A Review on Unified Power Quality Conditioner Control Techniques

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ABSTRACT
A review on unified power quality conditioner control techniques assesses the feasibility and performance of different controls used to enhance Unified Power Quality Conditioner (UPQC) for making the efficient utilization at consumer levels. This is intended to present a broad overview on the unified power quality conditioner system control strategies used for the improvement of various power quality issues with recent developments in the field. It is noticed that several researchers have used different controls to check performance of the power system withmanagementsingle-phaseand three-phase controls for the UPQC based on the unique function, task, application, or topology under consideration. Currently, there are so many industries using a high technology for the manufacturing and requiring a high quality of power supply. Therefore, the paper is focusing mainly on power quality disturbance and the control technique used to improve the quality of delivered power such as Unified Power Quality Conditioner (UPQC).

Keywords
Power quality, UPQC, Active filters, p-q-r power theory, d-q theory,SAF, PAF, current compensation, voltage compensation.

1. INTRODUCTION
Power quality is very important term that includes all aspects associated with magnitude, phase and inverse time of the voltage and current analogy existing in a power circuit. Any problem coherent in voltage, current or inverse time deviation that results in Failure of the customer equipment is known as power quality impurities. Therapid use of power electronics based equipment has produced a considerable impact on the quality of electric power supply. The deficiency in the quality of power system power can affect the production of power, damage of equipment or appliances, increased power losses, interference with communication lines and so forth. Therefore, it is obvious to maintain high standards of power quality. The enormous types of power quality issues are: Interruption, sag, swell, distortion, and harmonics. In recent years, more care is to be taken on the mitigation of voltage sag and swell together with help of control techniques of UPQC. The main cause for sag and swell is due to the sudden change of line current flowing through the source impedance. Therefore the analysis of UPQC stresses the maintenance of source current (current at PCC) and load voltage to be regulated. Application of different control strategies for controlling the shunt and series APFs presents a non-identical nature in the current flowing through the distribution system. Several control techniques proposed in literature are complex requiring different transformations simpler .Wide spread use of electrical drives and power electronics apparatuses for energy conversion creates major issues of power quality on the modern distribution grids. In addition renewable energy sources such as solar, wind etc., increase high level of complexity in grid operation and Also nonlinear loads based on solid-state devices cause current and voltage imperfections deteriorating the power quality of distribution systems. Besides, the neutral current due to zero sequence components which create heating in the neutral conductor and distribution transformers leading to voltage and current imperfections [1]. A continuous distortion less sinusoidal supply voltage is essential for safe operation of sensitive critical loads. Nonlinear load generally introduce impure content in the existing system in which will further increases the demand of required reactive power. On the other hand, development in the digital electronics communications and in process control has increased the number of sensitive loads that require ideal sinusoidal inputparameters for their safe performance [1, 2].

To soften the drawbacks produced by the nonlinear loads, unified power quality conditioners (UPQC) were presented during 1998 [1]. The main purpose of a UPQC is to purify the input quantity and required load current impurities, such as voltage disturbances like sags, swells, interruptions, imbalance, flicker, harmonics, reactive currents, and current unbalance. With such successive performance of UPQC ,it is able to nullify the problems as well as maintain the power quality at the point of installation on power distribution as well as industrial power sectors.

2. COMPENSATION DIVICES
Over the past several decades the transmission anddistribution of electric power has become extremely complicated and subject to very tight operationaland power quality specifications which are increasing the requirement of load, rapid increase in power transfer requirement, and the power system becomes increasingly difficult to maintain system reliability and less safe with respect to instabilities in the system. The whole capacity of transmission interconnections may not be comes under the use because of:

- Huge flow of power with less security for pooling.
- Inadequate and extra reactive power with respect to different part of the power system& large dynamic power swings between different parts of the system.

As the length of a line increases these problems become more pronounced [9]. The efficient optionis the instantaneous control of the operating voltage of bus (V), true power (P), the reactive power (Q), and the cause of imperfection like total harmonic voltage distortion (THDv).

3.UPQC- ADVANCED KEY OF POWER QUALITY ISSUES

Unified power quality control was widely studied by many peoples as an effective method to maintain and gives the efficient power quality of electrical distribution system. The utilization of unified power quality conditioner is nullify to the impurities related to voltage and current. Indirectly unified power quality conditioner is able to improve power quality at the point of installation on consumer power sectors [11]. With such performance of UPQC, it is the easiest solution to maintain the quality of the large capacity loads sensitive to supply voltage imbalance. The unified power quality conditioneris efficient combination of the series active power filter (APF) and shunt APF which are capable to compensate the voltage interruption if it supported by some energy storage or battery in the dc link [3].

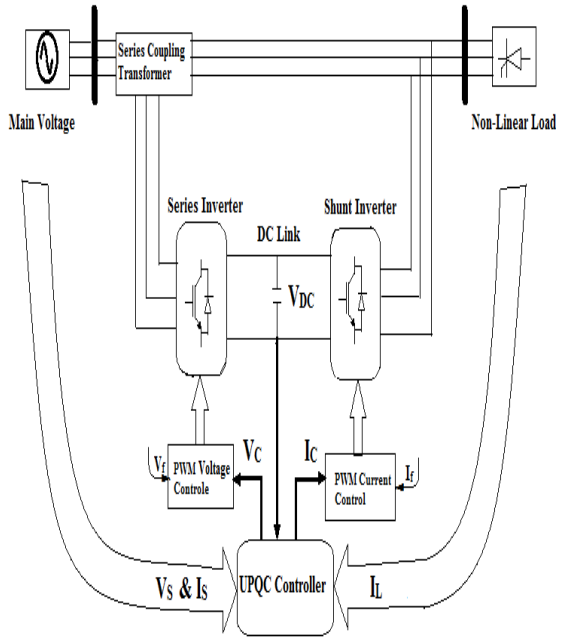

Fig.1 Representation Of UPQC

The shunt APF is normally connected so thatit will be able to solve load impurities like current harmonicsas well as the reactive power compensation, power factor improvement, current harmonic impurities, with large tolerance between all load [1,3], whereas the series APF is connected in a series with the line through series transformers. Itbehave like a controlled voltage source and capable to compensate all voltage related problems, such as voltage harmonics, voltage sag, voltage swell, flicker, etc. [12]

3.1 Different Control Strategies Used For UPQC

Control strategy plays the most significant role in any power Electronics based system which decides the behaviour and expected operation of a particular system. The resultant perfection of a UPQC system solely depends upon its control methodology. The control methodology gives the standard reference signals (current and voltage) and, thus decides the switching timing of inverter switches, such that the system instability related to quality should be maintain. There are several control strategies/techniquedescribed in this paper those caneffectively applied to UPQC systems. Several power quality problems are to be notified by the different researchers after the practical investigation of the power system which causes the malfunctioning of source and utility.

3.2 'D-Q'reference Base Theory (SRF Theory)

In the recent power system use of power electronics based devices or nonlinear loads are increases which disturbed the performance of system resulting in the injection of various impurities in normal voltage and current. Recent power devices becomes efficient for such type of problems which work as a tool to compensate the actual parameter of systems .These custom power devices improve the voltage and current condition. It consist of two filters named as series and shunt active power filter respectively.The series active power filters are able to compensate all voltage related problems. As compare to shun parameter calculation the series calculation is easy. Handy Fartine Blanchette write in "An Advanced control Algorithm for series hybrid active filter adopting UPQC [4] which uses the SRF theory for series active power filter for mitigation.

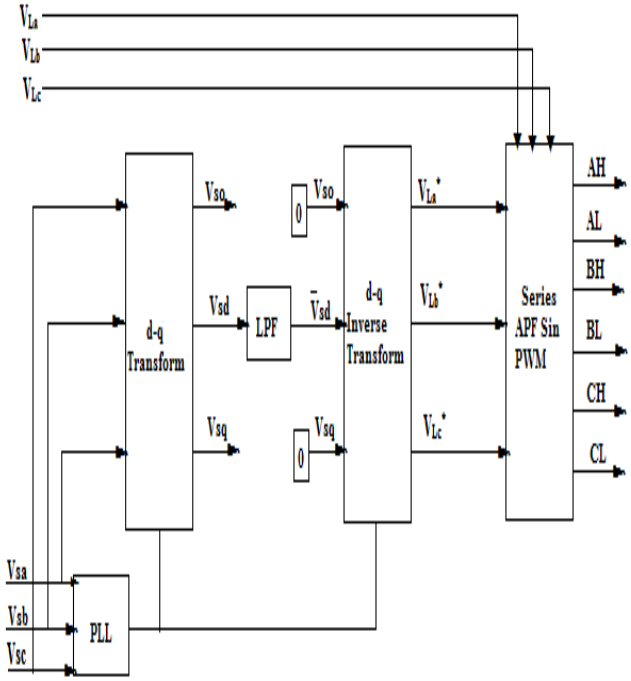

Fig.2 d-q Theory Representation

This algorithm relies on the Parks simplification use for the conversion of one domain to another. In the above control algorithm based on SRF, three-phase voltage signals are transformed to a synchronously rotating frame. In this approach, fundamental quantities become d-q quantities which can be separated easily through filtering.

3.3 P-Q-R Instantaneous Power Theory

In mathematical form the P-Q theory shortly can be explain by converting voltage and current form V_{abc} to $V_{0\alpha\beta}$ and I_{abc} to $I_{0\alpha\beta}$. By using Clarks Transformation Simulink library. Following are transformations are used for reference calculation. With the help of this p-q control mathematically it is possibleto analyse the system using a three phase four- wire Unified Power Quality Conditioner (UPQC) based on p-q-r instantaneous power theory. If there are harmonics and negative sequence exists in the current, the mathematically calculated reference current is not purely sinusoidal, this method provides an extra q-axis component is used to add to

the original current compensation strategy based on p-q-r theory to maintain a normal sinusoidal current waveform under distorted voltage [3]. With p-q-r theory, a control block model of an integration feedback of dc power is used to maintain the average de power to be zero.

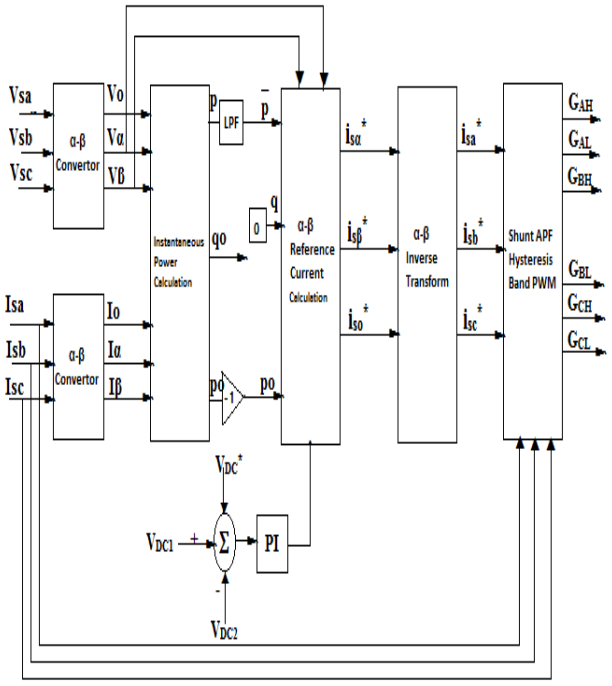

Fig.3 p-q Theory Representation

3.4 Control Algorithm Based On Fuzzy Logic

Fuzzifier transform the numeric value to the fuzzy set. The all logic calculation in fuzzy control is perform by interface engine which is the heart of the fuzzy operation.

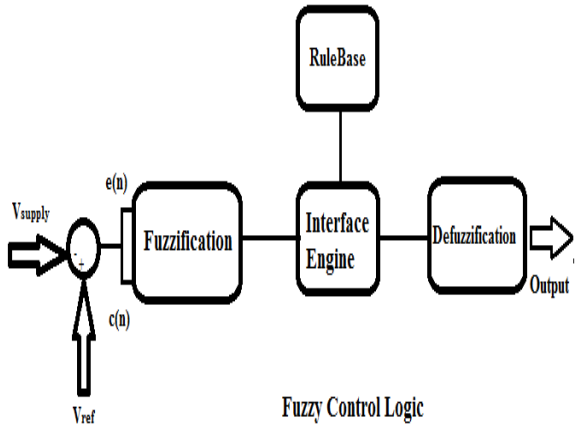

Fig.4 Fuzzy control

The membership function and control rules runs under the rule base. After the interfacing of fuzzification and rule base the output is represented by fuzzyset. Now the fuzzyset is transformed into the numeric value by using the defuzzification which gives the required output.[5]

3.5 Control Algorithem Based On Artificial Neural Network

Today power system is perfectly instable in reference with the dynamics of load also the various ideal features convenient for the normal operation of system is also dynamically with basic multivariable. Such type of system operate with moral force or dynamics required instant identification of flutter signals having maximum precision , firm processing of signals, quick and eminent response of controller. The conventional controller will not work satisfactory. The recent study proves the neural-Network based controller gives quick and eminent response while normalising the stability of system.[7].The ANN is the bunch of nonlinear element which are interconnected in the form of Artificial Neurons in simple fashion. It corresponds the brain in two prospect;

a) Knowledge is assumed by the network through the learning process.
b) Interneurons connection strengths are used to store the knowledge.

Topology of network, communication approach with their surroundings, fashion in which they are trained and their quality with ability to process information [13]. The R. Strzeleci, J.Rusinski and M. Jarnut in "Properties Simulation and Experimental investigation of the series –parallel active power filter state that a multilayer feed forward-type ANN based controller is designed. They describes control with three lags, the input layer with 2, the hidden layer with 21 and output layer with 1 neuron respectively.

3.6 Control Algorithm Based On Wavelet Transform

The Mehdi Forghani and SueedAfsharniadescribed in their paper which include the basic strucrure of "Online Wavelet Transform-Based Control Strategy for UPQC Control System" and how the specified control can effectively utilized to compensate the active power losses of the systems connected with unified power quality conditioner and active power injected to power system by the series active power filters, which cause dc-link voltage reduction [8]. Space vector modulation (SVM) in three-phase voltage-source and current-source converter based active filters has become the preferred PWM method for digital implementation [14], [15], [16].

Contribution of voltage sag and swell to power quality is more. Voltage sag for a very short duration can estimate lots of financial disturbance to industrial and commercial users. A decrease in RMS voltage between 10% to90% at a power frequency for duration from 0.5 cycles to 1 minute is called voltage sag and common problems for such situation are system faults, addition of large load, etc. The basic or fundamental magnitude and phase angle of complete current is infuse by using wavelet techniques. To cancel the unsymmetrical component of load current the positive sequence component is calculate. Obtain the reference current by multiplying the amplitude of positive sequence of source current to sin waveform with unit magnitude and phase current with fundamental component of positive sequence load voltage. In this way reactive component in load current will be cancelled.

This control algorithm which is describe above is used to enhance power system parameter by driving the UPQC to obtain the satisfied performance for current harmonics mitigation as well as voltage sag compensation. The practicability of the system using wavelet as a good tool for

current disturbance extraction for the shunt part of UPQC (PAF) and the manner it could be implement to identify the reduction in voltage and generate control signal to drive the series filters to boost up the voltage to tolerable level.

4. CONCLUSION

After this study of UPQC,we realized that, numerous control techniques are used for reference current and voltage signal generation as per requirement for series active power filter and shunt active power filter of power quality conditioner .Normally series APF is used to handle the voltage quality and shunt APF is used to handle current quality of power system.UPQC is one of custom power device in the distribution system solve the different power quality problems as voltage sag and swell, current harmonics etc. Also in future by using series and shunt APF separately UPQC can determine the changes in frequency using Genetic Algorithm(GA).

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