TECHNICAL NOTE

Quality of electrical power

When **energy** matters

socomec
Innovative Power Solutions

Contents

Introduction

This technical note builds on the different aspects of the quality of electrical energy and the technology used to analyse it. It explains why we need to monitor it through standard references, the events impacting it and the risks involved. The final section describes Socomec's solutions to this problem.

To help you in your reading, we use an analogy from the world of sport; the football match. There will be notes throughout the document reminding you of this analogy. Just as they are in the analysis of power quality, in a football match the rules of the game are to be respected and fouls can be committed by the players. The recorded images provide video assistance to the referee to identify the cause. In our power quality analysis, standards are the rules of the game, disturbances are the fouls and the network analyser is the referee's video backup.

Why do we need to monitor the quality of electrical energy?

The quality of the electrical energy is essential, for both the **electricity supplier** and the **user**.

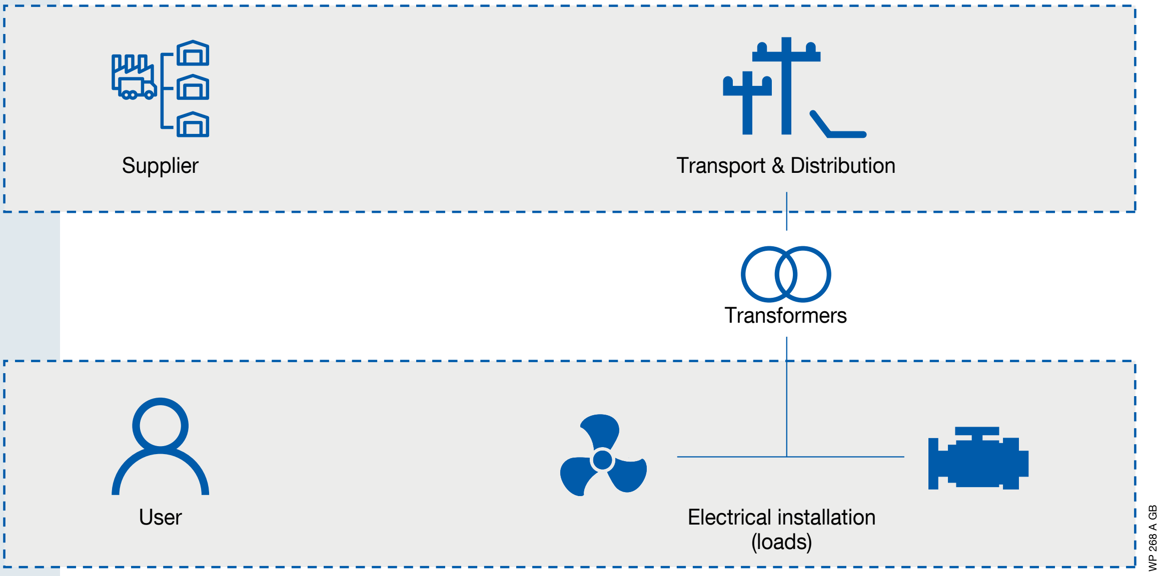

Fig. 1 – Electricity transport and use.

Energy suppliers are responsible for the quality of the electricity they provide. They must monitor and analyse any disturbances generated on the network. In the case of contractual commitments with their customers, they will have to prove that the quality of the energy supplied meets the terms of the contracts.

The wide-spread use of autonomous photovoltaic sources feeding into the grid has increased the risk of deterioration in power quality and therefore requires greater monitoring on the supplier's part.

The users, for their part, must monitor the energy quality of their business's electrical installation to ensure their electrical systems and equipment are working at their best.

Poor-quality energy has significant effects on equipment, including malfunctions, deteriorations or breakdowns, with adverse consequences on processes, especially in sensitive environments (industrial sites, hospitals, data centres, etc.). The costs of these malfunctions can be very high, for example, stopping production on an industrial site.

Identifying quality events is therefore crucial if we want to anticipate potential problems and **prevent malfunctions so we can correct them faster**.

To improve efficiency, it is also important to identify the origin of a disturbance:

- Is this disturbance coming from the distribution network or is it coming from the customer's electrical installation?
- Is the disturbance created by an incident on the network or was it generated by equipment in the installation?

The following sections build on these topics to help the user find a preventive approach to make better use of, maintain and continuously improve the quality of their electrical installation in complete peace of mind.

The concept of a football match is similar to analysing the quality of energy. In the electrical installation, the network analyser plays the role of the video assistant. The rules of the game to be respected are the standards and the fouls made by the players are the disturbances.

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Cost of poor-quality energy: according to a 2016 report from the Ponemon Institute, a single outage will cost a data centre more than €700,000. In May 2017, according to Network World, the power supply to British Airways' air traffic control system was down for 15 minutes, costing around €100 million.

How is it standardised?

Standards are the rules of the game.

General approach

A number of standards deal with the quality of electrical energy. They each have a different purpose and focus on describing the requirements of a specific context: electricity distribution, electrical installation, measuring instruments methods.
As described in the introduction, the approach to energy quality is different for both the electricity supplier and the user.

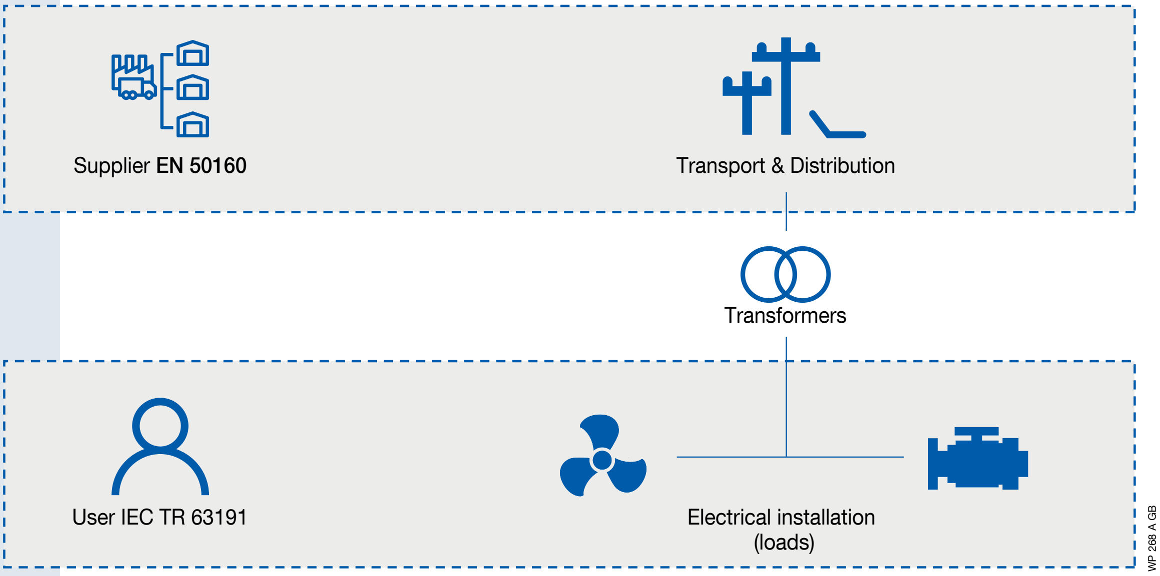

Fig. 2 – Electricity quality standards and fields of application.

The standard EN 50160 and the technical report IEC TR 63191 address electricity quality. While EN 50160 focuses on the voltage quality provided by the distribution network, IEC TR 63191 looks at the quality of power within the electrical installation; that is, the voltage but also the current running through the installation.

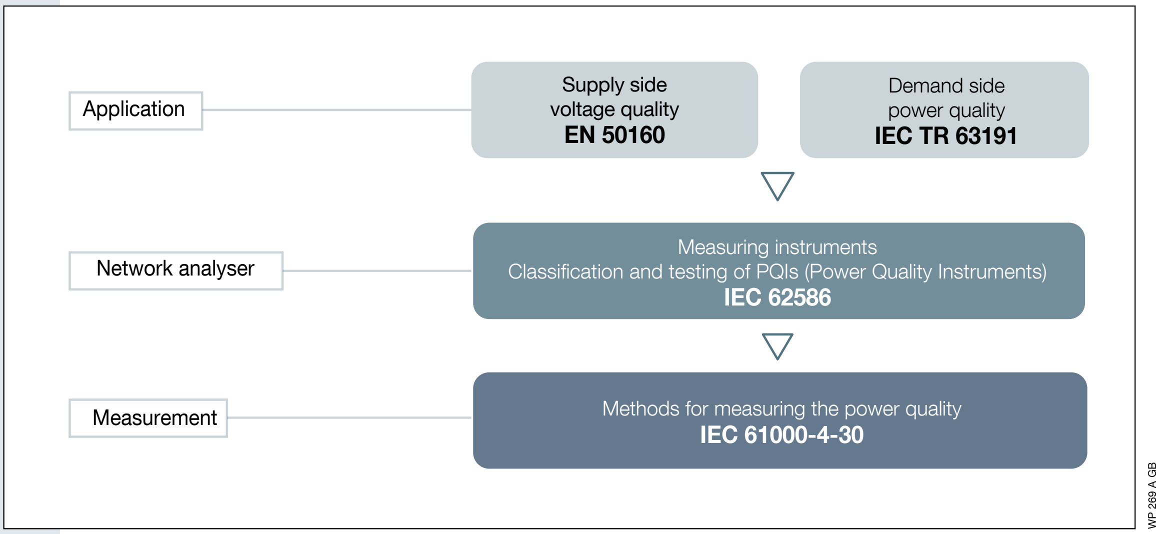

Fig. 3 – Hierarchy of application fields and measurement products.

Note that EN 50160 focuses on the quality of voltage at the point of delivery. It does not cover the current.

The analysis of the quality of electricity requires measuring of the relevant electrical parameters (voltage, current, harmonics, unbalance, voltage dip, voltage swell, etc.) using network analysers also called qualimeters or, according to the normative designation, Power Quality Instruments (PQIs).

What network analysers (PQIs) do:

- Characterise the voltage provided by distribution networks according to EN 50160 requirements.
- Qualify the quality of the voltage and current in an electrical installation as described in IEC TR 63191.

Standards associated with network analysers:

- Product standard IEC 62586.
- Standard methods of measuring electrical parameters (voltage, current and related events) described in IEC 61000-4-30, to provide measurement values These measuring methods are used by PQIs.

Standards covering electricity quality

This section details all the standards on electricity quality, including the above and others that deal with more specific points.

EN 50160 – Voltage characteristics of electricity supplied by public electricity networks

The European standard EN 50160 defines, describes and specifies the main voltage characteristics provided by a public network under normal operating conditions at the network user's point of delivery. This standard gives the values and limits of the voltage characteristics that can be expected at each delivery point of the public network under high, medium and low voltage.
Limits that should not be exceeded apply to the following parameters:
- variations in frequency,
- variations in supply voltage,
- voltage unbalance,
- voltage harmonics,
- voltage dips/swells

The measurement of electrical parameters must comply to the measurement methods developed in IEC 61000-4-30 described in the following paragraphs.

The data collected must be analysed and meet the limit criteria (for example, 95% of 10 min mean r.m.s. values of the supply voltage must be in the range Un ±10%).

	Limits	Integration time	Monitoring time	Threshold
Voltage variation	≤ Un ±10%	10 min.	1 week	95%
Flicker	Plt ≤ 1	2 hrs	1 week	95%
Voltage harmonics	H25 THD ≤ 8%	10 min.	1 week	95%
Voltage Unbalance	Ui/Ud ≤ 2%	10 min.	1 week	95%
Mains signalling voltages	< 10%Un	3 sec	1 day	99%
Frequency	49.5 to 50.5 Hz 49.5 to 52 Hz	10 sec 10 sec	1 year ...	99.5% 100%

Table 1: Limits defined in ***EN 50160*** *on low voltage.*

IEC/TS 62749 – Characteristics of electricity supplied by public networks

The standard IEC/TS 62749 is based on the same principle as EN 50160 but addresses the subject in the form of recommendations for the limit values of electrical parameters while focusing on international values (Europe, China, Canada, Australia).

The maximum limits follow EN 50160 and the measurement of electrical parameters must be compliant to the measurement methods developed in IEC 61000-4-30.

IEC TR 63191 – Demand side power quality management

IEC TR 63191, published in November 2018, is not a standard as such but rather a technical report. It is a tool providing the methodology behind implementing an approach to measure the power quality of an electrical installation in any kind of company (industry, hospitals, services, data centres).

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Contrary to EN 50160, IEC TR 63191 does not cover the quality of the supplied energy.

IEC TR 63191 looks at the quality of the power in the electrical installation, taking into account the quality of the voltage but also the current. Voltage disturbances can affect the current flowing through the installation and vice versa.

It details equipment impacted by non-quality events, those that cause disturbance and those that mitigate disturbances (see Tables 7 and 8).

IEC TR 63191 also sets out a methodology for implementing a measurement plan based around "monitoring the quality of the installation" by specifying which product to use (network analyser or power meter), depending on the type of monitoring.

IEC 62586 – Power quality measurement in power supply systems (PQIs)

Network analysers are designed to measure the quality of the power supply.
IEC 62586 provides common requirements for these instruments for helping in selection, comparison and evaluation. The measurement methods used by each instrument are identical so you can clearly compare measurements from instruments of different brands.

IEC 62586 is broken down into two complementary standards:
- IEC 62586-1: product standard defining the characteristics of network analysers also known as Power Quality Instruments (PQIs)
- IEC 62586-2: standard specifying the tests to be performed and the measurement uncertainties to be met for PQIs. To meet the requirements of IEC 62586-2, the measurement methods used by PQIs must be compliant to IEC 61000-4-30 as described below.

IEC 62586 defines 2 types of PQI that depend on the measurement method used.

Type	Measuring methods in accordance with IEC 61000-4-30	Application
PQI-A	Class A	Contractual verification of the conformity to standards or the resolution of disputes linked to the quality of the power supply (by following e.g. EN 50160)
PQI-S	Class S	Assessing the quality of an electrical installation

Table 2: Types of PQI.

PQIs can be:
- fixed (F) or portable (P),
- installed indoors or outdoors,
- used in various temperature ranges and in a normal or harsh EMC environment.

Based on these criteria, IEC 62586-1 defines a coding system to classify PQIs. Below is an example.

	PQI	Instrument for measuring power quality
PQI-A-FI1	A	Compliant to the class A measurement method of IEC 61000-4-30
	F	Fixed instrument
	I	Used indoors
	1	Temperature ranges from -25°C to +55°C in a normal EMC environment

Table 3: Example of coding a PQI.

IEC 61000-4-30 – Power quality measurement methods

As explained in the previous paragraph, PQIs use methods described in IEC 61000-4-30 to measure the power supply quality parameters of electrical networks.

IEC 61000-4-30 address two different classes.

Measurement methods include the detection and evaluation of quality events (voltage dips, swells, interruption, transient, rapid voltage change).

Class A	• The measurement method used when accurate time and time-stamp measurements are required to identify the event. For example, for contractual applications between an energy supplier and its customer that may require verification of compliance with standards or the resolution of a dispute. • Measurements of a parameter with two different instruments using a class A measurement method will produce consistent results.
Class S	• The measurement method used for applications such as survey projects or assessing the quality of the electrical installation without being involved in a contract. • S-class measurement requirements remain high but are more flexible than class A.

Table 4: Classes and measurement methods.

Some facts about measurement methods

The time interval for measuring parameters (network voltage, harmonics, interharmonics and unbalance must be 10 periods for a 50 Hz network or 12 periods for a 60 Hz network.
The values over 10/12 periods are then aggregated over three additional intervals:

- 150/180 period interval (150 periods for a nominal frequency of 50 Hz or 180 periods for a nominal frequency of 60 Hz),
- 10-minute interval,
- 2-hour interval.

Based on these time intervals, measurement aggregation methods (discontinuity, time synchronization, uncertainties, etc.) are described very precisely for each voltage and current parameter for classes A and S.
Although classes A and S use the same measurement intervals, the measurement processing requirements for class S are more flexible than for class A.

	Class A	Class S
Syncing measurement intervals	10-minute resynchronisation of 10-minute UTCs (coordinated universal time) pulse intervals	No mandatory synchronisation of measurement intervals
Uncertainty of clock time	< ± 20 ms at 50 Hz independently of the total time interval or < at ± 1 s per 24-h period if there is no external synchronisation	Time-clock uncertainty < ± 5 s per 24-h period
voltage measurement uncertainty	< ± 0.1%	< ± 0.5%

Table 5: Differences between classes A and S.

Voltage measurement

Voltage-related measurements are as follows:

- Frequency
- Voltage amplitude
- Flicker
- Voltage unbalance
- Voltage harmonics
- Voltage interharmonics
- Mains signalling voltage
- Rapid voltage change
- Voltage dip
- Voltage swell
- Voltage interruption
- Transient voltage

The current measurement methods are similar to those for voltage but current measurements are optional as part of class A or S.

Current measurements

Related measurements include:
- current amplitude
- current harmonics
- current interharmonics
- current unbalance

Standards IEEE 519 / 1159 / 1459

IEEE standards on power quality are used mainly in the United States.

IEEE 519 – Recommended Practice and Requirements for Harmonic Control in Electric Power Systems

IEEE 519 provides recommendations for voltage and current harmonic levels to be observed in the design of electrical installations that include both linear and non-linear loads.

IEEE 1159 – IEEE Recommended Practice for Monitoring Electric Power Quality

IEEE 1159 describes the different events (transients, voltage dips, voltage swells, harmonics, etc.) and their typical characteristics encountered in an electrical installation. The standard covers good practices when introducing measurement instruments for monitoring electrical quality in terms of the choice of instrument, measurement parameters, safety and connection. The document also deals with the interpretation of measurements.

IEEE 1459 – Definitions for the Measurement of Electric Power Quantities Under Sinusoidal, Nonsinusoidal, Balanced, or Unbalanced Conditions

IEEE 1459 provides the definitions used to measure electrical power quantities under sinusoidal, non-sinusoidal, balanced or unbalanced conditions.
The purpose of this standard is to propose useful concepts and definitions to assess the quality of electrical energy transmission, for billing purposes, to develop measurement algorithms and to design measurement instruments.

Disturbances are the fouls that players sometimes make.

What events affect the quality of electrical energy?

The standards described above deal with electrical measurements to qualify power quality. These measurements help analyse events that disturb power quality. This section focuses on accurately describing each of these events.

Events described

Deviation from the power frequency

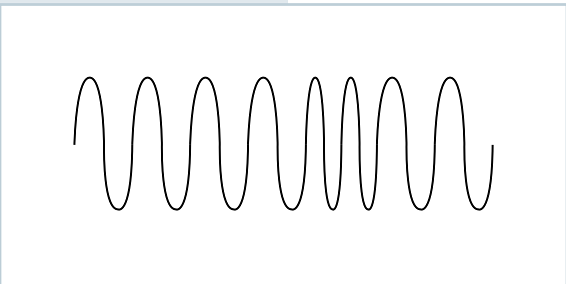

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Fig. 4 – Frequency deviation.

Definition

The phenomenon of a deviation from the power supply frequency is defined by a change in its value compared to the fundamental frequency (50/60Hz).

Frequency variations are limited in amplitude in a stable and interconnected distribution network.
However, it is possible to encounter significant frequency differences if the electrical infrastructure is poor or if sites generate their own local electricity and operate independently of the grid.

Increased frequency ⇨ power produced is greater than the power demanded.

Reduction in frequency ⇨ Less power produced than demanded.

Causes

Frequency variations are caused by an unbalance between the generated capacity and the connected load. In the case of renewable energy production, the frequency difference results from the source (generator or inverter) and its control system.

Voltage dip

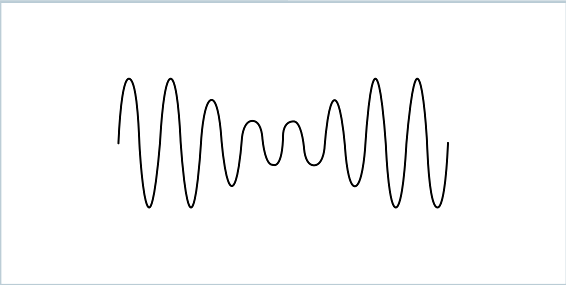

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Fig. 5 – Voltage dip.

In general, the residual voltage of the voltage dip is between 90% and 5% of the nominal voltage and its duration between 10 ms and 1 min.

Definition

A voltage dip is a temporary reduction of the voltage magnitude at a point in the electrical system below a threshold.
The main parameters are its depth and duration. The voltage dip will not necessarily appear on all phases.

Voltage dips are almost 3 times more likely in overground networks than underground. Most dips last less than 500 ms (around 90% of voltage dips) and the depth of most of these events is less than 50% (around 90% of voltage dips). Most voltage dips on networks occur on one phase, but they often reach the user in asymmetrical three-phase forms due to the downstream neutral conditions.

Causes

Voltage dips are mainly caused by network usage resulting in more current being demanded, which creates drops in voltage by circulating in the system's impedances (for example, motor start-ups and powering capacitors).
Defects (short circuits and insulation faults) can also cause voltage dips until the defective element is disconnected by the protection.
We need to distinguish between voltage dips which are related to an increase in current and therefore inherent in the behaviour of an electrical installation (in a factory, for example), and voltage dips from the distribution network which are not related to an increase in current.
Most voltage dips in the distribution network originate from the medium and high voltage network levels, rather than low voltage levels.

Voltage swell

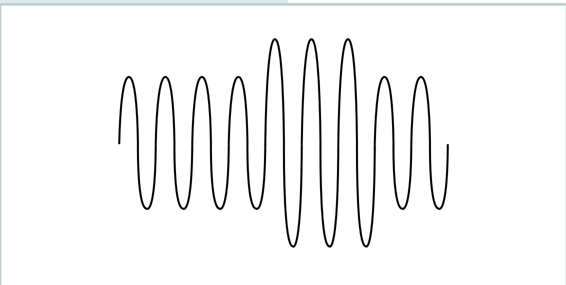

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Fig. 6 – Voltage swell.

In general, the voltage swell threshold is 110% of the nominal voltage and its duration between 10 ms and 1 min.

Definition

A voltage swell is a temporary increase of the voltage magnitude at a point in the electrical system above a threshold.
There are three types of swell: temporary, manoeuvring and atmospheric.
These three types may appear in differential mode (phase/phase or phase/neutral) or in common mode (phase/earth or neutral/earth).

Atmospheric swells are caused by lightning
- Either through direct contact.
- Or by voltage jumps induced by increases in the earth's potential.

Temporary voltage swells are due to

- An insulation defect between the phase and the earth that can result in a line-to-neutral voltage reaching a line-to-line voltage on one of the healthy phases.
- Ferroresonance: a rare and unregulated non-linear oscillatory phenomenon that can also lead to voltage swells.
- Neutral conductor failure: the line-to-neutral voltage (phase/neutral) of the least loaded phase can reach the line-to-line voltage (phase/phase).
- The overcompensation of reactive energy: shunt capacitors can cause a voltage swell.
- The Ferranti effect, when the end of one line is disconnected and the other end is live.

Switching voltage swells are caused by rapid changes in the network structure starting with

- Protection being actuated.
- Switching under load.
- Powering on capacitor banks.
- Variations in inductive currents.

Voltage interruption

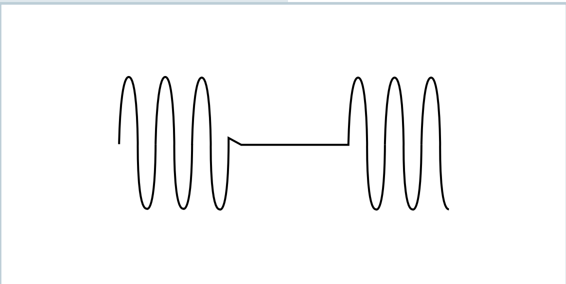

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Fig. 7 – Interruption.

Definition

An interruption is a reduction of the voltage magnitude at a point in the electrical system below a threshold. This is a special type of voltage dip.

Depending on its duration, an interruption is classified as a long or short break.

- Short break: less than 3 minutes.
- Long break: more than 3 minutes.

Generally, the threshold for interruption is 5% of the nominal voltage. The voltage interruption appears on all phases.

Causes

The causes of interruptions may vary, but are usually due to

- Damage to the electrical grid (lightning, animals, trees, car accidents, destructive weather conditions: high winds, heavy snow or ice on the lines, etc.)
- Equipment failure or triggering of a base circuit breaker

Although the infrastructure of public services is designed to automatically compensate for many of these phenomena, it is not infallible.
One of the most common examples that can cause an interruption in power systems is utility protection, such as automatic circuit reclosers.

Short outages are caused in a similar way to voltage dips by phenomena such as high current inrushes and defects involving fast trip recloser circuit breaker. Switching from sources can also cause brief power cuts.
Long power cuts are due to the ongoing isolation of permanent defaults or due to the voluntary actuation of equipment.

** Values chosen by default in the standard **EN 50160** describing the voltage limits expected at each delivery point of the main grid.*

IEC 60038 (IEC standard voltages) specifies nominal voltage values, based mainly on the evolution history of electrical installations around the world. These values have been recognised as the most appropriate for the design of electrical equipment and systems.

Supply voltage amplitude: low/high voltage value

Definition

Low value
This is the absolute difference between the measured value and the nominal value if the voltage value is less than the nominal value.

High value
This is the absolute difference between the measured value and the nominal value if the measured voltage value is more than the nominal value.

Causes

As part of the energy transition, the supply of renewable energy at all voltage levels can cause, among other things, a deviation from the supply voltage relative to its rated value.

Supply voltage unbalance

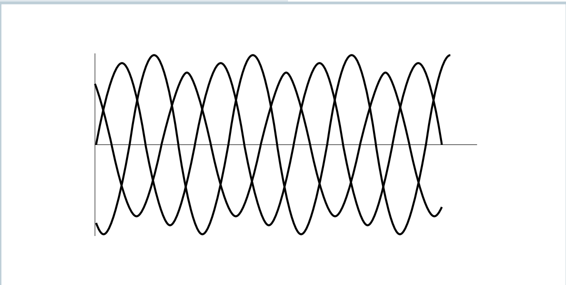

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Figure 8 – Voltage unbalance.

Definition

Voltage unbalance is considered a serious energy quality problem in the distribution of electricity.
A voltage unbalance is a condition in a polyphase system in which the r.m.s. values of the line-to-line voltages, or the phase angles between consecutive line voltages, are not all equal.

Causes

An unbalance is caused by
- A failure in the power factor correction equipment.
- An unbalanced or unstable supply.
- Single-phase loads distributed unevenly on the same power system.
- An open circuit on the primary of the distribution system.

** In general, the voltage unbalance threshold is 2%.*

Flicker

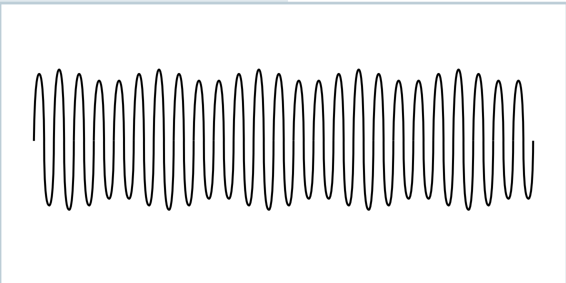

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Fig. 9 – Flicker.

Definition

Flicker is an impression of unsteadiness of visual sensation induced by a light stimulus whose luminance or spectral distribution fluctuates with time.
Fluctuations in voltage can cause lights to flicker, which is annoying to humans, even if the variations do not exceed a few tenths of a percent.
Electrical installations are not normally affected by these phenomena, as long as the amplitude of the variations remains less than 10%.
It should be noted that this phenomenon is less and less present due to the widespread use of LED lighting.

Pst and Plt are indicators of discomfort.
- The Pst (short time) is a 10-minute analysis.
- And the Plt (long time) is a 2-hour analysis of 12 Pst values.

The method of calculation is quite complex.
Put simply, a value of 1 corresponds to a perceived disturbance by 50% of individuals (calculation method according to the IEC 61000-4-15 standard).

Acceptable levels are around
- Pst = 0.35.
- Plt = 0.25.

Causes

These rapid voltage variations, whether repetitive or random, are caused by rapid variations in the power absorbed or produced by equipment such as welding machines, arc furnaces and wind turbines.
There are other sources of flicker:
- starting up or motor loads variation,
- activating or deactivating large loads,
- magnetic resonance tomography,
- elevators,
- compressors.

Mains signalling voltage

Definition

The Mains signalling voltage, also called “centralised remote control signals” in some applications, is a burst, often at non-harmonic frequencies (e.g. a 175 Hz signal), which remotely controls industrial equipment, meters and other equipment (e.g. to manage peaks/off-peaks).

Causes

It is a signal generated intentionally and coupled in a distribution network but should not disturb it. The limits of signal voltage are defined in EN 50065.

Current and voltage harmonics

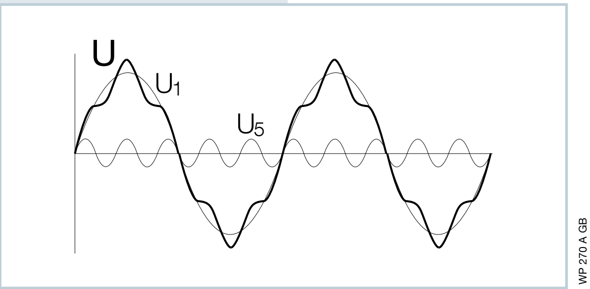

Fig. 10 – Distortion caused by a single harmonic (h=5).

Definition

Electrical signals are periodic, but not always perfectly sinusoidal. However, a periodic wave can be broken down into a series of sine waves whose frequency is a multiple of the fundamental frequency (decomposed in a Fourier series).
Harmonics are therefore components whose frequency is a multiple of the fundamental (50/60 Hz), which cause a distortion of the sine wave.

The harmonic distortion rate (THD for “total harmonic distortion”) provides synthetic information on signal deformation.

Causes

Current harmonics are caused by non-linear loads (e.g. electronic power supply) connected in the installation. A load is said to be non-linear when the current it picks up does not have the same waveform as the supply voltage. The flow of current harmonics through the impedances of the installation in turn creates voltage harmonics that distord the supply voltage and impact all the loads.
The level of current harmonics can be amplified by resonance phenomena, especially if capacitor banks are not installed with the necessary precautions.

Most sources cause odd-rank harmonics. However, arc furnaces, transformer start-ups or polarised loads also create even-rank harmonics.

The main sources of harmonics:
- industrial sources,
- power electronics equipment,
- electric arc loads,
- motor start-up and transformer actuation (temporary harmonics),
- domestic sources,
- equipment with converters and switched-mode power supply.

Current and voltage interharmonics

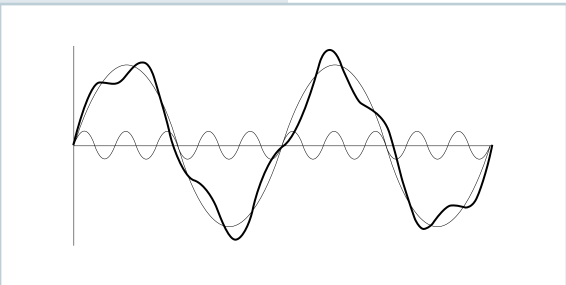

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Fig. 11 – Distortion caused by a single interharmonic (h=3.5).

Definition

Interharmonics have spectral components whose frequency is not an integer multiple of the fundamental.
The level of interharmonics is generally much lower than that of harmonics. It rarely exceeds 0.5% of the fundamental.

Causes

Interharmonics are most often due to installations producing rapidly variable harmonics, such as arc furnaces, cycloconverters, speed drives used under certain conditions (the 'modulation' of harmonics then causes the appearance of 'lateral bands' at intermediate frequencies); the presence of harmonic filters can greatly aggravate the phenomenon (amplification of intermediate frequencies, phenomena of instability in converters, etc.).

Rapid voltage change (RVC)

Definition

A RVC is a quick transition in r.m.s. voltage occurring between two steady-state conditions, and during which the r.m.s. voltage does not exceed the dip/swell thresholds.

Causes

Rapid voltage changes are caused by
- Motor start-ups.
- Activation/deactivation of capacitor banks.
- Transformers' inrush current.
- Switching of transformers.

Transient

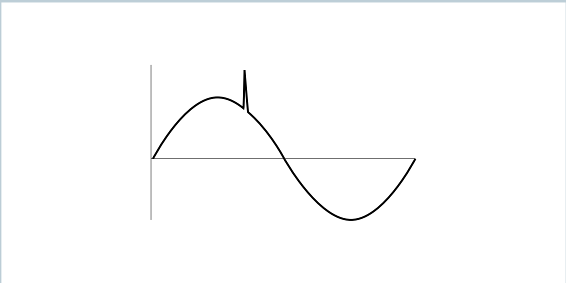

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Fig. 12 – Transient surge.

Definition

Voltage transients are voltage spikes or dips that appear only over durations less than the fundamental half-period (10 ms for a frequency of 50 Hz).

Causes

The strongest transient overvoltages for the distribution network, but fortunately the least frequent, are due to lightning. They can reach several kV in amplitude in overhead LV networks. These transients can also spread to underground LV networks.
More frequent transient overvoltages can occur at company installations under heavy power loads (motors, elevators, welders, capacitors) or when overcurrents are protected by isolating a fault by a fuse or a low-voltage high speed circuit breaker.
Cutting inductive loads can also cause transient overvoltages as can electrostatic discharges between 2 groups of unearthed devices.

Links between equipment and electrical events

The equipment in the electrical facilities will be linked to electrical events.
They can:
- be impacted by disturbances,
- be a source of disturbance, or,
- mitigate disturbances.

Overview

This table summarises the influences between the equipment and electrical events

		Equipment										
		Motors	Variable speed drives	Trans-formers	Capacitors	Generators (Gensets)	Uninterrupted Power Supply	Lighting	Office equipment (computers, printers, TVs, etc.)	Cabling	Programmable logic controllers (PLC)	Other generators (PVs, storage)
Electrical events												
Short and transient voltage events	Voltage dip	I,S	I,M				M	I	I		I	
	Voltage interruption						M		I		I	
	Voltage swell	I					M	I	I		I	
	Voltage transient	I	I		S		M		I		I	
Long voltage events	Voltage deviation	I							I			S
	Voltage unbalance	I										
	Frequency deviationy	I										
	Voltage flicker							I	S			
	Voltage harmonics (Uh)	I,S	S	S,I,M	S,I	I	S	S	S	I		S
	Voltage THD (THDu)	I,S	S	S,I,M	S,I	I	S	S	S	I		S
	Voltage interharmonics	I,S	S	S,I,M	S,I	I	S	S	S	I		S
Power-related events	Power factor	S	M	S,I	M	I		S		I		

I: Equipment impacted by a disturbance; S: Equipment source of disturbance; M Equipment mitigating a disturbance

Table 7 – Influences, electrical events and equipment
Source: IEC TR 63191 - Demand side power quality management

Equipment and disturbances in detail

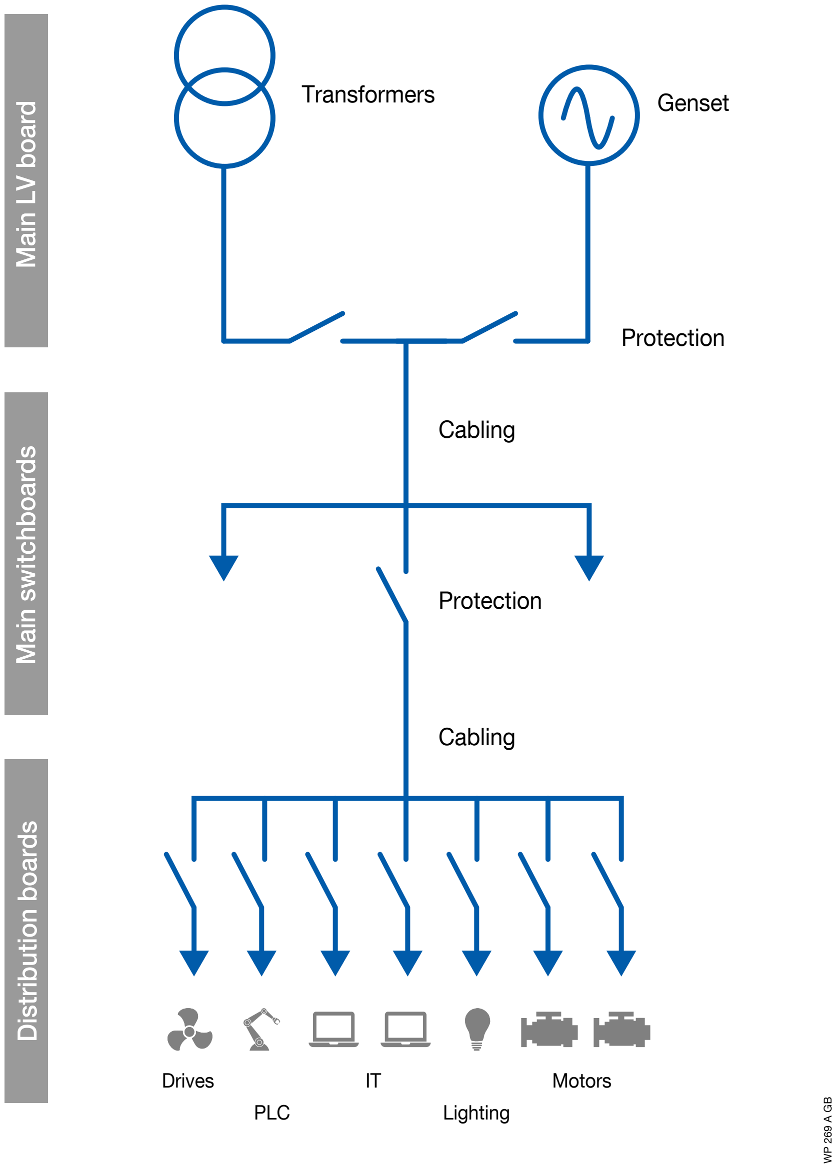


Fig. 13 – Electrical installation and equipment.

The following tables describe in detail:

- equipment disturbances and impacts,
- the resulting impacts on the electrical system when equipment is source of disturbance,
- disturbance-mitigating equipment and what the benefits are for the installation.

MOTOR		
Event impacting the motor	**Consequence**	**Impact on the equipment**
Voltage dip	Creating transient overcurrents	Damage Motor stalling
Transient voltage	Stress on the motor winding insulation	Degradation over time Risk of failure
Voltage swell	If more than 10%	Significant increase in losses inside the motor Overheating
Voltage unbalance	Generates a high current unbalance in the motor	Additional losses Increased temperature in the motor Major cause of motor failures
Frequency deviation	Motor speed variations	Ineffective operation Heating Additional power consumption
Harmonics	Vibrations	Mechanical damage
Motor as the source of disturbance	**Consequence**	**Impact on the installation**
Starting large electric motors individually or in groups	Current inrush	Reduced voltage in adjacent areas
The induction motor uses reactive energy to create a magnetic field	Decrease in power factor	Significant penalties on electricity bills Overloading the distribution system Increasing the company's carbon footprint

VARIABLE SPEED DRIVE		
Event impacting the drive	**Consequence**	**Impact on the equipment**
Voltage dip	Speed drive sensitivity	Risk of nuisance tripping of drive protection
Transient voltage	Stress on the drive diodes	Premature drive failure
Drive as the disturbance mitigator	**Consequence**	**Benefit to the installation**
The speed drive reduces inrush currents during a motor starting	Reduces the depth or even eliminates voltage dips associated with motor starting	Significantly lower risk of failure Improved motor life
Improved installation upstream of drives	Increased power factor	Reducing electricity bills Increasing the number of loads Reducing transmission losses Reducing the company's carbon footprint

TRANSFORMERS		
Event impacting the transformer	**Consequence**	**Impact on the equipment**
Harmonics	Heating	Premature ageing of the transformer
Low power factor	Creates an overload, overheating and additional losses in the transformers	Additional losses in the transformers
Transformer as the source of disturbance	**Consequence**	**Impact on the installation**
The transformer uses reactive energy to create a magnetic field	Decrease in power factor	Significant penalties on electricity bills Overloading the distribution system Increasing the company's carbon footprint

CAPACITOR		
Event impacting the capacitor	**Consequence**	**Impact on the equipment**
Switching of capacitor banks	Creates transient voltages	Transient voltages spread in the installation
Harmonics	Heating	Risk of destroying the capacitors
Capacitor as a disturbance mitigator	**Consequence**	**Benefit to the installation**
Power factor correction system	Corrected power factor	Reducing electricity bills Increasing the number of loads Reducing transmission losses Reducing the company's carbon footprint
GENERATOR – GENSET		
Event impacting the genset	**Consequence**	**Impact on the equipment**
Leading power factor	Group mismatching	Oversizing Overloading the genset
UNINTERRUPTED POWER SUPPLY (UPS)		
UPS as the source of disturbance	**Consequence**	**Impact on the installation**
Using older generations of UPS	Generating harmonics in the installation	Heating and premature aging of the installation's equipment Nuisance tripping of protection Power losses
UPS as a disturbance mitigator	**Consequence**	**Benefit to the installation**
The UPS protects downstream equipment	Elimination of disturbances such as voltage dips, swells, transients	Preservation of installation equipment
LIGHTING		
Event impacting lighting	**Consequence**	**Impact on the equipment**
Voltage dip	Multiple lights switching off and on again	Premature ageing of lights
Voltage drop Voltage swell	Voltage fluctuation	Creates visual interference
Voltage variations	Flickering	Deterioration in lighting quality
Interharmonics	Lighting interference	Deterioration in lighting quality
Lighting as the source of disturbance	**Consequence**	**Impact on the installation**
Compact fluorescent lights and LEDs generate harmonics	Generating harmonics in the installation	Heating and premature aging of the installation's equipment Nuisance tripping of protection Power losses
Fluorescent and discharge lamps are characterised by a low power factor	Decrease in the power factor in the installation	Significant penalties on electricity bills Overloading the distribution system Increasing the company's carbon footprint

IT		
Event impacting IT	**Consequence**	**Impact on the equipment**
Dips interruptions Swells	Interference to power supplies	Malfunction Data loss Premature degradation
Transient	Creates stress in semiconductors	Risk of premature failure Destruction
Voltage deviation	Power supplies outside their voltage range	Risk of destroying switch-mode power supplies
IT as the source of disturbance	**Consequence**	**Impact on the installation**
Switch-mode power supplies can be a source of harmonics	Generates harmonics in the installation in particular level 3 and multiple	Heating and premature aging of the installation's equipment Oversizing the neutral conductor to take into account rank 3 harmonics Nuisance tripping of protection Power losses

CABLING		
Event impacting the wiring	**Consequence**	**Impact on the equipment**
Harmonics	Harmonics generate heat in cables	Oversizing cables
Interharmonics	Heats the conductors	Oversizing cables
Power factor	Low power factor increases losses in the cables	Oversizing cables

PROGRAMMABLE LOGIC CONTROLLER (PLC)		
Event impacting the PLC	**Consequence**	**Impact on the equipment**
Dips	Malfunction	Disturbance to an industrial process
Interruption		
Swells		
Voltage drops	Automated devices can turn off if the voltage drops	Renders PLC useless Interruption to an industrial process

PROTECTION		
Event impacting the protection	**Consequence**	**Impact on the equipment**
Voltage dip	Nuisance opening or reconnection of switches and circuit breakers	Interruption to an industrial process Interruption to the continuity of service (hospitals, data centres, etc.)
Transient	Differentials tripping	Interruption to an industrial process Interruption to the continuity of service (hospitals, data centres, etc.)

Table 8 – Equipment and disturbances.

In red: Significant negative impacts on the installation, process or equipment
In green: Significant positive impacts on the installation, process or equipment

Possible solutions to disturbance phenomena

Here are some examples of possible solutions to disruptive events.

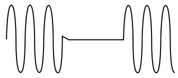
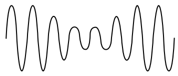
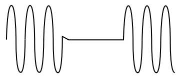
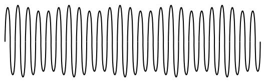
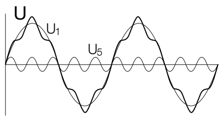
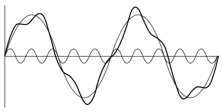
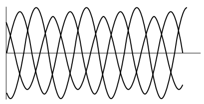
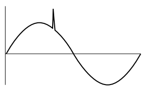
Disturbance event		Possible solutions
Long interruptions		• Emergency power (network) • Uninterrupted power supply (UPS)
Voltage dip		• Identifying the origin of the disturbance (network or customer installation) and acting accordingly • Network conditioner • Timing switches • Taken into account in the design of sensitive equipment • Uninterrupted power supply • Transfer switches
Short interruptions		
Flicker		• Synchronous compensator • Static Var compensators • Active conditioner • Serial capacitor
Harmonics		• Active or passive filtering • Anti-harmonics inductance • Protecting and oversizing capacitors • Separating polluting loads of sensitive loads • Equipment derating
Interharmonics		• Active or passive filtering • anti-harmonics filters • Taken into account in the design of sensitive equipment
Unbalances		• Balancing device • Balancing single-phase loads over all three phases • Network conditioner • Suitable protection for motors
Transient overvoltages		• Surge protective device • Galvanic separation • Insulation coordination • Choke inductance • Preload resistance

Table 9 – Main disruptive phenomena and some preventive or curative solutions.

Socomec solution for energy quality

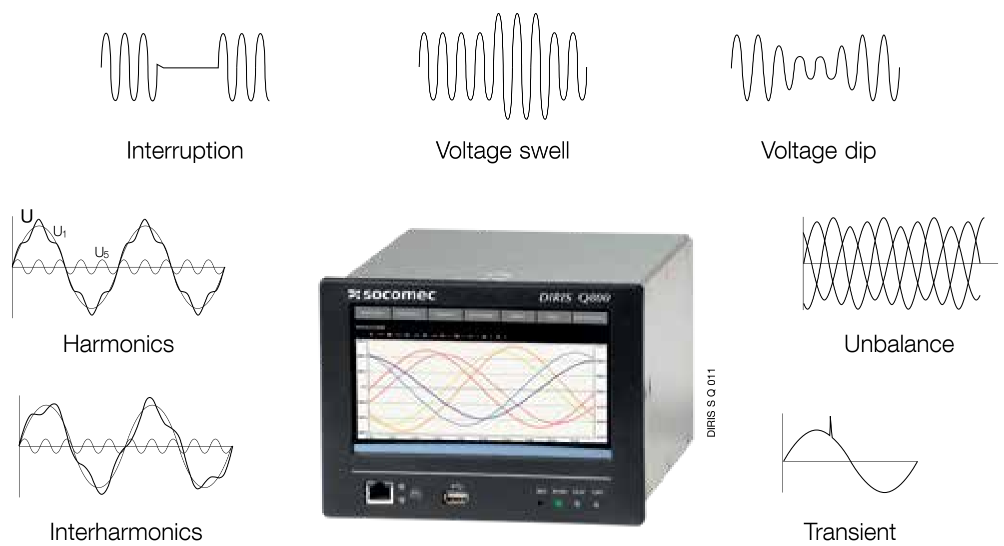
In the previous sections we talked about disturbances to energy quality. This section introduces all the measuring instruments to implement an energy quality monitoring approach with a particular focus on the DIRIS Q800 network analyser.

The network analyser represents the referee's video backup.

DIRIS Q800, the class A network analyser

The efficiency of a company depends on the quality and availability of its power network. It must control it to improve the efficiency of its installation, reduce production losses, optimise operating costs and cut maintenance costs.

To meet these requirements, the DIRIS Q800 is designed to measure, timestamp and record the various energy quality phenomena we saw in the previous section and help to analyse, understand and resolve problems on the distribution network and in the electrical facility.



DIRIS Q800

Network analyser

The 6 criteria for choosing your network analyser

1. Compliance with standards: *Check the network analyser's compliance with IEC 61000-4-30 and IEC 62586 with a third-party certification.*

2. Advanced features: *Make sure the device can monitor and record quality events to a high level of accuracy and has sufficient memory.*

3. Simplified connectivity: *Make sure the equipment can be easily connected to the installation you want to monitor (numbers of voltage and current measurement channels, communication ports and inputs/outputs).*

4. Ease of use: *Make sure the device can be operated in a simple and intuitive way.*

5. Data processing: *Make sure the device comes with the tools you need to process and understand the measurements done.*

6. Customer service: *Make sure the manufacturer can provide support for the device, from its installation to its daily use.*

1. High level of accuracy and compliant with standards

The measuring features of the DIRIS Q800 were developed to comply with standard IEC 61000-4-30 Class A. The product is also third-party certified according to product standard IEC 62586-2 Class A. Compliance with these standards ensures high accuracy and time synchronization.

The DIRIS Q800 calculates and provides compliance reports to EN 50160 standard. These binding reports are intended to verify the quality of the electrical energy delivered.

The network analyser also meets the following standards:
- Consumption analysis
  - Metering active energy: IEC 62053-22 class 0.2S
  - Metering reactive energy: IEC 62053-24 class 1
- Harmonics and interharmonics: IEC 61000-4-7
- Flickers: IEC 61000-4-15.

2. Advanced features associated with a high-end product

Generally installed at the Main LV board level, the DIRIS Q800 is a high-end PQI that continuously monitors the quality of the power.

All power quality measurements and events, such as dips, swells interruptions, harmonics, transients, frequency and voltage variations are reported, time-stamped and stored in the device's memory. It also has an internal battery that keeps the device running even in the event of a power cut. The data is stored for 5 years in its 16 GB internal memory.

- Dip/swell/interruption in voltage up to 10 ms.
- Current overload up to 10 ms.
- Transient up to 20 microseconds.
- Flicker.
- Mains signalling voltage.
- V, U, f, I, P, Q, S, FP, THD,K-factor, harmonics per rank (63), interharmonics.
- Unbalance.
- Energy.
- Waveforms.
- Fresnel diagram.
- Real-time and average values, min/max with time-stamp.
- Differential current.

3. Simplified connectivity to suit all installations

With its many features, the DIRIS Q800 has also been designed to integrate into any type of communications infrastructure.

It incorporates a number of communication functions:
- an embedded web server for different actions (visualising measurements and records, commissioning data export),
- real-time alarms with email notifications related to quality events,
- a 10/100Mb Ethernet port at the rear for a permanent connection in the electrical cabinet,
- a 10/100Mb Ethernet port at the front for local communication,
- communication protocols: HTTP, HTTPS, FTP, SFTP, NTP, Modbus TCP,
- RS485 port for Modbus RTU protocol communication,
- GPS for accurate RTC synchronisation,
- a WiFi port with outdoor antenna,
- CSV and PQDIF-format data recording.

Fixed vs. portable analyser:
Network analysers can be fixed or portable. Portable network analysers are intended for measurement campaign in a specific part of the installation Unlike a fixed device, they are not able to capture all the quality events that can occur at any time in the electrical installation.

4. Easy to use thanks to its ergonomic interface

With a generous size of about 20 x 15 cm and a high-definition display quality, the colour touchscreen offers smooth navigation and clear graphics. The interface and visuals are identical on the device's screen and web server, making it much easier to get to grips with and switch from one to the other.

Advanced features


DIRIS S Q 026

Harmonics


DIRIS S Q 027

Waveforms


DIRIS S Q 028

Fresnel diagram


DIRIS S Q 029

Transient events


DIRIS S Q 030

Dip/swell/interruption in voltage

What's more
To compare and understand your events, create your PQDIF files and analyse their data with the right software.

5. Related software for easy data processing

The DIRIS Q800 comes with the following related software for data processing:

- **Q800 Analyser**: Creates EN 50160-compliant reports with all the measurements recorded in the device, including ITIC curves.


SOFT 085

- **Q800 tool**: View and download all the measurements you need, with a class A network analyser.


SOFT 084

Key points

- Fixed network analyser to prevent quality failures and optimise your electrical energy costs.
- Third-party certification to IEC 62586-2 Class A.
- Compliance with IEC 62053-22 Class 0.2S.
- Real-time email alerts to track the installation's status and activity.
- Large colour touchscreen with the same display as the web server.
- Easy integration into any fixed installation.
- Software for energy quality analysis provided with the device.

To learn more about the DIRIS Q800, visit our website.

Go further and pinpoint the exact source of a disturbance

Identifying the origin of disturbances

Combining the DIRIS Q800 with the DIRIS Digiware monitoring system make the best use of the installation and precisely identify the origin of a disturbance. The DIRIS Digiware monitoring system, developed by Socomec, measures electrical parameters at the loads level to analyse their behaviour during disruptive events.

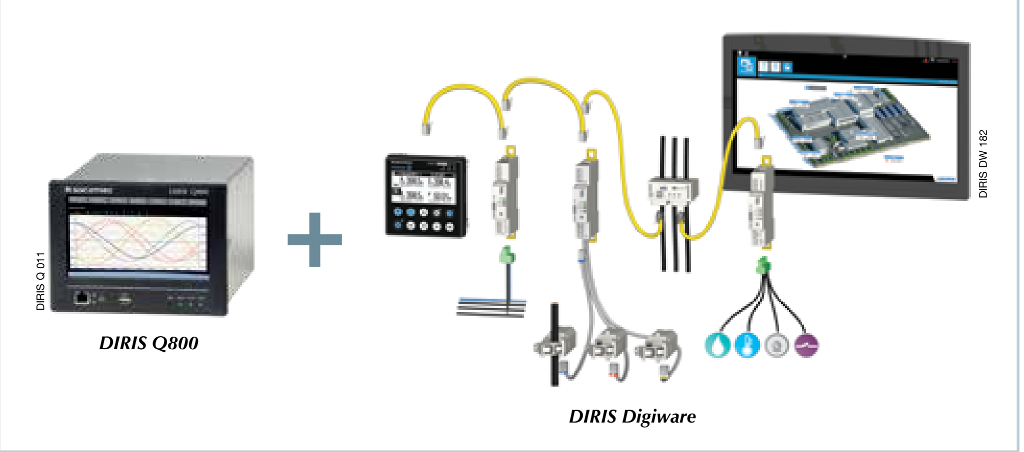


Fig. 14 – DIRIS Q800 and DIRIS Digiware association.

For example,
- if non-linear loads generate current harmonics then they can disrupt the voltage.

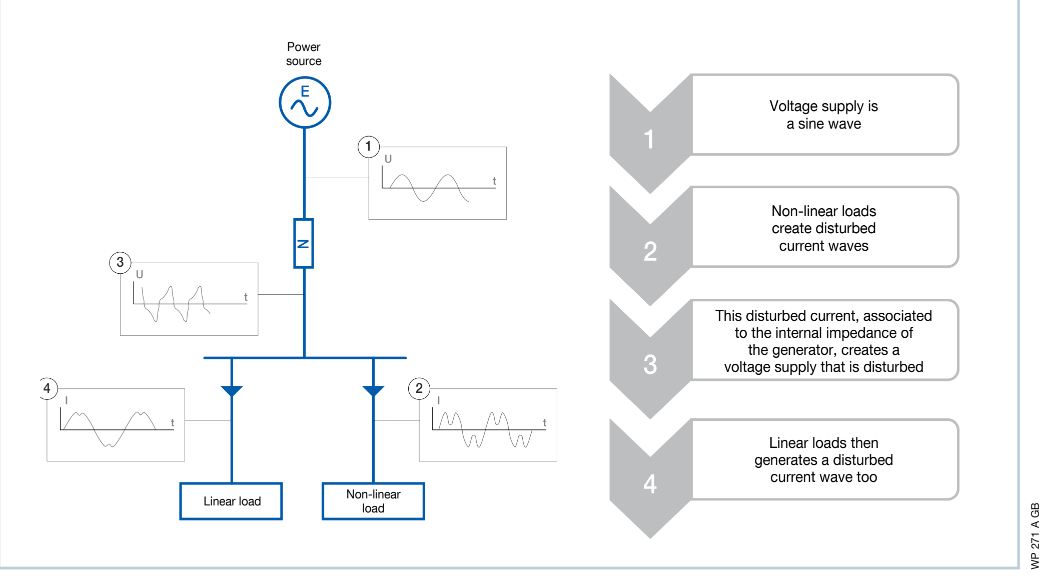


Fig. 15 – Impact of the use of non-linear loads.
Source: Technical note "Advanced measurements and applications".

To identify the origin of a voltage dip
- If there is no increase in current, then the disturbance comes from the distribution network.
- If there is an increase in current, then the disturbance comes from the customer installation. By analysing the current at each load, the disruptive load can be identified.

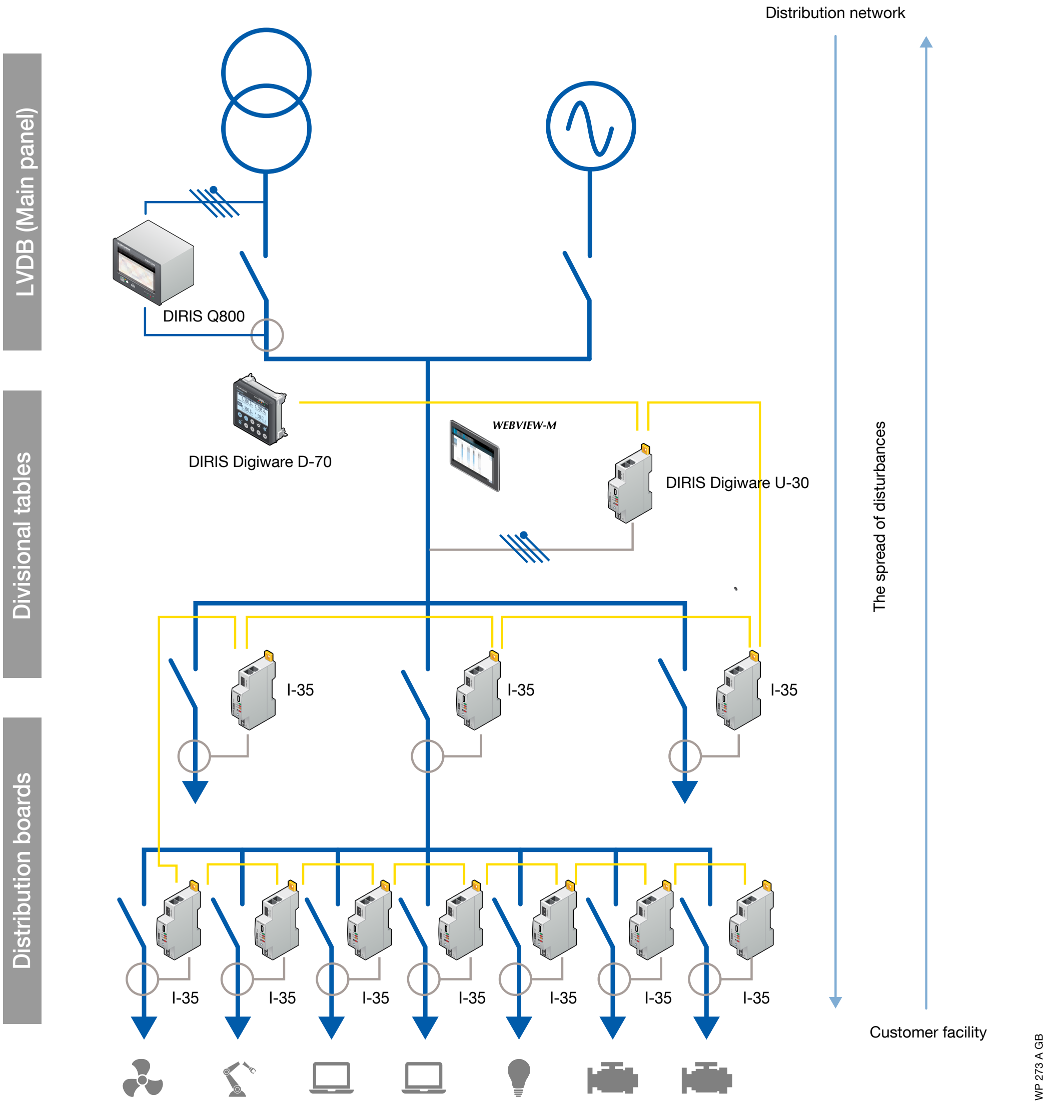


Fig. 16 – Identifying the origin of the disturbance.

An alarm notifies the user if a disruptive event occurs. All logged events are time stamped and stored for further analysis.
If the disturbance affects several loads, then a time stamped alarm is issued at each measurement point of these loads. This feature also helps you to better understand and locate the disturbance.

Monitoring the installation

Using a DIRIS Q800 together with the DIRIS Digiware monitoring system helps improve and maintain the overall quality of your electrical installation to ensure its availability and safety.

By monitoring the electrical parameters put in place the power quality over the entire electrical installation can be analysed by:
- characterising loads and their distribution in the installation,
- locating losses,
- detecting drifts,
- voltage variations,
- unbalances,
- harmonics.

Monitoring these parameters evolution helps to anticipate or detect equipment damage over time, the risk of protection devices tripping and process interruptions.
Installation monitoring gets the best out of the equipment, maximises the installation's continuity of service and performance by minimising losses and related overconsumption.

The DIRIS Digiware system complies with IEC 61557-12 standard dedicated to measuring products for monitoring electrical installation. See the technical note "IEC 61557-12 reference standard" for more information.

Conclusion

The quality of the energy has a direct impact on the **performance of the installation** (shutdown, lifespan, damage, etc.) and the efficiency of an organisation **depends on the efficiency, quality and availability of its electricity network**.

A substantial **normative support** provides the necessary elements for implementation of relevant electrical parameter measurements to analyse the network. **The DIRIS Q800 multifunction network analyser** provides the user with all the measures and reports required by these standards.
What's more, combination of both:

DIRIS Q800 network analyser + DIRIS Digiware monitoring system

helps to accurately identify the origin of energy quality disturbances.

These devices together form a powerful tool to help monitor power quality, analyse and understand the source of disturbances, anticipate and resolve events and implement available solutions.
This approach ensures business continuity, cost optimisation and reduced production losses for organisation.

What's more

Technical note
- Advanced measurements and applications

Technical note
- IEC 61557-12 reference standard

To find out more

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3,600 employees worldwide

10 % of sales revenue dedicated to R&D

400 experts dedicated to service provision

Your power management expert

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POWER MONITORING

POWER CONVERSION

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