



USE CASE

Power quality for data centers

Reliability and availability are key for successful data center operations
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Power quality declines

Electricity systems worldwide are experiencing a transition to decarbonize power generation through the large-scale deployment of centralized and distributed energy resources and renewable energies, gradually replacing conventional power plants.

In the future, power quality is expected to be significantly affected by the increase in renewable power generation. Other trends threaten to further deteriorate power quality:

The increased integration of power electronics, the use of inverters or switching processes of the energy supplier or semiconductors, the increasingly fluctuating power generation and finally the overall reduced stability of electrical systems.

For sensitive IT infrastructure such as server racks in data centers, reliable power quality (PQ) is critical. As technical progresses, they become even more sensitive to voltage events that can cause expensive downtime.

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It's all about **avoidance of downtime**

While 100% availability may be the goal, they can not be guaranteed by a data center operator. Yet, the so-called five-nines* availability service level agreement comes very close, guaranteeing no more than 5 minutes and 15 seconds per year of service downtime. Other prominent classifications are the HRG (Harvard Research Group) classes AEC-0 to AEC-5.

To achieve this goal, many operators concentrate their attention on power and cooling redundancy, on cybersecurity and physical security, to prevent unauthorized access and ensure safety. Although power quality can directly impact uptime and reliability, this topic is often underestimated.

A perfect solution therefore combines the overview of redundant grids and power flows in an EMS (energy management system)/PMS (power monitoring system), access controls and safety via a BMS (building management system), and PQ analysis in a single solution to have everything covered.

Power quality basics

Power quality refers to the level of consistency, reliability, and stability of electrical power. It is a general term to represent the phenomena affecting the user's equipment when the AC power exceeds or falls short of certain limits. Poor power quality can cause electrical or electronic equipment to malfunction, shut down unexpectedly, interfere with other sensitive electronic equipment, or fail prematurely. PQ issues can be responsible for both immediate or latent equipment damage and can affect the performance and lifespan of electrical and electronic equipment.

Optimal power quality means that AC current with a frequency of 50 Hz or 60 Hz is provided as an ideal sinus wave, without being affected by noise or distortion. The continuous operation of IT equipment can therefore be guaranteed 24/7. This corresponds to the ideal state, but in a data center different types of power quality problems can arise.

How the five nines translate into network downtime:

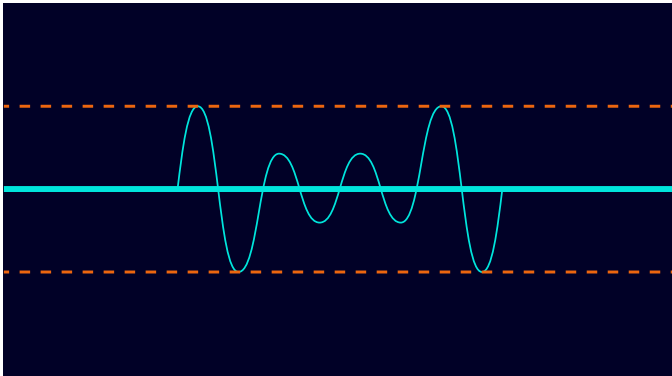
Availability	Max. downtime per year
99.999%	< 00:05:15
99.99%	< 00:52:36
99.9%	< 89:40:00

Availability Environment Classification (AEC) according to HRG:

HRG Class	Designation
AEC-0	Conventional
AEC-1	Highly Reliable
AEC-2	High Availability
AEC-3	Fault Resilient
AEC-4	Fault Tolerant
AEC-5	Disaster Tolerant

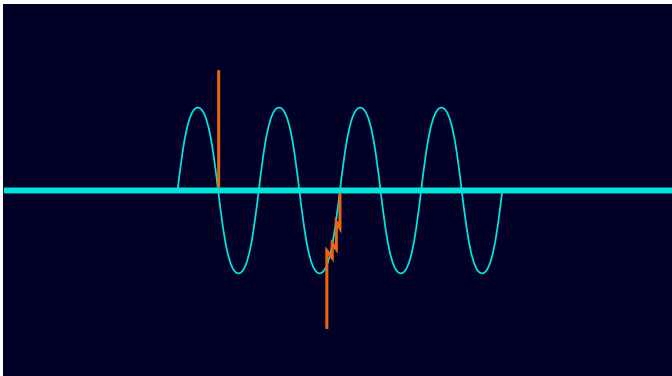
*Other prominent classifications are the HRG classes AEC-0 to AEC-5

The most common interferences:



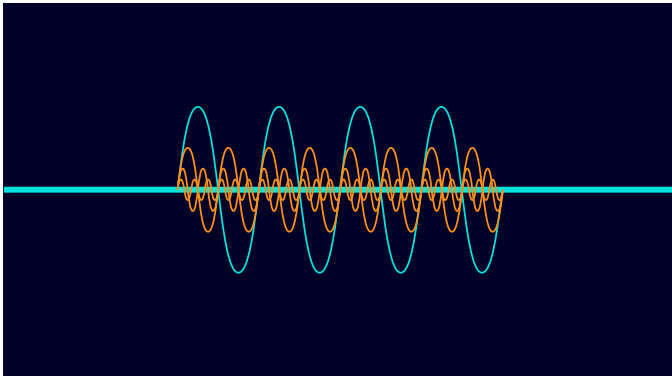
Voltage sag:

The supply voltage drops below 90% of the normal voltage level for a few milliseconds, which can lead to light flickering, storage losses and data errors.



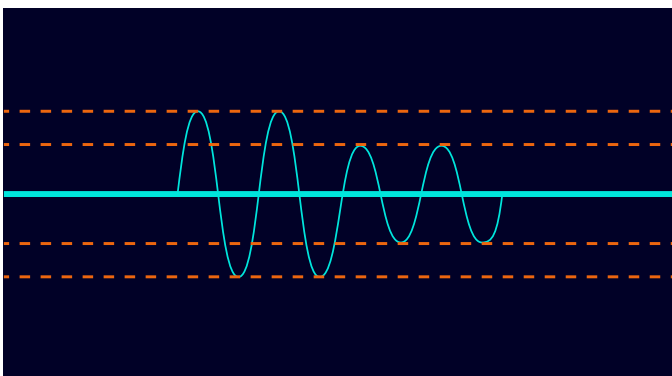
Transients:

Extremely brief overvoltages of up to several thousand volts, which can result in destroyed power supply units, and IT hardware damages.



Harmonics:

Multiples of the basic oscillation, which can lead to overheating of devices and malfunctioning of circuit breakers and fuses.



Voltage deviations:

Switching operations in the power grid, or starting heavy loads can lead to reduced efficiency and shutdown due to undervoltage tripping.

Power quality issues can render power infrastructures unstable and cause an unpredictable reboot of IT equipment or lead to an even more critical scenario, such as the tripping of a protection relay causing a disconnection from the distribution grid. It is therefore crucial to understand exactly which components are causing the problems.

Finding **weak spots**

Continuously recorded and evaluated measurements relevant to power quality help to detect interfering issues and offer the chance to prevent failures. Some of these issues do not seem obvious at first sight. Five possible weak spots in data centers should be regarded:

Medium-voltage infeed and Automatic Transfer Switches (ATS)

During normal operation, the PQ provided by the distribution network operator (DNO) must be known. Switching activities on DNO level produce voltage sags and transients which can influence the stability of the data center's internal power grid. Under less than ideal conditions, when the ATS switches to backup mode and the emergency generator supply power to the building, it can emit harmonic distortions into the MV distribution grid. A SICAM power quality measuring device installed in addition to an ATS provides information about PQ problems in both directions.

Low-voltage main power distribution units

In a data center, a substantial number of nonlinear loads come together. Each rectifier consumes power in a nonlinear manner. Harmonics can therefore flow back into the distribution grid. In critical situations, this can lead to unwanted tripping of one or more releases without a genuine over-current incident. Investigating the cause of such malfunctions is usually very time-consuming and expensive. However, with power quality instruments, harmonics are automatically measured and operators are alerted to any critical situation that could cause a protection relay to trip. With this information, they can initiate the necessary preventive maintenance measures to avoid future tripping.

Uninterruptible Power Supply (UPS)

To increase energy savings, the UPS will be processed in bypass eco-mode. Nevertheless, UPS needs to ensure that the signal for activation comes up before the ITIC curve limits

are reached. Such scenarios can be recorded and documented in a disturbance record by the power quality instrument SICAM Q200 using a very high sampling frequency of 1 MHz. It also needs to be considered that supra-harmonic pollutions won't be reduced by an UPS, resulting in the need for harmonics observation across a frequency range of 2 kHz up to 150 kHz which is part of the standard IEC 61000-4-30 Edition 3 and implemented in the power quality instruments.

Cooling system

Cooling causes a relevant part of a data center's energy consumption. During the last two decades, and driven by sustainability directives and energy efficiency measures, HVAC manufacturers have altered their cooling unit design in favor of variable frequency drives for the control of pumps, fans, and compressors. As a result, energy consumption has dropped over time at the cost of introducing more non-linear components that can lead to harmonic distortions. Cooling systems are also subject to restart in case of grid outage when the back-up generators are started up to provide power continuity to the whole facility.

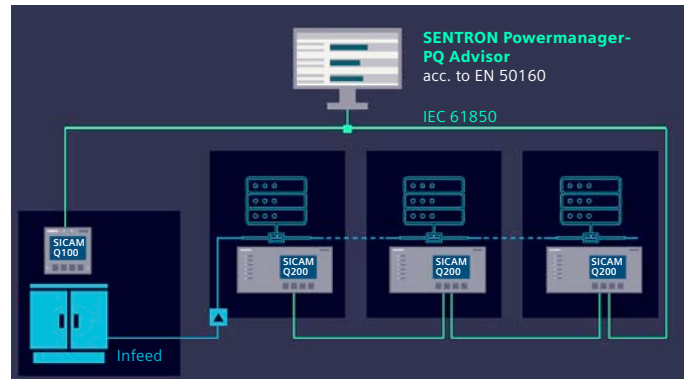
Power feed to the racks

The power supply of servers and IT equipment in general can be exposed to harmonics. These harmonic distortions affect the IT infrastructure and therefore have an impact on the crest factor. Although these power supplies have improved the power factor of the servers over time, their on-board rectifier generates additional high-frequency interference from 2 kHz to 150 kHz. These so-called supra-harmonics reduce the service life of all kinds of capacitors in electronic circuits and can also lead to LED flicker and interference. The SICAM Q200 measures these harmonics and displays them in a so-called heat map diagram. This information can be used to detect a faulty power supply unit at an early stage. And as part of predictive maintenance, it can be replaced before it causes major problems.

The technical solution

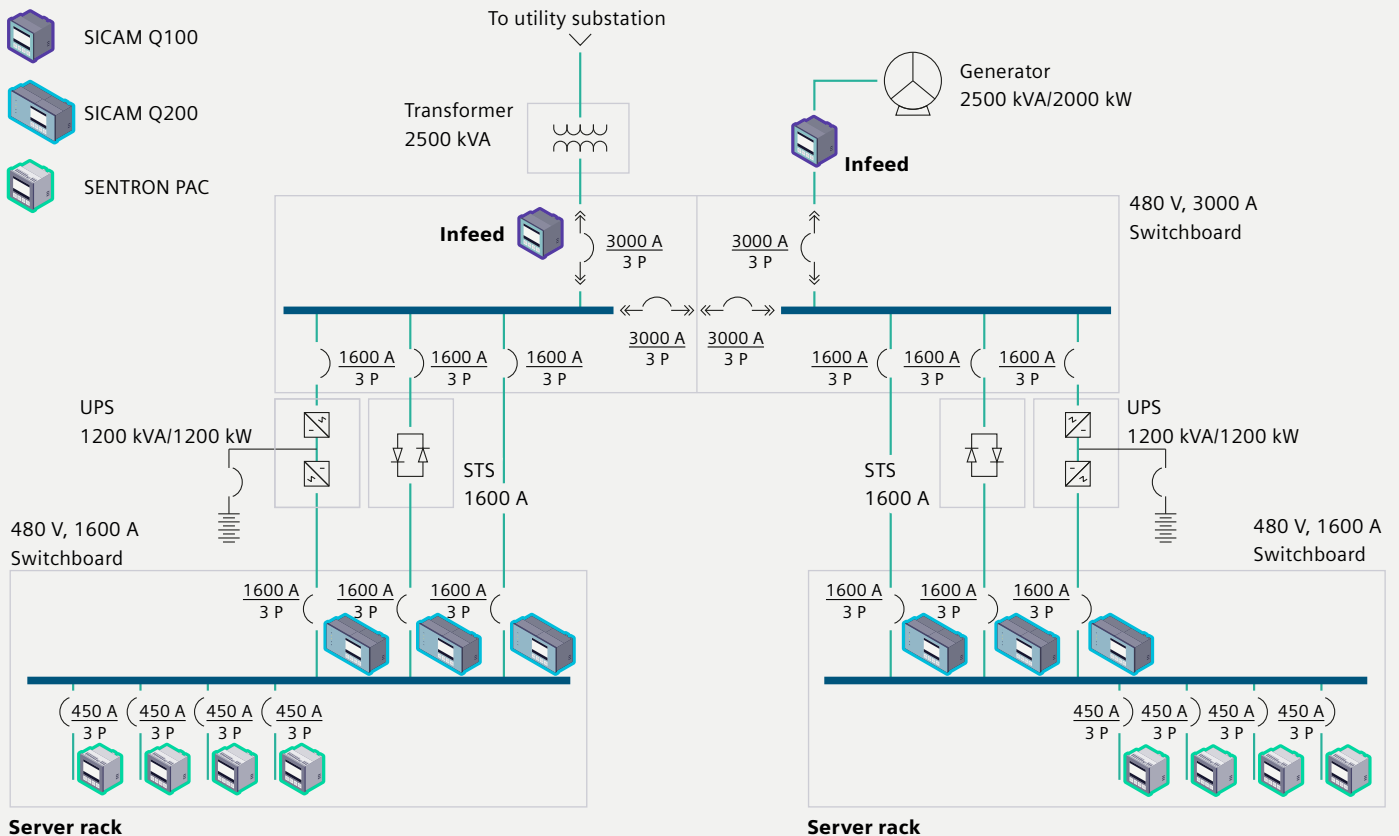
SENTRON Powermanager with the PQ Advisor function module can be used as a stand-alone PMS or as a combined BMS/PMS solution with Desigo CC. Paired with the SENTRON Powermanager module, SICAM Q100/Q200 power quality instruments, and SENTRON PAC measuring devices, it is the ideal setup for data center operations and other critical applications.

SICAM devices are connected via IEC 61850 protocol, energy counters and multifunctional measuring devices SENTRON PAC via Modbus TCP to SENTRON Powermanager. The software offers all relevant dashboards and views for analyzing the data including individual dashboard creation and predefined as well as customized reporting functions. The PQ Advisor function module within SENTRON Powermanager enables PQ analysis according to the relevant power quality standard EN 50160. Different views allow deeper insights such as the ITIC diagram or waveform records as a COMTRADE file.



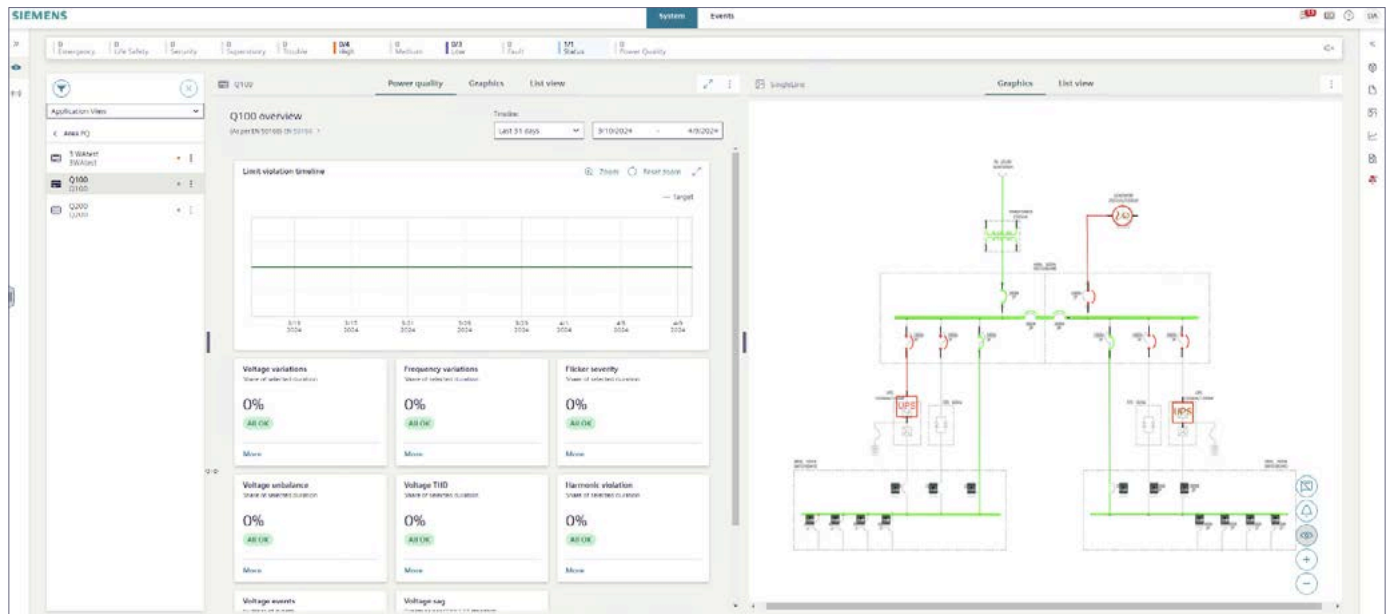
From measuring concept to operational software visualization

A principle representation including a measuring concept is a prerequisite. The following graphic shows a simplified principle illustration of a data center application with positioning of measuring equipment.



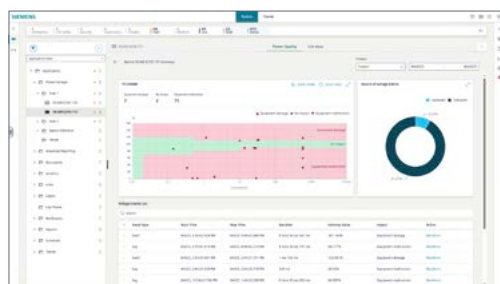
Simplified principle representation of a data center with positioning of measuring equipment

This visualization of the relevant power flows and measuring points can also be integrated in the operating software SENTRON Powermanager PQ Advisor. Therefore operators are able to locate and identify relevant instruments in the power distribution system of the data center. All detailed information like voltage events etc. recognized by a single device can be mapped in the graphical visualization of the chosen area.



Example of visualization of relevant indicators and SLD/measuring concept in SENTRON Powermanager PQ Advisor

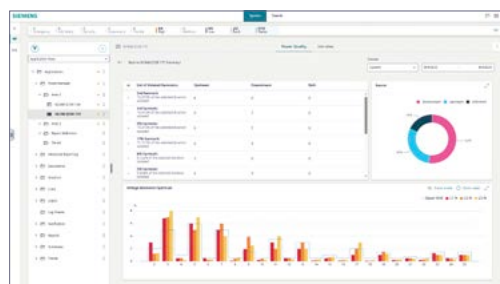
Examples for dashboards and reports* out of SENTRON Powermanager PQ Advisor:



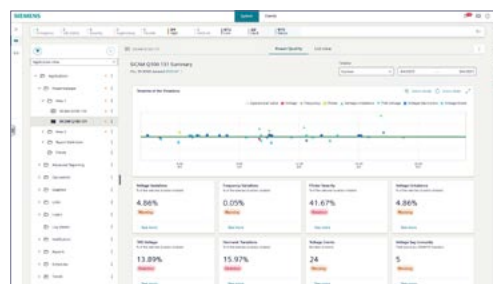
Identification of voltage events and their impact (ITIC diagram)



Voltage events: detailed waveform for in-depth evaluation



Analysis of the harmonic spectrum and sources to be able to intervene at an early stage



All power quality issues at a glance acc. to EN 50160

*according to EN 50160

Overview of **important steps**

In order to carry out power quality analysis the following points are important:

Power monitoring system with PQ analysis according to EN 50160

- SENTRON Powermanager with the PQ Advisor function module

Measuring devices:

Use the correct hardware

- At PQ relevant measuring points: SICAM Q100/Q200 power quality instruments
- General consumption measurement: SENTRON measuring devices

Knowledge of the relevant standard series is crucial in order to evaluate the quality of electrical energy in accordance with industry-specific requirements and to draw the right insights from the data obtained. We recommend Siemens PTI (Power Technologies International) Consulting as a service for detailed PQ analysis.

Parameters of a PQ analysis:

- Voltage sags, voltage swells, voltage deviations, harmonics, transients
- Point of measurement: Know where measurements need to be made, e.g. infeed, redundancy, distribution points, critical loads (server racks, sensitive machines etc.) or places with known issues.
- Continuous monitoring: PQ is often dynamic. It is therefore important to carry out measurements over a longer period of time in order to record fluctuations and recurring patterns.

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