A Review on Mitigation Techniques on Power Quality Issues

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Abstract: The electrical energy is one of the easily used forms of energy. It can be easily converted to other forms of energy. With the advancement of technology, the dependency on the electrical energy has been increased greatly. Computer and telecommunication networks, railway network banking, post office, life support system are few application that just cannot function without electricity. At the same time these applications demand qualitative energy. Power quality is a set of electrical boundaries that allows a piece of equipment to function in its intended manner without significant loss of performance or life expectancy. All electrical devices are prone to failure when exposed to one or more power quality problems. The electrical device might be an electric motor, a transformer, a generator, a computer, a printer, communication equipment, or a household appliance. All of these devices and others react adversely to power quality issues depending on the severity of problems. This paper is about the review of power quality problems and methods for correction.

Index terms — power quality, problems, corrective methods.

I. INTRODUCTION

Electrical energy is the most efficient and popular form of energy and the modern society is heavily dependent on the electric supply. The life cannot be imagined without the supply of electricity. At the same time the quality and continuity of the electric power supplied is also very important for the efficient functioning of the end user equipment. Most of the commercial and industrial loads demand high quality uninterrupted power. Thus maintaining the qualitative power is of utmost important.

The quality of the power is affected if there is any deviation in the voltage and frequency values at which the power is being supplied. This affects the Performance and life time of the end user equipment. Whereas, the continuity of the power supplied is affected by the faults which occur in the power system. So to maintain the continuity of the power being supplied, the faults should be cleared at a faster rate and for this the power system switchgear should be designed to operate without any time lag.

The power quality is affected many problems which occur in transmission system and distribution system. Some of them are like- harmonics, transients, sudden switching operations, voltage fluctuations, frequency variations etc. These problems are also responsible in deteriorating the consumer appliances. In order to enhance the behavior of the power system, these all problems should be eliminated.

With the recent advancements in power electronic devices, there are many possibilities to reduce these problems in the power system. One of them is the use of Flexible AC Transmission System (FACTS) devices. The connection of these devices in the power system helps in improving the power quality and reliability. [7]

II. TYPES OF POWER QUALITY ISSUES

2.1. Voltage Sag

Voltage sag is defined as a decrease in voltage magnitude below 90% of nominal, but not a complete interruption. The typical duration is from 3- 10 cycles, 50 to 167 milliseconds. Devices mostly affected are: Computers, programmable logic controllers, controller power supplies, motor starter contractor etc. [1]

2.2. Voltage Swells

A swell is a short duration increase in rms line voltage valid of 110 to 180 percent of the nominal line voltage for duration of 0.5 cycles to 1 minute. Voltage swells lasting longer than two minutes are classified as over voltages. Voltage swells and over voltages are commonly caused by large load changes and power line switching.

2.3. Interruption

Interruption occurs when voltage levels drop to zero. Interruptions are classified as momentary, temporary or long-term. Momentary interruptions occur when service is interrupted, but then is automatically restored in less than two seconds. Temporary interruptions occur when service is interrupted for more than two seconds, but is automatically restored in less than 2 minutes. Long-term interruptions last longer than two minutes and many require field work to restore service. [2]

2.4. Distortions

Distortion occurs when harmonic frequencies are added to the 60 hertz voltage or current wave form, making the usually smooth wave appear jagged or distorted distortion can be caused by solid state devices such as rectifiers, adjustable speed controls, fluorescent lights, & even computers. [3]

2.5. Transients

Transients are sudden but significant deviations from normal voltage or current levels. Transients typically last from 200 million that of a second to half a second. Transients are typically caused by lighting. Electro static discharges, load switching. [4]

2.6. Oscillatory & impulsive transient

Oscillatory transients are a sudden, non-power frequency change in the steady state condition of voltage, current or both, that includes both positive & negative polarity values.[5]

2.7. Flicker

Flicker can be defined as small amplitude changes in voltage levels occurring at frequencies less than 25 Hertz flicker is caused by large, rapidly fluctuating loads such as arc furnaces & electric welders. [6]

2.8. Noise

Electrical noise is a rapid succession of transients tracking up and down along the voltage wave form. The magnitude of these rapid transients is usually much less than of an isolated transient.

2.9. Voltage fluctuation

Voltage Fluctuations are described by IEEE as systematic variations of the voltage waveform envelope, or a series of random voltage changes, the magnitude of which falls between the voltage limits. Causes are arc furnaces, frequent start/stop of electric motors (for instance elevators) and oscillating loads. Consequences are most consequences are common to under voltages. The most perceptible consequence is the flickering of lighting and screens, giving the impression of unsteadiness of visual perception [14].

2.10. Blackouts

A power failure or blackout is a zero-voltage condition that lasts for more than two cycles. It may be caused by tripping a circuit breaker, power distribution failure or utility power failure. A blackout can cause data loss or corruption and equipment damage. Possible Solutions is using Generators [15].

III. POWER QUALITY SOLUTIONS

Several types of power enhancement devices have been developed over the years to protect equipment from power disturbances. The following devices play a crucial role in developing an effective power quality strategy.

3.1. Transient Voltage Surge Suppressors (TVSS)

By employing TVSS a level of safe value of voltage is reached to electronic load. Protection is employed for an electrical system against most transients. The transients appeared in the voltage makes lowest possible transient to be appeared at the service entrance. Transient Voltage surge suppressors are used as an interface between the power source and sensitive loads, so that the transient voltage clamped by the TVSS before it reaches the load. Surge Suppressors also called Transient Surge Protection devices. Surge suppressors are easily connected to the distribution panels or to main entrance of the cadres of low voltage in order to protect the power in the data centres, in industries, in medical, in telecommunications and in the residential etc. [13]

3.2. Filters

- Noise Filters

Noise filters are used to avoid unwanted frequency current or voltage signals (noise) from reaching sensitive equipment. This can be accomplished by using a combination of capacitors and inductances that creates a low impedance path to the fundamental frequency and high impedance to higher frequencies, that is, a low-pass filter. They should be used when noise with frequency in the kHz range is considerable.

- Harmonic Filters

Harmonic filters are used to reduce undesirable harmonics. They can be divided in two groups: passive filters and active filters. Passive filters consist in a low impedance path to the frequencies of the harmonics to be attenuated using passive components (inductors, capacitors and resistors). Several passive filters connected in parallel may be necessary to eliminate several harmonic components. If the system varies (change of harmonic components), passive filters may become ineffective and cause resonance. Active filters analyze the current consumed by the load and create a current that cancel the harmonic current generated by the loads. Active filters were expensive in the past, but they are now becoming cost effective compensating for unknown or changing harmonics [9].

3.3. Isolation Transformers

The main purpose of the isolation transformer is safety and protection of electronic components and the persons against electronic components and the person against electrical shock. It physically separates the power supplying from primary side and a secondary side circuit connected to electronic components and grounded metal parts which are in contact with the person. In some cases (Delta-Wye connection) isolation transformers keep harmonic currents generated by loads from getting upstream the transformer. The particularity of isolation transformers is a grounded shield made of nonmagnetic foil located between the primary and the secondary. Any noise or transient that come from the source in transmitted through the capacitance between the primary and the shield and on to the ground and does not reach the load. It provides a degree of isolation and filtering. These devices effectively reduce conducted electrical noise by physical separation of the primary and secondary through magnetic isolation. Isolation transformers reduce normal and common mode noises; however, they do not compensate for voltage fluctuations and power outages [10].

3.4. STATCOM

STATCOM or Static Synchronous Compensator is a power electronic device using force commuted devices like IGBT, GTO etc. to control the reactive power flow through a power Network and thereby increasing the stability of power network. STATCOM is a shunt device i.e. it is connected in shunt with the line. The term synchronous in STATCOM mean that it can either absorb or generate reactive power in synchronization with the demand to stabilize the voltage of the power network. Static VAR compensators (SVR) use a combination of capacitors and reactors to regulate the voltage quickly. Solid -state switches control the insertion of the capacitors and reactors at the right magnitude to prevent the voltage from fluctuating. The main application of SVR is the voltage regulation in high voltage and the elimination of flicker caused by large loads. It is normally applied to transmission networks to counter voltage dips/surges during faults and enhance power transmission capacity on long [8].

3.5. Dynamic Voltage Restorer

A dynamic voltage restorer (DVR) acts like a voltage source connected in series with the load. The output voltage of the DVR is kept approximately constant voltage at the load terminals by using a step-up transformer and/or stored energy to inject active and reactive power in the output supply trough a voltage converter [12].

3.6. Thyristor-Based Static Switch

The static switch is a versatile device for switching a new element into the circuit when voltage support is needed. To correct quickly for voltage spikes, sags, or interruptions, the static switch can be used to switch in one of the following: Capacitor, Filter, Alternate power line, Energy storage system. The static switch can be used in the alternate power line application. This scheme requires two independent power lines from the utility. It protects against 85% of the interruptions and voltage sags.

3.7. Uninterruptible Power Supply (UPS)

UPS systems provide protection in the case of a complete power interruption (blackout). UPS can solve many PQ problems. A UPS provides a finite

source of electrical power to support selected critical loads during a loss of normal power. This backup time ranges from seconds to hours. Nearly every UPS offers power conditioning and overvoltage protection. They also provide varying degrees of protection from surges, sags, noise or brownouts depending on the technology used [8].

3.8 Voltage Regulators

Voltage regulators maintain output voltage at nominal voltage under all but the most severe input voltage variations. Voltage regulators are normally installed where the input voltage fluctuates, but total loss of power is uncommon. There are three basic types of regulators:

Tap Changers: Designed to adjust for varying input voltages by automatically transferring taps on a power transformer. The main advantage of tap changes over other voltage regulation technology is high efficiency. Other advantages are wide input range, high overload current capability and good noise isolation. Disadvantages are noise created when changing taps and no waveform correction.

Buck Boost: Utilize similar technology to the tap changers except the transformer is not isolated. Advantages are the units withstand high in-rush currents and have high efficiency. Disadvantages are noise created when changing taps, poor noise isolation and no waveform correction.

Constant Voltage Transformer (CVT): CVT is also known as ferro-resonant transformers. The CVT is a completely static regulator that maintains a nearly constant output voltage during large variations in input voltage. Advantages are superior noise isolation, very precise output voltage and current limiting for overload protection. The lack of moving parts mean the transformer requires little or no maintenance. Disadvantages are large size, audible noise and low efficiency.

3.9. Unified Power Quality Conditioner (UPQC)

The unified power quality conditioner (UPQC) is a custom power device, which mitigates voltage and current-related PQ issues in the power distribution systems. The UPQC employs two voltage source inverters (VSIs) that is connected to a DC energy storage capacitor. A UPQC, combines the operations of a Distribution Static Compensator (DSTATCOM) and Dynamic Voltage Regulator (DVR) together. This combination allows a simultaneous compensation of the load currents and the supply voltages, so that compensated current drawn from the network and the compensated supply voltage delivered to the load are sinusoidal and balanced [11].

IV.CONCLUSION

The demand for electric power is increasing at an exponential rate and at the same time the quality of power delivered became the most prominent issue in the power sector. Thus, to maintain the quality of power the problems affecting the power quality should be treated efficiently. Among the different power quality problems, voltage sag is one of the major one affecting the performance of the end user appliances. The FACT devices like DVR, D-STATCOM are helpful in overcoming the voltage unbalance problems in power system. DVR is a series connected device and injects voltage to compensate the voltage imbalance, D-STATCOM is a shunt connected device and injects current into the system. These devices are connected to the power network at the point of interest to protect the critical loads. These devices also have other advantages like harmonic reduction, power factor correction.

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