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

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING
Vol. 2, Issue 3, March 2014

Different Control Strategies for Unified Power Quality Conditioner – A Review.

Aakash S. Shah[1], Professor Vishnu Patel[2], Professor Manish Patel[3]

M.tech Student, Electrical Engineering Department, U. V. Patel College of Engineering, Mehsana, India[1]

Asst. Professor, Electrical Engineering Department, U. V. Patel College of Engineering, Mehsana, India[2,3]

Abstract: Power quality has become an important factor in power systems. The main causes of a poor power quality are harmonic currents, poor power factor, supply-voltage variations, etc. To mitigate power quality problems, we have various equipments like active filter, passive filter, unified power flow controller and unified power quality conditioner etc. Among from them unified power quality conditioner was widely studied by many researchers as an eventual method to Improve power quality of electrical distribution System. To obtain the proper operation from UPQC, we need to control power filters of UPQC. To control them, there are different topology has been introduce. In this paper; several techniques are discussed and compared in terms of performance and implementation.

Keywords: Power quality, series and shunt active filter, unified power quality conditioner, control strategies, voltage control and current control.

I. INTRODUCTION

Electrical power system is design to provide high quality power for satisfactory operation of various electrical equipment. However the extensive use of non-linear loads in modem power system is becoming highly vulnerable to power quality and contributing to increased power quality issues. The main issues of a poor power quality are harmonic currents, poor power factor, supply-voltage variations, etc.It has been always a challenge to maintain the quality of electric power within the acceptable limits The adverse effects of poor power quality may result into increased power losses, abnormal and undesirable behaviour of equipments, interference with nearby communication lines, and so forth. The term active power filter (APF) is a widely used terminology in the area of electric power quality improvement. APFs have made it possible to mitigate some of the major power quality problems effectively. The UPQC is one of the APF family members where shunt and series APF functionalities are integrated together to achieve superior control over several power quality problems. The function of unified power quality Conditioner is to compensate supply voltage flicker/imbalance, reactive power, negative- Sequence current, and harmonics. The UPQC has the capability of improving power quality at the point of installation on power distribution systems.

Control strategy plays a vital role in the overall performance of the power conditioner. Rapid detection of disturbance signal with high accuracy, fast processing of the reference signal and high dynamic response of the controller are the prime requirements for desired compensation. Generation of appropriate switching

Pattern or gating signal with reference to command compensating signal determines the control strategy of the UPQC. Since derivation of reference signal from the measured distorted signal plays the main role, many theories and techniques were proposed or practiced over the years. These are either in frequency domain or in time domain. Different modifications of the power theories have been made for calculating the reference variables. To obtain the proper operation from UPQC, we need to control power filters of UPQC. To control them, there are different topology has been introduce. Some of them are listed here.

II. UNIFIED POWER QUALITY CONDITIONER

Unified power quality conditioners (UPQC) also known as universal active filters are ideal devices to improve power quality. A combination of series and shunt active filters forms UPQC.

The UPQC consisting of the combination of a series active power filter (APF) and shunt APF. Single-phase voltage controlled VSI used as a series active filter and a single-phase current controlled VSI used as a shunt active filter. The dc link of both active filters is connected to a common dc link capacitor. Series active filter suppresses and isolates voltage based distortions. The series APF is connected via a transformer in series with the AC line. Shunt active filter cancels current-based distortions. At the same time, it compensates reactive current of the load and improves power factor the shunt bi-directional converter is connected in parallel with the load terminals.

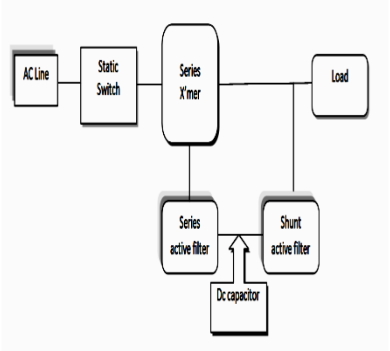

Figure 1. Block Diagram of UPQC

The configuration of the system is shown in figure.

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

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING
Vol. 2, Issue 3, March 2014

III. CONTROL STRATEGY

Control strategy plays the most significant role in any power Electronics based system. It is the control strategy which decides the behaviour and desired operation of a particular system. The effectiveness of a UPQC system solely depends upon its control algorithm. The UPQC control strategy determines the reference signals (current and voltage) and, thus, decides the switching instants of inverter switches, such that the desired performance can be achieved.

There are several control strategies/technique available in the existing paper those have successfully applied to UPQC systems.

IV. P-Q-R INSTANTANEOUS POWER THEORY

This method provides an analysis and control algorithm for a three phase four- wire Unified Power Quality Conditioner (UPQC) based on p-q-r instantaneous power theory. The p-q-r theory transforms a three phase four-wire voltage space vector into a single de voltage and the corresponding currents into a de based active power p- axis component and two imaginary power components, q- axis and r-axis.

If there are harmonics and negative sequence exists in the voltage, the calculated reference current is not sinusoidal. In this method an extra q-axis component is used to add to the original current compensation strategy based on p-q-r theory to maintain a sinusoidal current waveform under distorted voltage. With p-q-r theory, a control block model of an integration feedback of de power is used to maintain the average de power to be zero.

The analysis of the effect of sampling and quantization error on detection of de storage voltage, minimization of looping active power and loss power in the UPQC system and the consideration of power flow at the source side can be completed in the future work.

V. SWITCHING CONTROL METHOD

In this method six single phase H-bridge inverters are used in the structure of UPQC connected to a common dc storage capacitor. Of these six inverters three of them are used for series voltage insertion and the other three are used for shunt current injection. The UPQC current and voltage references are generated based on Fourier series extraction of fundamental sequence components using half cycle running (moving) averaging.

They also propose a Linear Quadratic Regulator based switching controller scheme that tracks a reference using the proposed compensator. This method is suitable for both utilities and customers having sensitive loads. From the utility standpoint, it can make the current drawn balanced sinusoidal. To accomplish this, the voltage at the point of common coupling must be of similar nature and also must contain the same amount of harmonics as the source. From the customer point of view, the UPQC can provide balanced voltages to their equipment that are sensitive to Voltage dips. At the same time, the UPQC also filters out the current harmonics of the load. Therefore, the operation of UPQC is ideal from both viewpoints.

VI. DIRECT DETECTION METHOD

A number of methods proposed where the instantaneous active and non-active powers are calculated directly from the a-b-c phase voltages and line currents. It eliminates the need for complicated X~coordinate transformation, thus reducing the computation volume and improving the detection speed. However, this method requires low pass filter like X~transformation.in method proposed in, the exact sinusoidal waveform of the voltage is stored in the memory (EPROM).

A microcomputer system reads the voltage values sequentially from the EPROM and compares it with the measured waveform and gives the reference values instantaneously. This method does not require calculation of an active current or voltage component and in this way a delay in compensator response is avoided.

VII. SYNCHRONOUS ‘D-Q’ REFERENCE BASE THEORY

This algorithm relies on the Parks transformation where three-phase voltage and current signals are transformed to a synchronously rotating frame. The active and reactive components of the system are represented by the direct and quadrate component, respectively. In this approach, fundamental quantities become d-q quantities which can be separated easily through filtering. To implement the synchronous reference frame some kind of synchronizing system PLL should be used.

The system is very stable since the controller deals mainly with the d- q quantities. The computation is instantaneous but incurs time delays in filtering the d-q quantities. This method is applicable only for three-phase systems. The modified synchronous reference frame, named as 'instantaneous id-iq method' is also proposed. This method is similar to synchronous reference frame method Except that the transformation angle is obtained from the voltage X~ components. The speed referential is no longer constant but it varies instantaneously depending on the waveform of the three-phase voltage system. In this method, no synchronizing circuit is needed.

VIII. CONTROL ALGORITHM BASED ON WAVELET TRANSFORM

This control algorithm is used to drive the UPQC to obtain the optimum performance for current harmonics mitigation and voltage sag compensation. the practicability of using wavelet as a good tool for current disturbance extraction for the shunt part of UPQC and the manner it could be used to detect the reduction in voltage and generate control signal to drive the series filters to boost up the voltage to tolerable level.

IX. CONTROL METHOD BASED ON H8

This method is based on h8 standard control of matching system that is used to design the h8 optimal controller of power quality. By analyzing the

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

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING
Vol. 2, Issue 3, March 2014

radical reasons of coupling effect between UPQC series unit and shunt unit, a simple and practical coordinated control strategy for UPQC series unit and shunt unit has been obtained by introducing corresponding voltage corrective link directly to UPQC series unit and shunt unit, respectively and by suitable mode of PWM in addition, the coupling effect between its series unit and shunt unit is eliminated fully. Therefore, the complex degree of the whole UPQC control system is simplified greatly.

Combined with a waveform tracking control method based on h8 model matching technology about power quality, the coordinated control between UPQC series unit and shunt unit is implemented through this strategy. The experimental results in indicate that the method can eliminate the steady-state phase shift and amplitude attenuation of the voltage tracking compensation of series unit and the current tracking compensation of shunt unit for UPQC. finally, the unified power quality multi-function control of UPQC is achieved. By application of a UPQC, the distribution network will become an ideal pure power source with high reliability and premium quality for power customer and those customers with pollution source will become qualified customers to the distribution system.

X. HYSTERESIS CONTROL ALGORITHM

In this control strategy, the unit vector templates are generating using PLL from three phase voltages measured at PCC. It generates the phase angle for the reference currents. The output of PLL together with a proper phase shift is used to generate three phase unity sinusoidal reference source currents. The magnitude of the reference source current is decided by the output of PI controller. The PI controller compares the measured DC link voltage with the reference value and its output is a measure of fundamental source current required to charge the capacitor. The measured source currents are compared with their reference values and the switching pulses for the shunt APF are generated using hysteresis controller.

XI. SPWM BASED CONTROL

SPWM controller is used to operate the voltage source inverter in such a way that the difference between the inverter voltage and the line voltage is widely adjusted so that the shunt APF generates or absorbs reactive power. The measured three phase voltages are fed to PLL to detect the phase angle of voltages. The measured voltage is passed through a first order low pass filter to attenuate voltage transients. This signal is then compared with a reference voltage and the voltage error is fed to the lag-lead function block, the output of which is fed to a PI controller. The output of PI controller is the angle representing the shift between the system voltage and the shun inverter voltage required to adjust the voltage of the dc link capacitor. This angle combined with the signal from PLL becomes the voltage modulating signal. The phase angle from the PLL is multiplied by a carrier, whose frequency is 33 times the operating frequency to generate the triangular signal whose amplitude is fixed between the extremities of unity. The triangular carrier is compared with the voltage modulating signal so as to obtain the firing pulses for the shunt APF.

XII. CONCLUSION

Most of the proposed or practiced control strategies for power quality conditioners have been reviewed with regard to performance and implementation. This work reveals that there has been a significant increase in interest of UPQC and associated control methods. This could be attributed to the availability of suitable power- switching devices at affordable price as well as generation of fast computing devices (microcontroller and DSP) at low cost. Each technique has its advantages and disadvantages.

REFERENCES

[1] A.jeraldine viji, dr.m.sudhakaran, "generalized UPQC system with an improved control method under distorted and unbalanced load conditions", international conference on computing, electronics and electrical technologies [ICCEET], 2012.

[2] G-myoung lee, dong-choon lee and jul-ki seok, "control of series active power filters compensating for source voltage unbalance and current harmonics", IEEE transactions on industrial electronics, vol. 51, no. 1, february 2004.

[3] Guo jian-guo, zhou jun, "integrated guidance-control system design based on h8 control", international conference on electrical and control engineering, 2010.

[4] Hirofumi akagi, yoshihira kanazawa, and akira nabae, member, "instantaneous reactive power compensators comprising switching devices without energy storage components", IEEE transactions on industry applications, vol. Ia-20, no. 3, may/june 1984.

[5] Hideaki fujita, hirofumi akagi, "the unified power quality conditioner: the integration of series- and shunt-active filters", IEEE transactions on power electronics, vol. 13, no. 2, march 1998.

[6] K.s.srikanth, shaik. Musthak ahmed, y.srinivasa rao,"enhancement of power quality based on unified power quality conditioner (UPQC)", international journal of engineering science and innovative technology (IJESIT),volume 2, issue 5, september 2013.

[7] Lr. Rezaeipour, a. Kazemi, "review of novel control strategies for UPQC", International journal of electric and power engineering , 2008

[8] Mr. Shaktisinh n. Gohil, prof. M. V. Makwana, "a comparative analysis of UPQC for power quality improvement", journal of information, knowledge and research in electrical engineering.

[9] M p selvan,S srinath, k vinothkumar, "comparative evaluation of performance of different control strategies on UPQC connected distribution system", 5th international conference on industrial and information systems, ICIIS 2010, jul 29 - aug 01, 2010.

[10] M. Forghani, s. Afsharnia , "wavelet based control strategy for UPQC control system used for mitigating Voltage sag", ©2006 IEEE

[11] P.vasudeva naidu b.basavaraja, "design of a SRF based mc UPQC used for load voltage control in parallel distribution systems", ©2012 IEEE.

[12] Shafiuzzaman k khadem,malabika basu, michael f conlon, "integration of UPQC for power quality improvement in distributed generation network – a review", IEEE.

[13] Tan zhili,zhu dongjiao, "study of detection method of the waveform compensation component of UPQC with improved p-q-r theory", ©2011 IEEE

[14] Vinod khadkikar, "enhancing electric power quality using UPQC: a comprehensive overview", IEEE transactions on power electronics, vol. 27, no. 5, may 2012.

[15] Yash pal, a.swarup, and bhim singh, "comparison of three control algorithms for single-phase UPQC",©2011 IEEE.