

# **Power Quality Improvement in Grid Connected Hybrid System using ANN Control Scheme**

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**ABSTRACT:** When hybrid power generation system integrated to power system it produces major stability and control problems. The influence of the hybrid system in the grid system concerning the power quality measurements are the active power, reactive power, voltage deviation, flicker, harmonics, and electrical behavior of switching operation and these are measured according to International Electro-Technical Commission (IEC). The power quality of the source current is significantly increased by reducing the Total Harmonic Distortion (THD). The activation function of the ANN is radial basic function based on the self adaptive discrete time generalized neural network. The proposed Inverter control scheme to mitigate the power quality issues for power quality improvement in the grid connected hybrid power generation system is simulated using MATLAB/ SIMULINK in power system block set. The control scheme has a capability to cancel out the harmonic parts of the load current and maintains the source voltage and current in-phase. The performance of the system using PI and ANN is compared.

**KEYWORDS:** Power Quality, Artificial Neural Network, Total harmonic distortion (THD), Hybrid Power Generation System.

## **I. INTRODUCTION**

A large number of interconnected solar panels are used in PV array. These panels may be installed as stationary or with sun tracking technology. It is a notable factor that the globally used solar PV output and the load matching is done in an increased manner, hence Maximum Power Point Tracker (MPPT) is employed. The PV arrays which is given a most attractive option among the renewable energy resources. It is employed in vast applications due to its high efficiency, increased reliability and less maintenance [1],[2]. Due to its wide range of advantages it is widely employed in various applications through roof top supply source. The main areas of advantage is that it can be located at the place of use and no distribution network is needed. Various applications of solar PV system are,

- Grid Interactive PV Power Generation
- Water Pumping
- Lighting
- Medical Refrigeration
- Village Power
- Telecommunication And Signaling
- Solar Furnaces

Power shortage is reduced by implementing distributed generation. The power electronic loads place a major role in industries. These nonlinear loads inject harmonic currents in the AC system and increase overall reactive power demand by the equivalent load. The major power quality problems are from system to load voltage sag/swell, voltage unbalance, voltage distortion and interruptions and from load to system are current harmonics, reactive current, current unbalance, voltage notching and voltage flickering [1]. These problems can be mitigated by using various techniques. Proportional Integral (PI) control [3] instead of power converter is implemented to manage reactive power interchange between wind farm and grid. To control power converter, a new current sharing approach is proposed in [4]. Pulse

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Width Modulation (PWM) based controller operates the inverter circuit to give a desired output. The power quality of the source current is significantly increased by reducing the Total Harmonic Distortion (THD). The activation function of the ANN is radial basic function based on the self adaptive discrete time generalized neural network. The proposed Inverter control scheme to mitigate the power quality issues for power quality improvement in the grid connected hybrid power generation system. In this paper inverter control is implemented to maintain unity power factor and power quality in the point of common coupling. Active and reactive power compensation is obtained because of the absence of FACTS devices. It also cancels harmonic current in the system. Separate Battery Energy Storage System also proposed in this paper. It will give rapid response and enhance the voltage stability of the system under fluctuation of wind turbine output.

## II. HYBRID POWER EXTRACTION WITH ANN CONTROL

The proposed hybrid power extraction from wind generator and solar panel with battery energy storage with distributed network is configured on its operating principle and is based on switching the inverter by using control strategy for critical load application is shown in fig. 1.

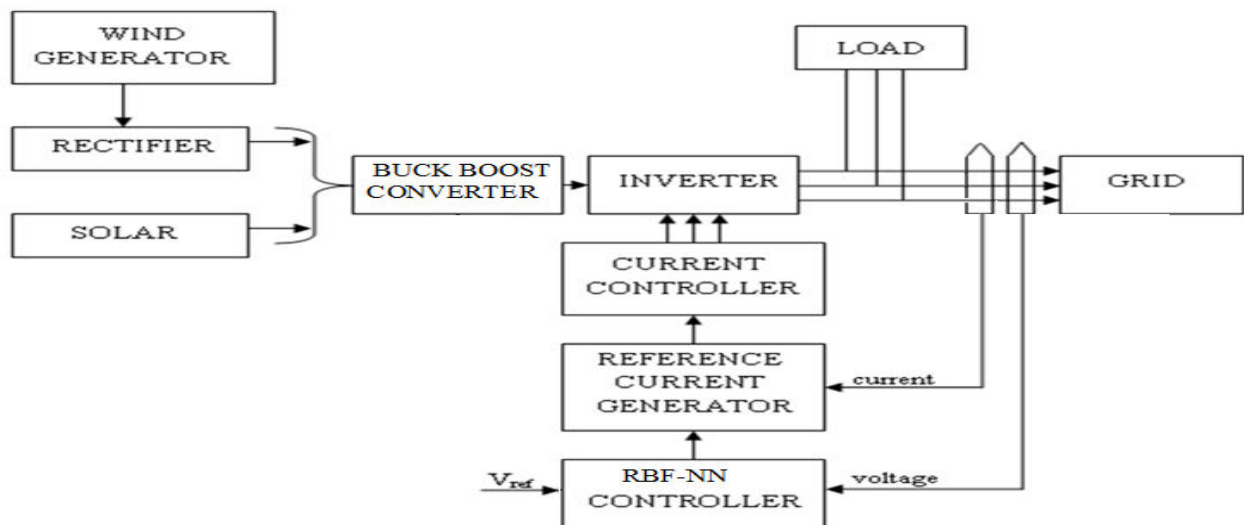


Fig.1. Scheme for Hybrid Power Generation

### A. Wind Energy Generating System

It consists of a wind turbine, Permanent Magnet Synchronous Generator and diode rectifier to get DC bus voltage. The following mathematical relation gives the wind turbine characteristic in the wind

$$P_{wind} = \frac{1}{2} \rho \pi R^2 V^3$$

Where  $\rho$  denotes air density (1.225 kg/m<sup>3</sup>),  $V_{wind}$  denotes the wind speed in m/s, and  $R$  denotes the rotor radius in meters. It is not possible to extract all kinetic energy of wind; this is called the power coefficient. It is a function of tip speed ratio and pitch angle.

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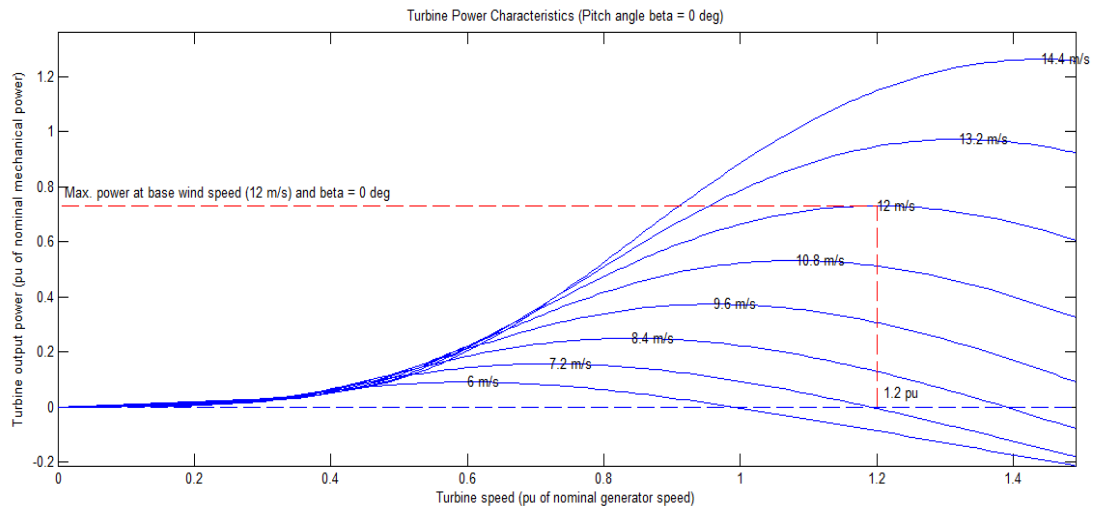


Fig. 2 Wind turbine speed-power characteristics

Where  $\rho$  denotes air density (1.225 kg/m<sup>3</sup>),  $V_{wind}$  denotes the wind speed in m/s, and  $R$  denotes the rotor radius in meters. It is not possible to extract all kinetic energy of wind is called power coefficient. It is a function of tip speed ratio and pitch angle.

$$P_{mech} = C_p P_{wind}$$

$$P_{wind} = \frac{1}{2} \rho \pi R^2 V^3$$

## B. Solar System

Photo-Voltaic (PV) cells produce electricity from sun. Materials used in computer chips are similar to materials used in PV cells. These materials absorb energy from sunlight, which isolates the electrons from their atoms and allows them to generate electric power.

PV cells are great because they don't require regular maintenance, are eco-friendly, and don't produce pollution in any form. The PV array is constructed solar cells. Each solar cell formed by a PN junction semiconductor, which produces currents by Photovoltaic effect. Fig. 3 shows solar cell parameters.

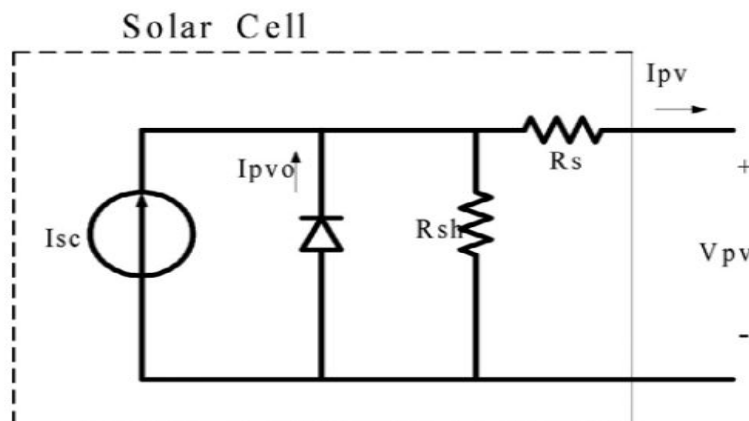


Fig. 3 Solar cell parameters

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Current and voltage values injected from PV cell can be calculated by using formula given below. These materials absorb energy from sunlight, which isolates the electrons from their atoms and allows them to generate electric power. PV cells are great because they don't require regular maintenance, are eco-friendly, and don't produce pollution in any form.

$$V_{pv} = \left(\frac{nKT}{q}\right) \ln\left(\left(\frac{I_{sc}}{I_{pv}}\right) + 1\right)$$

$$I_{pv} = I_{sc} - I_{pv0} e^{\left(\frac{q(V_{pv} + I_{pv}R_s)}{nKt} - 1\right)} - \left(V_{pv} + \frac{R_s I_{sc}}{R_{sh}}\right)$$

Where  $R_s$  &  $R_{sh}$  - Series and Shunt resistances respectively.

$I_{sc}$  - The light induced current,

$n$  - The ideality factor of p-n junction,

$I_{pv0}$  - The diode saturation current,

$K$  - Boltzmann constant ( $8.63 \times 10^{-5} \text{ J/}^\circ\text{K}$ ),

$q$  - The electronic charge.

$I_{sc}$  always depend on the irradiance level 'S' and the array temperature 'T'.

### III. MODELLING OF INVERTER CONTROL

#### A. Using conventional PI controller

The inverter control by using PI based voltage regulator is shown in fig. 4.

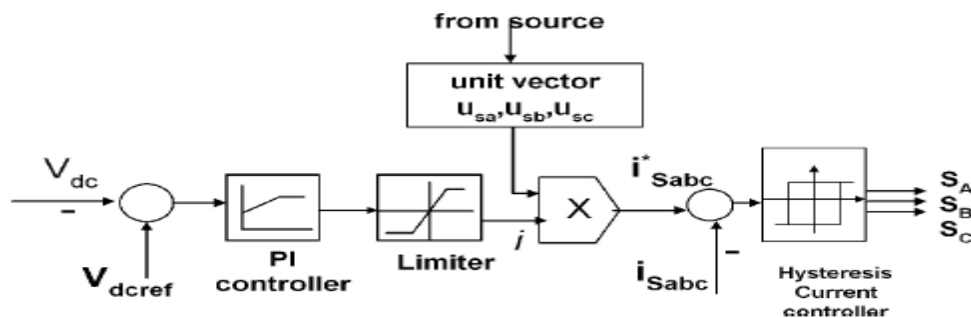


Fig. 4 PI Based Voltage Controller

#### B. Using ANN controller

Artificial Neural Network is fed by one input that is voltage error. This gives the source current output.

Fig. 5 shows ANN based voltage regulator.

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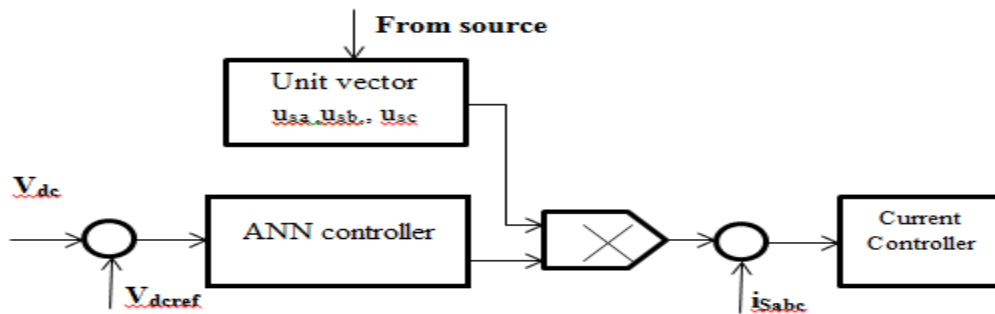


Fig. 5 ANN Based Voltage Controller

The control scheme is simulated using SIMULINK power system block set. The system parameters for given system is listed in Table 1.

S.NO	PARAMETERS	RATINGS
1	Grid Voltage	3-Phase, 600V,60Hz
2	Permanent Magnet Synchronous Generator	3.5KVA, 600V,60Hz,P=4, Speed=1440rpm, R <sub>r</sub> =0. 1 Ω , R <sub>s</sub> =0. 15 Ω , L <sub>s</sub> =L <sub>r</sub> =0. 06H
3	Line series inductance	300mH
4	Inverter parameters	DC Link Voltage=800V,DC Link Capacitance=100 μ F, Switching Frequency=2kHz
5	IGBT ratings	Collector Voltage=1000V, Forward Current=50A,Gate Voltage=20V,Power Dissipation=310w
6	Load parameters	Non-linear load=50kW

Table1. Proposed System Parameters

### IV.ANN CONTROLLER

A mathematical Weight enhances the effectiveness and increases the speed. Since there is no standard weights the values are assigned randomly. In general values of weights are elected from a choice [-a, +a] where 0.1 < a < 2. The weight adjustment progression is made by means of the following equation

$$W_{ij} = W'_{ij} + (1 - M). LR. e_j. X_j + M. (W''_{ij} - W'_{ij})$$

Biases are usually having the value as one which is added to the value at each node excluding the input node in the feed forward phase. The bias related with a exacting node is added to the expression  $B_j$ ,

$$B_j = \sum_i w_{ij} a_i$$

**V. RESULTS AND DISCUSSION**

The hybrid power generating system is integrated with the grid having critical load. Due to variation in hybrid power generation and nonlinear load source current of the grid affected. The three phase injected current into the grid from Inverter will cancel out the distortion caused by the non-linear load. Figure 5 shows the source current and voltage waveform of the test system without Inverter Control and the Figure 6 and 7 shows the corresponding FFT analysis waveform. From FFT analysis, it is shown that the Total Harmonic Distortion (THD) of the source current and voltage waveforms of the test system without Inverter Control are 24.42% and 25.03% respectively.

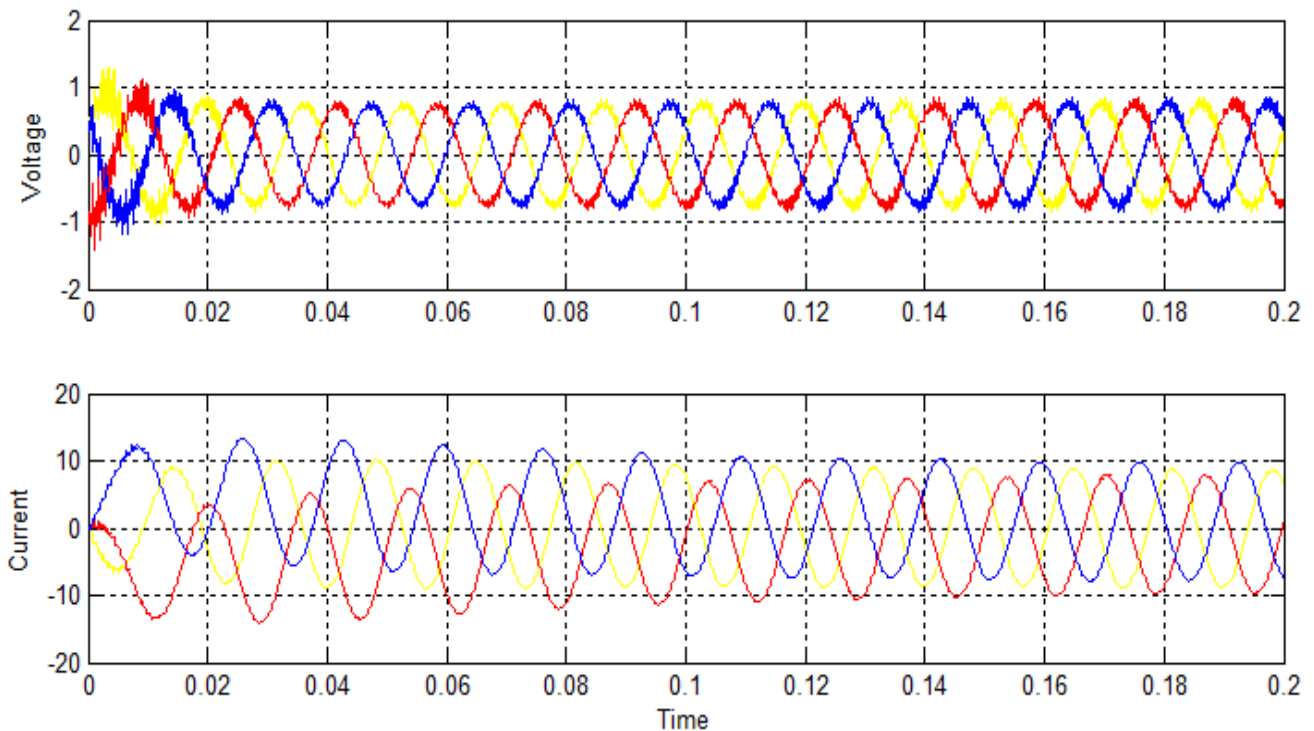


Fig.5. Source Current And Voltage Waveform Without Inverter Control

The source current and voltage waveform with and without inverter control varies with a definite interval of time. Fig 5 represents the source and voltage waveform without any inverter control. As the above graph lags in a perfect sinusoidal waveform and due to the fluctuations on the wind control of inverter is done to ensure that the total harmonic distortion is maintained up to the level as possible. The inverter control is done by implementing the Proportional integrator (PI) and also the artificial controllers like Artificial Neural Network (ANN). The inverter control scheme can be compared to identify the difference in the controller performance. The THD (Total Harmonic Distortion) level is maintained as good as possible by using soft computing inverter control schemes. The THD level of the voltage and the current signal is tested to be high without inverter control schemes. The THD level of the hybrid wind-pv system without inverter control scheme is given below,

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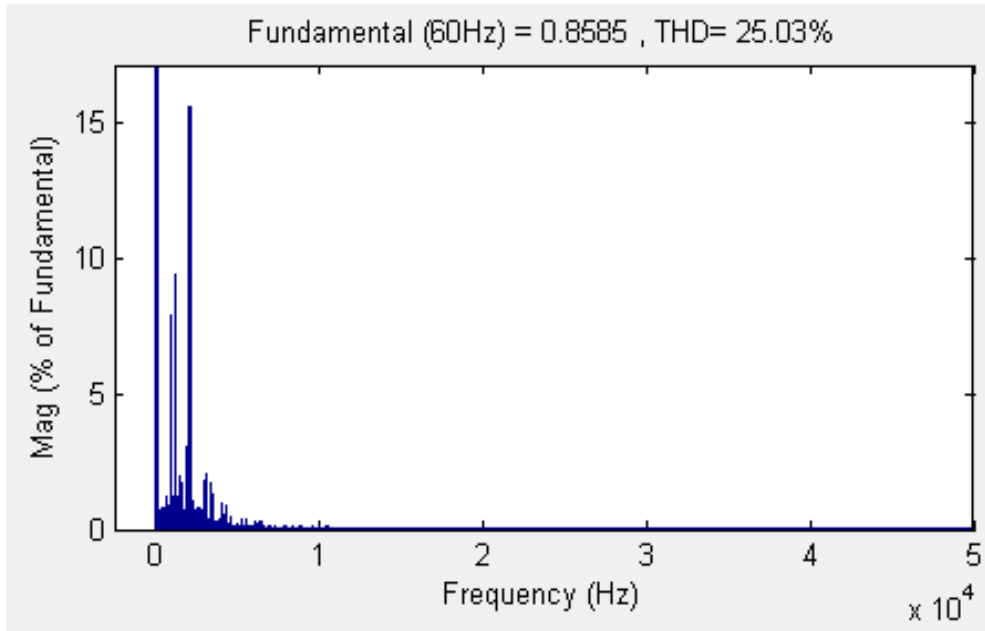


Fig.6. THD Value of Voltage Signal without Inverter Control

The THD value of the current signal without inverter control is found to be 24.42% as shown below.

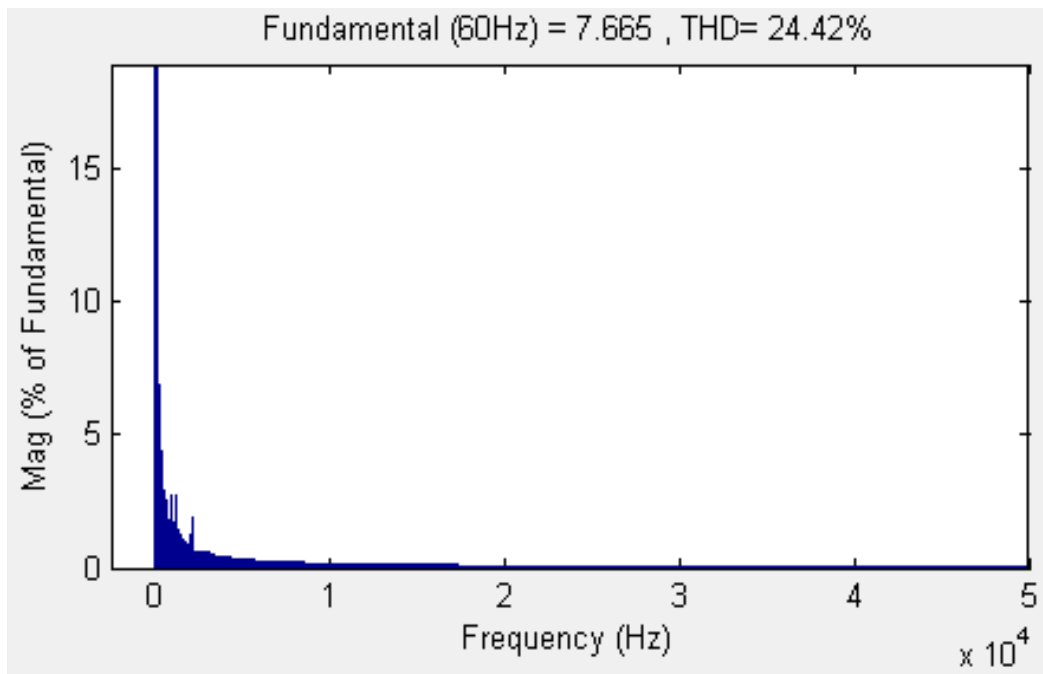


Fig.7. THD Value of Voltage Signal without Inverter Control

### A. Using PI Control Strategy

Figure 9 shows the source voltage and current waveforms of the test system with PI controller based INVERTER and the Figure 10 and 11 shows the corresponding FFT analysis waveform. From FFT analysis, it is observed that the THD

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of the source voltage and current waveforms of the test system with PI controller based INVERTER are 2.95% and 0.79% respectively.

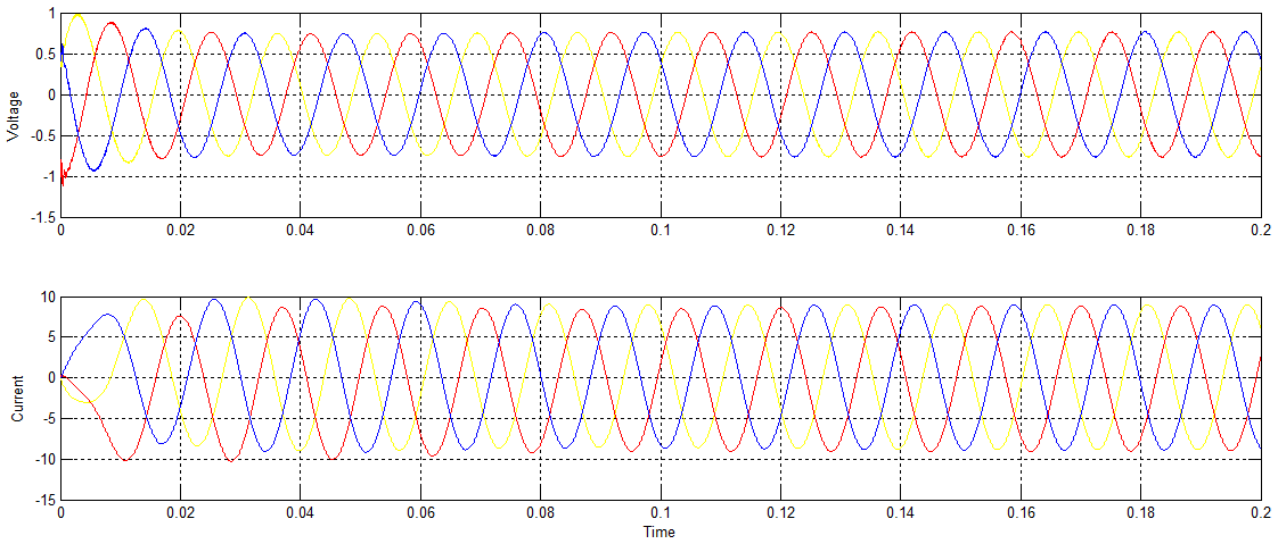


Fig.8. Source Current and Voltage Waveform With PI Inverter Control

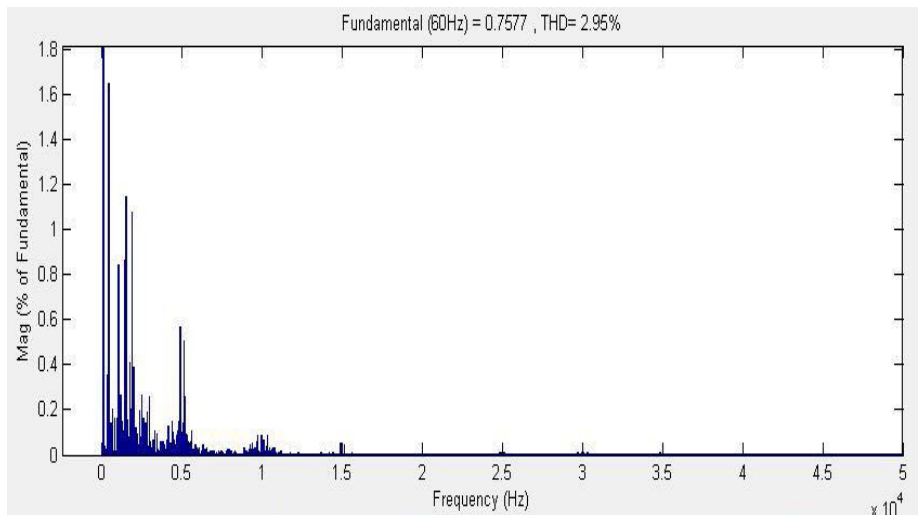


Fig.9. THD value of voltage signal with PI control



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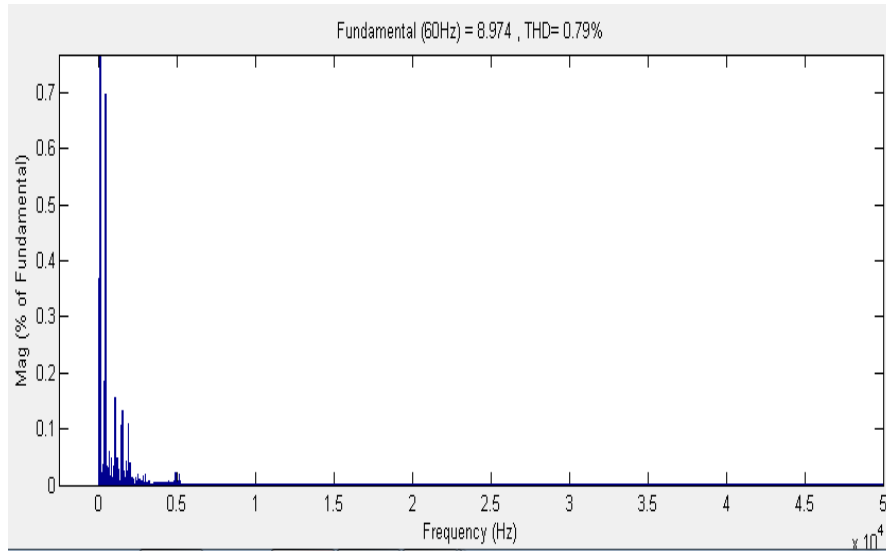


Fig.10. THD value of current signal with PI control

## B. Using Fuzzy Controller

Figure 14 shows the source voltage and current waveforms of the test system with FLC based INVETER control and the Figure 15 and 16 shows the corresponding FFT analysis waveform. It is shown from the FFT analysis, THD of the sourcevoltage and current waveforms of the test system with FLC based INVERTER control are 0.49% and 0.29% rep. Thus, it is observed that there is a further reduction in the THD value of the source voltage and current waveforms.

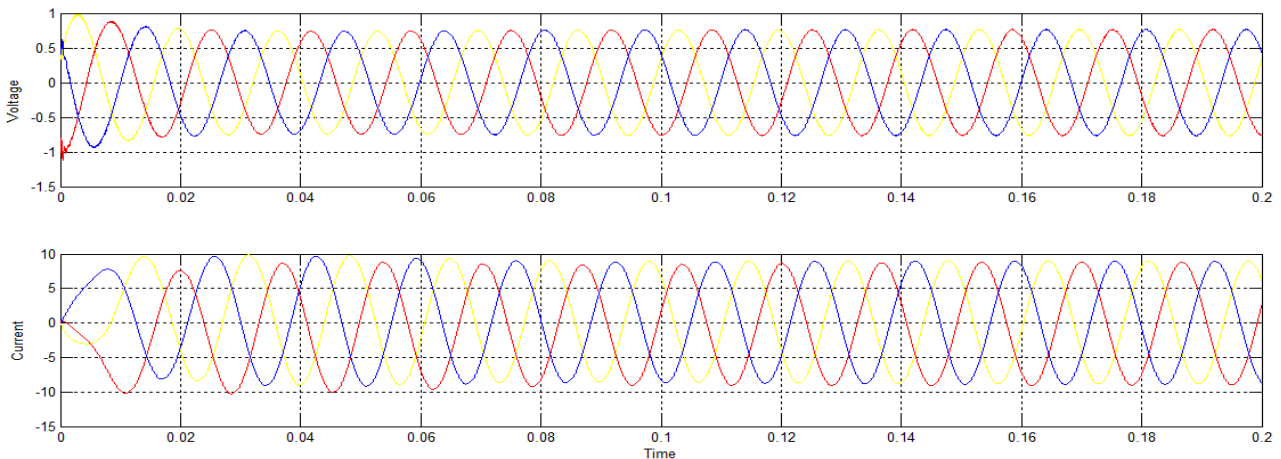


Fig.11. Source Current and Voltage Waveform With ANN Inverter Control

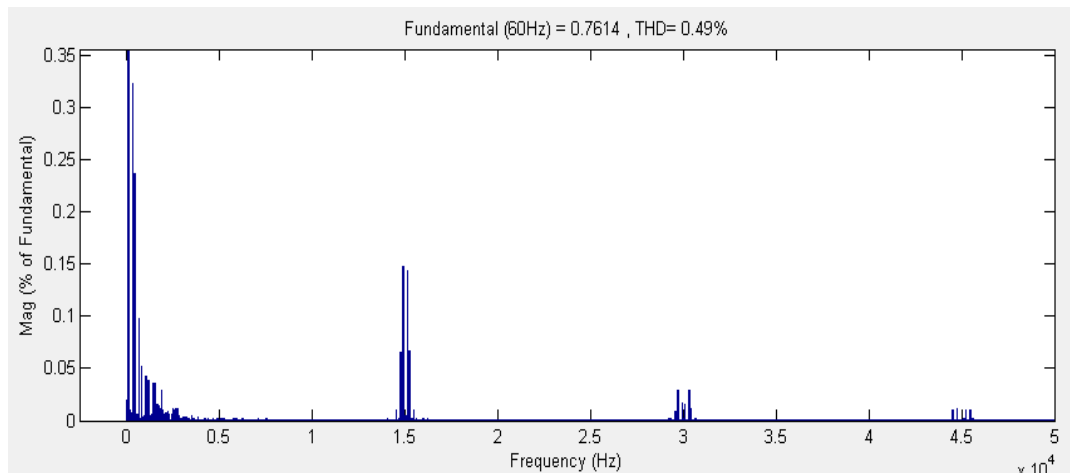


Fig.9. THD value of voltage signal with ANN control

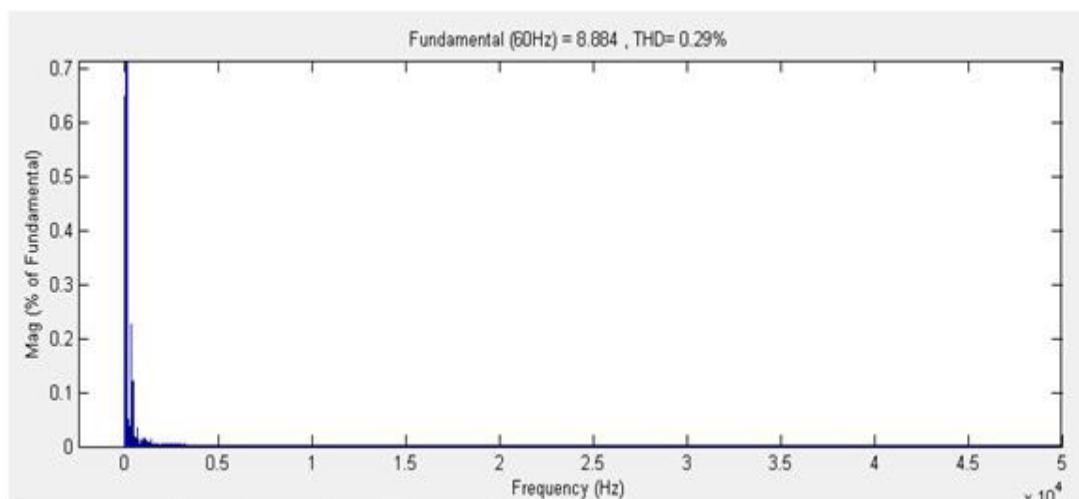


Fig.9. THD value of current signal with ANN control

## VI. CONCLUSION

The wind-solar hybrid system with battery energystorage and an inverter in current control mode for exchange of real and reactive power support to the non-linear load was proposed. The Fuzzy Logic controller based inverter control strategy has been developed for grid connected wind-solar hybrid system. Distributed Generation produce harmonics when integrate with grid sources. By using suitable control circuit this harmonics are reduced. The artificial neural controller based INVERTER is presented for grid connected Wind Energy Generating System. The proposed artificial neural based INVERTER have improved the power quality of source current significantly by reducing the THD from 22.45% to 0.29 %. It is clearly presented that INVERTER with artificial neural controller gives better performance than INVERTER with conventional PI controller.

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