A Review Paper on Power Quality Issues and Monitoring Techniques

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Abstract - *Power Quality (also known as PQ) is a highly newsworthy issue. Increasing use of semiconductor based electronic equipment & non-linear loads (such as computers & their peripherals, data servers, adjustable speed drivers, arc furnaces etc.) and rapid integration of non-conventional energy sources into grid network throws new challenges for the PQ environment This paper will help to understand the importance of power quality and various power quality issues which are affecting end users, equipment & system manufacturer, designers, electricity distributors, public authorities and general public.. We have also reviewed various power quality monitoring techniques which helps to detect, record and prevent power quality problems. This review of so far work carried out on power quality issues & monitoring techniques would be helpful for the researchers to do the future work related to power quality.*

Key Words: **Power Quality, Harmonic Distortion, Transients, Voltage swell, Disturbance Analyser**

1. INTRODUCTION

Power quality is an issue that necessities ceaseless consideration and has progressively been utilized as the key pointer for benchmarking of the genuine execution of numerous electrical utilities. Since nature of voltage holds huge significance in the usefulness of any power system, checking of voltage quality has turned into a noteworthy territory of examination. The characteristics of electricity like frequency, magnitude, waveform, and symmetry are subject to variations during the normal operation in a supply system due to changes of load, disturbances generated by certain equipment and the occurrence of faults which are mainly caused by external events. These characteristics vary at random with time, or reference to any specific supply terminal, and location with reference to any given instant of time due to sources of disturbances like - atmospheric phenomena, environmental conditions. Sometimes the equipment installed at the premises of an electricity user can inject disturbances (e.g. harmonic or inter-harmonic distortion, voltage fluctuations etc.) into the distribution networks. Till date lots of studies have been conducted on power quality issues and the literature is very rich. According to IEEE 100 Authoritative Dictionary of IEEE Standard Terms [1] Power quality is defined in the as the concept of powering and grounding electronic equipment in a manner that is suitable to the operation of that equipment and compatible with the premise wiring system and other connected equipment Utilities may want to define power quality as reliability. According to Mohan, Underland and Robbins [2] mentioned that advances in semi-conductor fabrication technology have made it possible to significantly improve the voltage & current-handling capabilities & the switching speed of power semi-conductor devices. Tekale Anil A [3] explained that the reducing no of switches can be advantageous to reduce switching losses which are helpful to overcome total harmonic distortion. Eldery, M.A., et al. [4] described PQ problems, such as sag, swell, harmonic distortion, imbalance, transient, and flicker, can impact customer operations, causing malfunction costs on lost production and downtime. Bucci, G., E. Fiorucci, C. Landi [5] mentioned ideally, the whole power system should be monitored by power quality monitors (PQMs) at each bus, then all the monitors should be integrated in a communication facility. Almeida, C.F.M., N. Kagan [6] mentioned that in recent years, several studies have been presented to solve the PQM placement problem by determining the optimal number and location of PQMs. A primary requisite in selecting the location of monitors is that the location must guarantee observability of the entire system and must ensure that any voltage sag event is captured by at least one PQM.

2. POWER QUALITY

It is defined as "a set of electrical boundaries that allows equipment to function in its intended manner without significant loss of performance or life expectancy." Power Quality as a term is also defined as the electrical network's (grid's) ability to supply clean and stable power flow acting as a perfect power supply that is always available, has a pure noise-free sinusoidal wave shape, and is always within voltage and frequency tolerances. However, deviations from these ideal conditions are frequent in most networks as the number of loads imposing disturbances is increasing rapidly.

2.1 Power Quality Issues

Power Quality Issues are those disturbances which affect the power supply system. Any power problem manifested in voltage, current, or frequency deviations that result in failure of customer equipment are known as power quality issue.

Power Quality disturbances can be divided into two basic categories:

1. Steady-state variations:-Small deviations from the desired voltage or current values.

i) Voltage fluctuations

ii) Voltage and current unbalance

iii) Harmonic distortion

2. Events:-Significant sudden deviations of voltage or current from the nominal or ideal wave shape.

i) Interruptions ii) Voltage sag

iii) Voltage swell IV) Transients

The most common types of Power Quality problems are presented below along with their description, causes and consequences: Voltage sag (or dip),interruptions, interruptions, spike, Voltage, Harmonic, Voltage, Noise, Voltage Unbalance

1) Voltage sag (or dip)

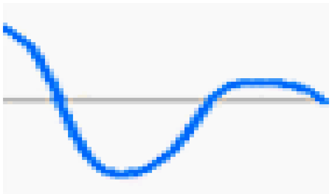

Fig 2.1 Voltage Sag

Description: A decrease of the normal voltage level between **10% and 90%** of the nominal rms voltage at the power frequency, for durations of 0, 5 cycle to 1 minute.

Causes: Faults on the transmission or distribution network (most of the times on parallel feeders). Faults in consumer's installation. Connection of heavy loads and start-up of large motors.

Consequences: Malfunction of information technology equipment, namely microprocessor-based control systems (PCs, PLCs, ASDs, etc) that may lead to a process stoppage. Tripping of contactors and electromechanical relays. Disconnection and loss of efficiency in electric rotating machines.

2) Very short interruptions

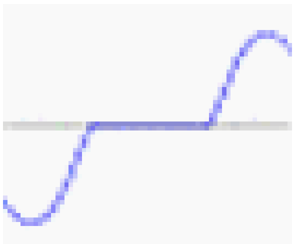

Fig 2.1 Very short interruptions

Description: Total interruption of electrical supply for duration from few milliseconds to one or two seconds.

Causes: Mainly due to the opening and automatic reclosure of protection devices to decommission a faulty section of the network. The main fault causes are insulation failure, lightning and insulator flashover.

Consequences: Tripping of protection devices, loss of information and malfunction of data processing equipment. Stoppage of sensitive equipment, such as ASDs, PCs, PLCs, if they're not prepared to deal with this situation.

3) Long interruptions

Fig 2.3 Long interruptions

Description: Total interruption of electrical supply for duration greater than 1 to 2 seconds

Causes: Equipment failure in the power system network, storms and objects (trees, cars, etc) striking lines or poles, fire, human error, bad coordination or failure of protection devices.

Consequences: Stoppage of all equipment.

4) Voltage spike

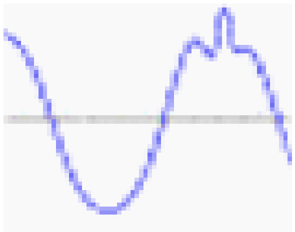

Fig 2.4 Voltage spike

Description: Very fast variation of the voltage value for durations from a several microseconds to few milliseconds. These variations may reach thousands of volts, even in low voltage.

Causes: Lightning, switching of lines or power factor correction capacitors, disconnection of heavy loads.

Consequences: Destruction of components (particularly electronic components) and of insulation materials, data processing errors or data loss, electromagnetic interference.

5) Voltage swell

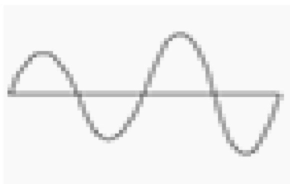

Fig 2.5 Voltage swell

Description: Momentary increase of the voltage, at the power frequency, outside the normal tolerances, with duration of more than one cycle and typically less than a few seconds.

Causes: Start/stop of heavy loads, badly dimensioned power sources, badly regulated transformers (mainly during off-peak hours).

Consequences: Data loss, flickering of lighting and screens, stoppage or damage of sensitive equipment, if the voltage values are too high.

3. POWER QUALITY MONITORING

Power quality monitoring is the process of gathering, analyzing, and interpreting raw measurement data into useful information. The process of gathering data is usually carried out by continuous measurement of voltage and current over an extended period. The process of analysis and interpretation has been traditionally performed manually, but recent advances in signal processing and artificial intelligence fields have made it possible to design and implement intelligent systems to automatically analyze and interpret raw data into useful information with minimum human intervention.

3.1 Need for Power Quality Monitoring

Power quality monitoring programs are often driven by the demand for improving the system wide power quality performance. Many industrial and commercial customers have equipment that is sensitive to power disturbances, and, therefore, it is more important to understand the quality of power being provided. We need Monitoring to characterize system performance and then match that system performance with the needs of customers. Monitoring characterizes specific problems like performing short-term monitoring at specific customer sites or at difficult loads. Monitoring can enhance power quality service by modifying the power system or by installing equipment within the customer's premises. Monitoring can provide just-in-time Maintenance to avoid catastrophic failure.

3.2 Power Quality Monitoring Techniques:

Various Power quality monitors are discussed below. Commercially available monitors are classified into:

1) PORTABLE MONITORS: It is used for troubleshooting after an event has taken place. Subdivided into:

I. Voltage recorders: Recorders digitize voltage and current signals by taking samples of voltage and current over time. It is used for continuous monitoring of steady state voltage variations. Most important factor to consider when selecting and using a voltage recorder is the method of calculation of the RMS value of the measured signal.

II. Disturbance analyzer: It is designed to capture events affecting sensitive devices. Thresholds are set and recording starts the moment when a threshold value is exceeded.

Fig 3.1 Portable Monitor

2) PERMANENT MONITORS: These monitors are permanently installed full system monitors, strategically placed throughout the facility, letting the users know any power quality disturbance as soon as it happened. It characterizes the full range of power quality variations. It Records both the triggered and sampled data. The triggering depends on RMS thresholds for RMS variations and on wave shape for transient variation. 'Real time monitoring system' is an example.

Fig 3.2 Permanent Monitors

3) REAL TIME MONITORING SYSTEM:

Real Time Monitoring System contains software and communication facilities for data collection, processing and result presentation. The software maintains a database of system performance information which can be accessed. At the heart we have a server computer optimized for database management and analysis. Both the disturbance analyzers and voltage recorders can be integrated into the real time monitoring system.

This permanent monitoring system has the following components:-

1) Measurement instruments: It Involve both the voltage recorder and disturbance analyzer. It has a trigger circuit to detect events. It includes a data acquisition board to acquire all the triggered and sampled data.

2) Monitoring workstation: It is used to gather all information from the measuring instruments. It periodically sends information to a control workstation.

3) Control workstation: This station configures the parameters of measuring instruments. It gathers and stores the data coming from the remote monitoring workstations. It does the data analysis and export.

4) Control software: This software drives the control workstation.it does the analysis and processing of data. Algorithms used for processing varies according to the system used. Algorithms used may be based on wavelet transforms or expert systems or some other advanced technique.

5) Database server: Database management system should provide fast and concurrent access to many users without critical performance degradation. Also, it should avoid any form of unauthorized access.

6) Communication channels: Selection of communication channel strongly depends on monitoring instruments, connectivity functions and on their physical locations. Some of the possible channels are fixed telephone channels by using a modem and mobile communication system by using a GSM modem.

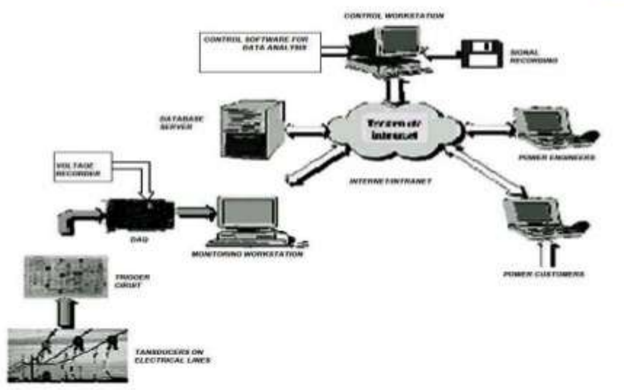

Fig 3.3 Schematic view of Real Time Monitoring System

4. DATA ANALYSIS OF POWER QUALITY MEASUREMENTS

Analysis is done by the control software and the method of analysis depends on the type of disturbance. The main objective of an analyser is to identify the type of event. Analyser looks for parameters in the measured data to characterize the waveform. Since individual inspection of all wave shapes is not easy due to the large size of database, a few characteristics are extracted from the measured data, mainly magnitude and duration. Since database has a lot of information and recorded data, analyser extracts only the relevant disturbances. Analyser groups the captured events in a number of classes. These classes are made by comparing the captured waveforms with the ideal waveforms. This classification is called disturbance classification. By comparing the captured events with libraries of power quality variation characteristics and correlating with system events, causes of variations can be determined. Every electrical disturbance has an associated waveform which describes its characteristics, which provides important clues to locate the source of electrical problem

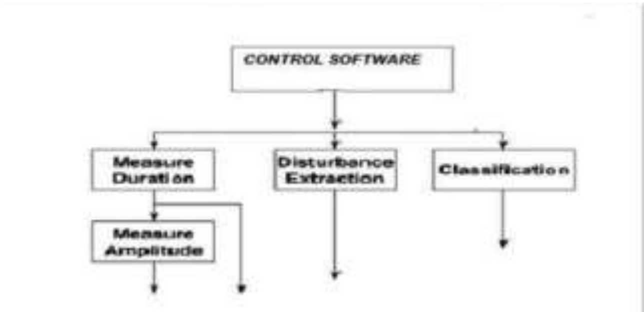

Fig 4.1 Methodology of Data Analysis

5. BENEFITS OF POWER QUALITY MONITORING

1) It ensures power system reliability.

2) It Identify the source and frequency of events.

3) It helps in the preventive and predictive maintenance.

4) Evaluation of incoming electrical supply and distribution to determine if power quality disturbances are impacting.

5) It determines the need for mitigation equipments.

6) Reduction of energy expenses and risk avoidances.

7) Process improvements-monitoring systems allow identifying the most sensitive equipments and installing power conditioning systems wherever necessary.

CONCLUSION

From this study we understand in brief different work done on power quality issues to provide a clear perspective on various aspects of the power quality to the researchers and engineers working in this field. To overcome the negative impact of poor power quality on equipment and businesses, suitable power quality equipment can be invested. Identifying the right solution remains the first step which can be achieved by proper monitoring techniques.

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