

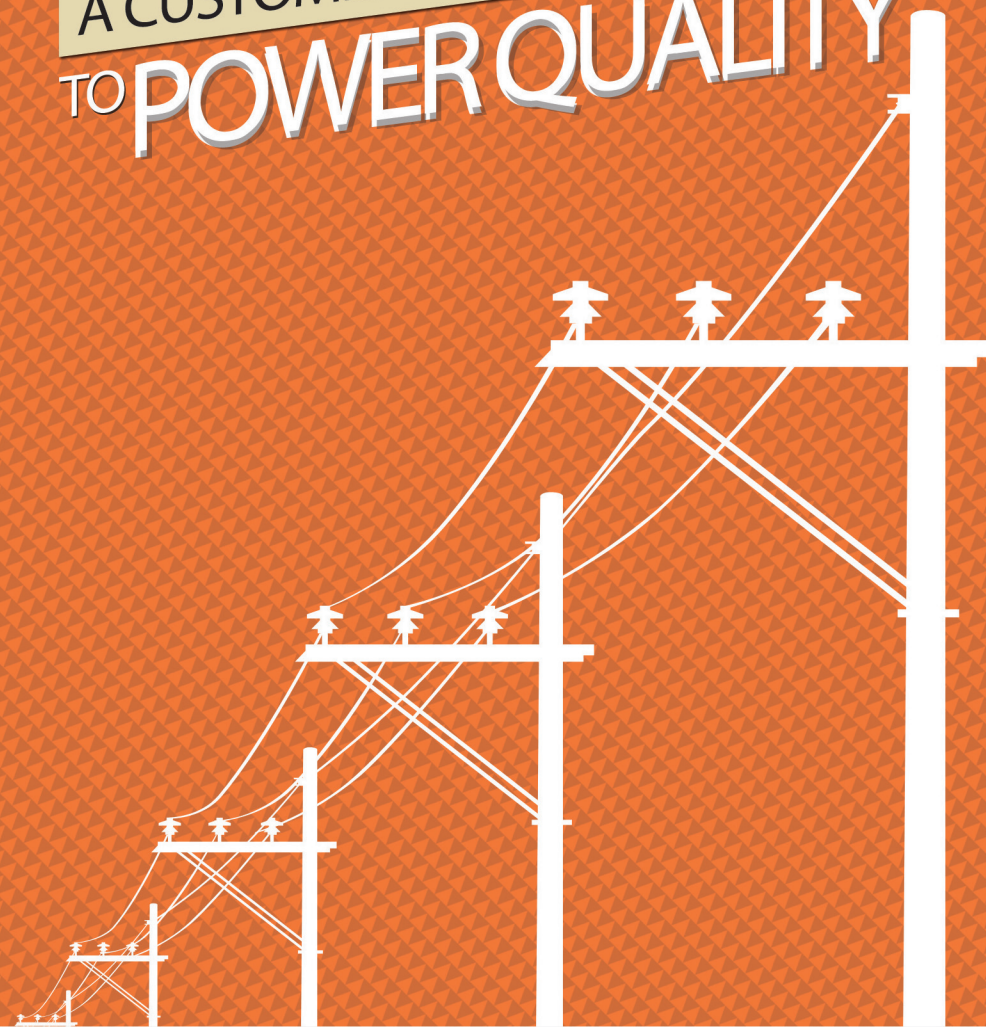


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2014



A CUSTOMER'S TECHNICAL GUIDE TO POWER QUALITY



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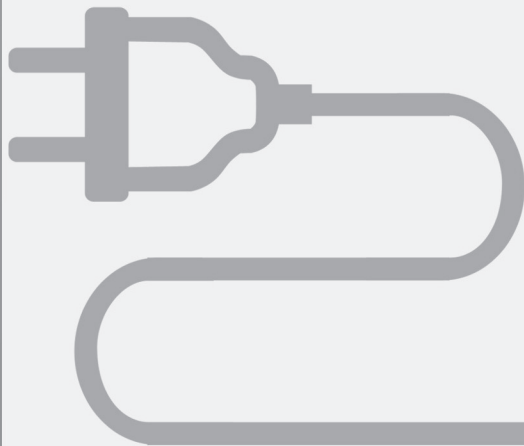
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This manual aims to help you understand the variables that affect power quality within the user system. The expert tips provided on load side trouble shooting and insights on equipment compatibility should serve to guide you in preventing potential power quality issues.



Power Quality & Supply Chain

POWER QUALITY

The quality of voltage, including its frequency and the resulting current, that are measured in the Grid, Distribution System, or any User System.

POWER SUPPLY CHAIN

The power supply chain is the network of stakeholders involved in power generation, transmission, distribution and end users. Ensuring power quality entails the concerted effort of all stakeholders. Power quality problems caused by one stakeholder can result in power disturbances that affect the rest.



POWER GENERATION

Power generation is the first process in the delivery of electricity to the end users. Bulk electricity is produced using a variety of fuel types such as, coal, natural gas, hydro, geothermal, oil-based and wind/biomass fuels. Meralco sources its power from independent power producers, 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.

In 2013, generation charges comprise almost 57% of the total electricity bill of a Meralco customer. These charges go directly to the generation companies.



TRANSMISSION

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

In 2013, an average of 9% of the total electricity bill is attributed to transmission and remitted to NGCP.



DISTRIBUTION

Distribution is the final stage in the delivery of electricity to the end-user. Distribution utilities deliver power from high voltage transmission grids to commercial and industrial establishments and residential end users. In the Philippines, the distribution utilities are owned by electric cooperatives, private corporations, or local government units granted with an exclusive franchise to operate a Distribution System. Distribution sector is a regulated industry.

In 2013, the distribution charges comprise an average of around 18% of the total electricity bill.



END USERS

The **business owner / facilities manager** is responsible for managing power costs and addressing power quality issues in their electrical system.

The **building contractor** is responsible for constructing safe and efficient electrical facilities that conform to set regulatory standards.



The **equipment operator** is responsible for safely operating and maintaining electrical equipment.



The **equipment supplier** is responsible for recommending equipment, whose voltage ratings are compatible with the distribution utility's supply voltage standards.



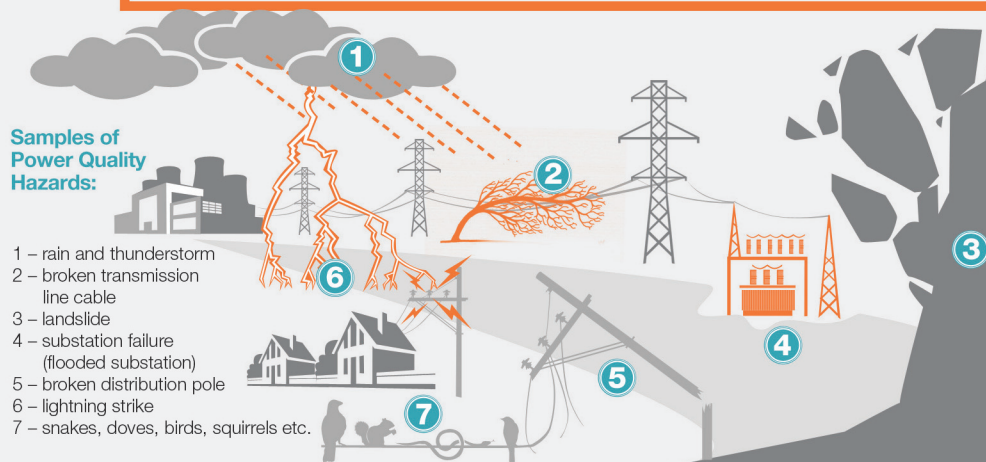
End Users & Distribution Utilities: Working Hand-in-Hand

The **electric meter** serves as the point of connection between the power distribution system and the user system. Operating and maintaining electrical facilities and systems right up to the meter or supply side are the responsibility of distribution utilities, while those beyond the meter or load side are that of end users.

Ensuring power quality requires the compatibility of the user system in accordance to the relevant power quality standards contained in the (PDC) Philippine Distribution Code.

Distribution utilities must maintain system reliability, and meet power quality standards, as mandated by the Energy Regulatory Commission and as prescribed in the Philippine Distribution Code.

In the Philippines, the distribution system is primarily overhead and is exposed to hazards that may affect power quality and reliability. As a responsible distribution utility, Meralco regularly conducts system reliability studies, upgrades and line maintenance such as tree pruning and installation of bird spikes and snake cones.

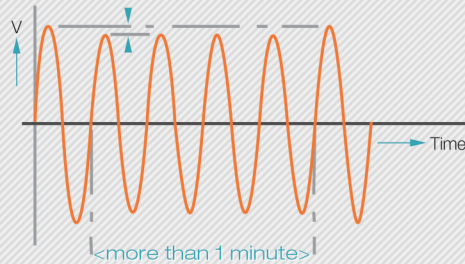


End users must understand the characteristics, capabilities and limitations of the distribution utility's power supply, and match their equipment's parameter settings and user system design with the distribution utility's service requirements and standards shown below:

Power Quality Parameter	Limit/s	Reference
Frequency Variations	Within 59.7 to 60.3 Hz	Philippine Distribution Code Section 3.2.2.2
Voltage Variations	Within plus or minus 10% of the contracted supply voltage Service Voltages for Meralco: 230V, 400V, 460V, 13.2kV, 13.8kV, 34.5kV, 69kv & 115kV	Philippine Distribution Code Section 3.2.3
Voltage Total Harmonics Distortion	Within 5%	Philippine Distribution Code Section 3.2.4.4
Voltage Unbalance	Within 2.5%	Philippine Distribution Code Section 3.2.5.2
Flicker Severity	1.0 for short term; 0.8 for long term	Philippine Distribution Code Section 3.2.6.4

Common Power Quality Problems

UNDER VOLTAGE



a. Definition

A Long Duration Voltage Variation where the RMS (root-mean-square) value of the voltage is less than or equal to 90 percent of the nominal voltage for a time greater than one minute.

b. Manifestation

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

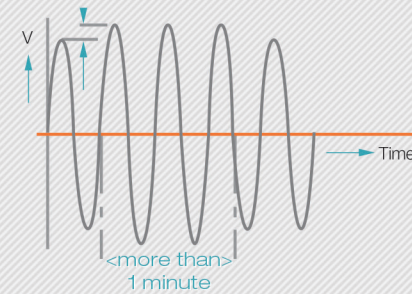
c. Typical Causes

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

d. Solutions

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

OVER VOLTAGE



a. Definition

A Long Duration Voltage Variation where the RMS (root-mean-square) value of the voltage is greater than or equal to 110 percent of the nominal voltage for a time greater than one minute.

b. Manifestation

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

c. Typical Causes

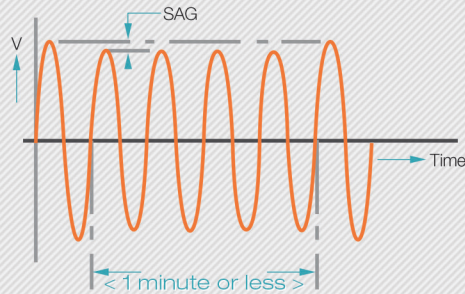
- Inappropriate tap settings of transformer
- Dropping of load

d. Solutions

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

Common Power Quality Problems

VOLTAGE SAG



a. Definition

A Short Duration Voltage Variation where the RMS (root-mean-square) value of the voltage decreases to between 10 percent and 90 percent of the nominal value, for a time greater than $\frac{1}{2}$ cycle but not exceeding one minute.

b. Manifestation

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

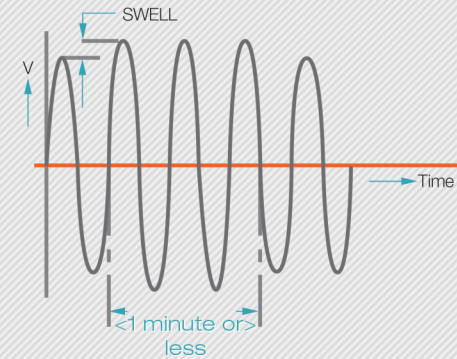
c. Typical Causes

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

d. Solutions

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

VOLTAGE SWELL



a. Definition

A Short Duration Voltage Variation where the RMS (root-mean-square) value of the voltage increases to between 110 percent and 180 percent of the nominal value, for a time greater than $\frac{1}{2}$ cycle but not exceeding one minute.

b. Manifestation

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

c. Typical Causes

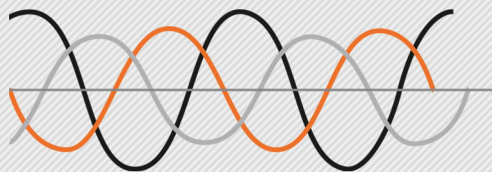
- Switching off of large electrical loads
- Switching on of capacitor bank
- Remote system faults

d. Solutions

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

Common Power Quality Problems

VOLTAGE UNBALANCE



a. Definition

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

b. Manifestation

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

c. Typical Causes

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

d. Solutions

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

FLICKER



a. Definition

Impression of unsteadiness of visual sensation induced by a light stimulus whose luminance or spectral distribution fluctuates with time.

b. Manifestation

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

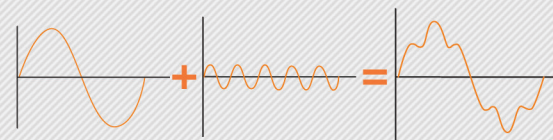
c. Typical Causes

- Operation of arc furnaces
- Constant switching on and off of electrical equipment

d. Solutions

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

HARMONICS



a. Definition

Sinusoidal voltages and currents having Frequencies that are integral multiples of the fundamental Frequency.

b. Manifestation

Motors and Generators

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

Transformers

- Abnormal heating
- Iron and copper losses
- Stray flux

Capacitors

- Resonance
- Dielectric failure

Electronic Equipment

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

Metering

- Inaccurate measurement

Power Cables

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

Switchgear and Relaying

- Increased heating
- Shortened insulation life

Power System

- Increased heating, resulting in power losses
- Control and monitoring system failure

Communication

- Telephone interference
- Residual/ground return currents

c. Typical Causes

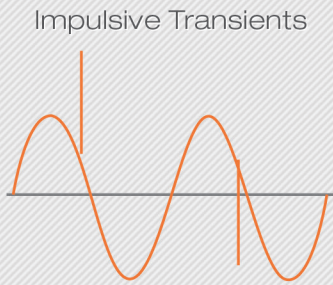
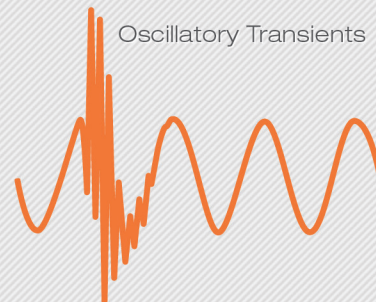
- Operation of arc furnaces and other arc discharge devices, such as fluorescent lamps
- Operation of resistance welding
- Excitation of magnetic core
- Operation of synchronous machines
- Operation of variable speed drives
- Mis-operation of solid state switches that modulate the current
- Use of switched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

d. Solutions

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

Common Power Quality Problems

TRANSIENTS



a. Definition

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

b. Manifestation

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

c. Typical Causes

- Lightning
- Switching of capacitor

d. Solutions

- Transient Voltage Surge Suppressor (TVSS)

Other factors that may affect Power Quality

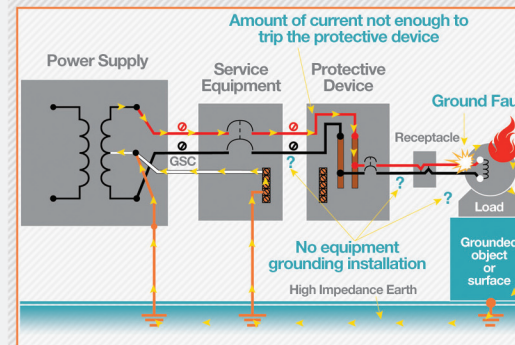
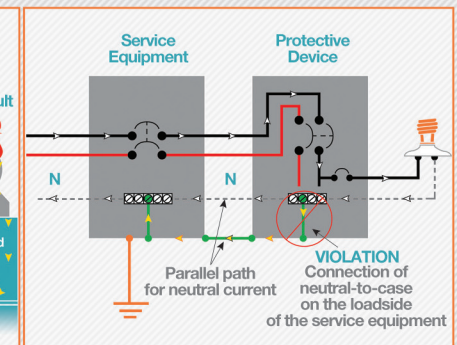
GROUNDING

a. Definition

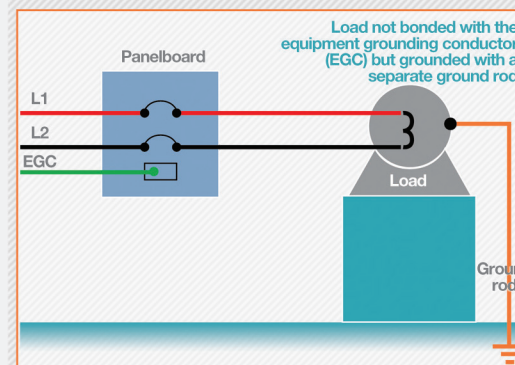
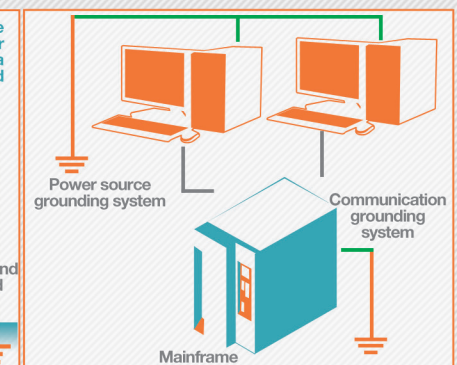
A conducting connection by which an electrical circuit or equipment is connected to earth or some conducting body of relatively large extent that serves as ground.

b. Typical Grounding Problems

- Missing equipment grounding conductors
- Multiple neutral-to-ground connection



- Ungrounded equipment (selfgrounding)
- Ground loops



d. Solutions

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

CHECKLIST FOR MAINTAINING POWER QUALITY



Power Quality Problem Manifestation on Equipment

✓ Begin power quality management during the planning and design stages of facility construction

The most cost-effective way to solve a power quality problem is to prevent it. Over time, the cost of solving it goes up. During the planning stage, identify the equipment, machinery and motors you would install, 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 easy diagnosis and troubleshooting in the future.

✓ Ensure that your voltage settings is 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, you may visit www.gmcddmc.ph or www.erc.gov.ph.

✓ Conduct a power quality assessment of your facilities before adding new equipment or electrical load

This would 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 your supplier or the equipment manufacturer for them to adjust your equipment's settings or else your equipment may malfunction.



✓ Voltage Rating

To avoid problems of overvoltage or under voltage, 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% more of or less 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 in a mismatched frequency will shorten the equipment's lifespan, accelerating its breakdown.

✓ Built-in power conditioning equipment

To ensure better voltage tolerance, purchase equipment with auto-volt features. For elevators, buy those with built-in reactors and filters to protect them from inrush current and to limit harmonics from the electrical load.

Industry	Equipment	Equipment Trouble
Real Estate	High-rise elevators	Blown fuse; frequent control system malfunction
Real Estate	Chillers	Erroneous tripping
Semicon	Wafer cutting machines	Frequent control system malfunction
Semicon/Manufacturing	Printed Circuit Board (PCB) Drilling Machine	Broken spindle
Manufacturing	Extrusion machines	Frequent control system malfunction
Manufacturing	Compressors	Frequent shutdown
Steel	Arc Furnace	Frequent shutdown
Steel	Lathe Machines	Burnt electronic board controller
Cement	Crusher Machine	Frequent shutdown
Healthcare	Magnetic Resonance Imaging (MRI) scanners	Burnt electronic circuit board
Gaming	Slot machines	Sudden shutdown

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 electrical conductors (plates) separated by a dielectric (i.e., insulator).

Distribution System - The system of wires and associated facilities belonging to a franchised Distributor, extending 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 Transmission System.

Inverter - An electronic device or circuitry that changes direct current (DC) to 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 1 minute.

Short Duration Voltage Variation - A variation of the root-mean-square (RMS) value of the voltage from nominal voltage for a time less than 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); a measurement of electro-magnetic losses, not efficiency.

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

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

Reliability - The probability that a System or Component will perform a required task or mission for 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 discussions, unless otherwise stated; in practical terms, the value given by the direct current, which when flowing through a given circuit for a given time period produces the same heat as that of the alternating current when flowing through the same circuit at the same time.

Shutdown - The condition of an 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 - unit of measurement of electrical pressure in an electrical system measured in volts; also considered electro-motive force; measured presence of an electric field.

FOR PROBLEMS ON
POWER QUALITY,
CONSULT YOUR
RELATIONSHIP MANAGER