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Power Quality Issues and Improvement Using Custom Power Device

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Abstract - Electrical *power quality refers to maintaining of sinusoidal voltage at rated values of magnitude and frequency. With the increased awareness among end-user regarding power quality issues and consequences, this article aims to facilitate the management of PQ by proposing methods to eliminate them. Each PQ disturbance affects the end-user differently. For understanding the effect of each PQ perturbation that may occur, a classification of causes, effects and appropriate solution using custom power devices is done. In conclusion, understanding of PQ issues' consequences and an appropriate solution can be beneficial to any electrical power end-user.*

Key Words: Power quality, transients, harmonics, DVR, DSATCOM, UPQC.

1. INTRODUCTION

In today's world with increasing need of competitiveness, there is the question of good quality power without disturbing the reliability and cost. The end-users are more aware of the consequences faced by using poor quality power and are challenging the utilities to generate good quality of power. An inadequate level of power quality leads to economical loss and unsustainable use of resources for the utility.

Nowadays, power distribution system can be configured as a three-phase three-wire or four-wire structure having a power-limit voltage source with significant source impedance, and a combination of various types of loads. Ideally, the system should provide a balanced and pure sinusoidal three-phase voltage of constant amplitude to the loads, and in turn the loads should draw a current from the line with unity power factor, zero harmonics, and balanced phases. Also to the four-wire systems, no excessive neutral current should exist. As a result, the maximum power capacity and efficiency of the energy delivery are achieved. However, with a fast increasing number of applications of power electronic drives connected to the distribution systems today, a complex problem of power quality is evolved characterized by voltage and current harmonics, voltage imbalances, voltage fluctuations, power frequency variations [1]

2. POWER QUALITY

Electrical power quality is the ability of a power system to function satisfactorily without causing any damage to the equipment. PQ may also be defined as degree of any deviation because of which performance of equipment connected is affected.

With the invent of new technologies various power electronic devices are now more sensitive to the reduction of PQ since it has electronic devices and control systems based on microprocessors whose operating characteristics are affected by disturbances in power supply. The consumers, on the other hand, being more aware and better informed about the impact of different electromagnetic disturbances on electrical equipment, as a result, suppliers are asked to provide electrical power at contracted quality parameters. Also if the utility is generating a bad quality of power could lead to losses in billions of dollars. Interconnection of power grids is done for providing better performance and reliability. If, somehow, one of the grid due to some non-linear load generates poor quality power could inject harmonics in the whole system thereby degrading PQ.

2.1 POWER QUALITY PROBLEMS

To function properly electronic devices require voltage to flow with consistent range. Power surges, transients, interruptions can cause the voltage to fluctuate outside these ranges. Power quality can be degraded by a number of reasons example external factors like falling of trees on the OHTL, natural calamities like floods, landslides, cyclones, lightning surges or internal factors by switching operation, transformer energization or by using large single phase loads, improper wiring. With proper application of power conditioning equipment and proper wiring and grounding most of power quality problems can be eliminated.

2.3 POWER QUALITY INVESTIGATION

The main objective of the PQ investigation is to properly identify the problem so that an appropriate solution could be provided. Causes of low PQ can be due to various reasons listed below;

Table -1: Causes and effects of poor power quality.

Problems	Causes	Effects
Transients	Lightening, back to back capacitor switching, Transformer energization	Failure of electronic equipment, motor running at high temperature, persistent tripping.

Interruptions	Power system faults, equipment failure, control malfunction, delayed reclosing of protective devices.	Unnecessary tripping of protective devices, loss of data, malfunctioning of data processing equipment, complete shutdown.
Voltage sag	Energization of heavy loads, system faults, ice buildup on overhead transmission lines, lightening.	Tripping of sensitive equipment, stalling of Motors, malfunction of process controllers, flickering in illumination device.
Voltage swells	De-energization of large loads, energization of large capacitor Bank.	Hardware failure, overheating.
Harmonics	Nonlinear loads	Resonance, overheating of cables, electromagnetic interference with communication lines, excessive losses.
Low power factor	Varying load in power system, industrial heating furnaces, induction machine, harmonic currents.	Increase cost of transmission lines, losses, poor efficiency, and penalty from utility.

2.4 SOLUTIONS

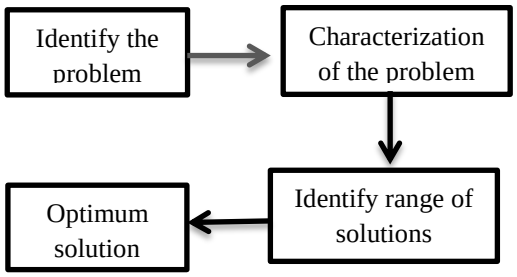

Fig -1: Evaluation procedure.

The mitigation of PQ problems may take place at different levels i.e. transmission, distribution and the end-user equipment. Between the different technical options available to improve PQ, custom power devices have proved out to be an important alternative to isolate loads from disturbances driving from grid. Custom power devices are power electronic based controllers used for PQ enhancement at distribution side. The power electronic controllers that are used as custom power devices based on voltage source converters are network reconfiguration type or compensating type. Network recognition type include solid state transfer switch (SSTC), solid state circuit breaker (SSCB) and solid state current limiter (SSCL). CPDs discussed in this review paper are Compensating type which include dynamic voltage regulator, distributed static compensator and unified power quality conditioner.

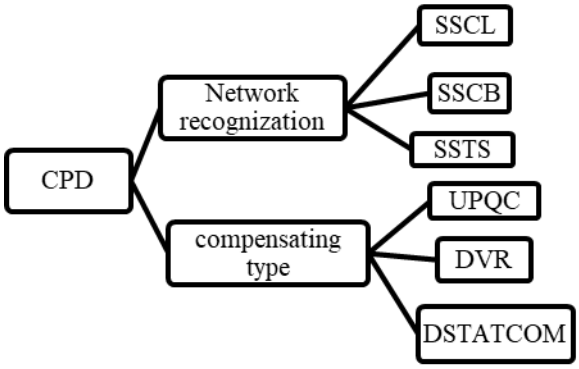

Fig -2: Classification of custom power devices.

2.4.1 DYNAMIC VOLTAGE REGULATOR.

Dynamic voltage restorer (DVR) injects voltage of required magnitude and frequency so that loads are insulated from power reliability issues hence protecting sensitive loads from voltage unbalances. It consists of an injecting transformer in series with power line, a voltage source converter, storage devices, a control and protecting system. DVR detects disturbances in the distribution side, generates AC power from DC source using voltage source converter which is then injected to the system via coupling transformer.

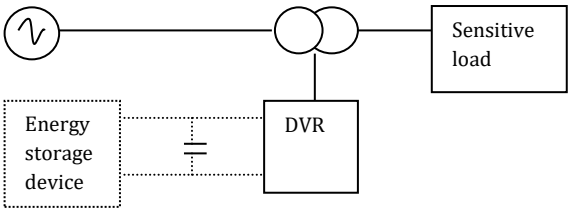

Fig -3: Schematic diagram of DVR in the system.

DVR not only smooth's out distorted voltage but also maintains a constant voltage profile. For longer duration of disturbances energy storage devices are used.

2.4.2 DSTATCOM

It consists of a two level voltage source converter, energy storage device, coupling transformer connected in shunt with the distribution side. Mostly it is used for providing continuously variable level of shunt compensation at the point of common coupling by injecting current in the distribution system which varies linearly with system voltage. By adjusting the magnitude and phase of the D-STATCOM output voltages' allows effective control of active and reactive power exchanges which is a major required phenomena for regulation of voltage in the transmission as well as distribution side. DSTATCOM continuously monitors the load rms voltage and compares it with reference signal generated. Then accordingly required harmonic currents are injected to compensate for the disturbances, thus preventing the disturbance from polluting all of the loads. Two types of control objectives in DSTATCOM are; AC voltage regulation of power system at the bus where it is connected and DC voltage control across the capacitor inside DSTATCOM.

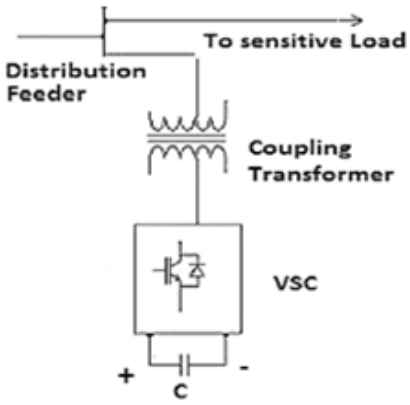

Fig -4: Schematic diagram of DSTATCOM in the system.

2.4.3 UNIFIED POWER QUALITY CONDITIONER.

UPQC involves both shunt and series compensation with a common DC link. It requires two VCS one in series and other in shunt which may work separately as series or shunt compensator and can also compensate active power. It is used for the mitigation of voltage and current disturbances that could affect sensitive electrical loads while compensating load reactive power [2]. The active series converter is used for the mitigation of supply side disturbances (voltage sag, swell, and flicker) by injecting voltage and the active shunt converter is responsible for disturbances caused by the end-user by injecting current in the system.

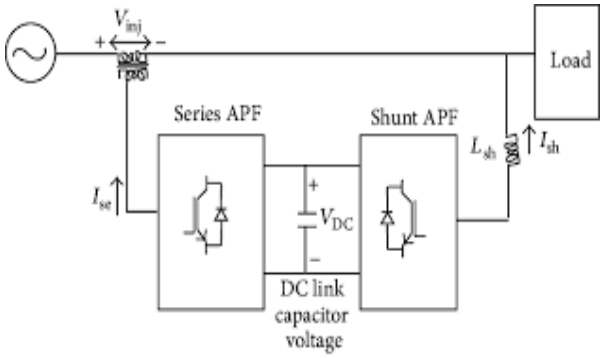

Fig -5: Schematic diagram of UPQC in the system.

3. CONCLUSION

This article highlighted the problems faced by disturbances on power quality in a more generalized manner by explaining custom power devices understanding of power quality related problems and consequences is important for better quality and reliability of power. Application of the given solutions facilitates better management of power quality issues. Compensating issues need to be analyzed in each context and integrated in the utility or end-user side thereby reducing economic losses, increase in reliability, and prevention from equipment failure. The PQ issue as such cannot be mitigated completely rather some serious damage is avoided by use of compensating devices.

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BIOGRAPHIES

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