A CUSTOMER'S
TECHNICAL GUIDE TO

POWER QUALITY

MERALCO

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This manual aims to help you understand the factors that affect power quality within the user system. Expert tips on load-side troubleshooting and insights on equipment compatibility serve to guide you in preventing potential power quality issues.

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Power Quality and the Power Supply Chain

What is Power Quality?

Any electrical equipment relies on a power supply to work, just as a regular vehicle relies on fuel to drive. And just as the performance of your car depends on the quality of the fuel used, the performance of electrical equipment is significantly reliant on the quality of the electricity fed into it. Regular quality fuel may be enough to power most cars, but if your machine is high-performance, it may also need premium quality fuel to achieve peak performance.

And as with fuel, the quality of electrical power varies extensively—this is often overlooked, and as a result, most are caught unaware when power quality problems arise.

In power systems, **power quality** refers to the **quality of voltage**, including its frequency and the resulting current, that are measured at the connection point of the end-users within the distribution system. It is defined by a set of boundaries or limits that allows most electrical systems to function properly. In the Philippines, this is bound by the **Philippine Distribution Code (PDC)**.

Power Quality Parameter	Limits	Reference
Voltage Variation	+/- 10% of Supply Voltage Supply Voltages of Meralco: 230V, 400V, 460V, 13.2kV, 13.8kV, 34.5kV, 69kV and 115kV	PDC Section 3.2.3
Frequency Variations	60 Hz +/- 0.5% Within 59.7 Hz to 60.3 Hz	PDC Section 3.2.2.2
Harmonics (Voltage and Current)	Within 5%	PDC Section 3.2.4.4
Voltage Unbalance	Within 2.5%	PDC Section 3.2.5.2
Flicker Severity	1.0 for short term 0.8 for long term	PDC Section 3.2.6.4

Why is Power Quality important?

As a power system operator for the grid and the distribution utility or a facilities manager of a commercial building, a manufacturing plant, a hospital, or any other vital institutions making use of sensitive electrical equipment, the proper and consistent functioning of all your equipment may make or break your operations.

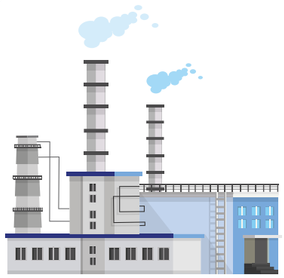
This is where good power quality is critical: to optimize the performance of the grid and distribution facilities, as well as customer facilities, in order to:

- ***Avoid disruptions during operation***
- ***Reduce operation and maintenance costs***
- ***Extend equipment life***
- ***Manage all other associated risks***

Power Quality and the Power Supply Chain

The Power Quality Chain

The Power Supply Chain is a network of stakeholders involved in the production of power **(Generation)**, transmission of power **(Transmission)**, delivery of power **(Distribution)** and consumption of power **(End-users)**. An issue at any point in the supply chain can cause a whole lot of problems that will affect all in the chain.

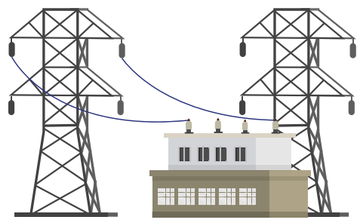


GENERATION

Power generation companies produce power from a variety of sources such as coal, natural gas, hydro, geothermal, and oil-based fuels. Base load power plants may vary in their power generating capacity from as low as 12 MW to 1000 MW.

Meralco sources its power from independent power producers (IPPs), private generation companies, and the Wholesale Electricity Spot Market (WESM). In the Philippines, the generation sector is a competitive and open industry. The top power producers include San Miguel Global Power, Aboitiz Power, DMCI Holdings and First Gen.

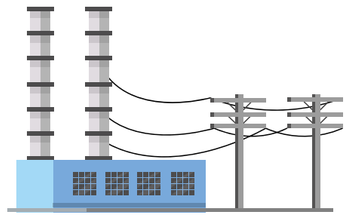
Generation charges comprise **almost 52.5%** of your total electric bill. These charges are pass-through charges and go directly to the power generation companies.



TRANSMISSION

Generated power is then fed to the grid to be transmitted over long distances. The Philippines' transmission grid is operated by the **National Grid Corporation of the Philippines (NGCP)**, a privately owned corporation. As the system operator of the grid, NGCP balances the demand and supply of electricity to efficiently serve all its customers that are part of the power supply chain: This includes power generators, private distribution utilities, cooperatives, government-owned utilities, ecozones, industries, and directly connected customers. The transmission sector is a regulated industry.

An average of 10.1% of your total electricity bill goes to transmission and remitted to NGCP. As with generation, this is a pass-through charge.

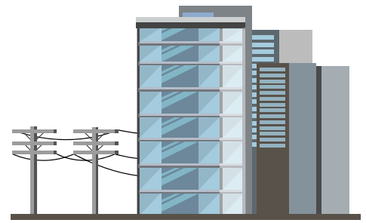


DISTRIBUTION

Distribution is the final stage in the delivery of electricity before it goes to the end-users. Distribution utilities (DU) convert the high voltage power from the grid to usable voltage levels for the consumers.

In the Philippines, distribution utilities are owned by electric cooperatives, private corporations or local government units granted with an executive franchise to operate in certain jurisdictions. The distribution sector is also a regulated industry.

Distribution charges comprise an **average of 20%** of your total electricity bill.

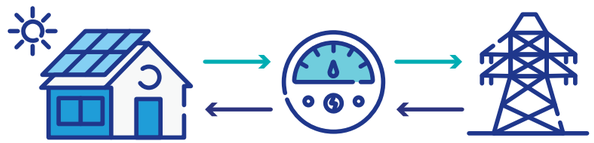


END USERS

End-users are the receiving end of the power supply chain. This includes residential, commercial, industrial customers and vital institutions like hospitals, military and police camps, government offices, and other mission-critical establishments. Streetlights are also included in this category.

- Residential
- Commercial
- Industrial
- Public (Streetlights)

Solar and Other Renewable Energy Sources + Net Metering Customers



Customers can also install renewable energy (RE) facilities with a capacity of up to 100kW within their properties. Under the Net Metering Program, any excess RE electricity can be exported back to distribution utilities like Meralco, and its corresponding value will be given as credits to the customer's next bill.

Customers with above 100kW capacity and customers whose capacity is solely for their own use are not covered by the Net Metering Program, but fall under the Zero Export (Own-Use). These customers are still required to inform the distribution utility about such installations to ensure that the RE facility does not inadvertently leak energy back to the grid. In both cases, the customers are referred to as prosumers (producer-consumer).

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End Users & Distribution Utilities: Working Hand-in-Hand

Power quality problems can affect everyone in the power supply chain. It may be caused by natural occurrences such as typhoons and lightning strikes, accidents, or by poorly maintained electrical equipment. If left unchecked or unattended, these disturbances and power quality issues can lead to downtime, or worse: complete shutdown, poor service, data errors, shortened equipment life, and increased service calls and complaints.

All these translate to lost time, productivity, and additional costs that may cause problems for the system or DU operator, facility manager and the customers. That is why it is very important that the End-users and DUs coordinate closely to avoid power-related concerns.

Scope and Responsibilities

As an End-user, it is essential to know the following points that define the responsibilities of each stakeholder to ensure good power quality.

Distribution Utilities (DU)

1. Ensure that the power supply falls within the power quality parameters as defined by the PDC.
2. Monitor and safeguard the distribution facilities—lines, poles, transformers, meters, and other DU assets—from potential issues and hazards.
3. Conduct studies and implement facility upgrades and improvements.
4. Handle maintenance and emergency situations such as broken or leaning poles and downed wires.
5. Attend to customer reports.
6. Interconnect prosumers and other embedded generators.

End-users

1. Ensure that electrical equipment are compatible with supply voltages and frequency.
2. Inform the DU of any changes in electrical connection that can potentially affect the service, such as load increases or upgrades. (This is also indicated in the contract for electric service signed by the customer with Meralco under Section 4: ‘To notify the Company of any increase or increase of my connected load.’)
3. Report possible hazards to distribution facilities, as well as emergency situations such as broken or leaning poles, downed wires, line sparks, and other similar electrical line problems.
4. For those with construction activities, ensure that safe distances to power lines are observed ***(vertical: 4.0 m, horizontal: 3.0 m)*** and inform the DU if there is a need for safety intervention such as line conductor covers and pole support.

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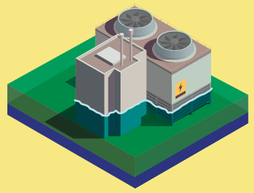
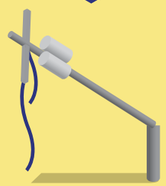
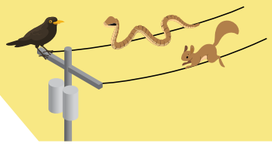
End Users & Distribution Utilities: Working Hand-in-Hand

Power Supply Hazards

Power quality hazards may be caused by natural occurrences, normal wear-and-tear, or by accidents. These hazards can not only disrupt power—these can also cause physical injuries, endanger lives, and cause damage to property. The following are examples of hazards that need to be reported and addressed immediately or after it is safe to do so.

HAZARDS	ACTION/RESPONSE	
	DISTRIBUTION UTILITY (DU)	CUSTOMER
 **THUNDERSTORMS AND LIGHTNING STRIKES**	• Immediate repair of affected lines • Installation of lightning arresters, ensuring that their ground connection is within required parameters for lightning strikes	Report any event of line troubles to the DU.
 **FLOODING**	• Maintain and upgrade substations affected by floods • Implement flood control and mitigation measures	Flooded communities or areas cannot be powered up until the water subsides. Customers are advised to shut down or turn off their main breakers and switches in the event of flooding without waiting for the DU to cut off power. Report flooded areas to the DU and local authorities.
 **BROKEN OR LEANING POLES**	• Repair broken or leaning poles immediately • Install pole support	Report to DU immediately after detection of any broken or leaning poles.
 **BROKEN, DOWNED, OR SPARKING WIRES**	• Repair line wire issues and remove foreign objects such as entangled kites • Prune tree branches nearing power lines	Avoid flying kites near power lines. Report any faulty wires to DU immediately upon detection.
 **ANIMALS**	Install snake cones, bird spikes, and other animal protection devices	Report to DU immediately upon detection.

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End Users & Distribution Utilities: Working Hand-in-Hand

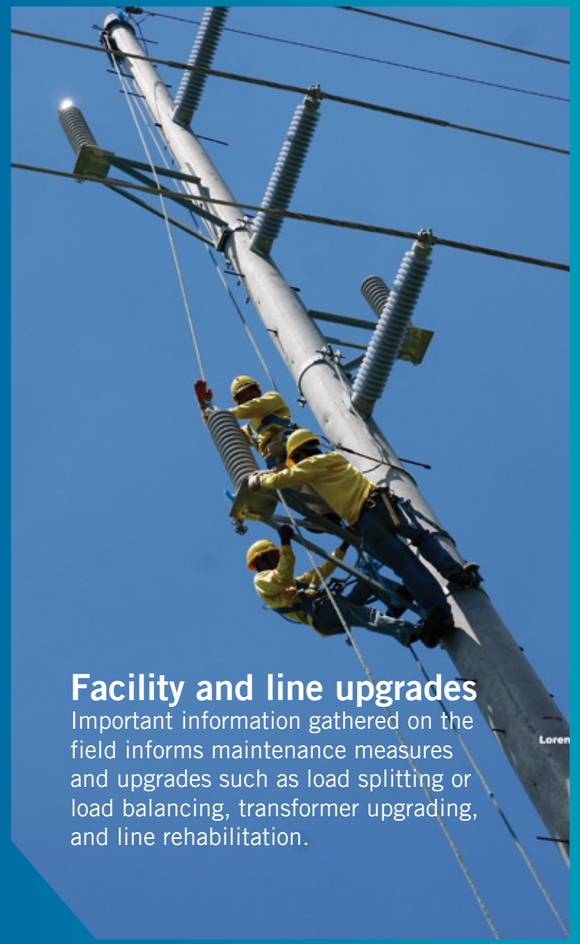
How Distribution Utilities Ensure Reliable Power

Aside from acting on and mitigating hazards on power lines, as your DU, Meralco diligently performs line monitoring, maintenance checks, and all other measures to ensure the reliability, integrity, and quality of power delivered to customers.

MERALCO IN ACTION: PROVIDING RELIABLE POWER

System reliability checks and studies

System reliability checks are done through consistent monitoring of circuits and loads of distribution transformers.



Facility and line upgrades

Important information gathered on the field informs maintenance measures and upgrades such as load splitting or load balancing, transformer upgrading, and line rehabilitation.

Distribution impact studies

Distribution impact studies are done to find out the potential effect of Solar PV installations and other renewable energy sources on the distribution system. These studies also determine if there is a need to upgrade any distribution facility to accommodate any RE generation from users.

Hazard prevention

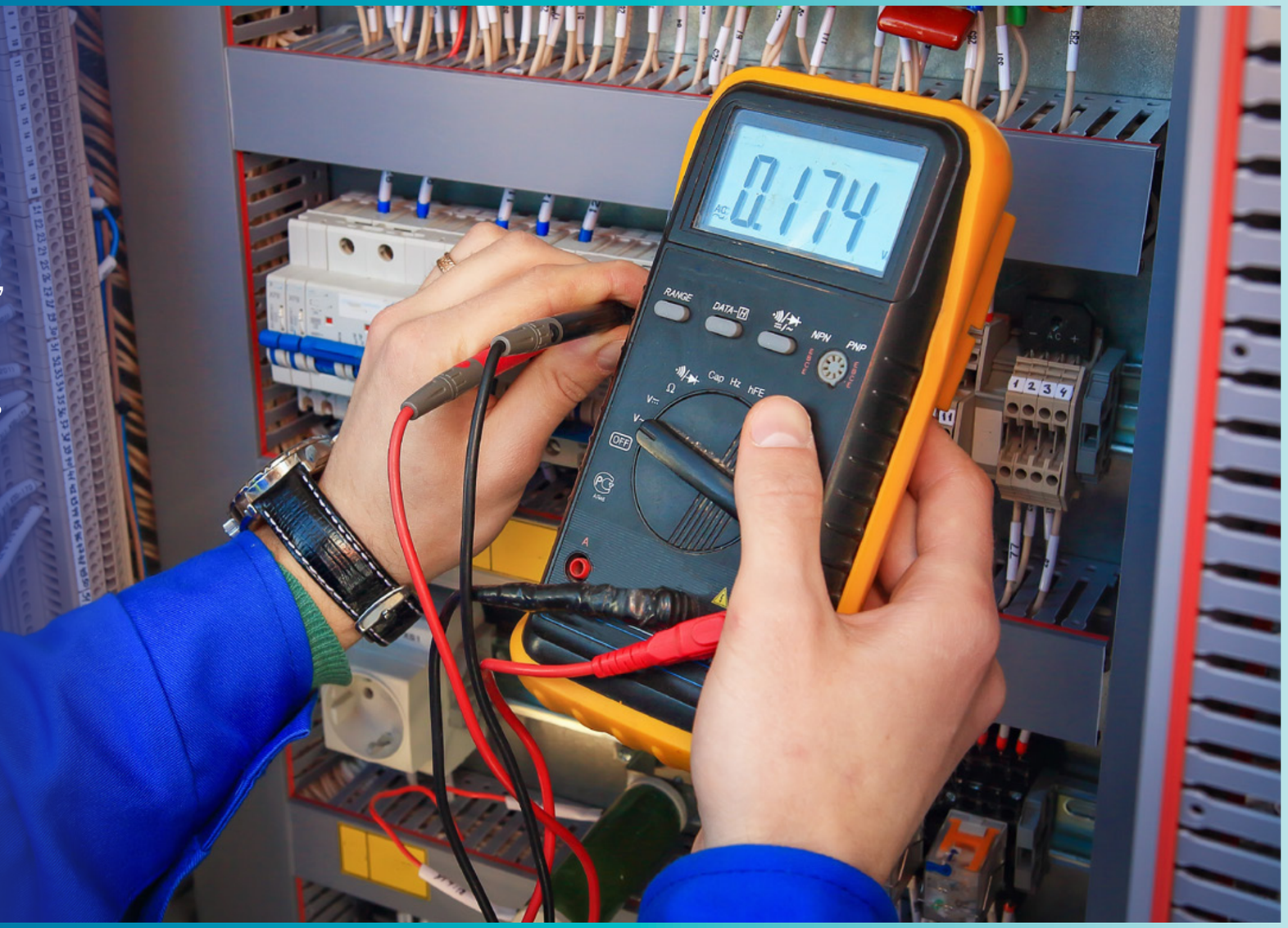
Some examples of hazard prevention measures include:

- Installation of conductor covers, more commonly done during construction activities. Contractors and developers play a critical role in assessing and anticipating this need before construction works start, and in informing the owners.
- Installation of snake cones and bird spikes to prevent certain animals from touching or getting near power lines, which may cause tripping.
- Tree pruning activities to prevent tripping power lines.
- Removal of foreign objects on power lines, such as entangled kites.

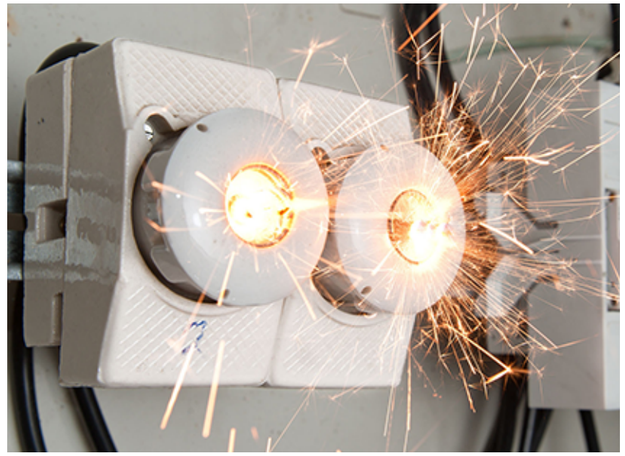
Your quick guide to Common Power Quality Problems

Power quality problems point to these common (and oftentimes detrimental) issues that are costing customers significantly in terms of energy waste, damage to equipment, and facility downtimes or shutdown:

- Voltage sags, swells and transients
- Voltage unbalance
- Voltage harmonics
- Grounding issues



Common Power Quality Problems



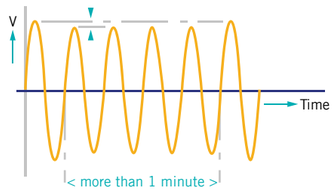
Voltage regulation: Variations, sags and swells

Voltage supplied by the DU through the customer's main supply or service entrance is at an average of any of the following voltages:

Low voltages: 230V, 400V, and 460V
Higher voltages: 13.2KV, 13.8KV, 34.5KV, 69KV, and 115KV

However, this voltage supply **goes up and down** depending on demand changes. If you have highly voltage-sensitive equipment, the Philippine Distribution Code (PDC) prescribes that customers should ensure that their equipment will be able to operate reliably and safely within the +/-10%voltage limits *(PDC 3.2.2)* during normal conditions.

UNDER-VOLTAGE



A long-duration voltage variation where the RMS (root-mean-square) value of the voltage is ≤ 90% of the nominal voltage for a time > 1 minute.

◄ MANIFESTATIONS ►

- Actuation of undervoltage relay
- Dropping out of motor controllers
- Increased heating losses
- Plant shutdown

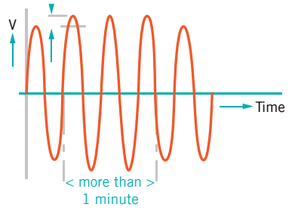
◄ TYPICAL CAUSES ►

- Inappropriate tap settings of transformer
- Switching off of capacitor banks
- Overloaded customer facilities

◄ SOLUTIONS ►

- Adjust transformer tap settings
- Use a constant voltage transformer (CVT) for voltage regulation
- Add transformer capacity
- Install an uninterruptible power supply (UPS)
- Install a voltage regulator

OVER-VOLTAGE



A long-duration voltage variation where the RMS is ≥ 110% of the nominal voltage for a time > 1 minute.

◄ MANIFESTATIONS ►

- Actuation of overvoltage relay
- Immediate malfunction of electronic devices
- Accelerated aging of equipment insulation
- Plant shutdown

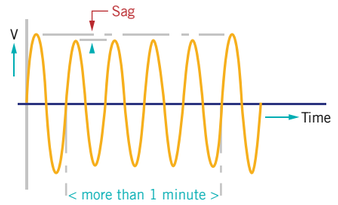
◄ TYPICAL CAUSES ►

- Inappropriate tap settings of transformer
- Load dropping

◄ SOLUTIONS ►

- Adjust transformer tap settings
- Use a constant voltage transformer (CVT) for voltage regulation
- Install an uninterruptible power supply (UPS)
- Install a voltage regulator

VOLTAGE SAG



A short-duration voltage variation where the RMS (root-mean-square) value of the voltage decreases to between 10-90% of the nominal value for a time greater than half a cycle but not exceeding 1 minute.

◄ MANIFESTATIONS ►

- Electronic equipment malfunction
- Unnecessary operation of protective relays
- Nuisance tripping of adjustable speed drives
- Plant shutdown

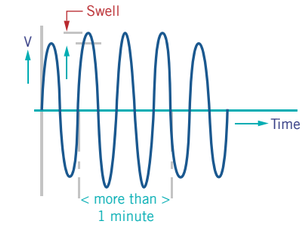
◄ TYPICAL CAUSES ►

- Switching on large electric motors
- Remote network faults (transmission or distribution)

◄ SOLUTIONS ►

- Use a constant voltage transformer (CVT) or static voltage regulator for voltage regulation
- Use a motor-generator set (M-G set) for voltage adjustment
- Install a dynamic voltage restorer (DVR)
- Install Flywheel Storage Systems
- Use an uninterruptible power supply (UPS)
- Use static transfer switch

VOLTAGE SWELL



A short-duration voltage variation where the RMS value of the voltage increases to between 110-180% of the nominal value for a time greater than half a cycle but not exceeding 1 minute.

◄ MANIFESTATIONS ►

- Unnecessary tripping of overvoltage relay
- Nuisance tripping of adjustable speed drives
- Plant shutdown

◄ TYPICAL CAUSES ►

- Switching off large electrical loads
- Switching on capacitor banks
- Remote system faults

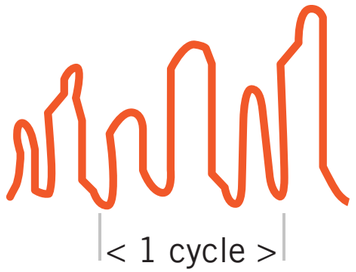
◄ SOLUTIONS ►

- Use a constant voltage transformer (CVT) or static voltage regulator for voltage regulation
- Use a motor-generator set (M-G set) for voltage adjustment
- Install a dynamic voltage restorer (DVR)
- Install Flywheel Storage Systems
- Use an uninterruptible power supply (UPS)
- Use static transfer switch

Common Power Quality Problems

Flicker

See a visible change in the brightness of a lamp? Flicker is the changing of light intensity caused by fluctuations in voltage. Power flickers can be caused by lightning strikes, damaged electrical equipment, and objects such as tree branches and other foreign objects contacting power lines.



A fluctuation of the luminance or spectral distribution of a light source with time.

MANIFESTATIONS

- Light flicker
- Video monitor distortion
- Nuisance tripping of electrical equipment

TYPICAL CAUSES

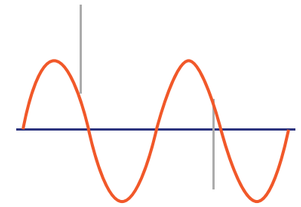
- Operation of arc furnaces
- Electrical equipment being constantly switched on and off

SOLUTIONS

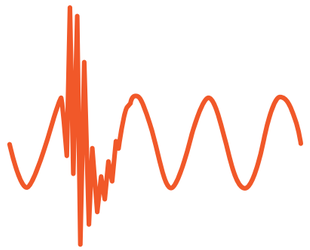
- Use a thyristor switched capacitor bank
- Connect to dedicated lines and transformers

Transients

Transients are sudden, high frequency deviations from the normal voltage or current levels. This can also be caused by lightning strikes, load switching, and faulty wiring or arcing ground faults. Transients typically cause component failure and data errors on the equipment.



Impulse Transients



Oscillatory Transients

High-frequency overvoltages caused by lightning, switching of capacitor banks or cables, current chopping, arcing ground faults, ferroresonance, and other related phenomena.

MANIFESTATIONS

- Accelerated aging of equipment insulation
- Capacitor failure
- Data errors

TYPICAL CAUSES

- Lightning
- Capacitor switch

SOLUTIONS

Use a Transient Voltage Surge Suppressor (TVSS)

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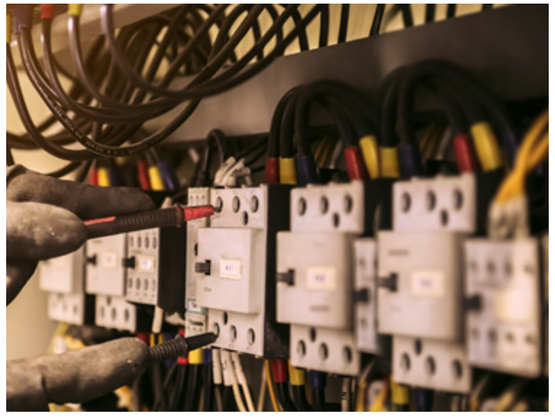
Common Power Quality Problems

Voltage Unbalance

Customers with a three-phase supply need a balanced three-phase voltage not only to enable the operation of their equipment, but in order to operate the equipment efficiently. A balanced three-phase voltage supply is closely tied to the operating efficiency of three-phase motors.

In 3-phase services, voltage unbalance may occur when single-phase electrical loads are unevenly distributed in each of the phases. This can create increased heating of 3-phase motors and one phase out issues.

The maximum deviation from the average of the three phase voltages divided by the average of the three phase voltages, expressed in percentage.



MANIFESTATIONS

- Increased heating of three-phase motors
- Overloaded neutral conductors

TYPICAL CAUSES

- Unbalanced distribution of single-phase electrical loads
- Unstable system neutral grounding
- One phase out power supply

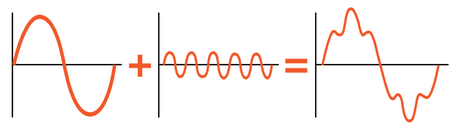
SOLUTIONS

- Redistribute single-phase loads
- Tighten loose connections
- Ensure system neutral grounding

Voltage Harmonics

Voltage harmonics are voltages that have frequencies that are multiples of the fundamental frequency (60 Hz). Simply put, harmonics **are waveform distortions**. They are caused by non-linear loads which draw non-sinusoidal currents from an essentially sinusoidal voltage source (AC). Examples of non-linear loads are variable speed drives and equipment that use an electronic power supply such as computers, LED lights, and television sets.

Voltage Total Harmonic Distortion (VTHD) and Current Total Demand Distortion (ITDD) must not exceed the allowable **5% tolerance** as this can cause abnormal heating, inaccurate metering measurements, and equipment breakdown.



Sinusoidal voltages and currents that have frequencies that are integral multiples of the fundamental frequency.

MANIFESTATIONS

Motors and generators
- Increased heating due to iron and copper losses
- Vibration and jerkiness of rotation
- Inability to accelerate to rated speed

Transformers
- Abnormal heating
- Iron and copper losses
- Stray flux

Capacitors
- Resonance
- Dielectric failure

Power cables
- Abnormal heating
- Insulation stress and failure
- Increased heating due to skin effect

Electronic equipment
- Misfiring of solid state switches
- Zero crossing distortion resulting in failure

Metering
- Inaccurate measurement

Switchgear and relaying
- Increased heating
- Shortened insulation life

Power system
- Increased heating resulting in power losses
- Failure of control and monitoring systems

Communication
- Telephone interference
- Residual/ground return currents

TYPICAL CAUSES

- Operation of arc furnaces and other arc discharge devices such as fluorescent lamps
- Operation of resistance welding
- Excitation of magnetic core
- Operation of synchronous machines
- Operation of variable speed drives
- Misoperation of solid state switches that modulate current
- Use of switched mode power supplies or electronic power supplies
- Operation of rectifiers and inverters

SOLUTIONS

- Use line or load side reactors
- Use passive or active filters
- Increase transformer capacity
- Use K-rated transformers
- Use large-sized cable

Common Power Quality Problems

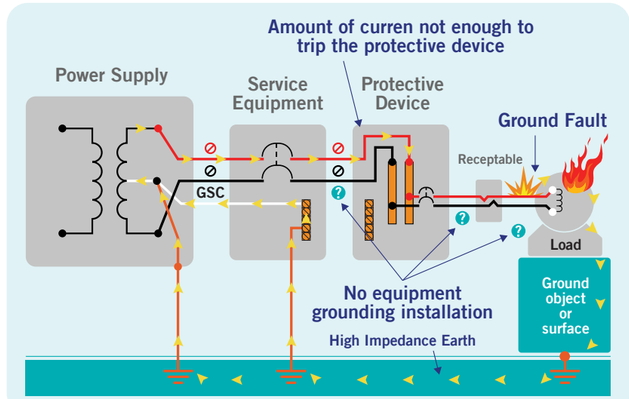
Grounding issues

Grounding is a basic electrical safety connection by which an electrical circuit or equipment is connected to the earth or some conducting body of relatively large extent that serves as the ground. Grounding problems are caused by missing equipment grounding or ungrounded equipment, as well as multiple neutral-to-ground connections. Many power quality issues can be solved with proper grounding.

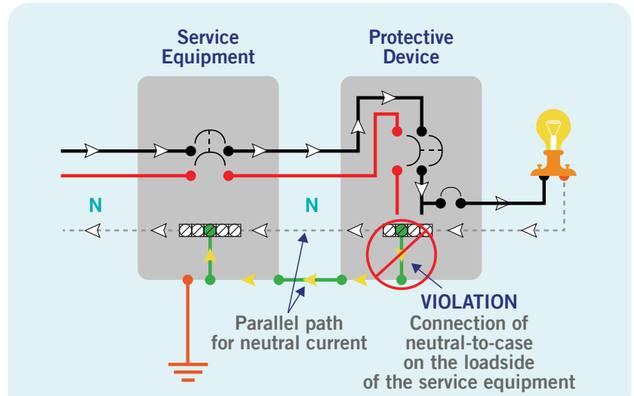
Avoiding grounding problems

- Comply with requirements and guidelines on wiring and grounding covered in the latest edition of the Philippine Electrical Code.
- Follow recommended design and installation practices based on international standards such as the IEEE (Institute of Electrical and Electronics Engineers) and IEC (International Electrotechnical Commission).

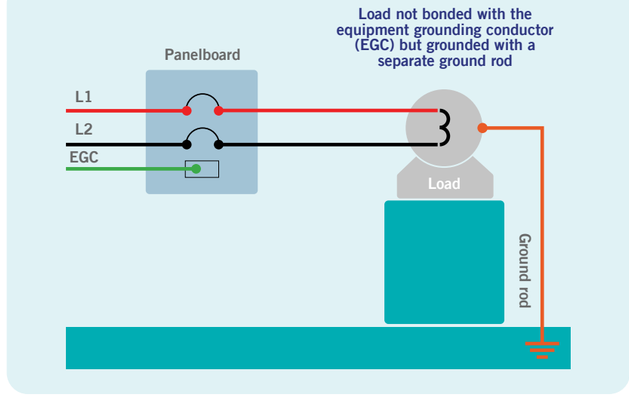
Typical grounding problems



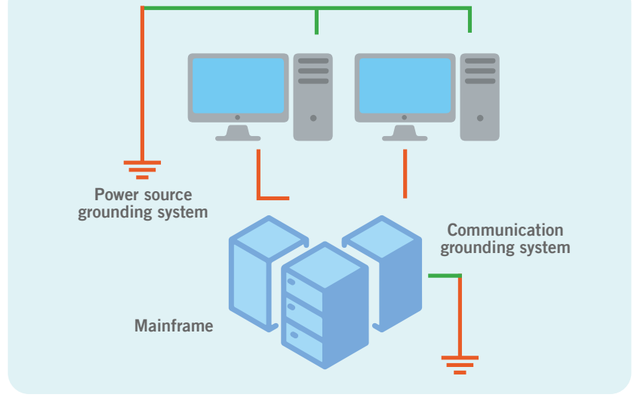
- Missing equipment grounding conductors



- Multiple neutral to ground connections



- Ungrounded equipment (selfgrounding)



- Ground loops

Your Checklist for Maintaining Good Power Quality

Begin power quality management during the planning and design stages of facility construction. The cost of solving power quality problems increases over time—so the most cost-effective way to solve a power quality problem is to prevent it.

- *During the planning stage:* Identify the equipment, machinery, or motors to be installed and their corresponding electrical load requirements.
- *During the design phase:* Ensure that proper wiring, grounding, and equipment matching have been considered.

Track and monitor power disturbances in your facilities. This would help you understand your power usage, and help you develop a database of common power quality problems and solutions for easier diagnosis and troubleshooting in the future.

Ensure that your voltage settings are compatible with the relevant power quality standards found in the Philippine Distribution Code. Your equipment's voltage rating should match your distribution utility's supply voltage standards. A mismatch is unsafe. For more information on these parameters, please visit **www.gmcdmc.ph** or **www.erc.gov.ph**.

Conduct a power quality assessment of your facilities before adding new equipment or electrical load. This will tell you if your electrical system is still capable of supporting additional electrical load requirements. If you need to modify your electrical system to match your additional electrical load requirements, contact your distribution utility.

Ensure that your equipment's voltage threshold settings are within your distribution utility's supply voltage variations. Most equipment can tolerate a certain amount of voltage variations. However, if these variations are beyond the range recommended by the equipment manufacturer, you need to bring your equipment back to the supplier or manufacturer so they can adjust your equipment's settings, or else your equipment may malfunction.

CONSIDERATIONS WHEN ACQUIRING EQUIPMENT

• Voltage rating
To avoid problems of overvoltage or undervoltage, only purchase equipment whose voltage rating is compatible with your distribution utility's supply voltage standards.

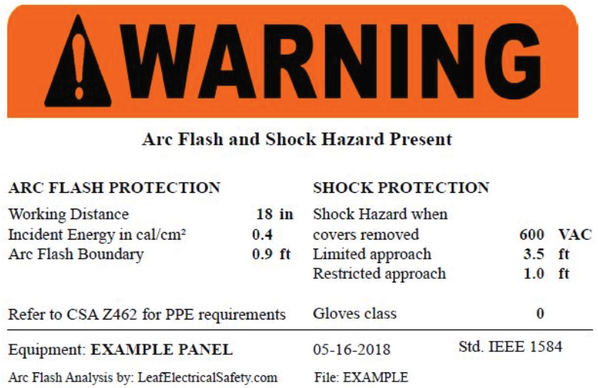
• Voltage tolerance
Based on the Philippine Distribution Code, a distribution utility's supply voltage can vary up to ±10% of its normal operational voltage. To avoid voltage problems, buy equipment that has the same voltage tolerance as that of your distribution utility.

• Frequency
Operating equipment at a mismatched frequency will shorten its lifespan and accelerate breakdown.

• Built-in power conditioning equipment
To ensure better voltage tolerance, purchase equipment with **auto-volt** features. For elevators, consider those with built-in reactors and filters that protect from inrush current and limit harmonics from the electrical load.

For safety, put up warning signs to identify potential hazards on panel boards, switch boards, transformer enclosure doors, and other energized control panels. At a minimum, the labels should contain a "WARNING" at the top of the label, the nominal system voltage, available incident energy and the corresponding working distance. Warning labels are necessary to ensure all workers and employees are well informed and safe while working around energized equipment.

Sample warning label



MERALCO

Customer Success Stories

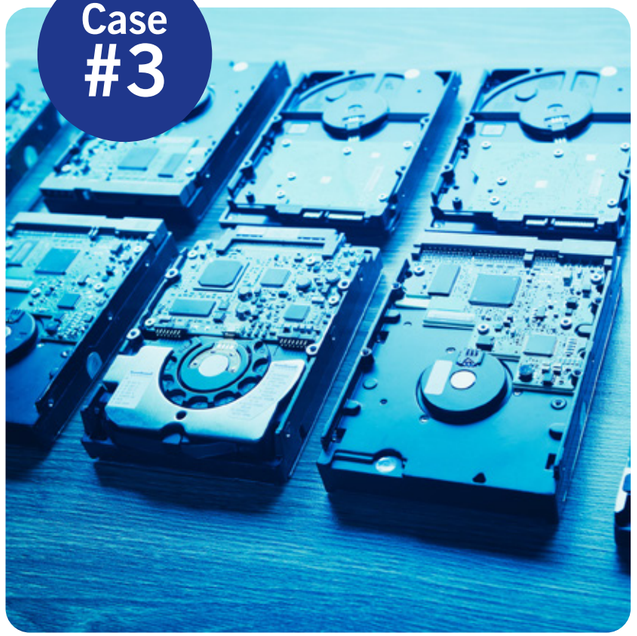
Case #1

The customer relies on large fans to aerate their production area. During a voltage sag, these fans would stop operating, and restarting them was a pain as their controls are located in hard-to-reach locations. A **voltage hold-in sag device** was connected to the fan controls as suggested by the utility engineers. Since then, the fans have been able to operate continuously despite suffering from the occasional voltage sag event.

Case #2

A customer's equipment's wiring components were melting, and excessive harmonics was suspected as the cause. Utility engineers proved the voltage harmonics to be within allowable limits. After further study, it was found out that **induction heating** was the culprit behind the melting of the wiring components.

Case #3



The computer hard disks of the customer's production machines frequently broke down with no apparent cause. Utility engineers recommended correcting the customer's **grounding system** after inspecting the facility. After the grounding system was improved, hard disk failures became a thing of the past.

Customer Success Stories

Case #4

A cold storage facility with new blast freezing technology allegedly complained of voltage unbalance that affected the operation of their compressors. The Energy Solutions Team validated the quality of supply voltage and found out that all power quality parameters, including voltage unbalance, were all within prescribed limits.

Further investigation showed that the **sensitive Current Unbalance setting** of the compressor is triggering the tripping. As a result of the study, the Energy Solutions Team recommended the adjustment of the Current Unbalance setting of the compressors. After the adjustment, the nuisance tripping problem was eliminated, and the facility now maintains continuous compressor operation.

When supplying new equipment, equipment suppliers usually set the equipment protection to a sensitive/tight setting in order to overprotect their equipment from damage. However, it often results in nuisance tripping which may hamper operation.

Case #5

A customer managing a residential condominium which is served at 400V L-L and 230V L-N complained of an overvoltage problem that resulted in frequent tripping of their fire pumps, which was later found out to be rated at 380V. The Energy Solutions Team validated that the quality of supply voltage was within prescribed limits and should not cause any malfunction to properly-matched equipment.

Given that there is a **voltage mismatch problem** between the 400V supply and 380V rated equipment, the team recommended possible solutions such as transformer tap-setting adjustment, installation of an isolation transformer, and the installation of an AVR.

It is the responsibility of the end-user (i.e. business owners and facilities managers) to ensure that their equipment voltage thresholds are within the distribution utility's supply voltage variations. Therefore, the end-user should find ways to bridge the voltage incompatibility between the rating of their equipment and the utility supply voltage.

However, in this case, since transformer tap setting adjustment is the most cost-effective among the possible solutions, Meralco accommodated the adjustment of the transformer tap setting.

Case #6

A manufacturing company requested Meralco's assistance on frequent unexplained tripping of their circuit breaker. A significant downtime loss is incurred every time the breaker trips.

Excessive heating was also observed on the subject breaker. Thermographic scanning and spot measurement conducted by the Energy Solutions Team eliminated the possibility of overloading conditions, and revealed that the location of the hotspot could possibly be due to **mechanical issues**. The customer validated the team's findings with the equipment supplier and the circuit breaker was replaced.

Regular preventive and predictive maintenance can help you avoid costly downtime due to equipment failure.

GLOSSARY

Ampere
A unit of measurement for the rate of current flow.

Capacitor
A passive two-terminal electrical component used to store energy electrostatically in an electric field. The forms of practical capacitors vary widely, but all contain at least two (2) electrical conductors (plates) separated by a dielectric (i.e. insulator).

Distribution System
The system of wires and associated facilities that belong to a franchised Distributor. It extends between the delivery points on the transmission, sub-transmission system, or generating plant connection and the point of connection to the premises of the End-user.

Frequency
The period of a sine wave measured in terms of the number of cycles per second.

Grid
The high-voltage backbone system of interconnected transmission lines, substations, and related facilities for the conveyance of bulk power. Also known as the Transmission System.

Inverter
An electronic device or circuitry that changes direct current (DC) into alternating current (AC). The input voltage, output voltage and frequency, and overall power handling are dependent on the design of the specific device or circuitry.

Long-Duration Voltage Variation
A variation of the root-mean-square (RMS) value of the voltage from nominal voltage for a time greater than one (1) minute.

Nominal Voltage
A nominal value assigned by a distribution utility to a circuit or system of a given voltage class for convenient designation.

Outage
An extended interruption of AC power.

Power Factor
The ratio of work performed (active power or watts) to the energy supplied by a system (apparent power or volt-amperes). It is a measurement of electromagnetic losses and not of efficiency.

Power Quality
The quality of the voltage, including its frequency and resulting current, measured in the grid, distribution system, or any user system.

Rectifier
An electrical device that converts alternating current (AC), which periodically reverses direction, into direct current (DC), which flows only in one direction. Rectifiers have many uses, often found serving as components of DC power supplies and high-voltage DC power transmission systems.

Reliability
The probability that a system or component will perform a required task or mission within a specified time in a specified environment. It is the ability of a power system to continuously provide service to its customers.

Root-mean-square (RMS) Value
The square root of the arithmetic mean of the squares of the instantaneous value of a quantity taken over a specified time interval and a specified bandwidth; all values of voltage and current in alternating current (AC) discussions, unless otherwise stated. In practical terms, it is the value given by the direct current (DC), which when flowing through a given circuit for a given time period, produces the same heat as that of the alternating current (AC) when flowing through the same circuit at the same time.

Short-Duration Voltage Variation
A variation of the root-mean-square (RMS) value of the voltage from nominal voltage for a time less than one (1) minute.

Shutdown
The condition of a piece of equipment when it is de-energized or disconnected from the system.

Transformer
An electrical device or equipment that converts voltage.

Thyristor
A solid state semiconductor device that may be used in power-switching circuits, relay-replacement circuits, inverter circuits, logic circuits, etc.

Voltage
The unit of measurement of electrical pressure in an electrical system measured in volts; also considered electromotive force; the measured presence of an electrical field.

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