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Power Quality Improvement by UPQC Using ANN Controller and its application

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ABSTRACT

The focus of this research report is on improving power quality by combining UPQC with an ANN logic controller (FLC) and a traditional proportional-integral (PI) controller. At the distribution side of the power system network, the unified power quality conditioner (UPQC) is utilised as a universal active power conditioning device to mitigate both current and voltage harmonics. In comparison to PID controllers, the suggested ANN logic controllers (FLC) are capable of offering good static and dynamic capabilities.

In commercial and industrial applications, any electrical power system comprises of a wide range of electrical, electronic, and power electronic equipment. Many variables affect the quality of power, including harmonic contamination caused by the addition of non-linear loads such as massive thyristor power converters and rectifiers, voltage and current flickering caused by arc in arc furnaces, sag and swell caused by load switching, and so on. Because most electronic equipment is nonlinear, it will cause harmonics in the system, which will influence the sensitive loads that will be supplied from it. The use of LC passive filters helps to overcome some of these issues. This type of filter, on the other hand, is incapable of resolving random variations in the load current and voltage waveforms. This issue can be solved using active filters. Active filters, on the other hand, come at a hefty price. They are difficult to put into practise on a big basis. The UPQC device combines a shunt active filter and a series active filter in a back-to-back configuration to compensate the supply voltage and load current at the same time, or to mitigate any type of voltage and current fluctuations and power factor correction in a power distribution network, so that improved power quality can be made available at the point of common coupling. The compensation theory and several control schemes employed in this study are based on the UPQC's PI and ANN controllers.

Keywords: Power Quality Improvement, UPQC using ANN controller, Active Flitter

I. INTRODUCTION

Since many loads at various distribution ends, such as adjustable speed drives, process industries, printers, domestic utilities; computers, microprocessor-based equipment, and so on, have become intolerant to voltage fluctuations, harmonic content, and interruptions, power quality (PQ) has become a major concern. Maintaining a fixed voltage at the Point of Common Coupling (PCC) for various distribution voltage levels despite voltage fluctuations, maintaining near unity power factor power drawn from the supply, blocking voltage and current unbalance from passing upwards from various distribution levels, reducing voltage and current harmonics in the system, and suppressing excessive supply neutral current are all issues that Power Quality (PQ) deals with. To enhance the power factor of ac loads, passive LC filters and fixed compensating devices with some degree of variation, such as thyristor switched capacitors and thyristor switched reactors, were formerly used. Fixed compensation, big size, ageing, and resonance are all disadvantages of such devices. Because of its dynamic and changeable solutions, equipment based on power semiconductor devices, such as active power filters (APFs), active power line conditioners (APLCs), and others, are being employed to address power quality concerns. FACTS (Flexible AC Transmission Systems) and Custom Power products like STATCOM (STatic synchronous Compensator), DVR (Dynamic Voltage Restorer), and others use similar control strategies and concepts to address power quality issues. They differ solely in terms of where they are deployed within a power system and the purposes for which they are deployed. Various extraction strategies for creating reference signals, as well as various modulation approaches for generating pulses, are explored in this study. The criteria for selecting a dc connection capacitor and the design of an interface filter are also explored.

II. UNIFIED POWER FLOW CONTROLLER

UPQC's basic block diagram is presented in Figure 1. Depending on the other non-linear loads connected to PCC, the voltage at PCC may or may not be distorted. We'll presume that the voltage at PCC is skewed in this case. A common dc connection connects two voltage source inverters that are linked back to back. The load is linked to one inverter in parallel. It functions as a shunt APF and aids in the compensation of load harmonic current as well as the maintenance of a constant dc link voltage. The second inverter, which uses series transformers to connect to the utility power, assists in keeping the load voltage sinusoidal.

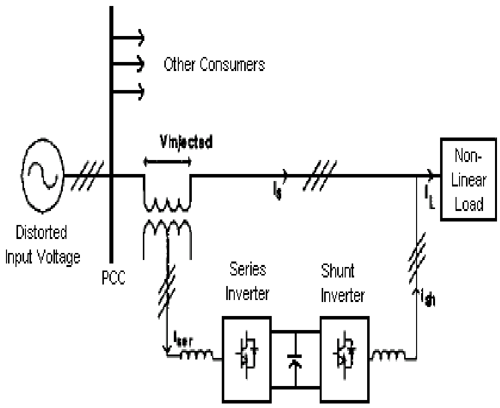

Fig 1 Basic Block Diagram of UPQC

The main drawback of the p-q theory is that it produces poor results when input/utility voltages are distorted and/or imbalanced. The reference load voltage signals derived for series APF are utilised instead of real load voltages to overcome these constraints.

For phase a, the load voltage and current in α-β coordinates can be represented by π/2 lead as

$$\begin{bmatrix} v_{La\_\alpha} \\ v_{Lb\_\beta} \end{bmatrix} = \begin{bmatrix} v_{La}^{*}(\omega t) \\ v_{La}^{*}\left(\omega t + {}^{\pi}/_{2}\right) \end{bmatrix} = \begin{bmatrix} V_{Lm} sin(\omega t) \\ V_{Lm} cos(\omega t) \end{bmatrix}$$

$$\begin{bmatrix} i_{La\_\alpha} \\ i_{La\_\beta} \end{bmatrix} = \begin{bmatrix} i_{La}(\omega t + \varphi_L) \\ i_{La}\left[(\omega t + \varphi_L) + {}^{\pi}/_{2}\right] \end{bmatrix}$$

Considering phase *a*, the phase-*a* instantaneous load active and instantaneous load reactive powers can be represented by

$$\begin{bmatrix} p_{La} \\ q_{La} \end{bmatrix} = \begin{bmatrix} v_{La\_\alpha} & v_{La\_\beta} \\ -v_{La\_\beta} & v_{La\_\alpha} \end{bmatrix} \cdot \begin{bmatrix} i_{La\_\alpha} \\ i_{La\_\beta} \end{bmatrix}$$

Where $p_{La} = \bar{p}_{La} + \tilde{p}_{La}$, $q_{La} = \bar{q}_{La} + \tilde{q}_{La}$

III. CONTROLING TECHNIQUES FOR UPQC

3.1 PI Controller

A PI Controller (proportional-integral controller) is a variant of the PID controller that does not employ the error's derivative (D).The controller output is given by

$$K_P\Delta + K_I \int \Delta \, dt$$

In the event of noisy data, the lack of derivative action may make the system more stable in the steady state. This is due to the fact that higher-frequency components in the inputs are more sensitive to derivative action. A PI-controlled system that lacks derivative action is less responsive to actual (non-noise) and relatively quick changes in state, making it slower to achieve set point and respond to disturbances.

3.2 Artificial Neural Networks

Artificial Neural Networks (ANNs) are simple electrical models based on the brain's neural structure. The brain learns mostly via experience. It is natural proof that problems that are beyond the capabilities of today's computers may be solved by compact, energy-efficient solutions. In addition, brain modelling provides a less technical approach to developing machine solutions. Now, advances in scientific study promise a first grasp of how the brain works naturally. This study demonstrates that the brain retains information in the form of patterns. Some of these patterns are quite complex, allowing humans to distinguish particular faces from a variety of perspectives. A new discipline of computing has emerged as a result of the process of storing information as patterns, using those patterns, and then solving problems. Following that is a one-layer network with R input elements and S neurons. The weight matrix W connects each element of the input vector p to each neuron input in this network. The ith neuron has a summer that combines its weighted inputs and bias to generate its own scalar output n. (i). Together, the different n(i) create an S-element net input vector n.

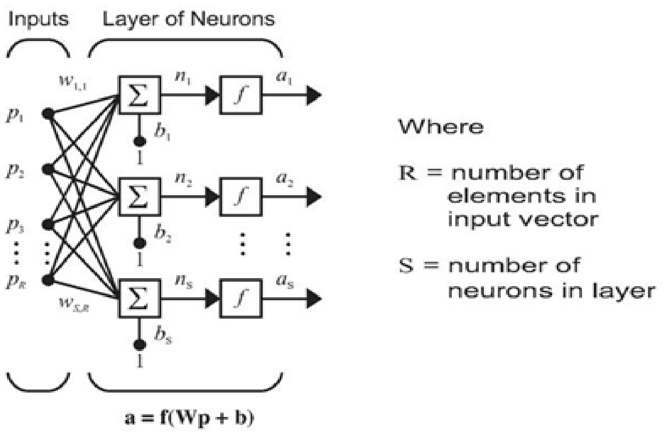

Fig 4 Single Layer Neural Network

IV. SIMULATION RESULTS

A 3-phase electrical system is simulated using MATLAB software to validate the proposed UPQC's working performance.

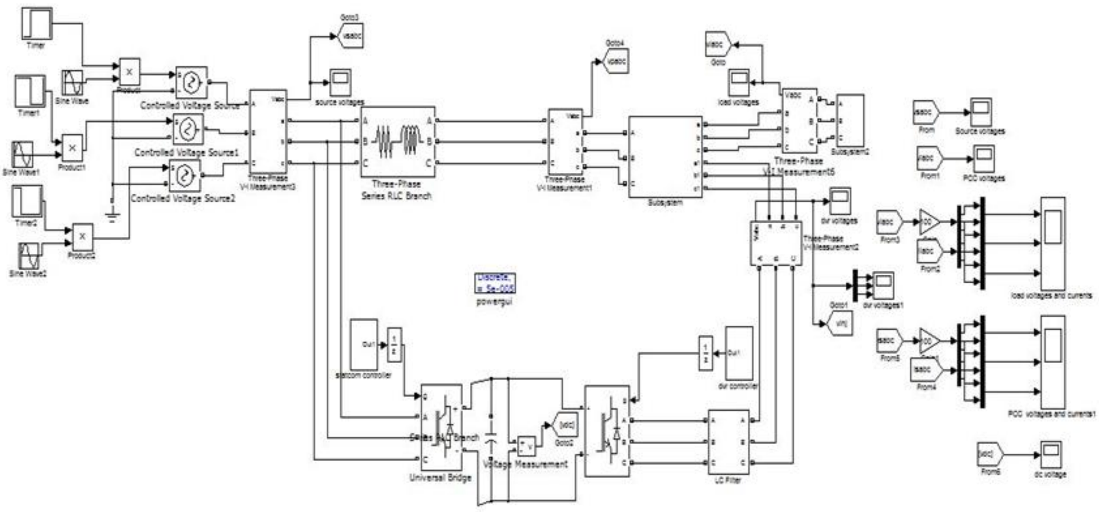

Fig 5 Matlab/Simulink Model

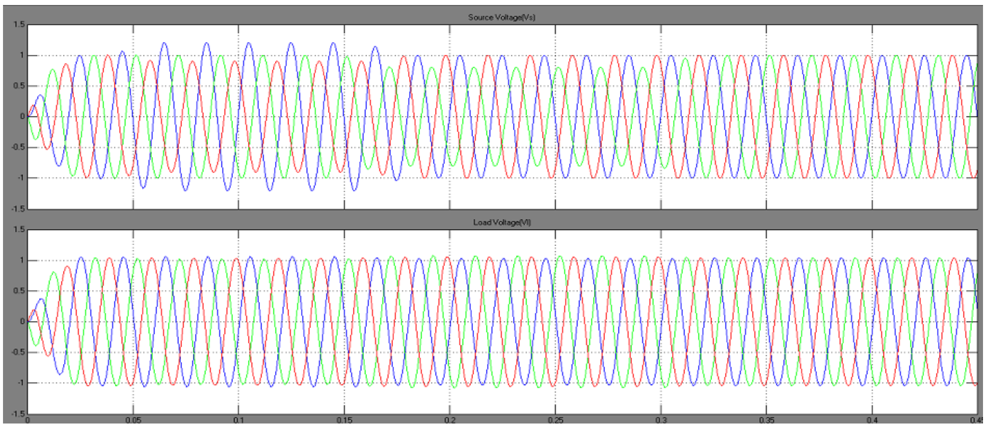

Fig 6 Matlab/Simulink Source and Load Voltages with PI Controller

Control techniques	Total harmonic distortion (THD %)
Pi controller	12.41%
ANN controller	5.84%

Table 1 (THD's) Of UPQC with Different Controllers

V. CONCLUSION

DVR, D-STATCOM, and UPQC are examples of custom power devices that can improve power quality in the distribution system. There is a variety of bespoke power devices with appropriate compensation based on the power quality problem at the load or in the distribution system. The UPQC (Unified Power Quality Conditioner) is a hybrid of series and shunt APFs that adjusts for supply voltage and load current inconsistencies in the distribution system. The UPQC employed in this project is a multifunction power conditioner that can adjust for various voltage disturbances in the power supply, rectify any voltage fluctuations, and prevent harmonic load current from entering the power system. For UPQC, a simple control mechanism based on the production of unit vector templates is given. In MATLAB, the proposed model was tested. The simulation results demonstrate that the suggested control technique efficiently compensates for input voltage and current harmonics induced by non-linear loads. The direct current control closed loop control techniques for the planned UPQC have been detailed. A suitable mathematical model of the UPQC has been developed with different shunt controllers (PI & ANN) and simulated results have been described, demonstrating that while compensation is performed in both cases, the response of the ANN controller is faster and the THD is lowest for both voltage and current, as shown in the plots and comparison table 1.

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