A Review of Various Control Strategies for Unified Power Quality Conditioner

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ABSTRACT

Power quality has become an important Role 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. 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 a r e 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 use of non-linear loads in modem power system is becoming highly so to increase power quality   Issues [1]. 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 effects of poor power quality may result into increased power losses, abnormal and undesirable behaviour of equipments, communication lines, and so forth [2]. 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 Conditioner is to compensate supply voltage [3].

Flicker/imbalance, reactive power, negative Sequence current, and harmonics [3]. The UPQC has the capability of improving power quality at the point of installation on power distribution systems. Control strategy plays a very important 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 .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 [2].

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 [12].

The main work of the active filter is harmonic reduction between a sub transmission system and a distribution system. The basic configuration of general UPQC consisting a combination of a series active and shunt active filter shows in Figure 1.
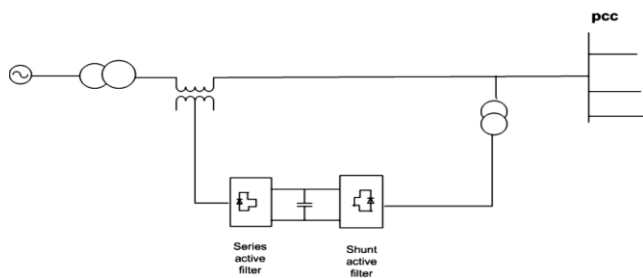

Figure 1 : Schematic of the UPQC[12]

The main work of the shunt filter is to absorb current harmonics, compensation of reactive power and negative sequence current and control the DC link voltage between both active filters. 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 [11].
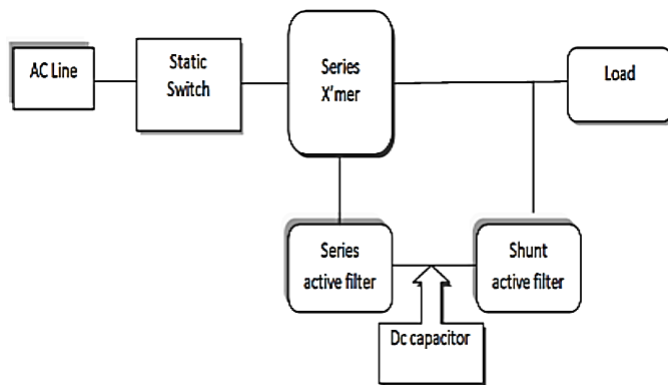

Figure 2 : Block Diagram of UPQC [12]

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 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.

A. 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 dc voltage and the corresponding currents into a de based active power p- axis component and two imaginary power components, q- axis and r-axis[1].

If there are harmonics and negative sequence 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 dc power is used to maintain the average dc power to be zero [10].

The analysis of the effect of sampling error on detection of dc 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.

B.SWITCHING CONTROL METHOD

In this method six single phase H-bridge inverters are used i n 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 averaging [2].

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 [8].

C.DIRECT DETECTION METHOD

A number of methods proposed where the instantaneous active and non-active power s 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 t h e 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 [7].

D.SYNCHRONOUS 'D-Q' REFERENCE BASE THEORY

In this paper algorithm realise 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 [11].

Then the system is very stable since the controller deals mainly with the d-q quantities. The computation is instantaneous 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 [10]. 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.

E. 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 some level [10].

F. HYSTERESIS CONTROL ALGORITHM

In this control strategy, the unit vector templates are generating using PLL from three phase voltages measured at point of common coupling. 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 [6]. 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 [4].

G. SPWM BASED CONTROL

In this method, 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 [6]. 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 given to a PI controller.

The output of PI controller is the angle representing the shift between the system voltage and the shunt 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 thirty three times the operating frequency to generate the triangular signal whose amplitude is fixed between the unity. The triangular carrier is compared with the voltage modulating signal so as to obtain the firing pulses for the shunt APF.

H. 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 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 [3].

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 are implemented through this control strategy [1]. The experimental results is 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. 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 [3].

IV. 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 c o n t r o l methods. This could be attributed to the availability of suitable power - switching devices at affordable price as well as generation of fast computing devices at low cost. Each technique has its advantages and disadvantages

V. REFERENCES

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