IJIREEICE

ISSN (Online) 2321-2004
ISSN (Print) 2321-5526

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering
ISO 3297:2007 Certified
Vol. 6, Issue 1, January 2018

A Review on 12-Pulse DSTATCOM For Mitigation of Power Quality Problems

Rakesh kumar[1], Mr. Vikas Sharma[2]

Department of Electrical Engineering, Emax Group of Institution, Ambala, India[1]

Department of Electronics & Communication Engineering, Emax Group of Institution, Ambala, India[2]

Abstract: Custom Power (CP) devices that mitigate these power quality problems have gained more attention in the recent decades. This work deals with conceptual study of DSTATCOM during voltage sag and swell on the power network. Power quality has become an important factor in power systems, for consumer and household appliances with production of various electric and electronic equipment and computer systems. The main causes of a poor power quality are harmonic currents, poor power factor, supply voltage variations etc. A complete simulation model of the proposed system will be developed in Matlab / Simulink Environment. The system will be simulated with different control strategies under different operating conditions for comparison.

Keywords: PMSM, Load Control, PI controller, Fuzzy Controller etc.

I. INTRODUCTION

Power quality issues are becoming more and more significant in these days because of the increasing number of power electronic devices that behave as nonlinear loads. With the proliferation of the power electronics devices, nonlinear loads and unbalanced loads, the power quality (PQ) in the power distribution network has degraded significantly. A wide diversity of solutions to power quality problems is available for both the distribution network operator and the end use. The power processing at source, load and for reactive and harmonic compensation by means of power electronic devices is becoming more prevalent due to the vast advantages offered by them [1].

There are two classes of power quality problems: phenomena due to low quality of current drawn by the load caused by nonlinear loads and voltage disturbances that cause faults in the power system. The most significant and critical power quality problems are voltage sags, voltage swells and current harmonics. These problems may cause tripping of sensitive electronic equipment with disastrous consequences in industrial plants where tripping of critical equipment can bear the stoppage of the whole production with high costs associated.

The power quality is seriously disturbed due to the widely use of nonlinear loads and various faults in power system. Moreover, the controlling equipment and electronic devices based on computer technology demand higher levels of power quality. This kind of devices is sensitive to small changes of power quality, a short time change on PQ can cause great economic losses. Because of the two reasons mentioned above, no matter for the power business, equipment manufacturers or for electric power customers, power quality problems had become an issue of increasing interest. Under the situation of the deregulation of power industry and competitive market, as the main character of goods, power quality will affect the price of power directly in near future.

Custom Power devices also called as power quality compensator employ power electronic or static controllers in medium or low voltage distribution systems for the purpose of supplying a level of power quality that is needed by electric power customers that are sensitive to root mean square (RMS) voltage variations and voltage transients. CP devices include static switches, power converters, injection transformers, master control modules and/or energy storage modules that have the ability to perform current interruption and voltage regulation functions in a distribution system to improve power quality. CP devices are generally used for voltage regulation, active filtering, load balancing or power factor correction. The paper is ordered as follows. In section II, it represents related work with proposed system. In Section III, It describes the power quality problems related to the system. The problem is defined in section IV. Finally, conclusion is explained in Section V.

II. RELATED WORK

Abdelazeem A. et. al. [1] proposed a novel custom power device based on distribution static compensator (DSTA TCOM) with PID controller driven by the unified error signal (UES) from a multi loop dynamic error controller scheme. Both DSTATCOM and UES are modified to meet the requirements for voltage stabilization, voltage waveform disturbance compensation and power factor improvement. A complete simulation model of the proposed system is developed in Matlab/Simulink Environment. The system is simulated with different control strategies under different operating conditions for comparison. The controllers and the control strategies are developed to have the novel DSTATCOM be operated for voltage stabilization, power factor improvement, energy losses reduction, power quality, and less harmonics distortion.

Juan Shi et. al. [2] presented the design of a fuzzy logic based controller of a 3MVA DSTATCOM for improving the power quality and stability of a distribution power system. Grey Wolf Optimisation (GWO) algorithm has been used to tune the scaling factors of the fuzzy logic controllers. Comparison study of PI controlled and fuzzy logic controlled DSTATCOM for improving the power quality and dynamic performance of a distribution power system is simulated using Sim Power System in MATLAB/Simulink environment. The performances of the DSTATCOM controllers are evaluated during grid side voltage sag and load variation. The simulation results in MATLAB/Sim Power Systems show that the fuzzy logic controlled DSTATCOM controller provides better system dynamic response and hence improves power quality and stability for the distribution power system.

Karanki et al.in [2] have suggested two new Voltage Source Inverter (VSI) topologies for UPQC application. The proposed topologies enabled UPQC to have a reduced DC link voltage without compromising the compensation capability. The first topology is a combination of the conventional neutral clamped topology and a capacitor in series with the interfacing inductor of the shunt active filter. The series capacitor enables reduction in DC link voltage requirement of the shunt active filter and simultaneously compensating the reactive power required by the load, so as to maintain unity power factor, without any compromise on the performance of the UPQC. In the second topology, the system neutral is connected to the negative terminal of the DC bus. This will avoid the requirement of the fourth leg in VSI of the shunt active filter and enables the independent control of each leg of the VSI with single DC capacitor. The two proposed topologies are carried out using PSCAD simulator and detailed results are presented. The investigators have concluded that the proposed topologies have less average switching frequency, less THDs in the source currents and terminal voltages with reduced DC link voltage as compared to the conventional UPQC topology.

Basu et al.in [4] have discussed the VA requirement issues of series and shunt compensators of UPQC-Q and its performance is verified in a laboratory prototype. The phasor diagram, control block diagram and typical experimental results are presented to confirm the validity of the theory. Computer simulation has been made using SABER simulator. A laboratory proto-type is built and the simulation results are validated by experimental results. The investigators concluded that the laboratory experiments confirm good performance of UPQC-Q in case of supply voltage sag and harmonic elimination of non-linear load to the utility.

Khadkikar et al.in [5] have evaluated the performance of UPQC in a complex distribution network with realistic parameters. The UPQC is supposed to be installed at a plant which is located at a considerable distance from the distribution transformer and there are some loads present in between, represented by equivalent MW or MVA. The UPQC is installed in order to isolate all the loads within the plant from any disturbance from the source side. In addition to this, UPQC is acting as a harmonic isolator, preventing any current harmonics going towards point of connection from the plant side. A MATLAB/SIMULINK based simulation is carried out in order to verify its performance based on Unit Vector Template Generation control. The investigators have concluded that these simulation results show the controller is operating effectively giving improved results. The current THD is reduced from 12.06% to 2.38% and the voltage THD at the load bus is reduced to 3.2% from 28.86%. The UPQC is maintaining the load voltage at desired level even during sags or swells on the system.

Hingorani et. al. [6] has presented the term custom power means the use of power electronics controllers for distribution systems. The custom power increases the quality and reliability of the power that is delivered to the customers. Customers are increasingly demanding quality in the power supplied by the electric company.

Asati et al**.** in [7] have presented the detailed description and configuration of the recently introduced controlling methods for DVR and DSTATCOM with their advantages, limitations and applicable conditions. The working of both D-STATCOM and DVR are based on VSC. A DVR injects a voltage in series with the system voltage and D-STATCOM injects a current into the system to correct the voltage sag, swell and interruption. The performance of these systems not only described by their topologies and components but greatly depends upon control algorithms they used and the modification of these algorithms can give a cost effective improvement on the performance of the device.

Farhoodnea et al. in [8] have presented a comprehensive literature survey on the optimization techniques that solve the optimal Custom Power Devices (CPD) placement problem and that have been proposed recently by various researchers. This survey covers most of the applied heuristic and hybrid optimization techniques such as Genetic Algorithm (GA) and Simulated Annealing (SA) to solve power system optimization problems.

Kolhatkar et al.in [9] discussed an optimized Unified Power Quality Conditioner (UPQC), which aims at the integration of series active and shunt active power filters with minimum VA loading of the UPQC. The series active filter is a DVR, which regulates the voltage at the load end with minimum VA loading of the overall UPQC by voltage injection at optimum angle. The proposed scheme has simple control logic and is quite effective in VA optimization of the overall UPQC. Validity of the proposed scheme is proved through simulation and an experimental investigation in laboratory at 120 V, 0.6 kVA single phase prototype model.

Brenna et al. in [10] have discussed the OPEN unified power quality conditioner (UPQC), composed of a power-electronic series main unit installed in the medium-voltage/low-voltage substation, along with several power-electronic shunt units connected close to the end users. The series and parallel units do not have a common dc link, so their control strategies are different than traditional UPQC control techniques. This device can achieve general improvement in PQ, reducing the most common disturbances for all customers that are supplied by the mains by using only the series unit. This new solution combines an improvement in PQ for all end users, with a cost reduction for those that need high quality power. The proposed solution has been analyzed and described, and a model of a 400-kVA LV grid is considered a test network to evaluate the steady-state performance and functioning limits. The results obtained under steady-state conditions justify the configuration chosen and good device performance.

D. Mohan Reddy et. al. [11] highlighted the improved dynamic performance of 7-level CHB multilevel inverter based DSTATCOM with energy backup scheme and controlled by PWM control technique founded by IRP theory for generation of reference current signals and the proposed system is dynamically evaluated with Matlab/Simulink.

III. CUSTOM POWER & POWER QUALITY PROBLEMS

The mitigation device and point of connection is chosen according to its economic feasibility and reliability that is required. Innovative solutions employing power electronics are often applied when rapid response is essential for suppressing or counteracting the disturbances, while conventional devices are well suited for steady-state or general regulation. There are two general approaches to mitigate the PQ problems. One, named as load conditioning, is to ensure that the process equipment is less sensitive to disturbances, allowing it to ride through the disturbances. The other is to install a line conditioning device that suppresses or counteracts the disturbances. Commercially available mitigation devices tend to protect against a group of PQ disturbances. Mitigation devices vary in size and can be installed at all voltage levels of a power system (high, medium and low voltages) [4].

Custom Power is a concept based on the use of power electronic controllers in the distribution system to supply value-added, reliable and high quality power to its customers. CP devices or controllers include APFs and DVRs that have the ability to perform harmonic mitigation and voltage compensation functions in a distribution system to improve reliability and/or power quality. For simple load applications, selection of the proper mitigation device is fairly straightforward. However, in large systems with many loads all aspects of the power system must be considered carefully. Also, when dealing with large systems it is necessary to know the different sensitive load requirements.

Need of Custom Power

The increased use of automated equipment, like adjustable speed drives, programmable logic controllers, switching power supplies, arc furnaces, electronic fluorescent lamp ballasts, automated production lines are far more vulnerable to disturbances than were the previous generation equipment and less automated production and information systems. It is however not only reliability that the consumers want these days, quality too is very important for them. With the deregulation of the electric power energy market, the awareness regarding the quality of power is increasing day by day among customers. Power quality is an issue that is becoming increasingly important to electricity consumers at all levels of usage [5].

In the several processes such as semiconductor manufacturing or food processing plants, a batch of product can be ruined by a voltage dip of very short duration. Even short dips are sufficient to cause contactors on motor drives to drop out. The factors mentioned point out the problems faced by the industry and awareness of consumers about quality of power due to which it has increasingly become important to provide the consumers with

ISO 3297:2007 Certified
Vol. 6, Issue 1, January 2018

the reliable as well as superior power quality. Thus the development of custom power has gained so much of widespread attention nowadays.

This work takes into account the most common power quality problems such as voltage sags/swells and current harmonics as shown in Figure 1.Together they account for high percentage of the power quality disturbances affecting most commercial and industrial customers.

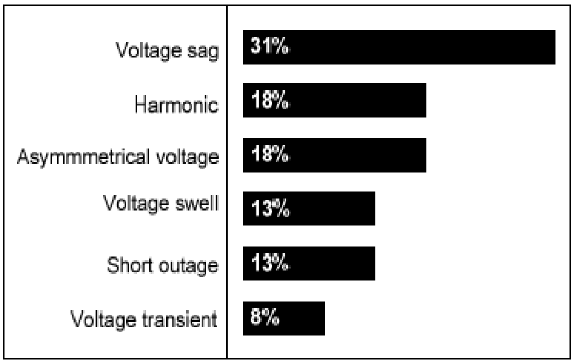

Figure 1: Percentage Occurrences of PQ Disturbances

Voltage Sag

Voltage sag is a brief decrease in the rms line voltage of 10 to 90 percent of the nominal line-voltage at the power frequency for durations from 0.5 cycle to 1 min. Voltage sags are generally related with system faults but can also be caused by energization of heavy loads or starting of large motors and overloaded wiring. The term sag describes a short-duration voltage decrease. Although the term has not been formally defined, it has been increasingly accepted and used by utilities, manufacturers and end users. Voltage sag problems in industrial equipment include relays opening due to the dip affecting the relay's coil voltage, under voltage sensors on the AC mains operating unnecessarily, incorrect reports from sensors, such as air flow sensors or water pressure sensors, circuit breakers or fuses operating, either due to the increase in current on non-dipped phases or (more often) due to a large increase in current immediately after the dip or a small section of highly-sensitive electronics that responds incorrectly to the sag.

Voltage Swells

A swell is a brief increase in the rms line-voltage of 110 to 180 percent of the nominal line-voltage for duration of 0.5 cycles to 1 minute. The voltage swells are usually associated with system fault conditions, but they are not as common as voltage sags. One way that a swell can occur is from the temporary voltage rise on the un-faulted phases during a single line to ground fault. Swells can also be caused by switching off a large load or energizing a large capacitor bank, insulation breakdown, sudden load reduction and open neutral connection. Voltage swells can negatively affect the performance of sensitive electronic equipment, cause data errors, produce equipment shutdowns, may cause equipment damage and reduce equipment life.

Current Harmonic Distortion

The harmonic voltage and current distortion are strongly linked with each other because harmonic voltage distortion is mainly due to non-sinusoidal load currents. Current harmonic distortion requires over-rating of series components like transformers and cables.

Voltage Interruptions

A voltage interruption is a large decrease in RMS voltage to less than a small percentile of the nominal voltage, or a complete loss of voltage. Voltage interruptions may come from accidents like faults and component malfunctions, or from scheduled downtime. Short voltage interruptions are typically the result of a malfunction of a switching device or a deliberate or inadvertent operation of a fuse, circuit breaker, or re-closer in response to faults and disturbances. Long interruptions are usually the result of scheduled downtime, where part of an electrical power system is disconnected in order to perform maintenance or repairs.

DOI 10.17148/IJIREEICE/612

IV. INTRODUCTION TO DSTATCOM

DSTATCOM is a Voltage source inverter (VSI) based static compensator device (STATCOM) applied to maintain bus voltage sags at the required level by supplying or receiving of reactive power in the distribution system. It is connected in shunt with distribution feeder with the help of coupling transformer. The single line diag. of DSTATCOM is shown in shown fig. 2.

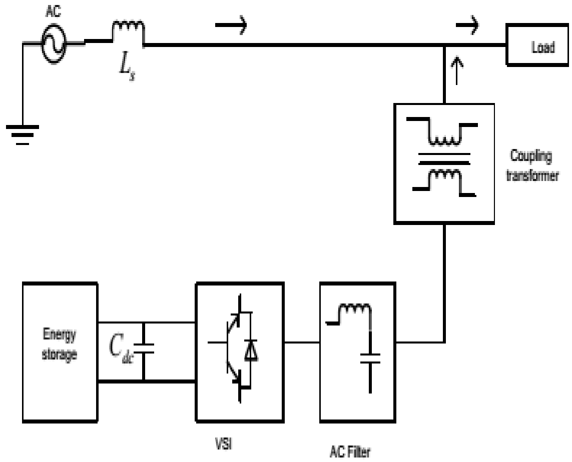

Figure 2:Distribution Static Compensator (DSTATCOM)

The purpose of the DSTATCOM is to cancel load harmonics fed to the supply. The coupling of DSTATCOM is three phase, in parallel to network and load. It work as current sources, connected in parallel with the nonlinear load, generating the harmonic currents the load requires also balance them in addition to providing reactive power. In order to compensate undesirable components of the load current the DSTATCOM injects currents into the point of common coupling. With an appropriated control strategy, it is also possible to correct power factor and unbalanced loads. This principle is applicable to any type of load considered a harmonic source.

In the power circuit, VSI converts DC voltage into controllable ac voltage, synchronized by ac filter and connected to AC distribution line through coupling transformer. The DSTATCOM can also rely and absorbed active power, by using energy storage in sufficient amount. The operating principle of DSTATCOM that it continuously monitors the load voltages and currents, determines the amount of compensation required by distribution system for a verity of disturbances. In this scheme, the active power flow is controlled by the angle between the ac system and VSI voltages; the reactive power flow is controlled by the difference between the magnitudes of these voltages. The DSTATCOM operates in both current and voltage control modes. The main advantages of STATCOM are:

- Quicker response time (A STATCOM has a step response of 8ms to 30 ms). This helps with compensation of negative phase current and with the reduction of voltage flicker.
- Active power control is possible with a STATCOM (with optional energy storage on dc circuit). This could further help with system stability control.
- No potential for creating a resonance point. This is because no capacitor banks or reactors are required to generate the reactive power for a STATCOM.

V. CONCLUSION

Voltage sags, swells and current harmonics are the most important power quality problems in commercial and industrial utility's customers. These power quality problems can cause tripping of sensitive electronic equipment, abnormal operations of facilities and tremendous economic losses. Custom Power devices have now been of interest for more than a decade that are able to improve the reliability and the quality of power delivered to electric power customers. DSTATCOM consisting of voltage source inverters with a common DC link is a Custom Power device and can simultaneously perform the tasks of Active Power Filter and Dynamic Voltage Restorer. In this work, the main objectives for the utilization of the studied equipment have been to reduce the distortion level and highly improving the power quality of the system.

IJIREEICE

ISSN (Online) 2321-2004
ISSN (Print) 2321-5526

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering
ISO 3297:2007 Certified
Vol. 6, Issue 1, January 2018

REFFERENCES

[1] Abdelazeem A. Abdelsalam, Adel M. Shara, " Improvement of Power Quality in Distribution Network Using a Novel DSTATCOM Device", IEEE 2015.
[2] SrinivasBhaskarKaranki, Mahesh K. Mishra and B. Kalyan Kumar, "Comparison of Various Voltage Source Inverter based UPQC Topologies", Proceedings of the International Conference on Power and Energy Systems (ICPS),pp 1-7, December 2011.
[3] Juan Shi, Amin Noshadi, " Fuzzy Logic Control of DSTATCOM for Improving Power Quality and Dynamic Performance", IEEE 2015.
[4] MalabikaBasu, S. P. Das and Gopal K. Dubey, "Performance Study of UPQC-Q for Load Compensation and Voltage Sag Mitigation", Proceedings of the IEEE 28th Annual Conference of the Industrial Electronics Society (IECON 02), Vol. 1, pp 698-703, November, 2002.
[5] V. Khadkikar,A. Chandra, A. O. Barry and T. D. Nguyen, "Application of UPQC to Protect a Sensitive Load on a Polluted Distribution Network", IEEEPower Engineering Society, General Meeting, 2006.
[6] H. Hingorani, "Introducing Custom Power", IEEE Spectrum, Vol. 32, No. 6, pp. 41-48, June 1995.
[7] ReenaAsati and Dr. N.R. Kulkarni. "A Review on the Control Strategies used for DSTATCOM and DVR", International Journal of Electrical, Electronics and Computer Engineering Vol. 2, No. 1, ISSN No. (Online): 2277-2626,pp 59-64, March 2013.
[8] MasoudFarhoodnea, Azah Mohamed, HussainShareef and HadiZayandehroodi, "A Comprehensive Review of Optimization Techniques Applied for Placement and Sizing of Custom Power Devices in Distribution Networks", PrzegladElektrotechniczny (Electrical Review), pp 261-265, 2012.
[9] Yashomani Y. Kolhatkar and S. P. Das, "Simulation and Experimental Investigation of an Optimum UPQC with Minimum VA Loading", Proceedings of the International Conference on Power Electronics and Drives Systems (PEDS), Vol. 1, pp 526-531, 2005.
[10] Morris Brenna, Roberto Faranda and Enrico Tironi, "A New Proposal for Power Quality and Custom Power Improvement: OPEN UPQC", IEEE Transactions on Power Delivery, Vol. 24, No. 4, pp 2107-2116, October 2009.
[11] D.Mohan Reddy, Dr.T.Gowrimanohar, " Dynamic Performance of Power Quality Improvement Using Multilevel DSTATCOM with DG Application", International Conference on Current Trends in Engineering and Technology, ICCTET'14.
[12] Vinod Khadkikar and Ambrish Chandra "A New Control Philosophy for a Unified Power Quality Conditioner (UPQC) to Coordinate Load-Reactive Power Demand Between Shunt and Series Inverters", IEEE Transactions on Power Delivery, Vol. 23, No. 4, pp 2522-2534, October 2008.
[13] Nikita Hari, K.Vijayakumar and SubhranshuSekhar Dash, "A Versatile Control Scheme for UPQC for Power Quality Improvement", Proceedings of the International Conference on Emerging Trends in Electrical and Computer Technology (ICETECT),pp 453-458, 23-24 March 2011.
[14] A.JeraldineViji and M.Sudhakaran, "Generalized UPQC system with an improved Control Method under Distorted and Unbalanced Load Conditions", Proceedings of the International Conference on Computing, Electronics and Electrical Technologies (ICCEET), pp 193-197, 2012.
[15] V. Khadkikar and A. Chandra, "A Novel Structure for Three-Phase Four-Wire Distribution System Utilizing Unified Power Quality Conditioner (UPQC)", Proceedings of the International Conference on Power Electronics, Drives and Energy Systems (PEDES), pp 1-6, December 2006.
[16] A.JayaLaxmi, G.Tulasi Ram Das, K.UmaRao , K.Sreekanthi and K. Rayudu., "Different control strategies for Unified Power Quality Conditioner at Load Side", Proceedings of the 1ST IEEE Conference on Industrial Electronics and Applications, pp 1-7, May 2006.