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Study and Implementation of Unitified Power Quality Controller for Mitigation of Power Quality Issues

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Abstract: This work deals with conceptual study of unified power quality conditioner (UPQC) 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. The Unified Power Quality Conditioner (UPQC) is a custom power device, which diminishes voltage and current related power quality issues. It uses a PWM control for firing the circuit and provides six clock pulses for operating the IGBTs circuit. It also prevents load current harmonics from entering the utility and corrects the input power factor of the load. In this, a frequency of 50 Hz is used for Indian systems.

Keywords: UPQC, DSTATCOM, DVR, PWM Pulses etc.

I. INTRODUCTION

Power Quality (PQ) may be defined as the concept of powering electronic apparatus in such a manner that is appropriate to the function of that apparatus and compatible with the other connected equipment in Institute of Electrical and Electronics Engineers (IEEE) Standard (IEEE Standard 519, 1995) [1]. According to International Electro-technical Commission (IEC), power quality is defined as set of parameters defining the properties of PQ as provided to the user in general conditions in terms of characteristics of voltage.

Current quality is concerned with deviations of the current from the ideal. The ideal current is a single-frequency sine wave of constant frequency and magnitude. Voltage and current are powerfully linked with each other. The ideal voltage is a single-frequency sine wave of constant frequency and constant magnitude. Power supply system can only control the quality of the voltage. It has no control over the currents that particular loads might draw. Therefore, the standards in the PQ area are devoted to maintaining the supply voltage within certain limits. Any significant deviation in the waveform magnitude, frequency or purity is a potential PQ problem.

The importance of PQ has risen very considerably over the last two decades due to a marked increase in the number of equipment which is sensitive to adverse PQ environments, the disturbances introduced by non-linear loads and the proliferation of renewable energy sources, among others. For improving the system performance for distribution system and with the growing development of the power semiconductor technology, the concepts of custom power was introduced to distribution systems.

Table 1: Percentage Occurrences of PQ Disturbances

PQ Problems	Percentage Occurrences
Voltage Sag	31%
Harmonics	18%
Asymmetric Voltage	18%
Voltage Swell	13%
Short Outage	13%
Voltage Transient	8%

There is an increased concern of PQ due to the following reasons:

- New-generation loads that use microprocessor and microcontroller based controls devices, are more sensitive to PQ variations than that equipment's used in the past.
- The demand for improved system efficiency provided growth of some devices like speed motor drives etc. for correcting the power factor and also for reducing losses. This results in increased level of harmonics in power systems.
- The client users have an awareness of issues related to PQ. Clients are now becoming knowledgeable about these issues like sag and swell etc

In this paper, it studies the UPQC system performance under voltage sag and swell. Further, in section II, it represents the related work of UPQC system and its various power quality problems. In Section III, It defines basics of proposed technique. In Section IV, It defines

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results of proposed System. Finally, conclusion is explained in Section V.

II. LITERATURE SURVEY

Authors [1] had discussed an acronymic list to envelop different UPQC aspects. In all, 12 acronyms were recognized, alphabetically. These were UPQC-D, UPQC-DG, UPQC-I, UPQC-L, UPQC-MC, UPQC-MD, UPQC-ML, UPQC-P, UPQC-Q, UPQC-R, UPQC-S, and UPQC-VAmin. In this, it had also been presented the most important control strategies and related concepts that were utilized to manage the UPQC operation.

Authors in [2] had suggested two Voltage Source Inverter (VSI) topologies which were used in UPQC. These were used to enable UPQC and provided reduced DC voltage. The first topology contains neutral clamped topology and a capacitor in series with inductor that became a shunt filter. The series capacitor is compensated the reactive power which was required by load. It helped to maintain unity power factor. In the second topology, the system neutral was linked to the negative terminal of the DC bus. This enabled the self-determining control of each leg of the VSI with single DC capacitor. For this, it used the PSCAD simulator. The results were presented and provided less THDs in the source currents and terminal voltages as compared to conventional topology.

Authors in [3] had discussed the conceptual learning of UPQC under voltage sag and swell on the power network. The UPQC can inject voltage. UPQC can absorb active power based on this injected voltage. Thus the UPQC can work in zero active power consumption mode, active power absorption mode and active power delivering mode. The series filter used in active power delivering mode and absorption mode during voltage sag and swell condition, respectively. The shunt filter helped series filter by maintaining dc link voltage at constant level. The shunt filter was used to compensate reactive power which was required by load. The MATLAB/SIMULINK results were provided for analysis.

Authors in [4] had discussed the main issues required for series and shunt filters of UPQC. Its performance was verified in laboratory. The results were presented by using SABER simulator. A laboratory proto-type was built and the results were validated by experimental results. The results concluded that these confirmed good performance of UPQC under sag and swell with presence of non linear load.

Authors in [5] presented the performance of UPQC in complex network under reliable parameters. In this, UPQC was installed at considerable distance from distribution transformer. Some non linear loads were present. The UPQC was used to isolate all loads within plant. UPQC was acting as a harmonic isolator which was used to prevent any harmonics. All simulations were carried out in MATLAB/SIMULINK. The results were presented and provided THDs upto 2.38%.

Authors in [6] had discussed the conceptual learning of UPQC under voltage sag and swell on the power network. They presented the term custom power means the use of power controllers for distribution systems. The custom power increased the quality and reliability of the power that was delivered to the customers. Customers were more and more demanding quality in the power supplied by the electric corporation.

Some researchers in [7] had presented the comprehensive explanation of controlling methods for DVR and D-STATCOM. They also included their advantages, limitations and appropriate conditions. Both D-STATCOM and DVR were based on VSC working. DVR is used to inject a voltage and D-STATCOM is used to inject a current into the system for handling PQ problems. Their performance was totally depends upon the control algorithms they used and also by their topologies and the alteration in these algorithms can give a cost efficient development on the performance of the device.

Authors in [8] had presented a comprehensive survey on the optimization method that may help to resolve the best possible Custom Power Devices (CPD) placement problem and that have been proposed recently by various researchers. This survey covered most of the applied heuristic and hybrid optimization techniques such as Genetic Algorithm (GA) and Simulated Annealing (SA) to solve power system optimization problems.

Some researchers in [9] discussed an UPQC which was optimized in nature. Its main aim was to integrate series active and shunt active power filters with least VA loading of the UPQC. The series active filter is a DVR, which was used to inject a voltage and provided regulation the voltage at the load end. The proposed scheme had simple control logic and was effective in optimization of the overall UPQC. Simulations results were presented and validated.

Authors in [10] had discussed the OPEN UPQC that composed of a main unit installed in the medium/low-voltage substation. 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 provided reduction in disturbances for customers and also achieved improvement in PQ with a cost reduction. The proposed model had been analyzed and described, and a model of a 400-kVA LV grid was considered to evaluate the performance.

III. SYSTEM MODEL

D-STATCOM is a Voltage Source Inverter (VSI) based Static Compensator Device (STATCOM) applied to maintain bus voltage sags at the required level by

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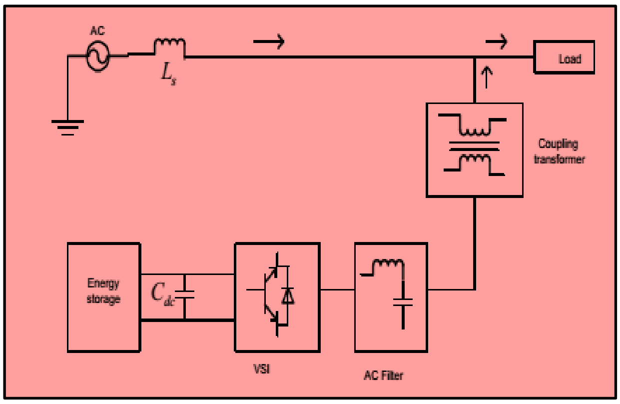

Figure 1: Distribution Static Compensator (D-STATCOM) Circuit

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 D-STATCOM is shown in shown Fig.1.The purpose of the D-STATCOM is to cancel load harmonics fed to the supply. The coupling of D-STATCOM 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.

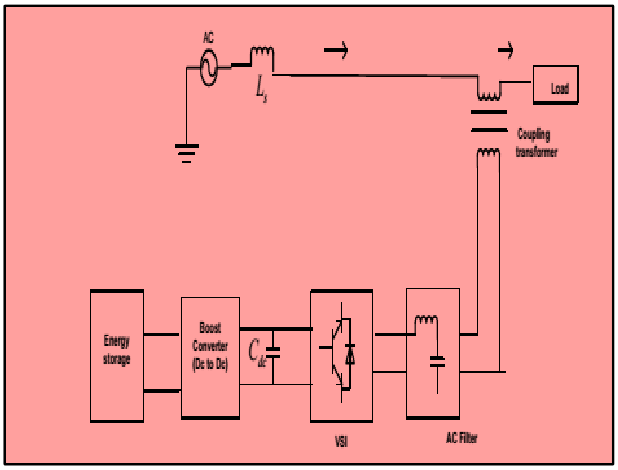

Figure 2: Generalized Block Diagram of DVR

Commercially, static series compensator is known as Dynamic Voltage Restorer (DVR). It is a high-speed switching power electronic controlling device. DVR is a series connected custom power device, designed to inject a dynamically controlled voltage in magnitude and phase in to distribution line via coupling transformer to correct load voltage. The generalized block diagram of DVR is shown in the Fig 2. It consists of energy storage device, a boost converter (dc to dc), voltage source inverter, ac filter and coupling transformer, connected in series. Here dc capacitor bank is used as energy storage device, which is interface by a boost converter. The boost converter regulates the voltage across the dc link capacitor that uses as a common voltage source for the inverters. The inverter generates a compensating voltage, which is inserted into distribution system through series matching transformer. The ac filter overcomes the effects on winding of coupling transformer and switching losses of control signal generating techniques for VSI. The main function of a DVR is to eliminate or reduce voltage sags seen by sensitive loads such as semiconductor manufacturing plant or IT industry.

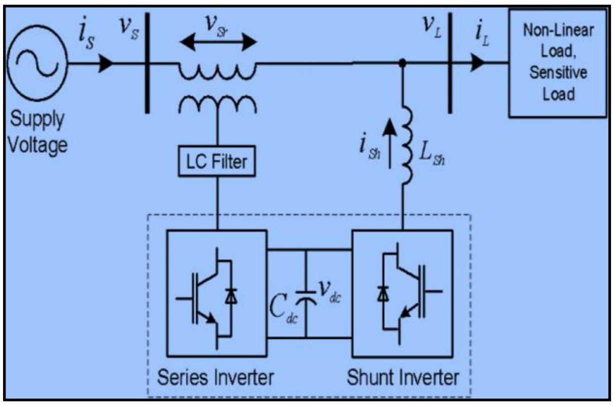

Figure 3: Unified Power Quality Conditioner

The best protection for sensitive loads from sources with inadequate quality, is shunt-series connection i.e. Unified PQ Conditioner (UPQC). Recent research efforts have been made towards utilizing UPQC to solve almost all PQ problems for example voltage sag, voltage swell, voltage outage and over correction of power factor and unacceptable levels of harmonics in the current and voltage. It is the combination of back to back connected shunt and series compensators through a common dc link. In this dc link storage capacitor is connected between two voltage source inverters for operating as combination of shunt and series compensator. The single line diagram of UPQC is shown in Fig 3. In other words; UPQC has the capability of improving PQ at the point of installation on power distribution systems or industrial power systems. UPQC, therefore, is expected as one of the most powerful solutions to large capacity sensitive loads to voltage flicker/imbalance.

IV. RESULTS & DISCUSSION

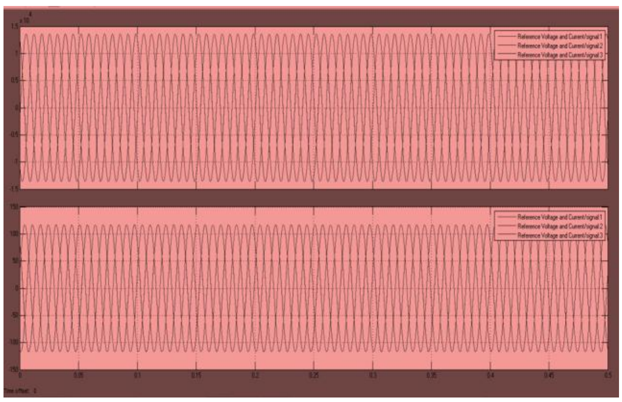

Figure 4: Reference Voltage & Current

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The system contains two controllers, one is connected in series and other is connected in parallel. It also contains transformers and filter banks for desirable output. The system is tested under different load conditions. A variable load is used to provide constant current output. Here, system uses three phase input programmable source. This system is best suited under several PQ problems like voltage sag, swell, harmonics and interruption etc. The series controller is designed to inject a dynamically controlled voltage in magnitude and phase into the distribution line via a coupling transformer to correct load voltage. This is known as Dynamic Voltage Regulator (DVR) which is popularly used as a series connected custom power device.

The purpose of the Shunt Controller is to compensate current unbalance, current harmonics and load reactive power demand fed to the supply. The coupling of shunt controller is three phase, in parallel to network and load. For verification of effectiveness of proposed designed system with realistic parameters, performance is simulated with MATLAB/SIMULINK. The UPQC performance with different PQ problems like Voltage sag, Swell, Harmonics and Interruptions are tested. Fig 4 shows the three phase reference voltage and current waveforms when UPQC is not connected in system. In this, these are constant in phase as well as in amplitude.

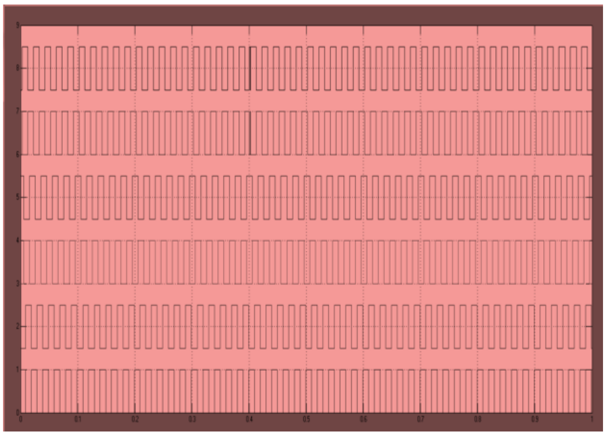

Figure 5: Firing Pulses for UPQC

Figure 6: Effect of Swell on Voltage & Current

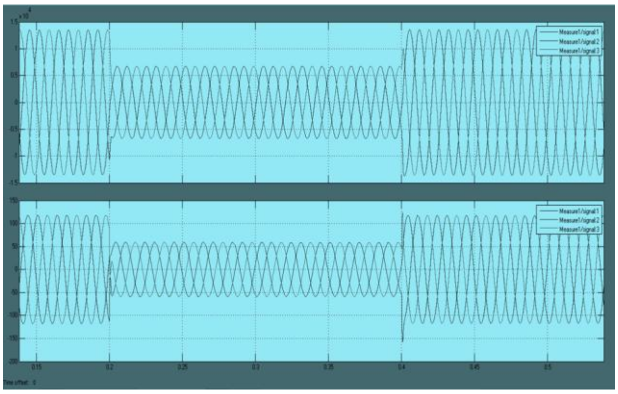

Figure 7: Effect of Sag on Voltage & Current

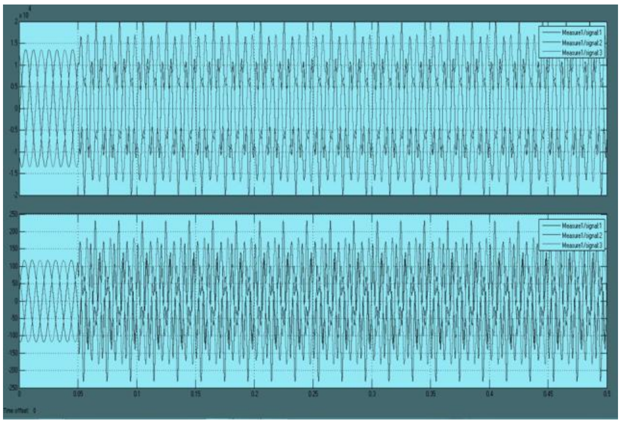

Figure 8: Effect of Harmonics on Voltage & Current

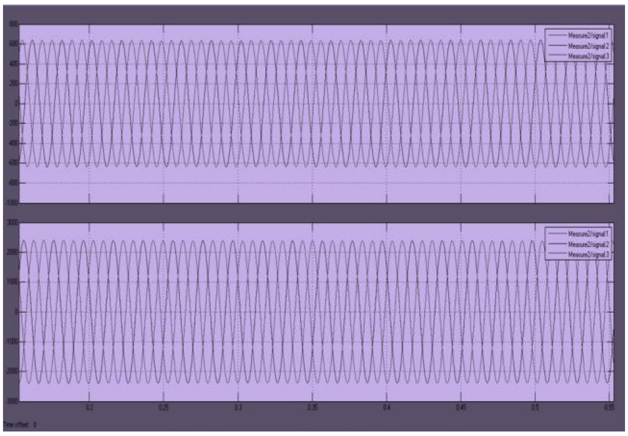

Figure 9: Constant Output Voltage & Current After Sag & Swell

Harmonics are caused by changeable frequency drives because of nature of rectifier design. The input waveform shows the 5th order harmonics in Fig. 8 and system is connected to UPQC to remove these problems and hence their resultant waveform signals are shown A voltage swell and sag of 50% is now introduced in the system for a time span ranging from 0.5 to 2 sec respectively. Under this condition, the currents are unbalanced and distorted; the terminal voltages are also unbalanced and distorted. The load output waveforms shows that UPQC maintains desired constant voltage level at load under sag or swell for longer duration on the system.

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Table 2: Impact of Harmonics on UPQC System

Order	Input THD	Output THD	Output Voltage
3rd	37.5	1.9	625
5th	36.1	1.9	625

V. CONCLUSION

In this work, it presents a UPQC Model with performance with non linear load. It uses a PWM control for firing the circuit and provides six clock pulses for operating the IGBTs circuit. It consists of two voltage source inverters with a common DC link and can act as DSTATCOM and DVR. In this work, the main objective is to reduce the distortion level and highly improving the PQ of the system. This thesis provides the development of UPQC for PQ improvement and realization of a flexible control approach to increase the UPQC performance. In this, a frequency of 50 Hz is used for Indian systems. In order to protect critical loads from harmonics, UPQC is suitable and satisfactory. It is adopted as the best solution for the compensation of voltage and current. In this, it can provide reliability upto power factor value of 0.9. It can handle harmonics upto 7th order. It provides constant output under sag and swell upto 90%.

REFERENCES

[1] V. Khadkikar, "Enhancing Electric Power Quality Using UPQC: A Comprehensive Overview", IEEE Transactions on Power Electronics, Vol. 27, No. 5, pp 2284-2297, 2012.

[2] S.B. Karanki, M. K. Mishra and B. K. Kumar, "Comparison of Various Voltage Source Inverter based UPQC Topologies", Proceedings of the International Conference on Power and Energy Systems (ICPS),pp 1-7,2011.

[3] V. Khadkikar, A. Chandra, A. 0. Barry and T. D. Nguyen, "Conceptual Study of Unified Power Quality Conditioner (UPQC)", Proceedings of the IEEE International Symposium on Industrial Electronics 2006, Canada, Vol. 2, pp 1088-1093, 2006.

[4] M. Basu, S. P. Das and G. 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, 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, 1995.

[7] R. Asati 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, 2013.

[8] M. Farhoodnea, A. Mohamed, H. Shareef and H. Zayandehroodi, "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] 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] VinodKhadkikar 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.

[12] 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.

[13] 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.

[14] 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.

[15] 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.