Eskom
Quality of supply

The means to safe, reliable and sustainable operations

Causes, effects and solutions for poor electrical quality of supply in power systems

Provision of electricity supply

In today's global society the importance and necessity of electricity as part of everyday life can't be underestimated. Electricity is the driving force behind various fields of human activity: engineering, communication and transport, entertainment, health and more importantly it fuels technological development and transformation. It is almost impossible to imagine life without electricity.

It is therefore important to have a look at electricity power quality. Wikipedia describes electric power quality as follows: "Electric power quality, or simply power quality, involves voltage, frequency, and waveform. Good power quality can be defined as a steady supply voltage that stays within the prescribed range, steady AC frequency close to the rated value, and smooth voltage curve waveform (resembles a pure sine wave). Without the proper power, an electrical device (or load) may malfunction, fail prematurely or not operate at all".

However it is impossible to provide or guarantee a completely disturbance-free and uninterrupted electricity supply in the real world. The reliability and quality of supply varies in different parts of any electrical system. Individual customers may experience more or fewer than the average number and duration of interruptions and disturbances. In most cases, equipment and appliances will function as expected. However, electricity supply conditions or the quality of supply (QOS) that might cause problems or unsatisfactory performances may exist, making it essential that facility owners are aware of and respond to these factors before making commitments to purchasing any equipment or altering installations.

Objective

The objective of this fact sheet is to inform and educate the public at a high level about quality of supply (QOS), the impact of poor QOS on facilities' performance and costs, the benefits of a good QOS and the potential impact of embedded generation such as renewable energy generators on QOS. Customer loads can generate unwanted harmonic currents, flicker, voltage sags, high levels of voltage regulation, etc. in the supplying network.

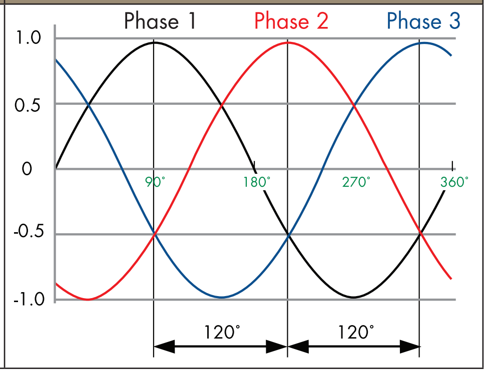
These effects via the network can, in turn, cause severe disturbances within businesses and other neighbouring electricity customers. Most renewable energy sources, process equipment and electro-technologies have elements of instant or continuous uncontrollability at various levels, which influence the quality of the power supply if not addressed via technical solutions or by means of responsible connection methods.

What is quality of supply

The misconception is that good power quality means a perfect wave form and/or uninterruptable power supply.

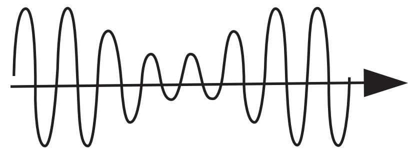
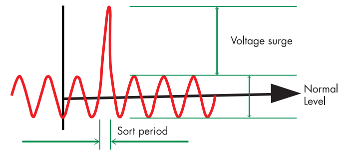
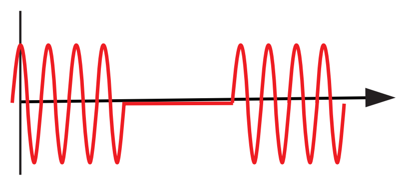
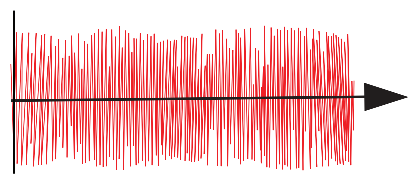
Both of these are desirable, but only accounts for two dimensions of the power supply. A power supply performance as defined in the aforementioned is unlikely in normal day-to-day operations due to nonlinearities in the load and supply infrastructure. The ideal quality of the electrical supply to a facility involves a steady voltage, at a set frequency and waveform within a prescribed distortion range.

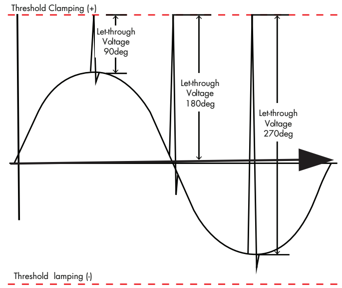
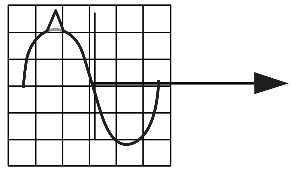
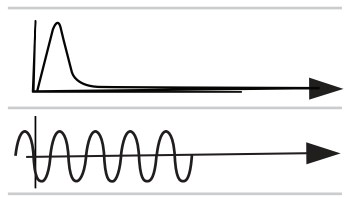
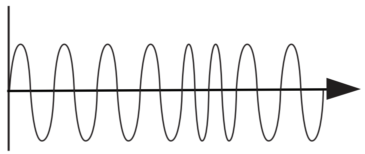
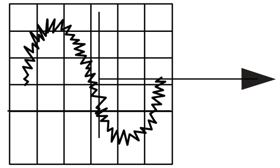
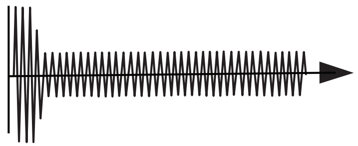
Quality of Supply (QOS) therefore refers to all disturbances in the supply and consumption of electricity and is classified in various parameters as set out in the following section.

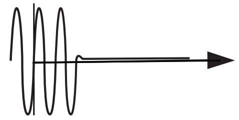
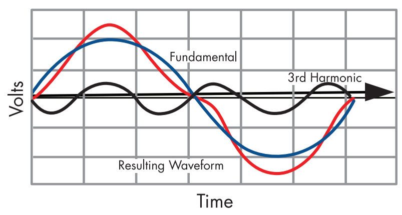
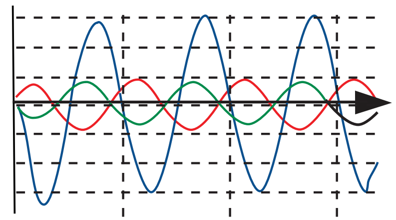
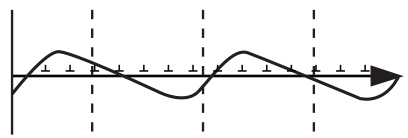
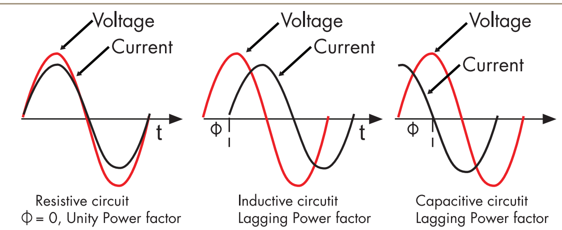
Description:	Typical wave diagram
A continuous alternating current, at the exact same voltage and frequency levels with no distortions over the time used.	

Perfect power quality of supply (QOS)

The causes and effects of a non-conformance in electrical quality of supply

Problem	Description:	Causes	Effects/impact	Typical wave diagram
Voltage sags / dips / under-voltage:	Sags or dips are a short-term reduction in voltage (that is 80-85% of normal voltage). Voltage sags typically are non-repetitive, or repeat only a few times.	Sags/dips/under-voltages are most often caused by fuse or breaker operation, motor starting, or capacitor switching.	Equipment failure or damage, system lock-up, data corruption, data loss, etc.	
Voltage spikes and surges:	Spikes or surges are a short-term increase in voltage.	Caused by lighting, utility grid switching or heavy industrial equipment being operated.	Equipment failure, reduced life, system lock-up, data corruption, data loss, etc.	 Source:www. http://electronicsbeliever.com
Power interruptions:	Power interruptions are zero-voltage events and are typically short duration events. The vast majority of power interruptions are less than 30 seconds long in transmission and distribution networks. Customers may however experience longer interruptions due to network protection operations.	Interruptions are typically due to network faults, fires, trees, birds on networks, severe weather or the utility needing to deal with planned or unplanned maintenance or supply constraints.	No power - Unable to use equipment.	 Source: http://www.st-ingegneria.com
Voltage flicker:	Voltage flicker is rapidly occurring voltage sags.	Voltage flicker is most commonly caused by rapidly varying equipment loads (by sudden and large increases in load currents) that require a large amount of reactive power. Positive reactive power is caused by inductive loads such as motors and transformers (especially at low loads). Negative reactive power is caused by capacitive loads. (Also see Power Factor below).	Sensation experienced by human visual system when subjected to luminance variations emitted by lamps. Besides the visual perception, flicker is responsible for some degree of irritability or annoyance. Flicker can disrupt control systems.	 Source: http://www.st-ingegneria.com

Problem	Description:	Causes	Effects/impact	Typical wave diagram
Power surges:	A power surge takes place when the voltage is 110% or more above the normal voltage supply. External power surges boost the voltage of electrical current flowing into your facility from the outdoor power line.	The most common cause for a power surge is heavy electrical equipment on the network being turned off.	During a power surge, damage to HVAC systems, appliances and electronics can occur.	 Source: http://www.securitysa.com
High-voltage spikes and surges:	High-voltage spikes occur when there is a sudden voltage peak of up to 6 000 volts.	These spikes are usually the result of nearby lightning strikes, but can be caused by utility grid or heavy industrial equipment switching on the grid. Static electricity can also cause spikes and surges.	Can cause premature failure of electrical and electronic (e.g. circuit boards) components due to overheating.	
Transients:	Transients take place when there is an extremely rapid voltage peak of up to 20 000 volts with a duration of 10 to 100 microseconds.	Transients are commonly caused by machinery on the grid starting and stopping, arcing faults, static discharge, lighting, switching impulses and utility fault clearing.	Damage to electrical equipment. Unusual equipment damage due to insulation failures or flash-over. Damage to electronic components. Total failure, lockup or misoperation of computers or micro-processor based equipment. Damage to cabling insulation through flashover, potentially resulting in loss of life through fire and electric shock.	
Frequency variation:	A frequency variation involves a change in frequency present in alternating current, supplied from the normally stable utility frequency of 50hz (for South Africa).	Frequency variation may be caused by erratic operation of emergency generators or unstable frequency power sources.	Any power with a frequency of as little as 1% above or below the standard 50hz risks damaging equipment and infrastructure if it persists. Small frequency deviations (i.e. -0.5 Hz on a 50 hz network) will result in automatic loadsheddi ng or other control actions to restore system frequency.	
Electrical line noise:	Electrical line noise is defined as radio frequency interference (RFI) and electromagnetic interference (EMI).	Line noise is caused by arc welders, switch mode power supplies, fault clearing devices, ground not dedicated or isolated, etc.	Causes unwanted effects in the circuits of computer systems. Data corruption, erroneous command functions, loss of command functions, improper electrical wave shapes, etc.	
Brownouts:	A brownout is a steady lower voltage than required or stipulated.	An example of a brownout is when some utilities cannot always meet the supply requirements and must lower the voltage to limit maximum power during peak electrical demand periods.	When this happens, systems can experience glitches, data loss and equipment failure.	

Problem	Description:	Causes	Effects/impact	Typical wave diagram
Blackouts:	A power failure or blackout is a zero-voltage condition that lasts for more than two electrical cycles.	A blackout may be caused by a tripped circuit breaker, power distribution failure or utility power failure where the electricity demand is higher than the available supply.	A blackout can cause data loss or corruption and often equipment damage.	
Harmonics:	Harmonics, or harmonic distortion, occur where currents and voltages are distorted and deviate from the normal sinusoidal waveforms in an electrical system.	Harmonics are caused by switch mode power supplies (some variable speed drives, etc.), non-linear loads, etc.	High neutral currents, overheated neutral conductors, overheated transformers, voltage distortion and loss of system capacity. Causes a sharp increase in the zero sequence current, and therefore increases the current in the neutral conductor. Creates excessive heating in induction motors. Harmonic currents cause losses in the AC system and can produce resonance in the system. Under resonant conditions, instrumentation and metering can be negatively affected.	
Unbalance:	Unbalanced voltages usually occur because of variations in loads on the electrical system. Perfectly voltage-balanced circuits are not possible in the real world	When the load (from equipment) on one or more of the electrical phases is different than the other(s), unbalanced voltages will appear. This usually occurs with various single phase loads being connected to the utility 3 phase supply, and not ensuring the load drawn from the system is the same on all three phases	Causes serious problems, particularly to 3-phase motors and other inductive devices. It also causes an increase in neutral currents which in turn cause line losses. A most damaging effect is that winding insulation (motors, transformers, solenoids, etc.) life is approximately halved for every 10°C increase in winding temperature. A 5.4% unbalanced voltage would result in an expected life of only 6% of normal due to the additional 40°C rise - a serious, substantial and unacceptable reduction. A motor with a service factor of 1.15 can typically withstand an unbalance of about 4.5% provided it is not operated above its nameplate rating. In this case the 5.4% unbalance is excessive even for a 1.15 service factor motor.	
Voltage regulation:	Voltage regulation is the magnitude of voltage changes from the sending to the receiving end of a transmission or distribution line. Similarly between various points of a facility electrical installation.	A poor Power Factor, brownouts, unstable generators, overburdened distribution systems and the start-up of heavy industrial equipment on the system influences the voltage regulation.	Some customers may observe unexpected effects like higher voltages at light loads, and lower voltage at high loads. This may also cause system lock-up, system shut down, data corruption, data loss, reduced performance and loss of system control.	
Power factor:	Power Factor is a measure of how efficiently electrical power is consumed.	The presence of inductive loads is the major cause of poor power factor. Inductive loads include motors (fans, pumps, etc.), solenoids, and relays.	Loss of profits and increased costs.	 Source: jshavaluk.blogspot.com

Impact of the above:

Prescription, high maintenance, equipment, or electricity bills:	Cause, Maintenance, Equipment And Electricity Bills are a function of the maintenance methodology, equipment and installation choices, QOS and the consumption of electricity.	High Maintenance and Power Bills are often due to damaged or incorrect electricity circuitry, incorrectly sized equipment, incorrect installations, insufficient control or management systems and a poor QOS.	Effects/Impacts, High maintenance cost. Damaged equipment. Wastage of electrical energy. All the aforementioned may be due to incorrectly sized equipment, incorrect installations and poor QOS. All result in loss of profits.

The impact of a non-conforming QOS

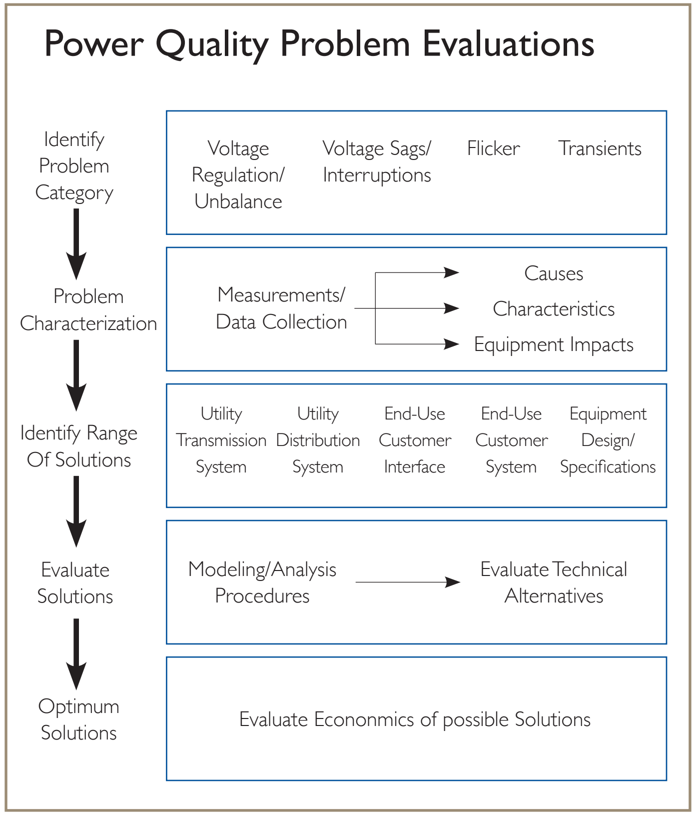
A poor QOS can reduce the speed and quality (increased rejects) of production in businesses, it can damage or destroy sensitive equipment, affect the electrical power infrastructure and supply stability and it can effect efficiencies and increase costs. Bad power quality also results in increased energy consumption through increased losses. Momentary voltage fluctuations can disastrously impact production - extended outages have a much greater impact.

The impact of embedded generation equipment, such as renewable generation equipment on QOS

Some forms of renewable energy have elements of instant uncontrollability at various levels such as wind speeds for wind turbines, water levels for hydro and cloud cover for Photovoltaic (PV) systems which will influence the quality of the power supply.

With the increased penetration of embedded renewable generator systems, specifically Photovoltaic (PV) and Wind generator systems, the traditional operation of power systems is drastically changing predominantly due to fluctuations in power supply. These fluctuations occur during the ramp-up (increase in power output) and ramp-down (decrease in power output) stages of a renewable system.

The output of PV systems, which cover the majority of renewable system installations in the market, is directly related to the intensity of the sun on the solar panel where the intensity is grossly influenced by cloud cover and shading. In the case of PV, ramp-up occurs during sun rise, cloud cover leaving or an inverter reactivating after a trip and ramp-down occurs at sun set, the arrival of cloud cover or inverters tripping. In a PV system the QOS is also affected by the quality of the inverter and battery backup system. The intermittency of wind, caused as a result of pressure changes that result in wind blowing or not, can also cause ramp-up and ramp-down of wind turbines the same way as water flow rate will cause changes in the generation rate of a hydro generation plant. These fluctuations in output are carried through to the network causing instability. Therefore, cloud cover or the drop in wind speed could result in a total, or a large percentage of plant loss, thus resulting in the loss of a generator on the network, causing a poor QOS. Furthermore, the power electronics in these power sources (inverters, converters etc) add further QOS issue which need to be factored into their design.



Power QOS solutions

Power quality evaluation process:
As described throughout this brochure; power quality problems include a wide range of different phenomena - each of which may have a number of different solutions that can be used to improve the power quality and equipment performance. The general steps associated with investigating many of these problems, with the interaction between the utility supply system and the customer facility, are provided in the process diagram (on the left). This process includes steps that are usually required in a power quality investigation, along with the major considerations that must be addressed at each step. The general process must also consider whether the evaluation involves an existing power quality problem, a problem that could result from a new design or from proposed changes to the system.

Protecting and improving power quality is a critical business worldwide. There are many choices of equipment and manufacturers dependent on your facility needs.

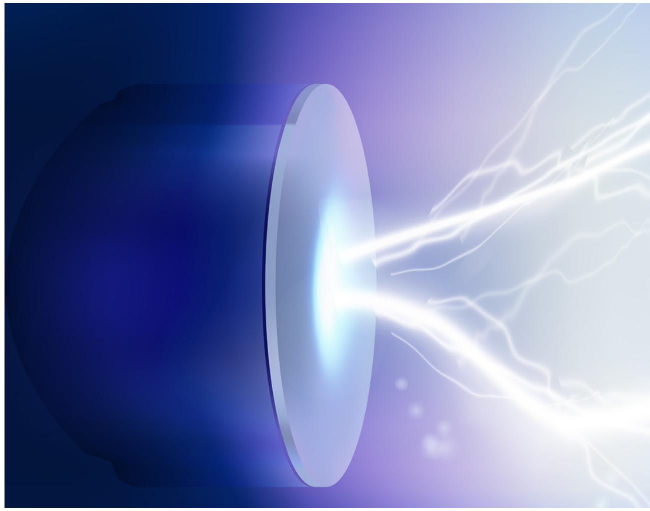
The most expensive solution is however not always the right solution for the problem. Both correct identification of the power problems and the consumer's needs should be identified and addressed to ensure an accurate assessment.

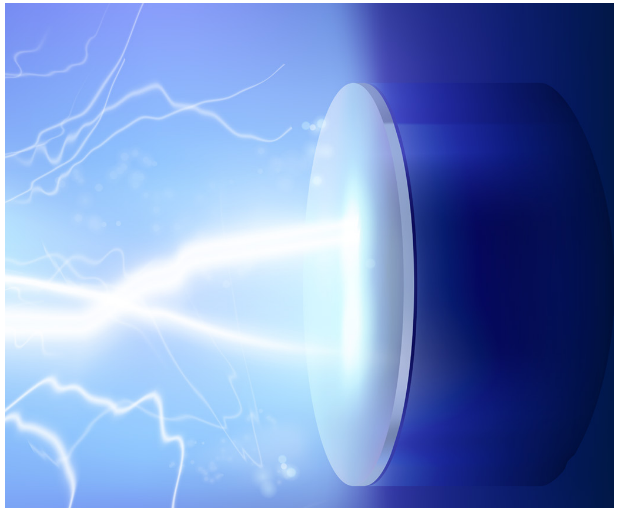
There are 7 basic categories of solutions to some of the power quality problems and effects, each having different capabilities, strengths and weaknesses:

1. **Surge suppressors**: A surge suppressor is often used to shield important, but less critical or highly sensitive equipment from Voltage surges or spikes. It is also used to complement more comprehensive power protection solutions. These are passive electronic devices that protect against transient high-level voltages. However, low frequency surges (slow changes at 400 Hz or less) can be too great for a surge suppressor attempting to clamp that surge.

2. **Voltage regulators / power conditioners:** A voltage regulator may also be referred to as a "power conditioner", "line conditioner", "voltage stabiliser", etc. Regardless of the terminology used, these devices are all essentially the same in that they provide voltage regulation and one or more additional power quality-related functions. A voltage regulator can correct and/or provide protection from power problems such as:

   I. Over or under voltage
   II. Voltage Fluctuations





III. Sags and Dips
IV. Line Noise and Swells
V. Phase Imbalance
VI. Short Circuits
VII. Brownouts and Surges

3. **Uninterruptable power supplies (UPS) - three basic types of UPSs exist**:
   - 3.1 **Standby (or offline):** The standby (UPS) - consists of a battery/power conversion circuit and a switch that senses irregularities in the electricity from the utility. The equipment to be protected is usually directly connected to the primary power source, and the power protection is available only when line voltage dips to the point of creating an outage. Some off-line UPSs include surge protection circuits to increase the level of protection they offer.
   - 3.2 **Line interactive**: Line interactive UPSs are hybrid devices that offer a higher level of performance by adding better voltage regulation and filtering features to the standby UPS design.
   - 3.3 **Double conversion (or online)**: Double conversion UPSs, often called "online", provide the highest level of power protection and are an ideal choice for shielding an organisation's most important computing and equipment installations. This technology uses the combination of a double conversion (AC to DC or DC to AC) power circuit and an inverter, which continuously powers the load to provide both conditioned electrical power and outage protection.

4. **Power factor correction**: Power factor correction means bringing the poor power factor of an AC circuit closer to the correct level (as close to one as possible) by using equipment which absorbs or supplies reactive power to the AC circuit. Generally, power factor correction can be done by using capacitors and/or synchronous motors in the affected circuit. A poor power factor can be corrected by adding parallel capacitors of the correct size and voltage to the relevant equipment or electricity supply. Series capacitors may be installed to "remove" the effect of leakage inductance that limits the output current. As electrical systems are becoming more complex and more electronics are being introduced, it is crucial to specify power quality equipment that can react at the correct speed and quantum.

5. **Generators**: Generators are machines that convert mechanical energy into electrical energy. They are usually used as a backup power source for a facility's critical systems such as elevators and emergency lighting in case of a blackout. However, they do not offer protection against utility power problems such as overvoltage and frequency fluctuations, and although most can be equipped with automatic switching mechanisms, the electrical supply is interrupted before switching is completed. Therefore it cannot protect against the damage that blackouts can cause to expensive equipment and machinery. If you use a generator to back up to a UPS during extended blackouts, the suggestion is that it be rated at about 2½ times higher than the UPS it is backing up.

6. **Harmonic filters**: Harmonic filters are series or parallel resonant circuits designed to shunt or block specific harmonic currents. A harmonic filter is a device that reduces, or mitigates, harmonics to tolerable/regulated levels. They are commonly used to lower harmonic distortion to the levels detailed in standards, recommendations (IEEE 519) and requirements for Harmonic Control in Electrical Power Systems. They reduce the harmonic currents flowing in the power system from the source and thereby reduce the harmonic voltage distortion in the system. Such devices are expensive and should only be used when other methods to limit harmonics have also been assessed. The application of

filters in a given situation is not always straightforward. The filters themselves may interact with the system or with other filters to produce initially unsuspected resonances. Hence in all but the most simple cases harmonic studies should be used to assist with the determination of the type, distribution and rating of the filter group. Two types of harmonic filters exist:

6.1 **Passive**: a series of inductors and capacitors try to filter the high frequency components, preventing them from reaching the mains. This has the disadvantage that it is also affected by the external harmonics on the mains and can overheat. It is impossible to prevent the external harmonics from being absorbed by the filter and it is very hard to size such filters because the effect of the external harmonics cannot easily be identified and designed for.

6.2 **Active**: a semiconductor based active front end (similar to a VSD active front end) detects and measures the harmonic frequencies generated by the drives and injects equal amounts of harmonic current in anti-phase to the generated harmonics. These cancel out, resulting in an acceptable level of harmonics. One of the greatest benefits of these units is that they are controlled and current limited and will not exceed their thermal limits. This means that if the harmonics should increase the unit will not overheat, although it might not remove all of the primary harmonics. Some active units provide a broad adjustment over four or five harmonic frequencies whilst others allow individual frequencies to be targeted.

7. **Active power filter**: Active power filters (APF) can perform the job of harmonic elimination. Active power filters can be used to filter out harmonics in a power system which are significantly below the switching frequency of the filter. The most effective emerging active power filters are:

7.1 **Shunt active power Filter**: The shunt active power filter, with a self-controlled DC bus, has a topology similar to that of a static compensator (STATCOM) used for reactive power compensation in power transmission systems. Shunt active power filters compensate load current harmonics by injecting equal but opposite harmonic compensating currents. In this case the shunt active power filter operates as a current source injecting the harmonic components generated by the load but phase shifted by 180°. The basic compensation principle: A voltage source inverter (VSI) is used as the shunt active power filter. This is controlled so as to draw or supply a compensating current (Ic) from or to the utility, such that it cancels current harmonics on the AC side, i.e. this active power filter (APF) generates the non-linearities opposite to the load non-linearities. Different waveforms are involved, i.e. the load current, desired source current and the compensating current injected by the shunt active power filter which contains all the harmonics, to make the source current purely sinusoidal. This eliminates the current harmonics and compensates the reactive power.

7.2 **Series active power filter**: Series active power filters were introduced to operate mainly as voltage regulators and as harmonic isolators between non-linear load and the utility system. The series connected filter protects the consumer from an inadequate supply voltage quality. This type of approach is especially recommended to compensate for voltage unbalances and voltage sags from the AC supply and for low power applications and represents economically attractive alternatives to UPSs, since no energy storage (battery) is necessary and the overall rating of the components is smaller. The series active filter injects a voltage component in series with the supply voltage and therefore can be regarded as a controlled voltage source, compensating voltage sags and swells on the load side. In many cases, the series active filters work as hybrid topologies with passive LC filters. If passive LC filters are connected in parallel to the load, the series active power filter operates as a harmonic isolator, forcing the load current harmonics to circulate mainly through the passive filter rather than the power distribution system. The main advantage of this scheme is that the rated power of the is a small fraction of the load kVA rating, typically 5%. However, the apparent power rating of the series active power filter may increase in case of voltage compensation. Hence, series active filters work to compensate the voltage harmonics on the load side. Series filters can also be useful for fundamental voltage disturbances. The series filter during an occasional supply voltage drop keeps the load voltage almost constant and only small instabilities and oscillations are observed during initial and final edges of disturbance.

Basic compensation principle: A voltage source inverter (VSI) is used as the series active power filter. This is controlled so as to draw or inject a compensating voltage (Vc) from or to the supply, such that it cancels voltage harmonics on the load side, i.e. this active power filter (APF) generates the distortions opposite to the supply harmonics. The different waveforms, i.e. source voltage, desired load voltage and the compensating voltage injected by the series active power filter which contains all the harmonics, makes the load voltage purely sinusoidal. Series active power filters therefore eliminate supply voltage harmonics.

7.3 Shunt-series active power filter (UPQC): As the name suggests, the shunt-series active power filter is a combination of a series active power filter and a shunt-active power filter described before. The shunt-active filter is located at the load side and can be used to compensate for the load harmonics. On the other hand, the series portion is at the source side and can act as a harmonic blocking filter. This topology is called a Unified Power Quality Conditioner. The series portion compensates for supply voltage harmonics and voltage unbalances, acts as a harmonic blocking filter and dampens power system oscillations. The shunt portion compensates load current harmonics, reactive power and load current unbalances. In addition, it regulates the DC link capacitor voltage. The power supplied or absorbed by the shunt portion is the power required by the series compensator and the power required to cover losses. General UPQC consists of the combination of a series active and shunt-active filter. The main purpose of the series active filter is harmonic isolation between a sub-electrical system and a distribution system. In addition the series active filter has the capability of voltage flicker/imbalance compensation as well as voltage regulation and harmonic compensation at the utility-consumer point of common coupling (PCC). The main purpose of the shunt active filter is to absorb current harmonics, compensate for reactive power and negative sequence current, and regulate the DC link voltage between both active filters.

Since renewable energy forms part of the energy mix on a network, various methods are developed globally to deal with the quality of supply issues. Some methods are technology orientated and some just a means of responsible connection methods.

In the case of renewable energy the following should be done to improve QOS:

Aggregation: Where PV systems are connected to the same power network but positioned various distances apart from each other to such an extent that the same weather conditions do not influence all systems at once, the intermittence will reduce fluctuations in the generated load. **Connection criteria**: Interconnection requirements need to be stipulated to ensure a smoother response to frequency deviation of PV systems when over frequency occurs.

Inverter settings or capabilities (Supporting frequency and voltage control): Smarter inverters are able to engage a smoother disconnection by operating according to a predefined characteristic curve and will assist with lesser immediate disruptions in frequency and voltage on the network. A further possibility is the local control for PV inverters connected to distribution grids by using built-in active and reactive power control capabilities. It is therefore possible for the inverter to lower its impact on the distribution grid by limiting its rise in voltage due to high solar irradiation, thus assisting in higher PV penetration levels.

Storage: The higher the renewable penetration levels become on a power grid, the more dependent it becomes on fast charge and discharge power and energy sources to alleviate the fluctuation in frequency and voltage. Battery storage systems have regulating and load following (balancing) service capabilities and are able to contribute to smoothing the fluctuation.

General measures to improve QOS:

- **Connection criteria:** To ensure quality of supply both the utility and the customer have grid connection obligations in meeting the set parameters in terms of Voltage dips, Frequency, Voltage harmonics and Voltage flicker. All electricity generators need to adhere to the NRS 048-2 standard and it is incumbent on the customer or designer to take these into consideration in the design and specification of the facility. The customer's obligation is to not interfere with an efficient and economical supply to other customers of Eskom by adhering to the Harmonics (IEC61727), Flicker (SANS61000-3-3) for <= 16A per phase and (SANS61000-3-5) for >16A per phase, Voltage unbalance (inverters larger than 4.6kVA must be balanced three phase) and the number of rapid Voltage changes which must not exceed the limits set out and stipulated in the standards mentioned.

- **Smart grids**: A smart grid is an electrical supply network that uses digital communications technology to detect and react to local changes in usage, has the ability to change the uncontrollability of variable renewable energy sources to a more controllable environment.

Metering, monitoring and identifying QOS issues

Power quality monitoring and assessments vary according to the type of facility and the equipment being used. The following provides some guidance on how to go about assessing or monitoring the power quality.

Power quality monitoring is the process of gathering, analysing and interpreting raw power measurement data into useful information. It involves, over a period of time, process of measuring voltage and current of the supply and examining its waveforms, although the analysis is not limited to these two quantities. It includes inspection of wiring, grounding and equipment connections. The monitoring

of power supply helps to detect present and potential power quality problems. Power quality monitoring helps to improve facility power quality performances.

Power utilities should ensure that the quality of power supplied is within specified and acceptable standards and be ready to normalise any technical issues that affect the quality of power delivered. However, the latest advances in electronic and communication technologies offers opportunities for metering and monitoring all sizes and complex power systems in an efficient manner. Facility owners and utilities can use this advantage to collect data on different parts of power networks, assess the performance of the system and respond accordingly while then enabling solutions to QOS issues.

Good power monitoring instruments provides useful information and reliable analysis about power quality. Examples may include:

- An in-plant power monitor which gives the voltage profile and wave shape of the supply for voltage sag, swell, voltage variation and harmonic level evaluation.
- Digital Fault Recorders trigger on fault events and records current, voltage and their waveform at the time of the fault for analysis.
- Disturbance analysers can measure a wide variety of power disturbances from a very short duration transient voltage to long duration under-voltages and outages.

- Flicker Meters are measuring devices to evaluate the level of voltage flicker annoyance. Flicker meters are special analysers which models the chain of (flickering) events between a typical 60W incandescent lamp and the average human eye and brain observation. It has two main parts, the first part attempting to simulate the behaviour of the set lamp-eye-brain and the second part focusing on statistical analysis of the instantaneous flicker perception circuit monitor which provides accurate, reliable and fast alarm detection and multiple levels of information on each power quality issue to help identify the source and cause of a problem including harmonic power flows, flickering, sag and swell.
- Oscilloscopes measure voltage and current and can display harmonics present in all power quality events.
- A Power Quality Meter and Analyser is an instrument similar to an oscilloscope but more suitable and more versatile for power quality monitoring. It can measure frequency, voltage, current, phase rotation, apparent and real power (Power Factor), harmonics and can also record and store the measured data and analyse it with PC-software.

High maintenance, equipment or electricity bills:

Generally 5 main QOS-related actions can be undertaken to reduce high maintenance, equipment, or electricity bills. These include:

8.1 Understanding the facility equipment loads and needs;

8.2 Repairing damaged, unbalanced or incorrect circuits or wiring;

8.3 Protecting, managing or unplugging electronic devices;

8.4 Use correctly sized equipment;

8.5 Ensuring the electricity system throughout the facility is stable and of an acceptable quality by correcting any distortions.

Energy advisory services

Eskom's role is to aid the client with basic information in the decision-making process. Thereafter the Eskom Advisor will fulfil the role of energy advisor as part of the team that the business selects.

Optimise your energy use

Eskom's Energy Advisors, in regions across South Africa, offer advice to business customers on how to optimise their energy use by:

- Understanding their energy needs
- Understanding their electrical systems (including QOS) and processes
- Investigating the latest technology and process developments, including electric heating and drying systems
- Analysing how to reduce energy investment costs
- Optimising energy use patterns in order to grow businesses and industries

Call 08600 37566, leave your name and number and request that an Energy Advisor in your region contacts you. Alternatively, e-mail an enquiry to **advisoryservice@eskom.co.za**.

A comprehensive book "Volume 8: Power Quality In Electrical Power Systems. A Holistic Approach" is available from Eskom at a cost: https://www.eskom.co.za/AboutElectricity/EskomPowerSeries/Pages/Volume8_PowerQualityInElectricalPowerSystems.aspx

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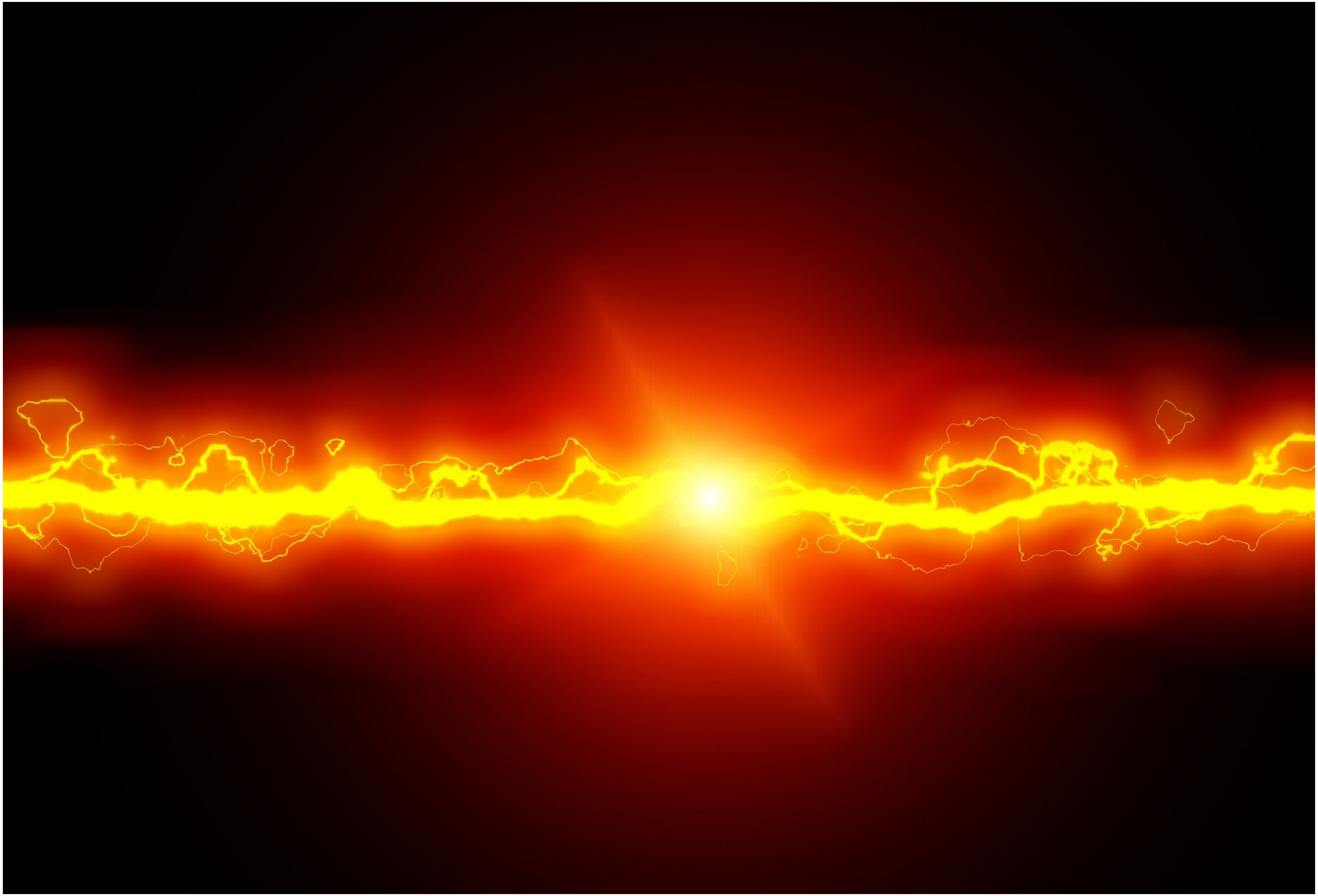

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