iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 3 **Issue:** II **Month of publication:** February 2015

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Improvement of Power Quality using Shunt Active Power Filter by Neural Learning Algorithm Technique

K.Poongothai[1] A.Senthil Kumar[2] Dr .P.Ajay-D-Vimal Raj[3]
[1]PG Scholar, Dept. of EEE, Sri Manakula Vinayagar Engineering College, Puducherry, India
[2]Research Scholar, Dept. of EEE, Pondicherry Engineering College, Puducherry, India
[3]Assistant Professor, Dept. of EEE, Pondicherry Engineering College, Puducherry

Abstract— **This paper presents a better analysis of Shunt active power filter for enhancing the power quality. The shunt active power filter has been designed to mitigate total harmonics distortions, instantaneous power factor and compensate the reactive power consumed by the load. The performance of shunt active power filter mainly depends upon the control technique and pulse generation technique. In this paper Unit Vector Template Generation control technique has been used to obtain the good performance of active filter. There are two different types of pulse generation technique such as Hysteresis Current Control and Neural Learning Algorithm has been studied and analysed. The performance of the proposed system is designed and tested under MATLAB/Simulink model.**
Keywords— **Power Quality, Power factor (pf), Total Harmonic Distortion (THD), Neural Learning Algorithm(NLA), Real Power, Reactive Power, True Power.**

I. INTRODUCTION

The present power system scenario mainly focused on the issue of power quality problems. The major research topic in the power distribution system is to improve the quality of power [1]-[3]. The primary cause for poor power quality is the arrival of power electronics based devices and non-linear loads in industries as well as commercial applications. The ideal power system has balanced, pure sinusoidal phase supply, the loads operating with unity power factor and zero harmonics. But practically this is not possible because the system comprises of linear and non-linear loads. Due to these complex loads there will be a change in the system parameters such as voltage, current and frequency together they are termed as 'Power quality issues'. The poor power quality results malfunction of devices and equipment, voltage and current harmonics and unbalances, low power factor and reactive power consumption. Among these harmonics is the primary index for poor power quality. In earlier days Passive filters are preferred for compensation purposes, but it holds the main drawback of introducing series or parallel resonance in the power system network. Also, its usage can be limited to the few range of harmonics.

The custom power devices [4]-[7] are appropriate devices designed to compensate the power quality problems produced by the load. The custom power device is classified on the basis of compensation they are shunt active power filter and series active power filter. The shunt active power filter is one of the most popular custom power devices [10]-[15]. The shunt active filter [7]-[9] is used to compensate the current related problems like current harmonics, lagging power factor and reactive power consumption [16] and [17].

The conventional shunt active power filter is designed with PI controller [10]-[12]. The problem of conventional method is the peak overshoot and settling time is observed to be very high which leads to increase in total harmonic distortion. In order to overcome this problem neural learning algorithm is proposed for current controller of the shunt active filter strategy [13]-[18].

This paper proposes neural learning algorithm for shunt active power filter [19]-[21] to the inherent issues, which govern the satisfactory delivery of electrical power to the customer. It ensures the power quality improvement using filter strategy the proposed work includes the state of the art methods for developing a power quality monitoring system.

A general introduction to the problem of power quality is presented in here in introduction, in section 2 the shunt active power filter for obtaining improved power quality is suggested, the control technique for shunt active power filter is discussed in Section 3, a mathematical approach to quantity the technique benefits of power quality is proposed in section 4, the simulation results for the various load conditions and its discussion is brought out in section 5, the conclusions of this paper finds a place in section 6.

II. SHUNT ACTIVE POWER FILTER

The shunt APF is used to compensate the current related power quality problems such as harmonics, inter harmonics, power

ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

factor variation and reactive power absorption. The circuit for shunt active power filter is shown in figure1. In this case the shunt APF acts as controlled current source [8] and [9]. It produces compensation current in order to compensate the load current harmonics. It injects an equal but opposite harmonic compensation current, which is 180^0 phase shift with the load current. It is applicable to any type of load considered as a harmonic source. And it also performs the operation of power factor correction. It act as a voltage regulator and harmonic isolator between the non-linear load and the utility source
The control technique for shunt active filter topology is discussed in following section.

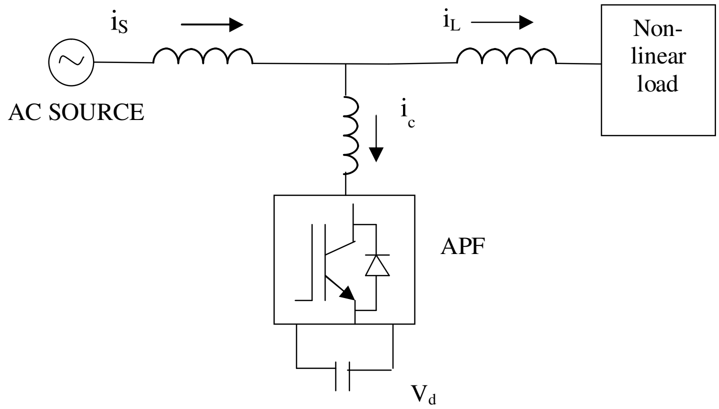


Fig.1. Shunt Active Power Filter

III. CONTROL TECHNIQUE USED IN SHUNT ACTIVE POWER FILTER

The control technique used in the shunt active filter is unit vector templates generations technique [2] using neural learning algorithm (NLA). The DC voltage of the converter is compared with reference DC voltage and that error is computed. The error is to be controlled by NLA and it also estimates the input current magnitude. Then it is multiplied with unit vector. The unit vector is calculated from source voltage by Phase Lock Loop. The reference current is the product unit vector and rated magnitude from controller. The difference of reference current and actual current gives harmonics produced by the load and it is fed to the hysteresis. The pulses produced from the hysteresis are fed to the converter. The converter reduces the harmonics in the system and improves the power quality. The modelling of shunt active filter is highlighted in Fig 2 and the block diagram for control technique is shown in Fig. 3. The following sections deals with the neural learning algorithm for the non-linear system.

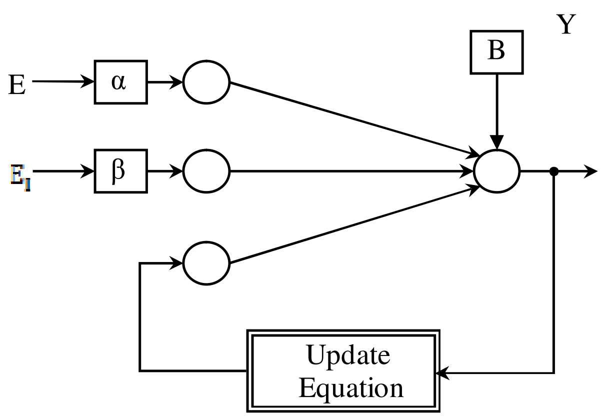


Fig.2. Neural Learning Network

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

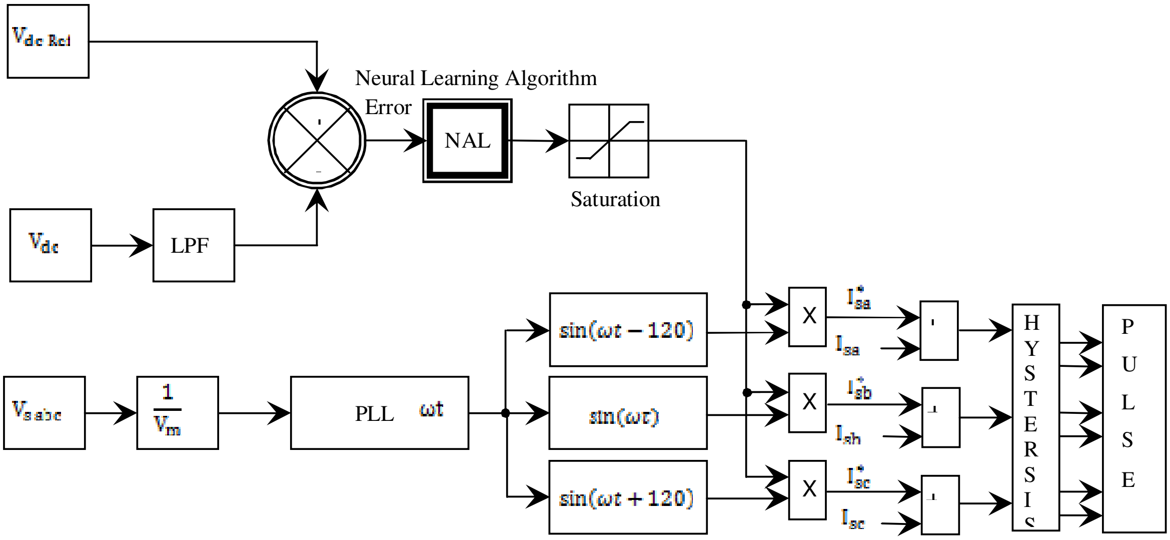


Fig. 3 Control Technique used in Shunt Active Filter

depends on the generation of reference current. The abilities of real-time learning, parallel computation, flexibility and adaptive property of artificial neural-network (ANN) is used to generate fast reference current for current controller of shunt active power filter strategy. The two layer ANN is trained on line by using proposed learning algorithm in order to generate reference current. The neural network for proposed learning algorithm is highlighted in Fig. 2.The inputs of the network are error, integral of error and feedback output signal. In general, each on-line training epoch consists of propagating the ANN input vector to compute its output, comparing this output with some reference to compute the training error, and finally modifying the ANN weights in such a way as to reduce the magnitude of this error to obtain the optimum value. Likewise, mean squared error of difference of actual DC voltage and reference DC voltage is compared with error tolerant. The weight of the each input neuron is trained in order to minimize the error and generate the optimum reference current magnitude with minimum oscillation

IV. MATHEMATICAL MODELLING

The instantaneous current can be written as,

$$i_s(t) = i_L(t) - i_c(t) \qquad \text{-------------(1)}$$

The source voltage is given by,

$$V_s(t) = v_m \sin wt \qquad \text{-------------(2)}$$

If a non-linear load is applied, then the load current will have a fundamental and harmonic components which ca be represented

$$i_L(t) = \sum_{n-1}^{\infty} I_n \sin(\omega t + \phi_n)$$

as,

$$= I_1 \sin(n\omega t + \phi_1) + \sum_{n-2}^{\infty} \sin(\omega t + \phi_n)$$

The instantaneous load power can be given as,

$$P_L(t) = V_s(t) * il(t)$$

$$= P_f(t) + P_r(t) + P_h(t) \qquad \text{--------------(3)}$$

The fundamental real power drawn by the load is,

$$P_f(t) = V_s(t) * i_s(t)$$

$$\text{where, } i_s(t) = I_m \sin \omega t$$

Source current supplied by the load after compensation is,

$$i_s(t) = P_f(t) / V_s(t) = I_1 \cos\phi_1 \sin \omega t = I_m \sin \omega t \qquad \text{-----------(4)}$$

Where $I_{sm} = I_1 \cos\phi_1$

There are also some switching losses in the PWM converter and hence the utility must supply a small overhead for the capacitor leakage and converter switching losses in addition to the real power of the load. The total peak current supplied by the source is,

$$I_{sp} = I_{sm} + I_{sl} \qquad \text{--------------(5)}$$

If the active power filter provides the total reactive power and harmonic power, then i_s (t) will be inphase with the source voltage and becomes sinusoidal. At this time the compensation current of the active power filter is,

$$i_c(t) = i_L(t) - i_s(t) \qquad \text{-------------(6)}$$

Hence it is necessary to estimate the reference source current. It is estimated by controlling the DC side capacitor voltage.
For a better compensation it is necessary that the main current to be sinusoidal and inphase with the source current irrespective of the load current. The desired source current after compensation is,

$$i_{sa}^* = I_{sp} \sin \omega t$$
$$i_{sb}^* = I_{sp} \sin(\omega t - 120) \qquad \text{-------------(7)}$$
$$i_{sc}^* = I_{sp} \sin(\omega t + 120)$$

Let $E = V_{dc\,Ref} - V_{dc}$ be error -------------(8)

EI be the Integral of error

α, β and μ are weight value corresponding to input and feedback signal

Y be the output of artificial neural network

$Y(k)$ and $Y(k-1)$ be the present and past value of network output

The update equation to minimize the error is given as

$$W(k) = \mu * Y(k-1) \qquad \text{--------------(9)}$$

The output of artificial neural network is given as

$$Y(k) = W(k) + \alpha * E(k) + \beta * E_I + b \qquad \text{------------(10)}$$

The Reference current can be given as

$$I_{s\,Ref}(t) = \left(Y * (V_{dc\,Ref} - V_{dc})\right) * \sin(\omega t) \qquad \text{------------(11)}$$

Where

Y is output of NLA

$(V_{dc\,Ref} \quad V_{dc})$ is error

$\sin(\omega t)$ is unit vector

Power Factor (PF) is given by,

$$PF = \cos(\emptyset) = \frac{\text{Real Power}}{\text{True Power}} \qquad \text{--------------(12)}$$

The Real Power Consumed by the load is given as

$$P = \sqrt{3} V_l I_l \cos(\emptyset) \quad (\text{watts}) \qquad \text{-------------(13)}$$

The Reactive power can be given as

$$Q = \sqrt{3} V_l I_l \sin(\emptyset) \quad (\text{VAR}) \qquad \text{-------------(14)}$$

The True Power Consumed by the load is given as

$$S = \sqrt{P^2 + Q^2} \quad (\text{VA}) \qquad \text{-------------(15)}$$

V. SIMULATION RESULTS AND DISCUSSION

A. System data and operating conditions:

1) Supply Voltage = 230Vrms

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

2) Supply Frequency = 50 Hz
3) Source Impedance = 1 Ohms and 0.1mH
4) Filter impedance = 1 Ohms and 10mH
5) Load impedance = 1 Ohms and 8mH
6) Load – Rectifier RL Load, R=7Ohms and L=20mH

Operating condition:

I. Normal Load Condition – 0 to 0.3sec and 0.5 to 0.7sec–here no change in Load

II Load Change Condition – 0.3 to 0.5sec – another R=7Ohms and L=20mH is added on DC side

B. Discussion:

The performance of Shunt active power filter using HCC technique and neural learning algorithm is analysed for rectifier RL non -linear load with respect to two different operating conditions in MATLAB/Simulink environment. The analysis has been carried out for voltage %THD, current %THD and power factor for with and without filter as below.

1) Analysis of THD% for voltage : The dynamic response of voltage waveform of load 1 for before and after compensation are representing in Fig. 4 and Fig. 5 and the voltage waveform for load II with and without filter is shown in Fig. 12 and Fig. 13. From the obtained result, for before compensation using NLA technique, the THD% is noticed to be 5.66% in operating condition I and in operating conditions II the THD% is 8.05%. The limitation of THD% for a load is 5% but from this analysis it is clearly shows that before compensation THD% in both operating conditions is found to be maximum then the prescribed limit. The THD% for voltage after compensation is found to be 0.49% in operating condition I and 0.485 in operating condition II. By using proposed neural learning algorithm 91.34% of THD is minimized in operating condition I and 94.04% of THD% in reduced in operating condition II. This analysis proves that the shunt active power filter strategy using proposed neural learning algorithm THD% of voltage is much minimized.

2) Analysis of THD% for current: The dynamic waveform of current for the non -linear load for without and with proposed approach is highlighted in Fig. 6 and Fig. 7. For without proposed approach, the THD% for current is seen to be 42.71% in operating condition I and 30.92% in operating condition II. Whereas with proposed approach, the THD% is observed to be 2.54% in operating condition I and 1.76% in operating condition II. By using the proposed neural learning algorithm for shunt active power filter 94.07% of THD is minimized in operating condition I and 94.31% of THD is reduced in operating condition II. This analysis demonstrates the performance of proposed neural learning algorithm amid of dynamic change of non -linear load. The THD% of current comparison for NLA technique is tabulated in table 1.

The current for non -linear load I and II for without and with filter for HCC technique are represented in the figures and 14 & 15. From the analysis, THD% for current is found to be 42.71% and 30.92% for operating condition I and II, it is very highly poisonous to dead the load and components in its network. Whereas with filter THD% of current is found to be 2.74% and 1.81% for operating condition I and II. In other word with filter 63.58% of THD can be reduced in operating condition I and in operating condition II with filter 94.14% of THD can be reduced. This demonstrates the performance of shunt active power filter on minimize of current total harmonic distortion. The THD% of current comparison for HCC technique is tabulated in table 2.

3) Analysis of power factor for without and with filter: The simulation results for power factor analysis of Load I for without and with filter are shown in Fig. 10 and Fig. 11. From the obtained results, without filter it is observed that the voltage and current waveform are not in phase by which the power factor is found to be 0.7483 whereas with proposed approach the voltage and current are found to be in phase with each other and the power factor is improved to 0.999. This approach ensures the performance of the shunt active power filter by improving the power factor.

The simulation results for power factor analysis of the Load II for without and with shunt active power filter is shown in figure 16 & 17. From the obtained results, without filter it is observed to be the voltage and current waveform are not in phase so that the power factor is found to be 0.7483 whereas with shunt active filter the voltage and current are found to be in phase with each other that means power factor is 0.999. This test ensures the performance of the shunt active power filter on improving the power factor amid of dynamic change of the non -linear load.

Figure 8 and 9 shows that the actual and reference DC voltage shunt active filter for load I using NLA and HCC technique respectively. The simulation results for DC link voltage of load II without and with shunt active shunt active filter is shown in figure 18.

Volume 3 Issue II, February 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

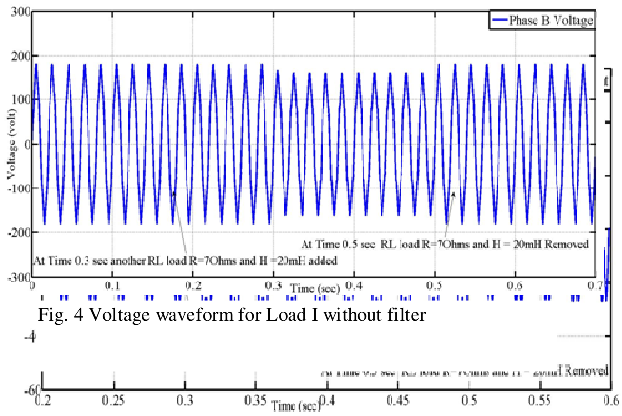


Fig. 4 Voltage waveform for Load I without filter

Fig. 6 Current waveform for Load I without filter

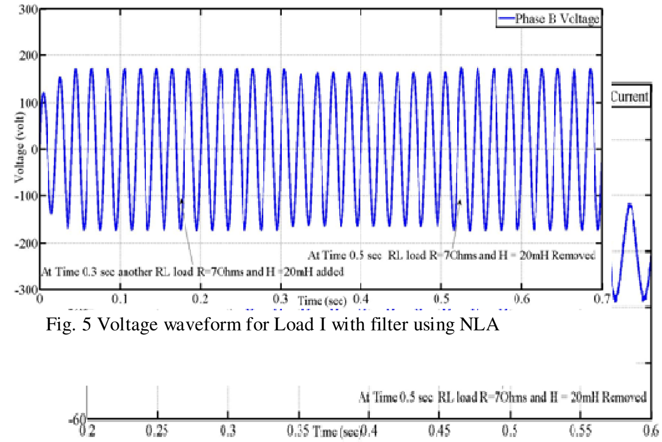


Fig. 5 Voltage waveform for Load I with filter using NLA

Fig. 7 Current waveform for Load I with filter

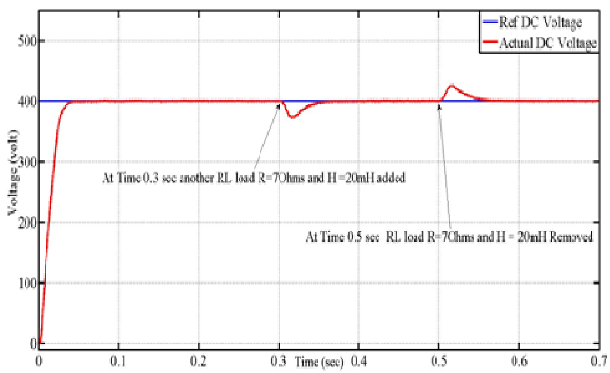


Fig. 8 .DC voltage waveform of the filter for Load I using NLA

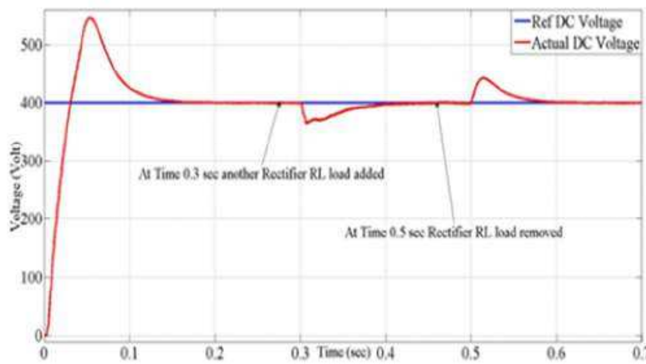


Fig. 9.DC voltage waveform of the filter for Load I using HCC technique

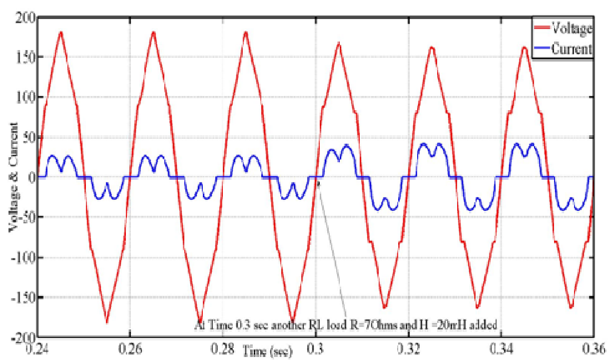


Fig.10. Power Factor for Load I without Filter

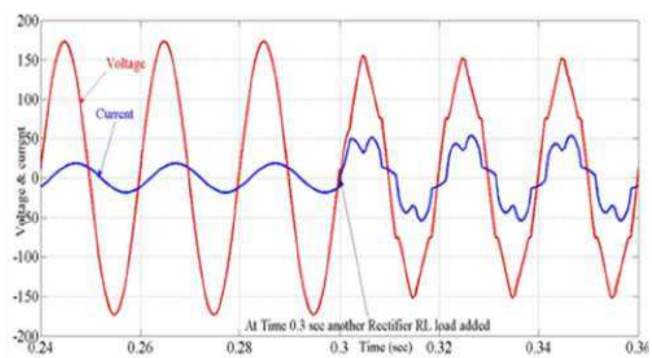


Fig.11. Power Factor for Load I with Filter

SIMULATION RESULTS FOR LOAD I

SIMULATION RESULTS FOR LOAD II

Volume 3 Issue II, February 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

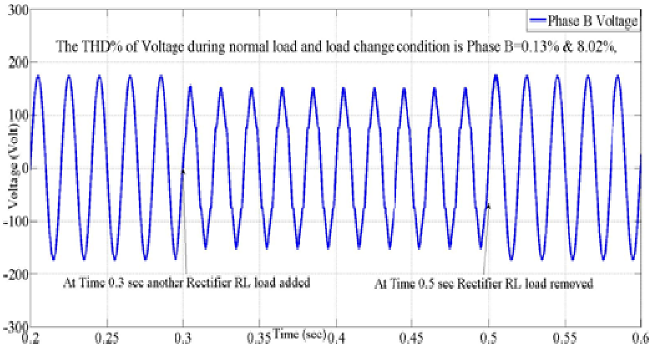


Fig. 12 Voltage waveform for Load II without filter

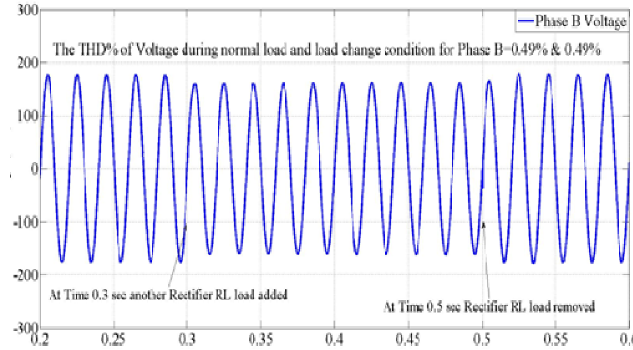


Fig. 13 Voltage waveform for Load II with filter

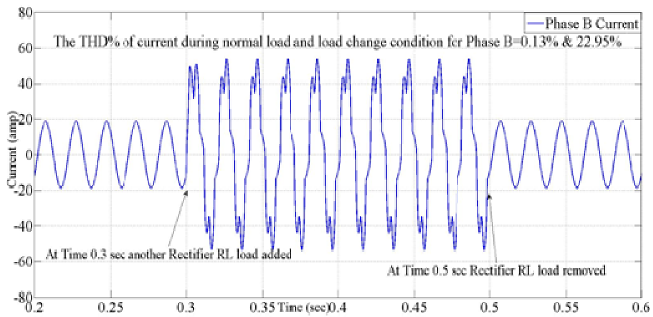


Fig. 14 Current waveform for Load II without filter

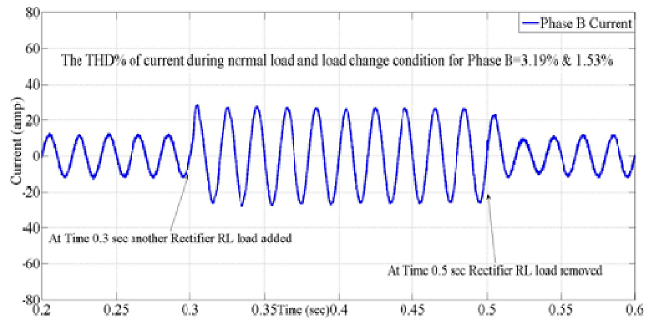


Fig. 15 Current waveform for Load II with filter

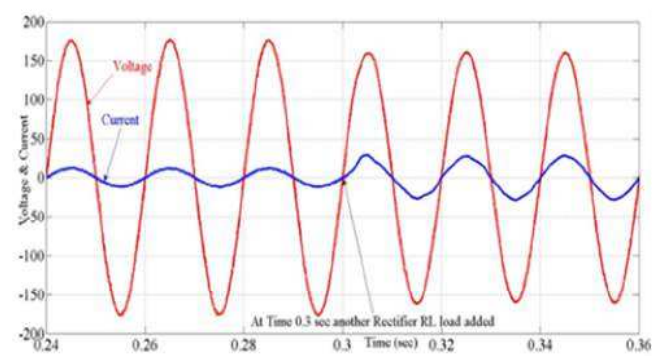


Fig.16. Power Factor for Load II without filter

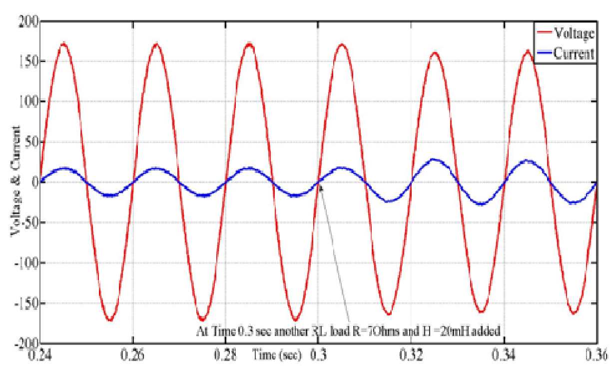


Fig.17. Power Factor for Load II with Filter

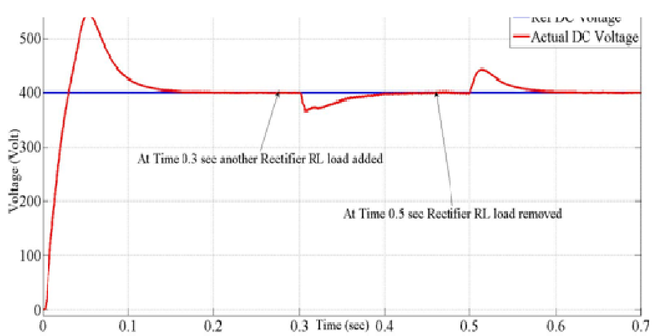


Fig. 18 DC voltage waveform of the filter for Load II

C. Tabulation comparison of THD% for with and without filter

Phases	THD% for Current by NLA technique					
	Operating Condition I			Operating Condition II		
	Without Filter	With Filter	Reduce in %	Without Filter	With Filter	Reduce in %
Phase A	42.67	2.28	94.66	30.92	1.73	94.41
Phase B	42.71	2.54	94.07	30.92	1.76	94.31
Phase C	42.66	2.23	94.77	30.91	1.65	94.66

Table1.Comparison of current THD% without and with filter for three phase system

Power	THD% for Current by HCC technique					
	Operating Condition I			Operating Condition II		
	Without Filter	With Filter	Reduce in %	Without Filter	With Filter	Reduce in %
Phase A	42.71	2.74	63.58	30.92	1.81	94.14
Phase B	42.69	2.78	63.50	30.91	1.61	94.53
Phase C	42.65	2.25	94.61	30.94	1.74	94.43

Table2. Comparison of power consumption by load without and with filter

VI. CONCLUSION

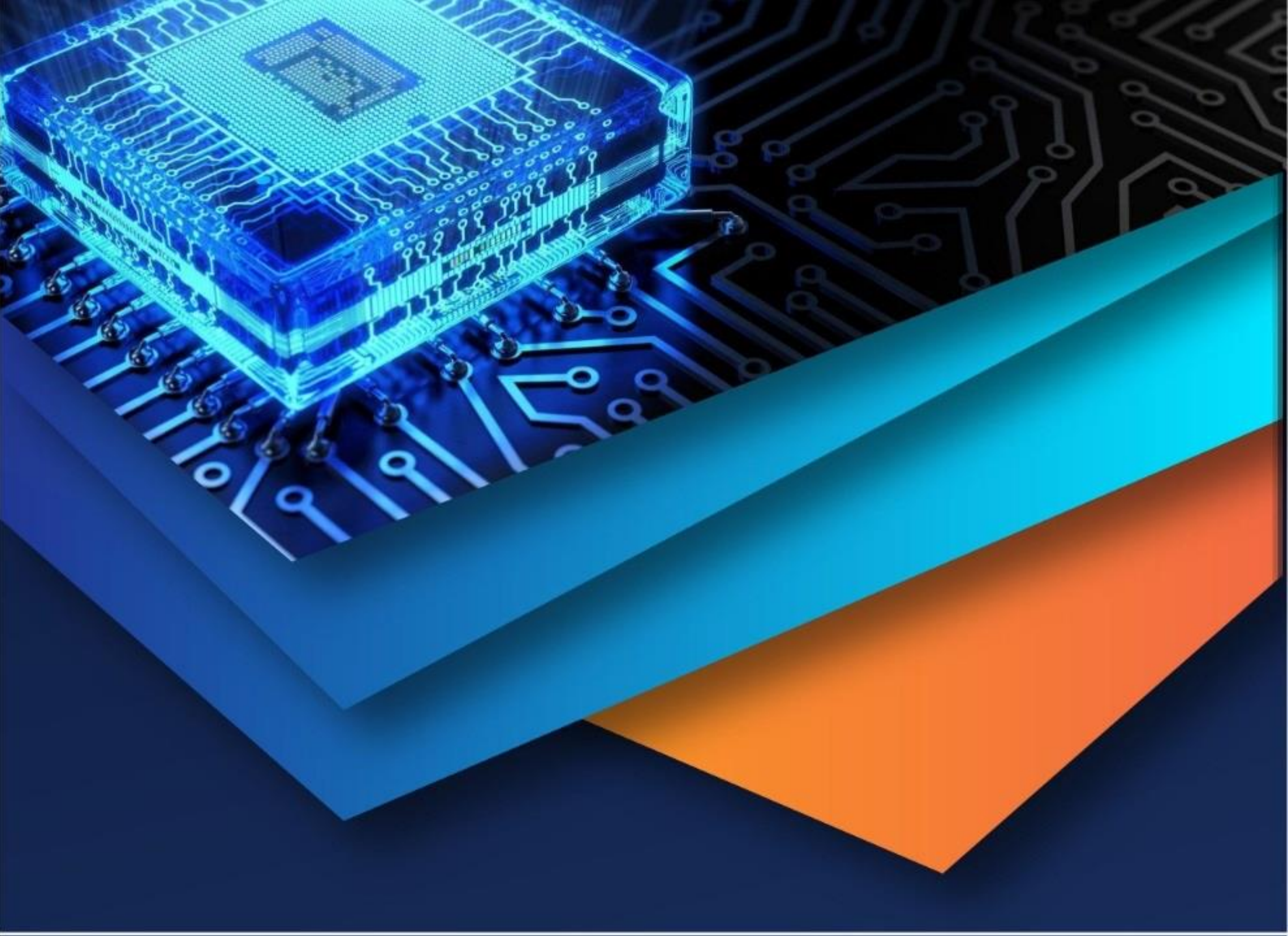
The detailed analysis of Shunt active power filter for various operating condition has been analysed. The operation of shunt active filter using Hysteresis Current Control and Neural Learning Algorithm under non-linear load conditions has been investigated. From the analysis it is observed that the voltage and current harmonics is being mitigates by shunt active power filter strategy using neural learning algorithm. The improvement of power factor and the reactive power consumption by the non-linear load has been achieved by the proposed shunt active power filter strategy. The better computation efficiency of the proposed artificial intelligence approach shows that it can be applied to a wide range of power quality problems. These test results bring out the advantage of neural learning algorithm for current controller of shunt active power filter for power quality enhancement.

REFERENCES

[1]. Abdelmadjid Chaoui, Jean Paul Gaubert, Fateh Krim, Gerard Champenois "PI Controlled Three-phase Shunt Active Power Filter for Power Quality Improvement"- Electric Power Components and Systems, 35, pp.1331–1344, 2007
[2]. Karuppanan P and Kamala kanta Mahapatra "PID with PLL Synchronization controlled Shunt APLC under Non-sinusoidal and Unbalanced conditions" National Power Electronics Conference (NPEC) Proceedings, IIT-Roorkee, June-2010.
[3]. W.M.Grady, M.J.Samotyj, A.H.Noyola "Survey of Active Power Line Conditioning Methodologies" IEEE Trans on Power Delivery, Vol.5, No.3, pp.1536-1542, 1990
[4]. E.E. EL-Kholy, A. EL-Sabbe, A. El-Hefnawy, Hamdy M. Mharous" Three-phase active power filter based on current controlled voltage source inverter" 2006 Elsevier
[5]. Bhim Singh, Kamal Al-Haddad and Ambrish Chandrs "A Review of Active Filters for Power Quality Improvements" IEEE Trans on Industrial Electronics, Vol.46, No.5, pp. 960-970, Oct-1999.

ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

[6]. Bhim Singh, Kamal Al-Haddad & Ambrish Chandra, "A New Control Approach to 3-phase Active Filter for Harmonics and Reactive Power Compensation"-IEEE Trans. on Power Systems, Vol. 46, No. 5, pp. 133 – 138, Oct-1999
[7]. L. Gyugyi, E. C. Strycula, "Active AC Power Filters"- in Proc. IEEE/IAS Annu. Meeting, 1976
[8]. Joao Afonso, Carlos Couto, Julio Martins "Active Filters with Control Based on the p-q Theory"- IEEE Industrial Elects Society Nletter-2000
[9]. Karuppanan P and Mahapatra, Kamala Kanta "Shunt Active Power Line Conditioners for compensating harmonics and reactive power" IEEE conference on Environment and Electrical Engineering, pp. 277 – 280, May 2010
[10]. Leszek S. Czarnecki "Instantaneous Reactive Power p-q Theory and Power Properties of Three-Phase Systems"- IEEE Trans on Power Vol. 21, No. 1, pp 362-367 Jan- 2006
[11]. Victor Fabián Corasaniti, Maria Beatriz Barbieri,Patricia Liliana Arnera, and María Inés Valla, "Hybrid Power Filter to Enhance Power Quality in a Medium-Voltage Distribution Network" IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 56, NO. 8, AUGUST 2009
[12]. P. Palanivel and Subhransu Sekhar Dash, "Multicarrier Pulse Width Modulation Based Three Phase Cascaded Mulitilevel Inverter Including Over Modulation and Low Modulation Indices" International Journal of Engineering Studies
[13]. Claudionor F. Nascimento, Azauri A. Oliveira Jr, Alessandro Goedtel and Ivan N. Silva "A Neural Networks-Based Method for Single-Phase Harmonic Content Identification" 2008 IEEE
[14]. Avik Bhattacharya and Chandan Chakraborty "A Shunt Active Power Filter With Enhanced Performance Using ANN-Based Predictive and Adaptive Controllers" IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 58, NO. 2, FEBRUARY 2011
[15]. H. Karimi, M. Karimi-Ghartemani, and M. R. Iravani, "An adaptive filter for synchronous extraction of harmonics and distortions," *IEEE Trans. Power Del.*, vol. 18, no. 4, pp. 1350–1356, Oct. 2003.
[16]. Widrow and M. A. Lehr, "30 years of adaptive neural networks: Perceptron, madaline and backpropagation," *Proc. IEEE*, vol. 78, no. 9, pp. 1415–1442, Sep. 1990.
[17]. C.-C. Tsai, H.-C. Huang, and S.-C. Lin, "Adaptive neural network control of a self-balancing two-wheeled scooter," *IEEE Trans. Ind. Electron.*, vol. 57, no. 4, pp. 1420–1428, Apr. 2010.
[18]. Y. M. Chen and R. M. O'Connell, "Active power line conditioner with a neural network control," *IEEE Trans. Ind. Appl.*, vol. 33, no. 4, pp. 1131– 1136, Jul./Aug. 1997.
[19]. L. L. Lai, C. T. Tse,W. L. Chan, and A. T. P. So, "Real time frequency and harmonic evaluation using artificial neural network," *IEEE Trans. Power Del.*, vol. 14, no. 1, pp. 52–59, Jan. 1999.
[20]. Singh, V. Verma, and J. Solanki, "Neural network-based selective compensation of current quality problems in distribution system," *IEEE Trans. Ind. Electron.*, vol. 54, no. 1, pp. 53–60, Feb. 2007.
[21]. S. Kumar, *Neural Networks—A Class Room Approach.* New Delhi, India: Tata McGraw-Hill, 2004.



10.22214/IJRASET

INDEX COPERNICUS 45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

TOGETHER WE REACH THE GOAL

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY