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Paper Authors

* KAPUDASI SIVA KRISHNA, D KAMALA
*Department of EEE, NOVA COLLEGE OF ENGINEERING & TECHNOLOGY JANGAREDDYGUDEM

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ANALYSIS OF IMPROVED ANN BASED RENEWABLE POWER GENERATION SYSTEMS WITH ACTIVE POWER FILTER PERFORMANCE

[1]KAPUDASI SIVA KRISHNA,   [2]D KAMALA

[1]PG SCHOLAR NOVA COLLEGE OF ENGINEERING & TECHNOLOGY JANGAREDDYGUDEM
[2]ASSISTANT PROFESSOR NOVA COLLEGE OF ENGINEERING & TECHNOLOGY JANGAREDDYGUDEM

Abstract— **Presently a day's Renewable vitality era framework being the rising new insurgency in creating office, however to interface it with the Grid we required high power static PWM converters which are one of the reason for unsettling influence in control quality in our framework. Along these lines, In this paper we are proposing another control method which depends on counterfeit neural system hypothesis utilized as a part of dynamic power channel by utilizing this the sustainable sources are synchronized with the matrix as well as enhances control quality by remunerating the present music and unequal current created by sudden unsettling influence in stack. The topology which is utilized for dynamic power channel is four-leg voltage source converter. The ANN controller is not just enhances the power quality, it additionally enhances the aggregate symphonious contortion in current by stifling the music. The scientific displaying of the proposed framework is clarified in the paper. The dynamic power channel is reenacted with two control system, for example, PI controller and ANN controller. The reproduction comes about and the unthinkable frame demonstrates the predominance of ANN controller over PI controller. The proposed circuit is tried under various working condition through reenactment in MATLAB/SIMULINK and the outcomes demonstrates the intensity of the framework.**

Index Terms— **Active power filter, four-leg converters, PI controller, ANN controller, THD, Renewable generation system**

I. INTRODUCTION

Presently a-days the substantial number of PCs and other touchy electrical burdens associated with the power lattice are specifically influenced by control quality issues [1]. A standout amongst the most imperative issues is identified with current sounds created by the expanding number of non straight loads associated with the power network, for example, diode and thyristor front-end rectifiers. As an outcome, these music can cause voltage twists, extra misfortunes in the influence framework, and breakdown of touchy electronic hardware. Therefore, symphonious limitation norms, for example, IEEE 519 [2], have been prescribed to constrain the consonant streams infused into the framework by non straight loads.

Shunt latent channels, comprising of tuned LC channels and high pass channels, have been customarily utilized as a straightforward and minimal effort answer for remunerate current music. In any case, their execution emphatically relies upon the

network impedance and can cause the undesirable parallel reverberation wonders with the framework. In the most recent decades, the expanding unwavering quality of energy semiconductor gadgets has roused the improvement of energy hardware answers for the issue of consonant flow into the lattice. The shunt dynamic power channel (APF), comprising fundamentally of a voltage source inverter (VSI) with a huge capacitor on its dc interface, is viewed as an entrenched answer for diminish the present music to the prescribed guidelines limits [3]– [13]. the non-uniform nature of energy era specifically influences voltage control and makes voltage twisting in control frameworks. This new situation in control conveyance frameworks will require more advanced remuneration systems. Albeit dynamic power channels actualized with three-stage four-leg voltage-source inverters (4L-VSI) have just been introduced in the specialized writing, the essential commitment of this paper is a prescient control calculation planned and executed particularly for this application. Customarily, dynamic power channels have been controlled utilizing pre tuned controllers, for example, PI-sort or versatile, for the present and also for the DC-voltage circles. PI controllers must be planned in view of the equal straight model, while prescient controllers utilize the non direct model, which is nearer to genuine working conditions.An accurate model obtained using predictive controllers improves the performance of the active power filter, especially during transient operating

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conditions, because it can quickly follow the current-reference signal while maintaining constant DC-voltage. So far, implementations of predictive control in power converters have been used mainly in induction motor drives. In the case of motor drive applications, predictive control represents a very intuitive control scheme that handles multi variable characteristics, simplifies the treatment of dead-time compensations, and permits pulse-width modulator replacement. However, these kinds of applications present disadvantages related to oscillations and instability created from unknown load parameters. One advantage of the proposed algorithm is that it fits well in active power filter applications, since the power converter output parameters are well-known. These output parameters are obtained from the converter output ripple filter and the power system equivalent impedance.

The paper is organized as follows: The proposed system topology is explained in chapter II. The complete description of the selected current reference generator implemented in the active power filter is presented in chapter III. The Control Scheme of DC bus voltage control and ANN control algorithm is described in chapter IV. Finally, the proposed active power filter and the effectiveness of the associated control scheme compensation are demonstrated through simulation results in chapter V.

II. PPROPOSED SYSTEM TOPOLOGY

The configuration of a typical power distribution system with renewable power generation is shown in Fig.1. It consists of various types of power generation units and different types of loads. Renewable sources, such as wind and sunlight, are typically used to generate electricity for residential users and small industries. Both types of power generation use ac/ac and dc/ac static PWM converters for voltage conversion and battery banks for long term energy storage. These converters perform maximum power point tracking to extract the maximum energy possible from wind and sun. An active power filter is connected in shunt at the point of common coupling to compensate current harmonics, current unbalance, and reactive power.

It is composed by an electrolytic capacitor, a four-leg PWM converter, and a first-order output ripple filter, as shown in Fig. 2. This circuit considers the power system equivalent impedance Zs, the converter output ripple filter impedance Zf, and the load impedance ZL. The four-leg PWM converter topology is shown in Fig. 3. This converter topology is similar to the conventional three-phase converter with the fourth leg connected to the neutral bus of the system. The fourth leg increases switching states from 8 (23) to16 (24), improving control flexibility and output

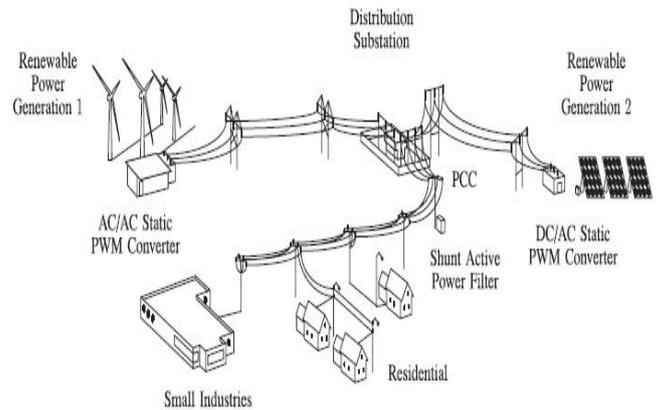voltage quality, and is suitable for current unbalanced compensation.

Fig. 1 Hybrid power generation system with a shunt active power filter
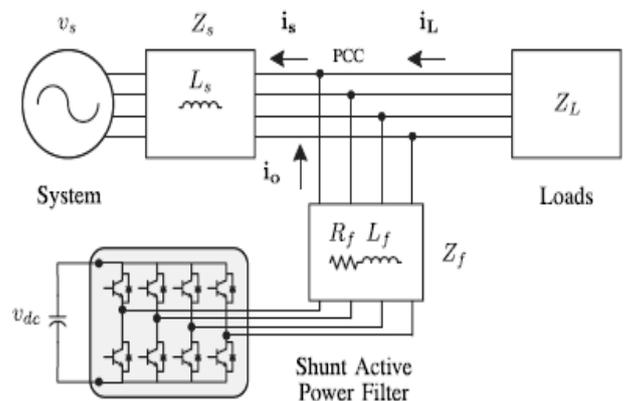

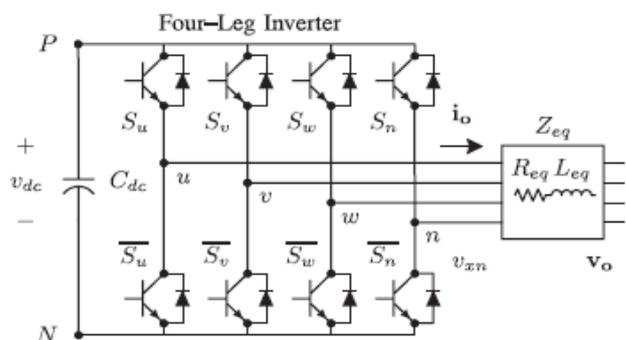Fig. 2 Three-phase equivalent circuit of the proposed shunt active power filter

Fig. 3 Two-level four-leg PWM-VSI topology

The voltage in any leg x of the converter, measured from the neutral point (n), can be expressed in terms of switching states, as follows:

$$v_{xn} = S_x - S_n \, v_{dc}, \quad x = u, \, v, \, w, \, n. \qquad (1)$$

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The mathematical model of the filter derived from the equivalent circuit shown in Fig. 2 is

$$\mathbf{v_o} = v_{xn} - R_{eq}\,\mathbf{i_o} - L_{eq}\frac{d\,\mathbf{i_o}}{dt} \qquad (2)$$

Where R_{eq} and L_{eq} are the 4L-VSI output parameters expressed as Thevenin impedances at the converter output terminals Z_{eq}. Therefore, the Thevenin equivalent impedance is determined by a series connection of the ripple filter impedance Z_f and a parallel arrangement between the system equivalent impedance Z_s and the load impedance Z_L

$$Z_{eq} = \frac{Z_s Z_L}{Z_s + Z_L} + Z_f \approx Z_s + Z_f. \qquad (3)$$

For this model, it is assumed that $Z_L >> Z_s$, that the resistive part of the system's equivalent impedance is neglected, and that the series reactance is in the range of 3–7% p.u., which is an acceptable approximation of the real system. Finally, in (2) $R_{eq} = Rf$ and $L_{eq} = Ls+ Lf$.

III. CURRENT REFERENCE GENERATION

A dq-based current reference generator scheme is used to obtain the active power filter current reference signals. The current reference signals are obtained from the corresponding load currents as shown in Fig. 5. This module calculates the reference signal currents required by the converter to compensate reactive power, current harmonic and current imbalance. The displacement power factor (sin $\varphi(L)$) and the maximum total harmonic distortion of the load (THD(L)) defines the relationships between the apparent power required by the active power filter, with respect to the load, as shown

$$\frac{S_{APF}}{S_L} = \frac{\sqrt{\sin\phi_{(L)} + THD_{(L)}{}^2}}{\sqrt{1 + THD_{(L)}{}^2}} \qquad (4)$$

Where the value of THD (L) includes the maximum compensable harmonic current, defined as double the sampling frequency fs. The frequency of the maximum current harmonic component that can be compensated is equal to one half of the converter switching frequency. The dq-based scheme operates in a rotating reference frame; therefore, the measured currents must be multiplied by the sin(wt) and cos(wt) signals. By using dq-transformation, the current component is synchronized with the corresponding phase-to-neutral system voltage, and the q current component is phase-shifted by 90◦. The sin(wt) and cos(wt) synchronized reference signals are obtained from a synchronous reference frame (SRF) PLL. The SRF-PLL generates a pure sinusoidal waveform even when the system voltage is severely distorted. Tracking errors are eliminated, since SRF-PLLs are designed to avoid phase voltage unbalancing, harmonics (i.e., less than 5% and 3% in fifth

and seventh, respectively), and offset caused by the nonlinear load conditions and measurement errors. Equation (8) shows the relationship between the real currents $iLx(t)$ ($x = u, v,w$) and the associated dq components(id and iq)

$$\begin{bmatrix} i_d \\ i_q \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \sin\omega t & \cos\omega t \\ -\cos\omega t & \sin\omega t \end{bmatrix} \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} i_{Lu} \\ i_{Lv} \\ i_{Lw} \end{bmatrix}. \qquad (5)$$

A low-pass filter (LFP) extracts the dc component of the phase currents id to generate the harmonic reference components $-\_id$. The reactive reference components of the phase-currents are obtained by phase-shifting the corresponding ac and dc components of iq by 180◦. In order to keep the dc-voltage constant, the amplitude of the converter reference current must be modified by adding an active power reference signal ie with the d-component, as will be explained in Section IV-A. The resulting signals $i*d$ and $i*q$ are transformed back to a three-phase system by applying the inverse Park and Clark transformation, as shown in (6). The cut off frequency of the LPF used in this paper is 20 Hz.

$$\begin{bmatrix} i_{ou}^* \\ i_{ov}^* \\ i_{ow}^* \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \frac{1}{\sqrt{2}} & 1 & 0 \\ \frac{1}{\sqrt{2}} & -\frac{1}{2} & \frac{\sqrt{3}}{2} \\ \frac{1}{\sqrt{2}} & -\frac{1}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix}$$
$$\times \begin{bmatrix} 1 & 0 & 0 \\ 0 & \sin\omega t & -\cos\omega t \\ 0 & \cos\omega t & \sin\omega t \end{bmatrix} \begin{bmatrix} i_0 \\ i_d^* \\ i_q^* \end{bmatrix}. \qquad (6)$$

The current that flows through the neutral of the load is compensated by injecting the same instantaneous value obtained from the phase-currents, phase-shifted by 180◦, as shown next

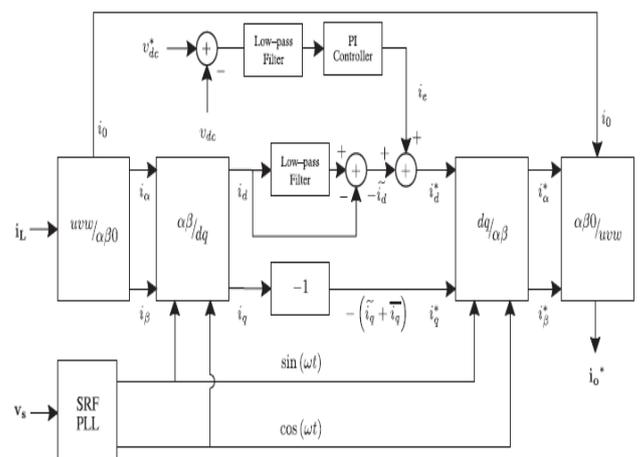$$i_{on}^* = -(i_{Lu} + i_{Lv} + i_{Lw}). \qquad (7)$$

Fig. 4 *dq*-based current reference generator block diagram

One of the major advantages of the *dq*-based current reference generator scheme is that it allows the implementation of a linear controller in the dc-voltage control loop. However, one important disadvantage of the *dq*-based current reference frame algorithm used to generate the current reference is that a second order harmonic component is generated in *id* and *iq* under unbalanced operating conditions. The amplitude of this harmonic depends on the percent of unbalanced load current (expressed as the relationship between the negative sequence current *iL,2* and the positive sequence current *iL,1*). The second-order harmonic cannot be removed from *id* and *iq*, and therefore generates a third harmonic in the reference current when it is converted back to abc frame. Fig. 6 shows the percent of system current imbalance and the percent of third harmonic system current, in function of the percent of load current imbalance. Since the load current does not have a third harmonic, the one generated by the active power filter flows to the power system.

IV. DC-VOLTAGE CONTROL

The dc-voltage converter is controlled with a traditional PI controller. This is an important issue in the evaluation, since the cost function (6) is designed using only current references, in order to avoid the use of weighting factors. Generally, these weighting factors are obtained experimentally, and they are not well defined when different operating conditions are required. Additionally, the slow dynamic response of the voltage across the electrolytic capacitor does not affect the current transient response. For this reason, the PI controller represents a simple and effective alternative for the dc-voltage control. √The dc-voltage remains constant (with a minimum value of6 *vs*(rms)) until the active power absorbed by the converter decreases to a level where it is unable to compensate for its losses.
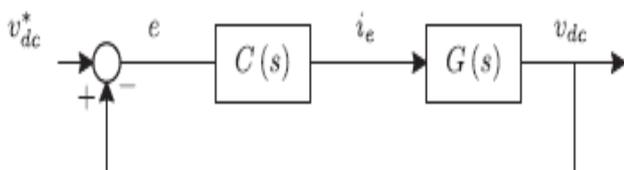

Fig. 5 DC-voltage control block diagram

The active power absorbed by the converter is controlled by adjusting the amplitude of the active power reference signal *ie,* which is in phase with each phase voltage. In the block diagram shown in Fig. 4, the DC-voltage*vdc* is measured and then compared with a constant reference value *v∗dc*. The error(*e*) is processed by a PI controller, with two gains, *Kp* and *Ti* .Both gains are calculated according to the dynamic response requirement. Fig. 7 shows that the output of the PI controller is fed to the dc-voltage transfer function *Gs,* which is represented by a first-order system. The equivalent closed-loop transfer function of the given system with a PI controller (12) is shown in (13)

$$C(s) = K_p \left(1 + \frac{1}{T_i \cdot s} \right) \tag{12}$$

$$\frac{v_{\text{dc}}}{i_e} = \frac{\frac{\omega_n^2}{a} \cdot (s + a)}{s^2 + 2\zeta\omega_n \cdot s + \omega_n^2}. \tag{13}$$

Since the time response of the dc-voltage control loop does not need to be fast, a damping factor $\zeta = 1$and a natural angular speed $\omega n = 2\pi \cdot 100$ rad/s are used to obtain a critically damped response with minimal voltage oscillation. The corresponding integral time $T_i = 1/a$ (13) and proportional gain Kpcan be calculated Zieglo nicholas method .

B. ANN CONTROLLER

Artificial Neural Networks are relatively crude electronic models based on the neural structure of the brain. The brain basically learns from experience. It is natural proof that some problems that are beyond the scope of current computers are indeed solvable by small energy efficient packages. This brain modelling also promises a less technical way to develop machine solutions. This new approach to computing also provides a more graceful degradation during system overload than its more traditional counterparts. These biologically inspired methods of computing are thought to be the next major advancement in the computing industry. Even simple animal brains are capable of functions that are currently impossible for computers. Now, advances in biological research promise an initial understanding of the natural thinking mechanism. This research shows that brains store information as patterns. Some of these patterns are very complicated and allow us the ability to recognize individual faces from many different angles. This process of storing information as patterns, utilizing those patterns, and then solving problems encompasses a new field in computing. This field, as mentioned before, does not utilize traditional programming but involves the creation of massively parallel networks and the training of those networks to solve specific problems. This field also utilizes words very different from traditional computing, words like behave, react, self organize, learn, generalize, and forget.

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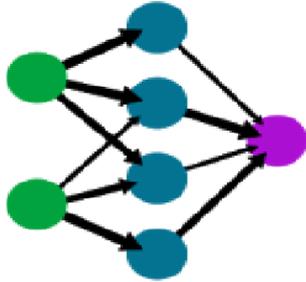## A Peer Reviewed Open Access International Journal
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Fig.6.Topology of neural network

Working of ANN:-

Currently, neural networks are the simple clustering of the primitive artificial neurons. This clustering occurs by creating layers which are then connected to one another. How these layers connect is the other part of the "art" of engineering networks to resolve real world problems. Basically, all artificial neural networks have a similar structure or topology as shown in Figure1. In that structure some of the neurons interfaces to the real world to receive its inputs. Other neurons provide the real world with the network's outputs. This output might be the particular character that the network thinks that it has scanned or the particular image it thinks is being viewed. All the rest of the neurons are hidden from view.

Training of ANN: -

Once a network has been structured for a particular application, that network is ready to be trained. To start this process the initial weights are chosen randomly. Then, the training, or learning, begins. There are two approaches to training - supervised and unsupervised. Supervised training involves a mechanism of providing the network with the desired output either by manually "grading" the network's performance or by providing the desired outputs with the inputs. Unsupervised training is where the network has to make sense of the inputs without outside help.

1. Supervised Training - In supervised training, both the inputs and the outputs are provided. The network then processes the inputs and compares its resulting outputs against the desired outputs. Errors are then propagated back through the system, causing the system to adjust the weights which control the network. This process occurs over and over as the weights are continually tweaked. The set of data which enables the training is called the "training set." During the training of a network the same set of data is processed many times as the connection weights are ever refined. The current

commercial network development packages provide tools to monitor how well an artificial neural network is converging on the ability to predict the right answer.

2. Un supervised, or Adaptive Training. The other type of training is called unsupervised training. In unsupervised training, the network is provided with inputs but not with desired outputs. The system itself must then decide what features it will use to group the input data. This is often referred to as self organization or adoption.

Here we are using the supervised training ANN controller. The compensator output depends on input and its evolution. The chosen configuration has seven inputs three each for reference load voltage and source current respectively, and one for output of error (PI) controller. The neural network trained for outputting fundamental reference currents. The signals thus obtained are compared in a hysteresis band current controller to give switching signals.
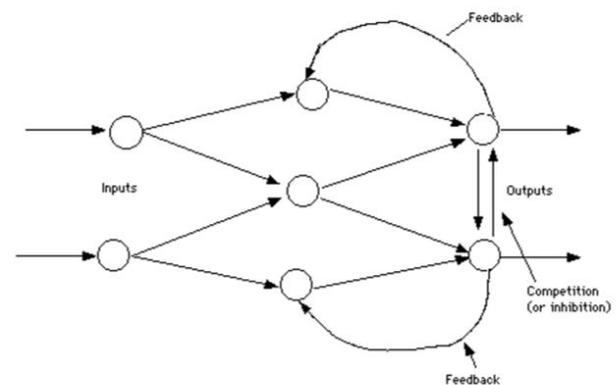

Figure.7 Simple Network with feedback and competition

Training is given as follows:-
net=newff(minmax(P),[7,21,3],
{„tansig‟,‟tansig‟,‟purelin‟},‟trainlm‟);
net.trainParam.show =50;
net.trainParam.lr = .05;
net.trainParam.mc = 0.95;
net.trainParam.lr_inc = 1.9;
net.trainParam.lr_dec = 0.15;
net.trainParam.epochs = 1000;
net.trainParam.goal = 1e-6;
[net,tr]=train(net,P,T);
a=sim(net,P);
gensim(net,-1);
            .
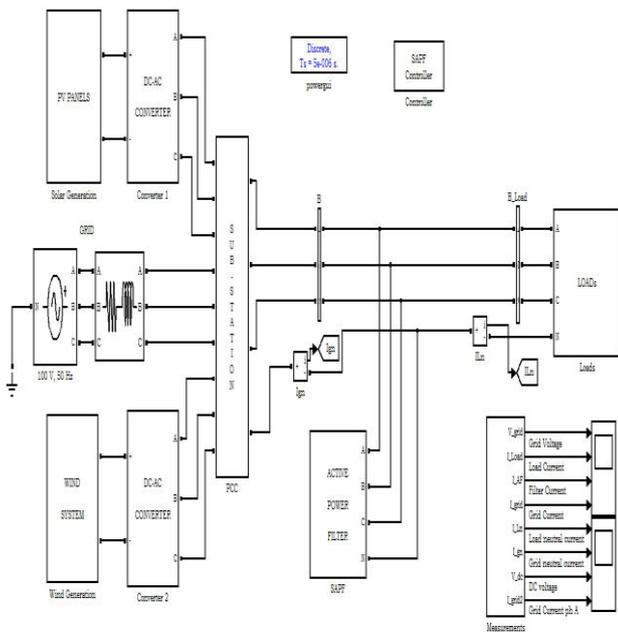
V. SIMULATION RESULTS

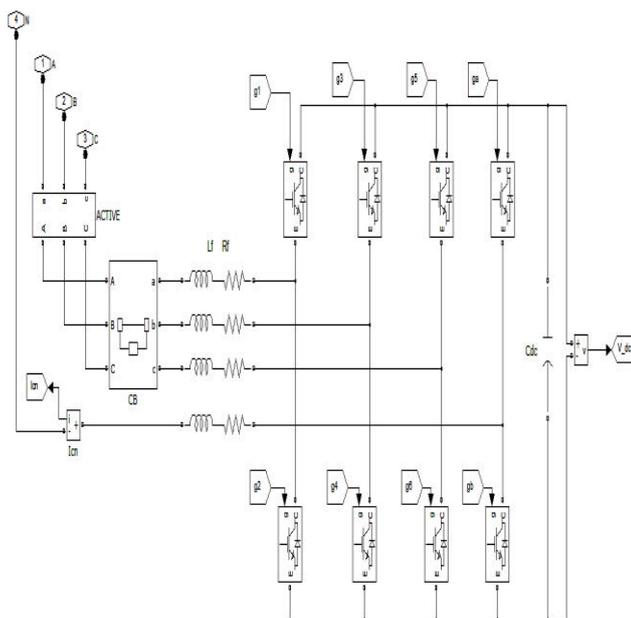Fig. 8 hybrid power generation system with a shunt active power filter

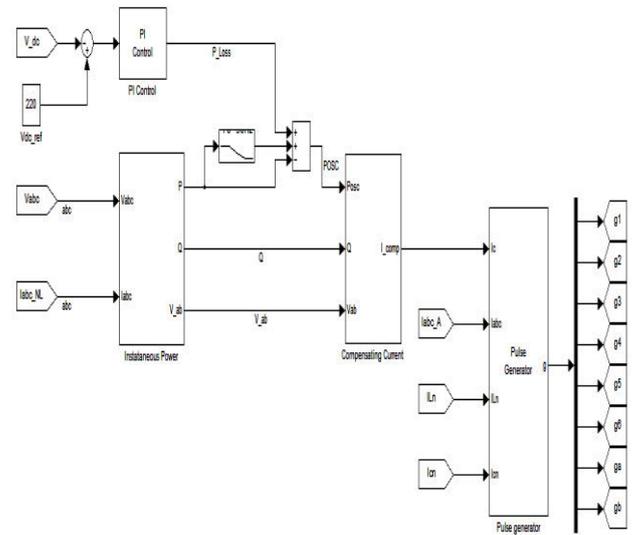Fig. 9 circuit of the proposed shunt active power
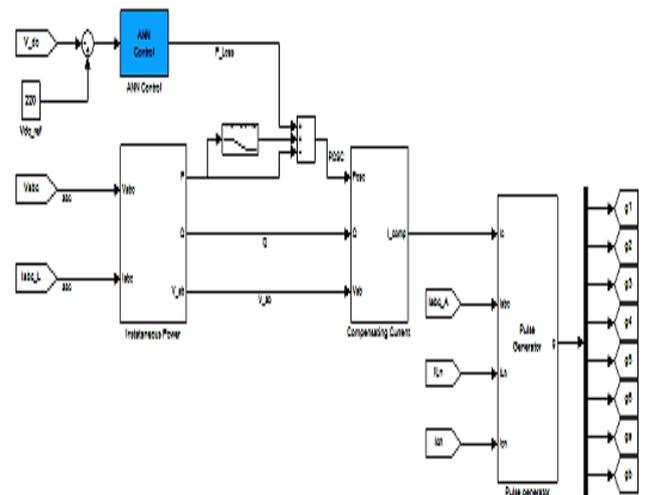

Fig. 10 dq-based PI current controller

Fig. 11 ANN based current controller

The Schematic diagram ANN based current controller is shown in Fig:11 gives the control scheme realization. The actual capacitor voltage is compared with a set reference value. The error signal is fed to ANN controller. The output of the ANN controller has been considered as a peak value of reference current. It is further multiplied by the unit sine vectors(u_{sa}, u_{sb}, u_{sc}) in phase with source voltage to obtain the reference currents(i_{sa}, i_{sb}, i_{sc}).These reference currents and actual currents are given to hysteresis based ,carrier less PWM current controller to generate switching signals of PWM converter.The difference of reference current template and actual current decides the operation switches.
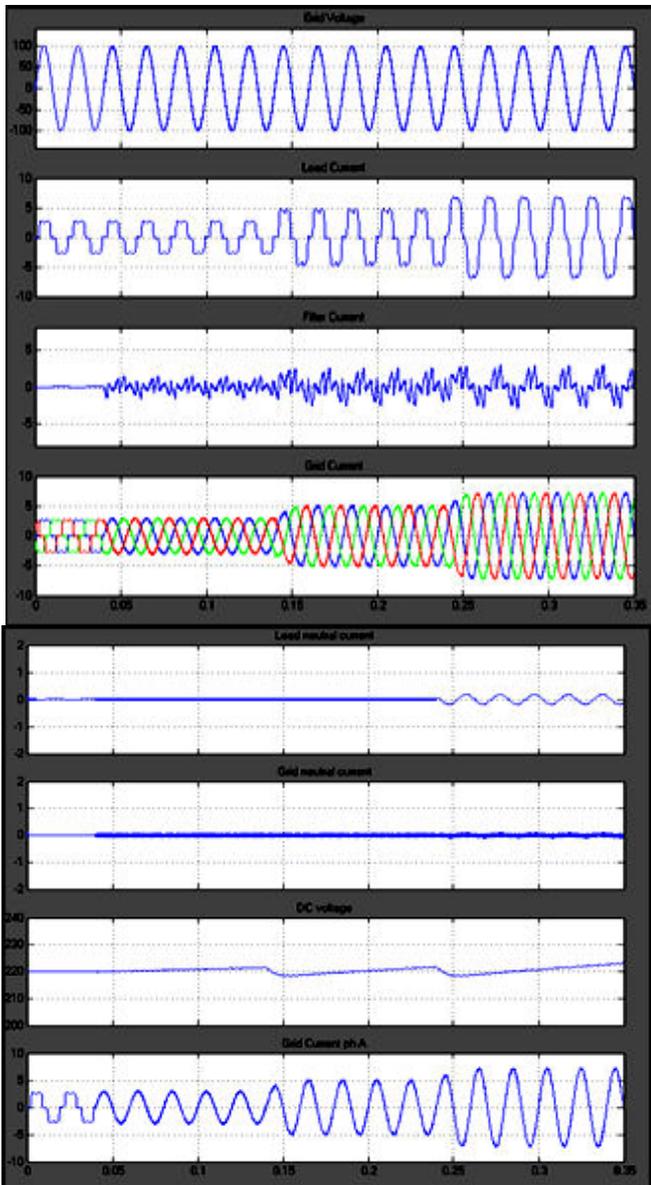
Fig. 12 Simulated waveforms of the proposed control scheme (a) Phase to neutral source voltage (b) Load Current (c) Active power filter output current (d) Load neutral current (e) System neutral current (f) System currents. (g) DC voltage converter (h) grid current

TABLE-1
%THD OF SOURCE CURRENTS USING PI AND ANN CONTROLLERS

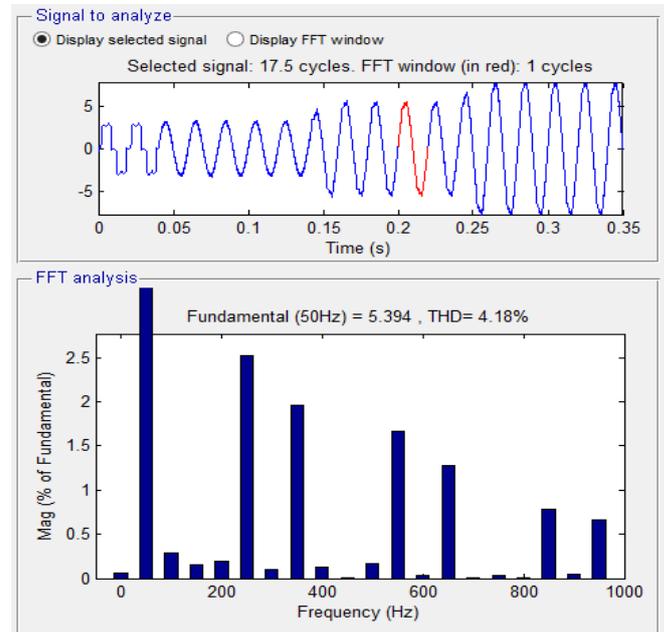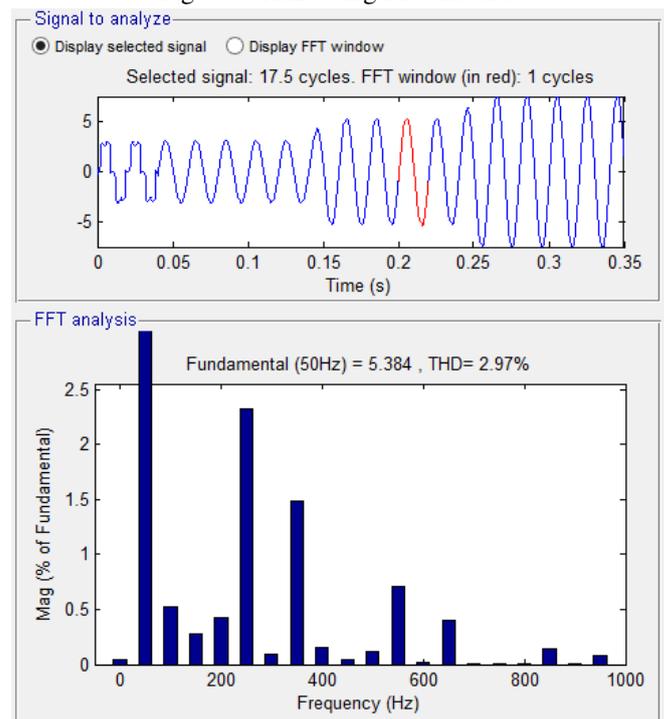| Controller	Nonlinear Load1	Nonlinear Load2	Unbalanced Load3
PI	2.53%	4.18%	2.75%
ANN	1.04%	2.97%	1.75%

Fig 13 %THD using PI controller

Fig 14 %THD using ANN controller

CONCLUSION

The feed-forward ANN controller based active power filter has been implemented in MATLAB/Simulink. The many results are presented to prove the proficient of the designed ANN controller. The THD of source current for active power filter using PI controller is 4.18%, whereas THD for it using ANN controller is 2.97%. The performance of designed ANN controller for active power filter is tested under different nonlinear load conditions and it numerical results are cataloged in table. The active power filter

improves the power quality of distribution system by rejecting harmonics and reactive power compensation of non-linear load. Hence, from the simulation results, it can conclude that ANN controller is more effective than PI controller.

REFERENCES

[1] Pablo. Acuna, Luis Moran, Marco Rivera, and Juan Dixon, "Improved Active Power Filter Performance for Renewable power generation Systems," *IEEE Trans. Power Electron.*, vol. 29,no. 2, , Feb. 2014.

[2] M. Aredes, J. Hafner, and K. Heumann, "Three-phase four-wire shunt active filter control strategies," *IEEE Trans. Power Electron.*, vol. 12,no. 2, pp. 311–318, Mar. 1997.

[3] S. Naidu and D. Fernandes, "Dynamic voltage restorer based on a fourlegvoltage source converter," *Gener. Transm. Distrib., IET*, vol. 3, no. 5,pp. 437–447, May 2009.

[4] N. Prabhakar and M. Mishra, "Dynamic hysteresis current control tominimize switching for three-phase four-leg VSI topology to compensatenonlinear load," *IEEE Trans. Power Electron.*, vol. 25, no. 8, pp. 1935–1942, Aug. 2010.

[5] V. Khadkikar, A. Chandra, and B. Singh, "Digital signal processor implementation and performance evaluation of split capacitor, four-leg and three h-bridge-based three-phase four-wire shunt active filters," *Power Electron., IET*, vol. 4, no. 4, pp. 463–470, Apr. 2011.

[6] F. Wang, J. Duarte, and M. Hendrix, "Grid-interfacing converter systems with enhanced voltage quality for micro grid application; concept and implementation," *IEEE Trans. Power Electron.*, vol. 26, no. 12, pp. 3501–3513, Dec. 2011.

[7] X.Wei, "Study on digital pi control of current loop in active power filter," in *Proc. 2010 Int. Conf. Electr. Control Eng.*, Jun. 2010, pp. 4287–4290.

[8] R. de Araujo Ribeiro, C. de Azevedo, and R. de Sousa, "A robust adaptive control strategy of active power filters for power-factor correction, harmonic compensation, and balancing of nonlinear loads," *IEEE Trans .Power Electron.*, vol. 27, no. 2, pp. 718–730, Feb. 2012.

[9] J. Rodriguez, J. Pontt, C. Silva, P. Correa, P. Lezana, P. Cortes, and U.Ammann, "Predictive current control of a voltage source ,inverter,"*IEEE Trans. Ind. Electron.*, vol. 54, no. 1, pp. 495–503, Feb. 2007.

[10] P. Cortes, G. Ortiz, J. Yuz, J. Rodriguez, S. Vazquez, and L. Franquelo,"Model predictive control of an inverter with output *LC* filter for UPS applications," *IEEE Trans. Ind. Electron.*, vol. 56, no. 6, pp. 1875–1883,Jun. 2009.

[11] Ms. Sonali. B. Maind," Research Paper on Basic of Artificial Neural Network". International journal of recent trend in computing and communication.