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An ANN Controller Based Static Synchronous Compensator

V.B.SHALINI

Assistant professor, Department of EEE, Jawaharlal Nehru Technological University Hyderabad College of Engineering Jagtial, Nachupally, Telangana

K.SAI TEJA

M.Tech, Department of EEE, Jawaharlal Nehru Technological University Hyderabad College of Engineering Jagtial, Nachupally, Telangana

ABSTRACT: In power system the existence of harmonics is the major issue because of power electronic loads. For proper operation of the power system the voltage should be of high quality. STATCOM is a shunt device used to control the real and reactive power. In This paper the 3-φ static synchronous compensator using ANN based logic controller for harmonic reduction is presented. A Voltage controller based P-Q theory utilizing ANN logic controller is used for the STATCOM control. In this paper MATLAB simulation is performed utilizing PI controller, Fuzzy logic and ANN logic controller. The PI controller cannot be used for the ideal operation for the short period in non-linear conditions. The simulation for the ANN based STATCOM is performed and results are provided, and from the results the THD is reduced.

I. INTRODUCTION

The electric supply should ideal and balanced for proper operation of the loads. Practically only generator output voltages are balanced. But the transmission line voltages can be unbalanced and distorted due to non-linear loads in the power system [1]. The main reason for the unbalance in the distribution system is the uneven distribution of single phase loads like commercial, industrial, rural electrical system etc., these loads may cause mild unbalances, interruptions and harmonics. The presents of faults cause more short-term disturbances.

As the electrical system contains lagging power factor loads for the long transmission of power we need reactive power compensation. STATCOM is a shunt device used for the reactive power control. STATCOM acts as a synchronous condenser. STATCOM can operate irrespective of the ac system voltage for the reactive power compensation. It can also be used for the stability improvement and Voltage regulation of the system.

In [2] and [3], the transfer of harmonics through converters is analyzed. The STATCOM contains a capacitor at dc side of the inverter; the large rating of the capacitor is used for the reduction of voltage ripple. The presence of harmonics on dc side and over current limiting capacity of the STATCOM explained in [4]–[6].

In this paper, the ANN controller based static synchronous compensator is designed. The STATCOM active and reactive power can be controlled by controlling the magnitude and phase of the fundamental component of the system.

II. CIRCUIT DIAGRAM

The schematic diagram of the STATCOM is as shown in Figure 1.The STATCOM is a shunt connected device consists of a 3-leg voltage source inverter, capacitor at the dc side and coupling inductor. The controller is utilized to give the required gating signal and in addition to control the dc capacitor voltage and voltage infused by the STATCOM. The execution is dissected by utilizing both PI controller and also Fuzzy Logic Controller

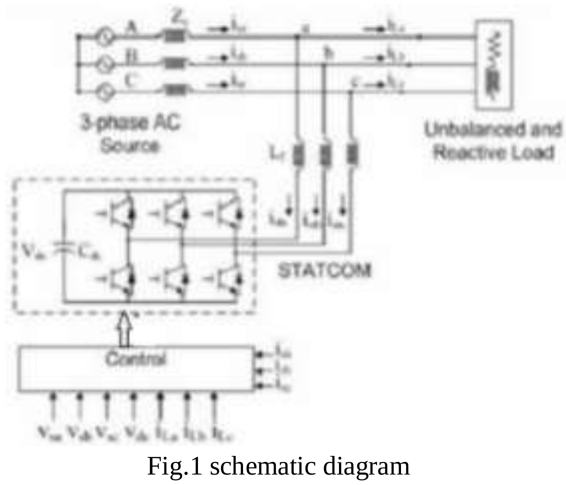

Fig.1 schematic diagram

III. D-Q TRANSFORMATION

The 3-φ ac components can be converted into dc by using the dq transformation. Here the 3 phases R, Y, B and are converted to two phases d

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and q. The instantaneous current and voltages converted into α, β by using Clarke transformation.

$$V = [V_R\ V_Y\ V_B],\ I = [I_R\ I_Y\ I_B] \qquad (1)$$

$$\begin{bmatrix} v_\alpha \\ v_\beta \\ v_o \end{bmatrix} = T \begin{bmatrix} v_R \\ v_Y \\ v_B \end{bmatrix} \qquad (2)$$

$$\begin{bmatrix} I_\alpha \\ I_\beta \\ I_o \end{bmatrix} = T \begin{bmatrix} I_R \\ I_Y \\ I_B \end{bmatrix} \qquad (3)$$

$$T = \sqrt{2/3}\begin{bmatrix} 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \\ 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} \end{bmatrix} \qquad (4)$$

Where T is the transformation matrix, and can be further transformed as,

$$\begin{bmatrix} v_d \\ v_q \end{bmatrix} = T \begin{bmatrix} v_\alpha \\ v_\beta \end{bmatrix} \qquad (5)$$

$$T = \begin{bmatrix} Cos\omega_\gamma & -Sin\omega_\gamma \\ Sin\omega_\gamma & Cos\omega_\gamma \end{bmatrix} \qquad (6)$$

Where, ω_γ is the angular velocity

IV. FUZZY CONTROLLER

The main disadvantage of the PI controller is that it cannot operate for non-linear systems. To overcome this Fuzzy logic controller is proposed. A fuzzy controller can work for both linear and in nonlinear systems. FL needs pre estimated numerical data keeping in mind the end goal to work.

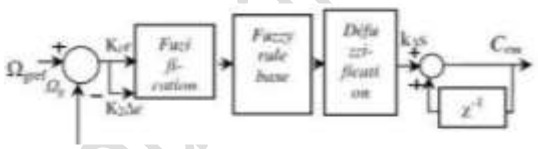

Fig.2: Fuzzy Logic Controller

In this system the input scaling factor has been designed such that input values are between -1 and +1. The triangular shape of the membership function of this arrangement presumes that for any particular E (k) input there is only one dominant fuzzy subset. The input error for the FLC is given as

$$E(k) = \frac{P_{ph(k)} - P_{ph(k-1)}}{V_{ph(k)} - V_{ph(k-1)}} \qquad (7)$$

$$CE(k) = E(k) - E(k-1) \qquad (8)$$

For instance, a straightforward temperature control system could utilize a solitary temperature criticism sensor whose information is subtracted from the order signal to process "error" and afterward time-separated to yield the error slant or rate-of change-of-error, in the future called "error-speck"

V. DESIGN OF ARTIFICIAL NEURAL NETWORK CONTROLLER

The basic neural network architecture consists of an input layer, middle or hidden layers for processing and computation, and an output layer. The number of inputs into the system gives the number of neurons to the 1st layer. For every input neuron single source is available. The number of hidden layers and the number of neurons per hidden layer are user defined. The number of neurons in the output layer depends on the number of outputs from the controller. A single neuron can have multiple input connections as well as multiple connections to the next neural layer.

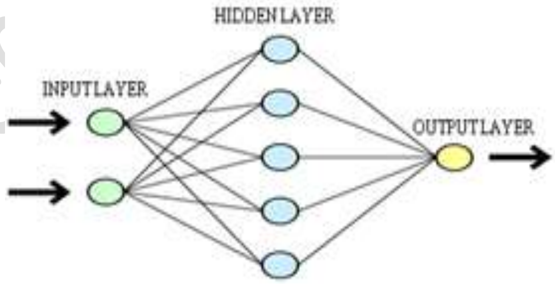

Fig.3: Artificial Neural Network Block Diagram

Input layer: The input layer or layer 1 collects data from a source.

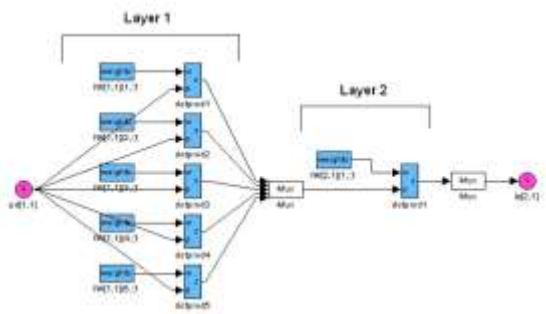

Fig.4: Artificial Neural Network Hidden Layers

Hidden Layer: this layer consists of two hidden layers for the computation of the data through the neurons. The first hidden layer consists of 5 neurons. The value of the neuron the function shifts left and right accordingly. This function

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output decides the second layer activation. The second hidden layer and inputs are summed together by this single neuron.

Output Layer: The output layer processes a scalar value. After the controller interprets the data, the two ANN's produce a scalar value each that are averaged together.

The neural network works according to the Eqn.9.

$$Y_i = \sum_{j=1}^{N} (W_{ij} X_j) \qquad (9)$$

Back-propagation: the response by the neural network is decided by some quantity. The error in the network can be reduced by taking the difference between the same inputs. This method is called as back propagation. This method is repeated for each set of inputs and error is back propagated through the network until the desired response is achieved.

VI. SIMULATION BLOCK DIAGRAM AND RESULTS

The simulation diagram for the desired model is provided. In shunt controller the required gate pulses are produced by the hysteresis controller. And 3- φ supply voltage was given to the fuzzy controller to get dq and theta.

Subsystem of FUZZY Logic controller:

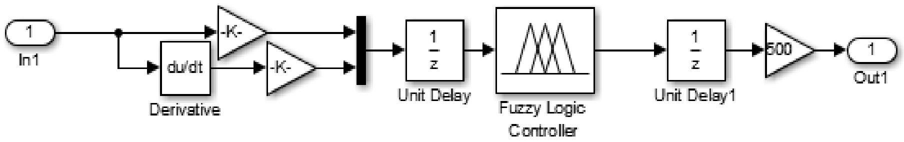

Fig.5: Simulation diagram of STATCOM using Fuzzy Logic controller

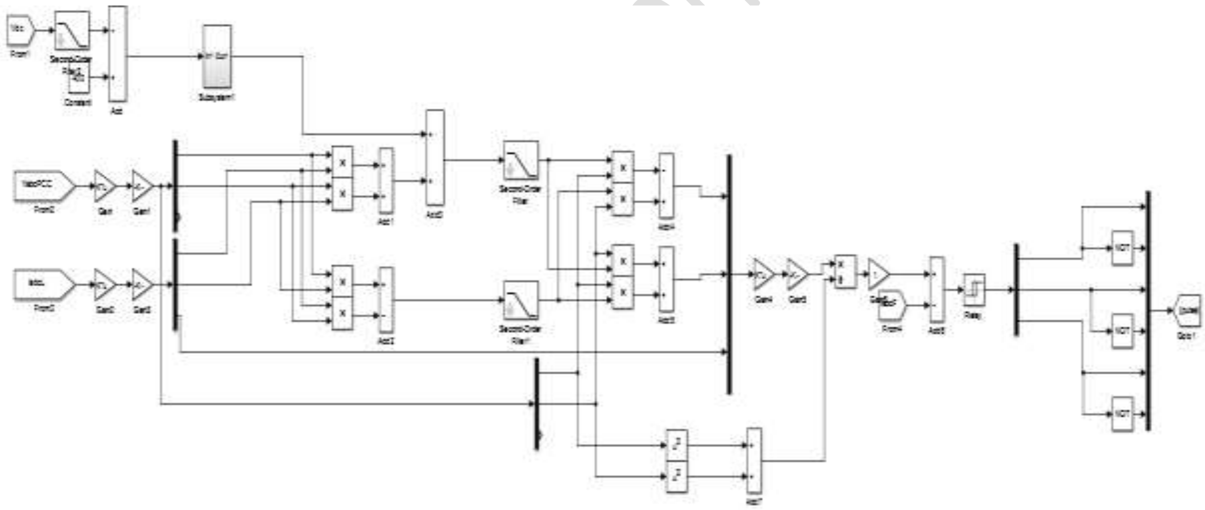

Fig.6: Diagram of STATCOM using FLC

Subsystem of ANN controller:

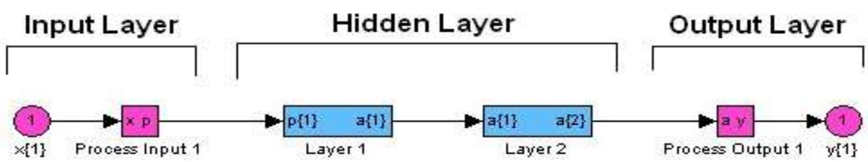

Fig.7: Simulation diagram of STATCOM using ANN controller

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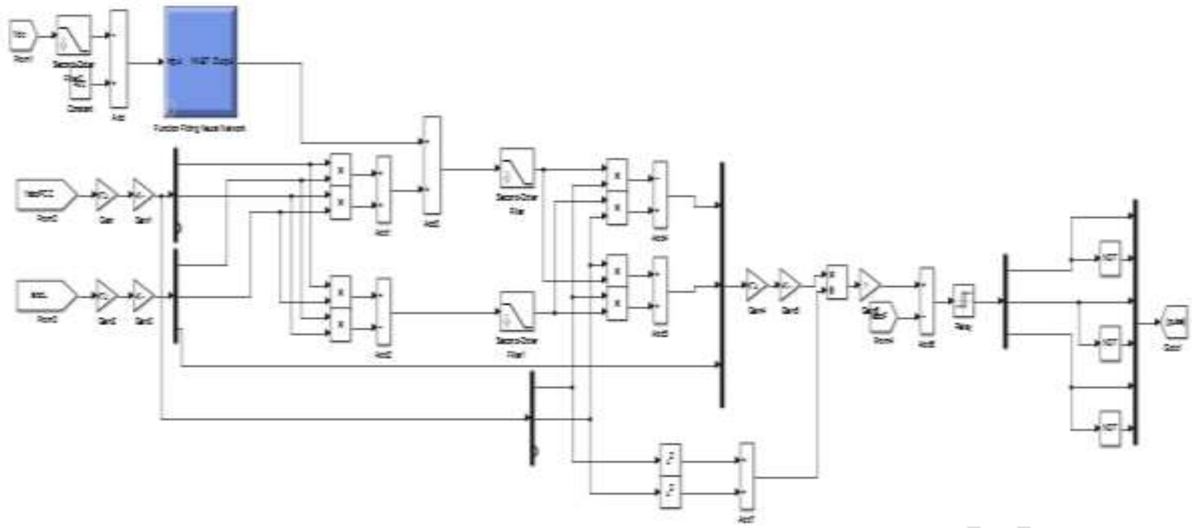

Fig.8: Diagram of STATCOM using ANN

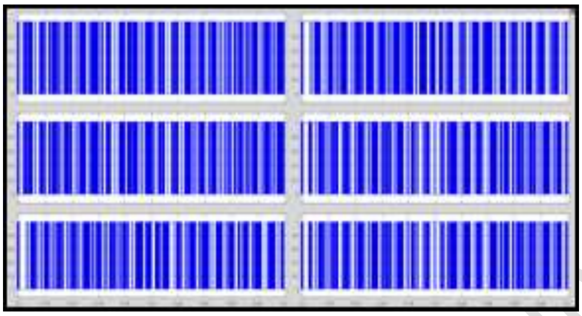

Fig.9: Pulses using FL controller.

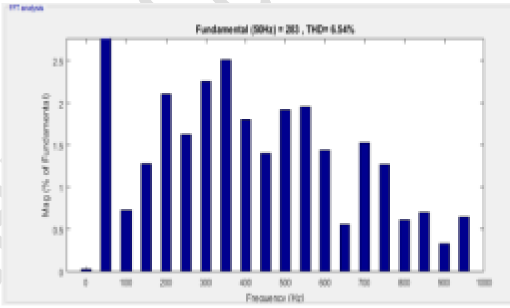

Fig.12: THD for the compensated Voltage harmonics

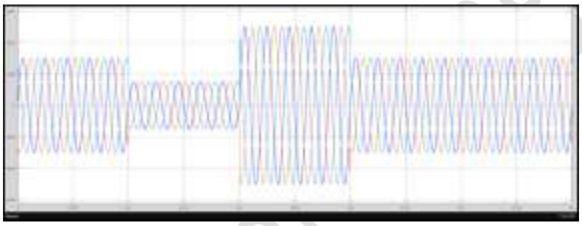

Fig.10: Uncompensated waveform of the voltage

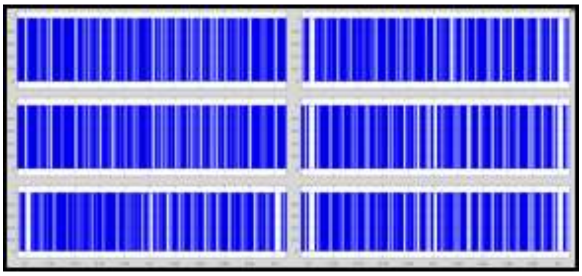

Fig.13: Gate pulses using ANN for STATCOM

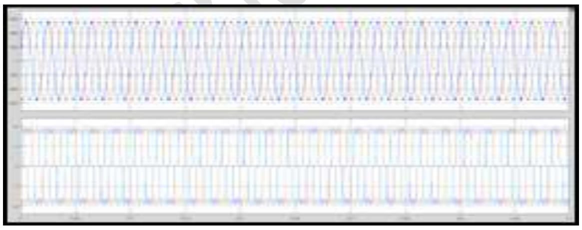

Fig.11: Compensated waveform V l and I l

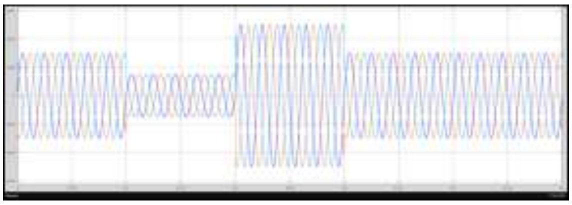

Fig.14: Uncompensated waveform of the voltage

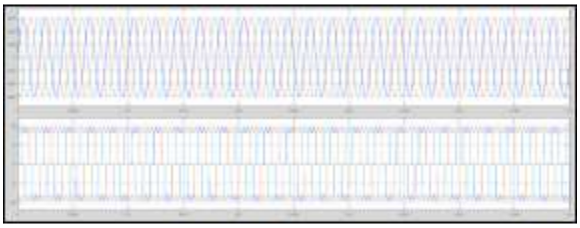

Fig.15: Compensated waveform V and I

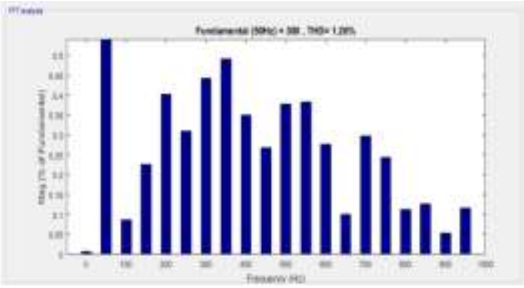

Fig.16: FFT analysis using ANN

The compensated waveforms for STATCOM using FL controller are shown in figure 11. The THD for the compensated voltage harmonics of STATCOM system using PI controller is 2.10% which is shown in figure 12. From the figures of FFT analysis the Total Harmonic Distortion value reduced by 2.10% to 1.26%.

Table 1: Comparison of THD value between Fuzzy and ANN Controller

Controller	Fuzzy Controller	ANN Controller
Voltage Harmonics (%)	2.10	1.26

From the results obtained, STATCOM with Fuzzy controller has more total harmonic distortion than the STATCOM with ANN Controller. The harmonic compensation of ANN Controller based STATCOM is better than fuzzy logic controller.

VII. CONCLUSION

In this paper a Static Synchronous Compensator system is designed by utilizing ANN controller. The P-Q theory has been utilized as a part of the control of active filters which influences the phase to supply currents sinusoidal, adjusted, and in phase with the voltages. MATLAB simulation demonstrates results of the STATCOM utilizing Fuzzy logic controller (FLC) and ANN controller. From the results we can observe that THD was exceptionally decreased in ANN logic controller when compared with Fuzzy controller.

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