WIND ENERGY CONVERSION SYSTEM IS CONNECTED TO GRID WITH ASF & ANN CONTROLLER

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ABSTRACT:
This study deals with a three-phase multifunctional grid-connected inverter interfaced with a wind energy conversion system (WECS) is described. The studied system consists of a permanent magnet synchronous generator (PMSG) based wind turbine, a rectifier and a three-phase voltage source inverter connected to the utility at the point of common coupling. To ensure the multifunctional feature, we propose a direct power control (DPC) which is applied to eliminate line current harmonics, compensate reactive power and feeding wind power into the utility. Simulation results are provided to demonstrate the effectiveness of the proposed system. The results show that the control algorithm of system is effective for eliminating harmonic currents, reactive power compensation and inject the active power available from the PMSG wind turbine into the load and/or grid, which allowed us to confirm the robustness of the proposed strategy.

Key Words – *PI controllers, ANN networks, Non linear loads.*

I. Introduction:

Non-traditional mode of era of power has numerous benefits over traditional assets of technology. It is eco-friendly, cost effective; harm unfastened, long lasting and more over harmless. Electricity era via wind strength is considered as socially useful and economically feasible for several applications. In a year many huge utility scale wind electricity vegetation are set up. There are specific components of a Wind Energy Conversion System (WECS), of which the most vital is the kind of generator used.

There are several types of generator used consisting of doubly fed Induction generator (DFIG), Self-excited induction generator (SEIG), and permanent magnet synchronous generator (PMSG). Among those generators, PMSG has several benefits, which make it very usable for WECS. Domestic and commercial devices use an increasing number of circuits having a non-linear conduct. They create, within the distribution networks, non-sinusoidal currents causing high harmonic currents. This brings about the reduction of power factor, reduces the performance and decreases the machine plays.

Traditionally, the most effective method to dispose of present day harmonics and to increase the strength element is using passive LC. However, the use of passive clear out has many risks. Recently, due to the rapid development in modern electricity electronic technology, the previous works had been orientated totally on the lively filters in place of passive filters. The shunt energetic energy clear out (SAPF) is one of the maximum famous lively filters. The shunt active power clear out injects currents same however opposite with the harmonic components, therefore simplest the fundamental additives flows inside the factor of not unusual coupling (PCC).

In this venture, a PMSG wind turbine coupled with shunt lively electricity filter with the intention to inject the wind energy into the software grid. The whole device can provide the strength issue correction, harmonic removal, reactive electricity repayment, and simultaneously inject the lively energy to be had from the PMSG wind turbine into the load and/or grid. Many researches have been accomplished on energetic power clear out furnished through wind energy conversion System. And a lots of them they used ‘‘p–q principle” for harmonic currents detection and removal which is primarily based on harmonic currents identity and instantaneous present day manipulate loops.

This project proposes the direct power control (DPC) technique for a multifunctional grid-linked inverter interfaced with a wind energy conversion machine (WECS). The major purpose of DPC is to control the amplitude of the instantaneous energetic and reactive powers to generate the switching moments of the inverter switches. The active power command is provided from a dc-bus voltage controller block, while the reactive energy command is directly given from the outdoor of the controller. Errors among the instructions and the anticipated comments energy are input to the hysteresis comparators. Inner contemporary manipulate loops and PWM modulator aren't required in DPC because the converter switching states are selected by using a switching desk based totally on the instantaneous errors among the commanded and envisioned values of energetic and reactive powers.

The standard manipulate gadget of a multifunctional grid linked inverter interfaced with a wind electricity conversion machine is constructed inside the Matlab/Simulink surroundings. Then, the simulations outcomes are supplied to validate the correctness of the adopted manage gadget.

The traditional regular-velocity Wind Energy Conversion System the usage of squirrel cage Induction Generator or Dually Fed Induction Generator (DFIG), but the electricity supplied to the load is does not music the Maximum power factor. The MPPT manipulate approach is usually carried out that permits you to alternate the wind electricity into electric energy at higher efficient degrees, within the wind electricity technology device. In this task we're studying approximately the variable velocity wind electricity conversion Wind electricity Conversion System.

In literature available grid connected WECS is available in shunt configuration and series configurations [1-3]. Compare to voltage sources converters (VSC), current source converters (CSC) have significant features such as protects from the short circuits, improve power factor, control real & reactive power, and simple structure. The similarity in CSC employed series configurations is it can operate in mono polar mode. HVDC mono polar is suffered with system insulation; wind generator must require the neutral point. To handle this problem require transformer (low frequency) connection between generator and converter. This problem is also solved by medium frequency rating transformer (MFT) reported in [4-6]. Mon polar HVDC has still facing challenges in terms of economical and flexibility.

In paper mainly focused on reduces the insulation of WECS system employing inverter. Here inverter acts as shunt active power filter. In Mono polar need the transformer setup it may act as bulk on total system. In mono polar links current divides equally, in bi polar used dc link control method it helps to improve over system efficiency. The next sections of this paper is summarized as follows, configuration of grid connected WECS in Section –II, presented control scheme in section –III, MATLAB simulation results in section –IV and concluded in section-V.

II. System Configuration:

The configuration of grid interconnected with WECS is shown in figure.1. In this inverter it acts as a shunt active power filter.

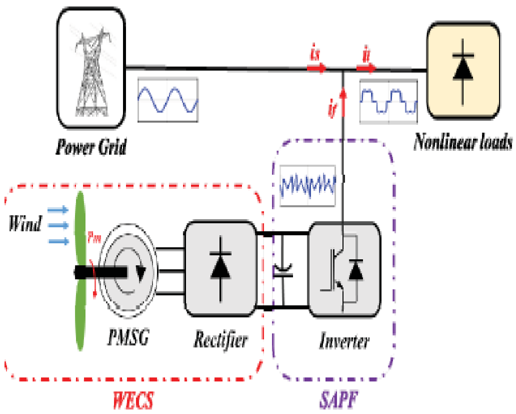

Fig.1. Grid connected WECS with non linear load

The Dynamic Modelling of PMSG is described below. The equivalent circuit diagram of PMSG is shown in Fig.2 and Fig.3.

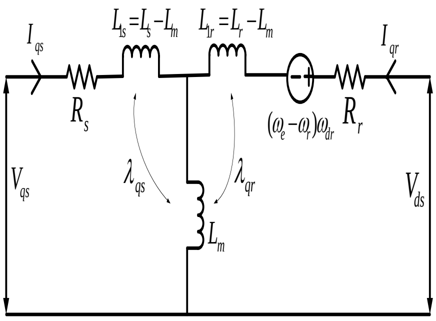

Fig.2: Equivalent circuit of PMSG (q-axis circuit)

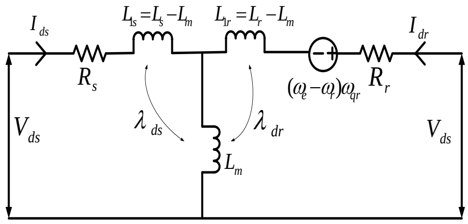

Fig.3: Equivalent circuit of PMSG (d-axis circuit)

The stator circuit equations are given by

$$V_s{}^r = R_s i_s{}^r + \frac{d\lambda_s}{dt} + J\omega_k \lambda_s{}^r \quad (1)$$

$$V_r{}^r = R_r i_r{}^r + \frac{d\lambda_r}{dt} + J(\omega_k - \omega_r)\lambda_r{}^r \quad (2)$$

where,

$v_s{}^r, v_r{}^r$= Stator and rotor voltage space vectors,

$\lambda_s,{}^r\ \lambda_s{}^r$= Stator and voltage flux linkage space vectors,

$i_s{}^r, i_r{}^r$= Stator and rotor current space vectors and

ω_r= Rotor angular speed.

$$\lambda_s{}^r = L_s i_s{}^r + L_m i_r{}^r \quad (3)$$

$$\lambda_s{}^r = L_m i_s{}^r + L_r i_r{}^r \quad (4)$$

where,
L_s=Statorinductance,
L_r=Rotorinductance
L_m= Mutual inductance.

$$\frac{d\lambda^r{}_s}{dt} = v_s{}^r - \frac{R_S}{K}(L_r\lambda_r{}^r - L_m\lambda_r{}^r) - J\omega_k\lambda_s{}^r \quad (5)$$

$$\frac{d\lambda^r{}_r}{dt} = v_r{}^r - \frac{R_r}{K}(L_s\lambda_r{}^r - L_m\lambda_s{}^r) - J(\omega_k - \omega_r)\lambda_r{}^r \quad (6)$$

where, K =.$L_sL_r - L^2{}_m$

The flux linkage expression can be given as,

$$\frac{d}{dt}\begin{bmatrix}\lambda_{ds}\\ \lambda_{qs}\\ \lambda_{dr}\\ \lambda_{qr}\end{bmatrix} = \begin{bmatrix}\frac{-R_sL_r}{K} & \omega_k & \frac{-R_sL_m}{K} & 0\\ -\omega_k & \frac{-R_sL_r}{K} & 0 & \frac{-R_sL_m}{K}\\ \frac{-R_rL_m}{K} & 0 & \frac{-R_rL_s}{K} & (\omega_k - \omega_r)\\ 0 & \frac{-R_rL_m}{K} & -(\omega_k - \omega_r) & \frac{-R_rL_s}{K}\end{bmatrix}\begin{bmatrix}\lambda_{ds}\\ \lambda_{qs}\\ \lambda_{dr}\\ \lambda_{qr}\end{bmatrix} + \begin{bmatrix}V_{ds}\\ V_{qs}\\ V_{dr}\\ V_{qr}\end{bmatrix} \quad (7)$$

The torque expression is given by,

$$T_e = \frac{3}{2}\frac{p}{2}\frac{L_m}{L_s}(\lambda_s{}^r i_r{}^{*r}) \quad (8)$$

B. DPC Scheme:

DPC standards for direct power control scheme it is similar to direct torque control scheme. This approach is real power (Ps) and reactive power (Qs) is sensed instead of inverter output voltage and current [7-10]. This inverter switching pattern can be decides the total operation of WECS. It can be operated with ANN control scheme. DPC control scheme is shown in figure.4.

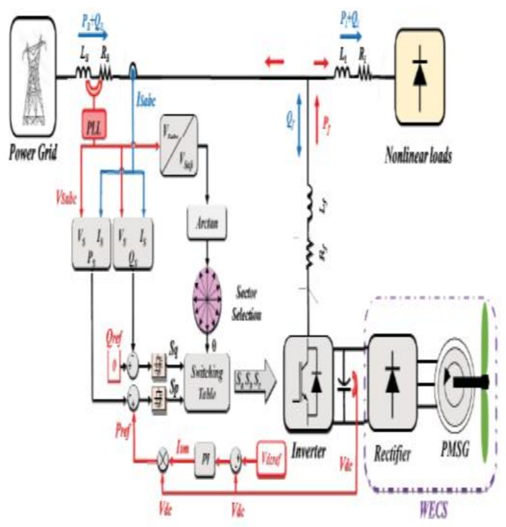

Fig.4. Grid connected WECS with DPC control scheme

III. Comparative study of PI controllers and ANN:

Conventional control strategy is available in two ways speed mode control strategies and current mode control strategies, these two control topology's are depends on the setting reference values. This reference values are electromagnetic torque and active power for current control method, In speed control method rotational speed of WT consider as reference value. Simulation results of WT system with current control method and speed control method. Speed control method is little faster dynamic response but complex to design compare current control method. Wind speed and generated rotational energy exactly measured in conventional control scheme. It may mismatch if anemometer does not measure wind speed due to wind gusts or influence of wind shadow.

The disadvantages of conventional control schemes are numerously overcome by using intelligent control strategies like ANN, ANN is a self tuning PI control algorithms. In this approach controller itself regulate the PI values and produce the maximum energy. Intelligent controllers are majorly applied for hill-climbing control and ANN controller to the MPPT control. However, these control algorithms are usually slow in speed because of fixed step disturbance. So, few advance hill-climbing control methods are proposed. For example, a method of using variable-step wind energy perturbation method to control the captured wind power was analysed. ANN based MPPT strategies are much advantages, it have robust speed control strategy against to wind gusts, production of oscillating torque. This control strategy does not depends on density of the air, have superior steady state and dynamic performances.

The simple structure of artificial network is shown in below figure.5a.

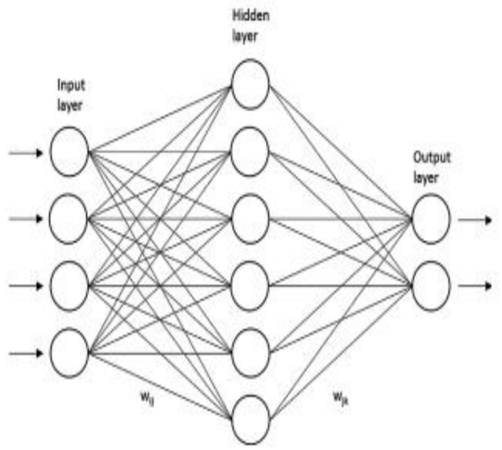

Fig.5a. Structure of ANN

ANN's structures works are depend on biological neurons. This structure provides a best solution to various problems that cannot be defined. The ANNs are much helpful to solve the wide range of problems that can be divided into seven categories such as

1. Pattern classification
2. Clustering
3. Approximation
4. Forecasting
5. Optimization
6. Association
7. Control

These are determining the inputs and output layers that will used to get desired system performance.

In this paper a six step ANN is employed to get desired performance of the system that can be shown in below figure.5b.

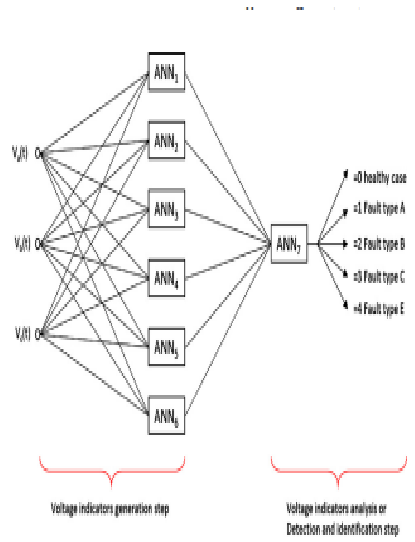

Fig.5b. structure of six step ANN

IV. Simulation Results:

The performance of grid connected WECS system, MATLAB simulation results are source voltage, source currents, active, reactive powers and harmonic spectrum without compensation is discussed in Case-A, with PI controllers discussed in Case-B and with ANN controllers is discussed in Case-C

Case A:

Simulation results before (without) harmonics compensation is shown in figure 6a to figure 6e.

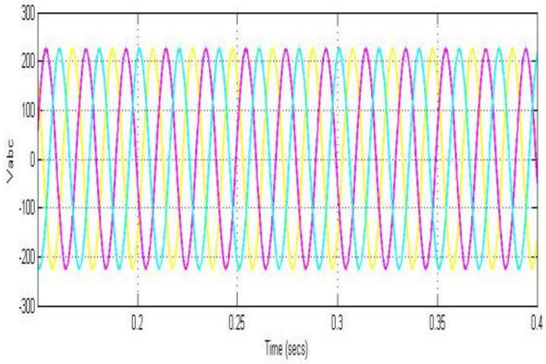

Figure.6 a. Source voltage

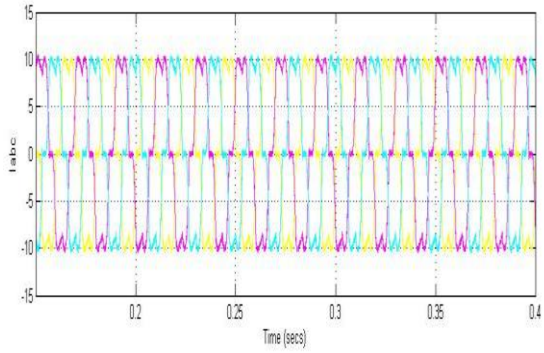

Figure6b. Source current

Form the figure. 6b it is clear that without compensation source current is more unbalance and contains harmonics.

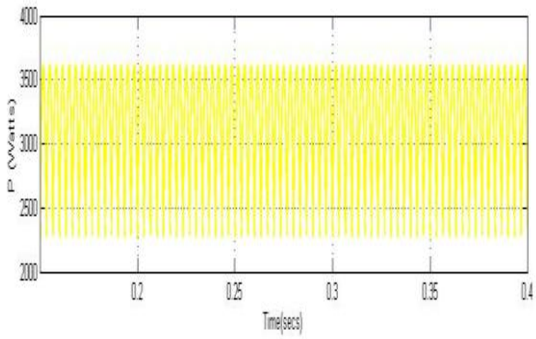

Figure6c. Real Power

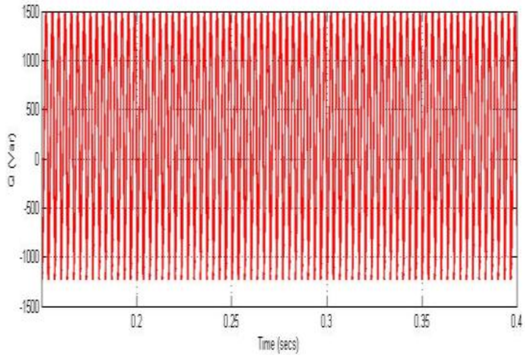

Figure6d. Reactive power

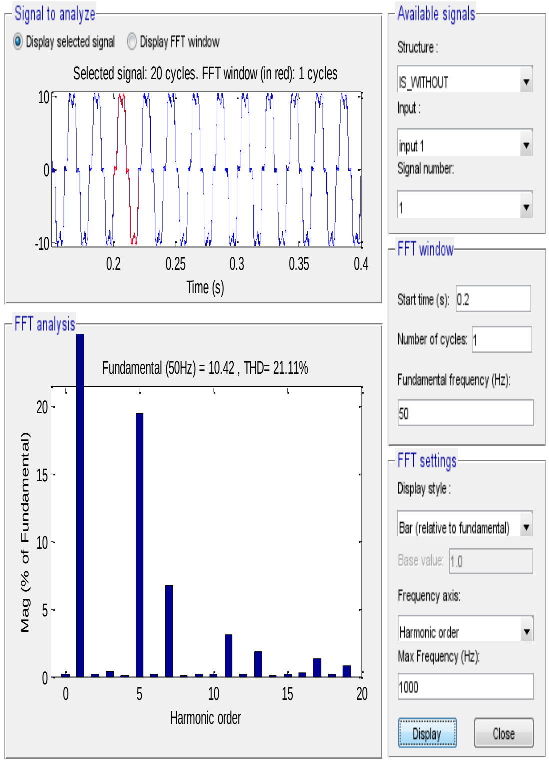

Fig.6e. THD of source current

From the simulation results in without compensation technique harmonic content in source current is high that is measured in terms of total harmonic distortion (THD) factor that is obtained around 21.11%.

Case B:

Simulation results after harmonics compensation with and without WECS employing PI controllers is shown figure.7a to 7f. From the simulation results is clear that harmonics in source current is less.

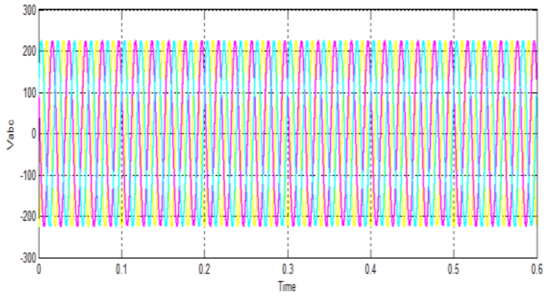

Figure.7a. Source voltage

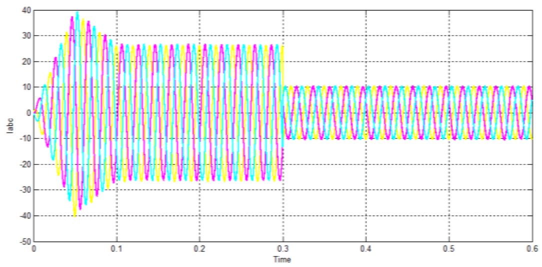

Figure.7b. Source current

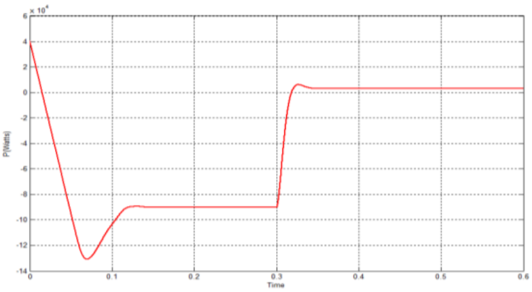

Figure.7c. Active power

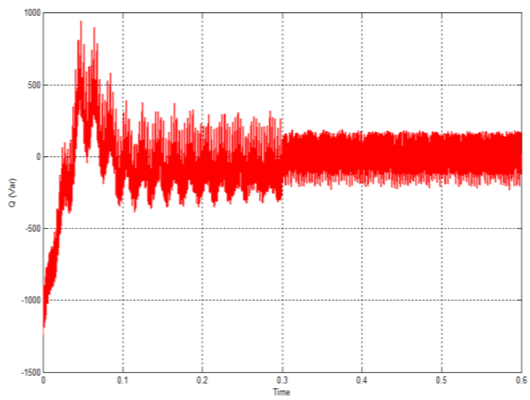

Figure.7d. Reactive power

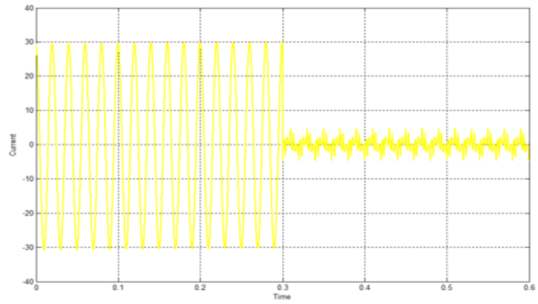

Figure.7e. Filter current

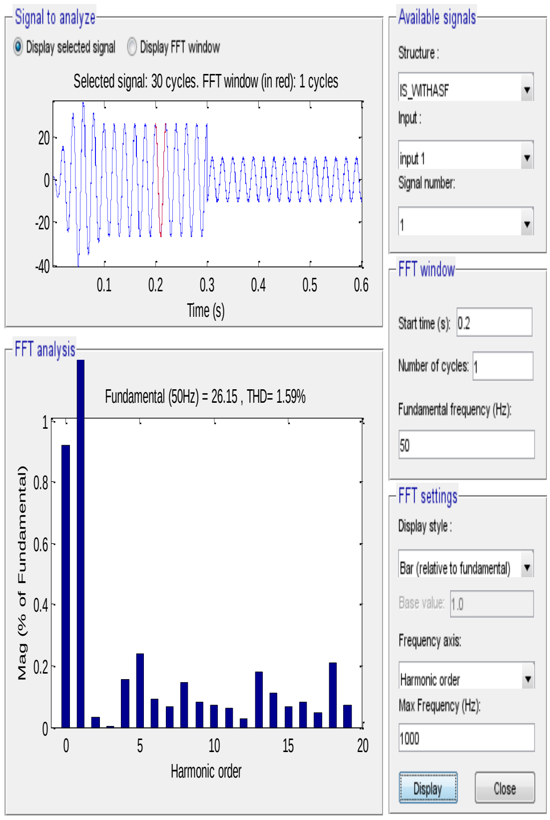

Figure.7f. THD of source current

From the THD spectrum it is clear that harmonics production in source is current is 1.59% it is 20 times less than without harmonic compensation technique.

Case C:

Simulation results after harmonics compensation with and without WECS Employing ANN are shown in figure 8a to figure 8f.

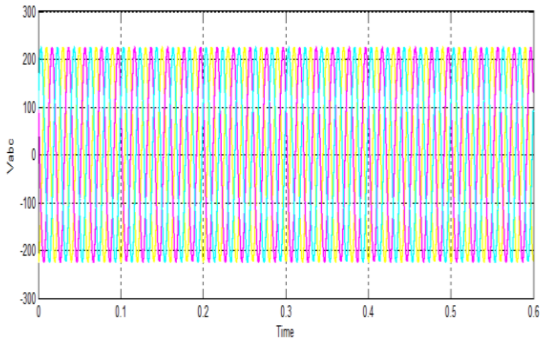

Figure.8a. Source voltage

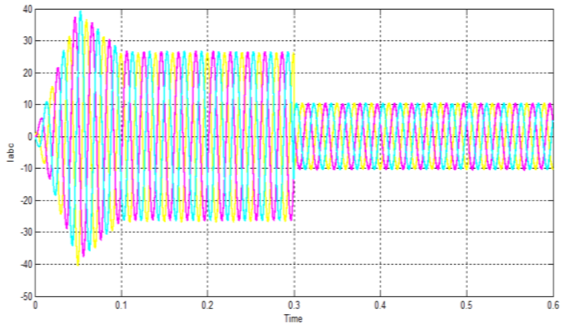

Figure.8b. Source current

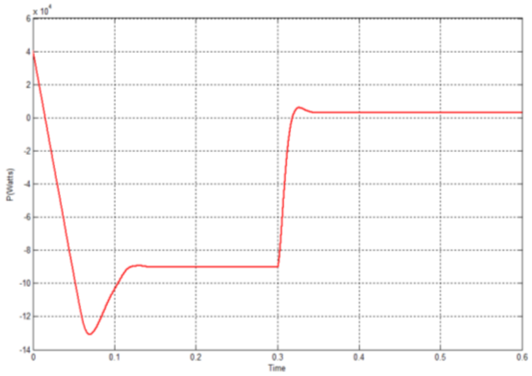

Figure.8c. Active power

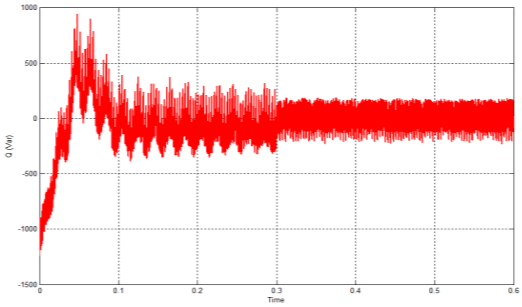

Figure.8d. Reactive power

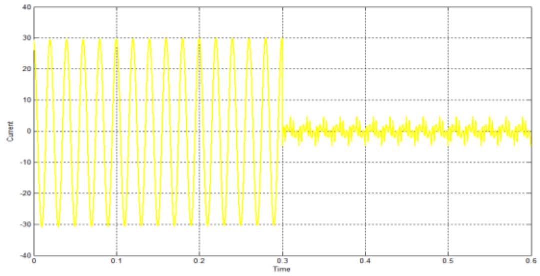

Figure.8e. Filter current

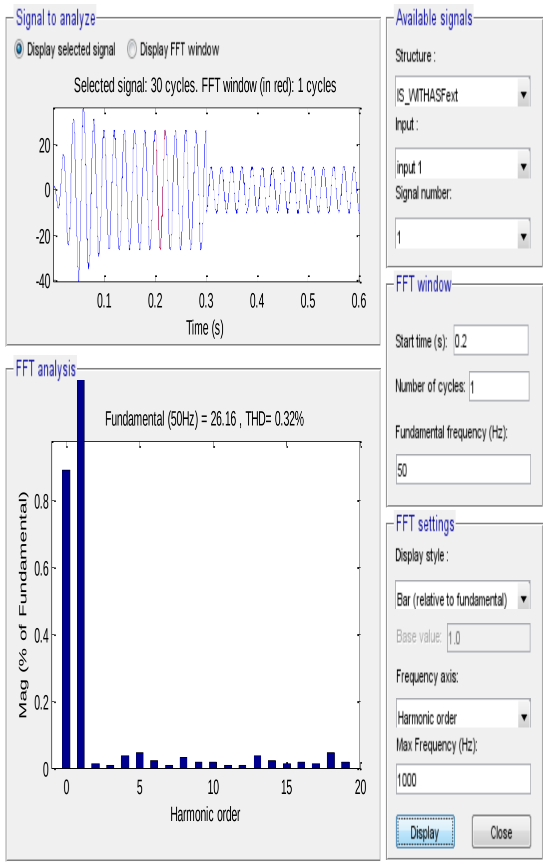

Fig.8f. THD of source current

From the THD spectrum it is clear that harmonics production in source is current is 0.32% it is almost negligible. Improve the response the system very accurately by using proposed ANN control technique.

V. Conclusion:

This project is implemented only with the WESC. Further it can be used with ANFIS energy conversion system, Such as ANFIS energy conversion system. In such system the combination of wind and PV statcom can also be developed with this controller.. As mentioned in conclusion the ANFIS system till to the day is applied only with the rotor side connection , however this can be applied to all grid side system. Along with harmonic reduction other methods are also used to provide the best utilization chances. ANFIS controller can be modelled further.

This project may set the platform for the other researches. As we know "The Need is the Mother of Invention". These present day need forces us to achieve greater success, in that aspect the proposed method may become guide map.

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