

# Active Filter Control Strategies for Renewable Power Generation Systems using ANN Controller

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## ABSTRACT

Presently multi day's Renewable imperativeness age structure being the growing new distress in making office, anyway to interface it with the Grid we required high power static PWM converters which are one of the explanation behind irritation in power quality in our system. Along these lines, In this paper we are proposing another control strategy which relies upon phony neural framework speculation used in unique power channel by using this the unlimited sources are synchronized with the structure just as upgrades control quality by compensating the present sounds and unequal current made by sudden disrupting impact in weight. The topology which is used for dynamic power channel is four-leg voltage source converter. The ANN controller isn't simply improves the power quality; it similarly upgrades the full scale consonant bowing in current by smothering the music. The numerical showing of the proposed system is cleared up in the paper. The dynamic power channel is reproduced with two control technique, for instance, PI controller and ANN controller. The proliferation results and the unbelievable structure show the commonness of ANN controller over PI controller. The proposed circuit is attempted under different working condition through proliferation in MATLAB/SIMULINK and the results shows the force of the structure

**Index Terms:** shunt Active Power Filter, Four-Leg Converters, PI Controller, ANN Controller, THD, Renewable Generation System.

## I. INTRODUCTION

Before long a-days the liberal number of PCs and other touchy electrical loads related with the power cross segment are obviously influenced by control quality issues [1]. A hero among the most fundamental issues is identified with current music made by the developing number of non direct loads related with the power structure, for example, diode and thyristor frontend rectifiers. Subsequently, these music can cause voltage bendings, extra catastrophes in the effect structure, and breakdown of delicate electronic hardware. From this time forward, symphonious hindrance checks, for example, IEEE 519 [2], have been embraced to limit the consonant streams

blended into the structure by non direct loads. Shunt inert channels, including tuned LC channels and high pass channels, have been commonly utilized as a reasonable and inconsequential effort answer for remunerate current sounds. Everything considered, their execution unequivocally relies on the cross section impedance and can cause the undesirable parallel reverberation ponders with the framework. In the most recent decades, the broadening enduring nature of essentialness semiconductor gadgets has goaded the improvement of imperativeness hardware answers for the issue of consonant stream into the cross area. The shunt dynamic power channel (APF), including essentially of a voltage source inverter (VSI) with a significant

capacitor on its dc interface, is viewed as a settled reaction for lessening the present sounds to the proposed tenets cutoff points [3]– [13]. The non-uniform nature of essentialness age plainly impacts voltage heading and makes voltage turning in control frameworks. This new condition in charge task structures will require progressively present day pay systems. In spite of the fact that one of a kind power channels executed with three-sort out four-leg voltage-source inverters (4L-VSI) have as of late been appeared in the particular creation, the key duty of this paper is a keen control figuring orchestrated and finished particularly for this application.

Overall, one of a kind power channels have been controlled utilizing pre tuned controllers, for example, PI-sort or adaptable, for the present and furthermore for the DC-voltage circles. PI controllers must be outlined in context on the comparable direct model, while keen controllers utilize the non straight model, which is nearer to legitimate working conditions. A precise model got utilizing insightful controllers overhauls the execution of the dynamic power channel, particularly amidst transient working conditions, since it can rapidly take after the present reference flag while keeping up persisting DCvoltage. Starting quite recently, utilization of farsighted control in control converters have been utilized by and large in affirmation engine drives. By goodness of engine drive applications, wise control addresses a very instinctual control plot that handles multi variable properties, disentangles the treatment of dead-time pay, and allows beat width modulator substitution. Notwithstanding, these sorts of occupations show deterrents identified with developments and flimsiness delivered utilizing dull weight parameters. One favored position of the proposed estimation is that it fits well in one of a kind power channel applications, since the power converter yield parameters are remarkable. These yield parameters are secured from the converter yield swell channel and the power framework undefined impedance. The paper is managed as takes after: The proposed framework topology is cleared up incompletely II. The entire depiction of the picked current reference generator executed in the dynamic power direct is displayed in region III. The Control Scheme of DC transport voltage control and ANN control figuring is depicted somewhat IV. At last, the proposed dynamic power channel and the sensibility of the related control

plot remuneration are showed up through reenactment acknowledges part V.

## II. PROPOSED SYSTEM TOPOLOGY

The arrangement of a typical spot control scattering system with limitless power age is showed up in Fig.1. It involves distinctive sorts of vitality age units and differing sorts of weights. Boundless sources, for instance, wind and light, are customarily used to make control for private customers and little endeavors. The two sorts of vitality age use cooling/cooling and dc/cooling static PWM converters for voltage change and battery banks for whole deal essentialness amassing. These converters perform most outrageous power direct after toward discrete the best imperativeness possible from wind and sun. A dynamic power divert is related in shunt at the motivation behind standard coupling to reimburse current music, current unbalance, and responsive power. It is shaped by an electrolytic capacitor, a four-leg PWM converter, and a firstorder yield swell channel, as showed up inFig. 2. This circuit thinks about the energy structure practically same impedance  $Z_s$ , the converter yield swell channel impedance  $Z_f$ , and the load impedance  $Z_L$ . The four-leg PWM converter topology is confirmed up in Fig. three This converter topology resembles the common three-arrange converter with the fourth leg related with the objective transport of the system. The fourth leg manufactures changing states from eight (23) to16 (24), upgrading manipulate versatility and yield voltage quality, and is appropriate for present day unequal pay. Two

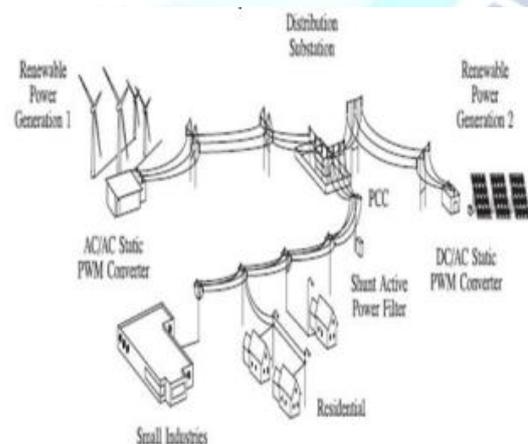


Fig 1. Hybrid power generation system with a shunt active power filter

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

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

$$v_o = v_{xn} - R_{eq} i_o - L_{eq} \frac{di_o}{dt} \quad (2)$$

Where Req and Leq are the 4Leg-VoltageSourceInverter output parameters expressed as Thevenin impedances at the converter output terminals Zeq.

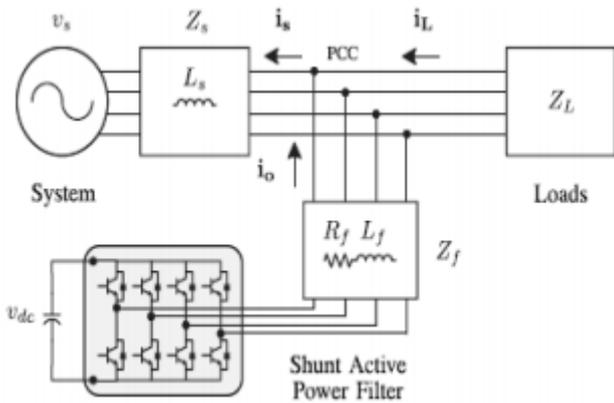


Fig.2. 3-phase equivalent circuit of the shunt active powerfilter.

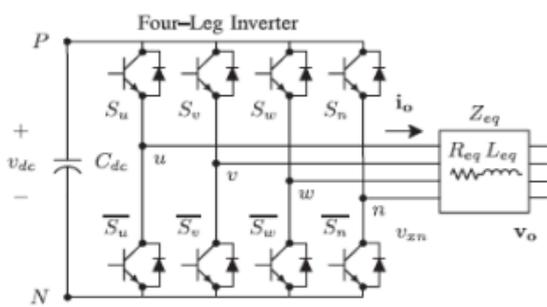


Fig.3. 2-level four-leg PWM-VSI topology.

Therefore, the Theveninequal impedance is determined by means of a sequence connection of the ripple filter impedance Zfand a parallel arrangement between the system equal impedance Zs and the load impedance ZL

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

For this model, it is assumed that  $Z_L \gg Z_s$ , that the resistive phase of the system's equal impedance is neglected, and that the collection reactance is in the vary of 3– 7% p.u., which is an acceptable approximation of the actual system. Finally, in (2)  $R_{eq} = R_{fand} Leq = L_s + L_f$ .

### III. CURRENT REFERENCE GENERATION

A dq-based present day reference generator plot is utilized to gather the dynamic strength channel contemporary reference signals. The present reference signals are gotten from the bearing on load flows as appeared in Fig. 5. This module

ascertains the reference flag flows required by way of the converter to remunerate receptive power, modern symphonious and cutting-edge lopsidedness. The uprooting power issue ( $\sin \phi(L)$ ) and the best all out consonant bending of the heap (THD(L)) characterizes the connections between the clear strength required through the dynamic strength channel, as for the heap, as regarded

$$\frac{S_{APF}}{S_L} = \frac{\sqrt{\sin^2 \phi(L) + THD(L)^2}}{\sqrt{1 + THD(L)^2}} \quad (4)$$

Where the estimation of THD (L) comprises the biggest compensable consonant current, characterised as twofold the inspecting recurrence fs. The recurrence of the greatest present day consonant section that can be repaid is equal to one portion of the converter exchanging recurrence. The dqbased conspire works in a turning reference outline; along these lines, the deliberate flows ought to be duplicated by using the  $\sin(\omega t)$  and  $\cos(\omega t)$  signals. By utilizing dq-change, the existing phase is synchronized with the referring to stage to-unbiased framework voltage, and the q present day phase is stage moved by using  $90^\circ$ . The  $\sin(\omega t)$  and  $\cos(\omega t)$  synchronized reference signals are gotten from a synchronous reference outline (SRF) PLL. The SRF-PLL creates an unadulterated sinusoidal waveform notwithstanding when the framework voltage is critically mutilated. Following errors are disposed of, due to the fact SRF-PLLs are supposed to keep away from stage voltage unbalancing, sounds (i.e., under 5% and 3% in fifth and seventh, separately), and balance delivered about via the nonlinear burden stipulations and estimation mistakes. Condition (8) demonstrates the connection between the true flows  $iLx(t)$  ( $x=u,v,w$ ) and the related dq components( $i_d$  and  $i_q$ )

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

A low-pass channel (LFP) separates the dc part of the stage flows  $i_d$  to create the consonant reference segments  $-i_d$ . The receptive reference segments of the stage flows are acquired by stage moving the relating air conditioning and dc parts of  $i_q$  by  $180^\circ$ . So as to keep the dc-voltage steady, the plentifulness of the converter reference current must be adjusted by including a functioning force reference flag i.e with the d-part, as will be clarified in Section IV-A. The subsequent signs  $i^*d$  and  $i^*q$ are changed back to a three-stage framework by applying the opposite Park and Clark change, as

appeared (6). The cut off recurrence of the LPF utilized in this paper is 20 Hz.

$$\begin{bmatrix} i_{Lu}^* \\ i_{Lv}^* \\ i_{Lw}^* \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \frac{1}{\sqrt{2}} & 1 & 0 \\ \frac{1}{\sqrt{2}} & -\frac{1}{2} & \frac{\sqrt{3}}{2} \\ \frac{1}{\sqrt{2}} & -\frac{1}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 \\ 0 & \sin \omega t & -\cos \omega t \\ 0 & \cos \omega t & \sin \omega t \end{bmatrix} \begin{bmatrix} i_{Ld}^* \\ i_{Lq}^* \\ i_{Lr}^* \end{bmatrix} \quad (6)$$

The modern-day that flows thru the impartial of the load is compensated by injecting the same instant fee obtained from the phase-currents, phase-shifted by means of 180°, as shown next

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

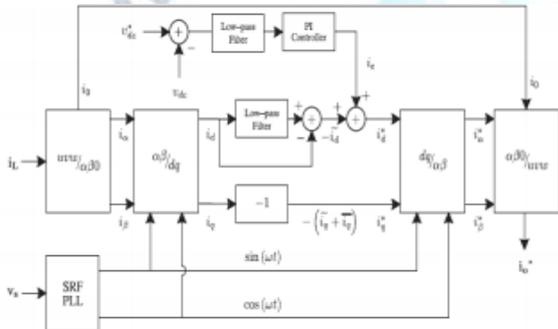


Fig4. dq-based current reference generator block diagram.

One of the noteworthy inclinations of the dq-based modern-day reference generator sketch is that it allows the execution of an instant controller in the dc-voltage control circle. Regardless, one vital downside of the dq-based cutting-edge reference layout figuring used to supply the current reference is that a 2nd demand consonant component is made in identity and iq below unequal working conditions. The plentifulness of this symphonious depends upon the percentage of uneven weight present day (imparted as the association between the poor layout modern-day  $i_{L,2}$  and the advantageous gathering current  $i_{L,1}$ ). The second-ask for consonant can not be ousted from identity and iq, and thusly creates a 1/3 symphonious in the reference current when it is changed over again to abc layout. Fig. 6 indicates the percent of shape modern-day inconsistency and the percent of third symphonious system current, in restriction of the percentage of weight modern-day imbalance. Since the save present day does no longer have a third symphonious, the one

delivered through the dynamic energy channel streams to the energy structure.

#### IV. DC-VOLTAGE CONTROL

The dc-voltage converter is managed with a conventional PI controller. This is an crucial trouble in the assessment, seeing that the price ability (6) is structured using simply current references, so as to hold a strategic distance from the utilization of weighting factors. For the most part, these weighting factors are obtained tentatively, and they are no longer very a lot characterised when distinct working stipulations are required. Moreover, the reasonable unique reaction of the voltage over the electrolytic capacitor does no longer impact the current transient reaction. Consequently, the PI controller speaks to a simple and successful alternative for the dc-voltage control. The dc-voltage stays consistent (with a base esteem of 6 vs(rms) ) till the dynamic energy fed on by using the converter diminishes to a dimension the place it can not make up for its misfortunes.

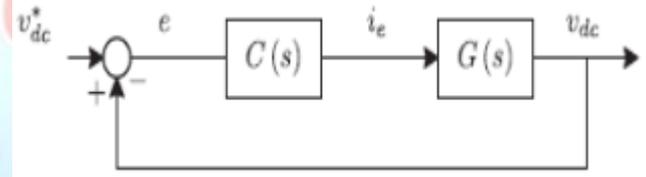


Fig 5. DC-voltage control block diagram.

The dynamic power consumed by the converter is constrained by changing the abundance of the dynamic power reference flag i.e., which is in stage with each stage voltage. In the square outline appeared in Fig. 4, the DC-voltage vdc is estimated and afterward contrasted and a consistent reference esteem v\*dc. The error(e) is handled by a PI controller, with two additions, Kp and Ti. The two increases are determined by the dynamic reaction prerequisite. Fig. 7 demonstrates that the yield of the PI controller is sustained to the dc-voltage exchange work Gs, which is spoken to by a first-request framework. The proportionate closedloop exchange capacity of the given framework with a PI controller (12) is appeared (13)

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

$$\frac{v_{dc}}{i_c} = \frac{\frac{\omega_n^2}{a} \cdot (s + a)}{s^2 + 2\zeta\omega_n \cdot s + \omega_n^2} \quad (13)$$

Since the time response of the dc-voltage manipulate loop does not need to be fast, a damping aspect  $\zeta = 1$  and a natural angular speed

$\omega_n = 2\pi \cdot 100$  rad/s are used to achieve a critically damped response with minimal voltage oscillation. The corresponding vital time  $T_i = 1/a$  (13) and proportional gain  $K_p$  can be calculated using Ziegler-Nichols method.

#### A. ANN CONTROLLER

Artificial Neural Networks are moderately rough electronic models dependent on the neural structure of the mind. The cerebrum essentially gains from experience. It is customary affirmation that a couple of issues that are past the degree of current PCs are to make certain resolvable by little essentialness beneficial packs. This cerebrum showing similarly guarantees a less explicit approach to manage machine arrangements. This better way to deal with oversee enrolling in like way gives an all the more simple defilement amidst framework over-load than its inexorably standard associates. These typically impelled strategies for figuring are acknowledged to be the going with enormous advancement in the selecting business. Without a doubt, even clear creature minds are set up for limits that are at present shocking for PCs. Eventually, moves in regular research guarantee a fundamental comprehension of the typical sense fragment. This examination demonstrates that cerebrums store data as models. A bit of these points of reference are remarkably tangled and permit us the capacity to see specific appearances from a wide extent of edges. This arrangement of verifying data as models, using those points of reference, and a while later managing issues melds another field in enrolling. This field, as said some time starting late, does not use standard programming yet rather consolidates the age of greatly parallel systems and the course of action of those structures to manage explicit issues. This field in like way uses words totally not equivalent to conventional enrolling, words like lightweight bag, respond, self compose, learn, total up, and disregard.

#### B. Working of ANN

Beginning at now, neural structures are the immediate grouping of the difficult phony neurons. This social occasion happens by means of making layers which are then associated with every other. How these layers interface is the other piece of the "workmanship" of organizing systems to select certifiable issues. In a prevalent sense, all phony neural systems have a for all intents and functions indistinguishable shape or topology as seemed in Figure 1. In that shape a contact of the neurons

interface to this existing actuality to get its records sources. Different neurons outfit this existing fact with the system's yields. This yield can also be the particular personality that the structure thinks about that it has checked or the precise image it receive is being seen. The relaxation of the neurons are gotten away view.

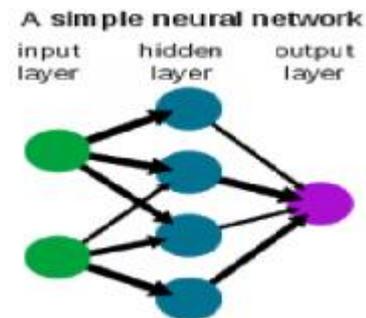


Fig 6. Topology of neural network

#### C. Training of ANN

At the point when a shape has been dealt with for a particular application, that device is set up to be prepared. To begin this strategy the necessary burdens are picked unpredictably. By at that point, the arranging, or learning, starts. There are two exclusive approaches to oversee making ready - regulated and unsupervised. Facilitated arranging joins an instrument of giving the system the best yield either with the aid of bodily "evaluating" the structure's execution or by way of furnishing the pined for yields with the information sources. Unsupervised arranging is the observe the shape needs to understand the obligations barring outside help.

1. Supervised Training - In coordinated getting ready, each the data sources and the yields are given The machine by using then constructions the statistics sources and mulls over its ensuing yields against the pined for yields. Oversights are then unfold lower back thru the structure, affecting the framework to alternate the thousands which manipulate the system. This approach takes place again and once more as the hundreds are continuously changed. The association of facts which connects with the status is acknowledged as the "arranging set." During the availability of a machine a near direction of action of facts is dealt with normally as the alliance masses are ever refined. The present enterprise sketch movement packs offer instruments to screen how nicely a delivered neural shape is fixating on the capability to envision the right answer.

2. Un directed, or Adaptive Training: The different type of planning is called unsupervised getting ready. In unsupervised putting up, the framework is outfitted with records sources anyway now not with wanted yields. The framework itself have to then pick out what highlights it will use to disguise away the information. This is reliably hinted as self alliance or selection Here we are making use of the coordinated arranging ANN controller. The compensator yield depends on facts and its movement. The picked arrangement has seven records sources three each for reference stack voltage and supply contemporary freely, and one for yield of screw up (PI) controller. The neural system orchestrated yielding key reference streams. The signs thusly received are taken a gander at in a hysteresis band cutting-edge controller to supply buying and selling signals.

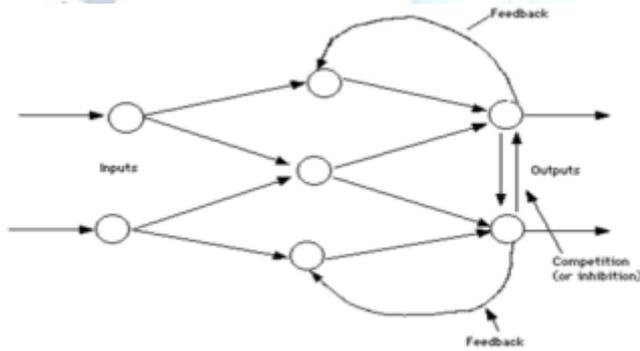


Fig 7. Simple Network with feedback and competition.

**V.SIMULATION RESULTS**

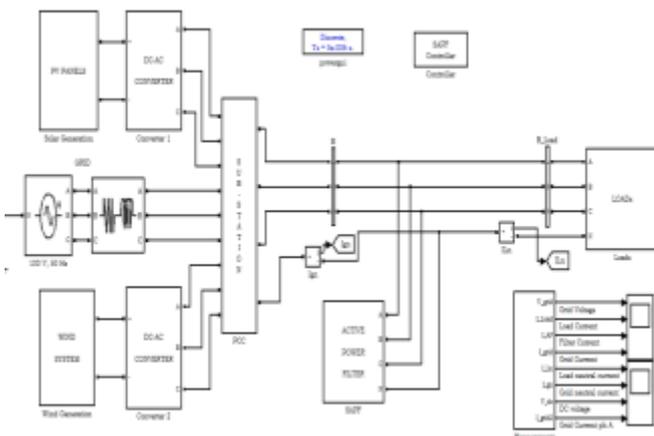


Fig 8. Hybrid powergeneration system with ashunt active power filter.

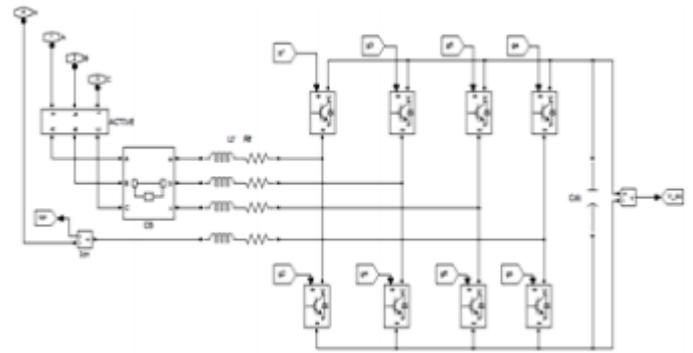


Fig 9. circuit of the shunt active power filter.

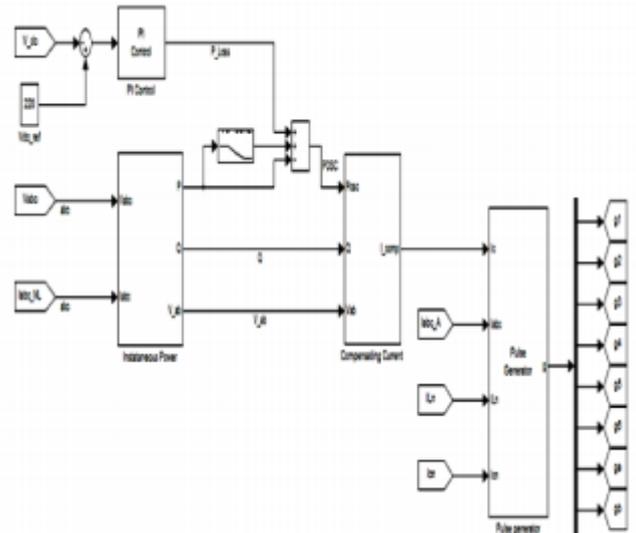


Fig 10. dq-based PIcurrent controller.

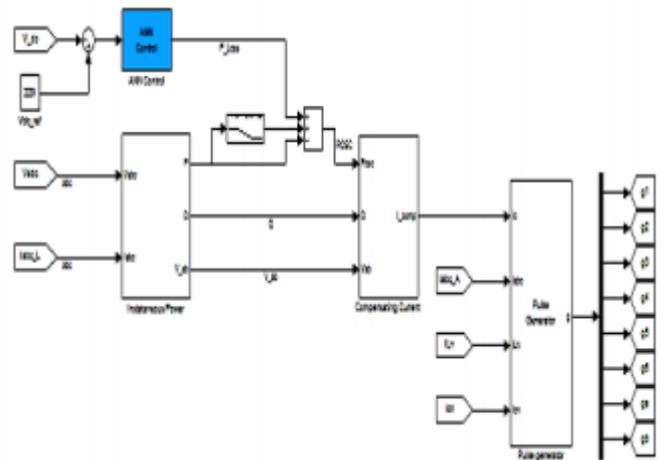


Fig 11. ANN based current controller.

The Schematic diagram ANN based current controller is showed up in Fig:11 gives the control contrive affirmation. The authentic capacitor voltage is differentiated and a set reference regard. The bungle banner is supported to ANN controller. The yield of the ANN controller hasbeen viewed as a zenith estimation of referencecurrent. It is moreover copied through the unitsine vectors(usa,usb,usc) in stage with source voltage to get the reference currents(isa,isb,isc).These

reference streams and veritable streams are given to hysteresis based ,carrier much lessPWM current controller to make buying and selling indications of PWM converter. The qualification of reference present day agency and actual contemporary options the motion switches.

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%

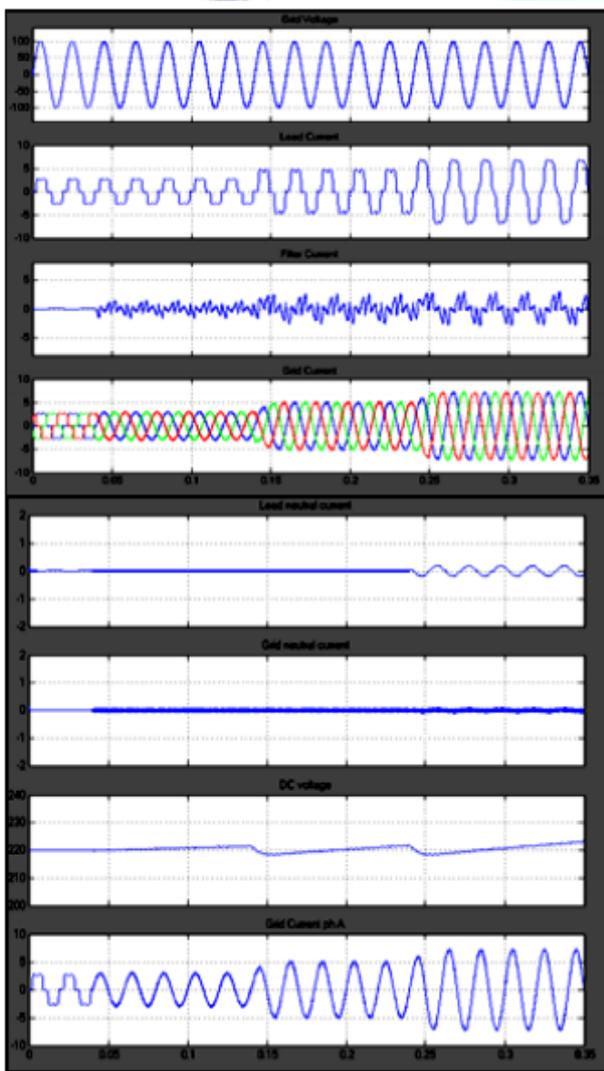


Fig 12. Simulated waveforms of the control scheme (a) Phase toneutral sourcevoltage (b) LoadCurrent (c) Active powerfilter output current (d) Loadneutral current (e) System neutralcurrent (f) Systemcurrents. (g) DCvoltage converter (h) grid current

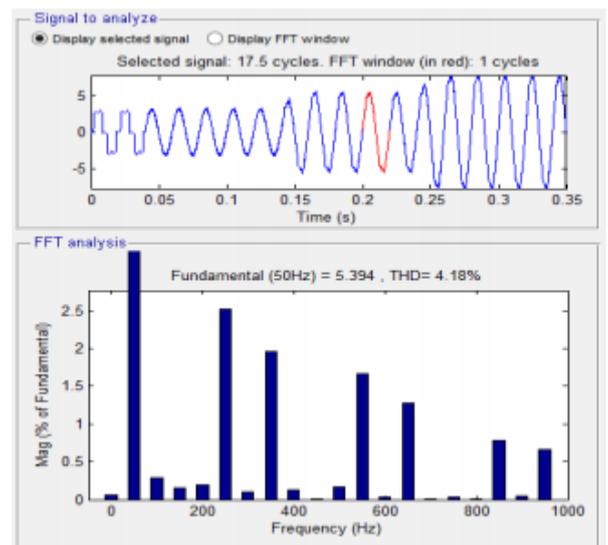


Fig 13. %THD using PI controller.

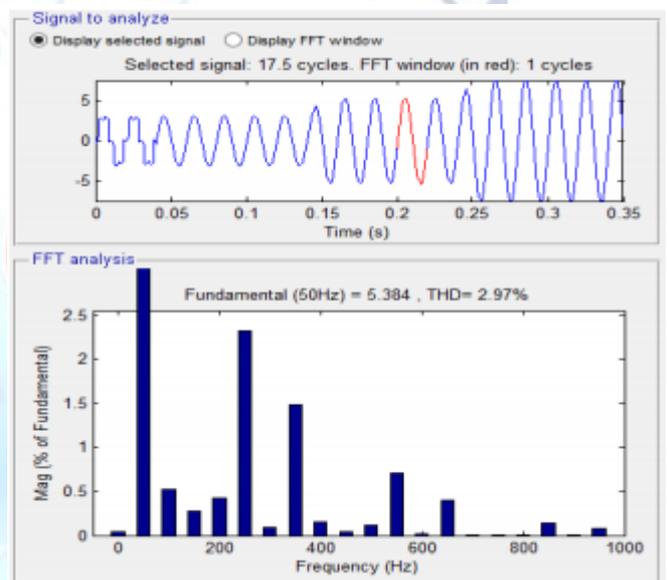


Fig 14. % THD using ANN controller.

## VI. CONCLUSION

The free forward ANN controller based one of a kind power direct has been acknowledged in MATLAB/Simulink. The various outcomes are appeared to display the fit for the masterminded ANN controller. The THD of source current for dynamic power channel utilizing PI controller is 4.18%, anyway THD for it utilizing ANN controller is 2.97%. The execution of made ANN controller for dynamic power channel is endeavored under various nonlinear weight conditions and it numerical outcomes are recorded in table. The dynamic power channel enhances the power thought of allocation framework by dismissing sounds and responsive power remuneration of non-straight load.Hence, from the preoccupation works out as intended, it can suspect that ANN controller is more sensible 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 four-leg voltage source converter," Gener. Transm. Distrib., IET, vol. 3, no. 5, pp. 437–447, May 2009.
- [4] Prabhakar and M. Mishra, "Dynamic hysteresis current control to minimize switching for three-phase four-leg VSI topology to compensate nonlinear 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.