NATIONAL INSTITUTE OF TECHNOLOGY, WARANGAL

DEPARTMENT OF ELECTRICAL ENGINEERING

A DSAPE Project Report

ON

Power Quality Improvement in Distribution System using ANN Based Shunt Active Power Filter

Under the guidance of

Prof. M. Sailaja Kumari

Submitted by:

Ganjikunta Jyothendra Sai	24EEM2R07
Rathla Meena	24EEM2R19
Neela Vinuthna	24EEM2R28
Kothula Sai Deepak	24EEM2S03
B Naidu	24EER1P01

NOVEMBER 2024

Table of Contents

ABSTRACT

This paper focuses on an Artificial Neural Network (ANN) controller-based Shunt Active Power Filter (SAPF) for mitigating the harmonics of the distribution system. To increase the performance of the conventional controller and take advantage of smart controllers, a feed forward-type (trained by a back propagation algorithm) ANN-based technique is implemented in shunt active power filters for producing the controlled pulses required for IGBT inverter.

The proposed approach mainly works on the principle of capacitor energy to maintain the DC link voltage of a shunt connected filter and thus reduces the transient response time when there is abrupt variation in the load. The entire power system block set model of the proposed scheme has been developed in MATLAB environment.

Simulations are carried out by using MATLAB, it is noticed that the %THD is reduced to 2.12% from 30.18% by ANN controlled filter. And also simulated by using PI controller it is noticed that the %THD is reduced to 2.14% from 30.18%. The simulated experimental results also show that the novel control method is not only easy to be computed and implemented, but also very successful in reducing harmonics.

Keywords

Shunt active power filter, ANN controller, PI Controller, Harmonic disturbance

1. INTRODUCTION

In recent years with the expansion of power semiconductor technology, power electronics-based devices such as adjustable-speed drives, arc furnace, switched-mode power supply, uninterruptible power supply etc are employed in various fields. Some of these converters not only increase reactive currents, but also produce harmonics in the source current. Due to the harmonics, there many losses in the power system. To mitigate the harmonics, there are different solutions are proposed and used by researchers in literature such as line conditioners, passive filters, active filter, etc., Firstly, conventional passive filter are used for elimination of the harmonics; but these passive filters having some disadvantages; such as large in size, fixed harmonic compensation, weight and resonance occurrence. The above drawbacks of passive filter can be overcome by the concept of active power filter approach.

Shunt-type active power filter (SAPF) is used to eliminate the current harmonics. The SAPF topology is connected in parallel for current harmonic compensation. The shunt active power filter has the capability to maintain the mains current balanced and sinusoidal after compensation regardless of whether the load is non-linear and unbalanced or balanced. Recent technological developments of switching devices and availability of inexpensive controlling devices, e.g., DSP-field-programmable-gate-array-centered system, accomplish an active power line conditioner, a natural option to compensate for harmonics.

The controller is the heart or primary component of the SAPF system. Conventional PI and PID controllers are used to extract the fundamental component of the load current thus facilitating reduction of harmonics and simultaneously controlling dc-side capacitor voltage of the voltage source inverter. Recently, different AI techniques controllers are used for shunt active power Filters. The Artificial Neural Networks (ANNs) have been systematically applied to electrical engineering. This method is considered as a new tool to design SAPF control circuits. The ANN presents two principal characteristics It's not necessary to establish specific input-output relationships but they are formulated through a learning process. Moreover, the parallel computing architecture increases the system speed and reliability.

2. CONFIGURATION OF SHUNT ACTIVE POWER FILTER(SAPF) AND ESTIMATION OF COMPENSATING CURRENT

The basic structure of shunt active power filter is shown in a figure below, it consists of the 3-phase source. Universal bridge, load along with active filters. A SAPF is to produce the compensation current. The non-linear load is the sum of source current and the harmonic current. The objective is to get the balanced supply current without harmonic and reactive components. The suitable current is injected by the SAPF corresponding to the load current. The SAPF is designed with ANN controller. The proposed controller, accounts for THD and DC voltage control, the controller have rapid dynamic response in case of load current deviation. The proper operation of the controller results in the generation of gate signals for 3-phase inverter which in turn is responsible for generating compensating currents. These compensating currents on injection through the 3-phase inverter results in harmonic compensation of source currents and improvement of power quality on the connected power system.

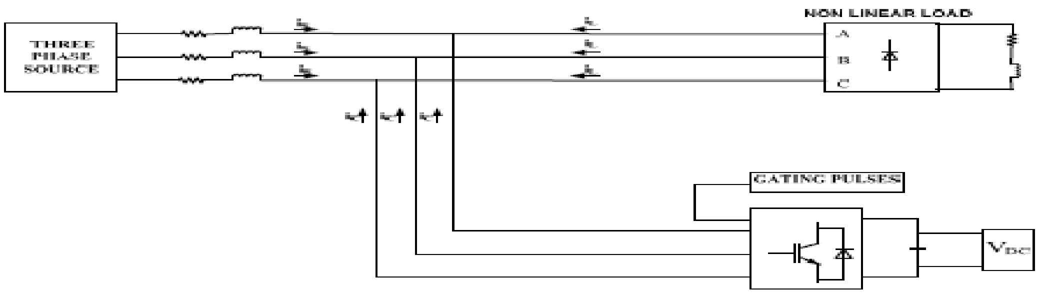


Figure1. Configuration of Shunt Active Filter

3. ANN CONTROLLER

An Artificial neural network (ANN), is a model (mathematical) inspired by biological neural networks. An ANN consists of an interlinked collection of artificial neurons, and it develops information using a connectionist method to calculation. It resembles the brain in two aspects: 1) The data is accumulated by the network through the learning process and, 2) Interneuron connection strengths are employed to store the data. These networks are categorized by their topology, the manner in which they communicate with their surroundings, the manner in which they are guided, and their capability to process information. ANNs are applied to solve artificial intelligence problems without necessarily creating a model of a real dynamic system.

For improving the performance of the suggested Shunt Active Power filter, single layer feedforward network (trained by the back propagation algorithm) is seen. This network consists of two layers and their corresponding neuron interconnections. ‘2’ neurons in input layer to receive the inputs. Hidden layer comprises of 21 neurons to which each of the processed input is fed. The output layer comprises of ‘1’neuron whose output is to be calculated as Ploss. Activation functions are assigned for each of the layers in order to train them. Hidden layer is given the Tan-Sigmoidal function as activation function and the output layer is being given the Pure-Linear activation function as activation function.

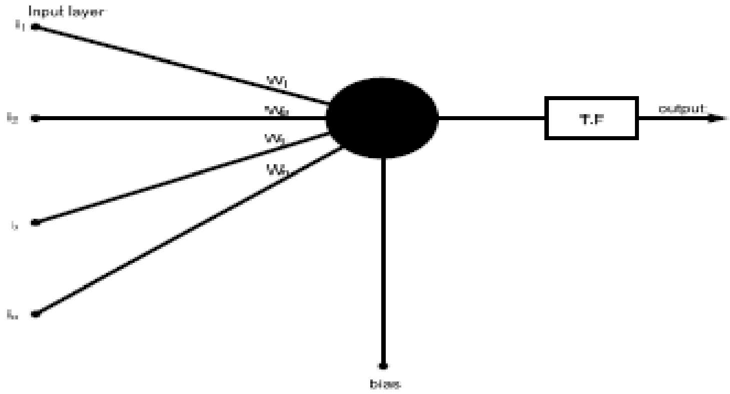


Figure 2. Internal blocks of proposed neural network

Algorithm for ANN

Step 1: Enter the number of inputs for a fed network (There are two inputs given by {ref, error} and one output {O}).

Step 2: Enter the number of layers.

Step 3: Create a new feed forward network with ‘TANSIG’ and ‘PURELIN’ transfer functions.

Step 4: Enter the number of epochs.

Step 5: Train the network for given input and targeted output.

Step 6: Generate simulation of the given network with a command ‘gensim’

The Neural Network is created with the set number of neurons in each layer using the above algorithm. At each training session, 500 iterations are done and 6 such a validation checks are taken out in order to minimize the scope of error occurrence. The main aim of this is to bring the performance to zero. The Learning rate is the major consideration in the training of the Artificial Neural Network (change of interconnection weights). It should not be too low that the training gets too delayed. It should not be excessively because the oscillations occur about the target values and the time needed to converge is too high and the training gets delayed.

For the considered controller, Neural Network is trained at a learning rate of 0.02. The compensator output depends on the input and its evolution.

Back propagation neural network

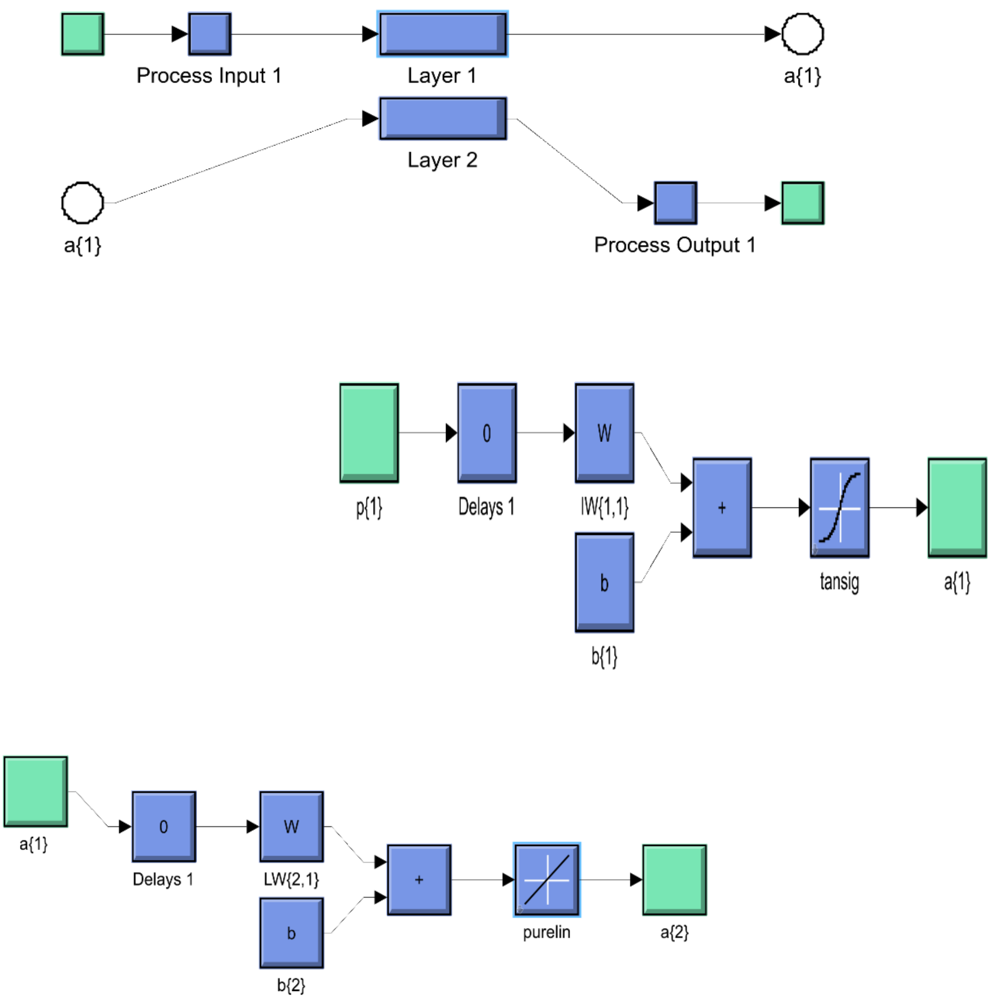


Figure 3: back propagation neural network

4.SIMULINK ENVIRONMENT

4.1 Simulation circuit for shunt active power filter

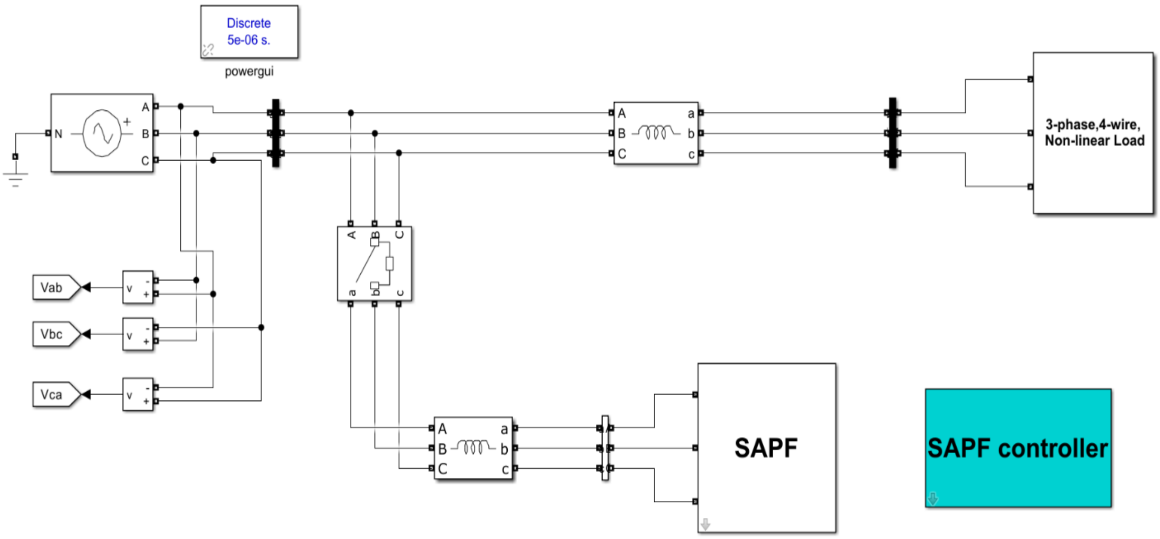
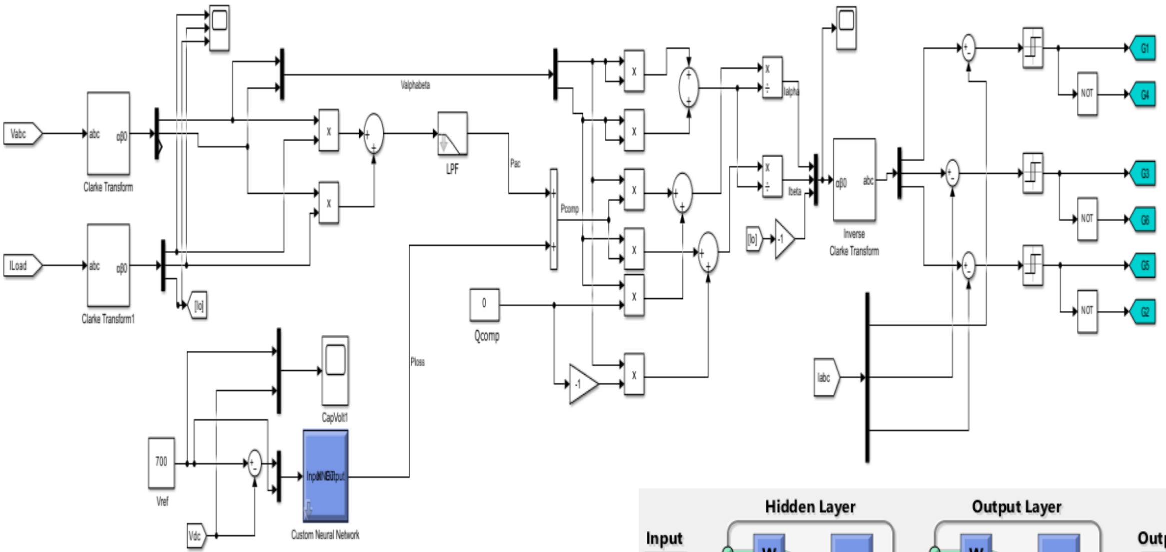


Figure 4: Circuit diagram for simulation

4.2 Controller circuit



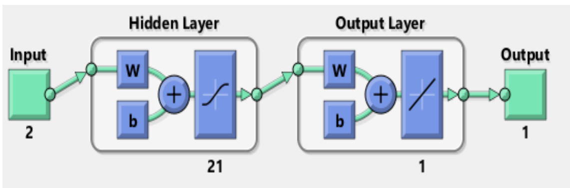


Fig. 5 Controller Circuit

4.2 Simulation Results

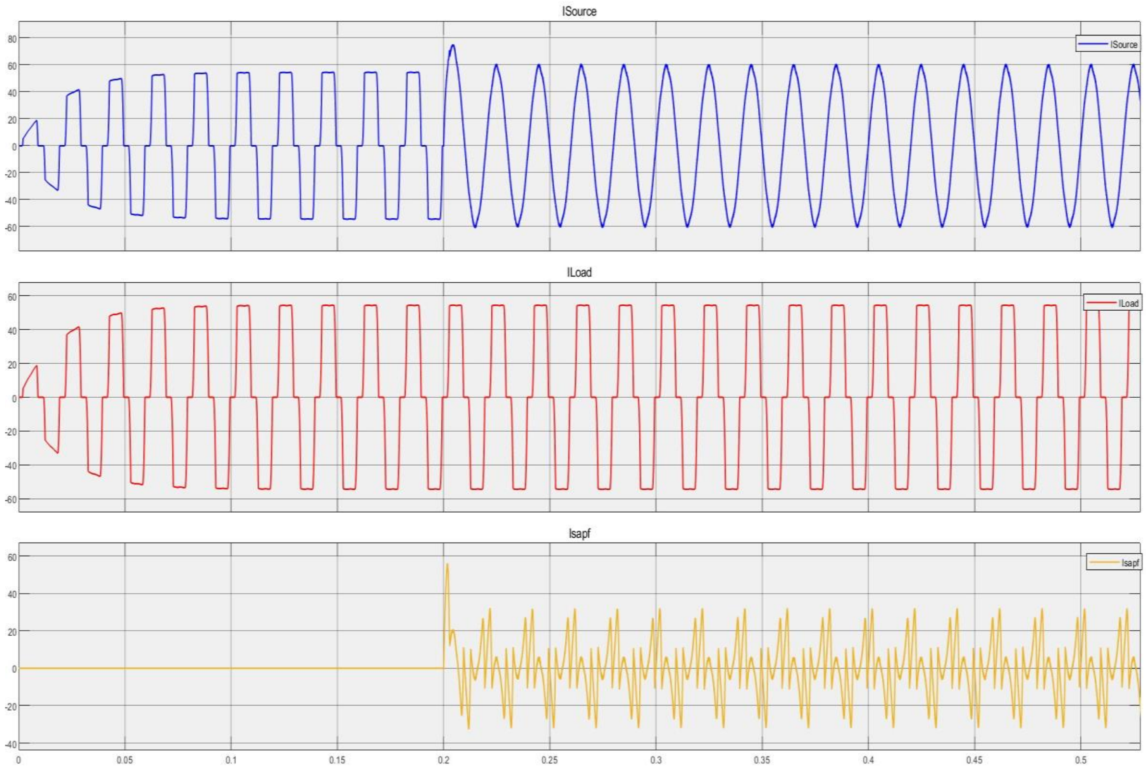


Figure 6: current waveforms

Figure 7: THD Analysis with ANN

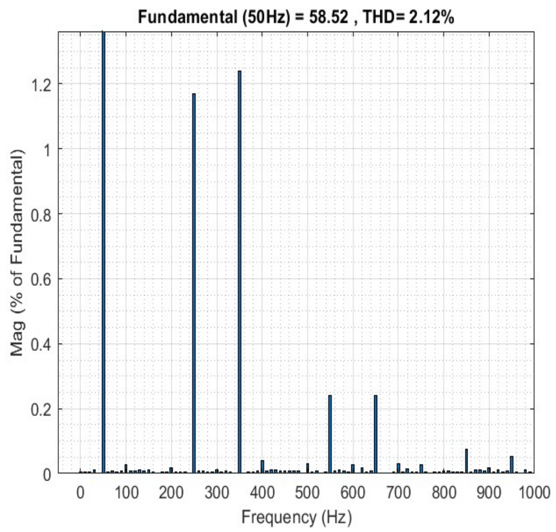
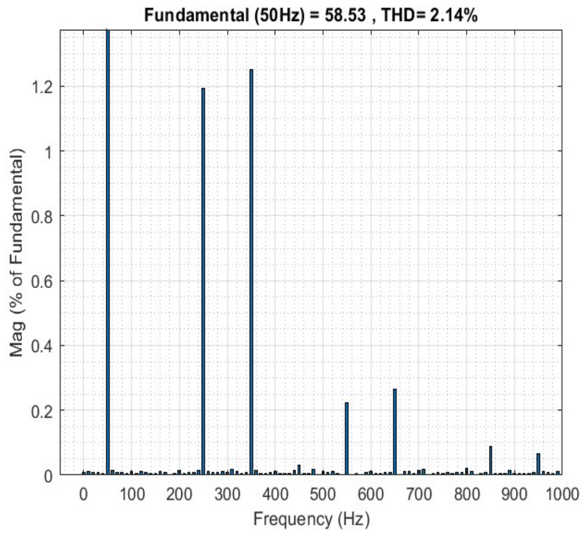


Figure 8: THD Analysis with PI



THD%	With out SAPF	With PI	With ANN
	30.18%	2.14%	2.12%

5. CONCLUSION

The obtained results show the simplicity and the effectiveness of the proposed intelligent controller under nonlinear load conditions. From the results, it can be observed that the current total harmonic distortion reduces better with ANN controlled active filter compared to without filter and with PI controller. The simulation and experimental results also show that the new control method is not only easy to be calculated and implemented, but also very effective in reducing harmonics.

6. REFERENCES

[1] H Doğan, R Akkaya. *A Simple Control Scheme for Single-Phase Shunt Active Power Filter with Fuzzy Logic Based DC Bus Voltage Controller*. Proceedings of the International Multi Conference of Engineers and Computer Scientists. IMECS. Hong Kong. 2009; II

[2] Boren Ren lin, Richard G Hoft. Power electronics inverter with neural networks. *IEEE Technology update series*. 1997; 12(2).

[3] YM Chen, RM O'Connell. Active power line conditioner with a neural network control. *IEEE Trans. Ind. Appl.,* 1997; 33(4): 1131–1136.

[4] JR Vázquez, Patricio Salmeron, F Javieralcantra, Jaine Prieto. A new active power line conditioner for compensation in un unbalanced /distorted electrical power system. 14th PSCC, Sevilla. 2002.

[5] N Pecharanin. *An application of neural network to harmonic detection in active filter*. Proc. WCCI- ICNN. 1994; 6: 3756–3756

[6] N Pechanranin, H Uitsui, M Sone. *Harmonic detection by using neural network*. Proc. IEEE Int. Conf. Neural Network., 1995, vol. 2, pp. 923–926.

[7] D Gao, Xiaoruisun. *A new method to generate current reference for active power filter*. Proc. IEEE CIEP, Alcapulco, Mexico. 2000: 99–103