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

Application of Fuzzy Based UPQC for Power Quality Enhancement with Minimum VA Rating

Sudarsi Rohan Abhinay
M. E (Power System & Automation),
SRKR Engineering College, Bhimavaram.

K.S.S.Prasad Raju, M.Tech, (Ph.D)
SRKR Engineering College,
Bhimavaram.

ABSTRACT:

Fuzzy logic starts with and builds on a set of user-supplied human language rules. This simplifies the job of the system designer and the computer, and results in much more accurate representations of the way systems behave in the real world. Additional benefits of fuzzy logic include its simplicity and its flexibility. Fuzzy logic can handle problems with imprecise and incomplete data, and it can model nonlinear functions of arbitrary complexity. If we don't have a good plant model, or if the system is changing, then fuzzy will produce a better solution than conventional control techniques. So fuzzy logic can be more fruitful in the field of power systems as it is always changing. This paper deals with Minimum VA rating handled by a Unified Power Quality Conditioner, which consists of Series and Shunt Active Power Filter.

The Series Active Filter is Dynamic Voltage Restorer (DVR), which regulates the voltage at the point of common coupling with minimum VA loading. The Shunt Active Filter is Distribution Static Compensator (DSTATCOM) which compensates the reactive power and eliminates the load current harmonics from the source current. In this paper, Fuzzy based controller is used to extract the harmonic component in the source current. The proposed compensator compensates the harmonics and reactive power in all three phases. To regulate the dc capacitor voltage, a current control method using hysteresis controller is proposed. In this proposed method the total power handled by UPQC is minimum than the other conventional methods and it has been investigated by simulation using MATLAB/SIMULINK.

Index Terms:
Unified Power Quality Conditioner (UPQC),Dynamic Voltage Restorer (DVR), Static Compensator (STATCOM), Minimum VA, Optimum angle, injection voltage and voltage sag.

INTRODUCTION

1.1. Introduction

Electric power quality may be defined as a measure of how well electric power service can be utilized by customers. Power Quality problem is an occurrence manifested as a nonstandard voltage, current or frequency that results in a failure or a miss-operation of end user equipment. To compensate harmonics conventional Passive Filters are used for specific number of harmonics. To compress total harmonic content Active Power Filter are used. For all types of power quality solutions at the distribution system voltage level DFACTS also called as Custom Power Devices are introduced to improve Power Quality.

1.2 Power Quality

Power quality is certainly a major concern in the present era. It becomes especially important with the introduction of sophisticated devices, whose performance is very sensitive to the quality of power supply. Modern industrial processes are based on a large amount of electronic devices such as programmable logic controllers and adjustable speed drives. Electronic devices are very sensitive to disturbances and thus industrial loads become less tolerant to power quality problems. Power Quality (PQ) has become an important issue since many loads at various distribution ends like adjustable speed drives, process industries, printers, domestic

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

utilities; computers, microprocessor based equipments etc. have become intolerant to voltage fluctuations, harmonic content and interruptions. 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. Recently, the importance of power quality issues has increased due to various reasons. First of all, there have been changes in the nature of electrical loads. On one hand, the characteristics of load have become more complex due to the increased use of power electronic equipment, which results in a deviation of voltage and current from its sinusoidal waveform. On another hand, equipments have become more sensitive to

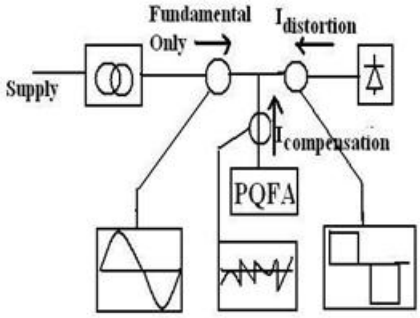
Reducing the effects of harmonics.

A variety of solutions exist to limit the problems due to harmonics. One approach is to make structural modifications within the plant. These include the connection of sensitive equipment to a clean part of the network. One could also choose twelve pulse drives rather than six pulse drives. These produce harmonics of which the order is given by the expression n = (12.i ± 1) where i is an integer greater or equal than 1. Thus the line current contains harmonics of the order 11, 13, 23 ... with a magnitude General principle of active filtering The principle of active filtering is fundamentally different from that of the passive filter. It was noted that the passive filter is not controlled and that the filtering is a result of the impedance characteristics. The active filter does instead measure the harmonic currents and generates actively a harmonic current spectrum in opposite phase to the distorting harmonic current that was measured. The original harmonics are thereby cancelled. The control of the active filter in combination with the active generation of the compensating current allows for a concept that may not be overloaded.

Harmonic currents exceeding the capacity of the active filter will remain on the network, but the filter will operate and eliminate all harmonic currents up to its capacity. It can also be noted that the active filter we are considering here has a parallel topology. Active filters also exist in series topology but there do not offer the same advantage as the parallel topology. The connection is much less flexible; it has higher losses and is over loadable like the passive filter. From this point onwards, "active filter" will only refer to the parallel topology.

Active Power Filters

SOLID-STATE control of ac power using thyristors and other semiconductor switches is widely employed to feed controlled electric power to electrical loads, such as adjustable speed drives (ASD's), furnaces, computer power supplies.., etc. Such controllers are also used in HV dc systems and renewable electrical power generation. As nonlinear loads, these solid-state converters draw harmonic and reactive power components of current from ac mains. In three-phase systems, they could also cause unbalance and draw excessive neutral currents. The injected harmonics, reactive power burden, unbalance, and excessive neutral currents cause low system efficiency and poor power factor. They also cause disturbance to other consumers and interference in nearby communication networks.



Principle of Active Filtering

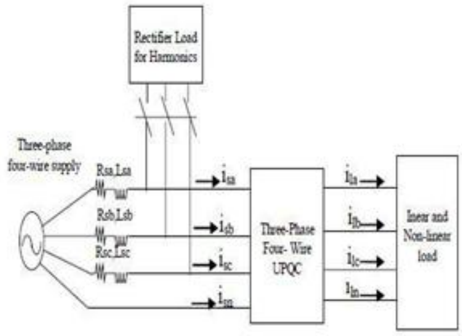
UNIFIED POWER QUALITY CONDITIONER (UPQC)

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

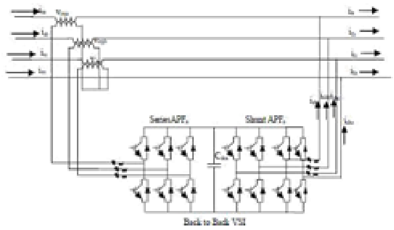
The unified power quality conditioner (UPQC) is a custom power device, which mitigates voltage and current-related PQ issues in the power distribution systems. In this paper, a UPQC topology for applications with non-stiff source is proposed. The proposed topology enables UPQC to have a reduced dc-link voltage without compromising its compensation capability. This proposed topology also helps to match the dc-link voltage requirement of the shunt and series active filters of the UPQC. The topology uses a capacitor in series with the interfacing inductor of the shunt active filter, and the system neutral is connected to the negative terminal of the dc-link voltage to avoid the requirement of the fourth leg in the voltage source inverter (VSI) of the shunt active filter.

The average switching frequency of the switches in the VSI also reduces, consequently the switching losses in the inverters reduce. The reported topologies of 3P-4W UPQC [7-13]use active compensation of source neutral current, while the uses of passive elements for the mitigation of source neutral current are advantageous over the active compensation due to ruggedness and less complexity of control.Hence, in this paper a star-delta supported 3P-4W UPQC is proposed for the mitigation of different PQ problems. The delta connected secondary of a star delta transformer provides a circulating path to the zero sequence current (io) in case of unbalanced load and hence the supply neutral current is reduced to zero. Moreover, star-delta supported 3P-4W UPQC may be realized using readily available three-leg VSIs.

The deregulated power market, adherence to different power quality standards [1-2] laid down bydifferent agencies has become a figure of merit for the utilities. On the other hand three-phase four-wire distribution systems are facing severe PQ problems. Some of these are high reactive power burden, voltage and current harmonics, poor power-factor, voltage sag, swells and voltage dip etc. Different devices such as rectifiers, inverters, adjustable speed drives, computer power supplies, furnaces and traction drives lead to non-linear current waveforms and hence degrade the quality of power



Three-phase, four wire distribution system



UPQC block diagram

Control Strategy of the UPQC

The proposed control strategy aims to generate reference signals for both shunt and series APFs of the UPQC. The proposed control technique is capable of successfully extracting most of the load current and source voltage distortions. The series APF is controlled to eliminate the supply voltage harmonics; whereas the shunt APF is controlled to alleviate the supply current from the harmonics, negative sequence current.

Reference Current control strategy:

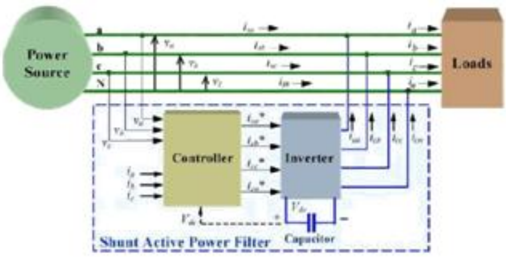
The control scheme of the shunt active power filter must calculate the current reference signals from each phase of the inverter using instantaneous real-power compensator. The block diagram as shown in Fig.4.4, that control scheme generates the reference current required to compensate the load current harmonics and reactive power. The PI controller is tried to maintain the dc-bus voltage across the capacitor constant of the cascaded inverter. This instantaneous real- power compensator with PI-controller is used to extracts

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

reference value of current to be compensated.

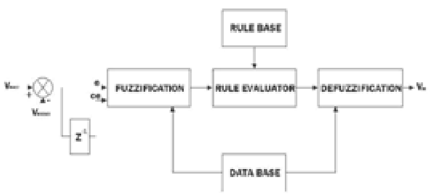
Real-Power (p) calculation:

The orthogonal coordinates of voltage and current $v\alpha$,$i\beta$ are on the α-axis and $v\beta$, $i\alpha$ are on the β -axis. Let the instantaneous real-power calculated from α -axis and β - axis of the current and voltage respectively. These are given by the conventional definition of real-power as:

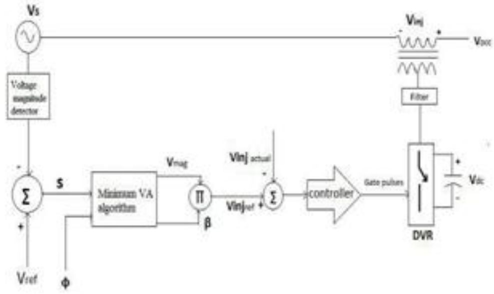


FUZZY LOGIC:

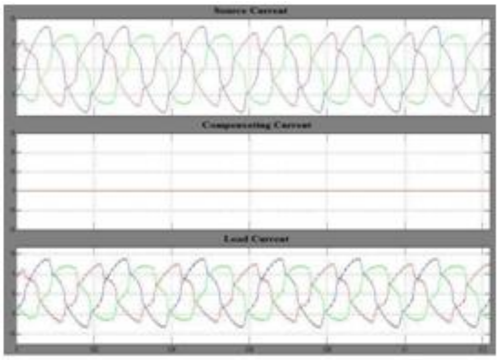
Fuzzy logic has rapidly become one of the most successful of today's technologies for developing sophisticated control systems. The reason for which is very simple. Fuzzy logic addresses such applications perfectly as it resembles human decision making with an ability to generate precise solutions from certain or approximate information. It fills an important gap in engineering design methods left vacant by purely mathematical approaches (e.g. linear control design), and purely logic-based approaches (e.g. expert systems) in system design While other approaches require accurate equations to model real-world behaviors, fuzzy design can accommodate the ambiguities of real-world human language and logic. It provides both an intuitive method for describing systems in human terms and automates the conversion of those.



DC voltage control using Fuzzy Logic

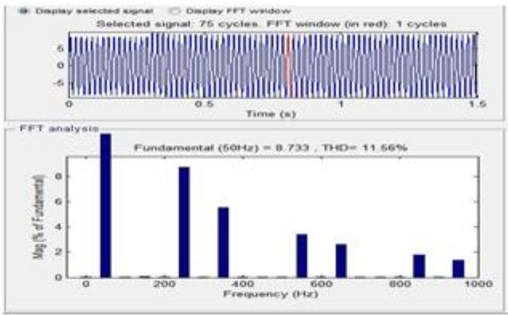


Block diagram of DVR



Current Waveforms without Compensation

THD Analysis under no compensation



CONCLUSION:

Both PI controllers based and fuzzy logic controller VSI based UPQC are implemented for harmonic and reactive power compensation of the non-linear load, voltage sag compensation. In this work the sag of the load voltage has been compensated by using the UPQC with minimum VA loading. And the total harmonic distortion of the source current has been reduced with the improved power factor. The results of various sag compensation methods are obtained separately and that results are compared with this method. The total VA obtained by this method is less than the other conventional methods.

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

And also the active power handled by the UPQC is less than the UPQC-P and the injected voltage through the series active filter is less than the UPQC-Q. Finally a new intelligent application is preferred for getting high stability factor, low error values, better THD values by using fuzzy logic controller.

REFERENCES:

[1] M R McGranaghan, D.R. Moeller and M.J Samotyj, "Voltage sags in industrial systems", IEEE Transactions on industry applications, Vol 29.no.2. Pp.397-402 April 1993.

[2] Annabelle van Zyl, Johan H.R. Enslin and RenCSpCe, "Converter Based Solution to Power Quality Problems on Radial Distribution Lines" IEEE Transactions on Industry Applications., Vol.32, No.6 December 1996.

[3] H.K Al-Hadidi, A.M.Gole and David A.Jacobson, "Minimum Power Operation of Cascade Inverter based Dynamic Voltage Restorer", IEEE Transactions on Power Delivery, Vol .23, No.2, April 2008.

[4] Woo Cheol Lee, Dong Myung Lee and TaeckKie Lee, "New Control Scheme for a Unified Power Quality Compensator –Q With Minimum Active Power Injection" IEEE Transactions on Power Delivery., Vol. 25, No.2, April 2010.

[5] Yashomani Y. Kolhatkar and ShyamaP.Das, "Experimental Investigation of a Single-Phase UPQC With Minimum VA Loading" IEEE Transactions on Power Delivery,Vol.15, No.1, January 2007.

[6] B.H. Li, S.S Choi and D.M. Vilathgamuwa, "Dynamic Voltage Restoration with Minimum Energy Injection" IEEE Transactions on Power Systems, Vol.15, No.1, February 2000.

[7] S. Saetieo, R. Devraj and D.A. Torrey, "The Design and Implementation of a Three Phase Active Power Filter based on Sliding Mode Control", IEEE Trans. Ind. Appl., Vol.19, No.2, pp.508-515, March 2004.

[8] K. Chatterjee, B.G. Fernandes and G K Dubey, "An Instantaneous reactive Volt-Ampere Compensator and Harmonic Suppressor System" IEEE Trans. Power Electron., Vol.14, No.2, pp.381-392, March 1999.

[9] N. G. Hingorani and L. Gyugyi, "Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems" New York: Wiley, December 1999.