ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Performance Analysis of Multi Converter-Unified Power Quality Conditioner for Power Quality Improvement

Ravi Muppana
Department of Electrical and Electronics Engineering,
Sarada Institute of Technology and Management ,
Srikakulam, Andhra Pradesh-532404, India.

V.Satish
Department of Electrical and Electronics Engineering,
Sarada Institute of Technology and Management ,
Srikakulam, Andhra Pradesh-532404, India.

T.Bhavani
Department of Electrical and Electronics Engineering,
Sarada Institute of Technology and Management ,
Srikakulam, Andhra Pradesh-532404, India.

Abstract:
This paper presents a new control technique for a multi converter unified power quality conditioner (MC-UPQC) system to deal with the major power quality problems such as voltage sags, voltage harmonics, current harmonics and unbalanced loads with more reactive power demand. In this paper, hysteresis current loop control technique of synchronous reference frame model is used for shunt active power filter (APF) and sinusoidal pulse width-modulation (SPWM) technique is used for series active power filter. With this control approach, reactive power sharing feature between shunt and series APF can be accomplished simultaneously in multi feeder without obstructing the main functions of the MC-UPQC under non ideal conditions. An detailed performance analysis is carried out on proposed structure using MATLAB/SIMULINK.

Keywords:
Multi Converter Unified Power quality Conditioner (MC-UPQC), Hysteresis current loop control, Active Power Filter (APF), Sinusoidal Pulse Width-Modulation (SPWM).

Introduction:

With increasing applications of nonlinear and electronically switched devices in distribution systems and industries, power-quality (PQ) problems, such as harmonics, flicker, and imbalance have become serious concerns. In addition, lightning strikes on transmission lines, switching of capacitor banks, and various network faults can also cause PQ problems, such as transients, voltage sag/swell, and interruption. On the other hand, an increase of sensitive loads involving digital electronics and complex process controllers requires a pure sinusoidal supply voltage for proper load operation [1-3]. Power Quality (PQ) mainly deals with issues like maintaining a fixed voltage at the Point of Common Coupling (PCC) for various distribution voltage levels irrespective of voltage fluctuations, maintaining near unity power factor power drawn from the supply, blocking of voltage and current unbalance from passing upwards from various distribution levels, reduction of voltage and current harmonics in the system and suppression of excessive supply neutral current. In order to meet PQ standard limits, it may be necessary to include some sort of compensation. Modern solutions can be found in the form of active rectification or active filtering. A shunt active power filter is suitable for the suppression of negative load influence on the supply network, but if there are supply voltage imperfections, a series of active power filter may be needed to provide full compensation [4-6]. Conventionally, passive LC filters and fixed compensating devices with some degree of variation like Thyristor switched capacitors, Thyristor switched

Cite this article as: Ravi Muppana, V.Satish & T.Bhavani, "Performance Analysis of Multi Converter-Unified Power Quality Conditioner for Power Quality Improvement", International Journal & Magazine of Engineering, Technology, Management and Research, Volume 5, Issue 2, 2018, Page 158-162.

reactors were employed to improve the power factor of A.C. loads. Such devices have the demerits of fixed compensation, large size, ageing and resonance. Nowadays equipments using power semiconductor devices, generally known as active power filters (APF's), Active Power Line Conditioners (APLC's) etc. are used for the power quality issues due to their dynamic and adjustable solutions. Flexible AC Transmission Systems (FACTS) and Custom Power devices like DSTATCOM (Distributed Static Compensator), DVR (Dynamic Voltage Restorer), UPQC (Unified Power Quality Conditioner) etc. deal with the issues related to power quality using similar control strategies and concepts [7-10]. In recent years, solutions based on flexible ac transmission systems (FACTS) have appeared. The application of FACTS concepts in distribution systems has resulted in a new generation of compensating devices. A unified power-quality conditioner (UPQC) is the extension of the unified power-flow controller (UPFC) concept at the distribution level is one the best solution to make the overall power distribution system more healthy [2-5]. It consists of combined series and shunt converters for simultaneous compensation of voltage and current imperfections in a supply feeder [8-9].

Custom Power Devices:

The concept of custom power was introduced by N.G.Hingorani [2]. Like flexible ac transmission systems (FACTS), the term custom power (CP) pertains to the use of power electronic controllers for distribution systems. Just as FACTS improves the reliability and quality of power transmission by simultaneously enhancing both power transfer volume and stability, the custom power enhances the quality and reliability of power that is delivered to customers. Under this scheme a customer receives a pre-specified quality power. This pre-specified quality may contain a combination of specifications of the following.

- Frequency of rare power interruptions.
- Magnitude and duration of over and under voltages within specified limits.
- Low harmonic distortion in the supply voltage.
- Low phase unbalance.
- Low flicker in the supply voltage.
- Frequency of the supply voltage within specified limits.

There are many custom power devices. The compensating device either compensates a load, i.e., correct its power factor, unbalance etc. or improve the quality of the supplied voltage. The compensating power electronic devices are either connected in shunt or in series or a combination of the both. The family of emerging power electronic devices being offered to achieve these custom power objectives includes:

- Distribution Static Compensator (DSTATCOM) to protect the distribution system from the effects of a polluting e.g. fluctuating, voltage sags and swells and non-linear loads.
- Dynamic voltage restorer (DVR) to protect a critical load from disturbance e.g. sags swells, transients or harmonics, originating on the interconnected distribution system.
- Unified Power Quality Conditioner (UPQC) is the combination of series and shunt APF, which compensates supply voltage and load current imperfections in the distribution system.

Unified Power Quality Conditioner (UPQC):

The Unified Power Quality Conditioner (UPQC) is a more complete solution for the power quality problem. The basic structure of this equipment is shown in shown in Fig. 1. In this figure, the UPQC is an association of a series and shunt active filter based on two converters with common dc link. The series converter has the function to compensate for the harmonic components (Including unbalances) present in the source voltages in such a way that the voltage on the load is sinusoidal and balanced. The shunt active filter has the function of eliminating the harmonic components of nonlinear loads in such a way that the source current is sinusoidal and balanced. This equipment is a good solution for the case when the voltage source presents distortion and a harmonic sensitive load is close to a nonlinear load as shown in Fig. 1.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

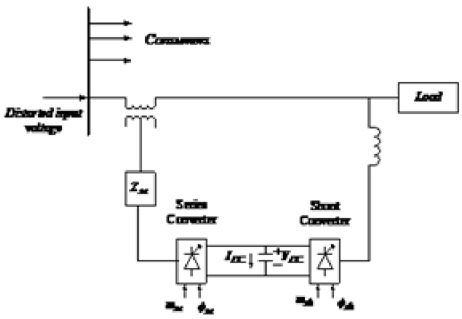

Fig. 1 Basic Block Diagram of UPQC

Multi Converter Unified Power Quality Conditioner (MC-UPQC):

A new configuration of a UPQC called the multi-converter unified power quality conditioner (MC-UPQC) is presented. The system is extended by adding a series-VSC in an adjacent feeder. The proposed topology can be used for simultaneous compensation of voltage and current imperfections both feeders by sharing power compensation capabilities between two adjacent feeders which are not connected. The system is also capable of compensating for interruptions without the need for a battery storage system and consequently without storage capacity limitations. The basic structure of the MC-UPQC is shown in Fig. 2. It consists of three VSCs (VSC1, VSC2, and VSC3) which are connected back to back through a common dc-link capacitor. In the proposed configuration, VSC1 is connected in series with BUS1 and VSC2 is connected in parallel with load L1 at the end of Feeder1. VSC3 is connected in series with BUS2 at the Feeder2 end. As shown in Fig. 2, all converters are supplied from a common dc-link capacitor and connected to the distribution system through transformer. Secondary (distribution) sides of the series-connected transformers are directly connected in series with BUS1 and BUS2, and the secondary (distribution) side of the shunt-connected transformer is connected in parallel with load L1.

Result analysis:

Let us consider that the power system in consists of two three-phase three-wire 380V (r.m.s, L-L), 50-Hz utilities.

The BUS1 voltage (u_{t1}) contains the seventh-order harmonic with a value of 22%, and the BUS2 voltage (u_{t2}) contains the fifth-order harmonic with a value of 35%. The BUS1 voltage contains 25% sag between 0.1 s < t < 0.2 s and 20% swell between 0.2 s < t < 0.3 s. The BUS2 voltage contains 35% sag between 0.15 s < t < 0.25 s and 30% swell between 0.25 s < t < 0.3 s. The nonlinear/sensitive load L1 is a three-phase rectifier load which supplies an RC load of 15Ω and 25 µF. Finally, the critical load L2 contains a balance RL load of 20 Ω and 80mH. The MC-UPQC is switched on at t = 0.02 s. The BUS1 voltage, the corresponding compensation voltage injected by VSC1 and finally load L1 voltage are shown in Figs. 3-5. In Figs. 3-5, only the phase a waveform is shown for simplicity and understanding and it is observed that the proposed MC-UPQC device is capable of compensating voltage at desired level.

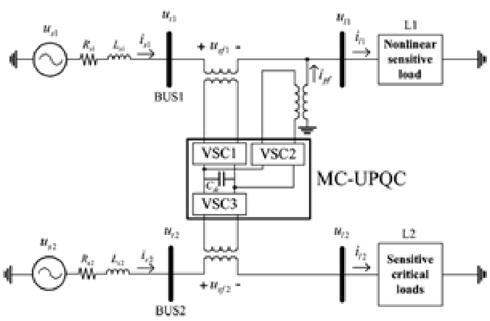

Fig. 2 Basic Block Diagram of MC-UPQC

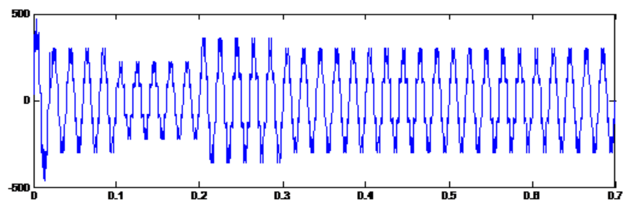

Fig. 3 Bus voltage at feeder 1

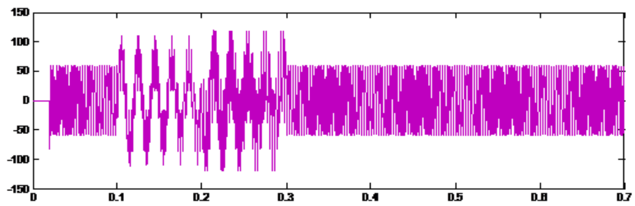

Fig. 4 Series compensated voltage at feeder 1

IJMETMR
ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

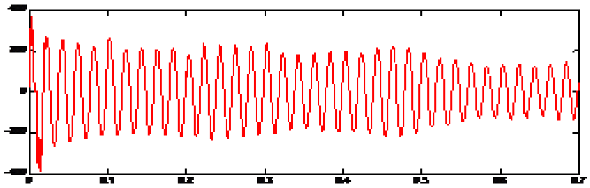

Fig. 5 Load voltage in feeder 1

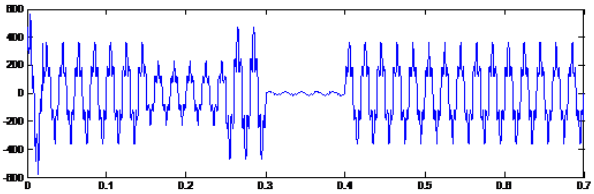

Fig. 6 Bus voltage at feeder 2

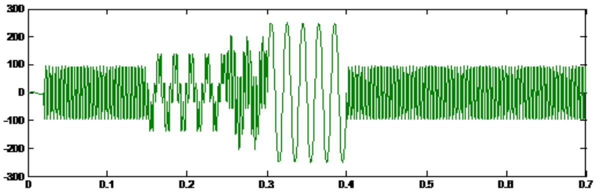

Fig. 7 Series compensated voltage at feeder 2

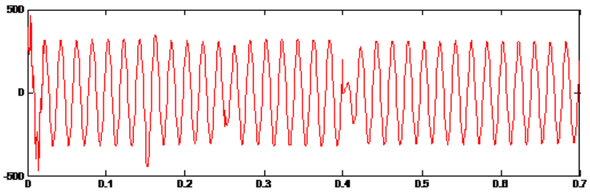

Fig. 8 Load voltage in feeder 2

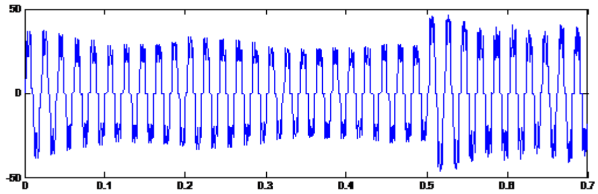

Fig. 9 Non-linear load current before compensation

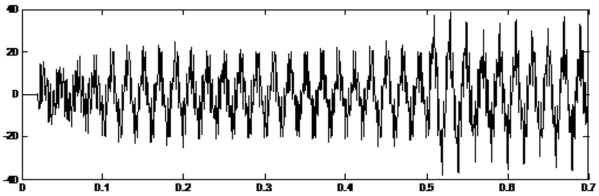

Fig. 10 Shunt compensated current

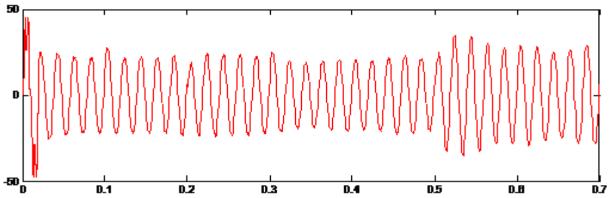

Fig. 11 Non-linear load current after compensation

Similarly, the BUS2 voltage, the corresponding compensation voltage injected by VSC3, and finally, the load L2 voltage are shown in Figs. 6-8. As shown in these figures, distorted voltages of BUS1 and BUS2 are satisfactorily compensated for across the loads L1 and L2 with very good dynamic response. The nonlinear load current, its corresponding compensation current injected by VSC2 and compensated Feeder1 current are shown in Figs. 9-11. The distorted nonlinear load current is compensated very well, and the total harmonic distortion (THD) of the feeder current is reduced from 28.5% to less than 5%. Also, the dc voltage regulation loop has functioned properly under all the disturbances, such as sag/swell in both feeders. From, Fig. 5, 8 and 11, it reveals that MC-UPQC device is capable of compensating both voltage and current simultaneously.

Conclusion:

In this article, a new unified power-quality conditioning system called MC-UPQC capable of compensation for voltage and current in adjacent feeder is modeled using MATLAB/SIMULINK and results are shown. The MC-UPQC is capable of fully protecting critical & sensitive loads against distortions, sag/swell, and interruption in two-feeder system. From these Results it can be concluded that the MC-UPQC system is also capable of compensating for interruptions without the need for a battery storage system.

References:

[1] Arindan Ghosh, Gerard Ledwich, "power quality enhancement using custom power devices", kluwer academic publishers, 2002.

[2] B.Singh, K. Al-Haddad, and A. Chandra. "A review of active power filters for power quality improvement. "IEEE Trans. Ind. Electron., vol.45. no.5.pp. 960-971, Oct.1999.

[3] C.A. Quinn and N.Mohan. "Active filtering of harmonic currents in three-phase, four-wire systems with three-phase and single-phase nonlinear loads" in proc. 7th IEEE APEC,1992. Pp. 829-836.

[4] .Khadkikar Vinod, Chandra Ambrish. A new control philosophy for a unified power quality conditioner (UPQC) to coordinate load-reactive power demand between shunt and series inverters. IEEE Trans Power Delivery October 2008;23(4):2522–34.

[5] Khadkikar Vinod, Chandra Ambrish. UPQC-S: A novel concept of simultaneous voltage sag/swell and load reactive power compensations utilizing series inverter of UPQC. IEEE Trans Power Electron September 2011;26(9):2414–25.

[6] Khadkikar Vinod, Chandra Ambrish. A novel structure for three-phase four wire distribution system utilizing unified power quality conditioner (UPQC). IEEE Trans Ind Appl September 2009;45(5):1897–902.

[7] Montero María Isabel Milanés, Cadaval Enrique Romero, González Fermín Barrero. Comparison of control strategies for shunt active power filters in three-phase four-wire systems. IEEE Trans Power Electron January 2007;22(1):229–36.

[8] Kesler Metin, Ozdemir Engin. Synchronous-reference-frame-based control method for UPQC under unbalanced and distorted load conditions. IEEE Trans Ind Electron September 2011;58(9):3967–75.

[9] Kanchan RS, Baiju MR, Mohapatra KK, Ouseph PP, Gopakumar K. Space Vector PWM signal generation for multilevel inverters using only the sampled amplitudes of reference phase voltages. IEE Proc Elect Power Appl March 2005;152(2):297–309.

[10] Saaki, Indranil, GT Chandra Sekhar, U. Salma, and B. Shankar Prasad. "Multiconverter unified power quality conditioning system using Artificial Neural Network technique." In India Conference (INDICON), 2011 Annual IEEE, pp. 1-7. IEEE, 2011.