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EFFICIENT POWER QUALITY: AN APPROACH TO ENERGY CONSERVATION

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ABSTRACT

Energy conservation refers to efforts made to reduce energy consumption. Energy conservation can be achieved through increased efficient energy use /in conjunction with decreased energy consumption and/ or reduced consumption from conventional energy sources. Energy conservation can result in increased financial capital, environmental quality, national security, personal security and human comfort. Individual and organizations that are direct consumes of energy choose to conserve energy to reduce energy costs and promote economic security. Industrial and commercial users can increase energy use efficiency to maximize profit. Standard economic theory suggests that technological improvements increase energy efficiency, rather than reduce energy use. It is said to occur in two ways. Firstly, increase energy efficiency makes the use of energy relatively cheaper, thus encouraging increased use. Secondly, increased energy efficiency leads to increased economic growth, which pulls up energy use in the whole economy. This does not imply that increased fuel efficiency is worthless, increase fuel efficiency enables greater production and a higher quality of life. Efficient energy use, sometimes simply called energy efficiency, is the goal of efforts to reduce the amount of energy required to provide product and service. For example, insulating a home allows a building to use heating and cooling energy to achieve and maintain a comfortable temperature. Insulating fluorescent lights or natural skylights reduce the amount of energy required to attain the same level of illumination compared to using traditional incandescent light bulbs. Compact fluorescent lights use two-third less energy and may last 6 to 10 times longer than incandescent lights. Improvements in energy efficiency are most often achieved by adopting a more efficient technology or production process.

Keywords: Conventional Energy Sources, Incandescent light, Illumination etc.

I. INTRODUCTION

Power quality is the set of limits of electrical properties that allows electrical systems to function in their intended manner without significant loss of performance or life. The term is used to describe electric power that drives an electrical load and the load's ability to function properly with that electric power. Without the proper power, an electrical device (or load) may malfunction, fail prematurely or not operate at all. There are many ways in which electric power can be of poor quality and many more causes of such poor quality power.

The electric power industry comprises electricity generation (AC power), electric power transmission and ultimately electricity distribution to an electricity meter located at the premises of the end user of the electric power. The electricity then moves through the wiring system of the end user until it reaches the load. The complexity of the system to move electric energy from the point of production to the point of consumption combined with variations in weather generation, demand and ogler factors provide many opportunities for the quality of supply to be compromised.While "power quality" is a convenient term for many, it is the quality of the voltage rather than power or electric current - that is actually described by the term. Power is simply the flow of energy and the current demanded by a load is largely uncontrollable.

The quality of electrical power may be described as a set of values of parameters, such as:

- Continuity of service
- Variation in voltage magnitude
- Transient voltages and currents
- Harmonics content in the waveforms.

It is often useful to think of power quality as a compatibility problems is the 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.

II. POWER QUALITY MEASURABLE QUANTITIES

The main definitions of power quality measurable quantities or occurrences are as follows:

2.1 Voltage Dip

A voltage dip is a reduction in the RMS voltage in the range of 0.1 to 0.9 p.u. (retained) for duration greater than half a mains cycle and less than 1 minute.Often referred to as a 'sag'. Caused by faults, increased load demand and transitional events such as large motor starting.Voltage dips, also called sags. The best-known sources of voltage dips and interruptions are listed below:

- The starting of a large load such as a motor or resistive heater.
- Loose or defective wiring such as insufficiently tightened box screws on mains conductors leading to the increase of your system impedance, thus making itself vulnerable to the effect of current increase.
- Faults or short circuits draw excessive currents until the protective devices such as a fase or circuit breaker operates

2.2 Voltage Swell

A voltage swell is an increase in the RMS voltage inthe range of 1.1 to 1.8 p.u. for a duration greater than half a mains cycle and less than 1 minute.Caused by system faults, load switching and capacitor switching.

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2.3 Transient

A transient is an undesirable momentary deviation of the supply voltage or load current. Transients are generally classified into two categories: impulsive and oscillatory as shown below (Fig.1):

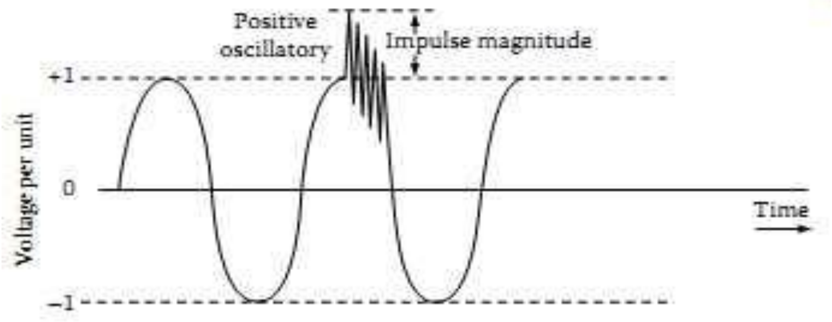

Fig.1: Transients are also called Voltage Spikes

2.4 Harmonics

Harmonics are periodic sinusoidal distortions of the supply voltage or load current caused by non-linear loads. Harmonics are measured in integer multiples of the fundamental supply frequency. Using Fourier series analysis the individual frequency components of the distorted waveform can be described in terms of the harmonic order, magnitude and phase of each component as shown in Fig.2

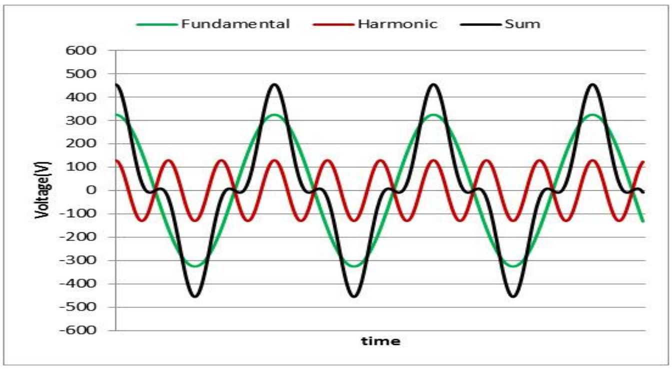

Fig.2: Harmonic Voltage Distortion

2.5 Distorted Voltage

Distorted voltage or current waveforms containing periodic distortions of a sinusoidal nature that are not integer multiples of the fundamental supply frequency are termed inter-harmonics.

2.6 Flicker

Flicker is a term used to describe the visual effect of small voltage variations on electrical lighting equipment (particularly tungsten-filament lamps). The frequency range of disturbances affecting lighting appliances, which are detectable by the human eye, is 1-30 Hz.

2.7 Voltage Imbalance

Voltage imbalance is defined as a deviation in the magnitude and/or phase of one or more of the phases, of a three-phase supply, with respect to the magnitude of the other phases and the normal phase angle (120°).

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2.8 Frequency Deviation

Frequency deviation is a variation in frequency from the nominal supply frequency above/below a predetermined level, normally ± 0.1%.

2.9 Transient Interruption

A transient interruption is defined as a reduction in the supply voltage or load current to a level less than 0.1p.u.for a time of not more than 1 minute. Interruptions can be caused by system faults, system equipment failures or control and protection malfunctions. Interruptions are considered to be measurable events coming under the field of 'Quality of Supply'.

2.10 Outage

An outage is defined as an interruption that has duration lasting in excess of one minute.

III. SOURCES OF POWER QUALITY PROBLEMS

(a)Power Electronic Devices

Power electronic devices are non-linear loads that create harmonic distortion and can be susceptible to voltage dips if not adequately protected. The most common 'economically damaging' power quality problem encountered involves the use of variable-speed drives. Variable-speed motor drives or inverters are highly susceptible to voltage dip disturbances and cause particular problems in industrial processes where loss of mechanical synchronism is an issue. The ideal solution to problems of this nature would be for systems engineers to specify equipment that has a 'reasonable level' of susceptibility to voltage dips from the outset.

(b) IT and Office Equipment

It equipment power supplies consist of a switched mode power supply (SMPS) and are the cause of a significant increase in the level of 3rd, 5th and 7th harmonic voltage distortion in recent years. Because the third harmonic is a 'triplen' harmonic it is of zero order phase sequence and therefore adds in the neutral of a balanced three-phase system. The increasing use of IT equipment has led to concern of the increased overloading of neutral conductors and also overheating of transformers.

(c) Arcing Devices

Electric arc furnaces, arc welders and electric discharge lamps are all forms of electric arcing devices. These devices are highly non-linear loads. The current waveform drawn is characterized by an increasing arc current limited only by the network impedance. Large arc furnace installations have typical current requirements of tens of thousands of amperes, welding sets draw current in the range of hundreds of amperes, individual electric discharge lamps draw only fractions of an ampere, but when it is considered that a large percentage of the domestic and commercial load requirement is contributed by lighting requirements this has a significant impact. Ray Arnold's article also presents solutions to problems in this area.

(d) Load Switching

The effect of heavy load switching on the local network is a fairly common problem causing transients to propagate through to other 'electrically close' equipment. These transients can be of surprisingly large voltage magnitude, but have very little energy due to their short duration, which is normally measured in terms of milliseconds. Electronic devices that may be sensitive to these voltage impulses can have their operation impaired. The effect of load switching on the voltage is typically encountered in the form of transient activity. This type of transient might occur as the result of switching in a heavy single-phase load, the effect seen on the voltage measured nearby. Other equipment can be protected from these switching transients by electrically isolating them from the affecting equipments.

(e) Large Motor Starting

The dynamic nature of induction machines means that they draw current depending on the mode of operation; during starting this current can be as high as six times the normal rated current. This increased loading on the local network has the effect of causing a voltage dip, the magnitude of which is dependent on the system impedance. It can take several seconds for motors to reach their rated speed and for this reason measures are taken to reduce the level of current drawn. These measures are dependent on the type of motor and drive. Most modern motors employ a sophisticated power electronic converter 'drive', which in most cases will control the motor's starting current to a reasonable level.

(f) Embedded Generation

Increasing levels of embedded generation predicted in the future are likely to have an effect on power quality. Although it cannot be stated that this increased level of dispersed generation on public distribution networks will degrade or improve power quality (this is an issue of some contention), it can be said that there are both advantages and disadvantages to the more widespread application of embedded generation where power quality is concerned.

(g) Environmental Related Damage

Lightning strikes are a cause of transient over-voltages often loading to faults on the electricity supply network. Lightning does not have a strike a conductor in order to inject transients onto the local network. Impulses can be induced if lightning strikes near a conductor. The local ground potential can be raised by a nearby strike leading to neutral current flowing to earth via a remote ground. This can have destructive effects on sensitive equipment. Lightning strikes that hit overhead lines often cause 'flash-overs' to neighboring conductors as the insulators break down. The strike will therefore not only consist of a transient over-voltage but also fault-clearing interruptions and dips.

High winds and storm conditions cause widespread disruption to the supply networks.

IV. POWER QUALITY MEASUREMENT AND MONITORING

After identifying the power quality problem, the following informations are required:

- The nature of the power quality problem.
- The estimated cost of the disturbance.
- The frequency of occurrence.
- The times at which the problem occurred.
- Information about the equipment affected.

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- Previous monitoring carried out at the site.

Measurable quantities in power quality include:

- Supply voltage variations
- Interruptions
- Voltage dips
- Voltage swells
- Harmonics
- Flicker etc.

V. REMEDIES OF POWER QUALITY PROBLEMS

To avoid or reduce the power quality problems, following measures are required and can be implemented:

5.1 Good Earthing Practices

A large number of reported power quality problems are caused by incorrect earthing practices. Verification of earthing arrangements, particularly when harmonics problems are reported, should always be conducted early in a power quality investigation.

5.2 Use of UPS

(a) Standby UPS: Consisting of a rectifier, battery, inverter and static switches, the standby UPS is the most popularly used UPS available today. The static transfer switches will be controlled to allow the load to be fed from the mains supply under normal operation, when there is a mains disturbance leading to a reduction in the mains voltage below some predetermined level the switches will open and close respectively). The load will then be fed from the battery, via the inverter ensuring continuation of supply to the load. The inverter output of a standby UPS must always operate in synchronism with the supply frequency to ensure a smooth transition from one supply to the other.

(b) Online UPS: An online UPS is configured such that the load is always fed from the UPS; in this way the load is isolated from the mains supply at all times. These systems are in general expensive and have high operating losses. Very similar to a standby system to view schematically, but with a manual transfer switch in place of the static transfer switches.

(c) Hybrid UPS: The hybrid UPS system has a configuration similar to standby UPS systems, with the exception that some form of voltage regulator, such as a ferro-resonant transformer, is used in place of the static switch device(s). The transformer provides regulation to the load and momentary ride-through when the transfer from mains supply to standby UPS is made.

5.3 Local or Embedded Generation

A form of local generation, such as a diesel generator, can be connected to allow for any shortfall in the mains capacity and also to provide ride-through for power quality disturbances. This will in most circumstances be viewed as an expensive solution, as the cost to keep a diesel generator running online

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indefinitely would be a high price to pay for improved power quality. However, some forms of embedded generation, such as micro-turbines, fuel cells and Stirling engines, are likely to have increased domestic usage in the near future.

5.5 Transfer Switches

Transfer switches are used to transfer a load connection from one supply to another, allowing the choice of two supplies for the load (or sub-network), should one supply suffer power disturbances then the other supply will be automatically switched in reducing the possibility of supply disruption to the load.

5.6 Static Breakers

The power electronic equivalent of a circuit breaker with a sub-cyclic response time. The static breaker will allow the isolation of faulted circuits in the shortest possible time frame, other nearby loads will therefore have improved power quality.

5.7 Active Filters and SVCs

The control of reactive power and therefore harmonics, can be achieved by controlling a proportion of the power systems current through a reactive element. Conventionally this is achieved by switching inductors and capacitors in shunt with the power system, using thyristors. With the SVC the control of the current is achieved by controlling the output voltage magnitude of an inverter. SVC's are used to absorb or inject reactive currents to eliminate the harmonic distorting currents drawn by non-linear loads. Unified power flow controllers (UPFCs) are similar to SVCs but allow both series and shunt compensation.

5.8 Passive Filters

Passive filters or power line filters are simple filters consisting of discrete capacitors and /or inductors. Normally designed to attenuate high frequencies (low-pass filters), fitted to equipment to remove higher order harmonic frequencies from the supply.

5.9 Energy Storage Systems

All electrical energy storage systems have the same basic components, interface with power system, power conditioning system, charge/discharge control and the energy storage medium itself. Each storage medium has different characteristics, energy density, charge/discharge time, effect of repeated cycling on performance and life, cost, maintenance requirements, etc. These characteristics help to make the decision of what storage medium is best suited to which application, each medium having merits that make it the most suitable in different circumstances. Energy storage systems available include:

- Superconducting magnetic energy storage.
- Flywheel energy storage.
- Battery/advanced battery energy storage.
- Capacitor or ultra-capacitor storage.

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So, by adopting above mentioned measures, we can avoid these problems and can maintain the quality of power better and as per the customer need.

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