL V C | PTCL |
| Unsolicited OFF | For DNP3, unsolicited messages from the controller are disabled. | N U UR E RL V C | PTCL |
| Unsolicited ON | For DNP3, unsolicited messages from the controller are enabled. | N U UR E RL V C | PTCL |
| UOV Available | Under/Over Voltage protection was made available. See Under and Over Voltage Protection (UOV), page 278. | N U UR E RL V C | PRTN |
| UOV Not Avail | Under/Over Voltage protection was made unavailable. See Under and Over Voltage Protection (UOV), page 278. | N U UR E RL V C | PRTN |
| UV Excess Seq | Under Voltage Protection excess sequences. | N U UR E RL V C | PRTN |
| UV Pickup | The measured voltage was equal to or below the under voltage threshold. | N U UR E RL V C | PRTN |
| UV Protection OFF | Under Voltage protection is turned off. See Under and Over Voltage Protection (UOV), page 278. | N U UR E RL V C | PRTN |
| UV Protection ON | Under Voltage protection is turned on. See Under and Over Voltage Protection (UOV), page 278. | N U UR E RL V C | PRTN |
| UV Reset | The measured voltage rose to equal or above the Under voltage trip threshold plus the dead band. | N U UR E RL V C | PRTN |
| UV Trip | The measured voltage was equal to or below the Under Voltage threshold for the Trip Delay count and a trip request was issued. | N U UR E RL V C | PRTN |
| V Series Switch | V Series switchgear connected. | V C | CTRL |
| V/I a/b/c/e: THD #.#% | Harmonic analysis alarm ON. Total harmonic distortion of #.#%. See Harmonic Analysis, page 511. | N U UR E RL V C | PQ |
| V/I a/b/c: THD OFF | Harmonic analysis alarm OFF. Below total harmonic distortion level. See Harmonic Analysis, page 511. | N U UR E RL V C | PQ |
| Very/Ext Inv IEC255, Definite Time, Instantaneous Only, Mod/Very/Ext Inv IEEE, TCC### | Different curve selected for Earth, NPS, Phase, Work Tag or Single Shot Protection. | N U UR E RL V C | PQ PRTN |
| Vnps ##### Volt | Directional Blocking measure of negative phase sequence volts. See *Directional Blocking (page 9-27)*. | N U UR E RL V C | PRTN |
| VWE/VWVE Emulator | SCEM type was VWE/VWVE Emulator. | V C | SWGR |
| Vzps ##### Volt | Directional Blocking measure of zero phase sequence voltage at the time of maximum earth or SEF current. This event can only occur with Directional Blocking ON. See *Directional Blocking (page 9-27)*. | N U UR E RL V C | PRTN |
| Vzps Bal DISABLED | Directional Blocking zero phase sequence voltage balancing disabled. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| Vzps Bal ENABLED | Directional Blocking zero phase sequence voltage balancing enabled. See Directional Blocking DIRB, page 347. | N U UR E RL V C | PRTN |
| w:Max Unack ### | Maximum number of unacknowledged I-Format APDU received. | N U UR E RL V C | PTCL |
| Wave Capt Avail | Waveform capture was made available. See Waveform Capture, page 501. | N U UR E RL V C | PQ |
| Wave Capt Not Avail | Waveform capture was not made available. See Waveform Capture, page 501. | N U UR E RL V C | PQ |
| Wave Capture OFF | Waveform capture was set OFF. See Waveform Capture, page 501. | N U UR E RL V C | PQ |

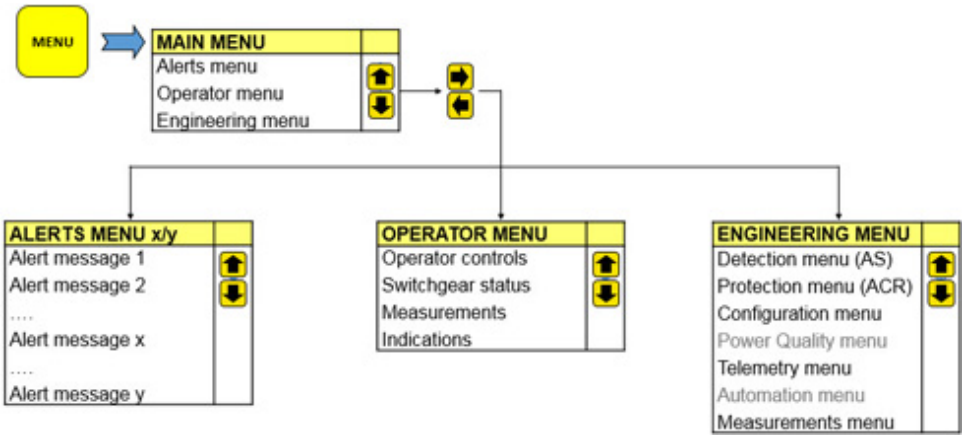
**Table 122 List of Events (Continued)**

| Event Text | Description | Switchgear | Category |
|---|---|---|---|
| Wave Capture ON | Waveform capture was set ON. See Waveform Capture, page 501. | N U UR E RL V C | PQ |
| Waveform Captured | Waveform data was captured. See Waveform Capture, page 501. | N U UR E RL V C | PQ |
| Waveform Playback | The simulation feature was playing back the captured waveform. See Waveform Capture, page 501. | N U UR E RL V C | CTRL |
| WCap Ratio ##### | Waveform capture ratio indicates the percentage prior to the trigger then the percentage after the trigger. See Waveform Capture, page 501. | N U UR E RL V C | PQ |
| WCap Window 0.5s | Waveform capture window was set to 0.5 s long. See Waveform Capture, page 501. | N U UR E RL V C | PQ |
| WCap Window 1s | Waveform capture window was set to 1 s long. See Waveform Capture, page 501. | N U UR E RL V C | PQ |
| WCap Window 2s | Waveform capture window was set to 2 s long. See Waveform Capture, page 501. | N U UR E RL V C | PQ |
| Work Tag | A work tag protection trip, or the quick key now controls the work tag. See Work Tag/Hot Line Tag, page 56. | N U UR E RL V C | CTRL<br>PRTN |
| Work Tag Applied | The Work Tag was applied. See Work Tag/Hot Line Tag, page 56. | N U UR E RL V C | CTRL<br>PRTN<br>SWGR |
| Work Tag OFF | The Work Tag was turned OFF. See Work Tag/Hot Line Tag, page 56. | N U UR E RL V C | PRTN<br>CTRL |
| Wrong Mode | When the switch was in a different mode (LOCAL, Remote or Work Tag Applied) to the device which attempted the close. See Local and Remote Control Modes, page 50, Hit and Run, page 55, Delayed Trip/Close Operation, page 54. | N U UR E RL V C | SWGR<br>CTRL |
| WSOS Close Req | WSOS initiated the close request. | N U UR E RL V C | SWGR |
| WSOS Trip Req | WSOS initiated the trip request. | N U UR E RL V C | SWGR |
| WSOS Un/Available | WSOS communications available or not available. | N U UR E RL V C | PTCL |

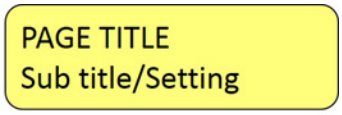
# Appendix J flexVUE Menu

## Appendix J.1 flexVUE Menu Structure

The ***flex*VUE** menu structure consists of a main menu and three sub-menus, Alerts, Operator, and Engineer.




The LCD display consists of 2 x 20 character lines. The top line is the page title and the bottom line could be either a sub title or a setting.




When the operator interface is turned on, or if the Menu key is pressed at any time while the operator interface is on, the display will go to the Main Menu with the Alerts Menu as the sub title.




Pressing the Right Arrow when this screen is displayed will navigate to the Alerts menu and display any alert that is active at the time.

Pressing the Down Arrow will display the Operator menu which can then be entered by pressing the Right Arrow.

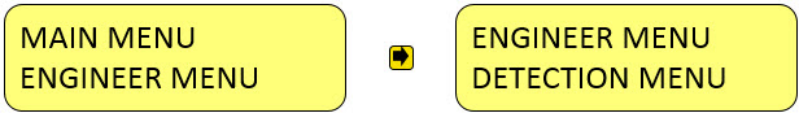



Pressing the Down Arrow again will display the Engineer menu which can then be entered by pressing the Right Arrow.

**ACR**




**AS**



The following table presents the procedure for finding a setting on the ***flex*VUE** O.I.:

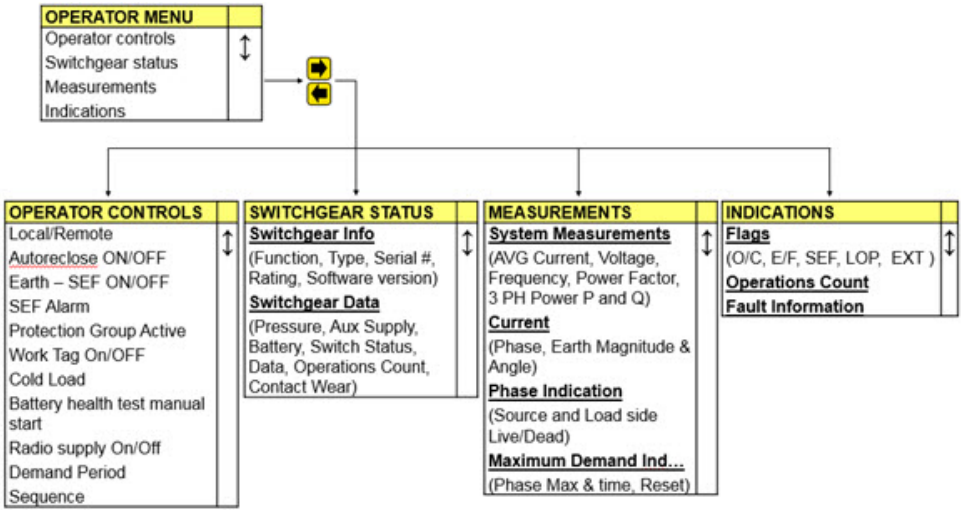
| Step | Action |
|---|---|
| 1 | Press **MENU** to bring up the menu navigation. |
| 2 | Use the **Up** and **Down** arrow keys to find the next required menu.<br><br>Example: **ENGINEER MENU** |
| 3 | Press **SELECT** or the **RIGHT** arrow key to enter the next menu in the navigation structure.<br><br>Example: **PROTECTION MENU** |
| 4 | Repeat steps 2 and 3 to continue through the indicated menu navigation.<br><br>Example: **DIRECTIONAL ELEMENTS > DIRECTIONAL BLOCKING > SEF** |
| 5 | Scroll through the settings (shown in title case) to the required setting.<br><br>Example: **Minimum $V_{zps}$** |
| 6 | For information on changing settings, refer to Chapter 4 Operator Functions. |

**NOTE:** On the ***flex*VUE** O.I. menu navigation, menus are shown in capitals and editable settings are shown in title case.

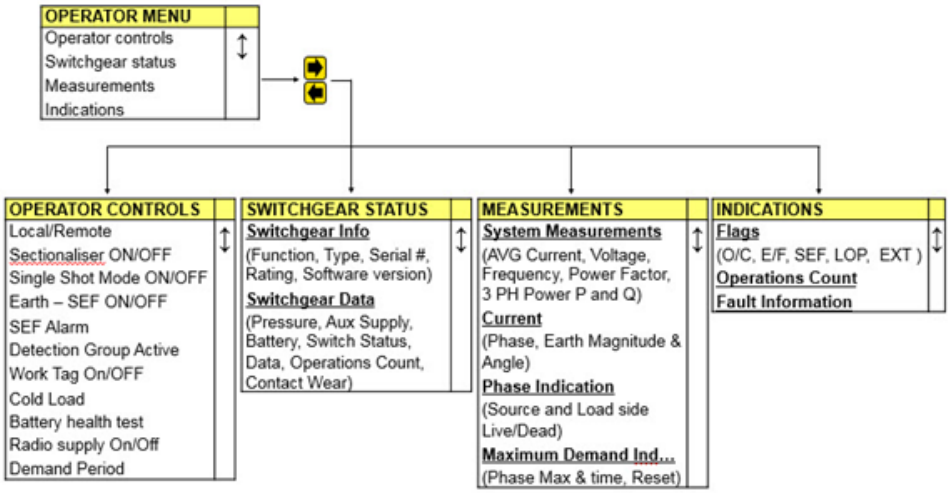
## Operator Menu

The **Operator** menu consists of four sub-menus, three of which have their own sub-menus.

**ACR**



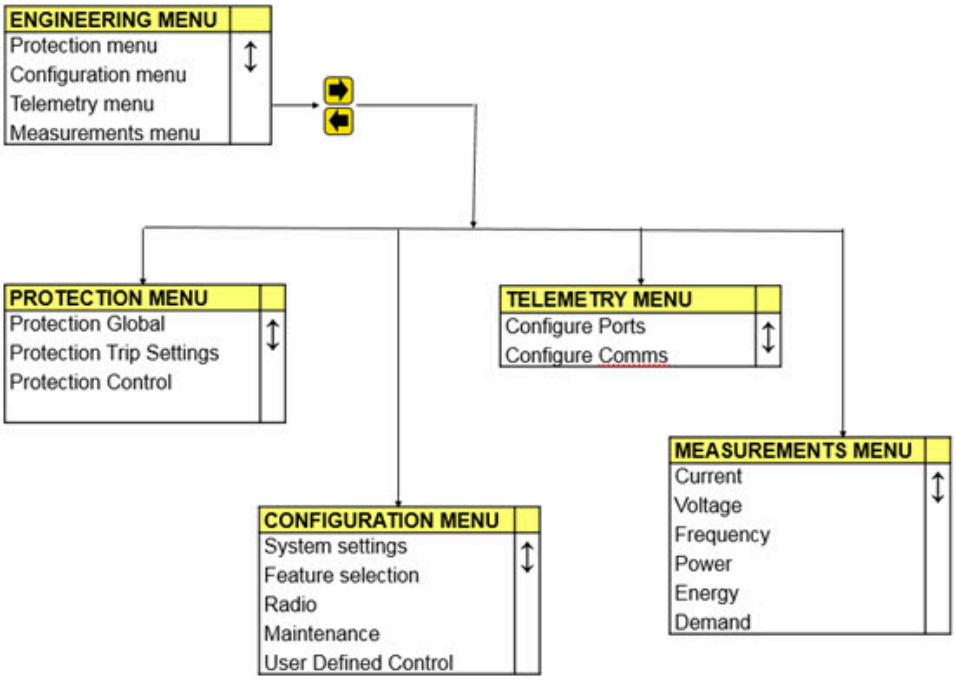
## AS



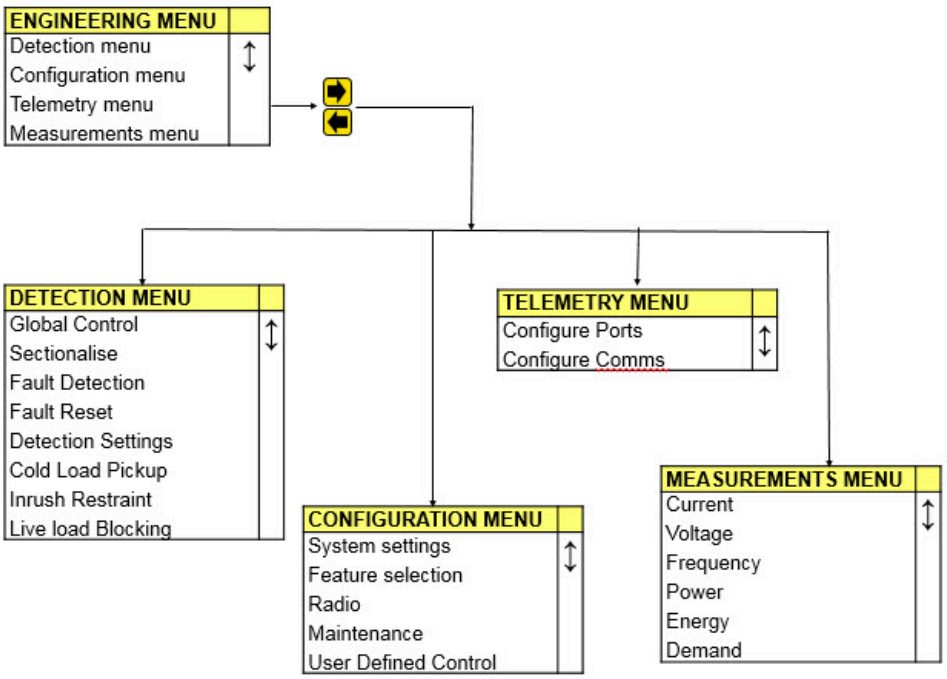

## Engineer Menu

The **Engineer** menu has four sub-menus all of which have further sub-menus. Two more sub-menus can be added.

## ACR



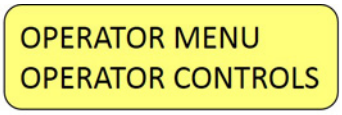
AS




# Appendix J.2 *flex*VUE Operator Menu Screens

## Operator Controls

The first sub-menu to be displayed when the Operator menu is entered is the Operator Controls. This sub-menu normally includes eleven settings pages with another 2 able to be added through feature selection.



### Table 123 *flex*VUE ACR Operator Controls

| Operator Menu → Operator Controls | | | |
|---|---|---|---|
| **Setting** | **Default** | **Additional** | **Feature Selected** |
| Control Mode | LOCAL CONTROL ON | | |
| Auto Reclose | Auto Reclose OFF | | |
| Phase Protection | Phase Protection ON | | Per Element Protection |
| Phase Mode | Phase Mode TRIP | | Per Element Protection |
| Earth Protection | Earth Protection OFF | | Per Element Protection |
| Earth Mode | Earth Mode TRIP | | Per Element Protection |
| SEF Protection | SEF Protection OFF | | Per Element Protection |
| SEF Mode | SEF Mode TRIP | | Per Element Protection |
| Earth/SEF Protection | E/F OFF, SEF OFF | | Per Element Protection Not Available |
| SEF Alarm | SEF Alarm OFF | | |
| NPS Protection | NPS Protection OFF | | Per Element Protection |
| NPS Mode | NPS Mode TRIP | | Per Element Protection |
| Negative Phase Sequence Protection | | NPS Protection OFF | Sequence Components Available<br><br>Per Element Protection Not Available |
| Active Protection Group | Protection **A** Active | | |
| Automatic Protection Group Selection | | APGS Change 60 s | Automatic Protection Group Selection Available |
| Work Tag status | Work Tag OFF | | |
| Cold Load status | COLD LOAD | | |
| Battery Health Test | Battery Test OFF, Ready | | |
| Radio Supply | Radio Supply OFF | | |
| Demand Period | Demand Period 15 min | | |
| Sequence | Single Shot Active | | |

**Table 124 *flex*VUE AS Operator Controls**

| Operator Menu → Operator Controls | | | |
|---|---|---|---|
| **Setting** | **Default** | **Additional** | **Feature Selected** |
| **Control Mode** | **LOCAL CONTROL ON** | | |
| Auto Sectionalise | Sectionaliser OFF | | |
| Single Shot | Single Shot Mode OFF | | |
| Phase Detection | Phase Detect ON | | Per Element Detection |
| Phase Mode | Phase Mode SECT | | Per Element Detection |
| Earth Detection | Earth Detect OFF | | Per Element Detection |
| Earth Mode | Earth Mode SECT | | Per Element Detection |
| SEF Detection | SEF Detect OFF | | Per Element Detection |
| SEF Mode | SEF Mode SECT | | Per Element Detection |
| Earth/SEF Protection | E/F OFF, SEF OFF | | Per Element Detection Not Available |
| SEF Alarm | SEF Alarm OFF | | |
| NPS Detection | NPS Detection OFF | | Per Element Detection |
| NPS Mode | NPS Mode SECT | | Per Element Detection |
| Negative Phase Sequence Detection | | NPS Detection OFF | Sequence Components Available<br><br>Per Element Detection Not Available |
| Active Detection Group | Detection A Active | | |
| Automatic Detection Group Selection | | ADGS Change 60 s | Automatic Detection Group Selection Available |
| Work Tag status | Work Tag OFF | | |
| Cold Load status | COLD LOAD | | |
| Battery Health Test | Battery Test OFF, Ready | | |
| Radio Supply | Radio Supply OFF | | |
| Demand Period | Demand Period 15 min | | |

## Switchgear Status (ACR and AS)

The Switchgear Status menu is divided into sub-menus for **Switchgear Info** and **Switchgear Data**.

Apart from the firmware version, the Switchgear Info menu includes information on the switchgear that does not change.




The pages are displayed in the following order:

**Table 125 *flex*VUE Switchgear Info**

| Operator Menu → Switchgear Status → Switchgear Info | |
|---|---|
| **Example** | **Description** |
| ACR Function | Switchgear function ACR or LBS |
| N Series Switch | Switchgear type N, E, U, W or RL |
| Switch S/N 137681 | Serial Number of the Switch |
| 12500 A Interruption | Rated interruption current |
| Rated 27,000 V | Rated voltage |
| 8000 A Continuous | Rated continuous current |
| Cubicle S/N 12345 | Serial Number of the Control Cubicle |
| Ver A50-00.01 | Firmware version |

The Switchgear Data menu includes information on the switchgear that could change over time. Contact wear is displayed using upper case letters indicating more information can be displayed by pressing the Right Arrow. The next level of the menu displays contact wear percentages for the three individual contacts.




The pages are displayed in the following order:

**Table 126 *flex*VUE Switchgear Data**

| Operator Menu → Switchgear Status → Switchgear Data | | |
|---|---|---|
| **First Level example** | **Second Level example** | **Description** |
| $SF_6$ Normal 38 kPag | | Gas Pressure (RL Series) |
| Aux Supply Normal | | Auxiliary Supply status |
| Battery Normal 27.0 V | | Battery Status and Voltage |
| Switch Connected | | Switchgear Status |
| Switch Data Valid | | Switchgear Data Status |
| OPS 0881 | | Operations Counter |
| CONTACT WEAR | U Contact 97.6% | U contact wear percentage |
| | V Contact 97.6% | V contact wear percentage |
| | W Contact 97.6% | W contact wear percentage |

## Measurements Menu (ACR and AS)

The Measurements menu is divided into four sub-menus for **System Measurements, Current, Phase Indication and Maximum Demand Indication.**

**System Measurements** is a summary of the three phase measurements.



**Table 127 *flex*VUE System Measurements**

| Operator Menu → Switchgear Status → Switchgear Data | |
|---|---|
| **Example** | **Description** |
| Current 100 A | Average value of the three phase currents. |
| Voltage 6350 V | Average value of the three phase – earth voltages.<br>Average value of three phase to Phase voltages can be displayed if configured. |
| Frequency 50.00 Hz | Frequency of the voltage on selected bushing. |
| Freq Src 50.00 Hz | Frequency of the voltage on the Source side. |
| Freq Load 50.00 Hz | Frequency of the voltage on the Load side. |
| PF 0.98 | Power Factor of the three phase system. |
| Power P 1876 kW | Three phase real power. |
| Power Q 331 kVAR | Three phase reactive power. |

## Current Menu

The Current menu displays the real time value and phase angle of the three phase and earth currents.




**Table 128 *flex*VUE Current Measurements**

| Operator Menu → Measurements Menu → Current | |
|---|---|
| **Example** | **Description** |
| A Ph 100 A -10° | 100 A A phase current lagging the A phase voltage by 10°. |
| B Ph 108 A 10° | 108 A B phase current leading the B phase voltage by 10°. |
| C Ph 94 A -10° | 94 A C phase current lagging the A phase voltage by 10°. |
| Earth 42 A 0° | 42 A Earth current in phase with the zero sequence voltage. |

## Phase Indication

The Phase Indication menu displays the Live/Dead status of the HV bushings according to the Live/Dead Indication setting which is 2000 V by default and has a setting range 2000...15,000 V.




**Table 129 *flex*VUE Phase Measurements**

| Operator Menu → Measurements Menu → Current | |
|---|---|
| **Example** | **Description** |
| A1 Live | Side 1 A Phase voltage to earth > Live/Dead Threshold. |
| A2 Live | Side 2 A Phase voltage to earth > Live/Dead Threshold. |
| B1 Dead | Side 1 B Phase voltage to earth < Live/Dead Threshold. |
| B2 Live | Side 2 B Phase voltage to earth > Live/Dead Threshold. |

**Table 129 *flex*VUE Phase Measurements (Continued)**

| Operator Menu → Measurements Menu → Current | |
|---|---|
| **Example** | **Description** |
| C1 Live | Side 1 C Phase voltage to earth > Live/Dead Threshold. |
| C2 Live | Side 2 C Phase voltage to earth > Live/Dead Threshold. |

## Maximum Demand Indicator Menu

The Maximum Demand Indicator menu displays the following information for each phase:

- Instantaneous phase current.
- Maximum phase current recorded since the last reset.
- The date and time that the maximum current was recorded.




**Table 130 *flex*VUE Maximum Demand Indications**

| Operator Menu → Measurement Menu → Maximum Demand Indicator | |
|---|---|
| **Example** | **Description** |
| A 40 A Max 100 A 21/11 16:27:15 | A Phase current is presently 40 A but a maximum of 100 A was recorded at 16:27:15 on 21/11 |
| B 56 A Max 108 A 21/11 16:27:15 | B Phase current is presently 56 A but a maximum of 108 A was recorded at 16:27:15 on 21/11 |
| C 50 A Max 100 A 21/11 16:27:15 | C Phase current is presently 50 A but a maximum of 100 A was recorded at 16:27:15 on 21/11 |

## The Indications Menu (ACR and AS)

The Indications menu includes Trip flags, operations counter and fault information.

If Protection is Off, Pickup Flags are displayed. An AS displays Fault flags. If a trip flag is set it indicates that element caused the most recent trip and the counter indicates the number of trips caused by that element since the last reset. If a pickup flag is set it indicates that element was the last one to pickup. A fault flag indicates which element detected a fault during the most recent sequence. Six pages are added for Interrupt Flags when Per Element Protection is available.




**Table 131 *flex*VUE Operator Menu Indications**

| Operator Menu → Indications | | |
|---|---|---|
| **First Level** | **Second Level** | **Description** |
| FLAGS | O/C □ 00 | Phase Overcurrent Element |
| | LOP □ 00(1) | Loss of Phase |
| | EXT □ 00(2),(1) | External Device |
| | E/F □ 00(1) | Earth Fault |
| | UOV □ 00(3) | Under/Over Voltage |
| | FRQ □ 00(4),(1) | Under/Over Frequency |

**Table 131 *flex*VUE Operator Menu Indications (Continued)**

| Operator Menu → Indications | | |
|---|---|---|
| **First Level** | **Second Level** | **Description** |
| | SEF □ 00 | Sensitive Earth Fault |
| | NPS □ 00(5) | Negative Phase Sequence |
| INTERRUPT FLAGS(6) | O/C A(6) □ | A Phase pickup and time out caused a supply interrupt. |
| | O/C B(6) □ | B Phase pickup and time out caused a supply interrupt. |
| | O/C C(6) □ | C Phase pickup and time out caused a supply interrupt. |
| | E/F(6) □ | E/F pickup and time out caused a supply interrupt. |
| | SEF(6) □ | SEF pickup and time out caused a supply interrupt. |
| | NPS(6) □ | NPS pickup and time out caused a supply interrupt. |
| OPS 0883 | | |
| Fault Information | No Fault | Type of fault that was last detected. For example, A-E, B-E, C-E, A-B, B-C, C-A, ABC |
| | Distance(7) | Distance to Fault in Km or Miles |
| | Impedance(7) | Fault impedance in Ohms |
| High $V^{zps}$ Alarm(8) | | |

(1) Not applicable for AS.

(2) Not displayed for Pickup flags.

(3) Only displayed when Under/Over Voltage protection is available.

(4) Only displayed when Under/Over Frequency protection is available.

(5) Only displayed when Sequence Components are available.

(6) Interrupt Flags are only displayed when Per Element Protection is available.

(7) Only displayed when Fault Locator is available.

(8) Only displayed when Directional Blocking or Directional Protection/Detection is On.

# Appendix J.3 *flex*VUE Engineer Menu Screens

## ACR

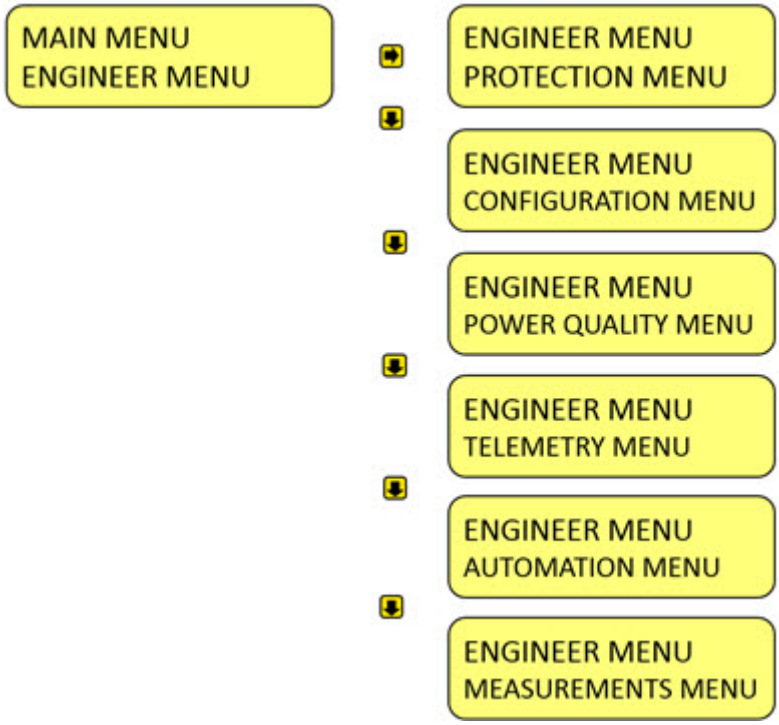
The Engineer menu for the ACR includes at least four sub-menus.

1. Protection Menu
2. Configuration Menu
3. Telemetry Menu
4. Measurement Menu

One or two more sub-menus can be added depending on which optional features are made available.

1. An Automation menu is added if either Loop Automation or Auto-Changeover are made available.
2. A Power Quality menu is added if one or more of the following four Power Quality features are made available.
   a. Supply Outage Measurement
   b. Waveform Capture
   c. Harmonic Analysis
   d. Sag and Swell Monitoring

When all six menus are available, they are displayed in the following order:




## Protection Menu

The Protection menu includes sub-menus as shown below. Sub-menus shown in bold are conditional on feature selection as indicated.

**Table 132 *flex*VUE Protection Menu**

| Engineer Menu → Protection | | | | |
|---|---|---|---|---|
| **1st Sub Menu** | **2nd Sub Menu** | **3rd Sub Menu** | **4th Sub Menu** | **Feature Selection** |
| PROTECTION GLOBAL | GLOBAL CONTROL | | | |
| | GLOBAL PICKUP(1) | PHASE | | |
| | | EARTH | | |
| | | SEF | | |
| | | NPS | | Sequence Components |
| | FAULT RESET | | | |
| PROT TRIP SETTINGS | AUTO RECLOSE | TRIP 1 | PHASE | |
| | | | PHASE RESET | Reset Curves |
| | | | EARTH | |
| | | | EARTH RESET | Reset Curves |
| | | | SEF | |
| | | | SEF RESET | Reset Curves |
| | | | NPS | Sequence Components |
| | | | NPS RESET | Reset Curves + Sequence Components |
| | | | RECLOSE | |
| | | TRIP 2 | PHASE | |
| | | | PHASE RESET | Reset Curves |
| | | | EARTH | |
| | | | EARTH RESET | Reset Curves |
| | | | SEF | |
| | | | SEF RESET | Reset Curves |
| | | | NPS | Sequence Components |
| | | | NPS RESET | Reset Curves + Sequence Components |
| | | | RECLOSE | |
| | | TRIP 3 | PHASE | |
| | | | PHASE RESET | |
| | | | EARTH | |
| | | | EARTH RESET | |
| | | | SEF | |
| | | | SEF RESET | |
| | | | NPS | |
| | | | NPS RESET | |
| | | | RECLOSE | |
| | | TRIP 4 | PHASE | |
| | | | PHASE RESET | Reset Curves |
| | | | EARTH | |
| | | | EARTH RESET | Reset Curves |
| | | | SEF | |
| | | | SEF RESET | Reset Curves |
| | | | NPS | Sequence Components |

**Table 132 *flex*VUE Protection Menu (Continued)**

| Engineer Menu → Protection | | | | |
|---|---|---|---|---|
| **1st Sub Menu** | **2nd Sub Menu** | **3rd Sub Menu** | **4th Sub Menu** | **Feature Selection** |
| | | | NPS RESET | Reset Curves + Sequence Components |
| | SINGLE SHOT | | PHASE | |
| | | | PHASE RESET | Reset Curves |
| | | | EARTH | |
| | | | EARTH RESET | Reset Curves |
| | | | SEF | |
| | | | SEF RESET | Reset Curves |
| | | | NPS | Sequence Components |
| | | | NPS RESET | Reset Curves + Sequence Components |
| | | | RESET | |
| | WORK TAG | | PHASE | |
| | | | PHASE RESET | Reset Curves |
| | | | EARTH | |
| | | | EARTH RESET | Reset Curves |
| | | | SEF | |
| | | | SEF RESET | Reset Curves |
| | | | NPS | Sequence Components |
| | | | NPS RESET | Reset Curves + Sequence Components |
| | UNDER/OVER FREQ | | UNDER FREQ | Under/Over Freq Prot |
| | | | OVER FREQ | Under/Over Freq Prot |
| | | | NORMAL FREQ CLOSE | Under/Over Freq Prot |
| | ROCOF | | | Under/Over Freq Prot |
| | UNDER/OVER VOLT | | UNDER VOLT | Under/Over Voltage Prot |
| | | | OVER VOLT | Under/Over Voltage Prot |
| | | | UV/OV CONFIG | Under/Over Voltage Prot |
| | LOSS OF PHASE | | | |
| | NVD PROTECTION | | | Neutral Voltage Displacement |
| | NVD ALARM | | | Neutral Voltage Displacement |
| | BROKEN CONDUCTOR PROT | | | Broken Conductor Avail |
| | BROKEN CON ALARM | | | Broken Conductor Avail |
| PROTECTION CONTROL | | COLD LOAD PICKUP | | |
| | | SYNC CHECK | | Sync Check Available |
| | | INRUSH RESTRAINT | | |
| | | HIGH CURRENT LOCKOUT | | |
| | | Dead Lockout | | |
| | | Live Load Blocking | | |
| | | Sequence | | |
| | | Fault Period | | |

**Table 132 *flex*VUE Protection Menu (Continued)**

| Engineer Menu → Protection | | | | |
|---|---|---|---|---|
| **1st Sub Menu** | **2nd Sub Menu** | **3rd Sub Menu** | **4th Sub Menu** | **Feature Selection** |
| DIRECTIONAL ELEMENTS | | DIRECTIONAL BLOCKING(2) | PHASE FAULT POLARISE | |
| | | | EARTH FAULT POLARISE | |
| | | | SEF POLARISE | |
| | | | NPS POLARISE | |
| | | | Vzps COMPENSATION | |
| | | | HIGH Vzps ALARM | |
| DIRECTIONAL ELEMENTS | | DIRECTIONAL PROTECTION | PHASE FAULT POLARISE | Directional Protection ON |
| | | | EARTH FAULT POLARISE | Directional Protection ON |
| | | | SEF POLARISE | Directional Protection ON |
| | | | NPS POLARISE | Directional Protection ON + Sequence Components |
| FAULT LOCATOR | | | | Fault Locator Available |

(1) Only displayed when Per Trip Thresholds are not available.

(2) Direction Blocking and Directional Protection are mutually exclusive.

## AS

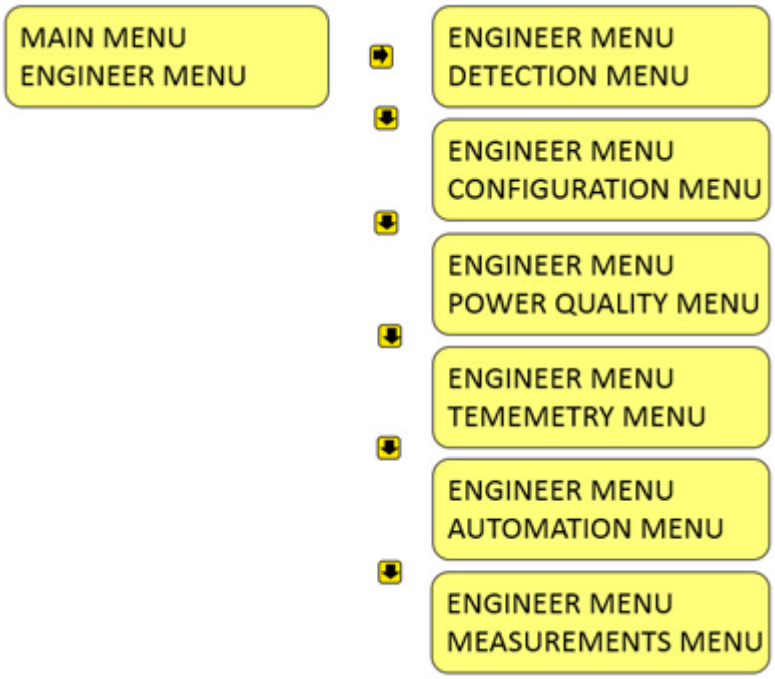
The Engineer menu for the AS includes at least four sub-menus.

1. Detection Menu
2. Configuration Menu
3. Telemetry Menu
4. Measurement Menu

One or two more sub-menus can be added depending on which optional features are made available.

1. An Automation menu is added if either Loop Automation or Auto-Changeover are made available.
2. A Power Quality menu is added if one or more of the following four Power Quality features are made available.
   a. Supply Outage Measurement
   b. Waveform Capture
   c. Harmonic Analysis
   d. Sag and Swell Monitoring

When all six menus are available, they are displayed in the following order:




## Detection Menu

The Detection menu includes sub-menus as shown below. Sub-menus shown in bold are conditional on feature selection as indicated.

**Table 133 *flex*VUE Detection Menu**

| **Engineer Menu → Detection** | | | |
|---|---|---|---|
| **1st Sub Menu** | **2nd Sub Menu** | **Default Setting** | **Feature Selection** |
| GLOBAL CONTROL | | Active Detection Group A | |
| | | Copy Off | |
| | | Detection On | |
| | | Sectionaliser Off | |
| | | E/F On, SEF On | Per Element Detection N/Avail |
| | | Phase Detection On | Per Element Detection Avail |
| | | Phase Mode SECT | Per Element Detection Avail |
| | | Earth Detection On | Per Element Detection Avail |
| | | Earth Mode SECT | Per Element Detection Avail |
| | | SEF Detection On | Per Element Detection Avail |
| | | SEF Mode SECT | Per Element Detection Avail |
| | | SEF Alarm On | |
| | | NPS Detection On | Per Element Detection Avail |
| | | NPS Mode SECT | |
| | | Single Shot Mode Off | |
| | | Supply Fail 3.0 s | |
| SECTIONALISE | | Trip on Count 1 | |
| | | Trip on SEF Count 1 | |
| | | Trip on NPS Count 1 | |
| | | Seq Reset Time 30 s | |
| FAULT DETECTION | PHASE | Phase Set 200 Amp | |

**Table 133 *flex*VUE Detection Menu (Continued)**

| Engineer Menu → Detection | | | |
|---|---|---|---|
| **1st Sub Menu** | **2nd Sub Menu** | **Default Setting** | **Feature Selection** |
| | | Phase Pickup x 1.0 | |
| | EARTH | Earth Set 40 Amp | |
| | | Earth Pickup x 1.0 | |
| | SEF | SEF Set 4 Amp | |
| | | SEF Pickup x 1.0 | |
| | NPS | NPS Set 40 Amp | Sequence Components Avail |
| | | NPS Pickup x 1.0 | Sequence Components Avail |
| FAULT RESET | | Fault Reset 50 ms | |
| | | Phase Reset 90% | |
| | | Earth Reset 90% | |
| | | SEF Reset 90% | |
| | | NPS Reset 90% | Sequence Components Avail |
| | SECTIONALISE/TRIP 1/ PHASE DETECTION | Definite Time | |
| | | Definite Time 1.00 s | |
| | | No Instantaneous | |
| DETECTION SETTINGS | SECTIONALISE/TRIP 1/ EARTH DETECTION | Definite Time | |
| | | Definite Time 1.00 s | |
| | | No Instantaneous | |
| | SECTIONALISE/TRIP 1/ EARTH DETECTION | Definite Time | |
| | | Definite Time 1.00 s | |
| | | No Instantaneous | |
| | SECTIONALISE/TRIP 1/SEF DETECTION | Definite Time | |
| | | Definite Time 5.00 s | |
| | | No Instantaneous | |
| | | Alarm Definite Time 1.00 s | |
| | SECTIONALISE/TRIP 1/NPS DETECTION | Definite Time | Sequence Components Avail |
| | | Definite Time 1.00 s | Sequence Components Avail |
| | | No Instantaneous | Sequence Components Avail |
| | SINGLE SHOT/PHASE DETECTION | Definite Time | |
| | | Definite Time 1.00 s | |
| | | No Instantaneous | |
| | SINGLE SHOT/EARTH DETECTION | Definite Time | |
| | | Definite Time 1.00 s | |
| | | No Instantaneous | |
| | SINGLE SHOT/SEF DETECTION | Definite Time | |
| | | Definite Time 5.00 s | |
| | | No Instantaneous | |
| | | Alarm Definite Time 1.00 s | |

**Table 133 *flex*VUE Detection Menu (Continued)**

| Engineer Menu → Detection | | | |
|---|---|---|---|
| **1st Sub Menu** | **2nd Sub Menu** | **Default Setting** | **Feature Selection** |
| | SINGLE SHOT/NPS DETECTION | Definite Time | |
| | | Definite Time 1.00 s | |
| | | No Instantaneous | |
| | SINGLE SHOT/RESET | Single Shot Reset Time 0 s | |
| | UNDER OVER VOLTAGE/ UNDER VOLTAGE | UV Detection Off | |
| | | UV Mode ALARM | |
| | | Phase Logic AND | |
| | | Pickup Voltage 0.90 pu | |
| | | Definite Time 1.00 s | |
| | UNDER OVER VOLTAGE/ OVER VOLTAGE | OV Detection Off | |
| | | OV Mode ALARM | |
| | | Phase Logic AND | |
| | | Pickup Voltage 1.10 pu | |
| | | Definite Time 1.00 s | |
| | UNDER OVER VOLTAGE/ UV/OV CONFIGURATION | Nom P-E V 6.300 kV | |
| | | Definite Time | |
| | | Fault Reset 50ms | |
| | BROKEN CONDUCTOR DETECTION | Broken Conductor Detection Off | |
| | | Set 1.00 INPS/IPPS | Broken Conductor Available |
| | | Definite Time 10.00 s | Broken Conductor Available |
| | | Reset 90% | Broken Conductor Available |
| | | Reset Time 0.05 s | Broken Conductor Available |
| COLD LOAD PICKUP | | CLP Phase Off | |
| | | CLP Earth Off | |
| | | CLP SEF Off | |
| | | CLP NPS Off | Sequence Components Avail |
| | | Cold Load Time 120 min | |
| | | Cold Load Mult x 2.0 | |
| SYNC CHECK | | Sync Check Off | Sync Check Available |
| | | Sync Check Inactive | Sync Check Available |
| | | Close Retry Off | Sync Check Available |
| | | Close Retry 300s | Sync Check Available |
| | | Voltage On | Sync Check Available |
| | | Voltage Diff 0.02 pu | Sync Check Available |
| | | Voltage Min 0.50 pu | Sync Check Available |
| | | Voltage Max 200 pu | Sync Check Available |
| | | Nom P-E V 6.30 kV | Sync Check Available |
| | | Frequency On | Sync Check Available |
| | | Frequency Diff 0.10 Hz | Sync Check Available |

**Table 133 *flex*VUE Detection Menu (Continued)**

| Engineer Menu → Detection | | | |
|---|---|---|---|
| **1st Sub Menu** | **2nd Sub Menu** | **Default Setting** | **Feature Selection** |
| | | Frequency Min 45.00 Hz | Sync Check Available |
| | | Frequency Max 65.00 Hz | Sync Check Available |
| | | Phase On | Sync Check Available |
| | | Phase Diff 6 deg | Sync Check Available |
| INRUSH RESTRAINT | | Inrush Off | |
| | | Inrush Time 0.10 s | |
| | | Inrush Mult x 4.0 | |
| | | Inrush Type Zero Detect | |
| | | Inrush Type SOHIR | SOHIR Available |
| | | SOHIR Logic AND | SOHIR Available |
| | | SOHIR Thres 20% | SOHIR Available |
| Live Load Block | | Off | |
| FAULT LOCATOR | | Fault Locator Off | Fault Locator Available |
| | | $R_{PPS}$ 0.0001 ohm/km | Fault Locator Available |
| | | $X_{PPS}$ 0.0001 ohm/km | Fault Locator Available |
| | | $R_{zPS}$ 0.0001 ohm/km | Fault Locator Available |
| | | $X_{zPS}$ 0.0001 ohm/km | Fault Locator Available |
| Fault Period | | 10 s | Close on Fault Trip Available<br>Per Element Detection Available |
| DIRECTIONAL ELEMENTS | DIRECTIONAL BLOCK/ PHASE FAULT POLARISE | Fault Direction Forward & Reverse | Directional Blocking On |
| | | Low Polarising Block Off | Directional Blocking On |
| | | Minimum $V_{QUAD}$ 500 V | Directional Blocking On |
| | | Characteristic Angle -45 deg | Directional Blocking On |
| | | Voltage Memory Off | Directional Blocking On |
| | DIRECTIONAL BLOCK/ EARTH FAULT POLARISE | Decision $V_{ZPS}$ | Directional Blocking On |
| | | Fault Direction Forward and Reverse | Directional Blocking On |
| | | Low Polarising Block Off | Directional Blocking On |
| | | Minimum $V_{ZPS}$ 500 V | Directional Blocking On |
| | | Characteristic Angle 135 deg | Directional Blocking On |
| | DIRECTIONAL BLOCK/SEF FAULT POLARISE | Decision $V_{ZPS}$ | Directional Blocking On |
| | | Fault Direction Forward and Reverse | Directional Blocking On |
| | | Low Polarising Block Off | Directional Blocking On |
| | | Minimum $V_{ZPS}$ 500 V | Directional Blocking On |
| | | Characteristic Angle 135 deg | Directional Blocking On |
| | DIRECTIONAL BLOCK/NPS FAULT POLARISE | Fault Direction Forward & Reverse | Directional Blocking On + Sequence Components Available |
| | | Low Polarising Block Off | Directional Blocking On + Sequence Components Available |
| | | Minimum $V_{NPS}$ 500V | Directional Blocking On + Sequence Components Available |

**Table 133 *flex*VUE Detection Menu (Continued)**

| Engineer Menu → Detection | | | |
|---|---|---|---|
| **1st Sub Menu** | **2nd Sub Menu** | **Default Setting** | **Feature Selection** |
| | | | Directional Blocking On + Sequence Components Available |
| | $V_{ZPS}$ COMPENSATION | $V_{ZPS}$ Balancing Off | Directional Blocking On |
| | HIGH $V_{ZPS}$ ALARM | High Alarm Mode Off | Directional Blocking On |
| | | High Time 10 s | Directional Blocking On |
| | | High Set-point 500 V | Directional Blocking On |
| | DIRECTIONAL DETECTION/ PHASE FAULT POLARISE | Low Polarising Voltage Action – No Action | Directional Detection On |
| | | Minimum $V_{QUAD}$ 500 V | Directional Detection On |
| | | Characteristic Angle -45 deg | Directional Detection On |
| | | Forward Sector 90 deg | Directional Detection On |
| | | Reverse Sector 90 deg | Directional Detection On |
| | | Voltage Memory Off | Directional Detection On |
| | DIRECTIONAL DETECTION/ EARTH FAULT POLARISE | Decision $V_{ZPS}$ | Directional Detection On |
| | | Low Polarising Voltage Action – No Action | Directional Detection On |
| | | Minimum $V_{ZPS}$ 500 V | Directional Detection On |
| | | Characteristic Angle 135 deg | Directional Detection On |
| | | Forward Sector 90 deg | Directional Detection On |
| | | Reverse Sector 90 deg | |
| | DIRECTIONAL DETECTION/ SEF FAULT POLARISE | Decision $V_{ZPS}$ | Directional Detection On |
| | | Low Polarising Voltage Action – No Action | Directional Detection On |
| | | Minimum $V_{ZPS}$ 500 V | Directional Detection On |
| | | Characteristic Angle 135 deg | Directional Detection On |
| | | Forward Sector 90 deg | Directional Detection On |
| | | Reverse Sector 90 deg | Directional Detection On |
| | DIRECTIONAL DETECTION/ NPS FAULT POLARISE | Low Polarising Voltage Action – No Action | Directional Detection On + Sequence Components Available |
| | | Minimum $V_{NPS}$ 500 V | Directional Detection On + Sequence Components Available |
| | | Characteristic Angle 120 deg | Directional Detection On + Sequence Components Available |
| | | Forward Sector 90 deg | Directional Detection On + Sequence Components Available |
| | | Reverse Sector 90 deg | Directional Detection On + Sequence Components Available |
| | $V_{ZPS}$ COMPENSATION | VZPS Balancing Off | Directional Detection On |
| | HIGH $V_{ZPS}$ ALARM | High Alarm Mode Off | Directional Detection On |
| | | High Time 10 s | Directional Detection On |
| | | High Set-point 500 V | Directional Detection On |

**NOTE:** Directional Blocking and Directional Detection are mutually exclusive features.

## Configuration Menu (ACR and AS)

The Configuration menu consists of at least 5 sub-menus some of which have another level of sub-menus. When IOEX is made available, a sixth first level sub-menu is created which has its own sub-menus for IOEX-A and IOEX-B.

**Table 134 *flex*VUE Configuration Menu**

| Engineer Menu → Configuration Menu | | |
|---|---|---|
| **1st Sub Menu** | **2nd Sub Menu** | **Feature Selection** |
| SYSTEM SETTINGS | DISPLAY | |
| | NETWORK PARAMETERS | |
| | METERING PARAMETERS | |
| FEATURE SELECTION | PROTECTION/DETECTION(1) | |
| | AUTOMATION | |
| | GENERAL | |
| | COMMUNICATIONS | |
| | POWER QUALITY | |
| | FAULT LOCATOR | |
| RADIO SETTINGS | | |
| MAINTENANCE | BATTERY TEST | |
| IOEX STATUS | IOEX Module A | IOEX Available |
| | IOEX Module B | IOEX Available |
| USER DEFINED CONTROL | | |
| (1) An ACR has a Protection sub-menu in Feature Selection, an AS has a Detection sub-menu. | | |

## Power Quality Menu (ACR and AS)

The Power Quality is not displayed unless at least one of the three power quality features supported by the operator interface has been made available. These features are:

1. Supply Outages
2. Sag and Swell
3. Waveform Capture

A fourth feature, Harmonic Analysis can only be configured and monitored using WSOS. If Harmonic Analysis is the only power quality feature that's available, the Power Quality menu will not be displayed on the operator interface.

**Table 135 *flex*VUE Power Quality Menu**

| Engineer Menu → Power Quality Menu | | |
|---|---|---|
| **1st Sub Menu** | **2nd Sub Menu** | **Feature Selection** |
| SUPPLY OUTAGES | | Supply Outage Available |
| SAG SWELL MENU(1) | SAG/SWELL MONITORING | Sag/Swell Available |
| | SAG MONITORING | Sag/Swell Available |
| | SWELL MONITORING | Sag/Swell Available |
| WAVE CAPTURE MENU | WAVEFORM CAPTURE | Waveform Capture Available |
| | WAVEFORM TRIGGER | Waveform Capture Available |
| (1) Not supported when the controller is configured as an AS. | | |

# Telemetry Menu (ACR and AS)

The Telemetry Menu has two sub-menus:

1. Configure Ports Menu
2. Configure Communications

# Configure Ports

The Configure Ports sub-menus are slightly different for PowerLogic ADVC Controller due to the different communications ports available on this controller.

**Table 136 PowerLogic ADVC *flex*VUE Telemetry Menu**

| 1st Sub Menu | 2nd Sub Menu |
|---|---|
| CONFIGURE PORTS MENU | IOEX/WSOS |
| | Modem |
| | 10BASE-T |
| | 10BASE-T 2 |
| | USB 1 |
| | USB 2 |
| | USB 3 |

# Configure Communications (ACR and AS)

The Configure Communications menu has three sub-menus by default but more are created when additional features are made available through Feature Selection.

**Table 137 *flex*VUE Configure Communications Menu**

| Engineer Menu → Telemetry Menu → Configure Communications | | |
|---|---|---|
| **1st Sub Menu** | **2nd Sub Menu** | **Feature Selection** |
| WSOS MENU | WSOS COMMS | |
| | WSOS COMMS STATS | |
| DNP3 MENU | DNP COMMS | |
| | DNP COMMS STATS | |
| | DNP TRANS SERVICES | |
| | DNP UNSOLICITED | |
| | DNP DIAGNOSTICS | |
| | DNP DATABASE CONFIG | |
| TRACE MENU | COMMS TRACE | |
| | COMMS TRACE STATS | |
| IOEX MENU | IOEX Module A | IOEX Available |
| | IOEX Module B | IOEX Available |
| IEC 60870-5-101/4 | IEC-101 COMMS | IEC 60870-5-101/4 Available |
| | IEC-101 COMMS STATS | IEC 60870-5-101/4 Available |
| | IEC-101 TRANS SRVCS | IEC 60870-5-101/4 Available |
| | IEC-101 CONFIG | IEC 60870-5-101/4 Available |
| MODBUS MENU | MBUS COMMS | Modbus Available |
| | MBUS COMMS STATS | Modbus Available |
| NTP MENU | NTP OFF | NTP + Time Zone Available |

**Table 137 *flex*VUE Configure Communications Menu (Continued)**

| Engineer Menu → Telemetry Menu → Configure Communications | | |
|---|---|---|
| **1st Sub Menu** | **2nd Sub Menu** | **Feature Selection** |
| | NTP SERVER 1 | NTP + Time Zone Available |
| | NTP SERVER 2 | NTP + Time Zone Available |
| | NTP SERVER 3 | NTP + Time Zone Available |

## Automation Menu (ACR and AS)

The Automation menu is similar to the Power Quality menu in that it is not displayed unless at least one applicable feature is available. In the case of automation, applicable features are:

- Loop Automation
- Auto-Changeover

These two features are mutually exclusive so the Automation menu will be displayed if either of them is available.

**Table 138 flexVUE Automation Menu**

| Engineer Menu → Automation Menu | | |
|---|---|---|
| **1st Sub Menu** | **2nd Sub Menu** | **Feature Selection** |
| LOOP AUTOMATION MENU | LA CONFIGURATION | Loop Automation Available |
| | LA COMMUNICATIONS | Loop Automation Available + LA Logic Intelligent |
| | OVERLOAD CONTROL | Loop Automation Available + LA Logic Intelligent + Tie Control Message |
| AUTO-CHANGEOVER MENU | ACO CONFIG | Auto-Changeover Available |
| | ACO COMMS | Auto-Changeover Available |
| | ACO COMMS STATS | Auto-Changeover Available |
| | ACO TIMERS | Auto-Changeover Available |

## Measurement Menu (ACR and AS)

The Measurement menu has 6 first level sub menus. Sequence Components available adds a Sequence sub-menu to Voltage.

**Table 139 *flex*VUE Measurement Menu**

| Engineer Menu → Automation Menu | | | |
|---|---|---|---|
| **1st Level Sub Menu** | **2nd Level Sub Menu** | **3rd Level Sub Menu** | **Feature Selection** |
| CURRENT | MAGNITUDE AND ANGLE | A PHASE | |
| | | B PHASE | |
| | | C PHASE | |
| | | EARTH | |
| | SEQUENCE | $I_{PPS}$ | Sequence Components |
| VOLTAGE | PHASE/LINE SRC-LD | $I_{NPS}$ | Sequence Components |
| | | A-E (A-B) Volts(1) | |

**Table 139 *flex*VUE Measurement Menu (Continued)**

| Engineer Menu → Automation Menu | | | |
|---|---|---|---|
| **1st Level Sub Menu** | **2nd Level Sub Menu** | **3rd Level Sub Menu** | **Feature Selection** |
| | | B-E (B-C) Volts | |
| | | C-E (C-A) Volts | |
| | | A-E (A-B) Angles | |
| | | B-E (B-C) Angles | |
| | | C-E (C-A) Angles | |
| | SEQUENCE | $V_{pps}$ | Sequence Components |
| | | $V_{nps}$ | Sequence Components |
| | | $V_{zps}$ | Sequence Components |
| FREQUENCY | Frequency | | |
| | Source Frequency | | |
| | Load Frequency | | |
| POWER | THREE PHASE | | |
| | A PHASE | | |
| | B PHASE | | |
| | C PHASE | | |
| ENERGY | Total | | |
| | Forward | | |
| | Reverse | | |
| SYNCHRONIZATION | Global In Sync | | Sync Check Available |
| | Voltage In Sync | | Sync Check Available |
| | Frequency In Sync | | Sync Check Available |
| | Phase In Sync | | Sync Check Available |
| DEMAND | DAILY MAX DEMAND | | |
| | WEEKLY MAX DEMAND | | |
| | MONTHLY MAX DEMAND | | |
| (1) Voltages can be displayed as Phase to Earth or Phase to Phase values. | | | |

# Appendix K *setVUE* Menu

## Appendix K.1 *setVUE* ACR Menu Structure

The ***setVUE*** displays are organized into logical groups called Display Groups. Within each group is a menu of pages and some pages have sub-pages.

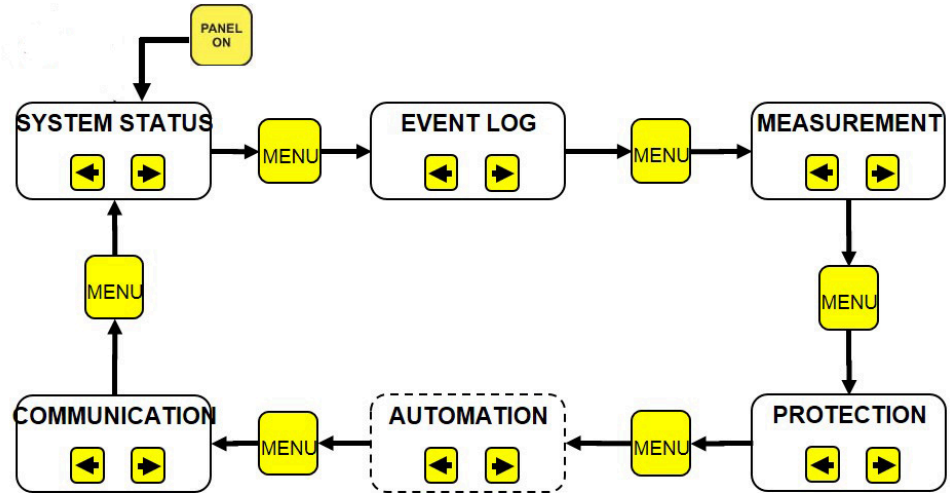



**Figure 356**
***setVUE*** Menu Structure

The Automatic display group only appears if an automation feature i.e. Loop Automation or Auto Changeover is available. Otherwise the display will move from Protection directly to the Communications display group.

Pressing the **MENU** key causes the display to move to the next group in turn.

The **Left** and **Right Arrow** keys are used to scroll through the screens within a display group.

All display groups are circular. So pressing the **Right Arrow** key when the last screen in the group is being displayed will cause the display to return to the first screen.

The individual screens in each of the display groups are shown in Appendices K.2 to K.6

The following table represents the procedure to find the settings on the ***setVUE*** O.I.

**Table 140 Finding an ACR setting on the *setVUE* O.I.**

| Step | Action |
|---|---|
| 1. | Press **MENU** until the menu group you require is displayed on the screen.<br>Example: **PROTECTION.** |
| 2. | Use the arrow keys to scroll through until you find the required menu.<br>Example: **PROTECTION SETTINGS** > **Directional Blocking 3** |
| 3. | On that menu is the setting you are looking for.<br>Example: **Minimum $V_{zps}$** |
| 4. | For information on changing settings refer to Chapter 4 Operator Functions, page 49. |

The structure of the ***setVUE*** menu changes when the **Custom Menu** is used.

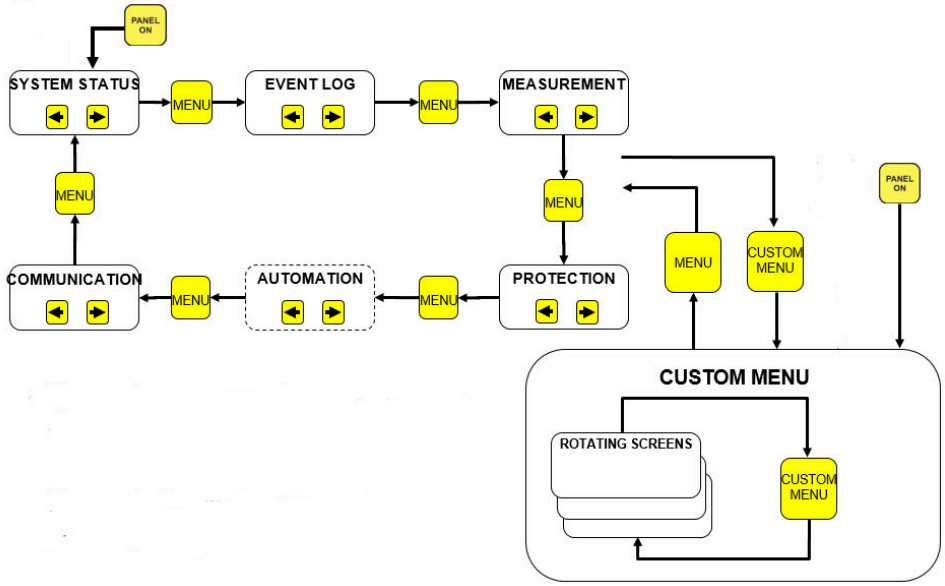



**Figure 357**
***set*VUE** Custom Menu

When the Custom Menu has been configured using WSOS it can be accessed by pressing the **Custom Menu** key on the operator interface.

Continuing to press the **Custom Menu** key will cause the display to step through the selected screens.

Alternatively the display may have been configured to scroll automatically when the operator interface is on.

Pressing the **Custom Menu** key will have no effect if it has not been configured.

The display will return to the main menu if the **Menu** key is pressed.

# Appendix K.2 *set*VUE ACR System Status Pages

This appendix shows all of the System Status display group pages and list display options and setting ranges.

The System Status display group contains the operator settings and information relating to the ratings and configuration of the device.

The basic System Status display group consists of 16 default pages.

Up to 19 additional pages (shown below in blue) can be added depending on the features that have been enabled.

**Table 141 *set*VUE System Status Menu Pages for ACR**

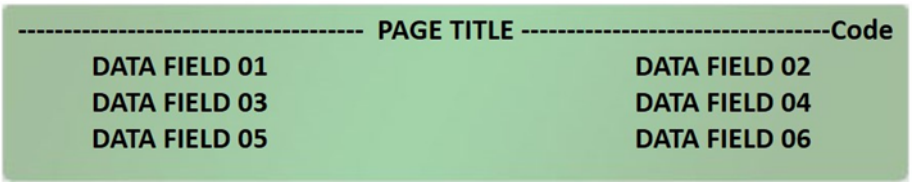
| System Status Menu | |
|---|---|
| **Default pages** | **Additional pages** |
| Trip Flags/Pickup Flags | Plant Details(1) |
| Supply Interrupt Flags(2) | Options – Protection 1(3) |
| Operator Settings 1 | Options – Protection 2(3) |
| Operator Settings 2 | Options – Protection 3(3) |
| Operator Settings 3 | Options – Protection 4(3) |
| Operator Settings 4(2) | Options – Automation(3) |
| System Settings 1 | Options – Controller 1(3) |
| System Settings 2 | Options – Controller 2(3) |

**Table 141 *set*VUE System Status Menu Pages for ACR (Continued)**

| System Status Menu | |
|---|---|
| **Default pages** | **Additional pages** |
| Switchgear Status | Options – Communications 1(3) |
| Fault Information | Options – Communications 2(3) |
| Live/Dead Indication | Options – Power Quality(3) |
| Phase Voltage and Power Flow | Quick Key Selection(4) |
| Terminal Designation/Rotation | IOEX-A Status(5) |
| Radio | IOEX-B Status(5) |
| Switchgear Type and Ratings | Hit and Run(6) |
| Switchgear Wear/General Details | Waveform Capture(7) |
| | Waveform Trigger(7) |
| | Battery Test(8) |
| User Defined Control 1 | |
| User Defined Control 2 | |
| (1) Plant details available.<br>(2) Per Element Protection available.<br>(3) Panel display options available.<br>(4) Quick key configuration available.<br>(5) IOEX available<br>(6) Hit and Run available.<br>(7) Waveform capture available.<br>(8) Battery health test available. | |

The top line of each page is the page title. To the right of the title is the letter S which indicates that the page being displayed is part of the System Status display group.

The next three lines are the data on display. Most displays have six data fields. The standard layout is shown below.




Where details of individual pages are shown below a small column has been added to the right of each field to indicate the type of data displayed. The letters in this column have significance as follows:

**O** Operator Controlled

**D** Display Only (that is cannot be changed)

**P** Password Protected (that is cannot be changed unless the password is entered)

**R** Operator Controller Reset (that is resets a field or group of fields)

If the standard menu is running the System Status menu will be displayed when the Panel On key is pressed.

The first page to be displayed in the System Status menu is the **Trip Flags** page shown below.

# ACR Trip Flags Page




The trip flags for Negative Phase Sequence, Under and Over Voltage as well as Under and Over Frequency will only appear on this page if these features have been made available.

| TRIP FLAGS S | | | | | |
|---|---|---|---|---|---|
| O/C<br>☐<br>■<br>00-99 ABC | R | LOP<br>☐<br>■<br>00-99 ABC | R | EXT<br>☐<br>■<br>00-99 | R |
| E/F (G/F)<br>☐<br>■<br>00-99 | R | UOV<br>☐<br>■<br>00-99(1) | R | FRQ<br>☐<br>■<br>00-99 | R |
| SEF (SGF)<br>☐<br>■<br>00-99 | R | NPS<br>☐<br>■<br>00-99(3) | R | OPS 0000-9999 | R |
| (1) Only displayed if Under/Over Voltage protection is available.<br>(2) Only displayed if Under/Over Frequency protection is available.<br>(3) Only displayed if Sequence Components are available. | | | | | |

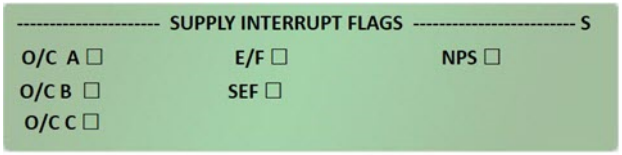
The title of this page will change to PICKUP FLAGS and not display EXT if protection is Off.

| PICKUP FLAGS S | | | | | |
|---|---|---|---|---|---|
| O/C<br>☐<br>■<br>00-99 ABC | R | LOP<br>☐<br>■<br>00-99 ABC | R | | R |
| E/F (G/F)<br>☐<br>■<br>00-99 | R | UOV<br>☐<br>■<br>00-99 | R | FRQ<br>☐<br>■<br>00-99 | R |
| SEF (SGF)<br>☐<br>■<br>00-99 | R | NPS<br>☐<br>■<br>00-99 | R | OPS 0000-9999 | R |

The other pages in this group can be displayed by pressing the left and right arrow keys.

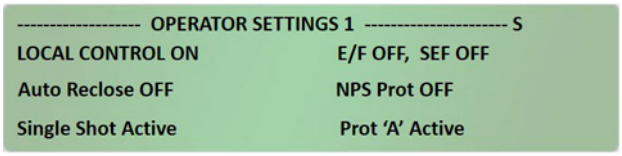
Pressing the right arrow key when the Trip Flags page is displayed will move the display to the Supply Interrupt Flags page if Per Element Protection is available, otherwise it will be the first of three **Operator Settings** pages.

## ACR Supply Interrupt Flags(14)




| SUPPLY INTERRUPT FLAGS S | | | | | |
|---|---|---|---|---|---|
| O/C A ☐ ■ | R | E/F ☐ ■ | R | NPS ☐ ■ | R |
| O/C B ☐ ■ | R | SEF ☐ ■ | R | | |
| O/C C ☐ ■ | R | | | | |

## Operator Settings 1

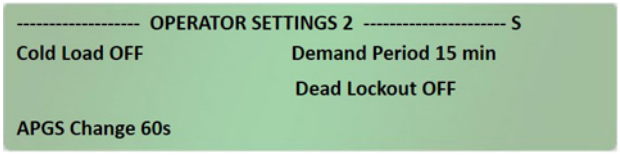



| Operator Settings 1 | | | |
|---|---|---|---|
| LOCAL CONTROL ON<br>Remote Control On<br>Hit and Run ON<br>Hit and Run OFF | O | E/F (G/F) OFF, SEF (SGF) OFF<br>E/F (G/F) ON, SEF (SGF) OFF<br>E/F (G/F) ON, SEF (SGF) ON<br>E/F (G/F) ON<br>E/F (G/F) OFF | O |
| Auto Reclose OFF<br>Auto Reclose ON<br>Protection OFF(1) | O | NPS OFF<br>NPS ON<br>NPS Prot Alarm | O |

(14) This page is only displayed when Per Element Protection is available.

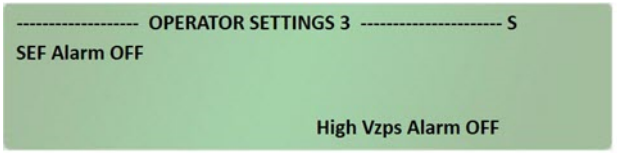
| Operator Settings 1 | | | |
|---|---|---|---|
| Lockout<br>Single Shot Active (blank in normal op)<br>Reclose 1,2, and 3<br>When configured as a Sectionaliser:<br>Supply Interrupt 1<br>Supply Interrupt 2<br>Supply Interrupt 3<br>Supply Interrupt 4<br>Sectionaliser Trip | D | Protection Auto(2)(3)<br>Prot A, B...J Active(4)<br>Auto A Active<br>Auto B Active | O<br>O<br>D<br>D |
| (1) If Protection Off is not allowed (System Status Options 1) this option is not shown.<br>(2) Navigation of this field starts with *Protection Auto* (when configured) to minimize key presses.<br>(3) If APGS is not allowed (System Status Options 1) this option is not shown.<br>(4) One of ten different Protection Groups (A...J) can be active. If Protection Group D is active the display will read Prot D Active. | | | |

## Operator Settings 2




| Operator Settings 2 | | | |
|---|---|---|---|
| Cold Load OFF<br>Cold Load IDLE<br>Cold Load NO CHANGE<br>Cold Load MAX<br>CLP 120 min x 2.3 mult(1) | O | Demand Period 15 min<br>Demand Period 5 min<br>Demand Period 30 min<br>Demand Period 60 min | |
| | | NPS Lockout OFF<br>NPS Lockout ON | |
| APGS Change 60 s (Range 10 s...180 s) | | | |
| (1) This field is display only when configured as Cold Load OFF. | | | |

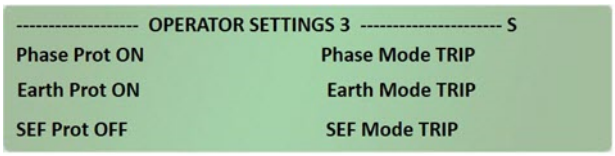
## Operator Settings 3




| Operator Settings 3 | | | |
|---|---|---|---|
| SEF Alarm OFF(1)<br>SEF Alarm ON | O | | |
| | | | |

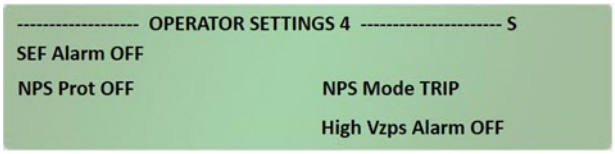
| Operator Settings 3 | | | |
|---|---|---|---|
| | | High $V_{zps}$ Alarm OFF(2)<br>High $V_{zps}$ Alarm ON | O |
| (1) This setting displayed on Operator Settings 4 when Per Element Protection is Available.<br>(2) This setting only displayed when Directional Blocking is ON. | | | |

## Operator Settings 3 (with Per Element Protection Available)




| Operator Settings 3 | | | |
|---|---|---|---|
| Phase Prot OFF(2)<br>Phase Prot ON | O | Phase Mode TRIP(1)<br>Phase Mode ALARM | O |
| Earth Prot OFF(1)<br>Earth Prot ON | O | Earth Mode TRIP(1)<br>Earth Mode ALARM | O |
| SEF Prot OFF(1)<br>SEF Prot ON | O | Earth Mode TRIP(1)<br>Earth Mode ALARM | O |
| (1) This setting displayed on Operator Settings 4 when Per Element Protection is Available.<br>(2) This setting only displayed when Per Element Protection is Available. | | | |

## Operator Settings 4(15)



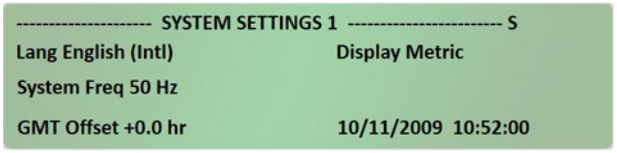

| Operator Settings 4 | | | |
|---|---|---|---|
| SEF Alarm OFF<br>SEF Alarm ON | O | | |
| NPS Prot OFF(1)<br>NPS Prot ON | O | NPS Mode TRIP(1)<br>NPS Mode ALARM | O |
| | | High $V_{zps}$ Alarm OFF(1)<br>High $V_{zps}$ Alarm OFF | D |
| (1) This page is only displayed when Per Element Protection is Available. | | | |

The next two pages display the **System Settings**.

The System Settings pages are generally configured according to the geographic location of the device.

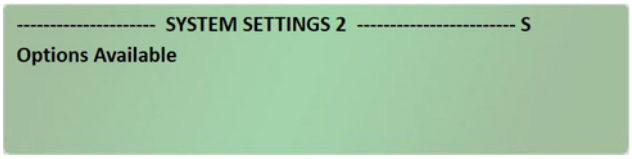
(15) This page is only displayed when Per Element Protection is Available.

## System Settings 1




| System Settings 1 | | | |
|---|---|---|---|
| Language English (Intl)<br>Language English (USA)<br>Lingua Portuguesa – Portugues (Brasil) | O | Display Metric<br>Display Imperial | |
| System Frequency 50 Hz<br>System Frequency 60 Hz | P | | |
| GMT Offset +0.0 hr | O | DD/MM/YYYY (MM/DD/YY) HH:MM:SS | O |

## System Settings 2



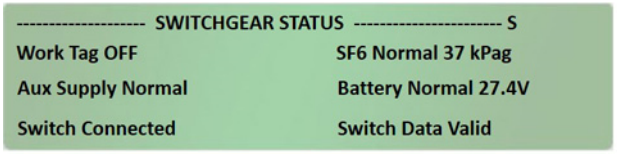

| System Settings 2 | | | |
|---|---|---|---|
| Options Available<br>Options Not Available | P | | |

Once the device has been initially configured, the menu can be de cluttered by making Options unavailable which removes the ten Options pages.

The **Switchgear Status** page contains mainly read only fields relating to the condition of the device.

The Work Tag can also be applied from this screen.

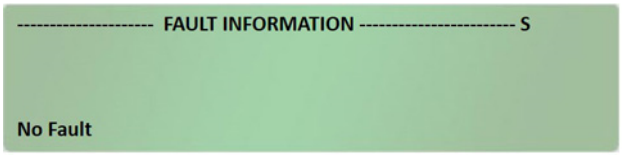
## Switchgear Status



| Switchgear Status | | | |
|---|---|---|---|
| Work Tag Off<br>Work Tag Applied | O | $SF_6$ Normal 37 kPag<br>$SF_6$ Normal 5.5 psig<br>(N Series only) | D |
| Auxiliary Supply Normal<br>Auxiliary Supply Fail | D | Battery Normal x.xV<br>Battery OFF<br>Battery Low Volts x.xV<br>Battery Overvolt x.xV | D |
| Switch Connected<br>Switch Unplugged | D | Switch Data Valid<br>Switch Data Invalid | D |

The next page displays **Fault Information**.

## Fault Information

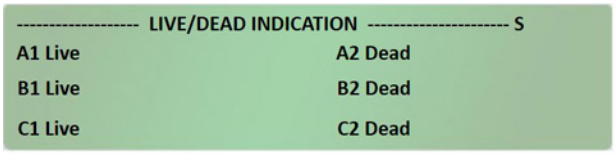



| Fault Information | | | |
|---|---|---|---|
| No Fault<br>Fault Type: A-E, B-E, C-E<br>Fault Type: A-B, B-C, C-A<br>Fault Type: ABC | D | | |

Live/Dead Indications display the status of each bushing with the capability to measure voltage.

**NOTE:** The PMSet U Series can only measure voltage on the bushings on the I side unless optional external CVT's are fitted. When no voltage measurement is possible, the display will read Unavailable.

## Live/Dead Indication

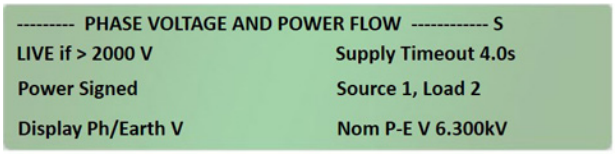



| Live/Dead Indication | | | |
|---|---|---|---|
| A1 Live or Ai Live<br>A1 Dead or Ai Dead | D | A2 Live or Ax Live<br>A2 Dead or Ax Dead | D |
| B1 Live or Bi Live<br>B1 Dead or Bi Dead | D | B2 Live or Bx Live<br>B2 Dead or Bx Dead | D |
| C1 Live or Ci Live<br>C1 Dead or Ci Dead | D | C2 Live or Cx Live<br>C2 Dead or Cx Dead | D |

**NOTE:** Live/Dead indications are shown for the individual phases according to the Phase Configuration settings on the Terminal Designation/Rotation page.

Phase Voltage and Power Flow contains settings relating to the display of voltage and power.

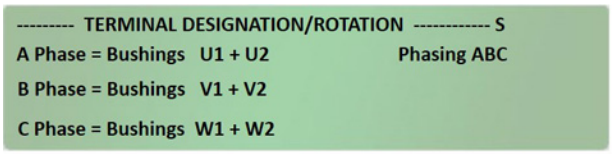
## Phase Voltage and Power Flow




| Phase Voltage and Power Flow | | | |
|---|---|---|---|
| Live if > 2000 V<br>(Range 2000...15000 V) | P | Supply Timeout 4.0 s<br>(Range 0.1...100.0 s) | P |
| Power Signed<br>Power Unsigned | P | Source 1, Load 2 or Source I, Load x<br>Source 2, Load 1 Source x, Load i | |
| Display Phase/Earth (Gnd) V<br>Display Phase/Phase V | P | Nom P-E V 6.300 kV<br>(Range 2000...25,000 V) | |

The Terminal Designation as well as phase rotation is shown on the next page.

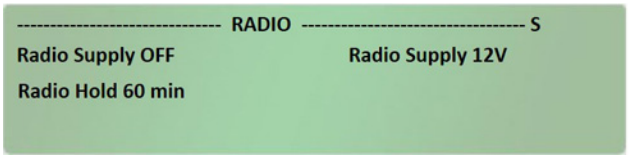
## Terminal Designation/Rotation




| Terminal Designation/Rotation | | |
|---|---|---|
| A Phase Bushings = U1 + U2<br>A Phase Bushings = U1 + U2<br>A Phase Bushings = V1 + V2<br>A Phase Bushings = W1 + W2<br>A Phase Bushings = V1 + V2<br>C Phase Bushings = W1 + W2 | Phasing ABC<br>Phasing ACB<br>Phasing BAC<br>Phasing BCA<br>Phasing CAB<br>Phasing CBA | P |
| B Phase Bushings = V1 + V2<br>B Phase Bushings = W1 + W2<br>B Phase Bushings = U1 + U2<br>B Phase Bushings = U1 + U2<br>B Phase Bushings = W1 + W2<br>B Phase Bushings = V1 + V2 | | |
| C Phase Bushings = W1 + W2<br>C Phase Bushings = V1 + V2<br>C Phase Bushings = W1 + W2<br>C Phase Bushings = V1 + V2<br>C Phase Bushings = U1 + U2<br>C Phase Bushings = U1 + U2 | | |

The Radio page is used to configure the radio voltage and hold up time.

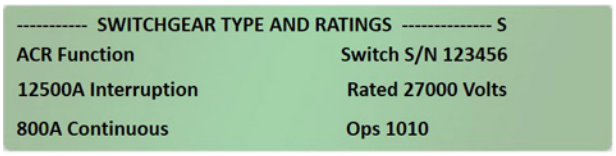
## Radio




| Radio | | | |
|---|---|---|---|
| Radio Supply OFF<br>Radio Supply ON<br>Radio Supply Shutdown | D | Radio Supply 12 V<br>(Range 5 V...15 V) | P |
| Radio Hold Time 60 min<br>(Range 0 min...1440 min) | P | | |

Switchgear Type and Ratings displays information about the connected switchgear. The controller reads this information from the SCEM.

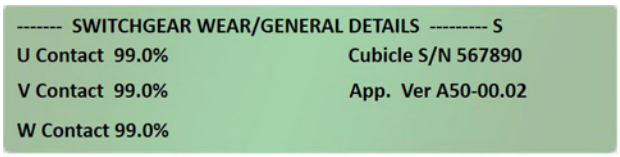
## Switchgear Type and Ratings




| Switchgear Type and Ratings | | | |
|---|---|---|---|
| ACR Function | D | Switch S/N xxxxxx | D |
| 12500 A Interruption | D | Rated 27000 Volts | D |
| 630 A Continuous | D | Ops 1010 | D |

The page for Switchgear Wear and General Details also includes the firmware version and cubicle serial number.

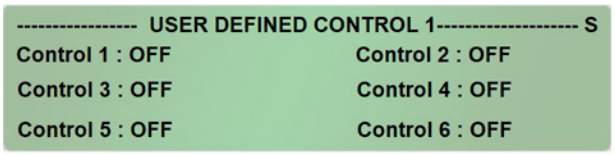
## Switchgear Wear/General Details




| Switchgear Wear/General Details | | | |
|---|---|---|---|
| U Contact 99.0% | D | Cubicle S/N xxxxxx | D |
| V Contact 99.0% | D | App. Version A50-00.02 | D |
| W Contact 99.0% | D | | |

The User Defined Control pages 1 and 2 are found at the end of the System Status menu.

## User Defined Control







| User Defined Control 1 | | | |
|---|---|---|---|
| Control 1 OFF<br>Control 1 ON | P | Control 2 OFF<br>Control 2 ON | P |
| Control 3 OFF<br>Control 3 ON | P | Control 4 OFF<br>Control 4 ON | |
| Control 5 OFF<br>Control 5 ON | P | Control 6 OFF<br>Control 6 ON | |

| User Defined Control 2 | | | |
|---|---|---|---|
| Control 7 OFF<br>Control 7 ON | P | Control 8 OFF<br>Control 8 ON | P |

## Additional System Status pages

Additional pages are added to the System Status display group when certain features are made available. When Plant Details is made available, that page appears following the Switchgear Wear/General Details page.

## Plant Details




This is a page to display user entered information. The info is entered via WSOS. It can be ASCII text or numbers.

## Options

When Options Available is selected on the System Settings 2 page as it is by default, another ten optional pages are added to the System Status display group.

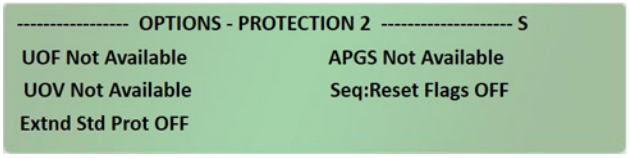
The first four are related to Protection.

## Options – Protection 1



| Options – Protection 1 | | | |
|---|---|---|---|
| Protection OFF Not Allowed<br>Protection OFF Allowed | P | SEF (SGF) Not Available<br>SEF (SGF) Available | P |
| E/F OFF Allowed<br>E/F OFF Not Allowed | P | Sequence Components Not Available<br>Sequence Components Available | P |
| NPS OFF Not Allowed<br>NPS OFF Allowed<br>**NOTE:** Not displayed unless Sequence Components are Available. | P | Reset Curve Not Available<br>Reset Curve Available | P |

## Options – Protection 2



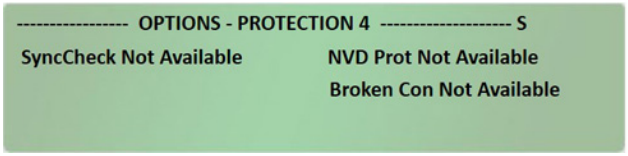

| Options – Protection 2 | | | |
|---|---|---|---|
| Under/Over Frequency Not Available<br>Under/Over Frequency Available | P | APGS Not Available<br>APGS Available | P |
| Under/Over Voltage Not Available<br>Under/Over Voltage Available | P | Sequence: Reset Flags OFF<br>Sequence: Reset Flags ON | P |
| Extended Standard Protection OFF<br>Extended Standard Protection ON | P | | |

## Options – Protection 3




| Options – Protection 3 | | | |
|---|---|---|---|
| Max Time/Curve OFF<br>Max Time/Curve ON | P | Conditional Reclose Not Available<br>Conditional Reclose Available | P |
| SOHIR Not Available<br>SOHIR Available | P | Conditional Reclose Time Out 5 s<br>(Range 0...3600 s)<br>Not displayed unless Conditional Auto Reclose is available. | P |
| Auto Reclose Dead time/Element OFF<br>Auto Reclose Dead time/Element ON | P | | |

## Options – Protection 4




| Options – Protection 4 | | | |
|---|---|---|---|
| Sync Check Not Available<br>Sync Check Available | P | NVD Protection Not Available<br>NVD Protection Available | P |
| | | Broken Conductor Not Available<br>Broken Conductor Available | P |

Following the protection options pages there is a single page for Automation.

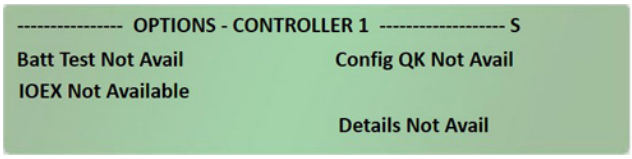
## Options – Automation




| Options – Automation | | |
|---|---|---|
| Automation OFF<br>Loop Automation Available<br>Auto Change Over Available | P | |

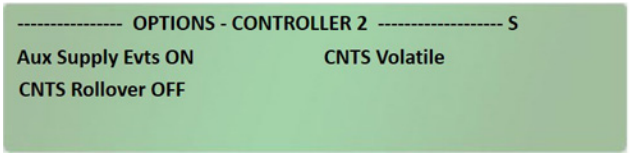
The next two options pages relate to the controller.

## Options – Controller 1




| Options – Controller 1 | | | |
|---|---|---|---|
| Battery Test Not Avail<br>Battery Test Available | P | Configurable Quick Keys Not Avail<br>Configurable Quick Keys Available | P |
| IOEX Not Available<br>IOEX Available | P | | |
| | | Details Not Available<br>Details Available | P |

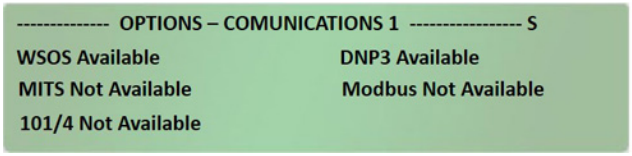
## Options – Controller 2




| Options – Controller 2 | | | |
|---|---|---|---|
| Auxiliary Supply Events ON<br>Auxiliary Supply Events OFF | P | Counters Volatile<br>Counters Non Volatile | P |
| Counters Rollover OFF<br>Counters Rollover ON | P | | |

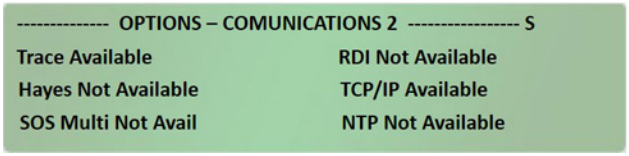
The next two options pages relate to communications.

## Options – Communications 1




| Options – Communications 1 | | | |
|---|---|---|---|
| WSOS Available<br>WSOS Not Available | P | DNP3 Available<br>DNP3 Not Available | P |
| MITS Not Available<br>MITS Available | P | Modbus Not Available<br>Modbus Available | |
| IEC 60870-5-101/104 Not Available<br>IEC 60870-5-101/104 Available | P | | |

## Options – Communications 2




| Options – Communications 2 | | | |
|---|---|---|---|
| Trace Available<br>Trace Not Available | P | Radio Data Interface Not Available<br>Radio Data Interface Available | P |
| Hayes Modem Driver Not Available<br>Hayes Modem Driver Available | P | TCP/IP Not Available<br>TCP/IP Available | P |
| SOS Multi Drop Driver Not Available<br>SOS Multi Drop Driver Available | P | Network Time Protocol Not Available<br>Network Time Protocol Available<br>**NOTE:** NTP cannot be made available unless Time Zone is available. | |

The last options page is for power quality features.

## Options – Power Quality




| Options – Power Quality | | | |
|---|---|---|---|
| Supply Outage Measure Not Available<br>Supply Outage Measure Available | P | Waveform Capture Not Available<br>Waveform Capture Available | P |
| Harmonics Not Available<br>Harmonics Available | P | Sag and Swell Not Available<br>Sag and Swell Available | P |

Making Quick Key Configuration available on the Options – Controller 1 page adds a Quick Key Selection page to the System Status menu after the options pages.

## Quick Key Selection




| Quick Key Selection | | | |
|---|---|---|---|
| Setting assigned to Quick Key 1 | P | Setting assigned to Quick Key 3 | P |
| Setting assigned to Quick Key 2 | P | Setting assigned to Quick Key 4 | P |

When IOEX is available, **IOEX-A** and **IOEX-B** pages appear in the System Status menu. IOEX can be made available on the Options – Controller 1 page.

## Hit and Run




| Hit and Run | | | |
|---|---|---|---|
| Hit and Run Close Off<br>Hit and Run Close 10 s...120 s | P | Hit & Run Trip Off<br>Hit & Run Trip 10 s...120 s | P |

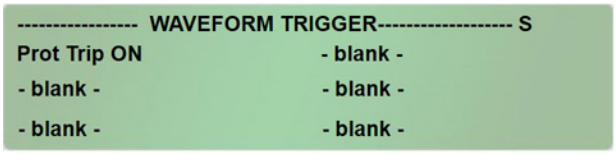
Making Waveform Capture available on the Options – Power Quality page adds two pages, **Waveform Capture** and **Waveform Trigger** to the System Status menu.

## Waveform Capture




| Waveform Capture | | | |
|---|---|---|---|
| Waveform Capture OFF<br>Waveform Capture ON | P | Waveform Capture Window 2 s<br>Waveform Capture Window 1 s<br>Waveform Capture Window 0.5 s | P |
| Waveform Capture Ratio 50/50<br>Waveform Capture Ratio 10/90<br>Waveform Capture Ratio 20/80<br>Waveform Capture Ratio 30/70<br>Waveform Capture Ratio 40/60<br>Waveform Capture Ratio 60/40<br>Waveform Capture Ratio 70/30<br>Waveform Capture Ratio 80/20<br>Waveform Capture Ratio 90/10 | P | Capture Now ON<br>Capture Now OFF<br>Waveform Captured<br>This field only displayed when Waveform Capture is ON | D |

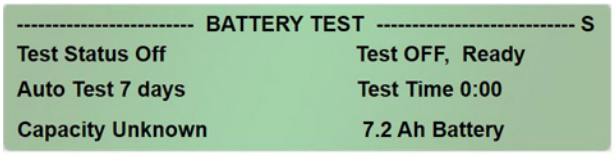
## Waveform Trigger



| Waveform Trigger | | | |
|---|---|---|---|
| Protection Trip<br>Manual Trip<br>Manual Close<br>Auto Close<br>Harmonics<br>Pickup<br>- blank- | O | - blank-<br>Protection Trip<br>Manual Trip<br>Manual Close<br>Auto Close<br>Harmonics<br>Pickup | O |
| - blank-<br>Protection Trip<br>Manual Trip<br>Manual Close<br>Auto Close<br>Harmonics<br>Pickup | O | - blank-<br>Protection Trip<br>Manual Trip<br>Manual Close<br>Auto Close<br>Harmonics<br>Pickup | O |
| - blank-<br>Protection Trip<br>Manual Trip<br>Manual Close<br>Auto Close<br>Harmonics<br>Pickup | O | - blank-<br>Protection Trip<br>Manual Trip<br>Manual Close<br>Auto Close<br>Harmonics<br>Pickup | O |

Battery Test can be made available in Options – Controller 1 and adds one page to the System Status menu.

## Battery Test




| Battery Test | | | |
|---|---|---|---|
| Test Status OFF<br>Test Status AUTO | P | Test OFF, Ready<br>Test START<br>Test ABORT | P |
| Auto Test 7 days<br>(Range 1...31 days)<br>Auto Test Disabled | P | Test Start Time 00:00 | P |
| Capacity Unknown<br>Capacity OK<br>Capacity NOT OK | D | 7.2 Ah Battery<br>12 Ah Battery | P |

# Appendix K.3 *set*VUE ACR and AS Measurement Menu Screens

This appendix shows all of the Measurement display group pages and lists display options and setting ranges.

The real time or instantaneous measurements appear at the start of the menu, followed by supply outage information, sag and swell monitoring with historical records at the end.

The basic Measurement display group consists of nine default pages.

Up to six additional pages can be added depending on the features that have been enabled.

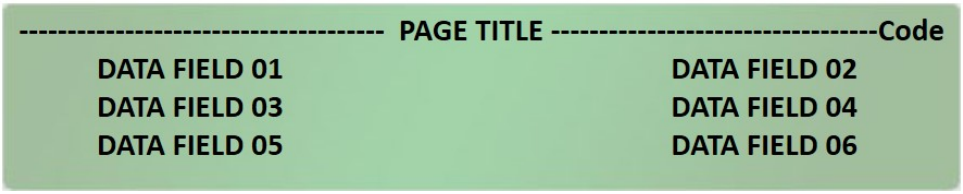
The table below shows a complete list of available pages and their position in the measurement menu.

**Table 142 *set*VUE Measurement Pages for ACR and AS**

| Measurement Menu | |
|---|---|
| **Default pages** | **Additional pages** |
| System Measurements | |
| Current | |
| Voltage | |
| | Sequence Voltage(1) |
| Frequency | |
| Power | |
| | Synchronization(2) |
| | Supply Outages(3) |
| | Sag/Swell Monitoring(4) |
| | Sag Monitoring(4) |
| | Swell Monitoring(4) |
| Daily Maximum Demand | |
| Weekly Maximum Demand | |
| Monthly Maximum Demand | |
| Maximum Demand Indicator | |
| (1) Sequence components available.<br>(2) Sync check available.<br>(3) Supply outages available.<br>(4) Sag/Swell available. | |

The top line of each page is the page title. To the right of the title is the letter M which indicates that the page being displayed is part of the Measurement display group.

The next three lines are the data on display. Most displays have six data fields. The standard layout is shown below.



Where details of individual pages are shown below a small column has been added to the right of each field to indicate the type of data displayed. The letters in this column have significance as follows:

**O** Operator Controlled

**D** Display Only (that is cannot be changed)

**P** Password Protected (that is cannot be changed unless the password is entered)

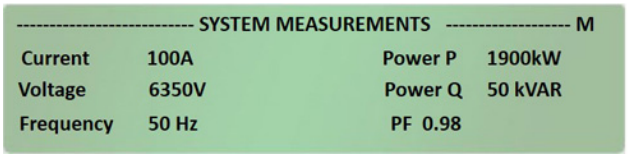
**R** Operator Controller Reset (that resets a field or group of fields)

If the standard menu is running, the measurement menu can be accessed by pressing the Panel On key and then pressing the Menu key two times.

The first page to be displayed in the Measurement menu is the **System Measurements** page shown below.

## System Measurements (AS)

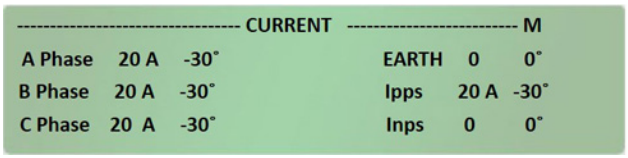
The values shown on the System Measurements page for current and voltage are averaged over the three phases.




| System Measurements | | | | |
|---|---|---|---|---|
| Average Phase Current | D | Total Power P | 1900 kW | D |
| Average Phase Voltage | D | Total Power Q | 200 kVAR | D |
| Frequency 50.0 Hz | D | PF | 0.98 | D |

## Current

Phase angles shown on the **Current** page are relative to their respective phase voltages.

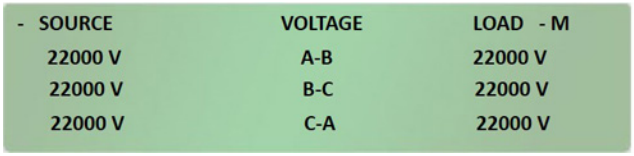



| Current | | | | | | |
|---|---|---|---|---|---|---|
| A Phase current | 20 A | -30° | Earth current | 0 A | 0° | D |
| B Phase current | 20 A | -30° | Positive Phase Sequence current | 0 A | 0° | D |
| C Phase current | 20 A | -30° | Negative Phase Sequence current | 0 A | 0° | D |

## Voltage

**Voltages** can be displayed as Phase to Phase or Phase to Earth values.

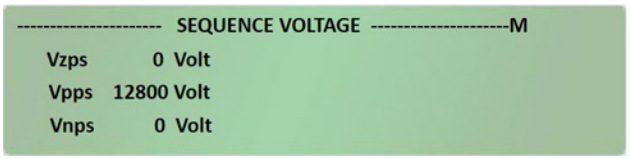
Source and Load sides always display the same voltage per phase when the switch is closed.




| Source | Voltage | Load | |
|---|---|---|---|
| A – B phase source voltage 22000 V | A-B (A-E) | A - B load side voltage 22000 V | D |
| B - C phase source voltage 22000 V | B-C (B-E) | B – C load side voltage 22000 V | D |
| C - A phase source voltage 22000 V | C-A (C-E) | C – A load side voltage 22000 V | D |

## Sequence Voltage

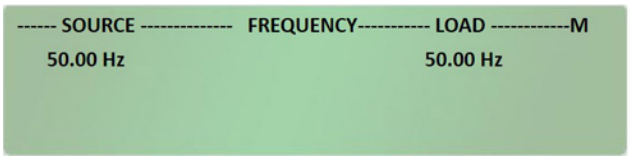
**Sequence Voltages** are not displayed in the Measurement menu unless Sequence Components are available.




| Sequence Voltage | |
|---|---|
| Zero Phase Sequence Voltage | D |
| Positive Phase Sequence Voltage | D |
| Negative Phase Sequence Voltage | D |

## Frequency

**Frequency** is measured on the source and load sides and displayed in Hertz to two decimal places.




If there in insufficient voltage present to measure the frequency reliably, the display will read Unavailable.

| Source | Frequency | Load | |
|---|---|---|---|
| Source side frequency | | Load side frequency | D |

## Power

The **Power** page displays per phase values for real power, reactive power and power factor.

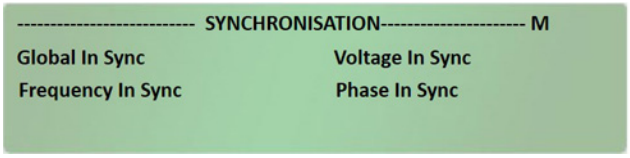



| Power | | | | |
|---|---|---|---|---|
| A | A Phase Real Power | A Phase Reactive Power | A Phase Power Factor | D |
| B | B Phase Real Power | B Phase Reactive Power | B Phase Power Factor | D |
| C | C Phase Real Power | C Phase Reactive Power | C Phase Power Factor | D |

## Synchronization

The **Synchronization** page indicates whether voltage, phase and frequency across an open switch are synchronized according to the current Sync Check settings. Global will only indicate synchronization when voltage, phase and frequency are all in sync.

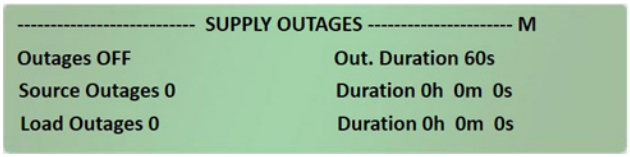
This page is only displayed when Sync Check is available.




| Synchronization | | | |
|---|---|---|---|
| Global In Sync<br>Global Unsynchronised | D | Voltage In Sync<br>Voltage Unsynchronised | D |
| Frequency In Sync<br>Frequency Unsynchronised | D | Phase in Sync<br>Phase Unsynchronised | D |

## Supply Outages

The **Supply Outages** page only appears in the Measurement menu if Supply Outages have been made available on the Options – Power Quality page in the System Status menu or through WSOS.




| Supply Outages | | | |
|---|---|---|---|
| Outages OFF<br>Outages ON | P | Outage Duration<br>(Range 1...3600 s) | P |
| Source Outages since last reset | D | Accumulated Source Outage Duration | D |
| Load outages since last reset | D | Accumulated Load Outage Duration | D |

## Sag/Swell Monitoring

The **Sag/Swell Monitoring** page only appears in the Measurement menu if Sag/Swell has been made available on the Options – Power Quality page in the System Status menu or through WSOS.




| Sag/Swell Monitoring | | | |
|---|---|---|---|
| Nominal Phase to Earth Voltage<br>(Range 2000...25,000 V) | P | | |
| Fault Reset Time<br>(Range 0...10,000 ms) | P | | |
| Curve (Definite Time Only) | P | | |

## Sag Monitoring

The **Sag Monitoring** page only appears in the Measurement menu if Sag/Swell has been made available on the Options – Power Quality page in the System Status menu or through WSOS.

Sag monitoring can be On and Off independently of Swell monitoring.




| Sag Monitoring | | | |
|---|---|---|---|
| Sag Monitor OFF<br>Sag Monitor ON | P | | |
| Pickup Voltage<br>Set with PU values | P | | |
| (Definite Time 0.01...100 s) | P | | |

## Swell Monitoring

The **Swell Monitoring** page only appears in the Measurement menu if Sag/Swell has been made available on the Options – Power Quality page in the System Status menu or through WSOS.

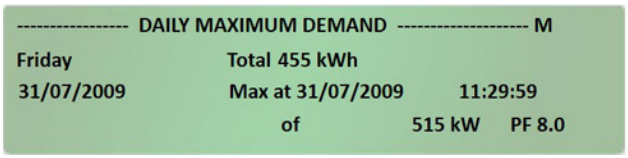
Swell monitoring can be On and Off independently of Sag monitoring.



| Swell Monitoring | | | |
|---|---|---|---|
| Swell Monitor OFF<br>Swell Monitor ON | P | | |
| Pickup Voltage<br>Set with PU values | P | | |
| (Definite Time 0.01...100 s) | P | | |

## Daily Maximum Demand

The controller maintains a log of **Daily Maximum Demand** records that show the total energy and peak power for each day. The most recent record i.e. the previous day, is displayed by default. The Date/Time displayed is the end of the period when the peak average power was logged.




| Daily Maximum Demand | | | |
|---|---|---|---|
| Previous Day | | Total Energy for previous day (kWh) | |
| Yesterday's date | | Date/Time for peak power | |
| | | Peak power and power factor | |

Earlier records can be viewed by pressing the **SELECT** key to enter the history mode and navigating using the Left and Right Arrow keys.

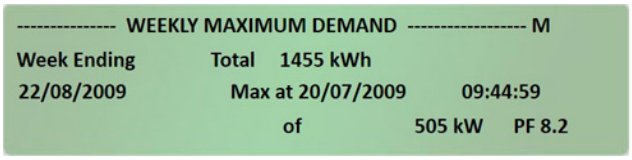
When earlier records are being displayed, the title changes to:

## Daily Maximum Demand History

To return to the most recent record, press the **MENU** key.

## Weekly Maximum Demand

The controller maintains a log of **Weekly Maximum Demand** records that show the total energy for the week as well as the peak power and the period during which it occurred. The most recent record i.e. the previous week, is displayed by default. The Date/Time displayed is the end of the period when the peak average power was logged.




| Weekly Maximum Demand | | | |
|---|---|---|---|
| Total energy for the week (kWh) | | | |
| The date at the end of the week | | Date/Time for period of peak power | |
| | | Peak power and power factor | |

Earlier records can be viewed by pressing the **SELECT** key to enter the history mode and navigating using the Left and Right Arrow keys.

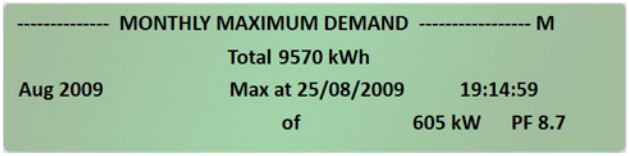
When earlier records are being displayed, the title changes to:

## Weekly Maximum Demand History

To return to the most recent record, press the **MENU** key.

## Monthly Maximum Demand

The controller maintains a log of **Monthly Maximum Demand** records that show the total energy for the week as well as the peak power and the period during which it occurred. The most recent record that is the previous week, is displayed by default. The Date/Time displayed is the end of the period when the peak average power was logged.




| **Monthly Maximum Demand** | | | |
|---|---|---|---|
| Total energy for the month (kWh) | | | |
| The month when this record was logged | | Date/Time for period of peak power | |
| | | Peak power and power factor | |

Earlier records can be viewed by pressing the **SELECT** key to enter the history mode and navigating using the Left and Right Arrow keys.

When earlier records are being displayed, the title changes to:

## Monthly Maximum Demand History

To return to the most recent record, press the **MENU** key.

## Maximum Demand Indicator




## Maximum Demand Indicator Details

The **Maximum Demand Indicator** displays the highest current recorded in each phase since it was last reset. The date/time the maximum current occurred in each phase is also recorded. The instantaneous phase current readings are also displayed.

| Maximum Demand Indicator | | | |
|---|---|---|---|
| A Phase | Instantaneous A phase current | Maximum A phase current recorded | Date/time maximum A phase current was recorded |
| B Phase | Instantaneous B phase current | Maximum B phase current recorded | Date/time maximum B phase current was recorded |
| C Phase | Instantaneous C phase current | Maximum C phase current recorded | Date/time maximum C phase current was recorded |

# Appendix K.4 *set*VUE ACR Protection Menu Pages

This appendix lists all of the Protection display group pages.

The basic Protection display group consists of 26 default pages.

Up to 96 additional pages can be added to the protection menu depending on the features that have been enabled.

The table below shows the complete list of available pages and their position in the protection menu.

**Table 143 *set*VUE Protection Menu Pages**

| Protection Menu | | |
|---|---|---|
| **Default Pages** | **Additional Pages** | **Alternate Pages** |
| Protection Setting 1...3 | | |
| Protection Setting 4(1) | | |
| Protection Setting 5, 6 | | |
| | Protection Setting Alarms 1, 2 | |
| | Protection Setting 7(2)(3) | |
| Protection Setting 8(8) | | |
| | Protection Setting 9(5) | |
| Cold Load Pickup Protection | | |
| | Sync Check Settings 1 - 4(6) | |
| | Directional Blocking Phase 1, 2(7) | Directional Protection 1(8) |
| | Directional Blocking Earth(7) | Dir Protection Phase 2, 3(8) |
| | Directional Blocking SEF(7) | Dir Protection Earth 4, 5(8) |
| | $V_{zps}$ Compensation(7) | Dir Protection SEF 6, 7(8) |
| | High $V_{zps}$ Alarm(7) | $V_{zps}$ Compensation(8) |
| | | High $V_{zps}$ Alarm(8) |
| | Phase Threshold Trip No 1(9) | |
| Phase Protection Trip No 1 | | |
| | Phase Protection Reset No 1(10) | |
| | Phase Threshold Trip No 2(9) | |
| Phase Protection Trip No 2 | | |
| | Phase Protection Reset No 2(10) | |
| | Phase Threshold Trip No 3(9) | |
| Phase Protection Trip No 3 | | |
| | Phase Protection Reset No 3(11) | |
| | Phase Threshold Trip No 4(12) | |

**Table 143 *set*VUE Protection Menu Pages (Continued)**

| Protection Menu | | |
|---|---|---|
| **Default Pages** | **Additional Pages** | **Alternate Pages** |
| Phase Protection Trip No 4 | | |
| | Phase Protection Reset No 4(11) | |
| | Phase Single Shot Threshold Trip(12) | |
| Phase Single Shot Prot Trip | | |
| | Phase Single Shot Prot Reset(11) | |
| | Phase Work Tag Threshold Trip(12) | |
| Phase Work Tag Prot Trip | | |
| | Phase Work Tag Prot Reset(11) | |
| | Phase Protection Max Times(13) | |
| | Earth Threshold Trip No 1(12) | |
| Earth Protection Trip No 1 | | |
| | Earth Protection Reset No 1(11) | |
| | Earth Threshold Trip No 2(12) | |
| Earth Protection Trip No 2 | | |
| | Earth Protection Reset No 2(11) | |
| | Earth Threshold Trip No 3(12) | |
| Earth Protection Trip No 3 | | |
| | Earth Protection Reset No 3(11) | |
| | Earth Threshold Trip No 4(12) | |
| Earth Protection Trip No 4 | | |
| | Earth Protection Reset No 4(11) | |
| | Earth S Shot Threshold Trip(12) | |
| Earth Single Shot Prot Trip | | |
| | Earth Single Shot Reset(11) | |
| | Earth W Shot Threshold Trip(12) | |
| Earth Work Tag Prot Trip | | |
| | Earth Work Tag Reset(11) | |
| | Earth Protection Max Times(13) | |
| | SEF Threshold Trip No 1(12) | |
| SEF Protection Trip No 1 | | |
| | SEF Protection Reset No 1(11) | |
| | SEF Threshold Trip No 2(12) | |
| SEF Protection Trip No 2 | | |
| | SEF Protection Reset No 2(14) | |
| | SEF Threshold Trip No 3(11) | |
| SEF Protection Trip No 3 | | |
| | SEF Protection Reset No 3(15) | |
| | SEF Threshold Trip No 4(16) | |
| SEF Protection Trip No 4 | | |
| | SEF Protection Reset No 4(15) | |

**Table 143 *set*VUE Protection Menu Pages (Continued)**

| Protection Menu | | |
|---|---|---|
| **Default Pages** | **Additional Pages** | **Alternate Pages** |
| | SEF Single Shot Threshold Trip(16) | |
| SEF Single Shot Protection Trip | | |
| | SEF Single Shot Prot Reset(15) | |
| | SEF Work Tag Threshold Trip(16) | |
| SEF Work Tag Protection Trip | | |
| | SEF Work Tag Prot Reset(15) | |
| | SEF Protection Max Times | |
| | NPS Threshold Trip No 1(16) | |
| | NPS Protection Trip No 1(17) | |
| | NPS Protection Reset No 1(18) | |
| | NPS Threshold Trip No 2(17) | |
| | NPS Protection Trip No 2(18) | |
| | NPS Protection Reset No 2(19) | |
| | NPS Threshold Trip No 3(17) | |
| | NPS Protection Trip No 3(18) | |
| | NPS Protection Reset No 3(19) | |
| | NPS Threshold Trip No 4(17) | |
| | NPS Protection Trip No 4(18) | |
| | NPS Protection Reset No 4(19) | |
| | NPS Single Shot Threshold Trip(17) | |
| | NPS Single Shot Protection Trip(18) | |
| | NPS Single Shot Prot Reset(19) | |
| | NPS Work Tag Threshold Trip(17) | |
| | NPS Work Tag Protection Trip(18) | |
| | NPS Work Tag Prot Reset(19) | |
| | NPS Protection Max Times(19) | |
| | | |
| | Under/Over Frequency Protection 1,2(20) | |
| | Rate of Change of Frequency(20) | |
| | NVD Protection 1, 2(20) | |
| | NVD Alarm 1, 2(21) | |
| | Broken Conductor Protection(21) | |
| | Broken Conductor Alarm(21) | |
| | Under Voltage Protection(22) | |
| | Over Voltage Protection(22) | |
| | Under/Over Voltage Protection(22) | |
| | Under/Over Voltage Protection(22) | |
| | Fault Locator(23) | |

**Table 143 *set*VUE Protection Menu Pages (Continued)**

| Protection Menu | | |
|---|---|---|
| **Default Pages** | **Additional Pages** | **Alternate Pages** |
| | Conductor Characteristics(24) | |

(1) Not displayed when Per Trip Thresholds are available.

(2) Only displayed when Extended Standard Protection On.

(3) Not displayed when Per Element Protection is available.

(4) Only displayed when either Close on Fault Trip or Per Element Protection are available.

(5) Only displayed when Ground Fault Neutralizer is available.

(6) Only displayed when Sync Check available.

(7) Only displayed when Directional Blocking is available.

(8) Only displayed when Directional Protection is available Directional Blocking and Directional Protection are mutually exclusive.

(9) Only displayed when Per Trip Thresholds are available.

(10) Only displayed when Reset Curves are available.

(11) Only displayed when Reset Curves are available.

(12) Only displayed when Per Trip Thresholds are available.

(13) Only displayed when Extended Maximum Time per Curve is on.

(14) Only displayed when Reset Curves are on.

(15) Only displayed when Per Trip Thresholds are available.

(16) Only displayed when Per Trip Thresholds and Sequence Components are both available.

(17) Only displayed when Sequence Components are available.

(18) Only displayed when Sequence Components and Reset Curves are available.

(19) Only displayed when Sequence Components and Extended Maximum Time per Curve are on.

(20) Only displayed when Under/Over Frequency Protection is available.

(21) Only displayed when Neutral Voltage Displacement is available.

(22) Only displayed when Broken Conductor is available.

(23) Only displayed when Under/Over Voltage Protection is available.

(24) Only displayed when Fault Locator is available.

The top line of each page is the page title. To the right of the title is the letter P which indicates that the page being displayed is part of the Protection display group.

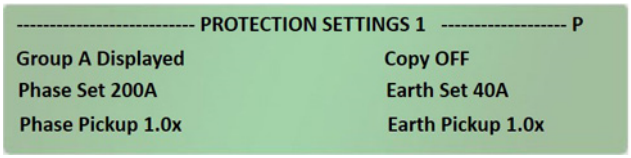
The next three lines are the data or information on display. Most displays have six data fields. The standard layout is shown below.




If the standard menu is running, the protection menu can be accessed by pressing the Panel On key and then pressing the Menu key three times.

The first page to be displayed in the Protection menu is the **Protection Settings 1** as shown below.

## Protection Settings 1




# Appendix K.5 *set*VUE ACR and AS Communications Menu Screens

This appendix shows all of the Communications display group pages and lists display options and setting ranges.

The basic Communications display group consists of 28 (ADVC) default pages.

Up to 17 additional pages 13 (ADVC) can be added to the communications menu depending on the features that have been enabled.

**Table 144 *set*VUE Communications Menu Pages for ACR and AS**

| Communications Menu | | | |
|---|---|---|---|
| **Sub-Menu** | | | |
| **Defaults** | **Additional** | **Level 1** | **Level 2** |
| Configure Ports (ADVC) | | IOEX/WSOS | IOEX/WSOS 1 |
| | | | IOEX/WSOS2 |
| | | Modem | Modem 1 |
| | | | Modem 2 |
| | | | Modem 3 |
| | | | Modem 4 |
| | | Port-10BaseT | 10BaseT |
| | | | 10BaseT Statistics |
| | | Port-10BaseT2 | 10BaseT 2 |
| | | | 10BaseT 2 Statistics |
| | | USB-Port-1 | USB-1 |
| | | USB-Port-2 | USB-2 |
| | | USB-Port-3 | USB-3 |
| WSOS | | WSOS Communications | |
| | | WSOS Communications Statistics | |
| DNP3 | | DNP Communications | |
| | | DNP Communications Statistics | |
| | | DNP Transmission Services 1, 2 | |
| | | DNP Unsolicited 1, 2, 3 | |
| | | DNP Diagnostics 1, 2 | |
| | | DNP Database Configuration | |
| Trace Port | | Communications Trace | |
| | | Communications Trace Statistics | |
| | I101/4[1] | IEC 870-101 Communications | |

**Table 144 *set*VUE Communications Menu Pages for ACR and AS (Continued)**

| Communications Menu | | | |
|---|---|---|---|
| **Sub-Menu** | | | |
| **Defaults** | **Additional** | **Level 1** | **Level 2** |
| | | IEC 870-101 Communications Statistics | |
| | | IEC 870-101 Transmission Services 1 | |
| | | IEC 870-101 Transmission Services 2 | |
| | | IEC 870-101 Transmission Services 3 | |
| | | IEC 870-101 Configuration 1 | |
| | | IEC 870-101 Configuration 2 | |
| | Modbus(2) | Modbus Communications | |
| | | Modbus Communications Statistics | |
| | MITS(3) (ADVC2 only) | MITS Communications | |
| | | MITS Communications Statistics | |
| | | MITS Transmission Data | |
| | | MITS Time Configuration | |
| | NTP Communications/ Servers | NTP Communications | |
| | | NTP Servers | |
| | Radio Data Interface(4) | RDI Driver Communications | |
| | | RDI Communications Statistics | |

(1) Only displayed when IEC 60870-5-101/104 is available.

(2) Only displayed when Modbus is available.

(3) Only displayed when MITS is available.

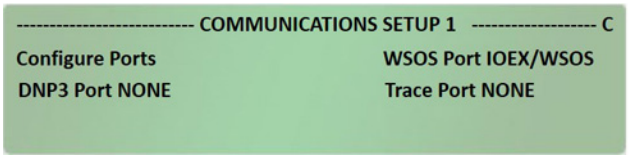
(4) Only displayed when Radio Data Interface Driver is available.

The communications menu is different from the other menus on the ***set*VUE** O.I. which means that it cannot be navigated from the first page using the Left or Right Arrow keys.

Each field on the first page is actually a sub-menu which must be selected and then entered before normal navigation can take place.

The first page displayed in the Communications menu is the **Communications Setup** page shown below.

## Communications Setup 1




To enter one of the sub-menus displayed, navigate to it using the Select key and press Menu. Once the selected sub-menu has been entered it can be navigated in the normal manner.

The top line of each page is the page title. To the right of the title is the letter C which indicates that the page being displayed is part of the Communications display group.

The next three lines are the data or information on display. Most displays have six data fields. The standard layout is shown below.




If the standard menu is running, the protection menu can be accessed by pressing the Panel On key and then pressing the Menu key four times.

# Appendix K.6 *set*VUE ACR and AS Automation Menu Screens

This appendix shows all of the Automation display group pages and lists display options and setting ranges.

The Automation display group can consist of between 3 and 8 pages depending on the configuration when Loop Automation is available or 3 pages when Auto-Changeover is available.

The Automation display group does not appear in the menu structure by default. It is only displayed when either of the two automation features, Loop Automation and Auto-Changeover has been made available. These features are mutually exclusive.

**Table 145 *set*VUE Automation Menu Pages for ACR and AS**

| **Automation Menu** | |
|---|---|
| **Loop Automation** | **Auto-Changeover** |
| Loop Automation Status(1) | Auto-Changeover Configuration(2) |
| Loop Automation Configuration 1(1) | Auto-Changeover Communications(2) |
| Loop Automation Configuration 2(1) | Auto-Changeover Communications Stats(2) |
| Loop Automation Configuration 3(3) | |
| Loop Automation Configuration 4(4) | |
| Loop Automation Configuration 5(5) | |
| LA Communications(6) | |
| LA Downstream Communications(7) | |
| LA Tie Communications(8) | |

(1) Only displayed when Loop Automation is available.

(2) Only displayed when Auto-Changeover is available.

(3) Only displayed when Loop Automation is available and Device Type is Tie.

(4) Only displayed when Loop Automation is available, Logic is Intelligent and Tie Control is Message.

(5) Only displayed when Loop Automation is available, Device Type is Tie and Logic is Classic.

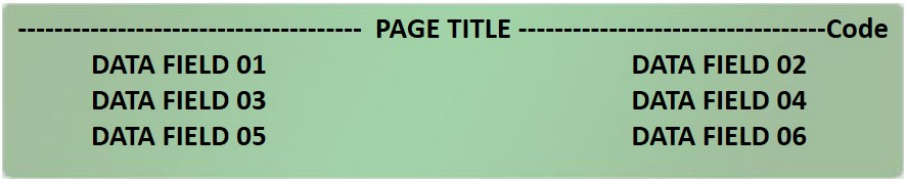
(6) Only displayed when Loop Automation is available and Logic is Intelligent.

(7) Only displayed when Loop Automation is available, Logic is intelligent and Device Type is not Tie.

(8) Only displayed when Loop Automation is available, Logic is intelligent and Device Type is Tie.

The top line of each page is the page title. To the right of the title is the letter A which indicates that the page being displayed is part of the Automation display group.

The next three lines are the data or information on display. Most displays have six data fields. The standard layout is shown below.




When Loop Automation is available, the first page to be displayed in the Automation menu is the **Loop Automation Status** page.




When Auto-Changeover is available, the first page to be displayed in the Automation menu is the **Auto-Changeover Configuration** page.




# Appendix K.7 *set*VUE AS Menu Structure

The ***set*VUE** displays are organized into logical groups called Display Groups. Within each group is a menu of pages and some pages have sub-pages.

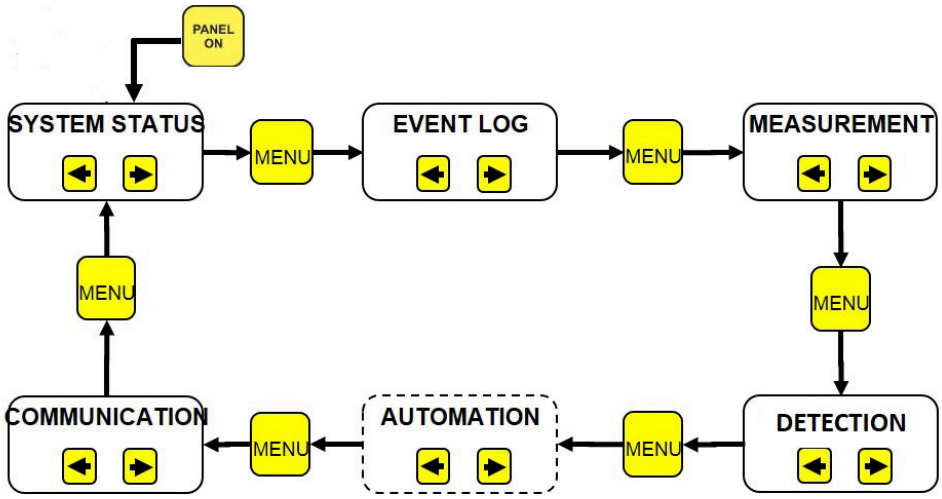



**Figure 358**
***set*VUE** AS Menu Structure

The Automatic display group only appears if an automation feature i.e. Loop Automation or Auto Changeover is available. Otherwise the display will move from Detection directly to the Communications display group.

Pressing the **MENU** key causes the display to move to the next group in turn.

The **Left** and **Right Arrow** keys are used to scroll through the screens within a display group.

All display groups are circular. So pressing the **Right Arrow** key when the last screen in the group is being displayed will cause the display to return to the first screen.

The individual screens in each of the display groups are shown in Appendices M.2 to M.6

The following table represents the procedure to find the settings on the ***set*VUE** O.I.

**Table 146 Finding an AS setting on the *set*VUE O.I.**

| Step | Action |
|---|---|
| 1. | Press **MENU** until the menu group you require is displayed on the screen.<br>Example: **DETECTION.** |
| 2. | Use the arrow keys to scroll through until you find the required menu.<br>Example: **DETECTION SETTINGS** > **Phase Detection** |
| 3. | On that menu is the setting you are looking for.<br>Example: **Definite Time** |
| 4. | For information on changing settings refer to Chapter 4 Operator Functions, page 49. |

The structure of the ***set*VUE** menu changes when the **Custom Menu** is used.

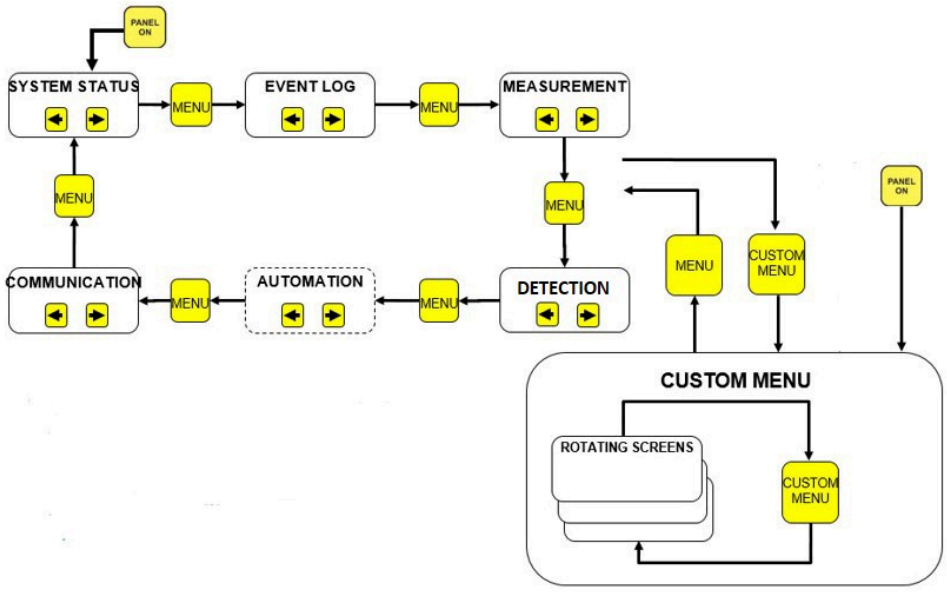



**Figure 359**
***set*VUE** AS Custom Menu

When the Custom Menu has been configured using WSOS it can be accessed by pressing the **Custom Menu** key on the operator interface.

Continuing to press the **Custom Menu** key will cause the display to step through the selected screens.

Alternatively the display may have been configured to scroll automatically when the operator interface is on.

Pressing the **Custom Menu** key will have no effect if it has not been configured.

The display will return to the main menu if the **Menu** key is pressed.

# Appendix K.8 *set*VUE AS System Status Pages

This appendix shows all of the System Status display group pages and list display options and setting ranges.

The System Status display group contains the operator settings and information relating to the ratings and configuration of the device.

The basic System Status display group consists of 16 default pages.

Up to 19 additional pages (shown below in blue) can be added depending on the features that have been enabled.

**Table 147 *set*VUE System Status Menu Pages for AS**

| System Status Menu | |
|---|---|
| **Default pages** | **Additional pages** |
| Fault Flags/Pickup Flags | |
| Supply Interrupt Flags(1) | Options – Detection 1(2) |
| Operator Settings 1 | Options – Detection 2(2) |
| Operator Settings 2 | Options – Detection 3(2) |
| Operator Settings 3 | Options – Automation 2(2) |
| Operator Settings 4(1) | Options – Controller 1(2) |
| System Settings 1 | Options – Controller 2(2) |
| System Settings 2 | Options – Communications 1(2) |
| Switchgear Status | Options – Communications 2(2) |
| Fault Information | Options – Power Quality(2) |
| Live/Dead Indication | Quick Key Selection(3) |
| Phase Voltage and Power Flow | IOEX – A Status(4) |
| Terminal Designation/Rotation | IOEX – B Status(5) |
| Radio | Hit and Run(5) |
| Switchgear Type and Ratings | Waveform Capture(6) |
| Switchgear Wear/General Details | Waveform Trigger(6) |
| Plant Details(7) | Battery Test(8) |
| | |
| | User Defined Control 1 |
| | User Defined Control 2 |
| (1) Per Element Detection available.<br>(2) Panel display options available.<br>(3) Quick key configuration available.<br>(4) IOEX available.<br>(5) Hit and Run available.<br>(6) Waveform capture available.<br>(7) Plant Details Available.<br>(8) Battery health test available. | |

The top line of each page is the page title. To the right of the title is the letter S which indicates that the page being displayed is part of the System Status display group.

The next three lines are the data on display. Most displays have six data fields. The standard layout is shown below.



Where details of individual pages are shown below a small column has been added to the right of each field to indicate the type of data displayed. The letters in this column have significance as follows:

**O** Operator Controlled

**D** Display Only (that is cannot be changed)

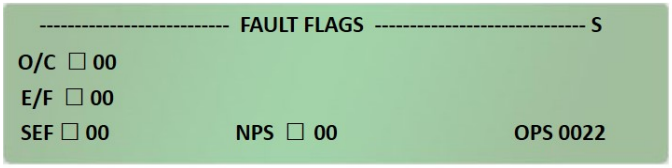
**P** Password Protected (that is cannot be changed unless the password is entered)

**R** Operator Controller Reset (that is resets a field or group of fields)

If the standard menu is running the System Status menu will be displayed when the Panel On key is pressed.

The first page to be displayed in the System Status menu is the **Fault Flags** page shown below.

## Fault Flags Page (AS)




The fault flags for Negative Phase Sequence will only appear on this page if Sequence Components have been made available.

| ---------- FAULT FLAGS ---------- S | | | | | |
|---|---|---|---|---|---|
| O/C<br>☐<br>■<br>00-99 ABC | R | | | | |
| E/F (G/F)<br>☐<br>■<br>00-99 | R | | | | |
| SEF (SGF)<br>☐<br>■<br>00-99 | R | NPS(1)<br>☐<br>■<br>00-99 | R | OPS<br>0000-9999 | R |
| (1) Only displayed if Sequence Component are available. | | | | | |

The title of this page will change to PICKUP FLAGS if Detection is Off.

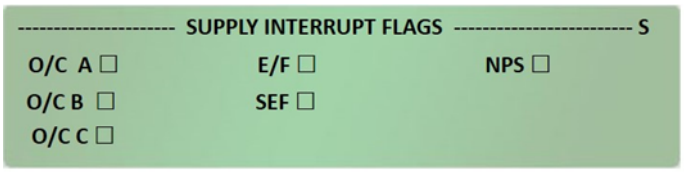
| ---------- PICKUP FLAGS ---------- S | | | | | |
|---|---|---|---|---|---|
| O/C<br>☐<br>■<br>00-99 ABC | R | | | | |
| E/F (G/F)<br>☐<br>■<br>00-99 | R | | | | |

| ---------- PICKUP FLAGS ---------- S | | | | | |
|---|---|---|---|---|---|
| SEF (SGF)<br>☐<br>■<br>00-99 | R | NPS(1)<br>☐<br>■<br>00-99 | R | OPS<br>0000-<br>9999 | R |
| (1) Only displayed if Sequence Component are available. | | | | | |

The other pages in this group can be displayed by pressing the left and right arrow keys.

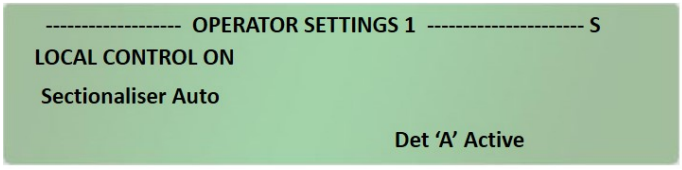
Pressing the right arrow key when the Fault Flags page is displayed will move the display to the **Supply Interrupt Flags** page if Per Element Detection is available, otherwise it will be the first of three **Operator Settings** pages.

## Supply Interrupt Flags(16) (AS)




| ---------- SUPPLY INTERRUPT FLAGS ---------- S | | | | | |
|---|---|---|---|---|---|
| O/C A<br>☐<br>■ | R | E/F<br>☐<br>■ | R | NPS<br>☐<br>■ | R |
| O/C B<br>☐<br>■ | R | SEF<br>☐<br>■ | R | | |
| O/C C<br>☐<br>■ | R | | | | |

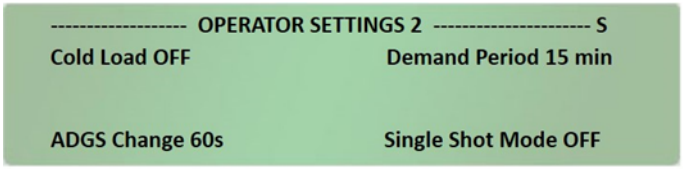
## Operator Settings 1 (AS)




(16) Only displayed if Per Element Detection is available.

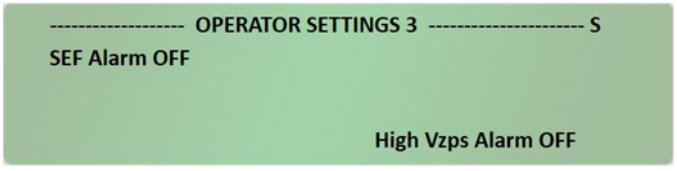
| Operator Settings 1 | | | |
|---|---|---|---|
| LOCAL CONTROL ON<br>Remote Control On<br>Hit and Run ON<br>Hit and Run OFF | O | | |
| Sectionaliser OFF<br>Sectionaliser Auto<br>Detection OFF | O | | |
| Blank in normal operation.<br>Supply Interrupt 1<br>Supply Interrupt 2<br>Supply Interrupt 3<br>Supply Interrupt 4<br>Sectionaliser Trip | D | Det Auto<br>Auto A Active<br>Auto B Active etc<br>Auto J Active<br>Det A, B ……. J Active | O<br>O<br>D<br>D |

## Operator Settings 2 (AS)



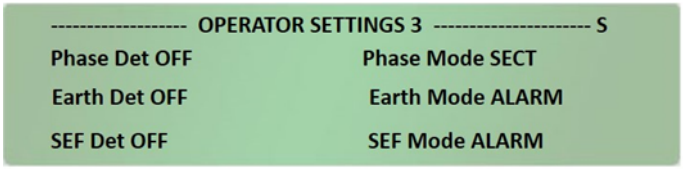

| Operator Settings 2 | | | |
|---|---|---|---|
| Cold Load OFF<br>Cold Load IDLE<br>Cold Load NO CHANGE<br>Cold Load MAX<br>CLP 120 minute x 2.3 mult(1) | D | Demand Period 15 min<br>Demand Period 5 min<br>Demand Period 30 min<br>Demand Period 60 min | O |
| | | | |
| ADGS Change 60 s (Range 10 s...180 s) | O | Single Shot Mode OFF<br>Single Shot Mode ON | O |
| (1) This field is display only when configured as Cold Load OFF. | | | |

## Operator Settings 3 (AS) (Per Element Detection not available)



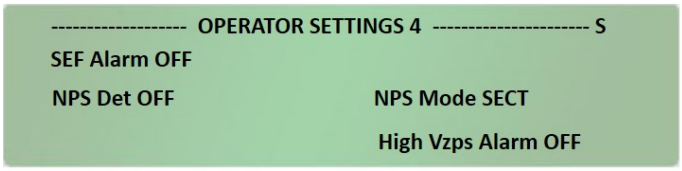
| Operator Settings 3 | | | |
|---|---|---|---|
| SEF Alarm OFF(1)<br>SEF Alarm ON | O | | |
| | | High $V_{ZPS}$ Alarm OFF<br>High $V_{ZPS}$ Alarm ON | D |
| (1) This setting displayed on Operator Settings 4 when Per Element Detection is Available. | | | |

## Operator Settings 3 (AS) (Per Element Detection available)



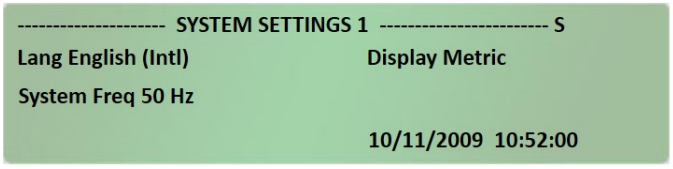

| Operator Settings 3 | | | |
|---|---|---|---|
| Phase Det OFF(1)<br>Phase Det ON | O | Phase Mode SECT(2)<br>Phase Mode ALARM | O |
| Earth Det OFF(2)<br>Earth Det ON | O | Earth Mode SECT(2)<br>Earth Mode ALARM | O |
| SEF Det OFF(2)<br>SEF Det ON | O | Earth Mode SECT(2)<br>Earth Mode ALARM | O |
| (1) This field is display only when configured as Cold Load OFF.<br>(2) This setting only displayed when Per Element Detection is Available. | | | |

## Operator Settings 4 (AS) (Per Element Detection available)



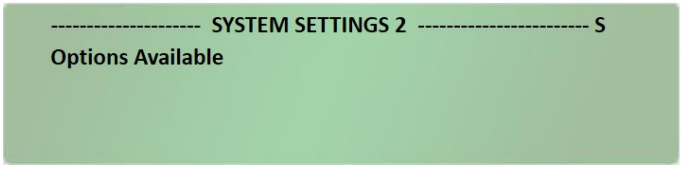

| Operator Settings 4 | | | |
|---|---|---|---|
| SEF Alarm OFF<br>SEF Alarm ON | O | | |
| NPS Det OFF<br>NPS Det ON | O | NPS Mode SECT<br>NPS Mode ALARM | O |

## System Settings 1 (AS)



| System Settings 1 | | | |
|---|---|---|---|
| Language English (Intl)<br>Language English (USA)<br>Lingua Portuguesa – Portugues (Brasil) | O | Display Metric<br>Display Imperial | |
| System Frequency 50 Hz<br>System Frequency 60 Hz | P | | |
| | | DD/MM/YYYY (MM/DD/YY)<br>HH:MM:SS | O |

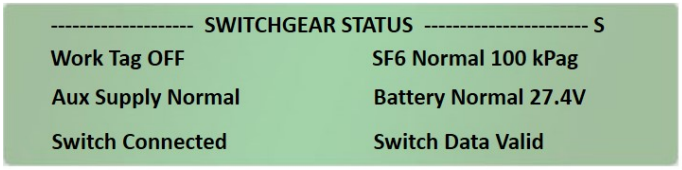
## System Settings 2 (AS)




| System Settings 2 | | | |
|---|---|---|---|
| Options Available<br>Options Not Available | P | | |

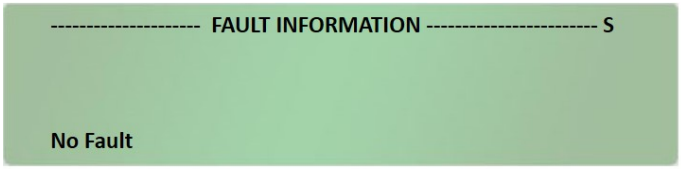
Once the device has been initially configured, the menu can be decluttered by making Options unavailable which removes the nine Options pages.

## Switchgear Status (AS)



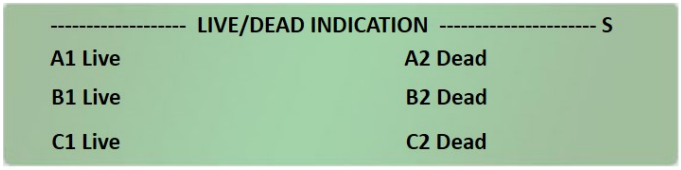

| Switchgear Status | | | |
|---|---|---|---|
| Work Tag Off<br>Work Tag Applied | O | $SF_6$ Normal 37 kPag<br>$SF_6$ Normal 5.5 psig<br>(N Series only) | D |
| Auxiliary Supply Normal<br>Auxiliary Supply Fail | D | Battery Normal x.xV<br>Battery OFF<br>Battery Low Volts x.xV<br>Battery Overvolt x.xV | D |
| Switch Connected<br>Switch Unplugged | D | Switch Data Valid<br>Switch Data Invalid | D |

## Fault Information (AS)




| Fault Information | | | |
|---|---|---|---|
| No Fault<br>Fault Type: A-E, B-E, C-E<br>Fault Type: A-B, B-C, C-A<br>Fault Type: ABC | D | | |

## Live/Dead Indication (AS)




| Live/Dead Indication | | | |
|---|---|---|---|
| A1 Live or Ai Live<br>A1 Dead or Ai Dead | D | A2 Live or Ax Live<br>A2 Dead or Ax Dead | D |
| B1 Live or Bi Live<br>B1 Dead or Bi Dead | D | B2 Live or Bx Live<br>B2 Dead or Bx Dead | D |
| C1 Live or Ci Live<br>C1 Dead or Ci Dead | D | C2 Live or Cx Live<br>C2 Dead or Cx Dead | D |

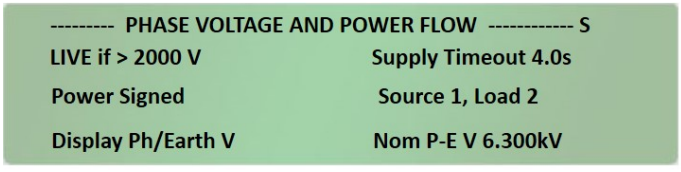
**Live/Dead Indications** display the status of each bushing with the capability to measure voltage.

**NOTE:** The RL Series can measure voltage on all six bushings. The PMSet U Series can only measure voltage on the bushings on the I side unless optional external CVT's are fitted. When no voltage measurement is possible, the display will read Unavailable.

**NOTE:** Live/Dead indications are shown for the individual phases according to the Phase Configuration settings on the Terminal Designation/Rotation page.

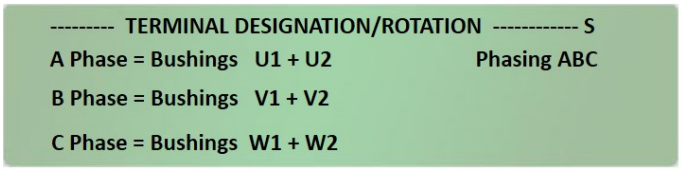
**Phase Voltage and Power Flow** contains settings relating to the display of voltage and power.

## Phase Voltage and Power Flow (AS)



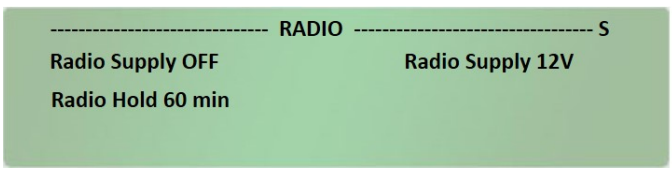
| Phase Voltage and Power Flow | | | |
|---|---|---|---|
| Live if > 2000 V<br>(Range 2000 V...15000 V) | P | Supply Timeout 4.0 s<br>(Range 0.1 s...100.0 s) | P |
| Power Signed<br>Power Unsigned | P | Source 1, Load 2 or Source I, Load x<br>Source 2, Load 1 Source x, Load i | P |
| Display Phase/Earth (Gnd) V<br>Display Phase/Phase V | P | Nom P-E V 6.300 kV<br>(Range 2000 V...25000 V) | P |

## Terminal Designation/Rotation (AS)



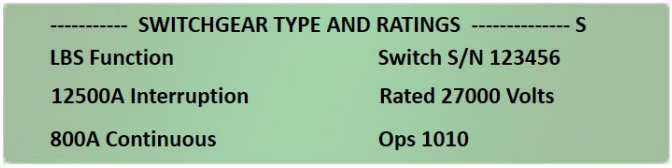

| Terminal Designation/Rotation | | | |
|---|---|---|---|
| A Phase Bushings = U1 + U2<br>A Phase Bushings = U1 + U2<br>A Phase Bushings = V1 + V2<br>A Phase Bushings = W1 + W2<br>A Phase Bushings = V1 + V2<br>C Phase Bushings = W1 + W2 | | Phasing ABC<br>Phasing ACB<br>Phasing BAC<br>Phasing BCA<br>Phasing CAB<br>Phasing CBA | P |
| B Phase Bushings = V1 + V2<br>B Phase Bushings = W1 + W2<br>B Phase Bushings = U1 + U2<br>B Phase Bushings = U1 + U2<br>B Phase Bushings = W1 + W2<br>B Phase Bushings = V1 + V2 | | | |
| C Phase Bushings = W1 + W2<br>C Phase Bushings = V1 + V2<br>C Phase Bushings = W1 + W2<br>C Phase Bushings = V1 + V2<br>C Phase Bushings = U1 + U2<br>C Phase Bushings = U1 + U2 | | | |

## Radio (AS)



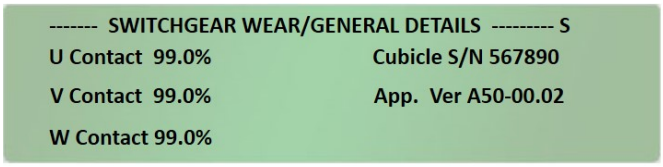
| Radio | | | |
|---|---|---|---|
| Radio Supply OFF<br>Radio Supply ON<br>Radio Supply Shutdown | D | Radio Supply 12 V<br>(Range 5 V...15 V) | P |
| Radio Hold Time 60 minutes<br>(Range 0...1440 minutes) | | | |

## Switchgear Type and Ratings (AS)




| Switchgear Type and Ratings | | | |
|---|---|---|---|
| ACR Function | D | Switch S/N xxxxxx | D |
| 12500 A Interruption | D | Rated 27000 Volts | D |
| 630 A Continuous | D | Ops 1010 | D |

## Switchgear Wear/General Details (AS)




| Switchgear Wear/General Details | | | |
|---|---|---|---|
| U Contact 99.0% | D | Cubicle S/N xxxxxx | D |
| V Contact 99.0% | D | App. Version A50-00.02 | D |
| W Contact 99.0% | D | | |

## Additional System Status pages

Additional pages are added to the System Status display group when certain features are made available. When Plant Details is made available, that page appears following the Switchgear Wear/General Details page.

## Plant Details (AS)



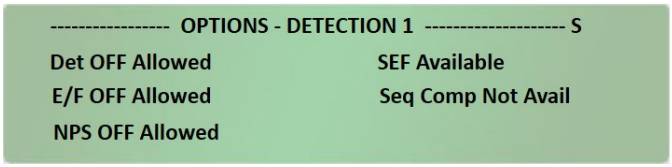

This is a page to display user entered information. The info is entered via WSOS. It can be ASCII text or numbers.

# Options

When Options Available is selected on the System Settings 2 page as it is by default, another ten optional pages are added to the System Status display group.

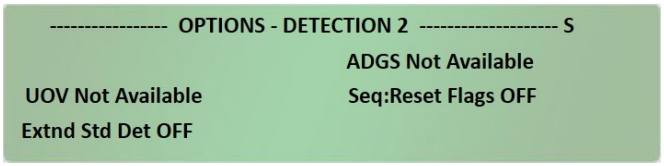
The first four are related to Protection.

## Options – Detection 1 (AS)



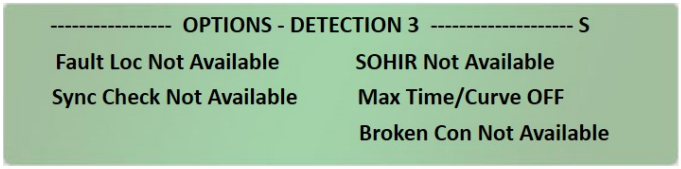

| Options – Detection 1 | | | |
|---|---|---|---|
| Detection OFF Not Allowed<br>Detection OFF Allowed | P | SEF (SGF) Not Available<br>SEF (SGF) Available | P |
| E/F OFF Allowed<br>E/F OFF Not Allowed | P | Sequence Components Not Available<br>Sequence Components Available | P |
| NPS OFF Not Allowed<br>NPS OFF Allowed<br>Not displayed unless Sequence Components are Available | P | | |

## Options – Detection 2 (AS)




| Options – Detection 2 | | | |
|---|---|---|---|
| | | ADGS Not Available<br>ADGS Available | P |
| Under/Over Voltage Not Available<br>Under/Over Voltage Available | P | Sequence: Reset Flags OFF<br>Sequence: Reset Flags ON | P |
| Extended Standard Detection OFF<br>Extended Standard Detection ON | P | | |

## Options – Detection 3 (AS)




| Options – Detection 3 | | | |
|---|---|---|---|
| Fault Locator Not Available<br>Fault Locator Available | P | SOHIR Not Available<br>SOHIR Available | P |
| Sync Check Not Available<br>Sync Check Available | P | Max Time/Curve OFF<br>Max Time/Curve ON | P |
| | | Broken Conductor Not Available<br>Broken Conductor Available | P |

Following the detection options pages there is a single page for Automation.

## Options – Automation (AS)




| Options – Automation | | | |
|---|---|---|---|
| Automation OFF<br>Loop Automation Available<br>Auto Change Over Available | P | | |

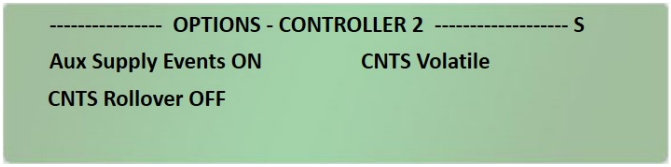
The next two options pages relate to the controller.

## Options – Controller 1 (AS)




| Options – Controller 1 | | | |
|---|---|---|---|
| Battery Test Not Avail<br>Battery Test Available | P | Configurable Quick Keys Not Avail<br>Configurable Quick Keys Available | P |
| IOEX Not Available<br>IOEX Available | P | | |
| | | Details Not Available<br>Details Available | P |

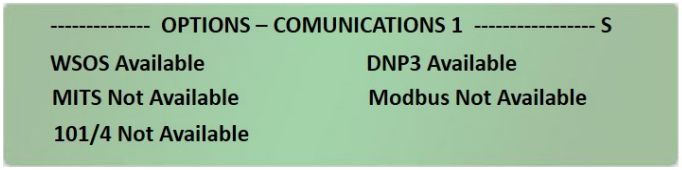
## Options – Controller 2 (AS)




| Options – Controller 2 | | | |
|---|---|---|---|
| Auxiliary Supply Events ON<br>Auxiliary Supply Events OFF | P | Counters Volatile<br>Counters Non Volatile | P |
| Counters Rollover OFF<br>Counters Rollover ON | P | | |

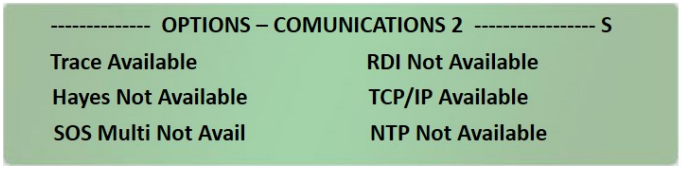
The next two options pages relate to communications.

## Options – Communications 1 (AS)




| Options – Communications 1 | | | |
|---|---|---|---|
| WSOS Available<br>WSOS Not Available | P | DNP3 Available<br>DNP3 Not Available | P |
| MITS Not Available<br>MITS Available | P | Modbus Not Available<br>Modbus Available | |
| IEC 60870-5-101/104 Not Available<br>IEC 60870-5-101/104 Available | P | | |

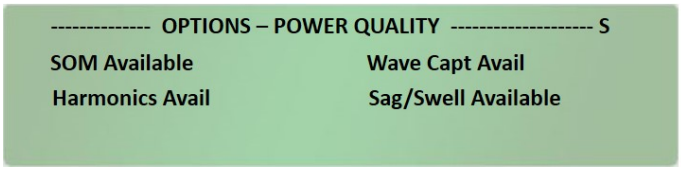
## Options – Communications 2 (AS)



| Options – Communications 2 | | | |
|---|---|---|---|
| Trace Available<br><br>Trace Not Available | P | Radio Data Interface Not Available<br><br>Radio Data Interface Available | P |
| Hayes Modem Driver Not Available<br><br>Hayes Modem Driver Available | P | TCP/IP Not Available<br><br>TCP/IP Available | P |
| SOS Multi Drop Driver Not Available<br><br>SOS Multi Drop Driver Available | P | Network Time Protocol Not Available<br><br>Network Time Protocol Available<br><br>NTP cannot be made available unless Time Zone is available. | |

The last options page is for power quality features.

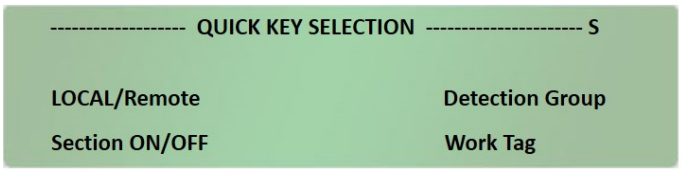
## Options – Power Quality (AS)




| Options – Power Quality | | | |
|---|---|---|---|
| Supply Outage Measure Not Available<br><br>Supply Outage Measure Available | P | Waveform Capture Not Available<br><br>Waveform Capture Available | P |
| Harmonics Not Available<br><br>Harmonics Available | P | Sag and Swell Not Available<br><br>Sag and Swell Available | P |

Making Quick Key Configuration available on the Options – Controller 1 page adds a **Quick Key Selection** page to the System Status menu after the options pages.

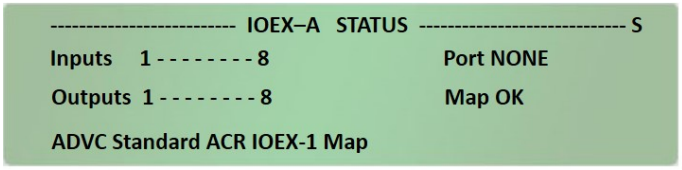
## Quick Key Selection (AS)

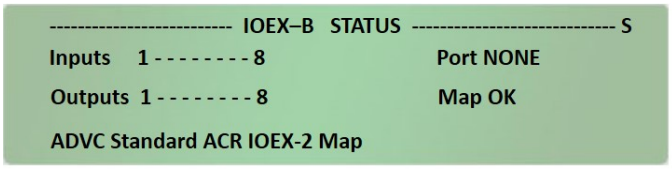



| Quick Key Selection | | | |
|---|---|---|---|
| Setting assigned to Quick Key 1 | P | Setting assigned to Quick Key 3 | P |
| Setting assigned to Quick Key 2 | P | Setting assigned to Quick Key 4 | P |

When IOEX is available, **IOEX-A** and **IOEX-B** pages appear in the System Status menu. IOEX can be made available on the Options – Controller 1 page.

## IOEX Status (AS)




| IOEX Status A (B) | | | |
|---|---|---|---|
| Inputs 1…….8 | D | Port None<br>Port IOEX/WSOS<br>Port USB-1<br>Port USB-2 | D |
| Outputs 1…….8 | D | Map OK<br>Invalid Map<br>Initialising<br>Unplugged<br>Wrong Type | D |
| Name of map running in this IOEX | | | D |

When Hit and Run has been made available through WSOS, a **Hit and Run** page is added to the System Status menu.

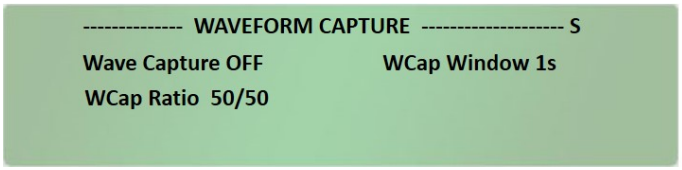
## Hit and Run (AS)




| Hit and Run | | | |
|---|---|---|---|
| Hit and Run Close Off<br>Hit and Run Close 10...120 s | P | Hit and Run Trip Off<br>Hit and Run Trip 10...120 s | P |

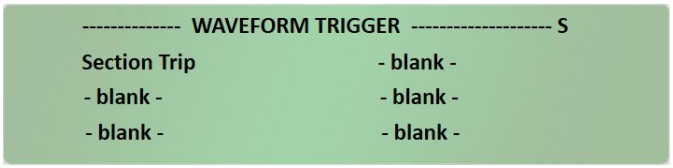
Making Waveform Capture available on the Options – Power Quality page adds two pages, **Waveform Capture** and **Waveform Trigger** to the System Status menu.

## Waveform Capture (AS)



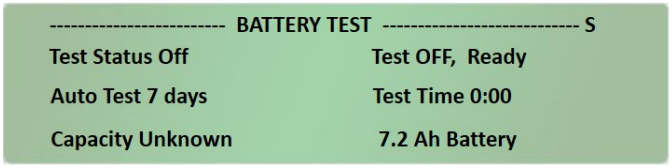
| Waveform Capture | | | |
|---|---|---|---|
| Waveform Capture OFF<br><br>Waveform Capture ON | P | Waveform Capture Window 2 s<br><br>Waveform Capture Window 1 s<br><br>Waveform Capture Window 0.5 s | P |
| Waveform Capture Ratio 50/50<br><br>Waveform Capture Ratio 10/90<br><br>Waveform Capture Ratio 20/80<br><br>Waveform Capture Ratio 30/70<br><br>Waveform Capture Ratio 40/60<br><br>Waveform Capture Ratio 60/40<br><br>Waveform Capture Ratio 70/30<br><br>Waveform Capture Ratio 80/20<br><br>Waveform Capture Ratio 90/10 | P | Capture Now ON<br><br>Capture Now OFF<br><br>Waveform Captured<br><br>This field only displayed when Waveform Capture is ON | D |

## Waveform Trigger (AS)



| Waveform Trigger | | | |
|---|---|---|---|
| Section Trip<br>Manual Trip<br>Manual Close<br>Auto Close<br>Harmonics<br>Pickup<br>- blank- | O | - blank-<br>Section Trip<br>Manual Trip<br>Manual Close<br>Auto Close<br>Harmonics<br>Pickup | O |
| - blank-<br>Section Trip<br>Manual Trip<br>Manual Close<br>Auto Close<br>Harmonics<br>Pickup | O | - blank-<br>Section Trip<br>Manual Trip<br>Manual Close<br>Auto Close<br>Harmonics<br>Pickup | O |
| - blank-<br>Section Trip<br>Manual Trip<br>Manual Close<br>Auto Close<br>Harmonics<br>Pickup | O | - blank-<br>Section Trip<br>Manual Trip<br>Manual Close<br>Auto Close<br>Harmonics<br>Pickup | O |

## Battery Test (AS)




| Battery Test | | | |
|---|---|---|---|
| Test Status OFF<br>Test Status AUTO | P | Test OFF, Ready<br>Test START<br>Test ABORT | P |
| Auto Test 7 days<br>(Range 1...31 days)<br>Auto Test Disabled | P | Test Start Time 00:00 | P |
| Capacity Unknown<br>Capacity OK<br>Capacity NOT OK | D | 7.2 Ah Battery<br>12 Ah Battery | P |

## User Defined Control (AS)




| User Defined Control 1 | | | |
|---|---|---|---|
| Control 1 OFF<br>Control 1 ON | P | Control 2 OFF<br>Control 2 ON | P |
| Control 3 OFF<br>Control 3 ON | P | Control 4 OFF<br>Control 4 ON | |
| Control 5 OFF<br>Control 5 ON | P | Control 6 OFF<br>Control 6 ON | |




| User Defined Control 2 | | | |
|---|---|---|---|
| Control 7 OFF<br>Control 7 ON | P | Control 8 OFF<br>Control 8 ON | P |

# Appendix K.9 *set*VUE AS Detection Menu Pages

This appendix lists all of the Detection display group pages.

The basic Detection display group consists of 15 default pages.

Up to 23 additional pages and 5 alternate pages can be added to the detection menu depending on the features that have been enabled.

The table below shows the complete list of available pages and their position in the Detection menu.

**Table 148 *set*VUE Detection Menu Pages**

| Detection Menu | | |
|---|---|---|
| **Default Pages** | **Additional Pages** | **Alternate Pages** |
| Detection Setting 1 | | |
| Detection Setting 2 | | |
| Detection Setting 3 | | |
| Detection Setting 4 | | |
| Detection Setting 5 | | |
| | Detection Setting Alarms 1(1),(2) | |
| | Detection Setting Alarms 2(1),(2) | |
| | Detection Setting Extended(2) | |
| Detection Setting 6 | | |
| Cold Load Pickup Detection | | |

**Table 148 *set*VUE Detection Menu Pages (Continued)**

| Detection Menu | | |
|---|---|---|
| **Default Pages** | **Additional Pages** | **Alternate Pages** |
| | Sync Check Settings 1(3) | |
| | Sync Check Settings 2(3) | |
| | Sync Check Settings 3(3) | |
| | Sync Check Settings 4(3) | |
| | Broken Conductor(4) | |
| | Directional Detection Phase 1(5) | Directional Blocking – Phase 1(6) |
| | Directional Detection Phase 2(6) | Directional Blocking – Phase 2(5) |
| | Directional Detection Earth 3(6) | Directional Blocking – Earth 3(5) |
| | Directional Detection Earth 4(6) | |
| | Directional Detection SEF 5(6) | Directional Blocking – SEF 5(5) |
| | Directional Detection SEF 6(6) | |
| | Directional Detection NPS 7(6) | Directional Blocking – NPS 7(5) |
| | Directional Detection NPS 8(6) | |
| | $V_{ZPS}$ Compensation(5) | |
| | High $V_{ZPS}$ Alarm(5) | |
| | Under Voltage Detection(7) | |
| | Over Voltage Detection(7) | |
| | Under/Over Voltage Detection(8) | |
| Phase Detection | | |
| Phase Single Shot Det Trip | | |
| Earth Detection | | |
| Earth Single Shot Det Trip | | |
| SEF Detection | | |
| SEF Single Shot Det Trip | | |
| NPS Detection | | |
| NPS Single Shot Det Trip | | |
| | Fault Locator(9) | |
| | Conductor Characteristics(8) | |

(1) Per Element Detection available

(2) Extended Standard Detection On

(3) Sync Check available

(4) Broken Conductor available

(5) Directional Detection On

(6) Directional Blocking On

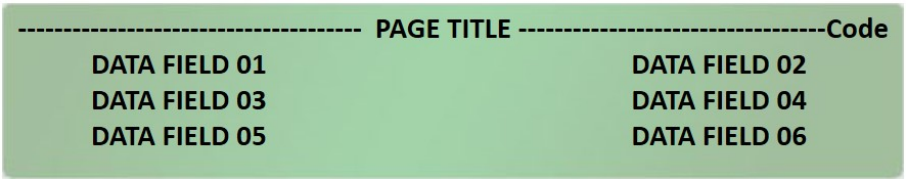
(7) Under/Over Voltage Detection available

(8) Under/Over Voltage Detection available

(9) Fault Locator available

The top line of each page is the page title. To the right of the title is the letter D which indicates that the page being displayed is part of the Detection display group.

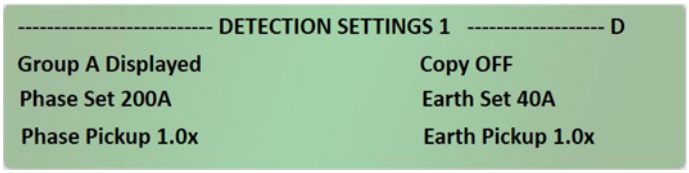
The next three lines are the data or information on display. Most displays have six data fields. The standard layout is shown below.




If the standard menu is running, the Detection menu can be accessed by pressing the Panel On key and then pressing the Menu key three times.

The first page to be displayed in the Protection menu is the **Protection Settings 1** page shown below.

## Detection Settings 1




# Appendix L Automation

## Appendix L.1 Loop Automation Operating Rules

In the following tables, the Sequence (Seq.) column indicates if the rule is applied during Isolation and Reconfiguration (I) or during Auto Restoration (R).

### Feeder Device

**Table 149 Loop Automation operating rules – Feeder Device**

| Rule No | Switch-gear State | Auto-Restore | Event | Action | Seq. |
|---|---|---|---|---|---|
| 1 | Closed | Off | Source Supply lost for longer than Loop Auto Time. | Switchgear opens and Loop Automation is turned off. | I |
| 2 | Closed | On | Source Supply lost for longer than Loop Auto Time. | Switchgear opens. | I |
| 3 | Closed | Off | Protection trip to Lockout. | Switchgear opens and Loop automation is turned off. | I |
| 4 | Closed | On | Protection trip to end of sequence. | Switchgear opens and Loop Automation stays on. | I |

**Table 149 Loop Automation operating rules – Feeder Device (Continued)**

| Rule No | Switch-gear State | Auto-Restore | Event | Action | Seq. |
|---|---|---|---|---|---|
| 5 | Open | On | Source Supply is restored and switchgear was initially tripped by Loop Automation. | Switchgear closes. | R |
| 6 | Open | On | Supply is restored to both sides of the switchgear. Either at the source then load or load then source. | Switchgear closes. | R |

## Mid-Point Device

**Table 150 Loop Automation operating rules – Mid-Point Device**

| Rule No | Switchgear (ACR) State | Auto-Restore | Event | Action | Seq. |
|---|---|---|---|---|---|
| 7 | Closed | On or Off | Source Supply lost for longer than Loop Auto Time. | Switch to reverse Protection Group | I |
| 8 | Closed | Off | Protection trip to Lockout. | ACR opens and Loop Automation is turned off. | I |
| 9 | Closed | On | Protection trip to end of sequence. | ACR opens and Loop Automation stays on. | I |
| 10 | Open | On | Supply is restored to both sides of ACR. | Switch to forward Protection Group and close ACR. | R |

## Tie Device

**Table 151 Loop Automation operating rules – Tie Device**

| Rule No | Switch-gear State | Auto-Restore | Restore Both Ways | Event | Action | Seq. |
|---|---|---|---|---|---|---|
| 11 | Open | On or Off | On or Off | Supply to both sides is lost for longer than Loop Auto Time. | No Action | I |
| 12 | Open | On | On or Off | Supply to load side is lost for longer than Loop Auto Time. | Switchgear closes if alternative supply is present. | I |
| 13 | Open | Off | On or Off | Supply to load side is lost for longer than Loop Auto Time. | Switchgear closes if alternative supply is present and turns Loop Automation off. | I |
| 14 | Open | On | On | Supply to source side is lost for longer than Loop Auto Time. | Activates reverse Protection Group and closes switchgear. | I |
| 15 | Open | Off | On | Supply to source side is lost for longer than Loop Auto Time. | Activates reverse Protection Group, closes switchgear and turns Loop Auto off. | I |

**Table 151 Loop Automation operating rules – Tie Device (Continued)**

| Rule No | Switch-gear State | Auto-Restore | Restore Both Ways | Event | Action | Seq. |
|---|---|---|---|---|---|---|
| 16 | Open | On or Off | Off | Supply to source side is lost for longer than Loop Auto Time. | No Action. | I |
| 17 | Closed | On | On or Off | Protection trip to Lockout. | Switchgear opens and Loop Automation is turned off. | I |
| 18 | Closed | On | On or Off | Power flow changes by 50% or more for Loop Auto Time. | Switchgear opens. (If supply is subsequently lost to either side then switchgear closes and Loop Automation turns off.) | R |
| 19 | Closed | On | On or Off | Power flow changes by 50% or more but returns to previous level before Loop Auto Time expires. | Switchgear stays closed and Loop Automation is turned off. | R |

# Appendix L.2 Loop Automation Status Messages

When Loop Automation is activated, its current status is displayed in WSOS on the Loop Automation Display page as well as on both ***flex*VUE** and ***set*VUE** operator interfaces.

All possible status messages appear in the list below.

**Table 152 List of Loop Automation status display messages**

| |
|---|
| Loop automation normal |
| Loop auto turned off by operator action. Must be on for automatic operation. |
| Mechanism fail or switchgear data invalid. |
| Gas pressure low |
| Gas pressure invalid. |
| Cap charge fail or battery abnormal |
| Loss of phase trip.<br>Will close when load supply restored/will close when source supply restored/operator restoration required/loop automation turned off. |
| Protection trip – will close when both source and load supplies come on. |
| Protection trip/sectionaliser trip<br>Operator restoration required/loop automation turned off. |
| Work Tag applied. |
| Loop auto on request denied.<br>Trip/Close circuit disconnected/mechanism fail or switchgear data invalid/cap charge fail or battery abnormal/gas low inhibit/invalid VT configuration/switch must be open/switch must be closed/ currently not available/work tag applied. |
| Currently not available. |
| Source side now dead – timing out |

**Table 152 List of Loop Automation status display messages (Continued)**

| |
|---|
| Will trip to isolate source/will change to protection group **#**/protection group **#** now active/will close to restore source supply/detected allow DT. Will close to restore. |
| Tripped on loss of source supply<br>Will close when source supply restored. |
| Tripped on loss of source supply |
| Source and load now live – timing out<br>Will close to restore normal state. |
| Source side now live – timing out<br>Will close to restore normal state/will close to restore load supply. |
| Loss of phase trip<br>Will close when source supply restored/will close when load supply restored/loop automation turned off. |
| Lost source supply – PROT GRP **#** active<br>Loop automation turned off. |
| Load side now live – timing out<br>Will close to restore normal state. |
| Load side now dead – timing out<br>Will close to restore load supply/detected allow DT. Will close to restore. |
| Load side now dead<br>Measuring dead time |
| Source side now dead<br>Measuring dead time |
| Source and load sides dead |
| Closed to restore load supply |
| LA time expired – allow DT not detected<br>Loop automation turned off |
| Loop automation normal<br>Detected allow dead time |
| Closed to restore source supply |
| LA time expired – allow DT not detected<br>Loop automation turned off |
| Normal FDR config. detected – timing out<br>Will trip to restore normal FDR config. |
| Supply lost – loop auto turned off. |
| Auto-restore unsuccessful |
| Unable to trip/close |
| Downstream operator failure<br>Operator restoration required |
| Upstream lockout<br>Operator restoration required |

**Table 152 List of Loop Automation status display messages (Continued)**

| |
|---|
| Communication error<br>Operator restoration required |
| Loop automation close inhibited<br>Loop automation turned off. |

# Appendix L.3 Loop Automation Settings Record

The following template shows the range of information required when preparing a network for Loop Automation configuration. The template may be modified as required to suit individual requirements.

**Table 153 Loop Automation setting sheet**

| **Loop Automation SETTING SHEET** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| GLOBAL PARAMETERS | | | | | | | Loop Automation TIME | | |
| Live Terminal Voltage | | | | Supply Timeout (ST) | | | Feeder and Mid-Point Devices:<br>LA Time = T1 + T2<br>= ……. | | |
| Coordination Time (T1) | | | | Single Shot Reset Time (2xT1) | | | | | |
| Max. Sequence Time (T2) | | | | Live Load Blocking | | | Tie Device:<br>LA Time = 2 (T1 + T2)<br>= …….. | | |
| Auto Changeover (T1+T2) | | | | Loop Automation Available Y/N | | | | | |
| DEV No: | TYPE | SERIES | SER No: | LOCA-TION | DIREC-TION | LA Time (s) | Auto Restore Available | AUTO-RESTORE ON - OFF | TIE Restore One/Two Way |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

# Appendix L.4 Loop Automation Settings Record Example

The following record shows the range of information recorded whilst preparing a network for Loop Automation configuration.

**Table 154 Loop Automation setting sheet example**

| **Loop Automation SETTING SHEET** | | | | |
|---|---|---|---|---|
| **GLOBAL PARAMETERS** | | | | **Loop Automation TIME** |
| Live Terminal Voltage | 2000 Volts | Supply Timeout (ST) | 10 s | Feeder and Mid-Point Devices:<br>LA Time = T1 + T2<br>= ……. |
| Coordination Time (T1) | 10 s | Single Shot Reset Time (2xT1) | 20 s | |
| Max. Sequence Time (T2) | 30 s | Live Load Blocking | OFF | Tie Device:<br>LA Time = 2 (T1 + T2) |

**Table 154 Loop Automation setting sheet example (Continued)**

| Loop Automation SETTING SHEET | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **GLOBAL PARAMETERS** | | | | | | | **Loop Automation TIME** | | |
| Auto Changeover (T1+T2) | | | 40 s | Loop Automation Available Y/N | | Y | = ……. | | |
| DEV No: | TYPE | SERIES | SER No: | LOCATION | DIREC-TION | LA Time (s) | Auto Restore Available | AUTO-RESTORE ON - OFF | TIE Restore One/Two Way |
| 1 | FDR | N | ACR 7077 | Whites Road | Source 1 | 40 | Available | ON | N/A |
| 2 | MP | U | ACR 7092 | Lytton Road Nth | Source 1 | 40 | Not Available | N/A | N/A |
| 3 | MP | U | ACR 6999 | Lytton Road West | Source 2 | 50 | Not Available | N/A | N/A |
| 4 | Tie | N | ACR 7078 | Fisherman Island | Source 2 | 40 | Not Available | N/A | BOTH |
| 5 | FDR | N | ACR 7091 | Hemnant substation | Source 2 | 40 | Available | ON | N/A |

# Appendix L.5 - Auto-Changeover Status Codes

**Table 155 Auto Changeover Status Codes**

| Code | Operator Interface ACO Status | WSOS Auto-Changeover Status |
|---|---|---|
| 17 | Not Ready: ACO OFF | Not Ready: ACO OFF |
| 20 | Not Ready: Both suppl. same state | Not Ready: Both supplies are in the same state |
| 25 | Not Ready: Preferred and Backup supplies dead | Not Ready: Both Preferred and Backup supplies are dead |
| 258 | Not Ready: Master maintenance required | Not Ready: Master maintenance required |
| 259 | Not Ready: Master is in a protection lockout | Not Ready: Master is in a protection lockout |
| 260 | Not Ready: Master not ready to operate | Not Ready: Master is not ready to operate |
| 261 | Not Ready: Master tripped from a different source | Not Ready: Master was tripped from a different source |
| 262 | Not Ready: Master Work Tag applied | Not Ready: Master Work Tag applied |
| 263 | Not Ready: Master in Local Mode | Not Ready: Master is in Local Mode |
| 264 | Not Ready: Master communications not responding | Not Ready: Master is not responding to communications |
| 265 | Not Ready: Master not enabled | Not Ready: Master is not enabled |
| 266 | Not Ready: Master has no supply voltage | Not Ready: Master has no supply voltage |
| 268 | Not Ready: Master failed to Trip or Close | Not Ready: Master has failed to Trip or Close |
| 269 | Not Ready: Master live aft HV Check | Not Ready: Master Load Side bushing failed to go dead after High Voltage Check Time |
| 270 | Not Ready: Master waiting for communications | Not Ready: Master is waiting for communications |
| 271 | Not Ready: Master Trip or Close isolated | Not Ready: Master Trip or Close circuit is isolated |
| 272 | Not Ready: Master closed from different source | Not Ready: Master was closed from a different source |
| 274 | Not Ready: Master Load side not dead | Not Ready: Master Load side is not dead |
| 277 | Not Ready: Master aborted | Not Ready: Master aborted |
| 279 | Not Ready: Master prot seq in progress | Not Ready: Master protection sequence in progress |
| 280 | Not Ready: Master port in Local Mode | Not Ready: Master communication port is in local mode |
| 514 | Not Ready: Slave maintenance required | Not Ready: Slave maintenance required |
| 515 | Not Ready: Slave is in a prot lockout | Not Ready: Slave is in a protection lockout |

**Table 155 Auto Changeover Status Codes (Continued)**

| Code | Operator Interface ACO Status | WSOS Auto-Changeover Status |
|---|---|---|
| 516 | Not Ready: Slave not ready to operate | Not Ready: Slave is not ready to operate |
| 517 | Not Ready: Slave tripped from a different source | Not Ready: Slave was tripped from a different source |
| 518 | Not Ready: Slave Work Tag applied | Not Ready: Slave Work Tag applied |
| 519 | Not Ready: Slave in Local Mode | Not Ready: Slave is in Local Mode |
| 520 | Not Ready: Slave comms not responding | Not Ready: Slave is not responding to communications |
| 521 | Not Ready: Slave not enabled | Not Ready: Slave is not enabled |
| 522 | Not Ready: Slave has no supply voltage | Not Ready: Slave has no supply voltage |
| 524 | Not Ready: Slave failed to Trip or Close | Not Ready: Slave has failed to Trip or Close |
| 525 | Not Ready: Slave live aft HV Check | Not Ready: Slave Load Side bushing failed to go dead after High Voltage Check Time |
| 526 | Not Ready: Slave waiting for comms | Not Ready: Slave is waiting for communications |
| 527 | Not Ready: Slave Trip or Close isolated | Not Ready: Slave Trip or Close circuit is isolated |
| 528 | Not Ready: Slave closed from diff src | Not Ready: Slave was closed from a different source |
| 530 | Not Ready: Slave Load side not dead | Not Ready: Slave Load side is not dead |
| 533 | Not Ready: Slave aborted | Not Ready: Slave aborted |
| 535 | Not Ready: Slave prot seq in progress | Not Ready: Slave protection sequence in progress |
| 536 | Not Ready: Slave port in Local Mode | Not Ready: Slave communication port is in local mode |
| 1044 | Waiting: Both suppl. same state | Waiting: Both supplies are in the same state |
| 1282 | Waiting: Master maintenance required | Waiting: Master maintenance required |
| 1283 | Waiting: Master is in a prot lockout | Waiting: Master is in a protection lockout |
| 1284 | Waiting: Master not ready to operate | Waiting: Master is not ready to operate |
| 1285 | Waiting: Master tripped from a different source | Waiting: Master was tripped from a different source |
| 1286 | Waiting: Master Work Tag applied | Waiting: Master Work Tag applied |
| 1287 | Waiting: Master in Local Mode | Waiting: Master is in Local Mode |
| 1288 | Waiting: Master comms not responding | Waiting: Master is not responding to communications |
| 1289 | Waiting: Master not enabled | Waiting: Master is not enabled |
| 1290 | Waiting: Master has no supply voltage | Waiting: Master has no supply voltage |
| 1292 | Waiting: Master failed to Trip or Close | Waiting: Master has failed to Trip or Close |
| 1293 | Waiting: Master live aft HV Check | Waiting: Master Load Side bushing failed to go dead after High Voltage Check Time |
| 1294 | Waiting: Master waiting for comms | Waiting: Master is waiting for communications |
| 1295 | Waiting: Master Trip or Close isolated | Waiting: Master Trip or Close circuit is isolated |
| 1296 | Waiting: Master closed from diff src | Waiting: Master was closed from a different source |
| 1298 | Waiting: Master Load side not dead | Waiting: Master Load side is not dead |
| 1301 | Waiting: Master aborted | Waiting: Master aborted |
| 1303 | Waiting: Master prot seq in progress | Waiting: Master protection sequence in progress |
| 1304 | Waiting: Master port in Local Mode | Waiting: Master communication port is in local mode |
| 1538 | Waiting: Slave maintenance required | Waiting: Slave maintenance required |
| 1539 | Waiting: Slave is in a prot lockout | Waiting: Slave is in a protection lockout |
| 1540 | Waiting: Slave not ready to operate | Waiting: Slave is not ready to operate |
| 1541 | Waiting: Slave tripped from a different source | Waiting: Slave tripped from a different source |
| 1542 | Waiting: Slave Work Tag applied | Waiting: Slave Work Tag applied |

### Table 155 Auto Changeover Status Codes (Continued)

| Code | Operator Interface ACO Status | WSOS Auto-Changeover Status |
|---|---|---|
| 1543 | Waiting: Slave in Local Mode | Waiting: Slave is in Local Mode |
| 1544 | Waiting: Slave comms not responding | Waiting: Slave is not responding to communications |
| 1545 | Waiting: Slave not enabled | Waiting: Slave is not enabled |
| 1546 | Waiting: Slave has no supply voltage | Waiting: Slave has no supply voltage |
| 1548 | Waiting: Slave failed to Trip or Close | Waiting: Slave has failed to Trip or Close |
| 1549 | Waiting: Slave live aft HV Check | Waiting: Slave Load Side bushing failed to go dead after High Voltage Check Time |
| 1550 | Waiting: Slave waiting for comms | Waiting: Slave is waiting for communications |
| 1551 | Waiting: Slave Trip or Close isolated | Waiting: Slave Trip or Close circuit is isolated |
| 1552 | Waiting: Slave closed from diff src | Waiting: Slave was closed from a different source |
| 1554 | Waiting: Slave Load side not dead | Waiting: Slave Load side is not dead |
| 1557 | Waiting: Slave aborted | Waiting: Slave aborted |
| 1559 | Waiting: Slave prot seq in progress | Waiting: Slave protection sequence in progress |
| 1560 | Waiting: Slave port in Local Mode | Waiting: Slave communication port is in local mode |
| 2305 | Running: Master is supplying the Load | Running: Master is supplying the Load |
| 2561 | Running: Master is supplying the Load | Running: Slave is supplying the Load |
| 3083 | Abort: One-Way CO executed | Abort: One-Way Changeover executed |
| 3091 | Abort: One-Way invalid state | Abort: One-Way is in invalid state |
| 3092 | Abort: Both suppl. same state | Abort: Both supplies are in the same state |
| 3094 | Abort: Manual CO executed | Abort: Manual CO was executed |
| 3330 | Abort: Master maintenance required | Abort: Master maintenance required |
| 3331 | Abort: Master is in a prot lockout | Abort: Master is in a protection lockout |
| 3332 | Abort: Master not ready to operate | Abort: Master is not ready to operate |
| 3333 | Abort: Master tripped from a different source | Abort: Master was tripped from a different source |
| 3334 | Abort: Master Work Tag applied | Abort: Master Work Tag applied |
| 3335 | Abort: Master in Local Mode | Abort: Master is in Local Mode |
| 3336 | Abort: Master comms not responding | Abort: Master is not responding to communications |
| 3337 | Abort: Master not enabled | Abort: Master is not enabled |
| 3338 | Abort: Master has no supply voltage | Abort: Master has no supply voltage |
| 3340 | Abort: Master failed to Trip or Close | Abort: Master has failed to Trip or Close |
| 3341 | Abort: Master live aft HV Check | Abort: Master Load Side bushing failed to go dead after High Voltage Check Time |
| 3342 | Abort: Master waiting for comms | Abort: Master is waiting for communications |
| 3343 | Abort: Master Trip or Close isolated | Abort: Master Trip or Close circuit is isolated |
| 3344 | Abort: Master closed from diff src | Abort: Master was closed from a different source |
| 3346 | Abort: Master Load side not dead | Abort: Master Load side is not dead |
| 3349 | Abort: Master aborted | Abort: Master aborted |
| 3352 | Abort: Master port in Local Mode | Abort: Master communication port is in local mode |
| 3586 | Abort: Slave maintenance required | Abort: Slave maintenance required |
| 3587 | Abort: Slave is in a prot lockout | Abort: Slave is in a protection lockout |
| 3588 | Abort: Slave not ready to operate | Abort: Slave is not ready to operate |
| 3589 | Abort: Slave tripped from a different source | Abort: Slave was tripped from a different source |

**Table 155 Auto Changeover Status Codes (Continued)**

| Code | Operator Interface ACO Status | WSOS Auto-Changeover Status |
|---|---|---|
| 3590 | Abort: Slave Work Tag applied | Abort: Slave Work Tag applied |
| 3591 | Abort: Slave in Local Mode | Abort: Slave is in Local Mode |
| 3592 | Abort: Slave comms not responding | Abort: Slave is not responding to communications |
| 3593 | Abort: Slave not enabled | Abort: Slave is not enabled |
| 3594 | Abort: Slave has no supply voltage | Abort: Slave has no supply voltage |
| 3596 | Abort: Slave failed to Trip or Close | Abort: Slave has failed to Trip or Close |
| 3597 | Abort: Slave live aft HV Check | Abort: Slave Load Side bushing failed to go dead after High Voltage Check Time |
| 3598 | Abort: Slave waiting for comms | Abort: Slave is waiting for communications |
| 3599 | Abort: Slave Trip or Close isolated | Abort: Slave Trip or Close circuit is isolated |
| 3600 | Abort: Slave closed from diff src | Abort: Slave was closed from a different source |
| 3602 | Abort: Slave Load side not dead | Abort: Slave Load side is not dead |
| 3605 | Abort: Slave aborted | Abort: Slave aborted |
| 3608 | Abort: Slave port in Local Mode | Abort: Slave communication port is in local mode |
| 3610 | Abort: Slave detect seq in progress | Abort: Slave detection sequence in progress |
| 3611 | Abort: Slave is in a detect lockout | Abort: Slave is in a detection lockout |
| 3612 | Abort: Slave upstream lockout | Abort: Slave upstream device is in lockout |

# Appendix M Operator Interface Feature Selection Fields (ACR)

**Table 156 Feature Selection fields on the Operator Interface for ACRs**

| Field | Location | | | |
|---|---|---|---|---|
| | flexVUE Operator Interface | | setVUE Operator Interface | |
| | Menu | Sub Menu(s) | Menu | Page |
| Protection Off Allowed/Not Allowed | Engineer | Configuration menu → Feature Selection → Protection | System Status | Options – Protection 1 |
| SEF Available/Not Available | Engineer | Configuration menu → Feature Selection → Protection | System Status | Options – Protection 1 |
| E/F Off Allowed/Not Allowed | Engineer | Configuration menu → Feature Selection → Protection | System Status | Options – Protection 1 |
| Sequence Components Available/Not Available | Engineer | Configuration menu → Feature Selection → Protection | System Status | Options – Protection 1 |
| NPS Allowed/Not Allowed | Engineer | Configuration menu → Feature Selection → Protection | System Status | Options – Protection 1 |
| Reset Curves Available/Not Available | Engineer | Configuration menu → Feature Selection → Protection | System Status | Options – Protection 1 |
| UOF Available/Not Available | Engineer | Configuration menu → Feature Selection → Protection | System Status | Options – Protection 2 |
| APGS Available/Not Available | Engineer | Configuration menu → Feature Selection → Protection | System Status | Options – Protection 2 |
| UOV Available/Not Available | Engineer | Configuration menu → Feature Selection → Protection | System Status | Options – Protection 2 |
| Sequence Reset Flags On/Off | Engineer | Configuration menu → Feature Selection → Protection | System Status | Options – Protection 2 |
| Extended Standard Protection On/Off | Engineer | Configuration menu → Feature Selection → Protection | System Status | Options – Protection 2 |
| Max Time/Curve On/Off | Engineer | Configuration menu → Feature Selection → Protection | System Status | Options – Protection 3 |
| Conditional Reclose Available/ Not Available | Engineer | Configuration menu → Feature Selection → Protection | System Status | Options – Protection 3 |
| SOHIR Available/Not Available | Engineer | Configuration menu → Feature Selection → Protection | System Status | Options – Protection 3 |
| Conditional Reclose Timeout 0 - 3600 s | Engineer | Configuration menu → Feature Selection → Protection | System Status | Options – Protection 3 |
| AR Dead time/Elt On/Off | Engineer | Configuration menu → Feature Selection → Protection | System Status | Options – Protection 3 |
| Fault Locator Available/Not Available | Engineer | Configuration menu → Feature Selection → Protection | System Status | Options – Protection 3 |
| Sync Check Available/Not Available | Engineer | Configuration menu → Feature Selection → Protection | System Status | Options – Protection 4 |
| NVD Protection Available/Not Available | Engineer | Configuration menu → Feature Selection → Protection | System Status | Options – Protection 4 |
| Broken Conductor Available/ Not Available | Engineer | Configuration menu → Feature Selection → Protection | System Status | Options – Protection 4 |
| Automation Off/Loop Automation Available/ACO Available | Engineer | Configuration menu → Feature Selection → Automation | System Status | Options – Automation |
| Battery Test Available/Not Available | Engineer | Configuration menu → Feature Selection → General | System Status | Options – Controller 1 |
| Configurable Quick Keys Available Available/Not Available | | | System Status | Options – Controller 1 |
| IOEX Available/Not Available | Engineer | Configuration menu → Feature Selection → General | System Status | Options – Controller 1 |

**Table 156 Feature Selection fields on the Operator Interface for ACRs (Continued)**

| Field | Location | | | |
|---|---|---|---|---|
| | flexVUE Operator Interface | | setVUE Operator Interface | |
| | Menu | Sub Menu(s) | Menu | Page |
| Details Available/Not Available | Engineer | Configuration menu → Feature Selection → General | System Status | Options – Controller 1 |
| Auxiliary Supply Events On/Off | Engineer | Configuration menu → Feature Selection → General | System Status | Options – Controller 2 |
| CNTS Volatile/Non Volatile | Engineer | Configuration menu → Feature Selection → General | System Status | Options – Controller 2 |
| Counters Rollover On/Off | Engineer | Configuration menu → Feature Selection → General | System Status | Options – Controller 2 |
| WSOS Available/Not Available | Engineer | Configuration menu → Feature Selection → Communications | System Status | Options – Communications 1 |
| DNP3 Available/Not Available | Engineer | Configuration menu → Feature Selection → Communications | System Status | Options – Communications 1 |
| MITS Available/Not Available | Engineer | Configuration menu → Feature Selection → Communications | System Status | Options – Communications 1 |
| Modbus Available/Not Available | Engineer | Configuration menu → Feature Selection → Communications | System Status | Options – Communications 1 |
| IEC101/4 Available/Not Available | Engineer | Configuration menu → Feature Selection → Communications | System Status | Options – Communications 1 |
| Trace Available/Not Available | Engineer | Configuration menu → Feature Selection → Communications | System Status | Options – Communications 2 |
| RDI Available/Not Available | Engineer | Configuration menu → Feature Selection → Communications | System Status | Options – Communications 2 |
| Hayes Available/Not Available | Engineer | Configuration menu → Feature Selection → Communications | System Status | Options – Communications 2 |
| TCP/IP Available/Not Available | Engineer | Configuration menu → Feature Selection → Communications | System Status | Options – Communications 2 |
| SOS Multi-drop Available/Not Available | Engineer | Configuration menu → Feature Selection → Communications | System Status | Options – Communications 2 |
| NTP Available/Not Available | Engineer | Configuration menu → Feature Selection → Communications | System Status | Options – Communications 2 |
| System Outage Measurements Available/Not Available | Engineer | Configuration menu → Feature Selection → Power Quality Menu | System Status | Options – Power Quality |
| Waveform Capture Available/ Not Available | Engineer | Configuration menu → Feature Selection → Power Quality Menu | System Status | Options – Power Quality |
| Harmonics Available/Not Available | Engineer | Configuration menu → Feature Selection → Power Quality Menu | System Status | Options – Power Quality |
| Sag/Swell Available/Not Available | Engineer | Configuration menu → Feature Selection → Power Quality Menu | System Status | Options – Power Quality |

# Appendix N Operator Interface Feature Selection Fields (ACR)

**Table 157 Feature Selection fields on the Operator Interface for an AS**

| Field | Location | | | |
|---|---|---|---|---|
| | flexVUE Operator Interface | | setVUE Operator Interface | |
| | Menu | Sub Menu(s) | Menu | Page |
| Detection Off Allowed/Not Allowed | Engineer | Configuration menu → Feature Selection → Detection | System Status | Options – Detection 1 |
| SEF Available/Not Available | Engineer | Configuration menu → Feature Selection → Detection | System Status | Options – Detection 1 |
| E/F Off Allowed/Not Allowed | Engineer | Configuration menu → Feature Selection → Detection | System Status | Options – Detection 1 |
| Sequence Components Available/Not Available | Engineer | Configuration menu → Feature Selection → Detection | System Status | Options – Detection 1 |
| NPS Allowed/Not Allowed | Engineer | Configuration menu → Feature Selection → Detection | System Status | Options – Detection 1 |
| ADGS Available/Not Available | Engineer | Configuration menu → Feature Selection → Detection | System Status | Options – Detection 2 |
| UOV Available/Not Available | Engineer | Configuration menu → Feature Selection → Detection | System Status | Options – Detection 2 |
| Sequence Reset Flags On/Off | Engineer | Configuration menu → Feature Selection → Detection | System Status | Options – Detection 2 |
| Extended Standard Detection On/Off | Engineer | Configuration menu → Feature Selection → Detection | System Status | Options – Detection 2 |
| Max Time/Curve On/Off | Engineer | Configuration menu → Feature Selection → Protection | System Status | Options – Detection 3 |
| SOHIR Available/Not Available | Engineer | Configuration menu → Feature Selection → Detection | System Status | Options – Detection 3 |
| Fault Locator Available/Not Available | Engineer | Configuration menu → Feature Selection → Detection | System Status | Options – Detection 3 |
| Sync Check Available/Not Available | Engineer | Configuration menu → Feature Selection → Detection | System Status | Options – Detection 3 |
| Broken Conductor Available/ Not Available | Engineer | Configuration menu → Feature Selection → Detection | System Status | Options – Detection 3 |
| Automation Off/Loop Automation Available/ACO Available | Engineer | Configuration menu → Feature Selection → Automation | System Status | Options – Automation |
| Battery Test Available/Not Available | Engineer | Configuration menu → Feature Selection → General | System Status | Options – Controller 1 |
| Configurable Quick Keys Available Available/Not Available | Engineer | | System Status | Options – Controller 1 |
| IOEX Available/Not Available | Engineer | Configuration menu → Feature Selection → Protection | System Status | Options – Protection 4 |
| Details Available/Not Available | Engineer | Configuration menu → Feature Selection → Protection | System Status | Options – Protection 4 |
| Auxiliary Supply Events On/Off | Engineer | Configuration menu → Feature Selection → Protection | System Status | Options – Protection 4 |
| CNTS Volatile/Non Volatile | Engineer | Configuration menu → Feature Selection → Automation | System Status | Options – Automation |
| Counters Rollover On/Off | Engineer | Configuration menu → Feature Selection → General | System Status | Options – Controller 1 |
| WSOS Available/Not Available | | | System Status | Options – Controller 1 |
| DNP3 Available/Not Available | Engineer | Configuration menu → Feature Selection → General | System Status | Options – Controller 1 |
| MITS Available/Not Available | Engineer | Configuration menu → Feature Selection → General | System Status | Options – Controller 1 |

**Table 157 Feature Selection fields on the Operator Interface for an AS (Continued)**

| Field | Location | | | |
|---|---|---|---|---|
| | flexVUE Operator Interface | | setVUE Operator Interface | |
| | Menu | Sub Menu(s) | Menu | Page |
| Modbus Available/Not Available | Engineer | Configuration menu → Feature Selection → General | System Status | Options – Controller 2 |
| IEC 101/4 Available/Not Available | Engineer | Configuration menu → Feature Selection → General | System Status | Options – Controller 2 |
| Trace Available/Not Available | Engineer | Configuration menu → Feature Selection → General | System Status | Options – Controller 2 |
| RDI Available/Not Available | Engineer | Configuration menu → Feature Selection → Communications | System Status | Options – Communications 1 |
| Hayes Available/Not Available | Engineer | Configuration menu → Feature Selection → Communications | System Status | Options – Communications 1 |
| TCP/IP Available/Not Available | Engineer | Configuration menu → Feature Selection → Communications | System Status | Options – Communications 1 |
| SOS Multi-drop Available/Not Available | Engineer | Configuration menu → Feature Selection → Communications | System Status | Options – Communications 1 |
| NTP Available/Not Available | Engineer | Configuration menu → Feature Selection → Communications | System Status | Options – Communications 1 |
| System Outage Measurements Available/Not Available | Engineer | Configuration menu → Feature Selection → Communications | System Status | Options – Communications 2 |
| Waveform Capture Available/ Not Available | Engineer | Configuration menu → Feature Selection → Power Quality Menu | System Status | Options – Power Quality |
| Harmonics Available/Not Available | Engineer | Configuration menu → Feature Selection → Power Quality Menu | System Status | Options – Power Quality |
| Sag/Swell Available/Not Available | Engineer | Configuration menu → Feature Selection → Power Quality Menu | System Status | Options – Power Quality |

# Appendix O Location of Settings on the Operator Interface

**Table 158 Location of settings on flexVUE and setVUE Operator Interfaces**

| Field | Location | | | |
|---|---|---|---|---|
| | flexVUE Operator Interface | | setVUE Operator Interface | |
| | Menu | Sub Menu(s) | Menu | Page |
| System Measurements | Operator | Measurements | Measurement | System Measurements |
| Feature Selection | Engineer | Configuration Menu → Feature Selection → Protection (ACR)<br>→ Detection (AS)<br>→ Automation (ACR+AS)<br>→ General (ACR+AS)<br>→ Communications (ACR +AS)<br>→ Power Quality Menu (ACR +AS) | System Status | Options –<br>Protection 1 (ACR)<br>Protection 2 (ACR)<br>Protection 3 (ACR)<br>Protection 4 (ACR)<br>Detection 1 (AS)<br>Detection 2 (AS)<br>Detection 3 (AS)<br>Automation (ACR+AS)<br>Controller 1 (ACR+AS)<br>Controller 2 (ACR+AS)<br>Communications 1 (ACR+AS)<br>Communications 2 (ACR+AS)<br>Power Quality (ACR+AS) |
| Local Settings | Engineer | Configuration Menu → System Settings → Display | System Status | System Status 1 |
| Communication Ports configuration | Engineer | Telemetry Menu → Configure Ports Menu | Communications | Configure Ports (sub-menu) |
| DNP3 port selection | Engineer | Telemetry Menu → Configure Comms → DNP3 Menu → DNP Comms | Communications | Communications Setup 1 → DNP Port |
| IEC 60870-5-101 port selection | Engineer | Telemetry Menu → Configure Comms → IEC 60870-5-101/4 → IEC-101 Comms | Communications | Communications Setup 1 → I101/4 Port |
| IEC 60870-5-104 port selection | Engineer | Telemetry Menu → Configure Comms → IEC 60870-5-101/4 → IEC-101 Comms | Communications | Communications Setup 1 → I101/4 Port |
| Modbus port selection | Engineer | Telemetry Menu → Configure Comms → Modbus Menu → MBUS Comms | Communications | Communications Setup 1 → Modbus Port |
| Modbus IP Networking | Engineer | Telemetry Menu → Configure Comms → Modbus Menu → MBUS IP Networking | Communications | Communications Setup 1 → Modbus (sub-menu) → Modbus IP Networking |
| MITS port selection | Engineer | Telemetry Menu → Configure Comms → MITS Menu → MITS Comms | Communications | Communications Setup 1 → MITS Port |
| Phase Configuration | Engineer | Configuration Menu → System Settings → Network Parameters | System Status | Terminal Designation/Rotation |
| Phase Rotation | Engineer | Configuration Menu → System Settings → Network Parameters | System Status | Terminal Designation/Rotation |
| Power Signed/Unsigned | Engineer | Configuration Menu → System Settings → Metering Parameters → Power Signed | System Status | Phase Voltage and Power Flow |
| Power Direction | Engineer | Configuration Menu → System Settings → Metering | System Status | Phase Voltage and Power Flow |

**Table 158 Location of settings on flexVUE and setVUE Operator Interfaces (Continued)**

| Field | Location | | | |
|---|---|---|---|---|
| | flexVUE Operator Interface | | setVUE Operator Interface | |
| | Menu | Sub Menu(s) | Menu | Page |
| | | Parameters → Source 1, Load 2 | | |
| Live Line Threshold and Supply Timeout | Engineer | Configuration Menu → System Settings → Network Parameters | System Status | Phase Voltage and Power Flow |
| Live/Dead Indications | Operator | Measurements Menu → Phase Indication | System Status | Live/Dead Indication |
| Per Phase Power | Engineer | Measurements Menu → Power → A Phase<br>B Phase<br>C Phase | Measurements | Power |
| Protection Trip Settings | Engineer | Protection Menu → Protection Trip Settings | Protection | Protection Setting 1 - 9 |
| Per Element Protection | Operator | Operator Controls<br>(8 pages added) | System Status | Operator Settings 3<br>Operator Settings 4 |
| Supply Fail Time | Engineer | Protection Menu → Protection Global → Global Control | Protection | Protection Setting 8 |
| Supply Interrupt Flags | Operator | Indications → Interrupt Flags | System Status | Supply Interrupt Flags |
| Per Element Reclose Times | Engineer | Protection Menu → Protection Trip Settings → Auto Reclose (+applicable Trip No page) | System Status | Applicable protection element/ trip pages e.g. Phase Protection Trip 1 |
| Broken Conductor | Engineer | Protection Menu → Protection Trip Settings → Broken Conductor | Protection | Broken Conductor Protection/ Alarm |
| Single Shot | Engineer | Protection Menu → Protection Trip Settings → Single Shot | Protection | Phase Single Shot Protection Trip<br>Earth Single Shot Protection Trip<br>SEF Single Shot Protection Trip<br>NPS Single Shot Protection Trip |
| Work Tag On/Off | Operator | Operator Controls → Work Tag | System Status | Switchgear Status |
| Work Tag Protection Settings | Engineer | Protection Menu → Protection Trip Settings → Work Tag | Protection | Phase Work Tag Protection Trip<br>Earth Work Tag Protection Trip<br>SEF Work Tag Protection Trip<br>NPS Work Tag Protection Trip |
| APGS Time Change | Operator | Operator Controls → APGS Change | System Status | Operator Settings 2 |
| APGS Auto | Operator | Operator Controls → Prot **x** Active (and select Protection Auto) | System Status | Operator Settings 1 (and select Protection Auto for the Prot **x** Active setting. |
| SEF Alarm On/Off | Operator | Operator Controls → SEF Alarm | System Status | Operator Settings 3 |
| SEF Alarm Settings | Engineer | Protection Menu → Protection Trip Settings → Auto Reclose<br>Trip 1<br>Trip 2<br>Trip 3 | Protection | SEF Protection Trip 1<br>SEF Protection Trip 2<br>SEF Protection Trip 3<br>SEF Protection Trip 1 |

**Table 158 Location of settings on flexVUE and setVUE Operator Interfaces (Continued)**

| Field | Location | | | |
|---|---|---|---|---|
| | flexVUE Operator Interface | | setVUE Operator Interface | |
| | Menu | Sub Menu(s) | Menu | Page |
| | | Trip 4<br>Single Shot<br>Work Tag | | SEF Protection Trip Single Shot<br>SEF Protection Trip Work Tag |
| NPS Alarm | Operator | Operator Controls → NPS Mode | System Status | Operator Settings 1 |
| Dead Lockout | Engineer | Protection Menu → Protection Control → Dead Lockout | System Status | Operator Settings 2 |
| Sequence Control | Engineer | Protection Menu → Protection Control → Sequence | Protection | Protection Setting 3 |
| Live Load Blocking | Engineer | Protection Menu → Protection Control → Live Load Block | Protection | Protection Setting 3 |
| High Current Lockout | Engineer | Protection Menu → Protection Control → High Current Lockout | Protection | Protection Setting 5 |
| Inrush Restraint | Engineer | Protection Menu → Protection Control → Inrush Restraint | Protection | Protection Setting 6 |
| SOHIR | Engineer | Protection Menu → Protection Control → Inrush Restraint | Protection | Protection Setting 6 |
| Cold Load Pickup | Engineer | Protection Menu → Protection Control → Cold Load Pickup | Protection | Cold Load Pickup Protection |
| CLP Status | Operator | Operator Controls → Cold Load | System Status | Operator Settings 2 |
| Vzps Balance | Engineer | Protection Menu → Directional Elements → Directional Block → Vzps Compensation | Protection | Vzps Compensation |
| High Vzps Alarm (DIRB) | Engineer | Protection Menu → Directional Elements → Directional Block → High Vzps Alarm | Protection | High Vzps Alarm |
| High Vzps Alarm Status (DIRB) | Operator | Indications → High Vzps Alarm | System Status | Operator Settings 3<br>(or Operator Settings 4 if Per Element Protection is Available) |
| Global Auto Reclose | Operator | Operator Controls → Auto Reclose | System Status | Operator Settings 1 |
| Forward and Reverse Auto Reclose | Engineer | Protection Menu → Protection Global → Global Control | Protection | Directional Protection 1 |
| Auto Restore | Engineer | Protection Menu → Protection Global → Global Control | Protection | Directional Protection 1 |
| Vzps Balance (DIRP) | Engineer | Protection Menu → Directional Elements → Directional Prot → Vzps Compensation | Protection | Vzps Compensation |
| High Vzps Alarm (DIRP) | Engineer | Protection Menu → Directional Elements → Directional Prot → High Vzps Alarm | Protection | High Vzps Alarm |
| High Vzps Alarm Status (DIRP) | Operator | Indications → High Vzps Alarm | System Status | Operator Setting 3<br>(or Operator Setting 4 if Per Element Protection is Available) |
| UOV Protection | Engineer | Protection Menu → Protection Trip Settings → Under Over Voltage | Protection | Under Voltage Protection<br>Over Voltage Protection |

**Table 158 Location of settings on flexVUE and setVUE Operator Interfaces (Continued)**

| Field | Location | | | |
|---|---|---|---|---|
| | flexVUE Operator Interface | | setVUE Operator Interface | |
| | Menu | Sub Menu(s) | Menu | Page |
| | | | | Under/Over Voltage Protection |
| Neutral Voltage Displacement | Engineer | Protection Menu → Protection Trip Settings → NVD Protection | Protection | NVD Protection 1<br>NVD Protection 2 |
| NVD Alarm | Engineer | Protection Menu → Protection Trip Settings → NVD Alarm | Protection | NVD Alarm 1<br>NVD Alarm 2 |
| Loss of Phase | Engineer | Protection Menu → Protection Trip Settings → Loss of Phase | Protection | Protection Setting 5 |
| UOF Protection | Engineer | Protection Menu → Protection Trip Settings → Under Over Frequency | Protection | Under/Over Frequency Protection 1<br>Under/Over Frequency Protection 2 |
| Rate of Change of Frequency (ROCOF) | Engineer | Protection Menu → Protection Trip Settings → ROCOF | Protection | Rate of Change of Frequency |
| Trip After (AS) | Engineer | Detection Menu → Sectionalise | Detection | Detection Settings 3 |
| SEF Trip After (AS) | Engineer | Detection Menu → Sectionalise | Detection | Detection Settings 3 |
| NPS Trip After (AS) | Engineer | Detection Menu → Sectionalise | Detection | Detection Settings 2 |
| Fault Flags (AS) | Operator | Indications → Flags | System Status | Fault Flags |
| Per Element Detection (AS) | Operator | Operator Controls<br>(8 pages added) | System Status | Operator Settings 3<br>Operator Settings 4 |
| Supply Fail Time (AS) | Engineer | Detection Menu → Global Control → Supply Fail | Detection | Detection Setting 6 |
| Supply Interrupt Flags (AS) | Operator | Indications → Interrupt Flags | System Status | Supply Interrupt Flags |
| Broken Conductor (AS) | Engineer | Detection Menu → Detection Settings → Broken Con Det | Detection | Broken Conductor |
| Single Shot (AS) | Operator | Operator Controls → Single Shot Mode | System Status | Operator Settings 2 |
| Single Shot Reset Time (AS) | Engineer | Detection Menu → Single Shot → Reset | Detection | Detection Settings 2 |
| Single Shot Fault Detect Timing (AS) | Engineer | Detection Menu → Detection Settings → Single Shot | Detection | Phase Single Shot Detection Trip<br>Earth Single Shot Detection Trip<br>SEF Single Shot Detection Trip<br>NPS Single Shot Detection Trip |
| Work Tag On/Off (AS) | Operator | Operator Controls → Work Tag | System Status | Switchgear Status |
| ADGS Change Time (AS) | Operator | Operator Controls → ADGS Change | System Status | Operator Settings 2 |
| ADGS Auto/Off (AS) | Operator | Operator Controls → Det **x** Active | System Status | Operator Settings 1 |
| SEF Alarm (AS) | Operator | Operator Controls → SEF Alarm | System Status | Operator Settings 3 |
| SEF Alarm Definite Time (AS) | Engineer | Detection Menu → Detection Settings Sectionalise → | Detection | - SEF Detection |

**Table 158 Location of settings on flexVUE and setVUE Operator Interfaces (Continued)**

| Field | Location | | | |
|---|---|---|---|---|
| | flexVUE Operator Interface | | setVUE Operator Interface | |
| | Menu | Sub Menu(s) | Menu | Page |
| | | - Trip 1<br>- Single Shot | | - SEF Single Shot Detection Trip |
| NPS Mode (AS) | Operator | Operator Controls → NPS Mode | System Status | Operator Settings 1 |
| Detection On/Off (AS) | Operator | Operator Controls → Auto Sectionalise | System Status | Operator Settings 1 |
| Live Load Blocking (AS) | Engineer | Detection → Live Load Block | Detection | Detection Settings 3 |
| Inrush Restraint (AS) | Engineer | Detection Menu → Inrush Restraint | Detection | Detection Setting 5 |
| SOHIR (AS) | Engineer | Detection Menu → Inrush Restraint | Detection | Detection Setting 5 |
| Cold Load (AS) | Engineer | Detection Menu → Cold Load Pickup | Detection | Cold Load Pickup Detection |
| Cold Load Status (AS) | Operator | Operator Controls → Cold Load | System Status | Operator Settings 2 |
| Vzps Balance (AS, DIRB) | Engineer | Detection Menu → Directional Elements → Directional Block → Vzps Compensation | Detection | Vzps Compensation |
| High Vzps Alarm (AS, DIRB) | Engineer | Detection Menu → Directional Elements → Directional Block → High Vzps Alarm | Detection | High Vzps Alarm |
| High Vzps Alarm Status (AS, DIRB) | Operator | Indications → High Vzps Alarm | System Status | Operator Settings 3<br>(Operator Settings 4 if Per Element Detection is available) |
| Vzps Balance (AS, DIRD) | Engineer | Detection Menu → Directional Elements → Directional Det → Vzps Compensation | Detection | Vzps Compensation |
| UOV Detection (AS) | Engineer | Detection Menu → Detection Settings → Under Over Voltage | Detection | - Under Voltage Detection<br>- Over Voltage Detection<br>- Under/Over Voltage Detection |
| Fault Locator (ACR) | Engineer | Protection Menu → Fault Locator | Protection | - Fault Locator<br>- Conductor Characteristics |
| Fault Locator (AS) | Engineer | Detection Menu → Fault Locator | Detection | - Fault Locator<br>- Conductor Characteristics |
| Fault Information | Operator | Indications → Fault Information | System Status | Fault Information |
| Displayed Units | Engineer | Configuration Menu → System Settings → Display | System Status | System Settings 1 |
| Sync Check (ACR) | Engineer | Protection Menu → Protection Control → Sync Check | Protection | Sync Check Settings 1 - 4 |
| Sync Check (AS) | Engineer | Detection Menu → Sync Check | Detection | Sync Check Setting 1 - 4 |
| Loop Automation | Engineer | Automation Menu → Loop Automation Menu → LA Configuration | Automation | Loop Automation |
| Intelligent Loop Automation Communications | Engineer | Automation Menu → Loop Automation Menu → LA Communications | Automation | - LA Communications<br>- LA Downstream Communications<br>- LA Tie Communications |

**Table 158 Location of settings on flexVUE and setVUE Operator Interfaces (Continued)**

| Field | Location | | | |
|---|---|---|---|---|
| | flexVUE Operator Interface | | setVUE Operator Interface | |
| | Menu | Sub Menu(s) | Menu | Page |
| Auto Changeover | Engineer | Automation Menu → Auto Changeover Menu →<br>- ACO Config<br>- ACO Comms<br>- ACO Comms Stats<br>- ACO Timers | Automation | - Auto Changeover Configuration<br>- Auto Changeover Communications<br>- Auto Changeover Communications Stats<br>- Auto Changeover Timers |
| Maximum Demand Records | Engineer | Measurements Menu → Demand - Daily Max Demand<br>- Weekly Max Demand<br>- Monthly Max Demand | Measurement | - Daily Maximum Demand<br>- Weekly Maximum Demand<br>- Monthly Maximum Demand |
| Maximum Demand Period | Operator | Operator Controls → Demand Period | System Status | Operator Setting 2 |
| Communications Diagnostics | Engineer | Telemetry Menu → Configure Comms → Trace Menu → Coms Trace | Communications<br>(Trace sub-menu) | Communications Trace |
| Single Shot Reset Timer | Engineer | Protection Menu → Protection Trip Settings → Single Shot → Reset | Protection | Protection Setting 2 |
| Maximum Fault Period (AS) | Engineer | Detection Menu → Fault Period | Detection | Detection Setting 6 |
| Loop Automation Mods | Engineer | Automation Menu → Loop Automation Menu → LA Configuration | Automation | Loop Automation Configuration 1 |
| Loop Automation UF Pause/Abort Tie Close | Engineer | Automation Menu → Loop Automation Menu → LA Configuration | Automation | Loop Automation Configuration 5 |

# Appendix P Scada Points

## Appendix P.1 Analogue Points to Monitor and Set Pick-up Thresholds for Overcurrent Protection

New SCADA Analogue input and control points have been made available to allow users to view and alter pick-up thresholds remotely (via SCADA) for both the Active Forward and Reverse Phase, Earth, SEF, and NPS elements. In addition, a further Analogue input and control point is provided for the Active Broken Conductor Pick-up threshold (ratio of $I_{nps}/I_{pps}$).

**NOTE:** The table below outlines the database points available Protection State Analogues and Protection Analog Controls features. For more details refer the N00-331 Database.

**Table 159 New Protection State Analogues**

| Appendix/ Sub Appendix | Point | Name | Description | Min | Max | Unit (s) | Res. | Dead band | Version Introduced |
|---|---|---|---|---|---|---|---|---|---|
| A2.5 | 5 | Phase Setting Current Active | The Phase setting current of the active protection group | 3 | 1260 | Amps | 1 | 1 | 50—14.70 |
| A2.5 | 6 | Earth Setting Current Active | The Earth setting current of the active protection group | 3 | 1260 | Amps | 1 | 1 | 50—14.70 |
| A2.5 | 7 | SEF Setting Current Active | The SEF setting current of the active protection group | 1 | 80 | Amps | 1 | 1 | 50—14.70 |
| A2.5 | 8 | NPS Setting Current Active | The NPS setting current of the active protection group | 1 | 1260 | Amps | 1 | 1 | 50—14.70 |
| A2.5 | 9 | Broken Conductor Setting Ratio | The Broken Conductor setting current of the active protection group | 10 | 100 | N/A | 0.—01 | 1 | 50—14.70 |
| A2.5 | 10 | Phase Setting Current Reverse | The Phase setting current of the active protection group | 3 | 1260 | Amps | 1 | 1 | 50—14.70 |
| A2.5 | 11 | Earth Setting Current Reverse | The Earth setting current of the active protection group | 3 | 1260 | Amps | 1 | 1 | 50—14.70 |

### Table 159 New Protection State Analogues (Continued)

| Appendix/ Sub Appendix | Point | Name | Descrip-tion | Min | Max | Unit (s) | Res. | Dead band | Version Intro-duced |
|---|---|---|---|---|---|---|---|---|---|
| A2.5 | 12 | SEF Setting Current Reverse | The SEF setting current of the active protection group | 1 | 80 | Amps | 1 | 1 | 50—14.70 |
| A2.5 | 13 | NPS Setting Current Reverse | The NPS setting current of the active protection group | 1 | 1260 | Amps | 1 | 1 | 50—14.70 |

### Table 160 New Protection Analog Controls

| Appendix/ Sub Appendix | Point | Name | Description | Min | Max | Unit (s) | Res. | Version Introduced |
|---|---|---|---|---|---|---|---|---|
| B.2 | 40 | Phase Setting Current Active | This controls the Phase Setting Current for the Active Protection/ Detection group | 3 | 1260 | Amps | 1 | 50—14.70 |
| B.2 | 41 | Earth Setting Current Active | This controls the Earth Setting Current for the Active Protection/ Detection group | 3 | 1260 | Amps | 1 | 50—14.70 |
| B.2 | 42 | SEF Setting Current Active | This controls the SEF Setting Current for the Active Protection/ Detection group | 3 | 1260 | Amps | 1 | 50—14.70 |
| B.2 | 43 | NPS Setting Current Active | This controls the NPS Setting Current for the Active Protection/ Detection group | 3 | 1260 | Amps | 1 | 50—14.70 |
| B.2 | 44 | Broken Conductor Setting Current Active | This controls the Broken Conductor Setting Current for the Active Protection/ Detection group | 3 | 1260 | Amps | 1 | 50—14.70 |
| B.2 | 45 | Phase Setting Current Active | This controls the Phase Setting Current for the Active Protection/ Detection group | 3 | 1260 | Amps | 1 | 50—14.70 |
| B.2 | 46 | Earth Setting Current Active | This controls the Earth Setting Current for the Active Protection/ Detection group | 3 | 1260 | Amps | 1 | 50—14.70 |
| B.2 | 47 | SEF Setting Current Active | This controls the SEF Setting Current for the Active Protection/ Detection group | 3 | 1260 | Amps | 1 | 50—14.70 |
| B.2 | 48 | NPS Setting Current Active | This controls the NPS Setting Current for the Active Protection/ Detection group | 3 | 1260 | Amps | 1 | 50—14.70 |

# Appendix P.2 — New SCADA Point for WSOS5 Online/Offline Status

A new digital status point is available for inclusion in user configurable telemetry I/O maps to indicate whether there is an active WSOS connection with the controller.

**NOTE:** The table below outlines the database points available WSOS communication status feature. For more details refer the N00-331 Database.

| Appendix/ Sub Appendix | Point # | Name | Description | Set = 1 | Clear = 0 |
|---|---|---|---|---|---|
| A.1.1 | 76 | WSOS Online | WSOS communication status. It is set OFF when there has been no communication from any WSOS for 10 minutes | WSOS online | WSOS offline |

# Appendix P.3 — New SCADA Point for Switchgear Series and Serial Numbers

A new analogue status point is available for inclusion in user configurable telemetry I/O maps to indicate the switchgear series and the PCOM (controller) serial number.

**NOTE:** The table below outlines the database points available Timed Trip Block feature. For more details refer the N00-331 Database.

**Table 161 New switchgear details Analogues**

| Appendix/ Sub Appendix | Point # | Name | Description | Min | Max |
|---|---|---|---|---|---|
| A.2.7 | 8 | Switch-gear Series | The switchgear series:<br>• 0 = Unknown<br>• 1 = N Series<br>• 5 = U Series<br>• 6 = W Series<br>• 8 = RL2 Series<br>• 10 = V/C Series<br>• 12 = E Series<br>• 13 = UR Series | 0 | 20 |

**Table 162 New controller details Analogues**

| Appendix/ Sub Appendix | Point # | Name | Description | Min | Max |
|---|---|---|---|---|---|
| A.2.8 | 18 to 20 | PCOM Serial number | Protection and Communications Module serial number. Available in 16-bit and 32-bit. | 0 | 2.1E+09 |

# Appendix P.4 — New SCADA Point for Accumulated Average Data

The new accumulated averaged data points are the protocol points in the A.3.4 section for a map version A50-12.00 or newer. These points are accumulated averaged data over the configurable history period (Figure 360).

These are the same data points as the configurable history data points recorded, however the configurable history point doesn't have to be selected to be reported by these protocol points.

This data is updated every configurable history period and synchronized to the hour.

If configured in the DNP3 map, these points will generate class 3 counter events when they are updated.

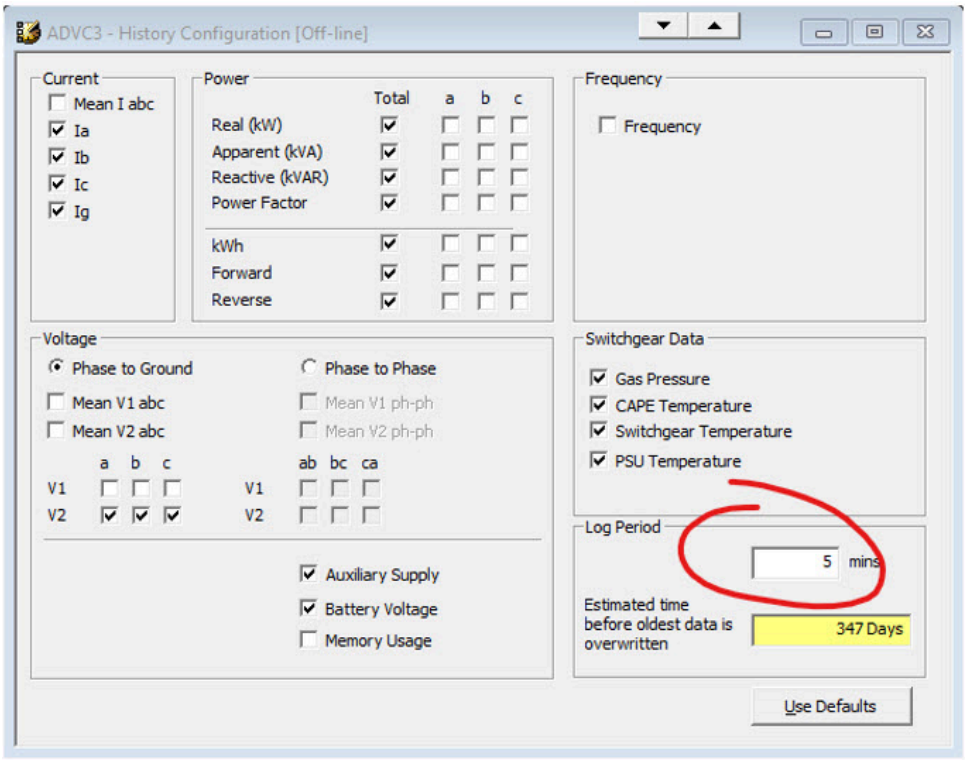



**Figure 360**
Configurable history period setting on WSOS

# Glossary

## A

**ACK:** Acknowledgement

**ACO:** Auto Changeover

**ACR:** Automatic Circuit Recloser

**ADGS:** Automatic Detection Group Selection

**ADVC:** Advanced Controller

**APGS:** Automatic Protection Group Selection

**AS:** Automatic Sectionaliser

**ASCII:** American Standard Code for Information Interchange

**ATDT:** Attention Dial Tone

**ATH:** Hayes *hang up* command

## C

**CA:** Collision Avoidance

**CAPE:** Control and Protection Enclosure

**CLT:** Custom Logic Tool

**CRC:** Cyclic Redundancy Check

**CT:** Current Transformer

**CTRL:** Controller

**CTS:** Clear To Send

**CVT:** Capacitive Voltage Transformer

## D

**DCD:** Data Carrier Detect

**DG:** Distributed Generation

**DHCP:** Dynamic Host Configuration Protocol

**DNP:** Distributed Network Protocol

**DT:** Definite Time

**DTR:** Data Terminal Ready

## E

**EDACS:** Enhanced Digital Access Communication System

**EF:** Earth (Ground) Fault

## F

**FDIR:** Fault Detection Isolation and Restoration

**FET:** Field Effect Transistor

**FSK:** Frequency Shift Keying

## G

**GF:** Ground Fault

**GFN:** Ground Fault Neutraliser

**GMT:** Greenwich Mean Time

**GND:** Ground, synonymous with earth

**GPO:** General Purpose Outlet

## H

**Hex:** Hexadecimal

**Hz:** Hertz (cycles per second)

## I

**IDMT:** Inverse definite Minimum Time

**IEC:** International Electrotechnical Commission

**IEEE:** Institute of Electrical and Electronics Engineers

**ILA:** Intelligent Loop Automation

**INST:** Instantaneous

**IOEX:** Input/Output Expander Card

**IP:** Internet Protocol

## K

**kPaG:** Kilopascal Gauge

## L

**LA:** Loop Automation

**LAN:** Local Area Network

**LBS:** Load Break Switch

**LCD:** Liquid Crystal Display

**LED:** Light Emitting Diode

**LOP:** Loss of Phase Protection

**LVIT:** Low Voltage Inhibit Threshold

## M

**MAC:** Message Authentication Code

**ms:** milli seconds

## N

**NPS:** Negative Phase Sequence

**NTP:** Network Time Protocol

**NWRK:** Network

## O

**O.I.:** Operator Interface

**OC:** Overcurrent (Phase)

**OCP:** Operator Control Panel

**OF:** Over Frequency Protection

**OV:** Over Voltage Protection

## P

**PPS:** Positive Phase Sequence

**PRTN:** Protection

**PSIG:** Pounds per Square Inch Gauge

**PSM:** Power Supply Module

**PSSM:** Power Supply and Switchgear Module

**PSTN:** Public Switched Telephone Network

**PSU:** Power Supply Unit

**PTCL:** Protocol

**PTT:** Per Trip Thresholds

**PTT:** Press To Talk

**PU:** Per Unit

## Q

**QAK:** Quick Action Key

## R

**RDI:** Radio Data Interface

**RTS:** Ready To Send

**RTU:** Remote Terminal Unit

## S

**SCADA:** Supervisory Control and Data Acquisition

**SEF:** Sensitive Ground Fault

**SGF:** Sensitive Ground Fault

**SI:** Supply Interrupt

**SOHIR:** Second Order Harmonic Inrush Restraint

**SOS:** Switchgear Operating System

**SVIIS:** Secondary Voltage Injection Interface Set

**SWGR:** Switchgear

## T

**TCP/IP:** Transmission Control Protocol/Internet Protocol

**TTS:** Test and Training Set

## U

**UF:** Under Frequency Protection

**UOF:** Under and Over Frequency

**UOV:** Under and Over Voltage

**USB:** Universal Serial Bus

**UTC:** Universal Time Coordinated

**UV:** Under Voltage Protection

## V

**VIB:** Voltage imbalance

**VT:** Voltage Transformer

## W

**WAN:** Wide Area Network

**WSOS:** Windows Switchgear Operating System

## Z

**ZPS:** Zero Phase Sequence

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