



A CHALLENGE FACING YOUR IN-HOUSE POWER SUPPLY

Power quality during the transition to a **new energy mix**

Along with the proportion of renewables used in electricity generation, the number of inverters in the grid is constantly increasing – and as a result, higher frequencies are becoming much more common in the power network. These have a negative effect on quality of supply, or power quality (PQ).

Poor supply quality not only leads to enormous financial damage but at the same time considerably impacts the environment. Every year, in German low- and medium-voltage grids alone an additional 175,104 metric tons¹⁾ of CO₂ is emitted due to losses caused by harmonics.

How exactly can PQ fluctuations be identified in the course of operations? And what are the typical disrupting signals that occur in a normal operating day? This document provides an overview of possible measures to identify and deal with PQ problems.

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1) Jacobsen, Benjamin, „Transition of energy system by regulating of Power Quality for efficiency improvements“, ScienceDirect, 2022

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Introduction

The transition to a new energy mix is in full swing. The traditional notion of energy flows – from the producer to the consumer – no longer reflects the reality in the grid. Companies and residential households have developed into “prosumers” (a acronym word created from “producers” and “consumers”), whose requirements and generation volumes are still subject to huge fluctuations.

The constant increase in electricity generation from wind power and photovoltaic panels is having a marked influence on both grids and consumers, including across system boundaries. Fluctuations in the quality of supply have become the rule rather than the exception. According to the European Power Quality Survey Report, as many as 30–40 percent of all unplanned plant downtimes can be attributed to inadequate quality of supply. In just 15 selected key industries in Europe, the associated costs are more than €150 billion²⁾ each year, and rising.

Companies that rely on photovoltaics (PV) to cover their peak load requirements sometimes have little reason to be happy when the sun is shining. Undetected defects in PV inverters can result in unusually high feed-in, and thus to irregularities in machine and plant operation. But it isn't always only the inverters associated with renewables that are at fault. Often the problems have their cause much closer at hand – in other words, within the company itself. Non-linear consumers like motors with a non-linear current-voltage curve, or fluorescent lights, can lead to PQ problems like falsely tripping circuit breakers or thermal loading of capacitors and wires. This applies not just to manufacturing but also for administrative structures in which, for example, power supplies providing DC current to the IT infrastructure, like printers, notebooks and servers, can compromise quality of supply.

Whereas traditional energy utility companies had substantial, and highly specific, subject-area knowledge on grid quality, many of the new “prosumers” only meet the minimum requirements specified in the regulations and norms at best. The normal, day-to-day situation, however, is characterized by multiple interactions between generation and consumption, which makes education and increased attention vital. This also means different handling for particular signals, continuous monitoring and working out the actions needed to prevent system outages, downtimes and the resulting PQ-based costs.

2) J. Manson, R. Targosz, “European Power Quality Survey Report”, Leonardo Energy, 2008

Typical quality problems in the grid

Changes in voltage amplitude in the grid caused by load changes can lead to deviations in rated voltage (upward or downward) under normal operating conditions.

Figure 1 illustrates possible repercussions.

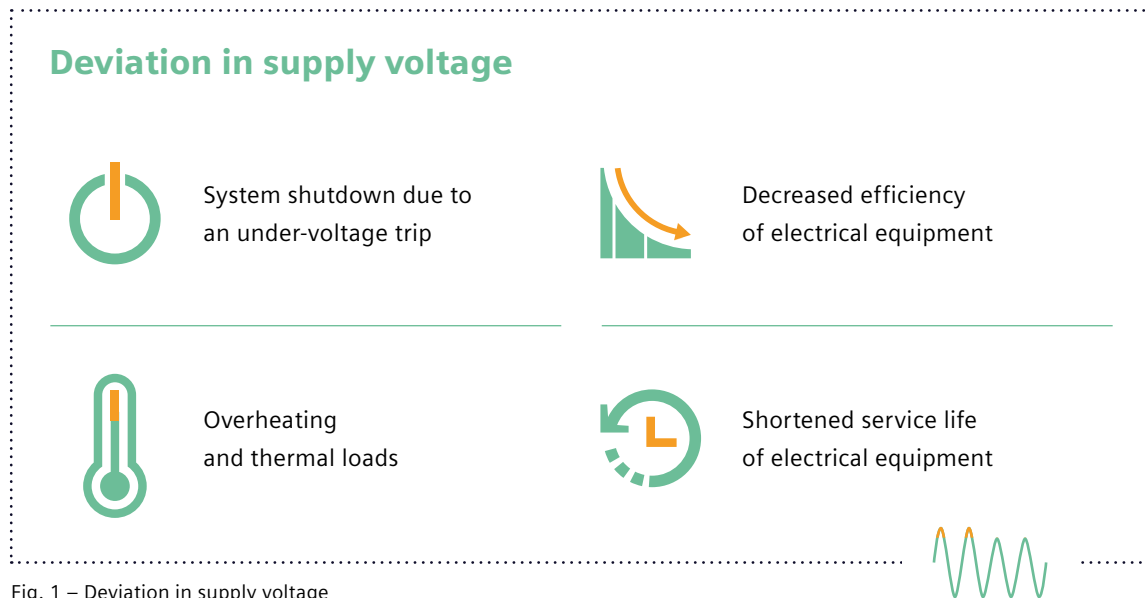


Fig. 1 – Deviation in supply voltage

Sources of electromagnetic disruption, e.g. inverters and non-linear consumers, can cause unwanted signals in the frequency band. Harmonics are the distortion of the ideal sinusoidal oscillation away from the basic frequency of 50 Hz caused by non-linear loads in the supply network (e.g. transformers, or DC power supplies for IT operations). Figure 2 shows some common effects.

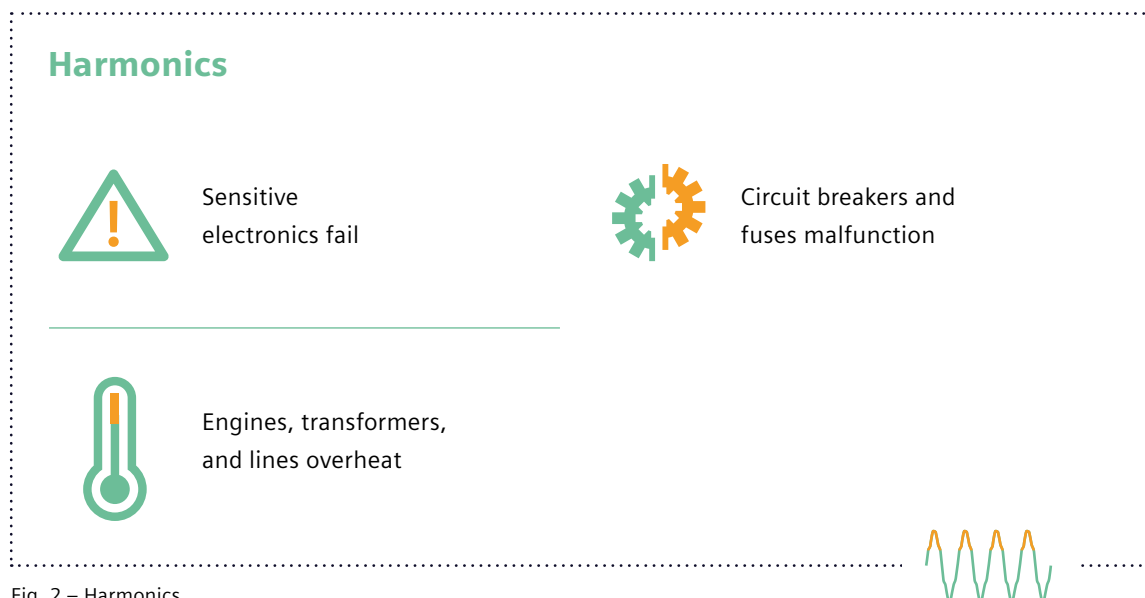


Fig. 2 – Harmonics

Temporary dips or swells can occur when major consumers, e.g. air-conditioners, are powered up or down. Other potential causes are short circuits triggered by faults, an inadequate power supply, or system outages and switching sequences at the energy utility company.

Figure 3 illustrates the consequences of these problems.

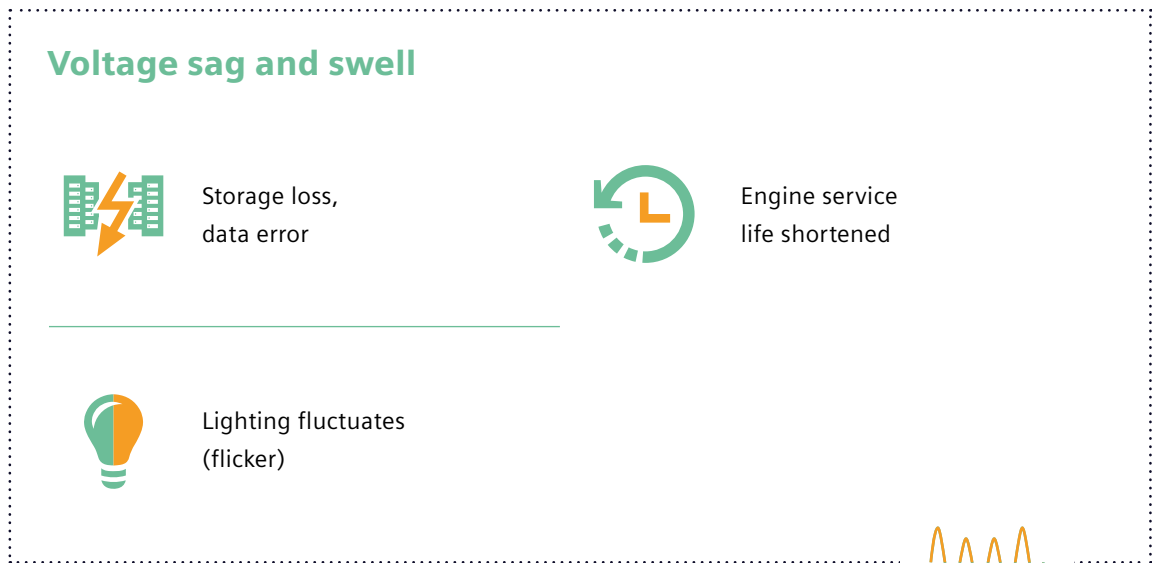


Fig. 3 – Consequences of short-term voltage sag or swells

Lightning strikes or static discharges can cause other, transient (short-term/temporary) disruptions. These take the form of voltage peaks or pulses, in which the voltage can suddenly change by several thousand volts. If the voltage change involves reversed polarity, this is known as a dip. This can take the form of the repercussions on machine or plant operation, or IT infrastructure, shown in figure 4.

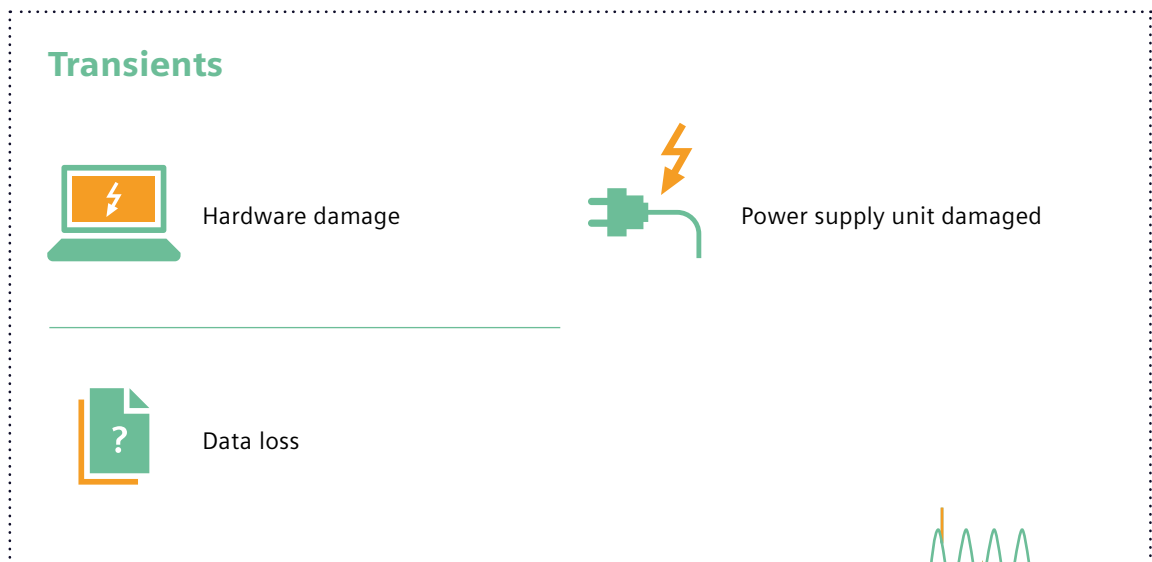


Fig. 4 – Consequences of transient disruptions

How companies can deal with PQ problems

1. Increased attention

Companies first need to consider power quality as a subject that affects all areas. It is essential to realize that the use of devices, machines and plant can affect the production and operational processes in other departments far beyond their own place of installation. It is often not enough to satisfy requirements in terms of cable cross-section, fuses and standards. Replacing mains-operated motors with speed-controlled units can result in poor grid quality if details of grid compatibility are ignored. Intensive discussions between designers, plant operators and power managers on questions of in-house supply quality have to become part of the daily routine. Various planning aids and standards can help in this regard.

2. Measuring and monitoring

PQ problems have to be identified before they can be prevented. This requires a combination of communication-capable measuring devices and power quality recorders with power monitoring software. This makes it easier to compare different measuring points and narrow down the causes of disruption. It is important to ensure that the measurement process in the devices is not influenced by the grid itself.

3. Ensure consistency

Conclusions about the source of disruption in the system can be drawn once the measurements have been recorded in the measuring instrument. The factor underlying malfunctions caused by voltage distortions can usually be found in one of these three areas³⁾:

- Energy utility company
- Plant operator
- Device manufacturer

Surrounding households or small companies can also affect power quality. Often, however, it may be assumed that the cause lies in devices that are not configured properly. If these are not converted, measures must be taken to fit active or passive filters to compensate for the harmonics.

3) Wissenswertes über Netzzrückwirkungen [What you need to know about grid disturbances] – VDE document series Hartmut Dornger, Prof. Manfred Fender VDE-Schriftenreihe Normen verständlich – [VDE document series on understanding standards] – VDE Verlag Berlin Offenbach 2013

Scenario A

Weather-dependent fluctuations in grid quality

The operator reports irregularities in operation after a system is delivered and commissioned. Set values are being lost, mainly on very sunny days.

Monitoring the connection between the system and the grid and recording the values with a PQ measuring instrument identified disruptions in the supply network as the cause. Precise analysis shows that a faulty PV inverter was feeding excessive power into the grid on sunny days, which caused the disruptions.

PQ measuring instruments and power monitoring software help identify and attribute the causes of a grid malfunction and the associated system errors quickly and clearly. Integrated web servers can even provide global monitoring of the grid quality required by a given system.

Mechanical engineers and system manufacturers operating internationally will benefit particularly from using this option to ensure smooth operation.

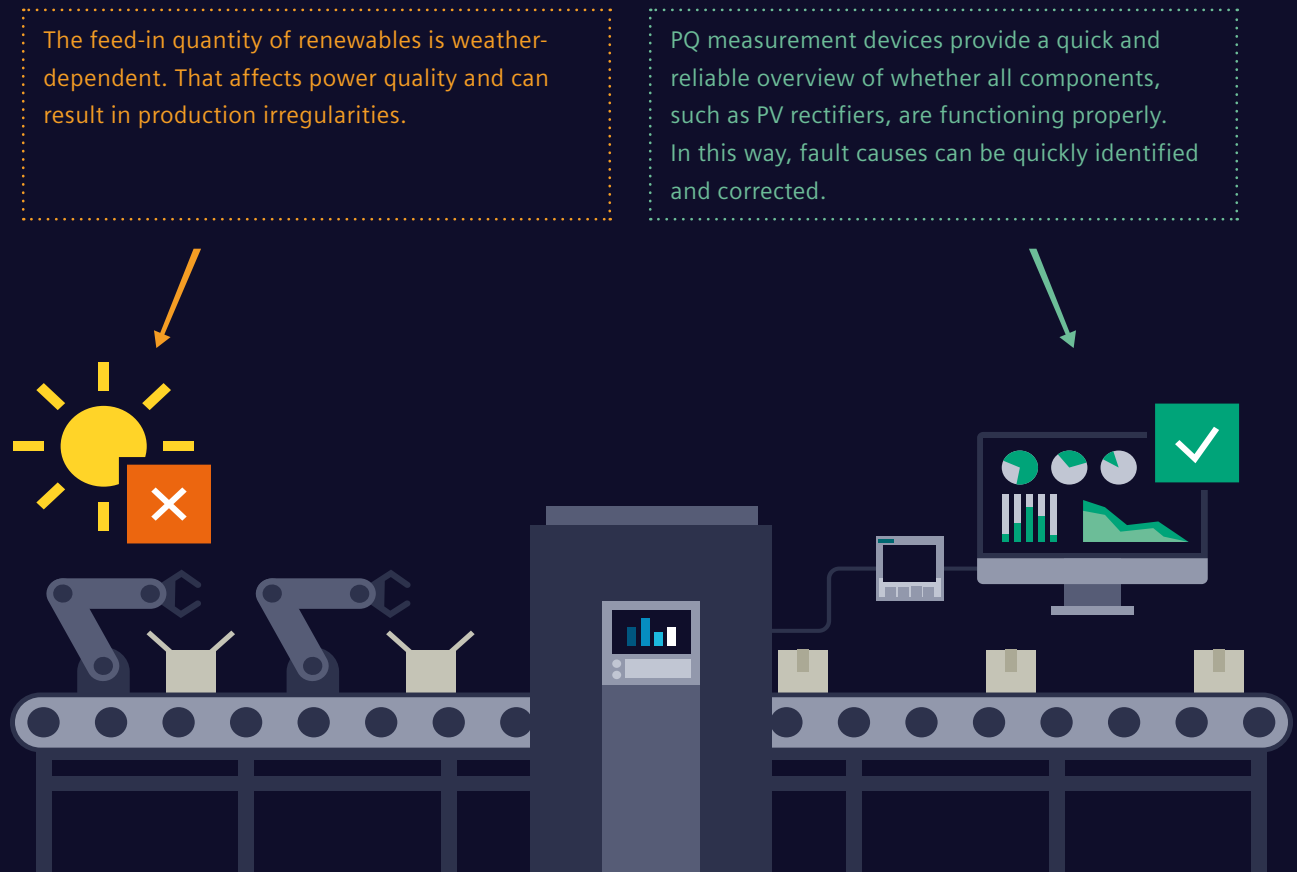


Fig. 5 – PQ measuring instruments provide reliable information about the current state of your power supply

Scenario B

Hidden faults when upgrading systems

Routine evaluations of EN 50160 reports highlighted an increase in excessive harmonics that coincided with a recent upgrade to the building ventilation system. Investigations revealed that either no network filters, or the incorrect filters, had been used for the frequency converters that were fitted. Fitting correctly configured filters substantially reduced the risk of consequential disruption to servers and other plant.

Continuous power monitoring and paying attention to PQ-relevant measurements will reveal design errors. As a result, corrective measures can be put in place in good time, plant downtimes can be avoided and consequential costs prevented.

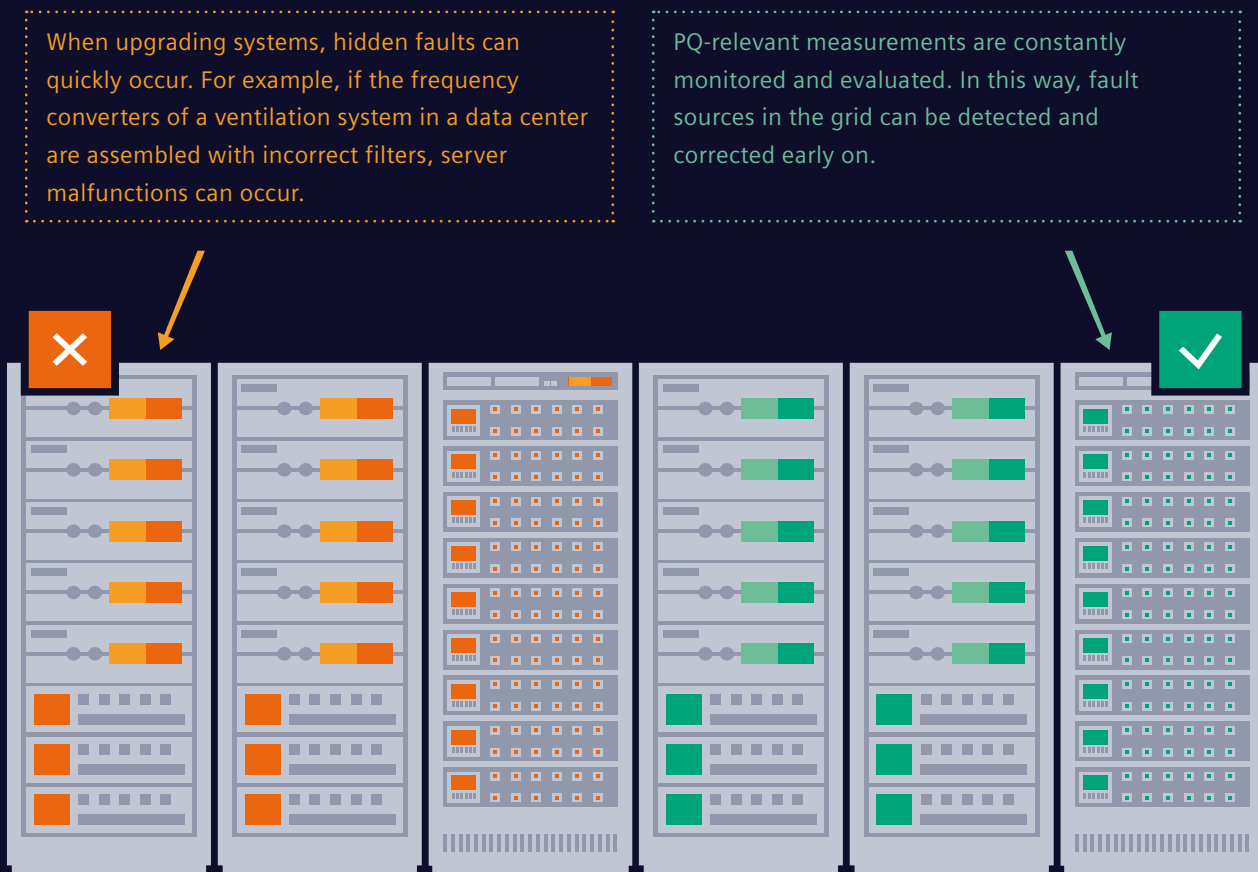


Fig. 6 – PQ measuring instruments keep you on the safe side during plant upgrades

Conclusion

The power monitoring equation

Power quality = voltage quality + availability + service quality

In an ideal situation, you can plan in advance to include, overdesign and approve all grid quality requirements, to avoid disruptions to operations. But very few designs can be based on an ideal situation as the starting point. The transition to a new energy mix is already in full swing, with all the upgrades, enhancements and savings that that involves. Machines and systems have to work equally well throughout the world, even if the quality of supply still falls short of the ideal.

Using measuring instruments for continuous power monitoring provides the necessary technical basis to assess quality of supply. As both a raw material and an added-value product, electric power must be subject to constant quality control.

**Published by
Siemens AG**

Smart Infrastructure
Low Voltage Products
Siemensstrasse 10
93055 Regensburg
Germany

For the U.S. published by
Siemens Industry Inc.

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Article No. SIEP-B10238-00-7600
Dispo 25600 TH S22-220143 WS 0622
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