Power Quality Monitoring and Compliance (NEMA)

Capture, Analyze, and Understand Power Quality Disturbances

EcoStruxure Power Digital Application

0100DB2315
12/2023

EcoStruxure™ Power

www.se.com

Schneider Electric™

Legal Information

The information provided in this document contains general descriptions, technical characteristics and/or recommendations related to products/solutions.

This document is not intended as a substitute for a detailed study or operational and site-specific development or schematic plan. It is not to be used for determining suitability or reliability of the products/solutions for specific user applications. It is the duty of any such user to perform or have any professional expert of its choice (integrator, specifier or the like) perform the appropriate and comprehensive risk analysis, evaluation and testing of the products/solutions with respect to the relevant specific application or use thereof.

The Schneider Electric brand and any trademarks of Schneider Electric SE and its subsidiaries referred to in this document are the property of Schneider Electric SE or its subsidiaries. All other brands may be trademarks of their respective owner.

Schneider Electric does not grant any right or license for commercial use of the document or its content, except for a non-exclusive and personal license to consult it on an "as is" basis.

Schneider Electric reserves the right to make changes or updates with respect to or in the content of this document or the format thereof, at any time without notice.

To the extent permitted by applicable law, no responsibility or liability is assumed by Schneider Electric and its subsidiaries for any errors or omissions in the informational content of this document, as well as any non-intended use or misuse of the content thereof.

AccuSine™, Acti 9™, Altivar™, ASCO™, BlokSeT™, ComPacT™, EcoStruxure™, EnerLin'X™, ETAP™, EVlink™, EvoPacT™, Galaxy™, Harmony™, Iso-Gard™, Masterclad™, MasterPacT™, MicroLogic™, Modicon™, Okken™, PowerLink™, PowerLogic™, PowerPacT™, Power-Zone™, PremSeT™, PrismaSeT™, Schneider Electric™, SM AirSeT™, Square D™, SureSeT™, TeSys™, TransferPacT™, Trihal™, and Vigilohm™ are trademarks and the property of Schneider Electric SE, its subsidiaries, and affiliated companies. All other trademarks (Cyber Sciences™, Hirschmann™) are the property of their respective owners.

Table of Contents

Overview

Context of Application

There are many different power quality disturbances which can adversely affect critical or sensitive equipment, processes, and buildings. Continuously measuring, understanding, and acting on these disturbances is key to limiting equipment damage and reducing process and building interruptions.

Several national and international power quality standards exist to help facilities avoid downtime or disruption of sensitive equipment:

- EN 50160 – European standard for industrial and commercial networks
- IEEE 519 – Global standard for voltage and current harmonics
- IEEE 1159 – US power quality standard
- IEC 61000-4-30 – International power quality measurement techniques standard

Though helpful, understanding compliance with these standards can be challenging and time-consuming.

Problem to Solve

The facility manager needs to:

- Understand which power quality events could adversely affect their processes or operations.
- Be able to monitor persistent power quality disturbances.
- Analyze and determine actions needed to correct issues.
- Comply with national and international standards which address allowable power quality limits and durations (as mentioned above).
- Use power quality standards as guidelines to help ensure the appropriate level of power quality provided by the electric utility.

Purpose of the Application

Monitor persistent steady state and event-based disturbances and power quality measurements

- Harmonics, current unbalance, flicker, and over/undervoltage conditions, transients, interruptions, etc.

Visualize and report on power quality data

- To adhere to any power quality industry standards such as CBEMA, ITIC, SEMI F47, EN 50160, IEC 61000-4-30, IEEE 519 and 1159.

Better understand power quality disturbances

- Trends and reports to understand potential issues that could affect operations
- Event details, such as waveforms, captured and studied
- Patented Disturbance Direction Detection to locate the directionality of events

Enable in-depth analysis of power quality issues

- Advanced dashboards and reports
- Analytics-based advisory services to improve performance across the system

Power Quality Overview Dashboard

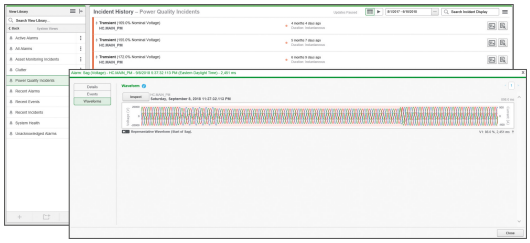
Application Outcomes

Live Data Display

Steady state disturbances such as harmonics, unbalance, and frequency can be visualized in real time.

Events and Alarms

Onboard events and alarms with timestamps.



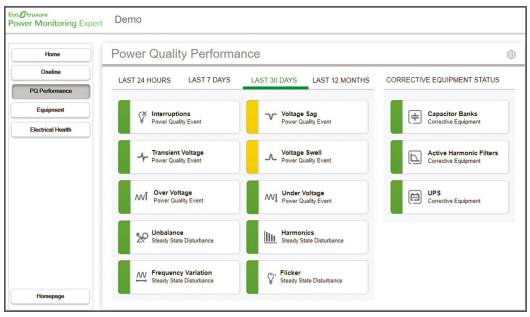
Smart Alarming

Trends

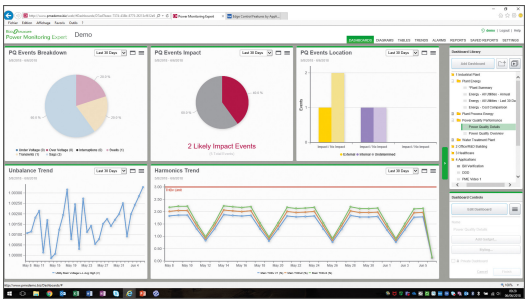
Steady state disturbances such as harmonics, unbalance, and frequency can be visualized as trends to monitor their evolution over time.

Dashboards

- Power quality performance diagrams
- Power quality dashboards



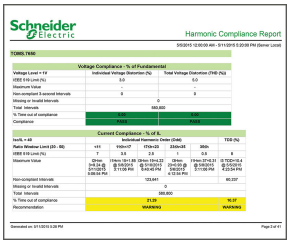
Power Quality Performance Status Panel



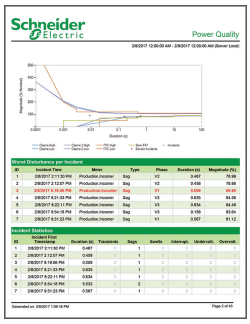
Power Quality Details Dashboard

Reports

- Power Quality Report
- Power Quality Analysis Report
- Power Quality Impact Report
- Harmonics Compliance Report
- IEC 61000-4-30 Report



Harmonic Compliance Report



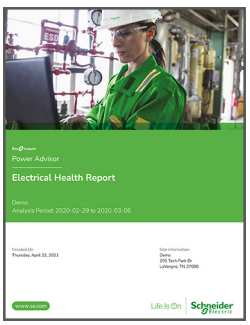
Power Quality Report

Analysis Tools

- Power events incident timeline
- Waveform viewer

Cloud-Based Analytics and Services

As an option, EcoStruxure Service Plan powered by EcoStruxure Power Advisor provides power quality analytics with recommendations from our Schneider Electric service experts.



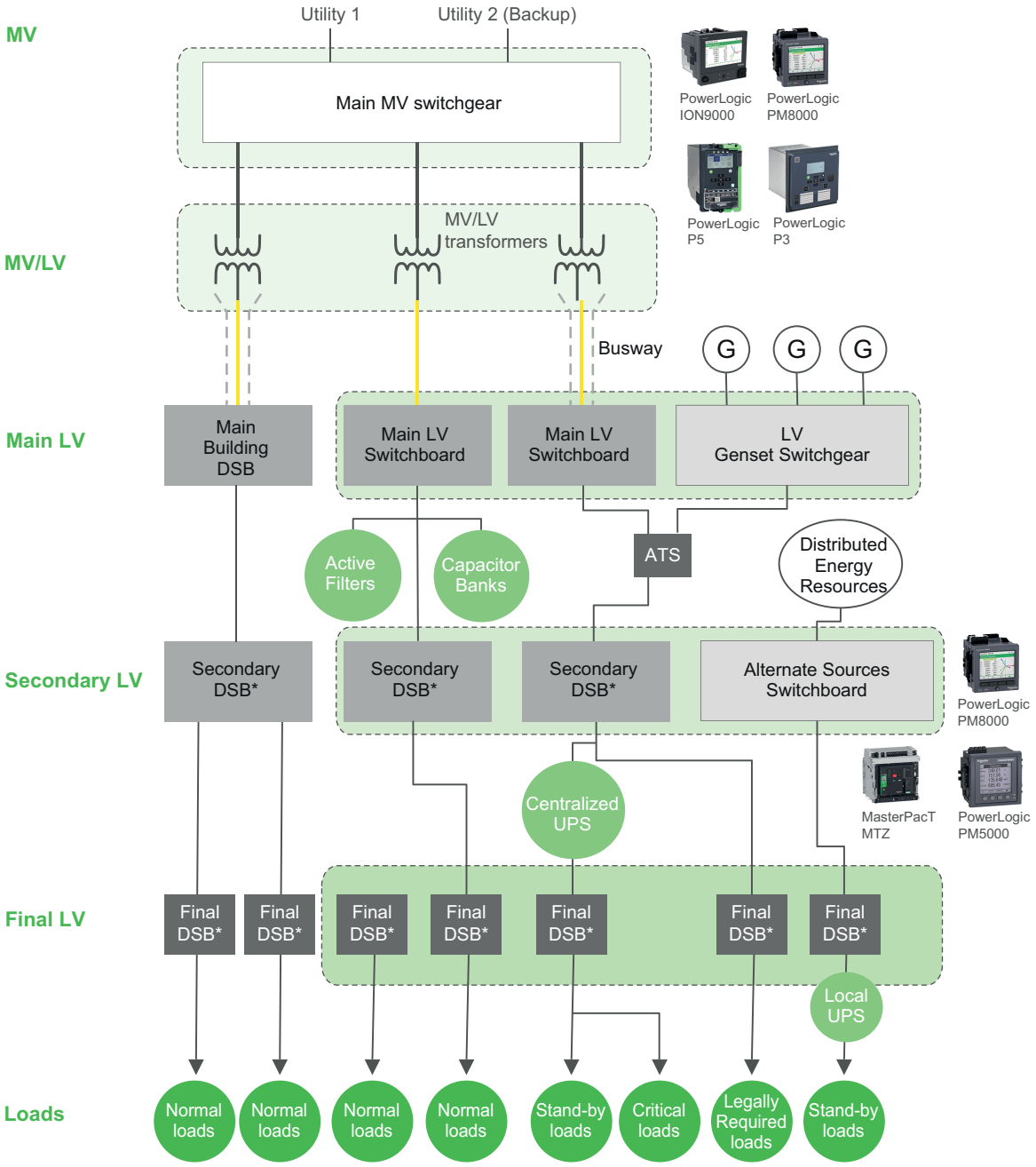
EcoStruxure Power Advisor Electrical Health Report

Electrical Architecture

For sensitive loads or critical applications, standalone power quality meters are recommended in parallel with protection devices for sub-cycle power quality event capture and Disturbance Direction Detection.

For non-sensitive loads or for measuring chronic steady-state disturbances, embedded metering in protection devices is sufficient.

The following diagram details the areas of the architecture where the connected products should be installed in order to implement the Power Quality Monitoring and Compliance application:



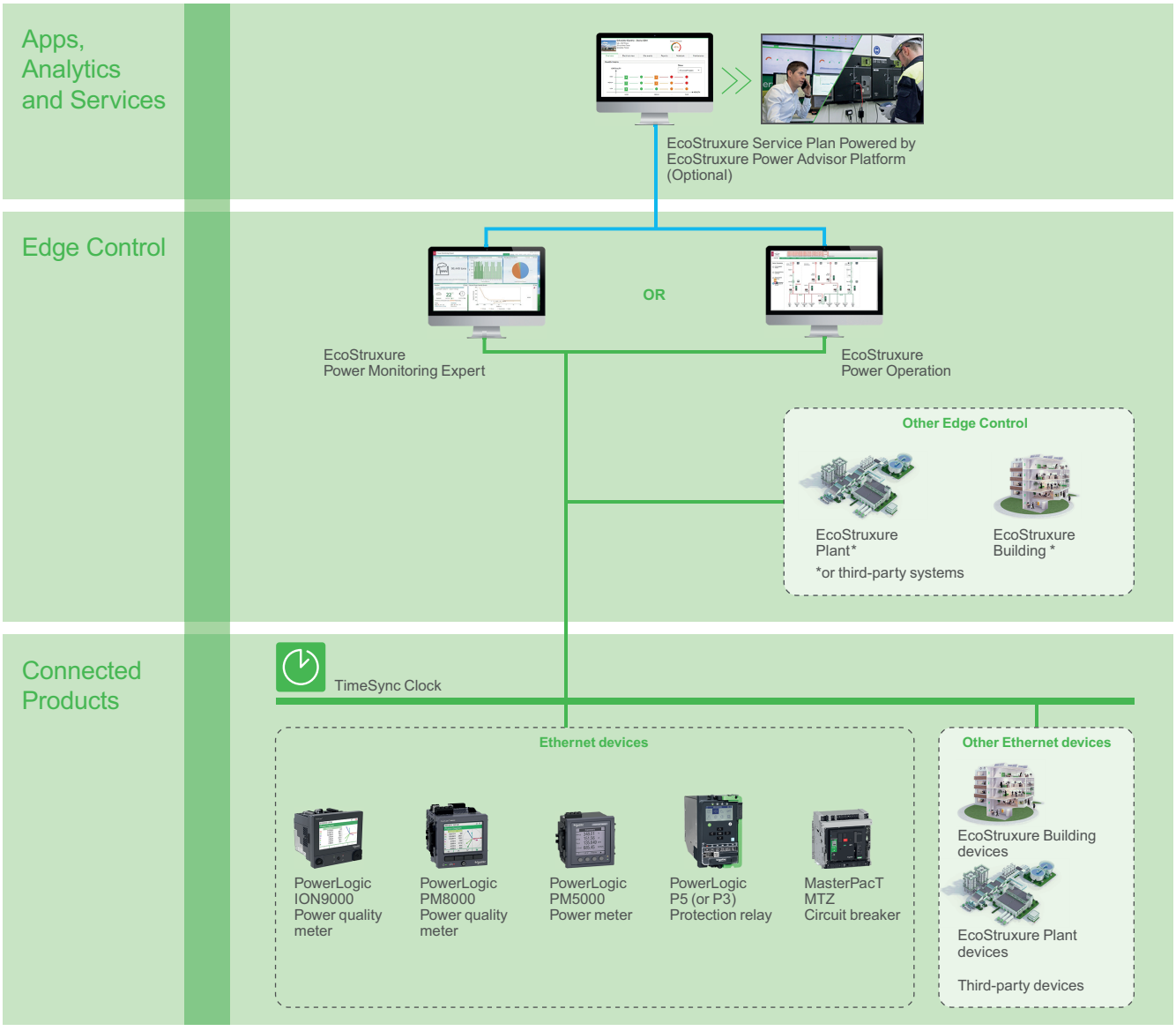
* DSB = Distribution Switchboard

Digital Architecture

The digital architecture of the Power Quality Monitoring and Compliance application recommends direct Ethernet connections to power quality measurement connected products. Data is captured on board connected products and uploaded into the Edge Control software (EcoStruxure Power Monitoring Expert or Power Operation) for data processing, visualization, and reporting.

As an option, data from EcoStruxure Power Monitoring Expert or Power Operation can be passed on to the EcoStruxure Power Advisor platform and interpreted by experts as part of the EcoStruxure Service Plan.

The recommended digital architecture for the application is shown below:

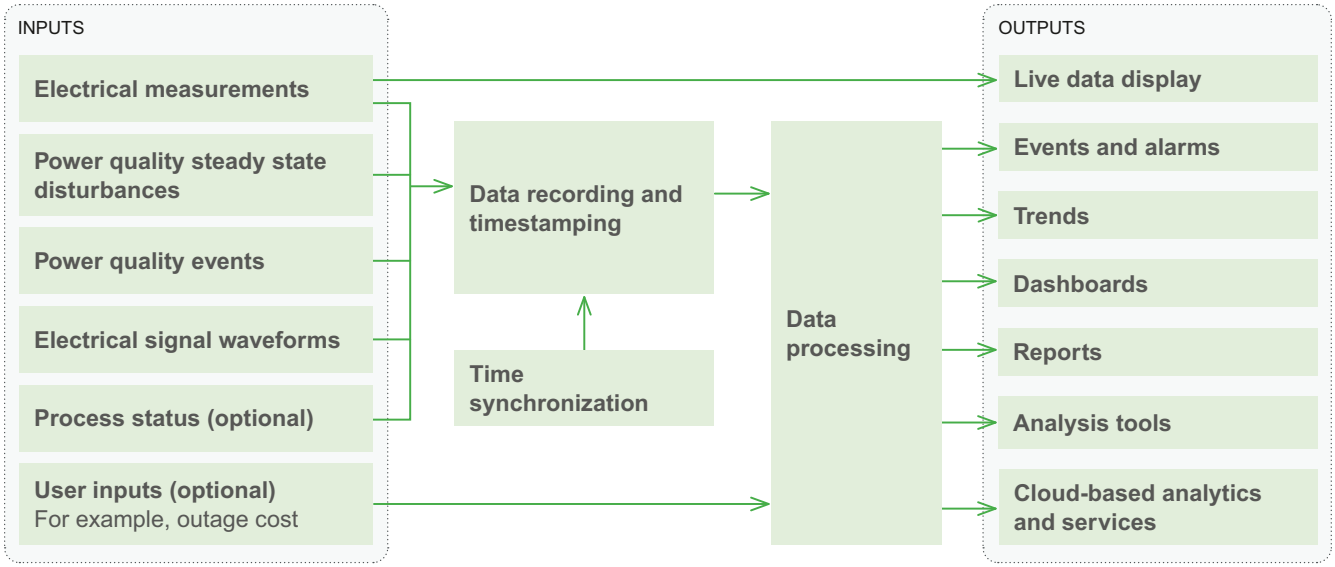


Ethernet - public LAN/WAN
Ethernet - technical LAN

System Description

Data Flow

The Power Quality Monitoring and Compliance application can be broken down as follows:



Inputs

The Power Quality Monitoring and Compliance application collects data from the connected products of the electrical installation to monitor and report on the power quality situation.

- **For main incomers and critical feeders**, power quality can be monitored on a continuous basis by power quality meters such as the PowerLogic ION9000, PM8000, and high-end models of the PM5000 series. These meters are capable of capturing sub-cycle power quality events (transients, voltage sags and swells, etc.).


PowerLogic ION9000


PowerLogic PM8000


PowerLogic PM5000

- **For less critical circuits**, steady state disturbances can be acquired either by embedded metering in protection devices such as the PowerLogic P5/P3 relays, MasterPacT MTZ circuit breaker, or by entry-level models of PM5000 power meters.


PowerLogic P5


PowerLogic P3


MasterPacT MTZ


PowerLogic PM5000

The following table outlines the limitations and capabilities of the connected products with respect to power quality data capture:

Product	Flicker measurement	Transient detection	Disturb-ance direction	Sag/swell monitoring	Harmonic distortion: total/individual/ interharmonics	Waveform capture
PowerLogic ION9000	Yes	Yes (20 µs)	Yes	Yes	Yes (+TDD[1]) / Yes / No[2]	Yes
PowerLogic ION9000T	Yes	Yes (100 ns)	Yes	Yes	Yes (+TDD[1]) / Yes / No[2]	Yes
PowerLogic PM8000	No	No	Yes	Yes	Yes / Yes / No	Yes
PowerLogic PM5000	No	No	No	No	Yes (+TDD[1]) / Yes / No	No
PowerLogic P5	No	No	No	Yes	Yes / Yes / No	Yes, on trip event only
PowerLogic P3	No	No	No	No	Yes / No / No	Yes, on trip event only
MasterPacT MTZ	No	No	No	No	Yes / Yes / No (with additional digital module)	Yes, on trip event only

The following table specifies how to select the right power meter depending on the chosen standard:

Product	IEC 61000-4-30 Class A/S	IEEE 519	IEEE1159	CBEMA, ITIC, SEMI F47
 PowerLogic ION9000	Class A	Yes (web, PME Harmonic Compliance Report)[3]	No	Yes (web, PME PQ Report)[4]
 PowerLogic PM8000 series	Class S	Yes (web, PME Harmonic Compliance Report)[3]	No	Yes (web, PME PQ Report)[4]

The following data are required to enable Power Quality Monitoring and Compliance:

Electrical Measurements

- Voltage, current, and power measurements need to be captured accurately and with a high sample rate.

Power Quality Steady State Disturbances

- Voltage and current harmonics
- Voltage and current imbalance
- Voltage fluctuations (flicker)
- Frequency variations

1. Total Demand Distortion
2. Does provide interharmonic measurements, but not Total Harmonic Distortion (THD) for interharmonics.
3. EcoStruxure Power Monitoring Expert: Harmonic Compliance Report
4. EcoStruxure Power Monitoring Expert: Power Quality Report

Power Quality Events

- Transients
- Interruptions
- Voltage sags and swells
- Overvoltage and undervoltage

Electrical Signal Waveforms

- High sample rate sinusoidal waveform data for all phases of voltage and current

User Inputs (Optional)

Additional optional user inputs such as outage cost can be input into the software analysis configuration to provide an estimate of the financial impact of power quality.

Data Recording and Timestamping

For highly critical applications, optimal chronological correlation is achieved with a time accuracy of ±1 millisecond (possible using PTP or GPS time synchronization).

For less critical applications, a time accuracy of ±100 milliseconds is adequate (with NTP and SNTP).

Advanced meters such as the PowerLogic ION9000, PM8000, and some PM5000 models (PM53xx and PM55xx) can timestamp and record onboard input data.


PowerLogic ION9000


PowerLogic PM8000


PowerLogic PM5000

For other connected products (PowerLogic P5/P3, MasterPacT MTZ[5], and entry-level PowerLogic PM5000 models) steady state disturbances are measured by the connected products and recorded by EcoStruxure Power Monitoring Expert or Power Operation.


PowerLogic P5


PowerLogic P3


MasterPacT MTZ


PowerLogic PM5000

5. For power quality measurements, MasterPacT MTZ has the option of adding the:
   * Individual Harmonics Analysis Digital module
   * Under/Overvoltage Digital module

EcoStruxure
Power Monitoring Expert

EcoStruxure
Power Operation

When acquiring data from other systems, timestamps can also be imported through OPC[6] or ETL [7].

For a comprehensive overview of device recording and timestamping capabilities, refer to Data Recording and Time Synchronization Capabilities of EcoStruxure Power Connected Products.

Time Synchronization

To reconstruct an accurate chronological view of events that take place during an electrical incident, all connected products must have on-board clocks that are designed to receive a time synchronization signal from an external master reference clock.

The purpose of time synchronization is to help ensure coordination among otherwise independent clocks.

TimeSync Clock

Data Processing

Power quality data is processed on board the device or in the Edge Control software for visualization.

Advanced power quality data processing is performed on board advanced power quality meters such as PowerLogic ION9000 or PM8000:

- Determination of transients, sags, swells, and interruptions
- Disturbance Direction Detection (DDD) for transients and voltage sags/swells (upstream, downstream)

PowerLogic
ION9000

PowerLogic
PM8000

Further data processing is performed in the Edge Control software (EcoStruxure Power Monitoring Expert or Power Operation):

- Evaluation of power quality inputs with thresholds and definitions as per internationally recognized standards such as IEEE 519, IEC 61000-4-30, IEEE 1159, CBEMA, ITIC, SEMI F47.

6. OPC: Open Platform Communications
7. The EcoStruxure Extract Transform Load (ETL) engine is a companion application for EcoStruxure Power Monitoring Expert and Power Operation. It is used to extract historical data from one application (Schneider Electric or third-party), then transform that data so it can be loaded into another application.

EcoStruxure
Power Monitoring Expert

EcoStruxure
Power Operation

With the addition of the Power Quality Performance module in Power Monitoring Expert or Power Operation, the following data processing is done to provide analytic views of power quality data:

- Calculation of Power Quality Rating (A/B/C/D/E/F) based on aforementioned standards
- Evaluation of Power Quality Impact based on the thresholds defined by ITIC standard
- Correlation of operations impact (for example, process interruption) with power quality events using an electrical input or physical signal from operations

Outputs

Live data, trends, smart alarming, and some dashboards and reporting are available by default in Edge Control software (EcoStruxure Power Monitoring Expert or Power Operation) for displaying power quality data.

EcoStruxure
Power Monitoring Expert

EcoStruxure
Power Operation

The optional Power Quality Performance module in EcoStruxure Power Monitoring Expert or Power Operation can provide further analytics, visualization, and reporting.

Lastly, EcoStruxure Power Advisor provides optional analytics-based support services to analyze power system data and provide actionable recommendations.

EcoStruxure
Power Advisor

Live Data Display

At any time, all related electrical measurements and steady state disturbances such as harmonics, unbalance, and frequency can be displayed in real time in EcoStruxure Power Monitoring Expert or Power Operation.

Predefined diagrams exist for the following power quality standards:

- **Analytic Views for IEEE 519**

  Voltage individual harmonics, voltage Total Harmonic Distortion (THD), current individual harmonics, and current Total Demand Distortion (TDD)

Events and Alarms

Power quality events captured and uploaded from connected products can be displayed as individual alarms in the Edge Control software and intelligently grouped as incidents during a given time period.

Related data such as waveforms can be accessed from the alarm interface for insight into the event details and root cause.

Trends

Steady state disturbances such as harmonics, unbalance, and frequency can be displayed as trends to monitor their evolution over time.

The following trends can be created:

- **For IEEE 519**

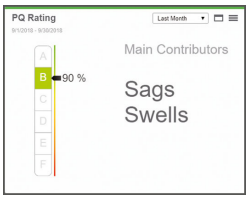
  Trends of voltage THD and current TDD (both mean and maximum values)

Dashboards[8]

Historical power quality events are displayed in dashboards with the following gadgets:

Power Quality Rating

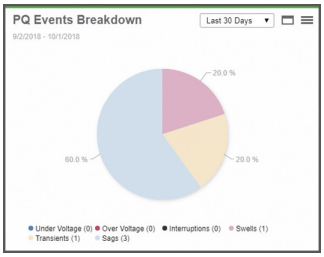
Shows a power quality rating in the form of a letter grade (A to F). The rating is a summary of multiple types of power quality disturbances. The information is shown as a graphic display of the letter grade, with a % power quality rating and a list of the main contributing disturbances.



Power Quality Rating

Power Quality Incident Breakdown

Shows a breakdown of the power quality events, by type, over a selected time period. The information is shown in a pie chart, as a percentage distribution of the events.



Power Quality Incident Breakdown

Power Quality Incident Impact

Shows the number of power quality events, over a period of time, that might have had a process impact, compared to those that most likely did not have an impact. It is a simplified representation of the CBEMA/ITIC curve in a pie chart format.

8. The Power Quality Performance module of EcoStruxure Power Monitoring Expert must be deployed to benefit from these features.

Events that are inside the curve are shown as "no impact events" and those outside the curve are shown as "likely impact events."

Power Quality Incident Impact

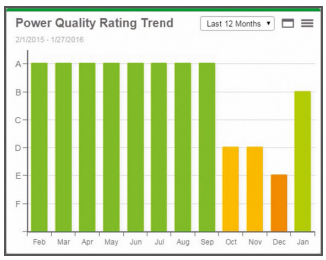
Power Quality Incident Location

Shows the number of power quality events, over a selected time period, grouped by location of origin (external, internal, undetermined). In addition, it indicates whether the events had a likely process impact or not. The information is shown in a column chart, grouped by impact assessment.

Power Quality Incident Location

Power Quality Rating Trend

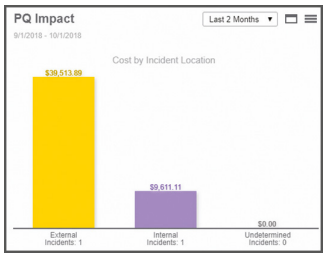
Shows the power quality rating, over a selected time period.



Power Quality Rating Trend

Power Quality Impact

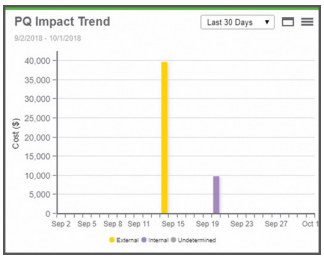
Shows the cost of power quality events with a process impact, over a selected time period. The information is shown in a column chart, grouped by location of power quality event origin (external, internal, undetermined).



Power Quality Impact

Power Quality Impact Trend

Shows the aggregated cost of power quality events with a process impact, over a selected time period.



Power Quality Impact Trend

Reports[9]

The following reports can be generated on demand or automatically, and sent via email to configured recipients.

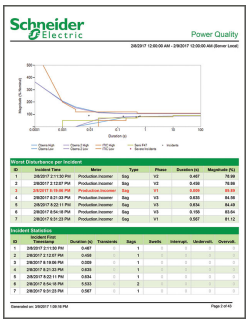
Power Quality Report

Summarizes the number and severity of voltage sags, swells, and transients over a period of time. The generated report includes a graphical representation of these power quality events plotted against one or more power quality curves, such as CBEMA (1996), CBEMA (Updated), ITIC, or SEMI F47 curves.

The Power Quality Report aggregates historical power quality data into power quality incidents:

- An incident is a summary, or aggregated event, which represents a number of individual power quality events (sags, swells, or transients) that occurred across an electrical network in a short period of time.
- A power quality event refers to a sag, swell, or transient event in the Event Log.

This report also displays waveform plots as well as RMS plots associated with a single incident, or all waveforms associated with their respective incidents.

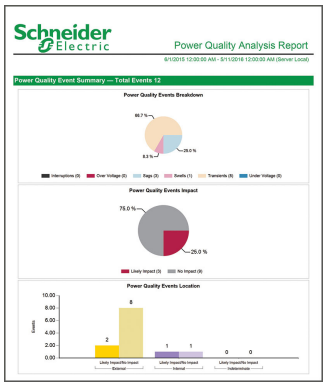


Power Quality Report

Power Quality Analysis Report

Summarizes power quality events and disturbances occurring in a production environment. Events include voltage transients, sags, swells, interruptions, and overvoltage and undervoltage events. Disturbances are related to harmonics, unbalances, flicker, and frequency variation. An understanding of these events and disturbances can help determine actions to reduce production downtime and to increase equipment lifetime and reliability.

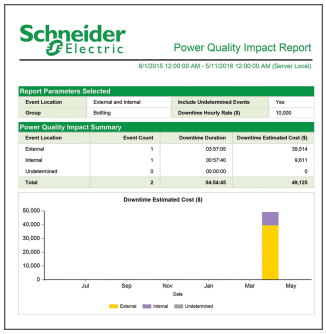
9. The Power Quality Performance module of EcoStruxure Power Monitoring Expert must be deployed to benefit from these features.



Power Quality Analysis Report

Power Quality Impact Report

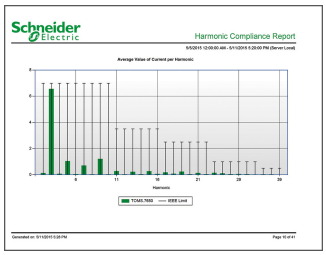
Indicates the impact from downtime that occurred for a power quality group and provides an estimated cost associated with a given period of time calculated using the rate defined in the Power Quality Group configuration file. It also provides information on power quality events that might be the cause of the downtime and indicates whether they occurred internally, externally, or from an undetermined location.



Power Quality Impact Report

Harmonics Compliance Report

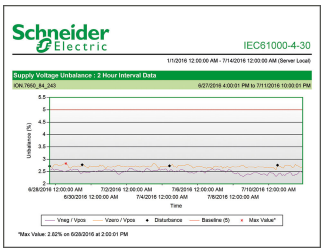
Shows an analysis of the harmonic compliance of selected sources based on the IEEE 519 reference limits.



Harmonics Compliance Report

IEC 61000-4-30 Report

Provides IEC 61000-4-30 compliance information by observation period (3 second, 10 minute, or 2 hour measurement interval) for one or more sources (voltage profile, THD profile, unbalance profile, flicker profile, frequency profile, and summary table).

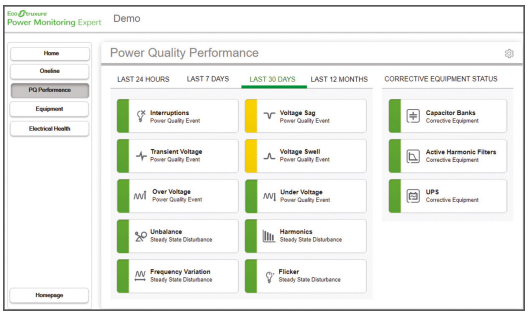


IEC 61000-4-30 Report

Analysis Tools

Power Quality Performance Diagrams[10]

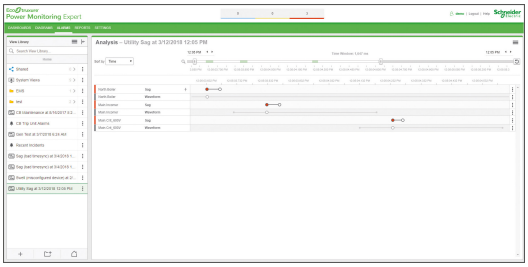
Green, yellow, and red status indicators are used for each event or disturbance type to represent the severity during various timeframes (24 hours, one week, last 30 days, etc.), based on power quality standards and recommended thresholds described in the Data Processing section.



Power Quality Performance Diagrams

Power Events Incident Timeline

This feature of EcoStruxure Power Monitoring Expert intelligently groups related events and alarms as single comprehensive incidents during a given time period. It helps highlight the root cause and the consequences of an incident.



Power Events Incident Timeline

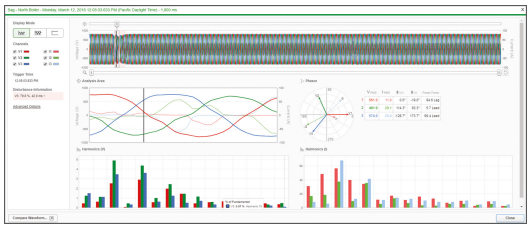
Waveform Viewer

Electrical signal waveforms can be displayed with a native waveform viewer in both EcoStruxure Power Monitoring Expert and Power Operation

These viewers allow for the following:

- Toggle on/off voltage/current channels
- RMS calculation, zoom, pan, export to CSV
- Interactive phasor and harmonic (voltage and current) diagrams
- Multiple waveform comparison

10. The Power Quality Performance module of EcoStruxure Power Monitoring Expert must be deployed to benefit from these features.



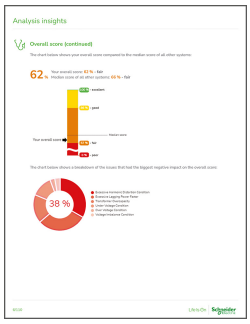
Waveform Viewer

Cloud-Based Analytics and Services

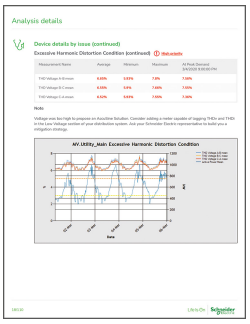
As an option, EcoStruxure Service Plan powered by EcoStruxure Power Advisor provides power quality analytics with recommendations from our Schneider Electric service experts.

System health checks can be run periodically and shared by a Schneider Electric service expert to help provide additional insights into persistent power quality issues, their potential impact or risk posed to the facility, and improvement recommendations or mitigation solutions.

EcoStruxure Service Plan Powered by EcoStruxure Power Advisor Platform



EcoStruxure Power Advisor Electrical Health Report - Overall Score



EcoStruxure Power Advisor Electrical Health Report - Device Details by Issue

Schneider Electric
35 rue Joseph Monier
92500 Rueil Malmaison
France

+ 33 (0) 1 41 29 70 00

www.se.com

0100DB2315