POWER QUALITY DYNAMICS – A REVIEW

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ABSTRACT

A power quality in electrical networks is one of today's most concerned areas of electrical power system. The power quality has serious economic implications for consumers, utilities and electrical equipment manufactures. Modernization and automation of industry involves increasing use of computers, microprocessors and power electronic systems such as adjustable speed drives. Integration of nonconventional generation technologies such as fuel cells, wind turbines and photo-voltaic with utility grids often requires power electronic interfaces. The power electronic systems also contribute to power quality problems(generating harmonics).Under the deregulated environment, in which electric utilities are expected to complete with each other, the customer satisfaction becomes very important. The impact of power quality problems is increasingly felt by customers- industrial, commercial and even residential.

Keywords: PQ, HC

I. INTRODUCTION

The PQ issue is defined as "any occurrence manifested in voltage, current, or frequency deviations that results in failure, damage, upset, or disoperation of end-use equipment.A simpler word power quality is a set of electrical boundaries that allow a piece of equipment to function in its intended manner without significant loss of performance or life expectancy. This definition embraces two things that we demand from an electrical device which are performance and life expectancy.

II. PROBLEMS ASSOCIATED WITH POWER QUALITY

2.1 Momentary Phenomena

2.1.1Transients

Transients are power quality disturbances that involve destructive high magnitudes of current and voltage or even both. It may reach thousands of volts and amps even in low voltage systems. However, such phenomena only exist in a very short duration from less than 50 nanoseconds to as long as 50 milliseconds. This is the shortest among PQ problems, hence, its name. Transients usually include abnormal frequencies, which could reach to as high as 5 MHz.

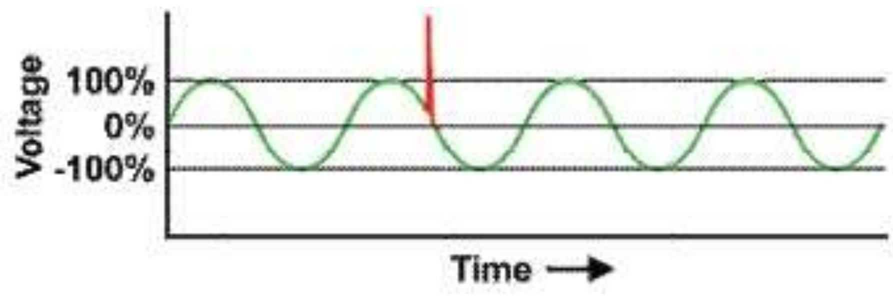

Figure - 1: Transients

2.1.2 Long Duration Voltage Variations

These are defined as the rms variations in the supply voltage at fundamental frequency for periods exceeding one minute. These variations are classified as-:

- Over voltages
- Under voltages
- Sustained interruption

2.1.3 Short Duration Voltage Variation

The short duration voltage variation are generally caused by fault conditions like single line to ground or double line to ground and starting of large loads such as induction motor. The voltage variations can be temporary voltage dips i.e. sag or temporary voltage rise i.e. swell or absolute loss of voltage which is known as interruptions.

These are classified as:-

- Sag
- Swell
- Interruptions

2.1.3.1 Sag

The American "sag" and the British "dip" are both names for a decrease in voltage to between 10% and 90% of nominal voltage for one half cycle to one minute .Sags account for the vast majority of power problems experienced by end users. They can be generated both internally and externally from an end users facility. Sags coming from the utility have a variety of causes including lightning, animal and human activity and abnormal utility equipment operation.

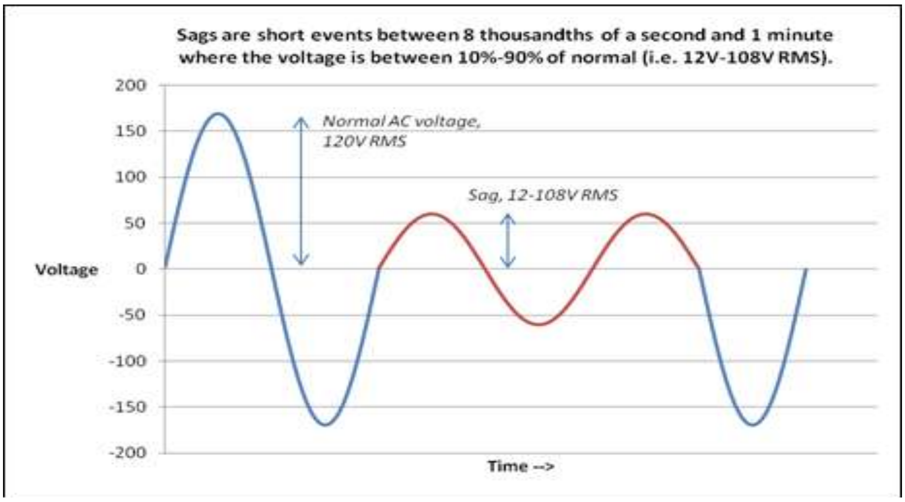

Figure-2: Sags are Short Events Between 8 Thousandths of a Second and 1 Minute Where The Voltage is Between 10%-90% of Normal

2.1.3.2 Swell

A swell is the opposite of a sag an increase in voltage above 110% of nominal for one half cycle to one minute. Although swells occur infrequently when compared to sags, they can cause equipment malfunction and premature wear. Swells can be caused by shutting off loads or switching capacitor banks on.

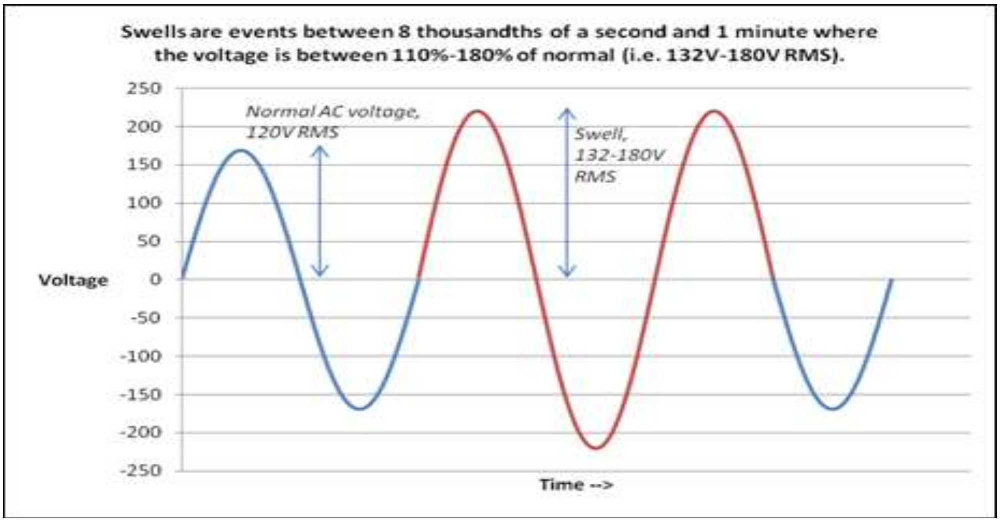

Figure 3:Swells are Event Between 8th Thousandth of a Second and 1 Minute Where The Voltage is Between 110%-180% of Normal

2.1.3.3 Interruptions

When the voltage drops below 10% of its nominal value it is called an interruption or a blackout. Interruptions have three classifications:-

Momentary (lasting 30 cycles to 3 seconds)

Temporary (lasting 3 seconds to 1 minute)

Sustained (lasting more than one minute)

Although interruptions are the most severe form of power problem, they are also the least likely to occur. Voltage sags are often mistaken for an interruption because equipment shuts down or lightening goes off since the voltage dropped below the point that these devices can operate. Where sags and under voltage typically represent more than 92% of power problem events, interruptions represent less than 4% of such problems.

2.2 STEADY STATE PHENOMENA

2.2.1 Waveform Distortion

This is defined as a steady state deviation from an ideal sine wave of power frequency There are five types of waveform distortion:-

- DC offset
- Harmonics
- Notching
- Noise

2.2.2 Voltage Unbalance

2.2.3 Voltage Fluctuations and Flicker

2.2.4 Power Frequency Variations

III. INVESTIGATION ON POWER QUALITY PROBLEMS

Now-a-days, the customers have become more aware of the ‘quality of service’ of the electricity. The network operator is obliged to deliver a voltage at the customer’s terminal that should remain within certain limits as specified in the national grid code or the standard. It is generally noticed that the electricity as it is produced in a conventional power plant by the utility is generally of high quality. But when it reaches the customer’s terminal, it might be distorted due to the disturbances in the transmission and distribution networks or for other reasons. Moreover, the electrical equipment's have become more complex in terms of their functionalities and the way they interact with other equipment's present in the network. Therefore, it is becoming an increasing problem for the utility to maintain good voltage quality because of the interactions of the customer's loads with the network 'Quality of service' defines the as a combination of the supply reliability, the power quality and the commercial relationship between the utility and the customer. Power quality is often considered as a combination of voltage and current quality. It is generally noticed that the network operator is responsible for voltage quality (VQ) at the point of connection (POC) while the current quality (CQ) at the POC is largely influenced by the customer's loads. These two characteristics VQ and CQ influence each other by mutual interaction that might cause distortion in the power supply at the POC.

PQ disturbances can be classified into two categories:

1) 'Continuous' or 'variation type' and

2) 'Discrete' or 'event type'.

Continuous type disturbances are present in every cycle and typically include voltage variations, unbalance, flicker and harmonics. The discrete type disturbances appear asisolated and independent events and mainly include voltage sags (sags), swells and oscillatory or impulsive transients.

IV. POWER QUALITY COMPLAINTS

Typical PQ complaints arise from the customer side when the functioning of the customer's sensitive devices (for example computers, data processing equipments, variable speed drives, electronic ballasts) is affected leading to data loss, corruption or damage of data, physical damage of sensitive devices, flickering of computer screens, or complete loss of the power supply. From various national and local surveys in the India and other countries like USA, it was found that about 70% of PQ disturbances at the POC are caused by the customers themselves or their neighbours due to the operation of the devices at their premises while the other 30% of PQ problems are originated from the network side because of natural events or other reasons. These results concluded that voltage sags (dips) andswells, transient over-voltages (due to capacitor switching), harmonics and grounding related problems are presented in Fig. 4

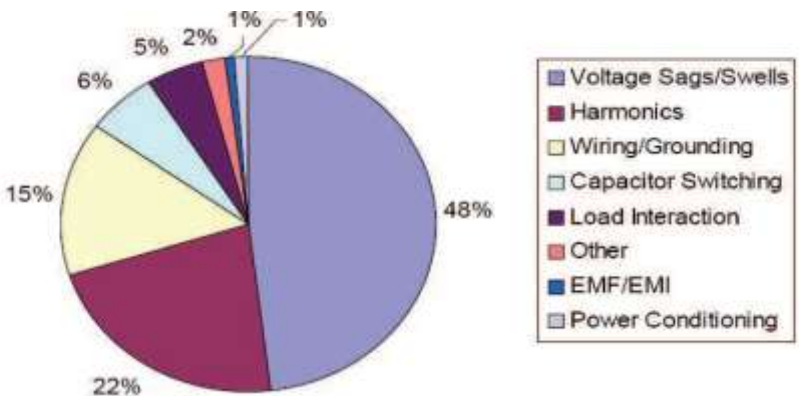

Figure: 4 PQ Problems Experienced by the Customers

V. POSSIBLE CAUSES OF POWER QUALITY PROBLEMS

The frequency of PQ disturbances and their associated problems depend on many factors such as: the type of customer and the equipment under use, the topology and length of the electric lines supplying the customers and the geographical area. The number and severity of PQ problems varies with climate conditions, operating practicesand the behaviours of the load.

Various circumstances that causePQ problems are as follows:

- Natural phenomena that leads to system disturbances. It can be due to the weather (e.g. storm, lightning etc.) and animal activity.
- Normal utility operations that include capacitor and load switching which cause transients in the power system operation.
- Neighbouring customers who are connected to the same or adjacent feeder of the network might cause PQ problems due to the operation of large or periodic high demand loads.
- The operation of customer's sensitive loads which have nonlinear behaviour and produce current harmonics in their operations. The current harmonics in combination with the network impedances produce distortions

VI. EFFECTS OF POOR POWER QUALITY

The effect of poor PQ on the electrical equipment varies from component to component. Each type of sensitive electronic equipment differs in the amount and intensities of electrical stress that it can tolerate before failing. The critical factors that determine the tolerances of the equipment are as follows:

- the nature, magnitude and duration of the PQ event
- the frequency of the event
- the sensitivity of the component to the event
- the location of the equipment within the customer's installations
- the age of the component

VII. TECHNICAL IMPACTS OF POOR POWER QUALITY

Two distinct methods of measuring the economic impact of poor PQ have been identified.

- The first method is the direct method which is an analytical approach to consider the probabilities and impacts of the events. This method leads to a precise answer about the cost of a PQ event but it is often difficult to obtain correct input values.
- The second method is an indirect method which considers historical data for analysis and the customer's willingness to pay in solving PQ problem.

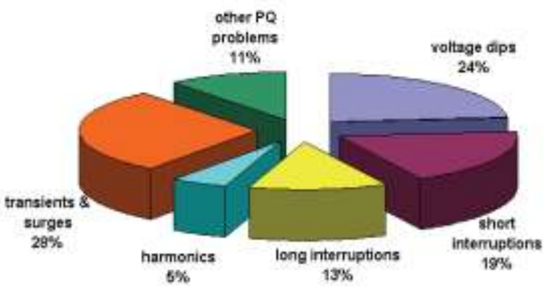

Fig. 5: Percentage Share of PQ and Interruption Costs

The survey was done over two years period among 62companies from different industries and service sectors. It was found that 90% of the totalfinancial losses are accounted to the industries. Fig. 5 shows the percentage shares of totalfinancial losses on various PQ aspects. It shows that 56% of total financial loss is a result of voltage dips and interruptions, while 28% of the costsare due to transients and surges. Other financial losses (16%) are because of harmonics,flicker, earthing and EMC related problems.

VIII. ECONOMIC IMPACT OF POWER QUALITY

The cost related to a PQ disturbance can be divided in

i) Direct costs: the cost that can be directly attributed to the disturbance. Include the damage and the equipment, loss of production, loss of raw material, restart cost etc.

ii) Indirect costs: These costs are very hard to evaluate. Investments to prevent PQ problemsmay be considered an indirect cost.

iii) Non material inconvenience: some inconvenience due to power disturbance cannot beexpressed in money, such as not listening to the radio or not watching TV. The only way toaccount is to establish an amount of money that the consumer is willing to pay to avoid thisinconvenience.

IX. METHODS FOR POWER QUALITY PROBLEMS CORRECTION

Correction methods include the following:

- Proper designing of the Load equipment.
- Application of passive, active and hybrid harmonic filters.
- Proper designing of the power supply system
- Application of voltage compensators.
- Use of uninterruptible power supplies (UPSs)
- Reliability on standby power

X. CONCLUSION

- Power quality maintenance is an important aspect in the economic operation of the system
- Various PQ problems may lead to another undesirable problems

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