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Causes and Impact of Quality Power System in the Country

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ABSTRACT *The power quality problem in practice generally expressed as problem found in voltage, current or frequency deviations which ultimately results in mal-operation of customer equipment. This problem causes deterioration in performance of various sensitive electronic/electric equipments. PQ problems may be very difficult to troubleshoot. The paper endeavored to present the causes and impact of quality power system suggesting proper solution like verify proper electrical connections and wiring; relocate equipment; reduce voltage motor starters; uninterruptible power supply; voltage ride-through equipment etc.*

Introduction:
Liberalization & Private investment across power sectors has gathered most changes in existing regulated system. The efforts are being made by State Power Utilities to reduce AT&C losses to an acceptable level and improve quality to ensure reliable supply to consumers. The power quality problem in practice generally expressed as any problem found in voltage, current or frequency deviations, ultimately results in mal-operation which causes deterioration of performance of various sensitive electronic/electric equipments. Good quality power system speaks as: Supply voltage should be within guaranteed tolerance of declared value. Wave shape should be pure sine wave within allowable limits for distortion. Voltage should be balanced in all three phases & supply should be reliable i.e continuous availability without interruption. Modern industrial machinery, commercial computer networks are prone to different failure. When the assembly line stops, or the computer network crashes for no apparent reason, very often the electric power quality is suspected. Power quality problems may be very difficult to troubleshoot, and often may not have any relation to actual problem. For example, in an industrial plant, faults of an automated assembly machine may ultimately be traced to fluctuations in the compressed air supply or a faulty hydraulic valve. In office building, the problems on local area network find their root cause with coaxial cable tee locations too close together causing reflections/signal loss. [1]

Power System & its Quality
Power quality is increasingly important issue and problems with powering and grounding can cause data and processing errors that affect production and service quality.

1. Lost production: Each time production is interrupted, business loses the margin.
2. Damaged products: Interruptions damage a partially complete product, cause the items to be rerun or scrapped.
3. Maintenance: Reacting to a voltage disruption can involve restoring production, diagnosing and correcting the problem, clean up and repair, disposing of damaged products.
4. Hidden costs: If impact of voltage sag is a control error, a product defect might discover.

Good Quality of Power System:
For good quality, supply voltage should be within guaranteed tolerance of declared value. In India, specifications related to power quality are ± 10% variation in voltage and ± 2% of frequency. Wave should be a pure sine wave within allowable limits for distortion. Voltage should be balanced in 3 phases & should be reliable; earthing system serves its purpose properly.

Causes of poor power quality:
The causes of poor quality can be attributed to variations in voltage, magnitude and frequency variations can be due to sudden rise or fall of load, outages, repetitive varying loading pattern in rolling mills, power electronic converters, lightning etc. Variations in frequency can rise of out of system dynamics or harmonics injection. Consequently the voltage or current wave forms of a power system ceases to be purely sinusoidal in nature but consist of harmonics and other noises. Impact of poor power quality:

The effect of these poor power quality problems has serious implication on the utilities and customers. Utility side impacts higher losses in transformers, cables etc. In conductors the neutral wires can burn due to the presence of third harmonics generated by non-linear loads. Power factor correction capacitors may puncture due to resonant conditions at resonant frequencies near lower order harmonics. The energy-meters, which are calibrated to operate under pure sinusoidal conditions, may give erroneous readings. Non-sinusoidal supply thus reduces torque and efficiency of motors. The computers and telecommunication equipment encounter loss of data and maloperation due to poor supply quality. Domestic electronic gadgets like digital clocks, VCDs/TVs are also affected by voltage distortions. The causes and consequences of problems can be traced to a specific type of electrical disturbance. By analyzing waveform of the disturbance, one can determine what problems facility has and what optimal solution is. For comparison purposes, a normal voltage waveform is 50 cycles per second at most plus or minus ten percent of nominal voltage. Power disturbances can be classified into following, each varying in effect, duration and intensity.

Voltage fluctuations:
Voltage fluctuations are changes or swings in the steady-state voltage above or below the designated input range for a piece of equipment. Fluctuations include both sags and swells.

1. Causes: Large equipment start-up or shut down; sudden change in load; improper wiring; or grounding; utility protection devices
2. Vulnerable equipment: Computers; Telefax; variable frequency drives; CNC machines; extruders;
3. Effects: Data errors; memory loss; shutdown; flickering lights; reduced motor life

Solutions: Verify proper electrical connections and wiring; relocate equipment; reduce voltage motor starters; uninterruptible power supply; voltage ride through equipment.

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Transients:
Transients, commonly called "surges," are sub-cycle disturbances of very short duration that vary greatly in magnitude. When transient occur, thousands of voltage can be generated into the electrical system, causing problems for equipment down the line.

1. Causes: Lighting; normal operation of utility equipment; equipment start-up and shutdown; welding equipment. 2 Vulnerable equipment: Phone systems; computers; fax machines; digital scales; gas pump controls; fire/security systems; variable frequency drives; CNC machines; PLCs.
3 Effects: Processing errors; computer lock-up; burned circuit boards; degradation of electrical insulation; equipment damage.
4 Solutions: Transient voltage surge suppression; uninterruptible power supply; isolation transformer.

Harmonics:
A sinusoidal component of a periodic wave of quality having a frequency that is an integral multiple of the fundamental frequency. It is a mathematical model, used to analyse distorted waveforms and current drawn by computers, electronic ballasts; variable frequency drives and other equipment, which have modern "transformer-less" power supplies.

Dynamic power system loads produce a time varying amplitude in current waveforms depending on the load characteristics which consists of the fundamental and harmonics components. These harmonic components distort the voltage or current waveforms thereby deteriorating the power quality. The non-linear loads such as inverter fed adjustable speed drives. UPS rectifiers and furnaces, cyclo-converters etc., form the major chunk of industrial loads. These ultimately contribute to the severe fluctuations in power quality. For assessing power quality it is important to know the total harmonic distortion i.e. the voltage and current distortion factors.

V THD = & I THD =

Vk = Voltage of Kth harmonic, Ik = Current of Kth harmonic

Where, V1 and I1 are the r.m.s values of fundamental components of voltage and current waveforms. Power quality deteriorates if the source has significant impedance causing the distortion of voltage of the load bus supplying combination of linear and non-linear loads. The quality of power expressed as a set of values of parameters, viz Continuity of service, Variation in voltage magnitude, Transient voltages/currents, Harmonic content in the waveforms for AC power. Power quality is a compatibility problem in which equipment connected to the grid compatible with the events on the grid, and is the power delivered by the grid, including the events, compatible with the equipment that is connected. Compatibility problems always have at least two solutions, in this case, either clean up the power, or make the equipment tougher. Tolerance of data-processing equipment to voltage variations is often characterized by the CBEMA curve, which give the duration and magnitude of voltage variations that can be tolerated. [2]

Ideally, AC voltage is supplied by a utility as sinusoidal having an amplitude and frequency given by national standards (in the case of mains) or system specifications (in the case of a power feed not directly attached to the mains) with an impedance of zero ohms at all frequencies.

No real-life power source is ideal and generally can deviate in at least the following ways:

- Variations in the peak or RMS voltage are both important to different types of equipment.
- When the RMS voltage exceeds the nominal voltage by 10-80% for 0.5 cycle to 1 minute, the event is called a "swell".
- A "dip" or"sag": RMS voltage below nominal voltage by 10- 90% for 0.5 cycle to 1 minute.
- Random/repetitive variations in RMS voltage between 90-110% of nominal produce phenomenon as "flicker" in lighting equipment. Voltage fluctuations produce objectionable light flicker.
- Abrupt, very brief increases in voltage, called "spikes", "impulses", or "surges", generally caused by large inductive loads being turned off, or more severely by lightning.
- "Under voltage" occurs when the nominal voltage drops below 90% for more than 1 minute. The term "brownout" is an apt description for voltage drops somewhere between full power (bright lights) and a blackout (no power- no light). It comes from the noticeable to significant dimming of regular incandescent lights, during system faults or overloading etc., when insufficient power is available to achieve full brightness in (usually) domestic lighting. This term is used to describe a reduction in system voltage by the utility or system operator to decrease demand or to increase system operating margins.
- "Overvoltage" occurs when the nominal voltage rises above 110% for more than 1 minute. Variations in the frequency.
- Variations in the wave shape usually harmonics. Nonzero low-frequency impedance.
- Nonzero high-frequency impedance

Some problems are a result of the shared infrastructure, a fault on the network may cause a dip that will affect some customers; the higher the level of the fault, greater the number affected. Harmonic problems can be dealt with by a combination of good design practice and well proven reduction equipment. [3]

A power conditioner (also known as a line conditioner or power line conditioner) is a device intended to improve the quality of the power that is delivered to electrical load equipment. While there is no official definition of a power conditioner, the term most often refers to a device that acts in one or more ways to deliver a voltage of the proper level and characteristics to enable load equipment to function properly. Sometimes power conditioner refers to a voltage regulator with at least one other function to improve power quality. [4]

An uninterruptible power supply can be used to switch off of mains power if there is a transient (temporary) condition on the line. However, cheaper UPS units create poor-quality power themselves, akin to imposing a higher-frequency and lower-amplitude square wave atop the sine wave. High-quality UPS units utilize a double conversion topology which breaks down incoming AC power into DC, charges the batteries, then remanufactures an AC sine wave. This remanufactured sine wave is of higher quality than the original AC power feed. [5]

Conclusion
We can see that power quality is taken as a compatibility problem that always have at least two solutions. Either clean up the power, or make the equipment tougher. Assessment of power quality is important to know the total harmonic distortion i.e. the voltage and current distortion factors. Power Quality is set of values of parameters like: Continuity of service, Variation in voltage magnitude, Transient voltages and currents and Harmonic content in the waveforms for AC power. Conditioners specifically work to smooth the sinusoidal A.C. wave form and maintain a constant voltage over varying loads.

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