Design of Neural Network Controlled DSTATCOM Using SRF Algorithm To Improve Power quality

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Abstract— *In this paper a design of an optimal ANN controlled Distribution Static Compensator (DSTATCOM) is presented for improvement of power quality .Now-a-days the power system network complexity is more increasing rapidly and most of the loads are inductive in nature. These loads draw more reactive power and also it causes harmonics and voltage variations in power system. To maintain the proper operation of interconnected power system we are using one of the FACTS devices such as DSTATCOM.DSTATCOM provides to maintain the desired power factor, voltage and also suppress the harmonic content in distribution network. The neural network controlled block diagram for DSTATCOM is incorporated and also it has been simulated for balancing the currents and elimination of harmonics for both linear and nonlinear loads. The simulation is taken out by MATLAB/SIMULINK and the results show the effectiveness of controlled DSTATCOM for improvement of power quality.*

Keywords*-ANN controller, DSTATCOM, Power quality, SRF algorithm.*

1. INTRODUCTION

Now-a-days the power system network is more complex and most of the loads are inductive in nature. These loads draw more reactive power and it is the main factor for increasing the distribution losses and various power quality problems. Conventionally, Static Var Compensators (SVCs) have been used in conjunction with passive filters at the distribution level for reactive power compensation and mitigation of power quality problems. Even though SVCs are more effective controller for reactive power compensation at the transmission level their limited range of bandwidth and size causes more losses and slower response. Another compensating system is a combination of SVC and active power filter, which can compensate three phase loads in a minimum of two cycles. Thus, a controller which continuously monitors the load voltages and currents to determine the right amount of compensation required by the system and the less response time should be a viable alternative. Distribution Static Compensator (DSTATCOM) has the capacity to overcome the above mentioned drawbacks by providing precise control and fast response.

A DSTATCOM is basically a converter based distribution flexible AC transmission controller while a DSTATCOM is employed at the distribution level or at the load end for dynamic compensation. The latter, DSTATCOM, can be one of the viable alternatives to SVC in a distribution network. Additionally, a DSTATCOM can also behave as a shunt active filter [1]-[2] to eliminate unbalance or distortions in the source current or to supply voltage, as per the IEEE-519 standard limits. Since a DSTATCOM is such a multifunctional device, the main objective of any control algorithm should be to make it flexible and easy to implement, in addition to exploiting its multi functionality to the maximum.

2. *BASIC PRINCIPLE OF DSTATCOM*

DSTATCOM is a controlled reactive source, which includes a Voltage Source Converter (VSC) and a DC link capacitor connected in shunt, capable of generating and/ or absorbing reactive power. The operating principles of a DSTATCOM are based on the exact equivalence of the conventional rotating synchronous compensator [4]. The AC terminals of the VSC are connected to the Point of Common Coupling (PCC) through an inductance, which could be a filter inductance or the leakage inductance of the coupling transformer, as shown in Figure 1.

The DC side of the converter is connected to a DC capacitor, which carries the input ripple current of the converter and is the main reactive energy storage element. This capacitor could be charged by a battery source, or could be precharged by the converter itself [5]. If the output voltage of the VSC is equal to the AC terminal voltage, no reactive power is delivered to the system. If the output voltage is greater than the AC terminal voltage, the DSTATCOM is in the capacitive mode of operation and vice versa. The quantity of reactive power flow is proportional to the difference in the two voltages It is to be noted that voltage regulation at PCC and power factor correction cannot be achieved simultaneously [4]. For a DSTATCOM used for voltage regulation at the PCC, the compensation should be such that the supply currents should lead the supply voltages; whereas, for power factor correction, the supply current should be in phase with the supply voltages. The control strategies studied in this paper are applied with a view to studying the performance of a DSTATCOM for power factor correction and harmonic mitigation.

2.1. BASIC SYSTEM CONFIGURATION

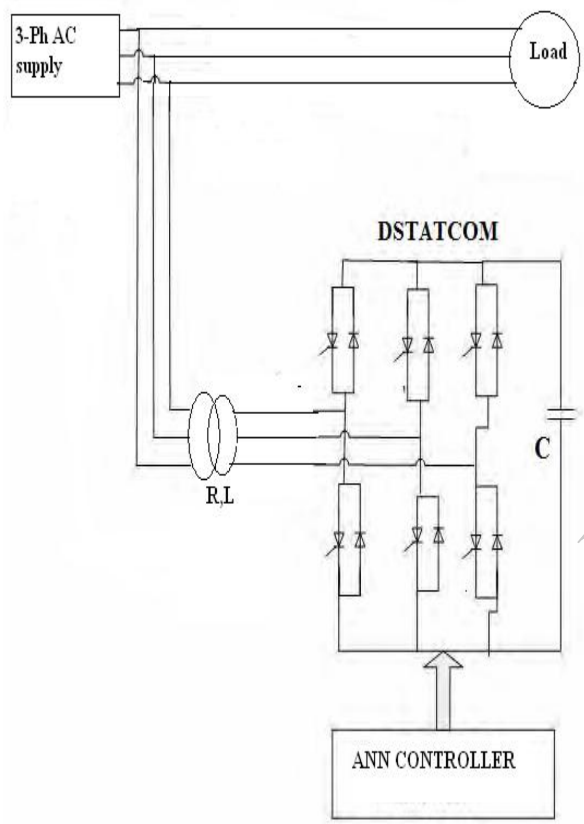


Fig: 1 Basic system configuration

The above fig.1 shows the fundamental block diagram of DSTATCOM with ANN controller .The DSTATCOM mainly consists of a two level voltage source converter a Dc energy storage device, coupling transformer.VSC converts the voltage across the capacitor into ac output voltages. These voltages are injected with AC system. The commonly used modulation is PWM to generate higher than fundamental frequency of currents for injection into system, such a way to maintain balancing current and harmonic compensation in source currents.

3. SRFALGORITHM TECHNIQUE FOR DSTATCOM

SRF algorithm is generally used as controlled technique for DSTATCOM.This algorithm is mainly accompanied by the transformation of three phase system to two phase system components.

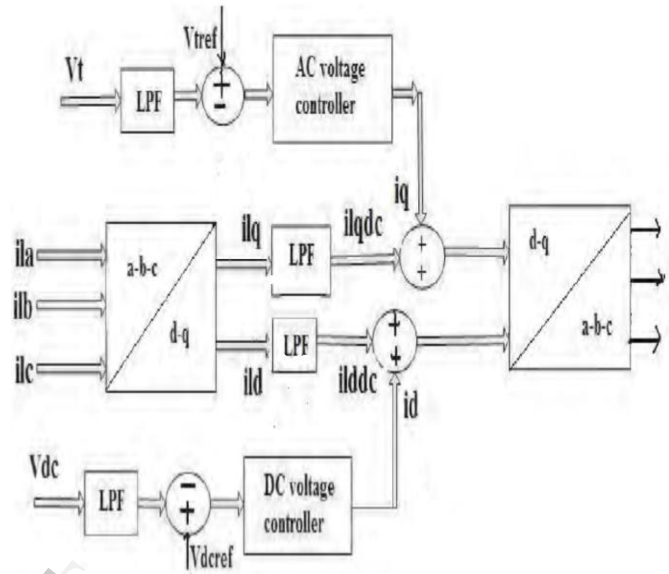


Fig: 2 Block diagram of SRF algorithm

The input voltages and currents are fed to the controller. The currents ila, ilb, ilc are transformed to d-q frame and these are filtered to a-b-c frame and are fed PWM generator to generate firing pulses of DSTATCOM.

4. ANN CONTROLEER ARCHITECTURE

Neural-networks is one of those words that is getting *fashionable* in the new era of technology. This area of neural networking is the "fuzziest" in terms of a definite set of rules to abide by. There are many types of networks - ranging from simple Boolean networks (perceptions), to complex self-organizing networks (Kohonen networks), to networks modelling thermodynamic properties (Boltzmann machines) The standard network architecture is shown in fig.3.

The network consists of several "layers" of neurons, an input layer, hidden layers, and output layers. Input layers take the input and distribute it to the hidden layers (so-called *hidden* because the user cannot see the inputs or outputs for those layers). These hidden layers do all the necessary computation and output the results to the output layer, which (surprisingly) outputs the data to the user.

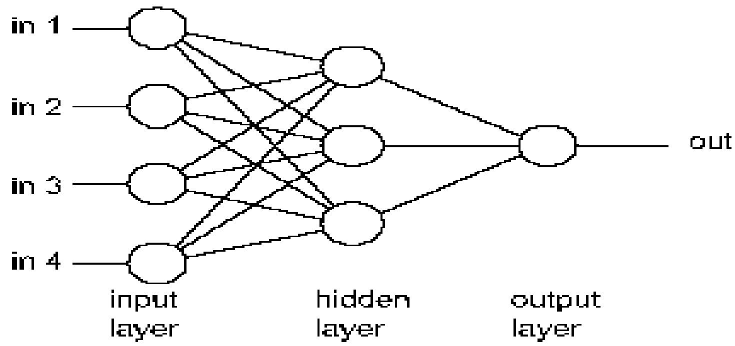


Fig: 3 ANN Controller Architecture

4.1 NEURAL NETWORK LEARNING:

Fig. 4 shows the Learning method in neural networks**.** Learning in a neural network is called training. Like training in athletics, training in a neural network requires a coach, someone that describes to the neural network what it should have produced as a response. From the difference between the desired response and the actual response, the error is determined and a portion of it is propagated backward through the network. At each neuron in the network the error is used to adjust the weights and threshold values of the neuron, so that the next time, the error in the network response will be less for the same inputs.

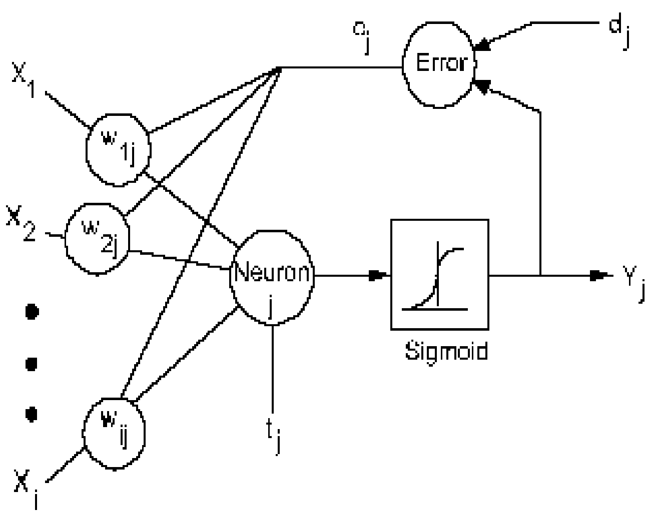


Fig: 4 learning method of ANN

This corrective procedure is called back propagation (hence the name of the neural network) and it is applied continuously and repetitively for each set of inputs and corresponding set of outputs produced in response to the inputs. This procedure continues so long as the individual or total errors in the responses exceed a specified level or until there are no measurable errors. At this point, the neural network has learned the training material and you can stop the training process and use the neural network to produce responses to new input data.

4.2. *TRAINING OFNEURAL NETWORK:*

The main aim of training of ANN is to finds the suitable weight values which may cause the desired output. For fast convergence back propagation algorithm is used.

- Select ANN topology with number of layers, nodes and initialize with random weights.
- Calculate the difference with the obtained output and actual output which is nothing but an error.
- If the error is not accepted change the weights until to get acceptable error either by changing no. of neurons in hidden layers.

Because error information is propagated backward through network, this type of training method is called backward propagation.

5. SIMULATION STUDIES AND DISCUSSION

The SIMULINK model of proposed DSTATCOM is shown in fig:5,and it is simulated in MATLAB SIMULINK to test the performance of the control method.

The ANN controller is used to generate gate pulses of each of VSC of DSTATCOM.The basic ANN Controlled circuit is shown in fig: 6.

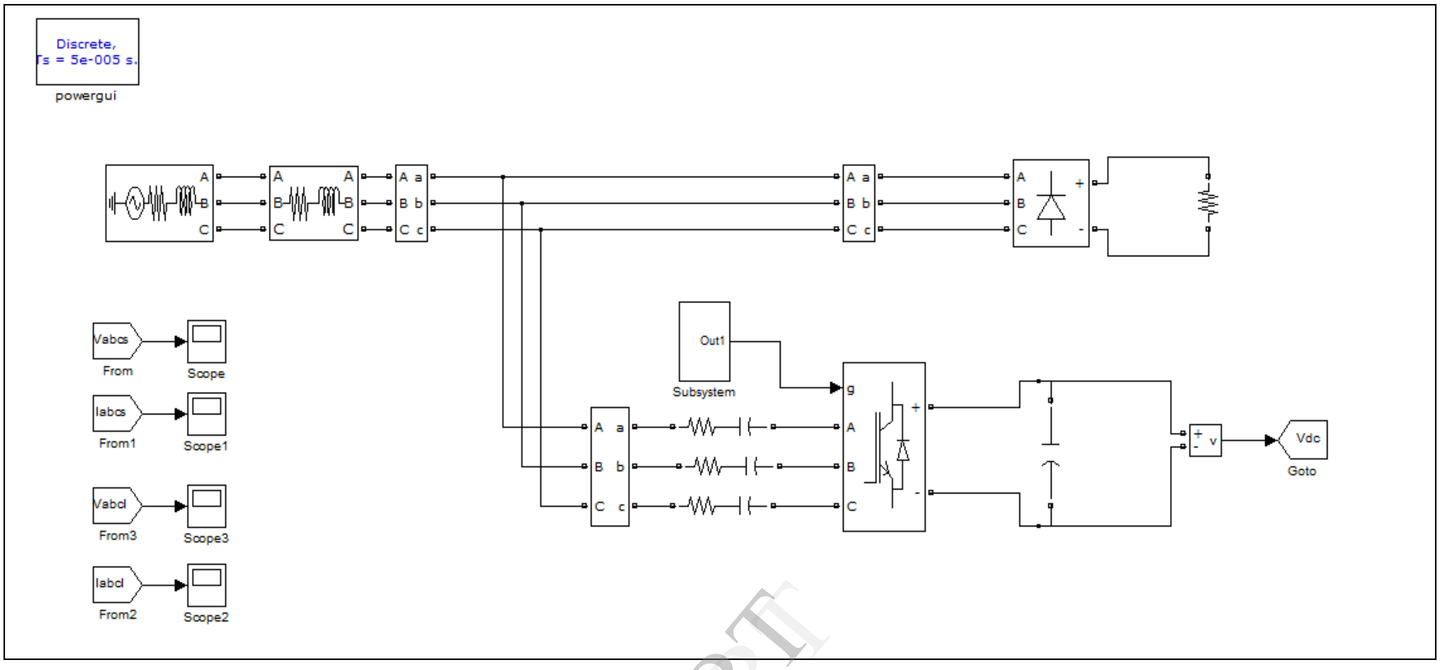


Fig: 5 Simulink Model ANN Controlled DSTATCOM

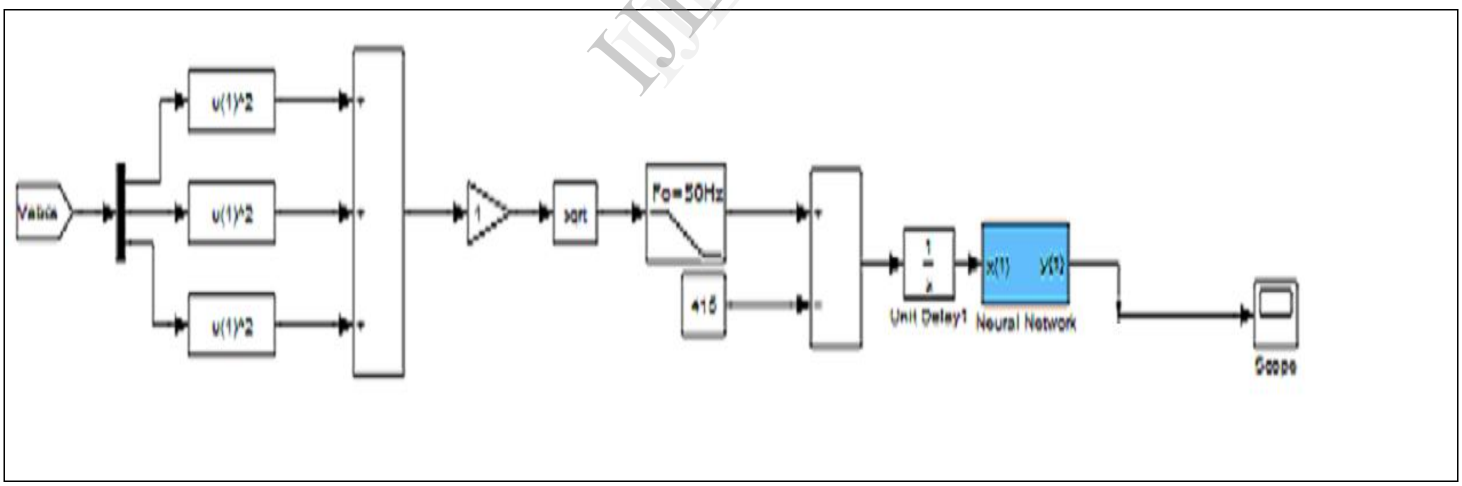


Fig: 6 Basic ANN Controlled Circuit

The simulation has been carried out by considering nonlinear load as shown in above fig [5]: Nonlinear load is to be taken as three phase bridge rectifier with resistive load. The proposed ANN controller is able to perform the compensation of reactive power and also to suppress the content of harmonics occurred in the system. Thus ANN controller is more effective for DSTATCOM. The waveforms of nonlinear load source voltage, source current, load voltage and load currents are as shown in fig; [7]

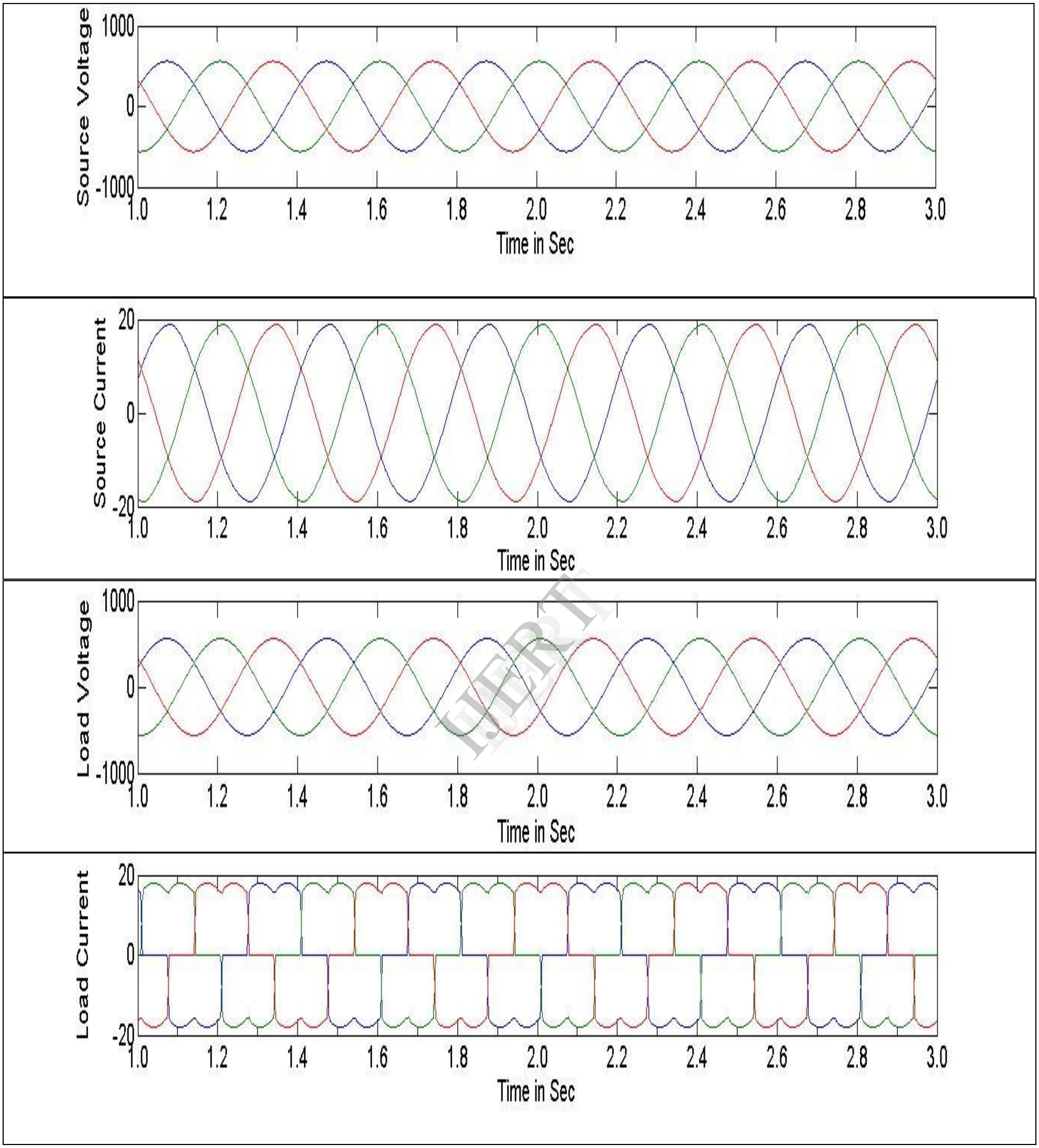


Fig: 7 Simulation results for nonlinear load: source voltage, source current, load voltage and load currents

5.1 SIMULATIN RESULS FOR LINEAR LOAD

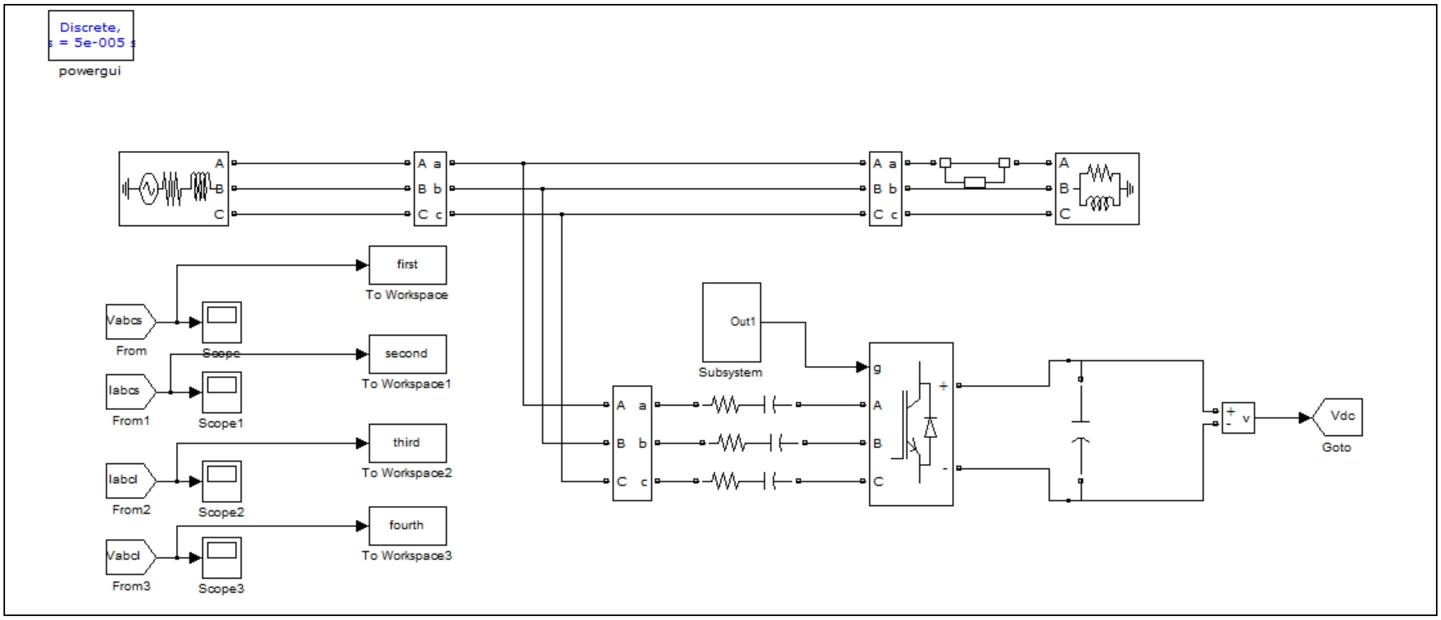
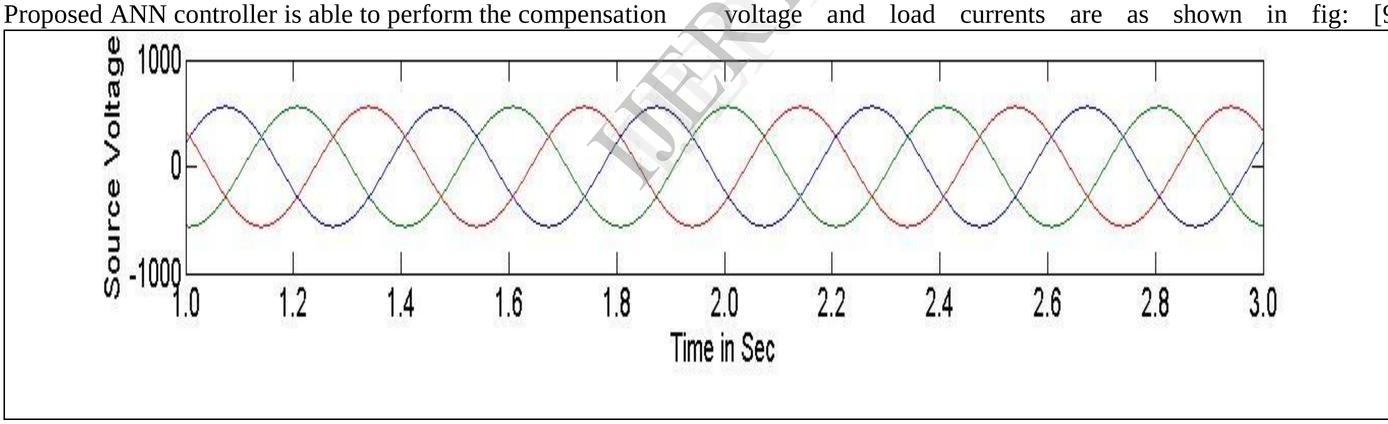
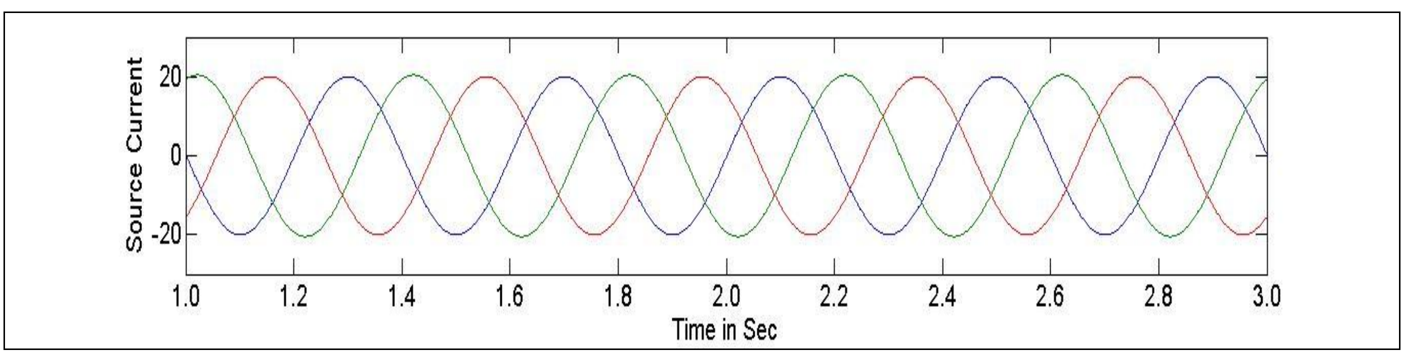


Fig: 8 Simulink model of ANN Controlled DSTATCOM

The simulation has been carried out by considering linear load as shown in above fig: [8] linear load is to be taken as RL. The Proposed ANN controller is able to perform the compensation Of reactive power and also to suppress the harmonics The waveforms of linear load source voltage, source current, load voltage and load currents are as shown in fig: [9]





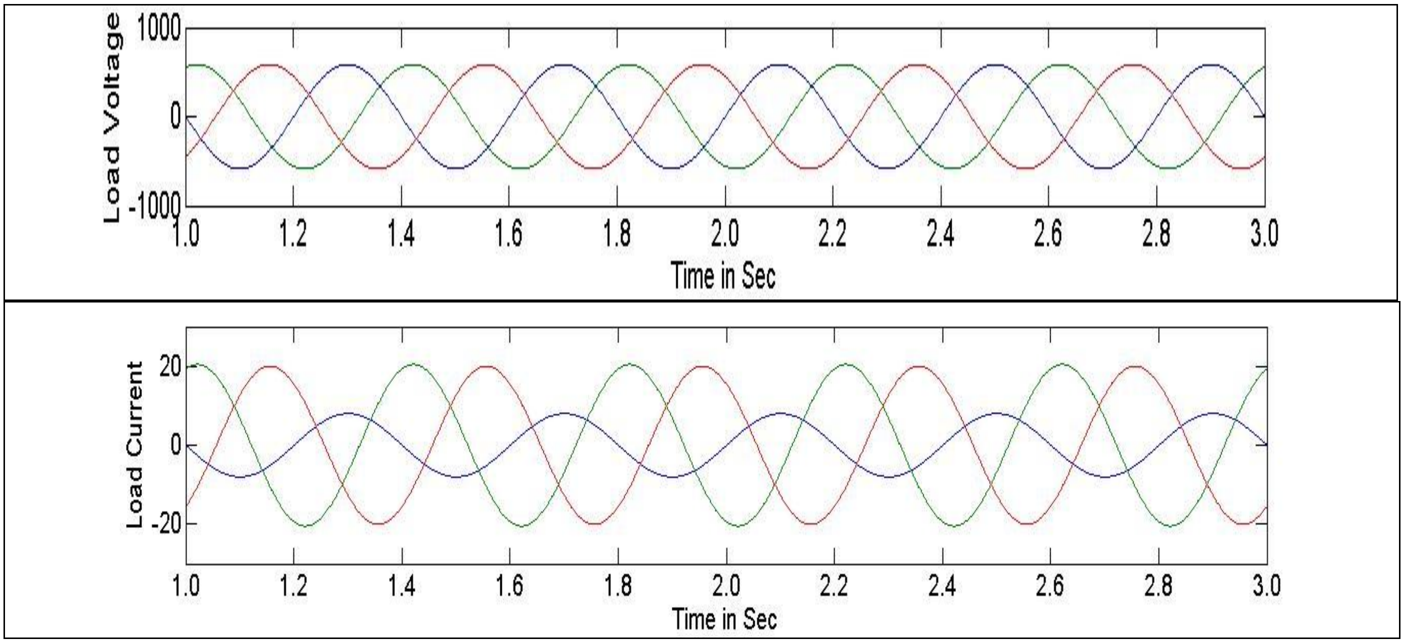


Fig:9 Simulation results for nonlinear load :source voltage ,source current, load voltage and load current

Comparison of Total Harmonic Distortion (THD)

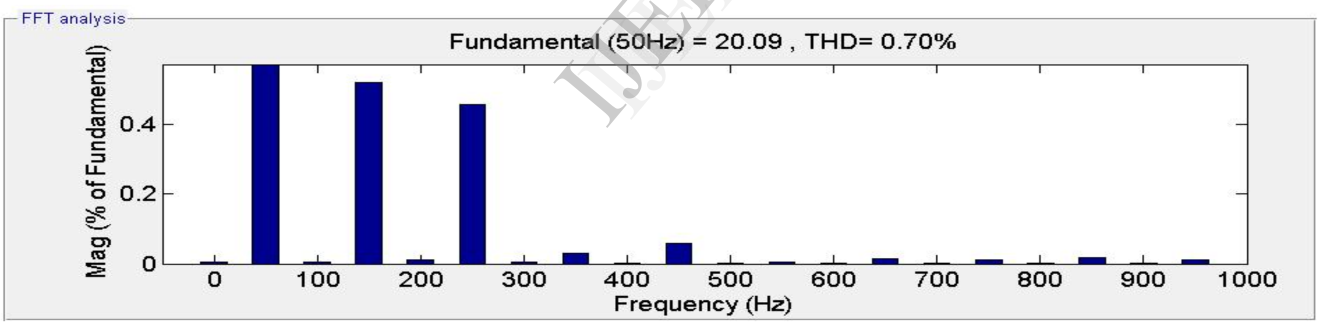


Figure 10(a) THD of load Current with ANN Controller

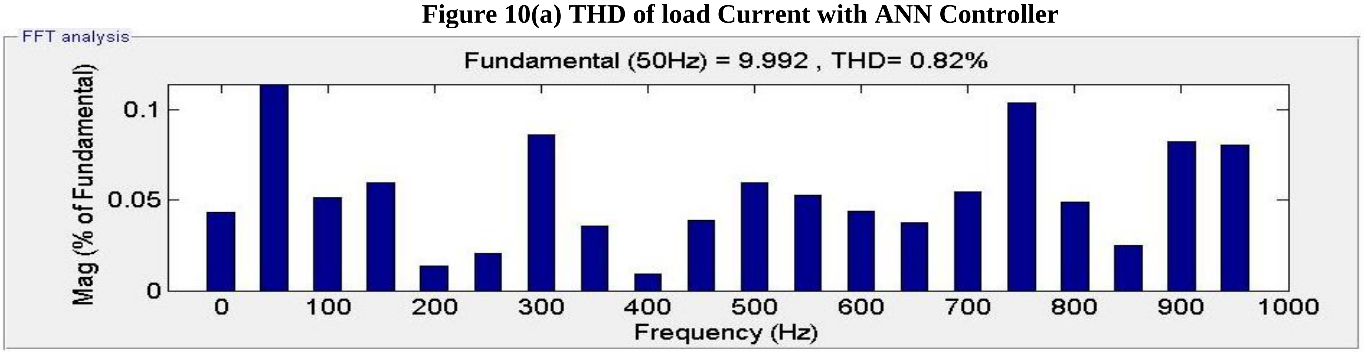


Figure 20(b) THD of load Current with FUZZY Controller

6. CONCLUSION

Considering the neural network controlled DSTATCOM, it is observed that the power quality of the interconnected power system is improved. The results can be tested for both linear and nonlinear loads in MATLAB/SIMULINK.The variation of THD with our proposed controller is compared to Fuzzy controller .The proposed ANN controller is not included any parameter which is dependent on system. The performance of ANN controlled DSTATCOM is more effective rather than other conventional controllers. By adding neural network control to DSTATCOM it reduces the harmonic content and also obtain the balancing currents and maintain the quality of power supply.

7. REFERENCES

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