A Review on Power Quality Problems and Improvement Techniques

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Abstact: **This paper will help the know different power quality Problems occurring in power system and provide brief idea about their solutions with comparative study. The term electric power quality (PQ) is generally used to assess and to maintain the good quality of power at the level of generation, transmission, distribution, and utilization of AC electrical power. Nonlinear loads. Therefore, power quality is quantified in terms of voltage, current, or frequency. In this paper power quality problems can be viewed as the difference between the quality of power supplied and the quality of power required for reliable operation of the load equipment The new concept of advanced power electronic based Custom Power Devices (CPDs) mainly distributed static synchronous compensator (D-STATCOM), dynamic voltage restorer (DVR) and unified power quality conditioner (UPQC) have been developed due to lacking the performance of traditional compensating devices to minimize power quality disturbances. The main purpose of this paper is to overlook the sources and determine the most common power quality problems occurring in the power system and study the methods available for improving these problems.**

INTRODUCTION

There are a number of reasons for the pollution of the AC supply systems, including natural ones such as lightening, flashover, equipment failure, and faults and forced ones such as voltage distortions and notches. A number of customer's equipment also pollute the supply system as they draw non-sinusoidal current and behave as nonlinear loads. Therefore, power quality is quantified in terms of voltage, current, or frequency deviation of the supply system, which may result in failure or mal-operation of customer's equipment. Typically, some power quality problems related to the voltage at the point of common coupling (PCC) where various loads are connected are the presence of voltage harmonics, surge, spikes, notches, sag/dip, swell, unbalance, fluctuations, glitches, flickers, outages, and so on. These problems are present in the supply system due to various disturbances in the system or due to the presence of various nonlinear loads such as furnaces, uninterruptible power supplies (UPSs), and adjustable speed drives (ASDs). However, some power quality problems related to the current drawn from the AC mains are poor power factor, reactive power burden, harmonic currents, unbalanced currents, and an excessive neutral current in polyphase systems due to unbalancing and harmonic currents generated by some nonlinear loads[1]. These power quality problems cause failure of capacitor banks, increased losses in the distribution system and electric machines, noise, vibrations, overvoltage's and excessive current due to resonance, negative sequence currents in generators and motors, especially rotor heating, dielectric breakdown, interference with communication systems, signal interference and relay and breaker malfunctions, false metering, interferences to the motor controllers and digital controllers, and so on. The power quality problems can be viewed as the difference between the quality of power supplied and the quality of power required for reliable operation of the load equipment. From this view, the problems can be resolved in any one of the following ways:

1. Design equipment and electrical systems to prevent electrical disturbances from causing equipment or systems to malfunction.
2. Analyze the symptoms of a power quality problem to determine its cause and solution.
3. Identify the medium that is transmitting the electrical disturbance and reduce or eliminate the effect of that medium.
4. Treat the symptoms of the power quality problem by the use of power conditioning equipment. Power conditioning equipment mitigates a power quality problem when it occurs.

Power Quality Parameters

Power quality is a measure of various parameters like voltage current and frequency within its predefined range. If there has any deviation generated various problems like voltage sag, voltage swell, transient, flicker, harmonics etc. which can be responsible for poor power quality[2].

Transients

It is an event that is undesirable and momentary in nature. It is the sudden change in one stead state operating condition to another.

Transients can be classified into two categories:

1. Impulsive and

2. Oscillatory

Impulsive Transient

An impulsive transientis a sudden non–power frequency change in the steady-state condition of voltage, current, or both that is unidirectional in polarity (either positive or negative). Impulsive transients are normally characterized by their rise and decay times. Due to high frequency nature, the shape of impulsive transients may be changed quickly by circuit components and may have significant different characteristics when viewed from different parts of the power system. They are generally not conducted far from the source[3].

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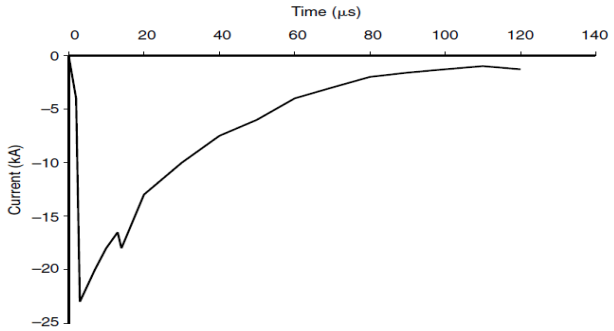

Fig. 1 Lightning stroke current impulsive transient

Oscillatory Transient

An oscillatory transient is a sudden, non–power frequency change in the steady-state condition of voltage, current, or both, that includes both positive and negative polarity values.

Instantaneous value of oscillatory transient changes polarity rapidly.

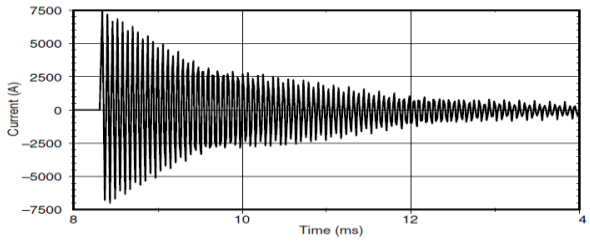

Fig.2 Oscillatory Transient caused due to back-to-back capacitor switching

Long-Duration Voltage Variations

When the rms value of voltage deviates for duration more than 1 minute, it is termed as long duration voltage variation.

Short-Duration Voltage Variations

When the rms value of voltage deviates for duration less than 1 minute, it is termed as long duration voltage variation. Each type of variation can be designated as instantaneous,momentary, or temporary, dependingon its duration.

Voltage Imbalance

Voltage imbalance is defined as the maximum deviation from the average of the three-phase voltages or currents, divided by the average of the three-phase voltages or currents, expressed in percent. The ratio of either the negative- or zero-sequence component to the positive-sequence component can be used to specify the percent unbalance. The source of voltage unbalances is single-phase loads on a three-phase circuit. Voltage unbalance can also be the result of blown fuses in one phase of a three-phase capacitor bank. Severe voltage unbalance can result from single-phasing conditions.

Power Quality Problems

poor load power factor:-the ratio of the real power flowing to the load to the apparent power in the electric circuit is called the power factor of the power system .it is an very important term of power system .the capacity of the circuit for doing work in a particular time is called real power and product of current and voltage is called apparent power. In power system because of various use of semiconductor devices or nonlinear load the wave shape of voltage and current are distorted which create the apparent power will be greater than the real power and get low power factor in the circuit. In case the power factor is low in an electric power system the amount of current flowing in the circuit draws more than a load with a high power factor for the same amount of useful power transferred. When the circuit has high current the energy lost in the circuit is higher and required larger wires and other electric equipment. [5]

Harmonics: - harmonics are sinusoidal voltage or current components having frequency are integer multiples of the supply frequency. Distortion means the alteration of the original shape of an object image sound waveform or other form of information and representation. Harmonics are also a type of distortion which changes the voltage and current waveform of fundamental power frequency. Various nonlinear loads , power semiconductor devices, flurescent lamps adjustable speed drives personal computers etc. are generated harmonics in power system .this create various harmful effect in system it can reducing the efficiency of system, plant mal-functioning of equipments , aging of installation ,overheating and failure of machines ,overloading of power factor correction capacitors and power transformers.[6]

Notching in low voltage:-when the current is commuted from one phase to another phase some disturbance in voltage waveform is called voltage notching .this is a type of power quality disturbance .voltage notch disturbs the voltage waveform and excites the natural frequency of the system usually these frequency range are in radio frequency range .which introduce the harmonic and nonharmonic frequency that are much higher than those found in higher voltage system .excision frequency create high frequency oscillations in the voltage of converter circuit .voltage notch damage capacitor banks ,create parallel resonance ,signal interference in logic and communication circuit, over loading in electromagnetic filters.[7]

Voltage Imbalance: voltage imbalance or unbalance is the ratio of maximum deviation from the average of 3 phase voltage and current to average of 3 phase voltage and current .there are many regions are responsible for the voltage unbalance such as unbalance incoming supply lines, nonequable transformer tap setting ,large single phase distribution transformer on the system ,faults in power transformer grounding ,open delta connected transformer

banks ,unequal impedance in conductors of power supply wiring ,heavy reactive single phase load such as welders etc.[8]
disturbance of supply power: - for a good power quality of a power system required completely sin wave of voltage and current. But interruption, distortion, sag, swell, flicker, over voltage, under voltage etc. are the disturbance in supply power which are responsible for various types of power loss in the system. Small duration voltage interruption create relay tripping over heating in the system, burning power supply, damage semiconductor component and many problem.

POWER QUALITY IMPROVEMENT TECHNIQUES METHOD:

Power quality problems can be defined as the difference between the quality of power supplied and the quality of power required for reliable operation of the load equipment. Several types of power enhancement devices have been developed over the years to protect equipment from power disturbances. Some of the effective and economic measures can be identified as following:
i)Power conditioning devices
ii) Custom power devices

i)Power conditioning devices

1-**Lightning and surge arrestors**: Arrestors are using to protect The transformers from lightning and voltage surges but are certainly not sufficient for limiting voltage disturbances to protect sensitive electronic circuits from voltage surges.
2-Transient Voltage Surge Capacitors (TVSC): These units clamp spikes to a level that it is safe for the sensitive loads. Employing an entire facility protection strategy will safeguard the electrical system against most transients.
3-Filters: Provide protection against high frequency low voltage noises. Filters are designed to pass the fundamental frequency and reject the higher frequency noise such as electromagnetic interference (EMI) and ratio frequency interference (RFI). Harmonics filters prevent the harmonics content of non linear loads from back to the power source.
4-Isolation transformer: Provides a degree of filtering and isolation. Isolation transformers reduce electrical noise by separation of the primary and secondary through magnetic isolation. Isolation transformer reduce noises and harmonics but it does not compensate for power outages and voltage fluctuations
5-Voltage Regulators
Voltage regulators maintain output voltage at nominal voltage under severe input voltage variations. There are three basic types of regulators:
i)Tap changing Transformer: Designed to adjust for varying voltages by automatically transferring taps on a power transformer. The main advantage of tap changers is high efficiency, wide input range, high over load current capability and good noise isolation compared to other voltage regulation technology. Disadvantages are noise created when changing taps and no waveform correction. The tap-changing transformer is: slow in response, exhibits contact erosion needs routine maintenance of its parts, has an uneconomical size and requires frequent replacement of transformer oil [9]
ii)Buck boost: Utilizes similar technology to the changers except the transformer being not isolated. One of the advantages is that it can withstand high in-rush currents. Disadvantages are noise created when changing taps, poor noise isolation and no waveform correction
iii)Constant Voltage Transformer (CVT): It is also known as Ferro resonant transformer. The CVT is a static regulator that maintains a nearly constant output voltage during large voltage variations in the input voltage. Advantages are superior noise isolation, very precise output voltage and current limiting for overload protection. The lack of moving parts means that the transformer requires little maintenance. Disadvantages are large size, audible noise and low efficiency.
6-Uninterruptible Power Supply (UPS)
UPS systems provide protection in the case of a complete power interruption. There are three major UPS topologies each providing different levels of protection: off-line UPS, Line interactive UPS and on-line UPS. Topology may be considered according to the load requirement based on efficiency, cost and transfer time. Moreover, UPS also requires a high level of maintenance because of, leakage of batteries and also needs replacement for every five years.

ii)CUSTOM POWER DEVICES

Customers are demanding electrical power with high quality from the electric utilities. Custom power devices are capable to solve power quality problems. The concept of custom power is based on the use of power electronic controllers in the distribution system for the purpose of providing reliable and high quality power that is needed by sensitive equipments to power quality variations.
Types of Custom Power Devices.
1-network reconfiguring type
2- compensating type
1-Network reconfiguring type (switchgear) which used for power quality enhancement and these include: Static current Breaker (SCB), Static current limiter(SCL) and Static Transfer Switch (STS).
i)Static Current Limiter (SCL):
SCL limits a fault current by quickly inserting a series inductance in the fault path. It consists of a pair of anti-parallel gate turn off thyristors switch with snubbers (RC circuit) and a current limiting inductor. The currents limiter is connected in series with a feeder such that it can restrict the current in the case of a fault downstream. In the healthy state, the opposite poled switch remains closed. These switches are opened, when a fault is detected, such that the fault current now flows through the current limiting inductor[9]
ii)Static Circuit Breaker (SCB):
SCB breaks a faulted circuit much faster than a mechanical circuit breaker. An SCB has almost the same topology as that of an SCL except that the limiting inductor is connected in series with an opposite poled thyristor pair. The Gate Turn Off thyristor (GTO) are the normal current carrying elements. The thyristor pair is switched on

simultaneously as the bidirectional switch GTO is switched off once a fault is detected. This will force the fault current to flow through the limiting inductor. The Thyristor pair is blocked after a few cycles if the fault still persists. The current through the thyristor pair will case to flow at the next available zero crossing of the current[10].

iii)Solid-State Switch Based on The Thyristor Device (STS):

The properties of a thyristor (ON- state and OFF-state) are used to perform an intelligent switch which can choose between two power sources and provide the best available power to the electrical load [9]. In most cases the STS is capable to limit the duration of voltage sags and interruptions to less than 0.5 cycle by transferring the loads from the affected feeder to a backup feeder. STS response is very high speed [11] but when both the feeders are affected by voltage disturbances STS become not suitable

2- Compensating type

which used for voltage regulation, Power factor correction , load balancing and active filtering. Compensating type are include: Distributed Static Compensator (DSTATCOM), Dynamic Voltage Restorer (DVR) and Unified Power Quality Conditioner (UPQC).

i)Dynamic Voltage Restorer:

DVR is a compensating custom power type device. Voltage Source Inverter (VSI) of DVR generates a compensating voltage, which is then injected in the distribution system by means of series injection transformer. Passive filter connected between the VSI and the injection transformer, eliminates the higher order harmonic components from the inverter output voltage. Energy storage device connected to the VSI provides the necessary active power for the compensation [11]. DVR compensation ability depends on the range of sags and size of the energy storage.

ii)DSTATCOM:

Shunt devices are effective to compensate small voltage variation, which can be controlled by reactive power injection. The ability to control the fundamental voltage at a certain point depends on the impedance to the supply and the power factor of the load. The compensation of a voltage dip by current injection is very difficult to achieve, because the supply impedance is usually low and the injected current has to be very high to increase the load voltage.

CONCLUSION:

In this paper, the various power quality improvement techniques and solutions were discussed. Poor power quality can create much serious effect on our power system like overheating in system equipment, over loading, harmonics generations, waveform distortion etc. which can be mitigated through various techniques through filters facts devices and power factor corrected circuits etc.The FACTS devices are used to improve the power transfer capabilities and stability margins of the transmission line. The custom power devices are effective to restore the sensitive load voltage to the pre-fault value and make it smooth under different cases of faults and nonlinear load condition. Some of these custom power devices include DSTATCOM, UPQC, and DVR etc.this paper will be helpful for researchers, users and suppliers of electrical power to get a guideline about the power quality.

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