APPLICATION OF ANN LOGIC CONTROLLER FOR IMPROVEMENT OF POWER QUALITY USING UPQC

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ABSTRACT

This project report emphasis enhancement of power quality by using UPQC with ANN logic controller (FLC), and with the conventional proportional-integral (PI) controller. The unified power quality conditioner (UPQC) is being used as a universal active power conditioning device to mitigate both current and voltage harmonics at a distribution side of power system network. The proposed ANN logic controllers (FLC) are capable of providing good static and dynamic performances compared to PID controller

I. INTRODUCTION

Power Quality (PQ) has become an important issue since many loads at various distribution ends like adjustable speed drives, process industries, printers, domestic utilities; computers, microprocessor based equipment 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. Conventionally, passive LC filters and fixed compensating devices with some degree of variation like thyristor switched capacitors, thyristor switched reactors were employed to improve the power factor of ac loads. Such devices have the demerits of fixed compensation, large size, ageing and resonance. Nowadays equipment using power semiconductor devices, generally known as active power filters (APF's), Active Power Line Conditioners (APLC's) etc. are used for the power quality issues due to their dynamic and adjustable solutions. Flexible AC Transmission Systems (FACTS) and Custom Power products like STATCOM (STATic synchronous Compensator), DVR (Dynamic Voltage Restorer), etc. deal with the issues related to power quality using similar control strategies and concepts. Basically, they are different only in the location in a power system where they are deployed and the objectives for which they are deployed. In this paper, various extraction algorithms for generating reference signals and various modulation techniques for generating pulses already developed and published are discussed. Criterion for selection of dc link capacitor and interfacing filter design are also discussed.

II. UNIFIED POWER FLOW CONTROLLER

Basic block diagram of UPQC is shown in Fig 1. The voltage at PCC may be or may not be distorted depending on the other non-linear loads connected at PCC. Here we assume the voltage at PCC is distorted. Two voltage source inverters are connected back to back, sharing a common dc link. One inverter is connected parallel with the load. It acts as shunt APF, helps in compensating load harmonic current as well as to maintain dc link voltage at constant level. The second inverter is connected in series with utility voltage by using series transformers and helps in maintaining the load voltage sinusoidal.

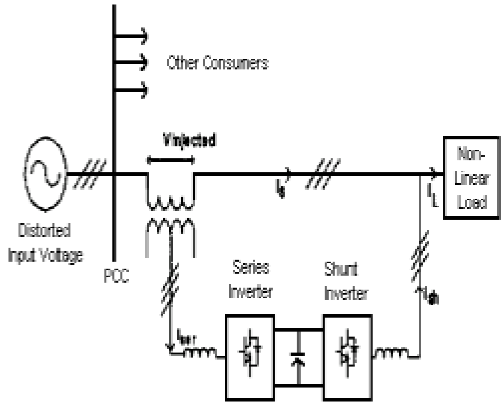

Fig 1 Basic Block Diagram of UPQC

The major disadvantage of p-q theory is that it gives poor results under distorted and/or unbalanced input/utility voltages. In order to eliminate these limitations, the reference load voltage signals extracted for series APF are used instead of actual load voltages.

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 special case of the PID controller in which the derivative (D) of the error is not used.

The controller output is given by

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

The lack of derivative action may make the system more steady in the steady state in the case of noisy data. This is because derivative action is more sensitive to higher-frequency terms in the inputs. Without derivative action, a PI-controlled system is less responsive to real (non-noise) and relatively fast alterations in state and so the system will be slower to reach set point and slower to respond to perturbations.

3.2 Artificial Neural Networks

Artificial Neural Networks are relatively crude electronic models based on the neural structure of the brain. The brain basically learns from experience. It is natural proof that are beyond the scope of current computers are indeed solvable by small energy efficient packages. This brain modeling also promises a less technical way to develop machine solutions. Now, advance in biological research promise an initial understanding of the natural thinking mechanism. This research shows that brain stores information, as patterns. Some of these patterns are very complicated and allow us the ability to recognize individual faces from any different angles. This process of storing information as patterns, utilizing those patterns, and then solving problems encompasses a new field in computing. A one-layer network with R input elements and S neurons follow. In this network, each element of the input vector p is connected to each neuron input through the weight matrix W. The ith neuron has a summer that gathers its weighted inputs and bias to form its own scalar output n(i). The various n(i) taken together form an S-element net input vector n.

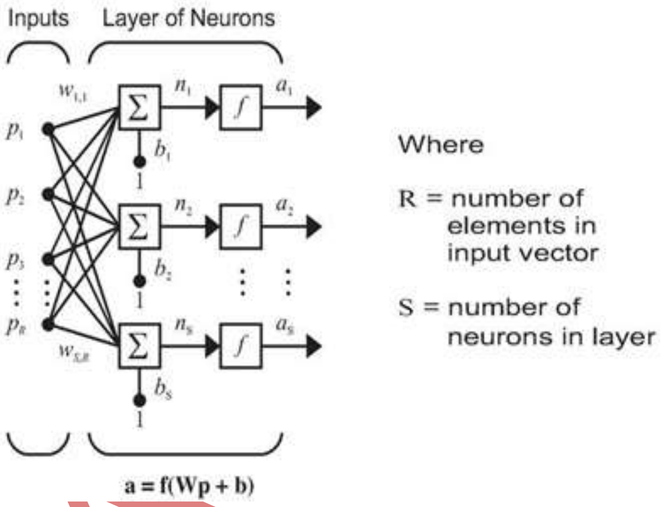

Fig 4 Single Layer Neural Network

IV. SIMULATION RESULTS

To verify the operating performance of the proposed UPQC, a 3-phase electrical system is simulated using MATLAB software.

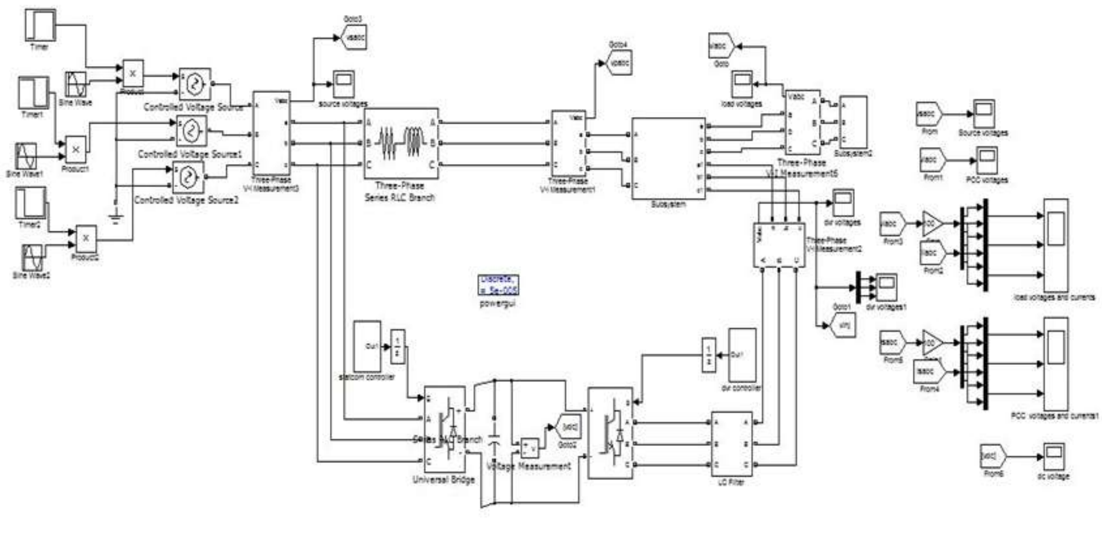

Fig 5 Matlab/Simulink Model

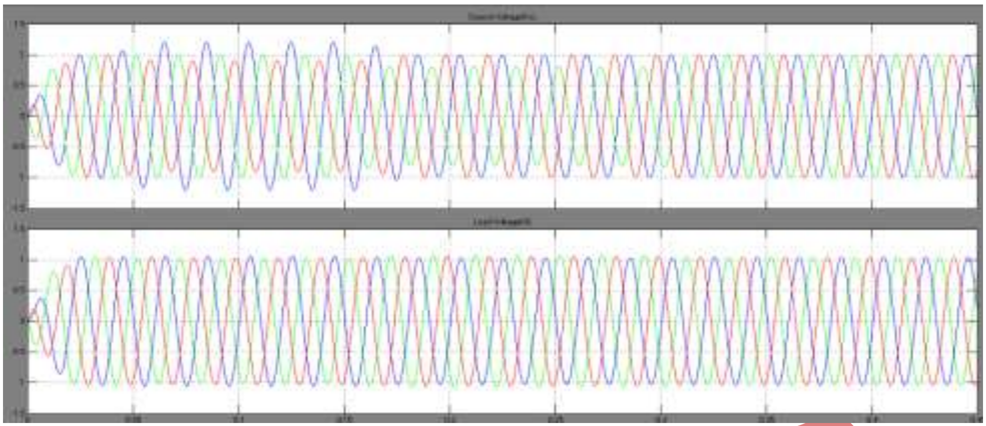

Fig 6 Matlab/Simulink Source and Load Voltages with PI Controller

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

Custom power devices like DVR, D-STATCOM, and UPQC can enhance power quality in the distribution system. Based on the power quality problem at the load or at the distribution system, there is a choice to choose particular custom power device with specific compensation. Unified Power Quality Conditioner (UPQC) is the combination of series and shunt APF, which compensates supply voltage and load current imperfections in the distribution system. The UPQC considered in this project is a multifunction power conditioner which can be used to compensate for various voltage disturbance of the power supply, to correct any voltage fluctuation and to prevent the harmonic load current from entering the power system. A simple control technique based on unit vector templates generation is proposed for UPQC. Proposed model has been simulated in MATLAB. The simulation results show that the input voltage harmonics and current harmonics caused by non-linear load can be compensated effectively by the proposed control strategy. The closed loop control schemes of direct current control, for the proposed UPQC have been described. A suitable mathematical model of the UPQC has been developed with different shunt controllers (PI & ANN) and simulated results have been described which establishes the fact that in both the cases the compensation is done but the response of ANN controller is faster and the THD is minimum for the both the voltage and current which is evident from the plots and comparison table 1.

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