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Enhancement of power quality profile through ANN Controller and UPQC

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***Abstract* – Various artificial intelligent techniques are used in more applications, in that techniques Artificial neural network (ANN) controller is used due to its improved performance compared to PI, FUZZY and ANFIS logic controllers. Because of using nonlinear loads the power quality issues are occurred due to distortions in the line voltage namely sag, swell and harmonics. These issues can cause the damage of the electric equipment's. By using special type of power electronic devices called FACTS these power quality issues are reduced. This paper proposes mitigation of PQ issues in distributed system with unified power quality conditioner (UPQC) by employing artificial neural network (ANN) controller. The (UPQC) unified power quality conditioner consists of series and shunt controllers with common DC link capacitor. The offset capabilities of the conventional UPQC system are restricted by using conventional PI controllers using the DC connected voltage regulation. In the proposed control technique, the UPQC's compensation potential is improved by the DC voltage estimate and DC voltage regulation dependent artificial neural network (ANN). The proposed system simulation results are studied and implemented in MATLAB environment.**

Keywords – Power quality, FACTS, Unified power quality conditioner, point of common coupling , PI, FUZZY controller, ANFIS controller.

I. Introduction

The power quality is the relation between electrical supply to electrical device. If the electric device operates correctly without being damaged, we would say the quality of power is good. If it electrical device damaged we would say that the quality power is poor. Here voltage and current are taken as considerations we would say good or poor quality [1]. The most of the structures of electrical power is back to back converters. In admiration to regulating structures, these converters may has various operation in compensation [2]. These converter may operate as shunt active power filter and series active power filter for mitigating the power quality issues like reduction of current harmonics and reduction of voltage quality issues [3]. This device named as unified power quality conditioner.

The unified power quality conditioner is grouping of shunt active power filter and series active power filter via coupled DC link capacitor [4], it is like same as unified power flow controller. The unified power quality conditioner is used in distribution system for regulate the current harmonics and mitigation of voltage disturbances. The unified power flow controller is used in transmission system for control the power flow [6].

The presentation of unified power quality conditioner depending upon how exactly compensation signals are resultant. The PI based unified power quality conditioner have been widely described [7] but tuning the PI controller is difficult task and it requiring linear scientific terms which fails to regulate the DC voltage under higher voltage drop situations. Fuzzy controller also failed to regulates the DC voltage [8]

Importance of the above-mentioned approaches to power quality control. This research gives a comprehensive description of two most thorough optimisation strategies –Adaptive neuro fuzzy inference system (ANFIS) and artificial neural networks (ANN). ANN has the capacity to read, recall, and take decisions, as opposed to traditional controllers and it gives less THD [9, 10]. ANN is instructed to act as a DC-connection tension estimator and a DC-connection voltage controller in the work proposed [11]. In this paper the recommended system with comparison of ANFIS and ANN controllers are implemented.

II Proposed System

The proposed system configuration of UPQC is indicated in figure.1. Unified power quality conditioner has 2 voltage source inverters with coupled DC link capacitor. One voltages source inverter is connected series with the electric source. The series voltage source inverter compensates the voltage sag and voltage swell at the point of common coupling (PCC). Another voltage source inverter is connected parallel to the load, it can mitigate the current harmonics at the load. These 2 voltage source inverters controlled by PWM technique

A. Series voltage source inverter

The series VSI also called as series active power filter or dynamic voltage restorer. It is a 3-phase 3-leg converter which is consist of 6 switches (IGBTs). The 3-phase of AC side connected to transformer primary winding and secondary winding is connected to the source bus as shown in figure.1. The main objective of this inverter in injecting the voltage along the AC bus. This series injection of voltage at suitable magnitude and phase can help for compensates the voltage sag and voltage swell in bus voltage. Voltage swell and voltage sag can be smoothed by series VSI so the load voltage is fairly stable

B. Shunt voltage source inverter

The shunt voltage source inverter also called as shunt active power filter or distributed static compensator. It is also 3-phase 3-leg converter. The 3-phase AC side is connected to the AC bus at the pcc through the reactor and transformer. A pulsed width modulation technique used for controlling the inverter. The main objective of this inverter is compensate the harmonics.

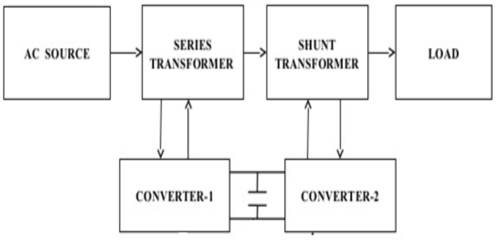

Fig.1 Configuration UPQC

III PROPOSED CONTROL TECHNIQUE

A.Shunt Controller

The below figure.2 shows the controlling circuit of the shunt inverter. The synchronous reference frame theory with ANN controller is applied for control the shunt inverter. Here load currents are applied to SRF transformation process dq0_, are moved to dq0- frame using sin and cos functions. These function are taken from phase locked loop using source voltage. Currents in the SRF are divided into two components shown in below

$$I_{Ldqo\_} = \frac{2}{3}\begin{bmatrix} cos\theta & \cos\left(\theta - \frac{2\pi}{3}\right) & \cos\left(\theta + \frac{2\pi}{3}\right) \\ sin\theta & \sin\left(\theta - \frac{2\pi}{3}\right) & \sin\left(\theta + \frac{2\pi}{3}\right) \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix} I_{abc\_} \quad (1)$$

The AC and DC side elements can passed through the LPF in this section [4];

$I_L = I_S + I_C$ (2)

Where $I_C$the shunt inverter is injected current and I_S is the source current. The injected reference currents are considered as follows [5];

$I_{fd}" = I_{ld}", I_{fq}" = I_{lq}"$ (3)

The system currents are considered as follow [5];

$I_{sd}" = I_{ld}", I_{sq}" = I_{lq}"$ (4)

Altering the loss and power received by a series inverter from a capacitor, can reduce the average power output of a DC bus. Other distortions such as the unbalanced and unpredictable loading current can cause DC power outages. To monitor the error occurring between the calculated and the required voltage of the capacitor voltage, an ANFIS controller is used. This signal control is used;

$I_{cd}" = I_{ld}" + \Delta I_{dc\_}$, $I_{cq}" = I_{lq}"$ (5)

By reversing a synchronous reference frame, reference currents will be moved to the ABC frame as a connection (1). The resulting reference currents in the PWM current controller is compared with shunt inverter output currents and control pulses required are generated. The required compensation current is used to shut off the inverter power switches Inverter produced.

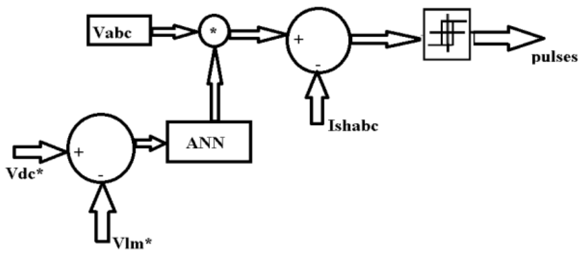

Fig.2 Control of block diagram of the shunt converter

B Series controller

The below fig.3 indicates the controlling circuit of the series inverter. Series inverter duty ration is the compensating voltage distortions induced by the distribution grid.

The voltage reference values injected into the grid via the series inverter are commutated. The load sinusoidal voltage control strategy is recommended for to control the series inverter. This would monitor the UPQC series inverter so as to compensate for entire distortions and to help the load voltage to stop. SRF method is to achieve this objective [8].

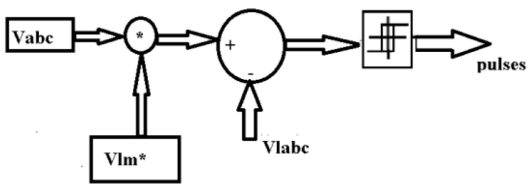

Fig.3 Control block diagram of the series inverter

I ANN controller

The (ANN) Artificial neural network is the data dispensation model i.e., motivated by the way of biological nervous schemes, such as brain, process data. The model and artificial neural network as indicated in figure.4. It contains 3 layers namely input, hidden and output layers

The input layer includes units (artificial neurons), on which networks learn about or otherwise process input from the outside world. The output layer contains units that respond to information about how some task has been learned. Between input and output layers hidden layers are available. The task of an occult layer is to convert the input into what the output device can somehow use. Most neural networks are fully connected to each neural layer in the previous (input) and the next layer (output) to suggest that each hidden neuron is fully connected to each neuron.

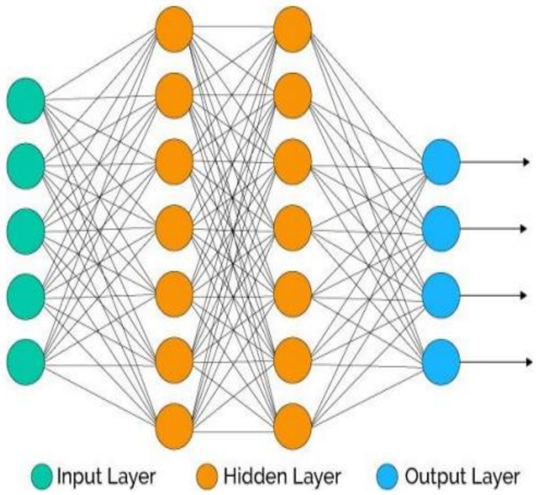

Fig. 4 Model of ANN

I Simulation results

The below figure.5 shows the MATLAB/SIMULINK circuit diagram of the recommended UPQC scheme. It contains nonlinear loads and PV with UPQC.

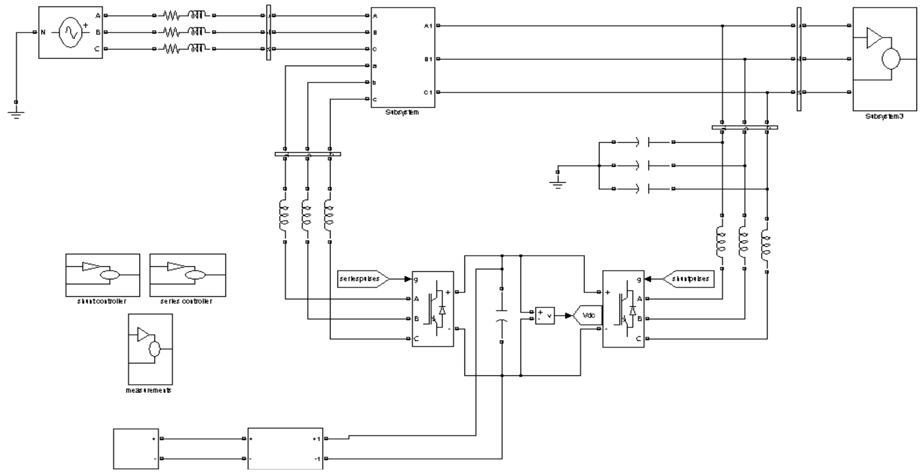

Fig.5 MATLAB/SIMULINK circuit diagram of the proposed system

CASE 1 Harmonics withANFIS controller

Figures 6, 7 and 8 indiactes the source current, injected current and load current ressopectively, load and source currents THDs also shown in fig.9 and fig.10.

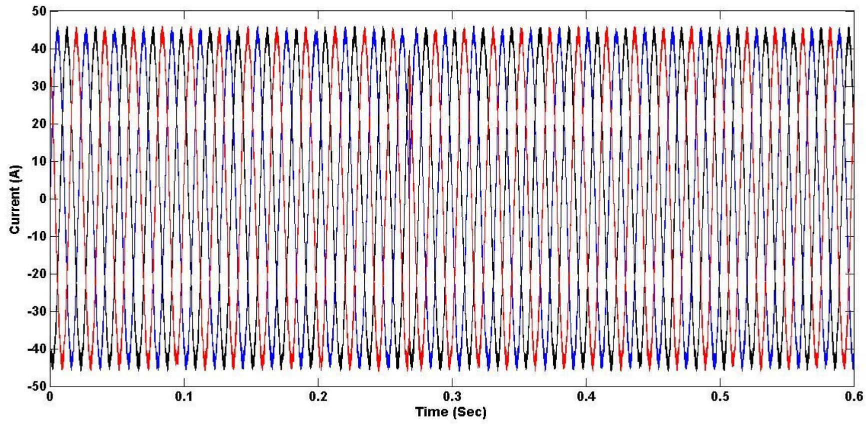

Fig.6 Source current

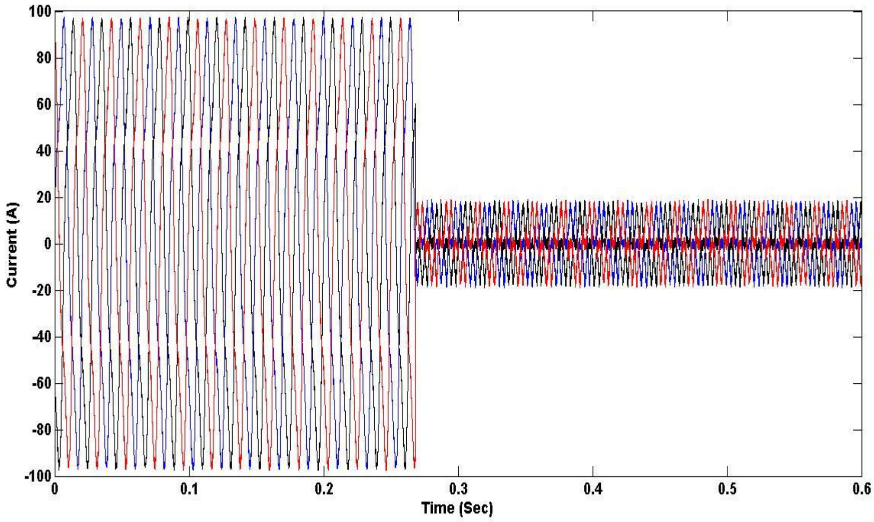

Fig.7 Injected current

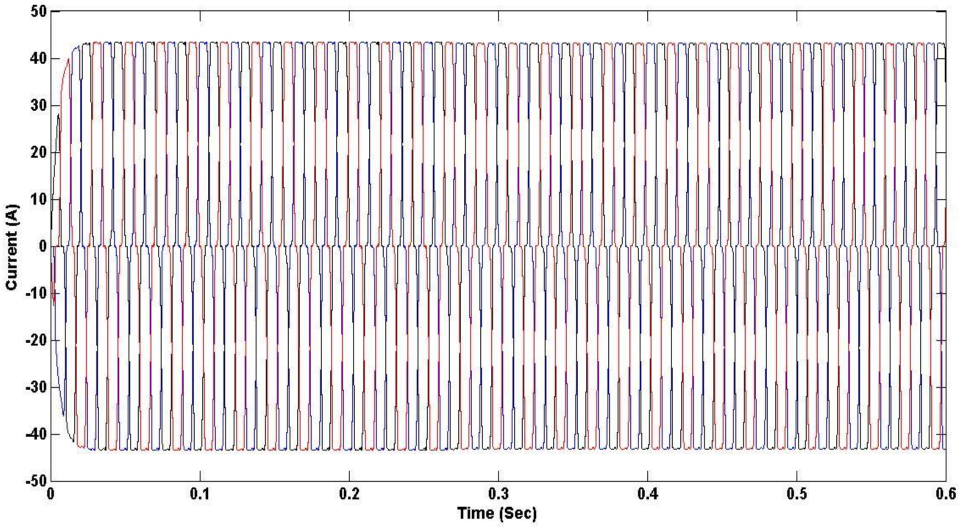

Fig.8 Load current

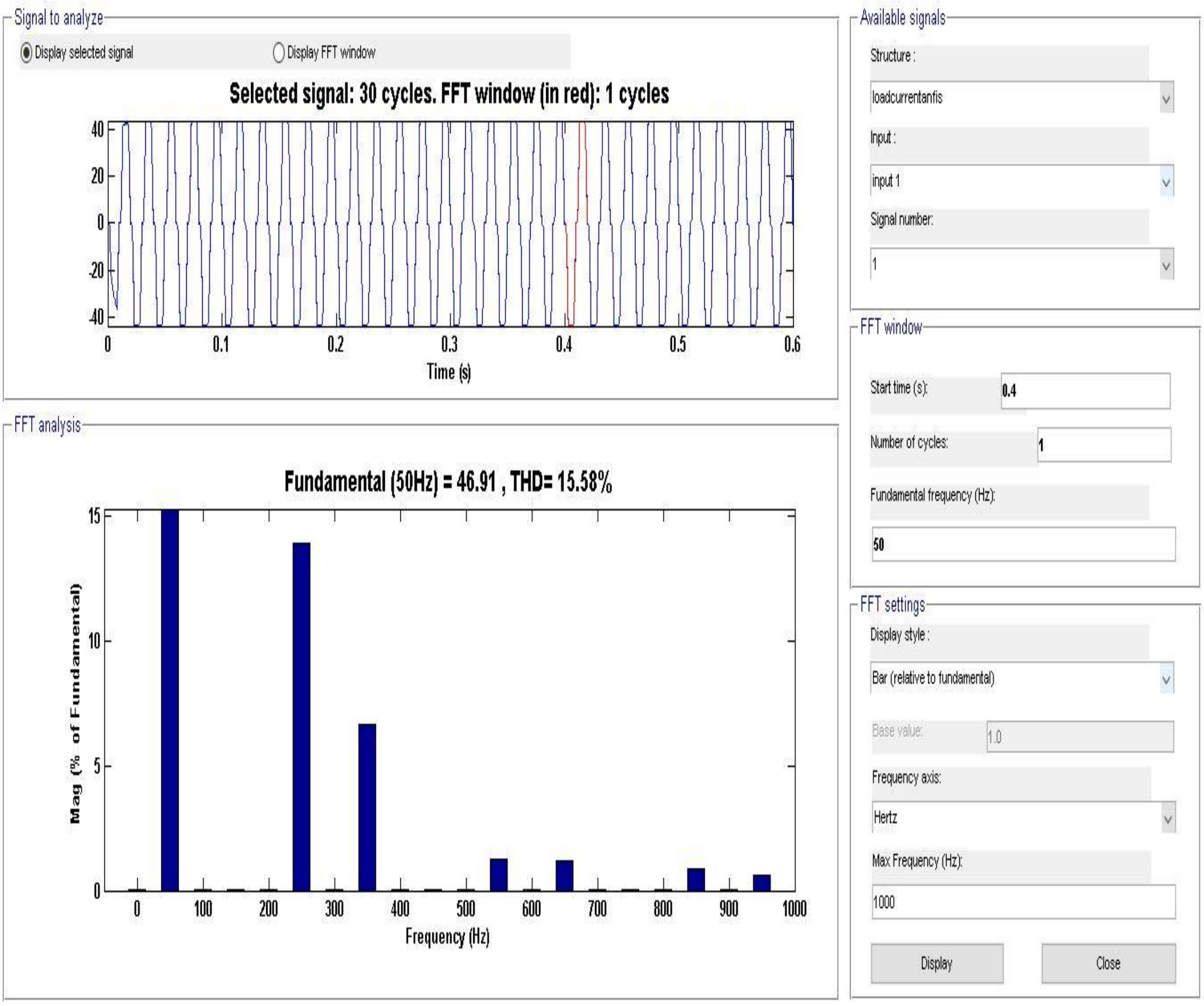

Fig.9 Load current THD is 15.58%

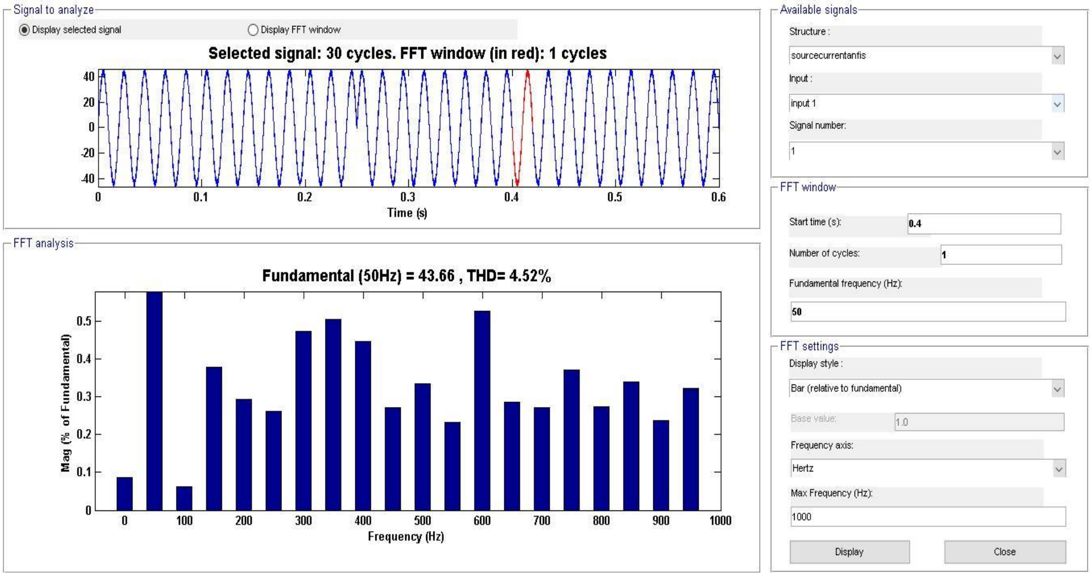

Fig.10 Source current THD is 4.52%

CASE 2 Harmonics With Proposed ANN Controller

Figures 11, 12 and 13 indiactes the source current, injected current and load current ressopectively, load and source currents THDs also shown in fig. 14 and fig. 15. Comparison of source current and load current THDs with ANFIS and ANN is shown in TABLE-1

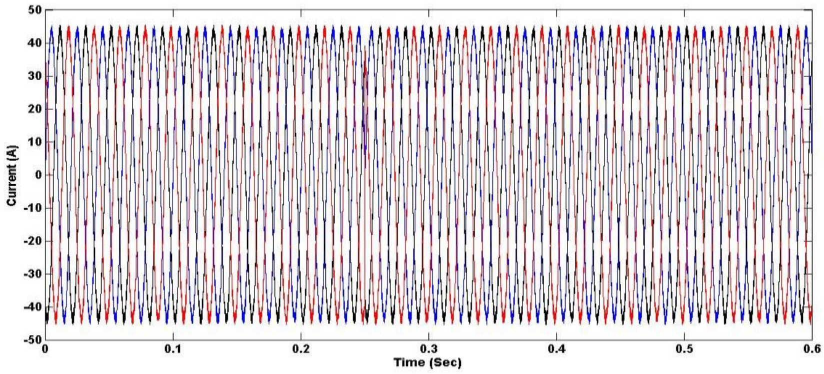

Fig.11 Source current

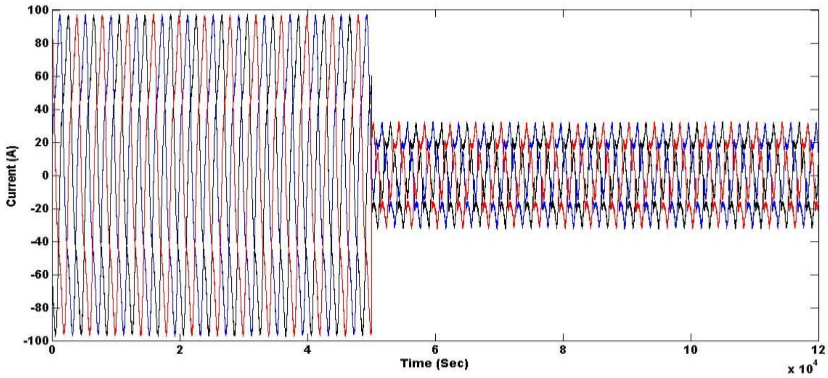

Fig.12 Injected current

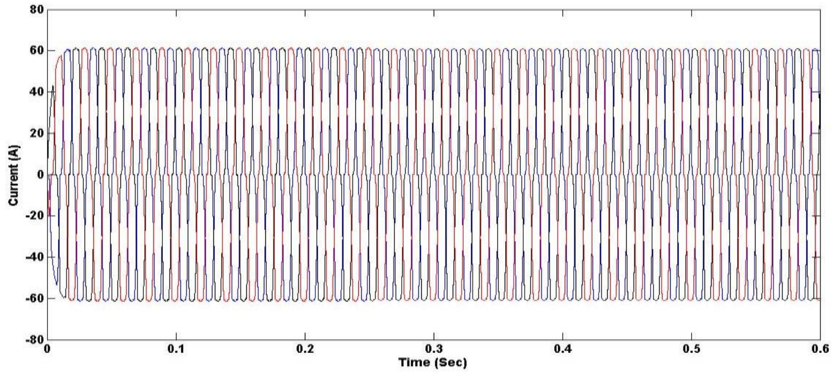

Fig.13 Load current

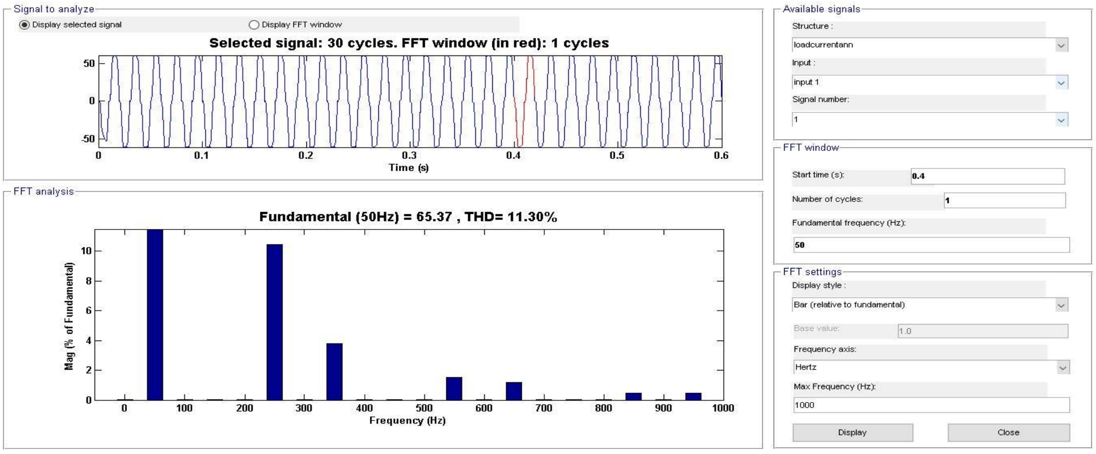

Fig.14 Load current THD is 11.30%

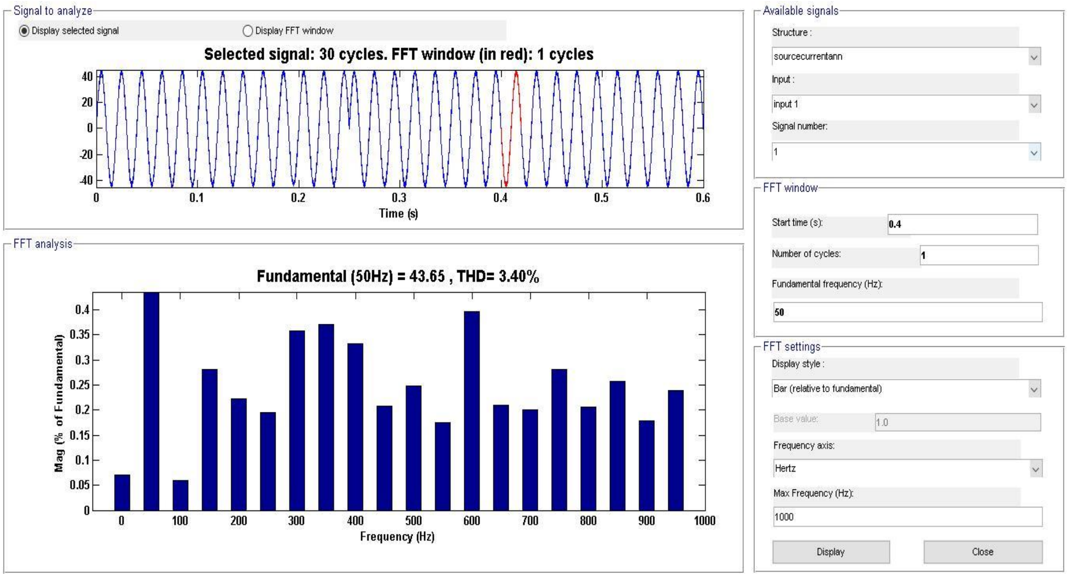

Fig.15 Source current THD is 3.40%

TABLE-1 COMPARISOIN TABLE

	Source current	Load current
ANFIS	4.52%	15.58%
ANN	3.40%	11.30%

IV. CONCLUSION

In this paper the performance of the proposed system is implemented with ANFIS and ANN controllers. The proposed system contains series inverter and shunt inverter via coupled DC link capacitor. The series inverter can reduces the voltage sag and swell and shunt inverter can compensate the load harmonic current and reactive power also. ANN based control strategy give less THD at load side and source side compared to conventional PI and ANFIS controllers. And it is designed by using SIMULINK/MATLAB environment.

REFERENCES

[1] J H. Eto et.al., IEEE Power & Energy Soc. General Meeting, Proc. 2019, Jul 22-26, 2019. A Comparative Review of Utility Reporting Practice to Monitor Electricity Delivery Incidents.

[2] S. P. Jolhe, et.al. 2016 International IEEE Green Engineering and Technology Conference (IC-GET), 2017. "Smart grid and power quality (PQ) issues."

[3] Kulwer International Series on Engineering & Computer Science, Vol. 3, No 11, pages 75-81.2017; 3. Ghosh et al., Power Quality Using Custom Power Device.

[4] In the IEEE transactions in Industrial Electronics, vol. 62, no. 3, pp. 1345-1352, March 2018, B.W. Frana etc., entitled "An improved IUPQC controller to provide additional Grid-Voltage Regulation as a STATCOM."

[5] Quoc-Nam Trinh et. al. Published in generating, transmitting and distributing IET "The best performance of unified energy quality conditioner with improved resonance control strategy." ISSN 1751-8687, 2017.

[6] IEEE Transactions for Power Quality 2017: Mihir Hembra metal., "Mitigating Power Quality Problems by the Use of Unique Energy Conditioner (UPQC).

[7] Uday Kishan Renduchintala et. al., "UPQC neuro-fuzzy driver base for improved micro grid power quality" "IEEE Power quality transactions, 2018.

[8] G. Satyanarayana, et.al., International Conferment on Green Computer Communication and Conservation (ICGCE) 2013, pages 731-736, 2015. "A critical analysis of the power characteristics of hybrid multi-filter conditioner topology".

[9] S. Pawar et.al. In Energy System and Applications, International Conference on 2015, pp. 224–227, IEEE, 2016, "DSTATCOM modelling and simulation for the enhancement of power efficiency in distribution systems using the SIMULLINE tool MATLAB."

[10] Babu et.al., the IEEE Power, Energy and Control(ICPEC), 2015 International Conference on,2015: "Performance investigation of Pi and Fuzzy voltage restoreers."

[11] "Improved Power Quality by Using Hybrid Fuzzy Managed IPQC at different load conditions," G. Satyanarayana et.al., K. Lakshmi Ganesh, 2013 International Conference on Energy Efficient Technologies for Sustainability (ICEETS), pp. 1243-1250, 2013.

[12] G. Satyanarayana et. al. The Springer LNCS Series-8947 ISSN-0302-9743, pp. 523-533, July 2015 "Tunings of Robust Performance of Adaptive Fuzzy-PI Drills DSTATCom for non-ligned process applications,"