A Review on Electrical Power Quality

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***Abstract*— Now a day’s power quality is a very important issue in power system. It represents quality assessment of the energy system in a different way. This paper starts with an introduction of power quality. After this factor affecting power quality and disturbances which has occurred in the power system are discussed with some review.**

***Keywords*—** Voltage sag, Voltage swell, Power Quality Standard, Factor affecting the power quality

I. INTRODUCTION

Nowadays Development of new technology in all the area is progressing at a faster rate. Scenario of power has a lot of changed. With the increase of capacity and size, power systems become more complex which reduced to reliability. But the enhancements of power electronic and electrical devices and appliances have become more sophisticated and they demand uninterrupted and conditioned power. Power quality is a term used to maintaining the sinusoidal waveform of power distribution bus voltage and rated magnitude current and frequency. So we can say that power quality term is used to express quality of power supply, voltage Quality, current quality and reliability of service, etc. If the power quality of any system is good ,then any load connected across it will run efficiently and satisfactory.

If the power quality of any system is bad, then any load connected across it will fail and efficiency of electrical installation will reduce. An electrical power system is expected to deliver undistorted sinusoidal rated voltage and current continuously at rated frequency to the end users. However, large penetration of power electronics based controllers and devices along with the restructuring of the electric power industry and small-scale distributed generation have put more stringent demand on the quality of electric power supplied to the customers (Arrillaga *et al*, 2000a; Arrillaga *et al*, 2000b; Dugan *et al*, 2003). To define power quality (PQ), the views of utilities, equipment manufacturers, and customers are completely different. Utilities treat PQ from the system reliability point of view. Equipment manufacturers, on the other hand, consider PQ as being that level of power supply, allowing for proper operation of their equipment, whereas customers consider good PQ that ensures the continuous running of processes, operations, and business. A PQ problem can be defined as “any power problem manifested in voltage, current and/or frequency deviations that result in failure or mal-operation of customers’ equipment”.

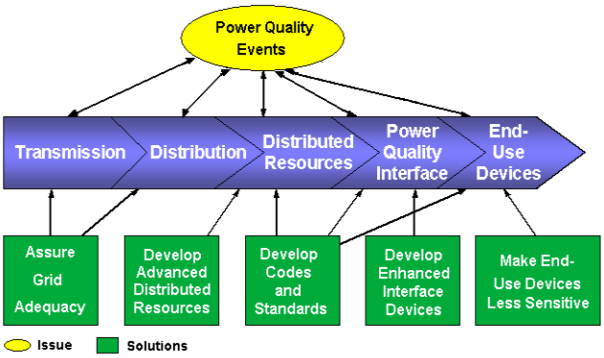

Fig.1 Power Quality Events

II. FACTOR AFFECTING THE POWER QUALITY

Power quality affected by various type of electrical disturbances. Almost electrical power quality disturbance depend on magnitude of supply voltage or frequency or on both magnitude of voltage and frequency.

2.1 Voltage/Current Unbalanc

Voltage or current unbalance may occur due to unbalanced loading. The operation of Fast Varying Loads (FVLs) in distribution systems is associated with high variation in the active power and bursts of distortion. FVLs affect surrounding loads sensitive to voltage rms variation and distortion.

Thus, they affect the quality of the supply. Bohorquez, V.B. Presents an overview of some electric loads that behave as FVLs. FVLs are characterized in his work in terms of the main two properties that distinguish them from other electrical loads, namely, the active power variation and the contribution to the distortion. When a FVL is the major load on a distribution system, the power variation and the burst of waveform distortion could reach unacceptable levels. Thus, compensation could be necessary. The requirements for this compensation are also presented by him paper on A control algorithm for hybrid compensation of Fast Varying Loads

A control algorithm for hybrid compensation of fast varying loads (FVLs) is presented by Bohorquez, V.B[15]. Compensators of FVLs should reduce the variation of power in distribution systems and should reduce bursts of waveform distortion. These two requirements are substantially different. Thus, it should have a hybrid structure. Therefore compensator of FVLs should be built of two separate compensators; one for the compensation of power variation and the other for compensation of the distorted component. The compensator for the power variation (CPV) can use a Flywheel Energy Storage System (FESS). In the compensator discussed in proposes work a Permanent-Magnet Synchronous Motor/Generator is used as the driving machine. The FESS is supplied from a PWM-based Inverter. A PWM inverter-based switching compensator is used for compensation of waveform distortion. A complete model of the integrated control of the compensator is discussedby him. The Current Physical Components (CPC) theory is used as the basis for generating reference signals for the hybrid compensator under discussion.

2.2 Interruption/Under Voltage/Over Voltage

Voltage magnitude below the rated value is called under voltage. The voltage magnitude above the rated value is called over voltage. When analyzing the quality of electrical power delivered to customers many parameters are considered. However the fundamental issue is the presence of voltage and its reliability and continued presence. Power systems all over the world experience big power failures from time to time leading to a total lack of voltage over a large area - called blackouts An automated method for preventing such a voltage collapse. Lis, R. & Blajszczak, G. propose method which calculates reactive power needed to mitigate the grid and points out the weak nodes where reactive power should be injected. This method was successfully applied and tested on the Polish transmission network.Rapidly increasing share of distributed generation (DG) in distribution networks introduced the need for active distribution network operation. As current distribution networks quality, network planning, protection were not designed to integrate the power generation, the DG introduced many technical challenges in sense of power schemes, voltage stability.

Pfajfar, T et.al work on the advantages of active approach in distribution network operation. They focus on a voltage quality problem and introduces the coordinated voltage control technique to increase the share of DG in distribution networks and at the same time supply the customers with the required voltage quality.

2.3 Voltage Sag

A voltage sag or voltage dip is a short duration in rms voltage which can be caused by a short circuit , overload or starting of electric motors. A voltage sag happens when the rms voltage decreases between 10 and 90 percent of nominal voltage for one –half cycle to one minute.

2.4 Voltage Swell

Voltage swells or surges are brief increases in voltage over the time range Gopi, R.J. [4] et.al proposed Stochastic assessment is a method to predict the severity, duration and number of voltage sags at a bus of interest in the transmission network. In this paper, a technique using impedance matrix for stochastic assessment was developed to predict the voltage magnitudes and duration due to faults at any bus in the electrical network. The results show that the impedance matrix method is able to compute the predicted voltage magnitude at any bus, duration of sag and the number of sags per year. In terms of voltage dips, the power quality target to be achieved may be limiting the voltage dips frequency in each node of a given network within a prefixed threshold Pilo, F. , Pisano, G. , Soma, G.G.[10] propose an improved algorithm able to find the most economical solutions to comply with this constraint has been developed. This improved algorithm considers by the same standards different corrective actions, with the aim at finding the best compromise between investment and benefits. Accordingly with this view, the goal is minimizing the cost that the distributors have to sustain for the protective measures, the cost paid by the customers for the damages caused by the not mitigated disturbances and for the premium quality contracts. The effectiveness of the proposed approach is proved by examples in a test network and in a small one derived from real cases.Leon-Martinez, V. et. Al [20] propose the work on Comparison of three reactive powers to analyze operation of wind turbines during voltage dips.Three instantaneous reactive power formulations - Delayed Voltage (DV) approach, Currents' Physical Components (CPC) approach and fundamental positive reactive power (FPRP) - are used for obtaining useful quantities in order to improve the operation analysis of the wind turbines. By comparing those reactive powers, useful and useless magnetic field components in the doubly fed wind turbines are identified. Non-fundamental reactive power and, thus, wind turbine harmonic magnetic field is obtained by the comparison of DV and CPC's approaches.

Negative reactive power, responsible of reverse magnetic fields, is defined by the comparison of CPC's fundamental reactive power and FPRP. Moreover, decomposition of the FPRP into two reactive power components, due to the reactors and caused by the imbalances, provides additional information about unbalance effects on the main magnetic field of the generator. These above established quantities are finally used to evaluate an actual wind-turbine subjected to a two-phase voltage dip.Mansour A. Mohamed An adaptive least squares algorithm has been developed for sag and swell detection in power system . voltage sag and swell detection , using this method , depend upon the calculation of true rms value of the voltage signal ,which make it more accurate . the method has been compare with peak voltage sag detection method and result show that the method is faster than peak technique.Yu Yilin and Xu Yonghai proposes an improved distance impedance method for voltage sag detection by judging the rate of change of magnitude and angle of voltage sag source could be correctly determined in power distribution network.

III. POWER QUALITY STANDARD

Power quality is a worldwide issue, and keeping related standards current is a never-ending task. It typically takes years to push changes through the process. Most of the ongoing work of the IEEE in harmonic standards development has shifted to modifying Standard 519-1992.

- *IEEE 519*

IEEE 519-1992, Recommended Practices and Requirements for Harmonic Control in Electric Power Systems, established limits on harmonic currents and voltages at the point of common coupling (PCC), or point of metering [1,18].

The limits of IEEE 519 are intended to:

1) Assure that the electric utility can deliver relatively clean power to all of its customers;

2) Assure that the electric utility can protect its electrical equipment from overheating, loss of life from excessive harmonic currents, and excessive voltage stress due to excessive harmonic voltage. Each point from IEEE 519 lists the limits for harmonic distortion at the point of common coupling (PCC) or metering point with the utility.

The voltage distortion limits are 3% for individual harmonics and 5% THD. All of the harmonic limits in IEEE 519 are based on a customer load mix and location on the power system. The limits do not apply to particular equipment, although, with a high amount of nonlinear loads, it is likely that some harmonic suppression may be necessary.

➢ *IEEE 519 Standard for Current Harmonics*

- *General Distribution Systems [120V- 69 kW]*

Below current distortion limits are for odd harmonics. Even harmonics are limited to 25% of the odd harmonic limits [1,3,5].

For all power generation equipment, distortion limits are those with ISC/IL<20.ISC is the maximum short circuit current at the point of coupling “PCC”.IL is the maximum fundamental frequency 15-or 30- minutes load current at PCC. TDD is the Total Demand Distortion (=THD normalized by IL)

- *General Sub-transmission Systems [69 kV-161 KV]*

The current harmonic distortion limits apply to limits of harmonics that loads should draw from the utility at the PCC. Note that the harmonic limits differ based on the ISC/IL rating, where ISC is the maximum short circuit current at the PCC, and I is the maximum demand load current at the PCC.

- *IEEE-519 - Voltage Distortion Limits*

The voltage harmonic distortion limits apply to the quality of the power. For instance, for systems of less than 69 KV, IEEE 519 requires limits of 3 percent harmonic distortion for an individual frequency component and 5 percent for total harmonic distortion.

➢ *IEC 61000-3-2 and IEC 61000-3-4 (formerly 1000-3-2 and 1000-3-4)*

- *IEC 61000-3-2 (1995-03)*

It specifies limits for harmonic current emissions applicable to electrical and electronic equipment having an input current up to and including 16 A per phase, and intended to be connected to public low-voltage distribution systems. The tests according to this standard are type tests.

- *IEC/TS 61000-3-4 (1998-10)*

It specifies to electrical and electronic equipment with a rated input current exceeding 16 A per phase and intended to be connected to public low-voltage AC distribution systems of the following types:

Nominal voltage up to 240 V, single-phase, two or three wires;Nominal voltage up to 600 V, three-phase, three or four wires;Nominal frequency 50 Hz or 60 Hz

These recommendations specify the information required to enable a supply authority to assess equipment regarding harmonic disturbance and to decide whether or not the equipment is acceptable for connection with regard to the harmonic distortion aspect.

The European standards, IEC 61000-3-2 & 61000-3-4, placing current harmonic limits of equipment, are designed to protect the small consumer's equipment. The former is restricted to 16 A; the latter extends the range above 16 A

IV. KEY ISSUES AND CHALLENGES IN CLASSIFICATION OF PQ DISTURBANCES

Accurate PQ disturbance classification, which depends on the several factors, is a difficult task. The following are the some of the major issues and challenges in automatic classification of PQ disturbances.

There exist a few literatures on the automatic classification of PQ event based on the underlying cause of the disturbance. Most of the methods deal with the type of the PQ event without specifying the underlying cause. For example, for a voltage sag event, it is desirable to know not only voltage sag, but also whether it is caused by the switching of a large load, a line-to ground fault, or any other reason. The work should be extended towards cause based classification instead of phenomenon based classification for better understanding of PQ events.

Classification of swell, dips and interruption, i.e. the classification of voltage magnitude events are addressed in many classification algorithms. New algorithms for classification of transients and harmonic distortion have to be explored. Transient identification requiring high frequency waveform recording devices and more robust classification methods is rarely addressed in literature with the exception of (Mamishev *et al*, 1996). The majority of classification techniques proposed is for single disturbances. Therefore, efforts need to be done for multiple disturbance classification. Currently, there are different approaches available for multi-class SVM. These approaches can be tested for their suitability in classification of PQ disturbances.

Performance of a classifier is highly dependent on the input extracted features. FT, WT and/or model based methods are the optimal starting point for generating features to be proved. The wavelet transform has limited utility in detecting, extracting sag disturbances features because the gradient of the disturbing events is comparable to that of the background signal.

The choice of a suitable mother wavelet function is another issue of concern in the classifier with the wavelet based extracted features. Because of its compact and localized properties in the time, frequency plane, Daubechies db4 has been the most frequently used. Another issue of concern is the number of decomposition levels required to avoid possible loss of some important information and to have accurate classifier since PQ disturbances cover a wide range of frequency.

V. CONCLUSION

To carry out any investigation in the power quality improvement it needs a thorough knowledge of the nature of the power quality issues over the particular location of transmission lines and complete understanding of FACTS devices and controllers. There are different processes to be used for power quality analysis of energy conversion systems. STATCOM and DSTATCOM is a powerful tool to analyze power disturbances in the energy system. These tools increase the system performance and efficiency of the system.

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