ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 7, July 2017

Voltage Regulation and Reactive Power Compensation using ANN Controlled Distributed STATCOM

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ABSTRACT: This project is an attempt to develop a hardware / simulation of Distributed STATCOM using the ANN controller. Any STATCOM device gives a better performance depending on the type of algorithm used to control generation of reference current, pulses for gating. In this project a back propagation algorithm (BP Algorithm) generates the pulses for the inverter circuit. The fundamental component of active and reactive load current, are calculated by BP algorithm. They play a major role in the estimation of source current references. Then the difference of the generated and targeted value is used in generating, the triggering pulse for the inverter. Later the voltage is inserted at the common coupling point in order to balance the reactive power, furthermore resulting in improvement in the quality of power. The model for simulation of DSTATCOM uses backward propagation control technique is compared with the conventional Pulse Width Modulated controlled DSTATCOM is also presented.

KEYWORDS: Artificial neural network, D-STATCOM, FACTS devices, PQ Theory, Power Quality.

I.INTRODUCTION

The Presently the best solution to solve control based problems is soft computing solution preferred to analytic models that are very confusing. The most fundamental element for Artificial intelligence that is trending nowadays is Artificial neural network (ANN) considering it better than any other traditional option to give good accuracy. Main issues associated with SP, medical field, robots and communications field could be sorted out using ANN. BP (back propagation) algorithm and multi-layered NN are the basic methods to design various applications. Literally, BP is the most popularly utilized for training algorithms and focuses to minimize the error in weight space by descent gradient. The minimum error weights are solutions for the algorithm used for training but the most difficult part of it is to identify minimum error values. The various values associated with the learning phase are the count of neurons occurring in each layer, the activation functions, least error value, neural network architecture, data base, no. of hidden layers, learning algorithm[1].

Power Transmission and Distribution are the complicated process, which requires the functioning of many considerations and aspects of the power system so that the output can be at its best and maximum [2].Power quality in the distribution systems has a greater impact on all the electronic and electric components connected measuring the changes in frequency, voltage and current measurement of the system. Power converters have increased in power supply and speed drivers recently is used to draw current harmonics from AC mains and increases supply demand respectively[3].

The device which is known as FACTS gives quick and constant have power over transmission variables like voltage value, line impedances and at last a phase angle between the two end voltages. Further the traditionally used power system is then used for distributing the lesser voltage that improves the quality of the power to make system stable. These traditionally used power systems are much identical to that of FACTS systems. The most popularly used custom devices are DSTATCOM, DVR, UPQC amongst which DSTATCOM is most famous and it can also be an

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affordable resolution for the reimbursement of the reactive power[4]. A study has been made on DSTATCOM related works. In spite of keeping the load voltage at a particular desired value there are several unwanted effects at the customer end [5].

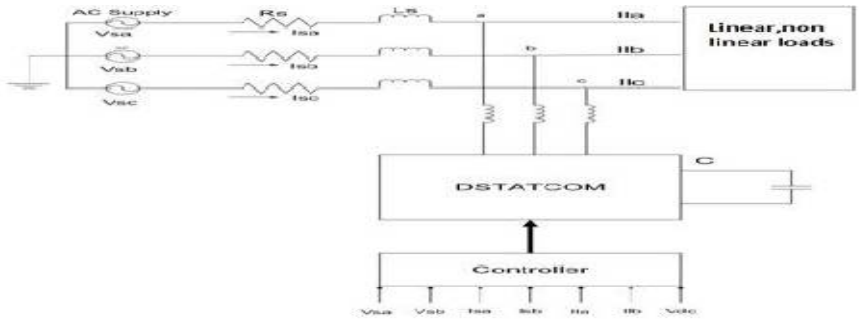

Fig1: DSTATCOM controlled by ANN architechture

The voltage source convertor based D-STATCOM has been linked to a AC mains which is three-phase and three- phase non-linear (or) linear loads with the impedance of grid internally. The entire device is developed with the aid of 6 IGBTs switches along with diodes that are not parallel. A 3 phase load can be a load of lagging power, a non-linear load. An RC filter has been linked to the device which is in parallel to the load as well as compensator in order to reduce the ripples in PCC voltage which is inserted by switching action of D-STATCOM. In order to minimize the ripples that occurs in the compensating current, the component known as interfacing the inductors. The efficiency of DTSTATCOM relies on the precision and certainty of detection of harmonic current.

There have been many theories which are existed for the production of source currents used for reference which is used to control VSC part of D-STATCOM in a 3 phase 4 wire systems. An approach using synchronous reference frame (SRF) & ANN is aided beneath the non-sinusoidal supply for 3 phased 4 wired VSC based D-STATCOM device which is executed on the grid and a premeditated reference current supply used to generate input pulses for VSC of D-STATCOM.

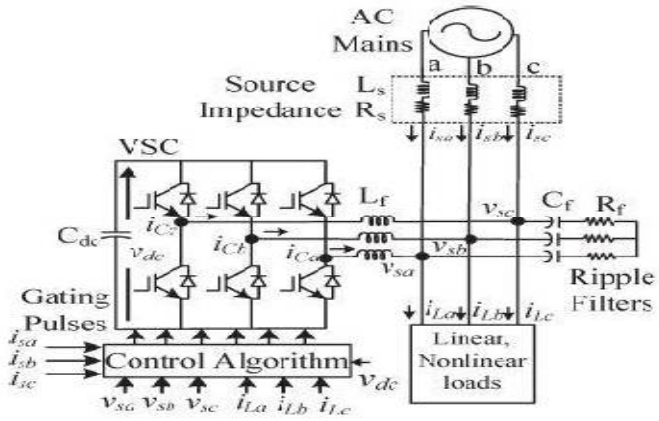

Fig 2: Circuit for VSC based D-STATCOM

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II. DSTATCOM VOLTAGE CONTROLLER

The major goal of control technique is controlling and taking care that a determined voltage is present at certain point where load is connected. The rms voltage at certain load point can be calculated using control system. The switching order of VSC is totally dependent on the pulse which is sinusoidal with modulation technique by which we can get greater of response and simplicity. This method offers much more adjustable choices for the low power applications. Therefore such new way of approach this uses the ANN controller for DT-STATCOM is to be projected through this work.

III. PROPOSED SYSTEM: Artificial Neural Architecture

ANN (Artificial neural network) has a number of strongly interconnected essentials such as, the artificial neurons, biological neuron abstraction. Some weights intensify or weaken the input signals prior to adding to the terminal depicted near a circle. A premeditated data flows to output via a transfer function. These neurons are attached with each other by creating different layers. The most commonly accepted method is known as feed forward architecture.

A Back Propagation is put into action with the 3 phase shunt linked power device which is called D-STATCOM used to remove or eradicate weighted value for reactive and active power current parameters present in non-linear loads. The BP algorithm is needed to eliminate the harmonics, balancing the load in 0 Volt Regulation mode with the DC voltage regulation of D-STATCOM and instruction of weight has 3 different parts.

- Upgrading of different training weights
- computation and BP of error signals
- Feed Forward of input signal training.

IV. CONTROL ALGORITHM

Compensation of reactive current, harmonic current and alleviation of currents that are not balanced are preferred activities of DSS (Distributed static series compensator). The main objective of DSTATCOM is to make source current pure sinusoidal. From eq. (1) and (2) the source voltages (V_{sa},V_{sb},V_{sc}) is converted to V_a and $V_ß$

$$V_{sa} = \sqrt{\frac{2}{3}}[V_{sa} - \frac{V_{sb}}{2} - \frac{V_{sc}}{2}] \quad (1)$$

$$V_{\beta} = [\frac{V_{sb} - V_{sc}}{\sqrt{2}}] \quad (2)$$

Similarly the load currents are converted as shown in equations (3),(4) and (5)

$$I_0 = \sqrt{\frac{1}{3}}[I_{La} + I_{Lb} + I_{Lc}] \quad (3)$$

$$I_{\alpha} = \sqrt{\frac{2}{3}}[I_{La} - \frac{I_{Lb}}{2} - \frac{I_{Lc}}{2}] \quad (4)$$

The a-ß currents can be measured using (9) and (10) to give p* and Q. Inverse Clarkes transformation can be used to convert this la', $I_ß$' to reference currents.

$$I_{\beta} = [\frac{I_{Lb} - I_{Lc}}{\sqrt{2}}] \quad (5)$$

The instantaneous real power (P) and reactive power (Q) are given by

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$$P = V_\alpha I_\alpha + V_\beta I_\beta \quad (6)$$

$$Q = V_\beta I_\alpha - V_\alpha I_\beta \quad (7)$$

$$I_\alpha^* = [\left(\frac{-1}{V_\alpha^2+V_\beta^2}\right)\left((P^* \times V_\alpha) + (Q \times V_\beta)\right)] \quad (8)$$

$$I_\beta^* = [(\frac{-1}{V_\alpha^2+V_\beta^2})((P^* \times V_\beta) + (Q \times V_\alpha)] \quad (9)$$

The reference currents that sre produced (I_a*, I_b * and I_c*)are compared with source currents I_{sa}, I_{sb} and I_{sc}. The generated error signals are given to hysteresis controller to produce the triggering pulses for the switches.

$$I_a^* = \sqrt{\frac{2}{3}}[I_\alpha^* + \frac{I_0}{\sqrt{2}} \quad (10)$$

$$I_b^* = \sqrt{\frac{2}{3}}[\frac{-I_\alpha^*}{2} + \frac{\sqrt{3}}{2} I_\beta^* + \frac{I_0}{\sqrt{2}}] \quad (11)$$

$$I_c^* = \sqrt{\frac{2}{3}}[\frac{-I_\alpha^*}{2} - \frac{\sqrt{3}}{2} I_\beta^* + \frac{I_0}{\sqrt{2}}] \quad (12)$$

V. SIMULATION AND RESULTS

PWM CONTROLLED DSTATCOM:

This During the simulation of DSTATCOM, the gate input signals can be obtained by using a PWM controller. The process of VSC switching depends on the PWM method that is sinusoidal as it is very simple and gives better results. A Pulse Width Modulation method offers more flexible option. This technique offers simplicity a good response.

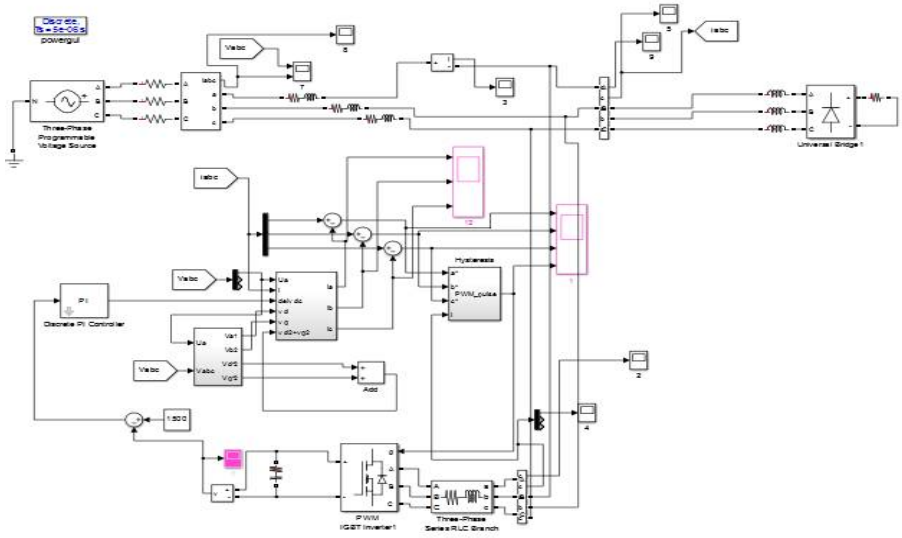

Fig4: PWM controlled DSTATCOM model for simulink

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Vol. 6, Issue 7, July 2017

PWM CONTROLLED DSTATCOM OUTCOME

The waveform in Fig5,6 shows source voltage (V_{sa}, V_{sb},V_{sc}) with source current (I_{sa}, I_{sb},I_{sc}) ,waveform of load current (I_{la},I_{lb},I_{lc}), compensating currents (I_{ca},I_{cb}, I_{cc}) and also the load voltage waveform (V_{abc}) under unbalanced nonlinear loads.

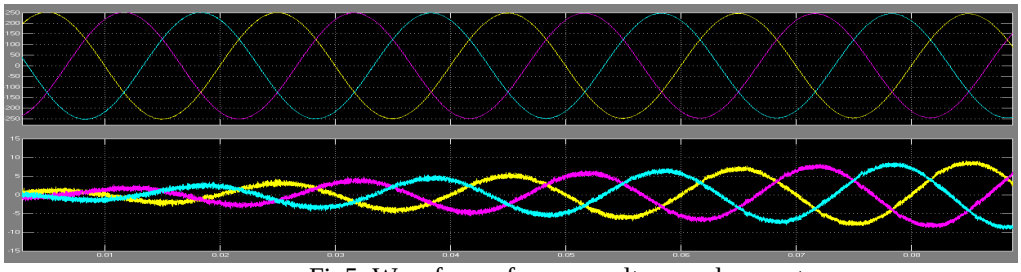

Fig5: Waveform of source voltage and current

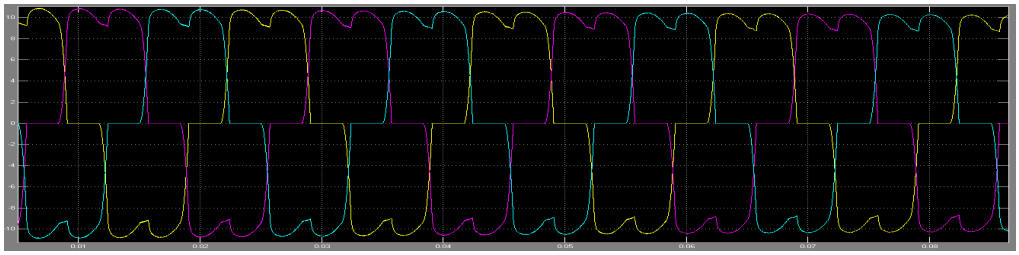

Fig6: Waveform Of Load Current

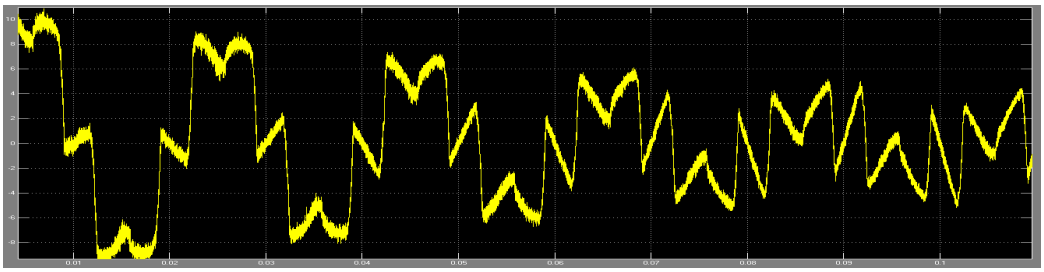

Fig7: Waveform Of Compensating Current

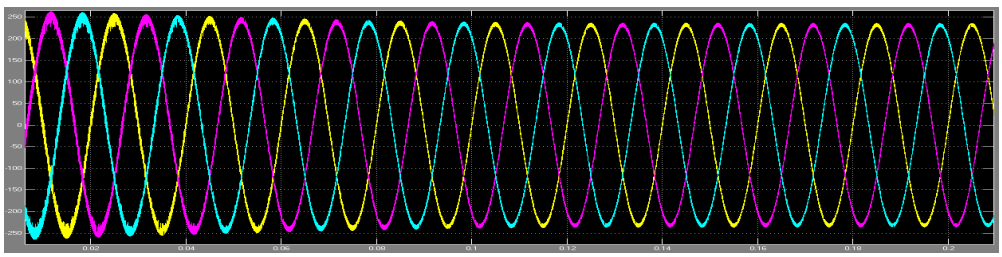

Fig8: Waveform of load voltage

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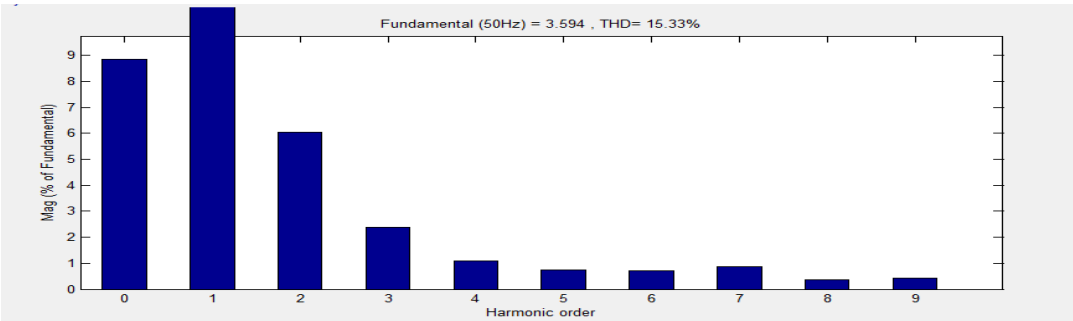

Fig9: THD analysis of input current

VI. PROPOSED METHODOLOGY: DSTATCOM CONTROLLED BY NEURAL NETWORK

The model shown below gives ANN controlled algorithm in MATLAB.

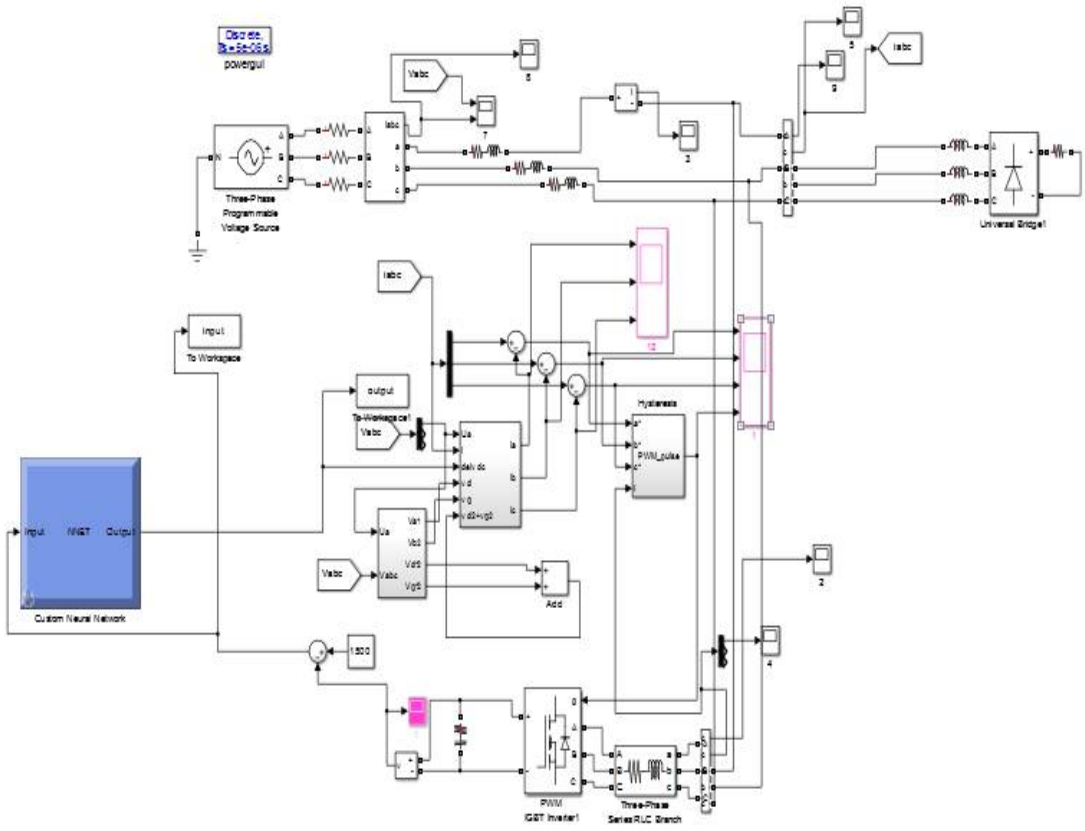

Fig10: Simulink modeling of ANN controlled DSTATCOM

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VII. CALCULATION OF REFERENCE CURRENT

The figure gives the MATLAB mathematical modeling of reference current calculation.

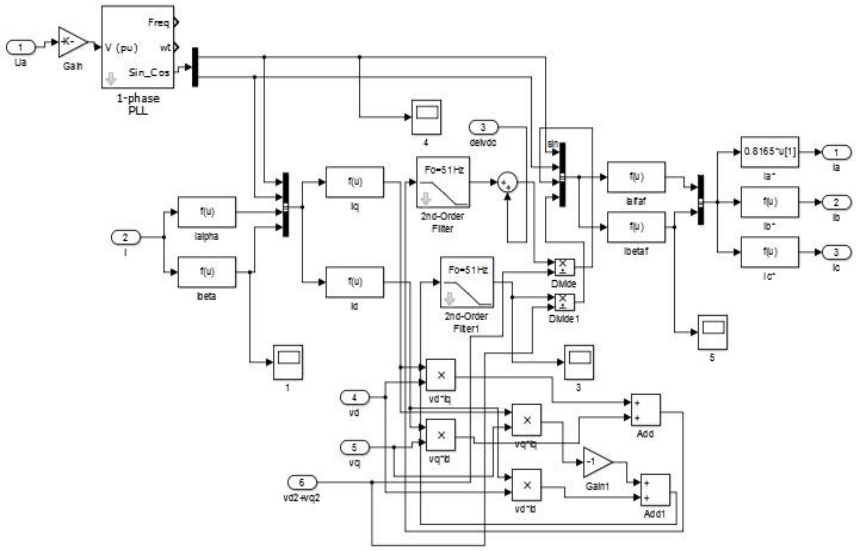

Fig11: Mathematical Modeling Of Reference Currents Calculation

VIII. OUTCOMES OF ANN CONTROLLED D-STATCOM

The below shown figure shows the waveforms of source voltages (V_{sa}, V_{sb}, V_{sc}) and source current (I_{sa}, I_{sb}, I_{sc}), load voltage(V_{abc}), load currents (I_{la}, I_{lb}, I_{lc}) and compensating current (I_{ca}, I_{cb}, I_{cc})

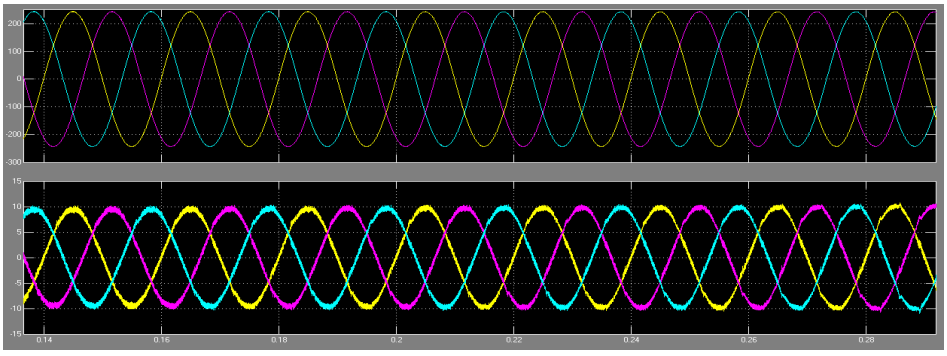

Fig12: Source Voltage and Current

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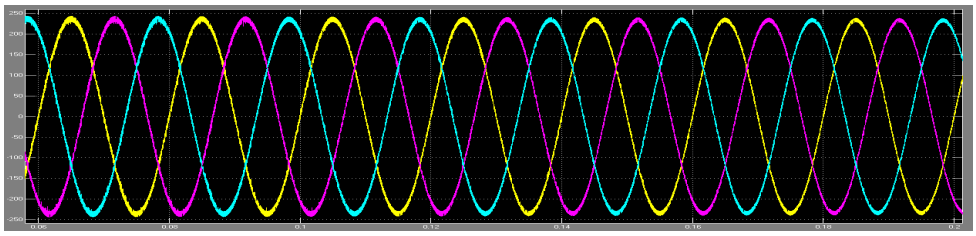

Fig13: Load Voltage

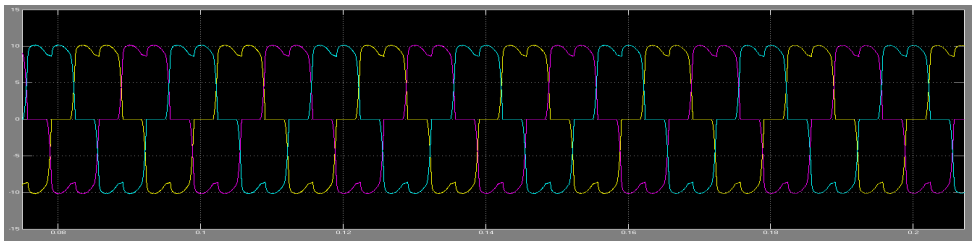

Fig14: Load Current

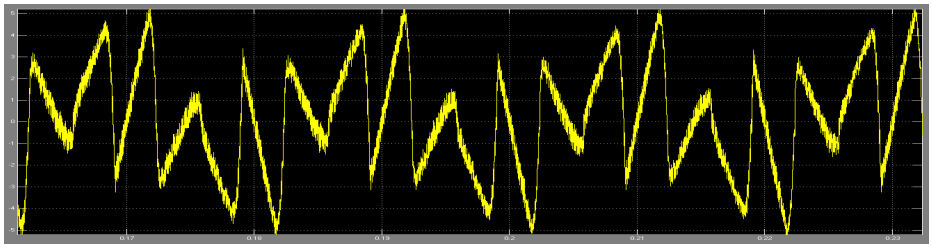

Fig15: Compensating Current

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ISSN (Online): 2278 – 8875

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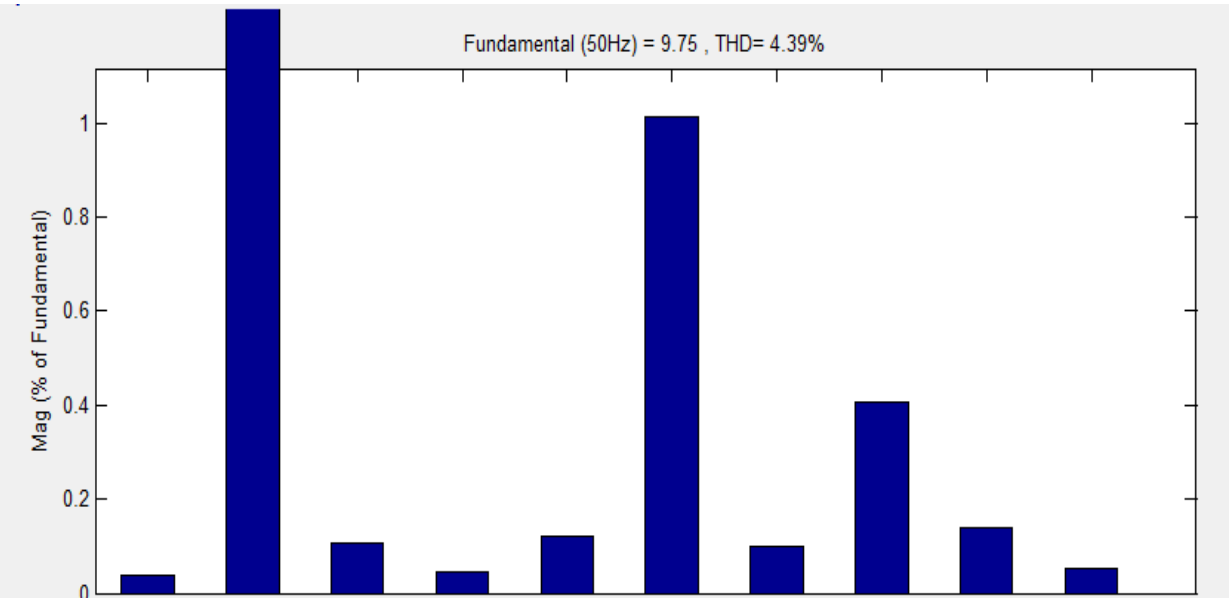

Fig16: THD Analysis Of Input Current

VIII. CONCLUSION

A VSC based DSTATCOM with a 3 phase power supply has been built for compensating non-linear loads using BP control algorithm to prove how effectively it performs. Thus the proposed algorithm has been used for extraction of reference source currents thereby generating the pulses for switching of IGBTs of VSC of DSTATCOM.

Considering the neural network controlled DSTATCOM, it is observed that the power quality of the interconnected power system is improved. The performance of ANN controlled DSTATCOM is more efficient than other conventional controllers. By adding neural network control to DSTATCOM it reduces the harmonic content, which improve the power factor and also reduce the voltage sag and quality of power can be maintained.

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