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Ann Based Unified Power Quality Conditioner for Power Quality Improvement

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Abstract:

Generally, this paper proposes technique of FACTs based controller called as unified power quality conditioner, which is used to mitigate problems on transferring power based voltage and currents in the distribution systems. Reducing the rating of dc-link voltage without compromising the compensation technique is one of the advantages of unified power quality conditioner technique. The series and shunt controllers as series connection with the combination of capacitor and inductor for filtering process, and the system neutral is also considered and directly connected to neutral of distribution system for avoiding the utilization of fourth leg in the shunt converter voltage source inverter. This paper also presents a concept for improving power quality of a power distribution system such as an ANN logic controller along with the UPQC control strategy. The simulation results are compared for both conventional PI controller and ANN controller.

Key Words: UPQC Controller; ANN; Power Quality and THD

INTRODUCTION

In the advancement of power electronic devices, such as thyristors, GTO thyristors, Insulated Gate Bipolar Transistors and many more devices, which are used to control electric power [1].

In three phase systems, the power electronics devices could also cause unbalances in voltage and draw excessive neutral currents due to their disturbances. Due to because of these current harmonics and changes in reactive power, unbalances, and excessive neutral currents causes' efficiency reduction and poor power factor. Therefore, improvement of power quality is one of the important issue since occurring of varying loads at distribution centers. Basically, the term Power Quality mainly deals with problems occurred in the system like improvement of voltage levels under variations in load or distribution levels at point of common coupling, maintaining of unity power factor from the supply, reducing the unbalances in current or voltages, harmonics in currents [2]. Conventionally, generally, passive filters have been used but these filters have the disadvantages of fixed compensation, large size, ageing and resonance. By providing added flexibility, Flexible AC transmission system has the capability to maintain the line power at its thermal ratings. These facts can certainly overcome the any of stability limits.

Operating Principle of Unified Power Quality Conditioner

Figure 1 shows The operational and control diagram UPQC. Based on the other non-linear loads connected at PCC the voltage at PCC may be or may not be distorted. This diagram has two converters connected with the common dc link capacitor those are series and shunt [3]. Shunt APF i.e converter is connected shunt with the transmission line at load side for maintain the dc link voltage under constant levels for compensating the harmonic current. The other converters are a series converter which is connected in series with utility terminals through series injection transformers and it maintains the load voltage sinusoidal.

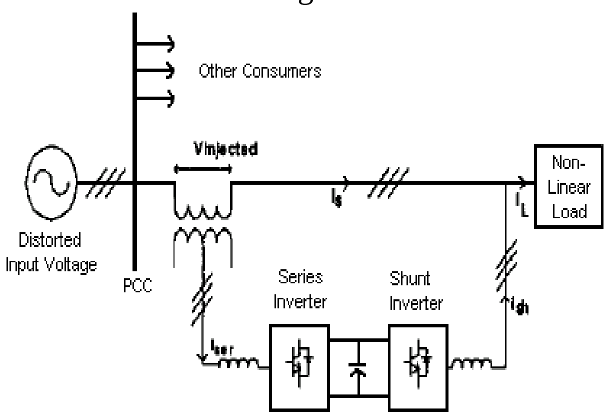

Figure 1 single line diagram of UPQC

As figure 2 shows the equivalent circuit for UPQC system which consists of Voltage Source Converter. In this method, neutral terminal of the system and -Ve terminal of the dc bus along with the are grounded along with the sereis capacitor and inductor for shunt active filter. One of the passive capacitive element has the capability to supply a part of the reactive power based on the requirment of the load, and the active filter [4] will compensate the balance reactive power and the harmonics present in the load.

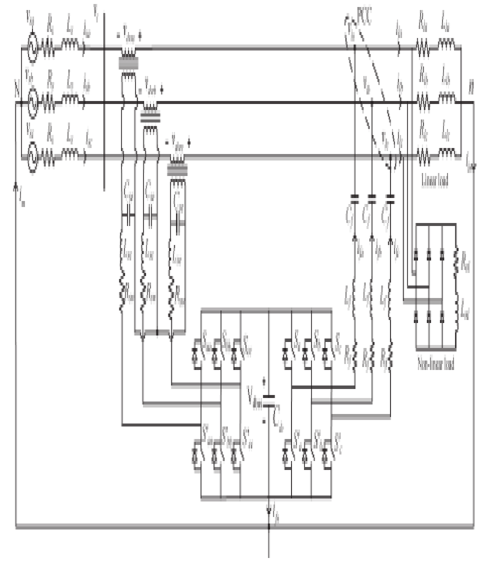

Figure 2: 3P4W UPQC equivalent circuit

The controlling technique for series and shunt converter of UPQC is designed based on the block diagram shown in figure 3.

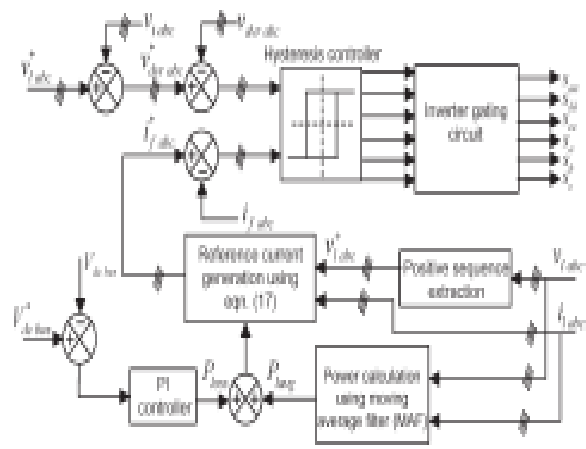

Figure 3: Block diagram of overall control structure with Series converter

For achieving multi-level control objectives series converters are used as mentioned in this last section. Hence, by considering suitable reference signals $i_{s\alpha}$, $i_{s\beta}$, $i_{s\gamma}$ different techniques can be implemented by the block “function selection and combination” is shown in Figure 3 [5]. For negative-sequence voltage Compensation current reference is

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generated by the unbalance correction scheme. Desired currents for active/reactive power are obtained by the power control strategy.

By utilization of non-linear loads the current drawn from the grid system is unbalanced. With the help of single phase PQ-theory current unbalance load currents are compensated. Single-phase p-q theory [6] can be implemented in park's transformation technique and the PQ theory is applied for each phase of unbalanced system independently and balanced three-phase system.

α-axis quantities are the actual load voltages and load currents, whereas the lead/lag load voltages and 90^0 lag/lead load currents are implemented as β-axis quantities. 90^0 lead is assumed in this paper for achieving a two-phase system for each phase.

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

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

Let us consider phase a with instantaneous values of load active and reactive powers as represented as

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

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

Artificial Neural Networks:

Figure 4 shows the structure of an ANN, in which fixed node indicated by a circle, an adaptive node indicated by square. In this structure hidden layers are presented in between input and output layer, these nodes are functioning as membership functions and the rules obtained based on the if-then statements is eliminated [7]. For simplicity, we considering the examined ANN has two inputs and one output. In this network, each neuron and each element of the input vector p are connected with weight matrix W. The hybrid learning algorithms are implemented for obtaining the values of system parameters. These learning algorithm's is a function of linear and non-linear parameters. These explanations are implemented in Matlab/Simulink software.

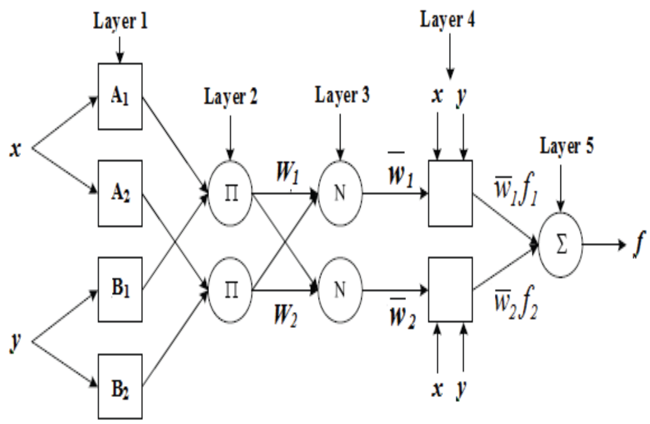

Figure 4. ANN architecture for a two-input multi-layer network

Where the two crisp inputs are x and y, the linguistic variables associated with the node function are Ai and Bi. The system has a total of five layers are shown in Fig 4.

Algorithm for Neuro Controller:

1. Assume the inputs and outputs in the normalized form with respect to their maximum values and these are in the range of 0-1.
2. Assure the No.of input stages given network.
3. Indicate the No.of hidden layers for the network.
4. Design the new feed forward network based on the system parameters 'transig' and 'poslin'.
5. Assume the learning rate be 0.02 for the given network.
6. Identify the number of iterations for the system.
7. Enter the goal.
8. Train the network based on the given input and outputs.

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9. for the given network Generate simulation with a command 'genism'

EXPERIMENTAL DIAGRAM AND RESULTS:

The experimental setup is done in MATLAB/SIMULINK as per the circuit shown in figure 1. The simulation circuit for the proposed ANN based UPQC system is shown in figure 5.

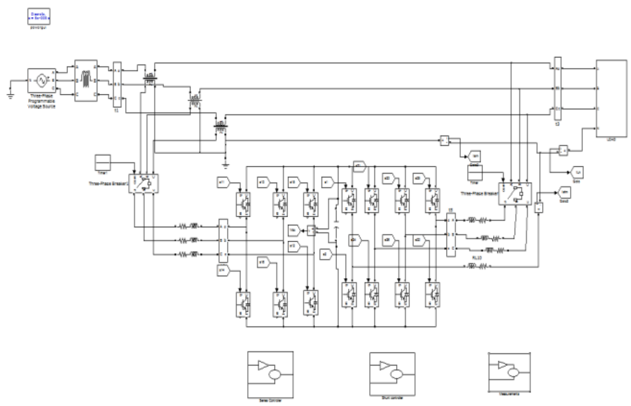

Figure 5: Simulation Diagram of 3P4W UPQC system

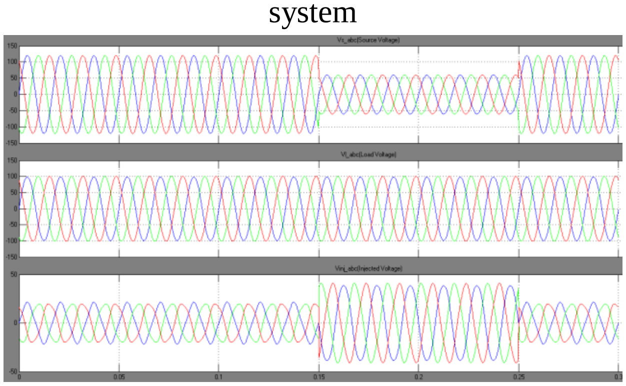

Figure 6 Matlab/Simulink source and load voltages.

Figure 6 shows the simulation results for the proposed system voltages. The sag is created between 0.15 sec to 0.25 sec and during this time the input voltage is reduced to 20% of its final value. And this drop is compensated with UPQC system as shown in figure 6.

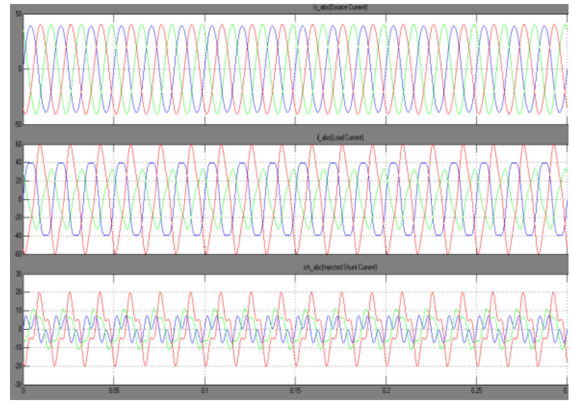

Figure 7 Matlab/Simulink source and load currents.

Figure 7 shows the system input, load and compensated currents. Due to usage of non-linear loads the system load current is effected by distortions and these distortions can be reduced by using shunt converter of UPQC as shown in figure 7.

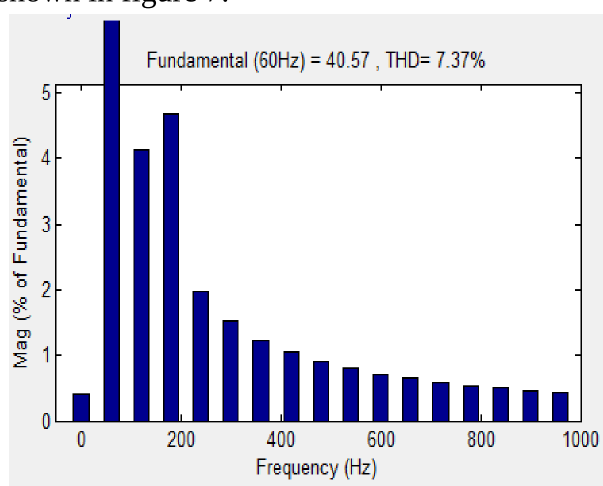

Figure 8: THD for source voltage with PI controller

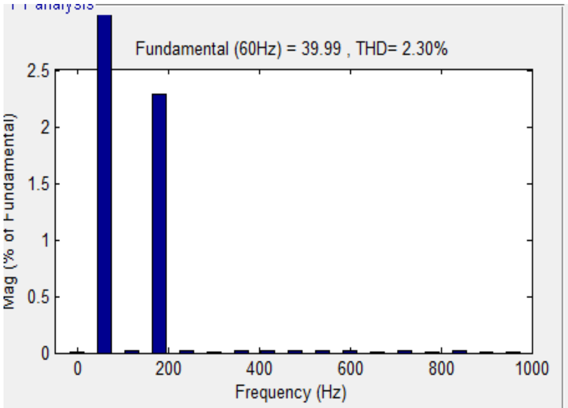

Figure 9: THD for source voltage with ANN controller

In order to get better controlling and more effiecient and reliable operation the same UPQC system is implemented with Artificial Neural Network Controller. And in this paper the resluts are compared between PI and ANN controllers. Figure 8 and Figure 9 shows the total harmonic distrotion values of the proposed system.

CONCLUSION

In this paper a 3P4W unified power quality conditioner is as a multiconverter power conditioner which can be used for compensating for the various disturbance in volatge and for preventing the current harmonic.

The Proposed model of unified power quality conditioner has been observed by conducting experiment in Matlab/Simulink. From this simulation results we conclude that the harminics caused by non-linear loads in voltage and currents can be reduced. A suitable mathematical model of the UPQC developed for designing of series and shunt converter controllers. And the showed simulation results are have been described which satisfies the compensation technique at both cases and the implementaed results with PI and ANN controllers and the results are compared bettween these two controllers. Out of these controllers, the artificial neural network controller is faster and the get minimum total harmonic distrotions for the system and shown in table 1.

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