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Power Quality Improvement in DFIG based Microgrid using ANN Controller

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Abstract:

This paper presents the power quality analysis of microgrid. The Hybrid system is a combination of PV, DFIG-Wind and Battery systems. Here, three various system of micro-grid are taken namely, PV-Battery system, DFIG system, Hybrid system to show the importance of DFIG and its in-built converters. The DFIG is a set of Grid and Rotor side converters. All the three systems are to be model and simulate in Matlab. The Grid Side Converter (GSC) of DFIG also utilized as inverter of PV System which reduces the cost of one converter also improves the power quality and harmonic distortions. To improve the power quality of proposed grid side converter is to be implement with ANN controller.

Introduction:

In the present scenario, maximum utilization of energy demand in the world is based on fossil fuels such as coal, natural gas and petroleum products. But, in this one of the major disadvantage from these products are global warming, and these result in great danger for life on the planet [1].

The alternative solution for this fossil fuels are utilization of renewable energy sources. The power generated by a wind energy system is depends on the climate conditions; for example, if in case of rainy or in case of cloudy conditions, it is not possible to meet the energy demand [2]. For flexible and reliable operation of the system, the best solution is to integrate the wind generation system with other renewable sources such as solar, electrolyzer, fuel cell or in some cases grid interconnection.

The capability of fuel cell power generation system, wind energy generation system and photovoltaic based hybrid system can be to overcome the inconvenience caused by the grid power system. Hence, in this paper the coordination of FC, Solar and wind generation system is considered for eliminating the fluctuations [3].

This simulation model is performed using Matlab and SimPower Systems and results are presented to verify the effectiveness of the proposed system [4]-[5]. The proposed grid connected hybrid energy generation system is shown in figure 1.

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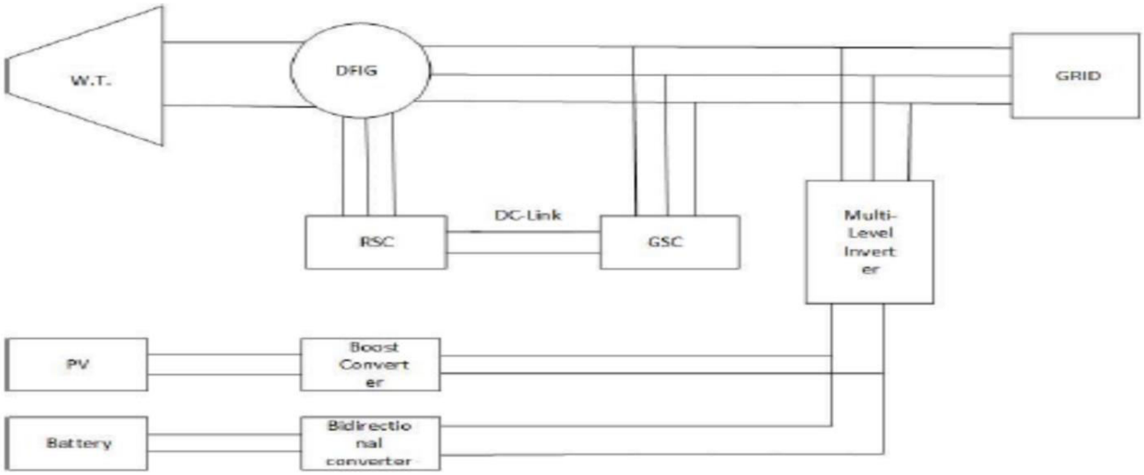

Fig 1: Configuration of proposed grid connected hybrid system

Figure 1 shows the configuration structure for hybrid system based fuel cell, solar and wind energy systems. The mechanical power captured from wind by a wind turbine can be formulated as [6]:

$$P_m = 0.5 \rho A C_p V^3$$

0.59 is the theoretical maximum value power coefficient value, It is based on two variables the pitch angle tip speed ratio (TSR). With respect to longitudinal axis turbine blades are aligned at an angle that is the pitch angle. The linear speed of the rotor to the wind speed is *TSR*.

Wind turbine "C Vs. λ" curve is shown in Figure.2. In practical designs, 0.4 to 0.5 is the maximum achievable range for high speed turbines and for slow speed turbines it is in the range of 0.2 to 0.4. At λopt its maximum value (C_{pmax}) is shown in Figure 2.

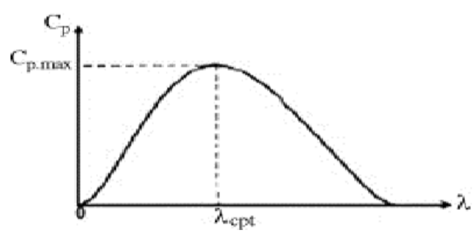

Figure 2: Power coefficient Vs Tip Speed Ratio

MODELLING AND DESIGN OF DFIG:

The doubly fed induction generator is the better solution for variable speed machines with tolerance ±30% of synchronous speed. The grid and the rotor are directly connected for the main stator winding is controlled with converters via slip rings as sown in Figure 3.

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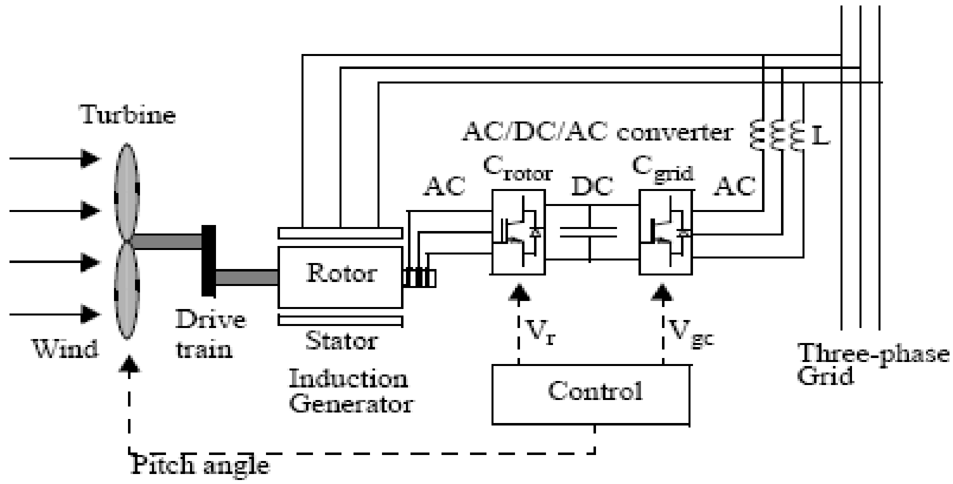

Figure 6: DFIG Connected to Wind Turbine

Figure 7 shows the overall RSC control scheme which is having two cascade loops. Vdr0 and Vqr0 are the from the two regulated current controllers outputs. And these signals are used for generating Pulses to RSC converter by PWM technique.

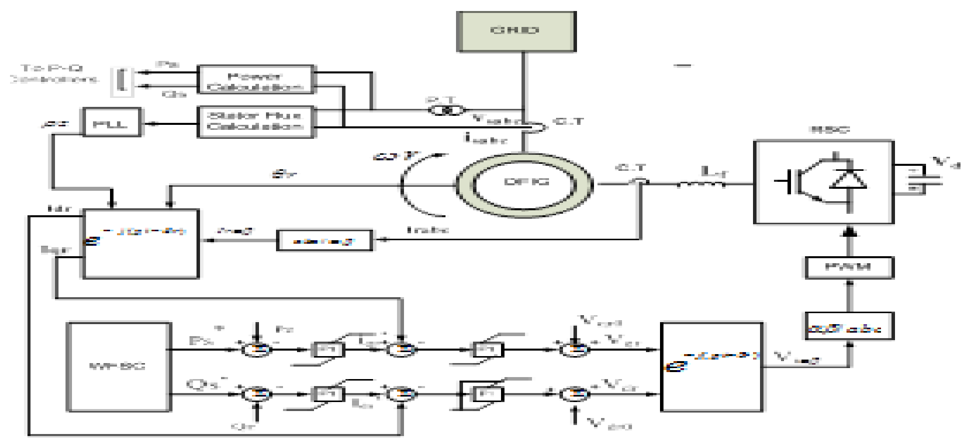

Figure 7: Control Diagram for the rotor side controller

MODELING OF SOLAR SYSTEM:

In electrical phenomenon photovoltaic network, the cell is that the essential part. PV exhibit is nothing however sunlight based cells region unit associated non-concurrent or parallel for increasing required current, voltage and high power [9]. Each cell is practically identical to a diode with an intersection designed by semiconductor material. It delivers the streams once lightweight consumed at the intersection, by the electrical marvel sway. It are frequently seen that a most electric outlet exists on each yield power diagram 4. The Figure 8 shows the (I-V) and (P-V) characteristics of the PV exhibit [10] [12] at entirely unexpected star intensities.

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$$I = I_{ph} - I_d - I_{sh}$$
$$I = I_{ph} - I_o[\exp(qV_d / nKT)] - (V_d / R_s)$$

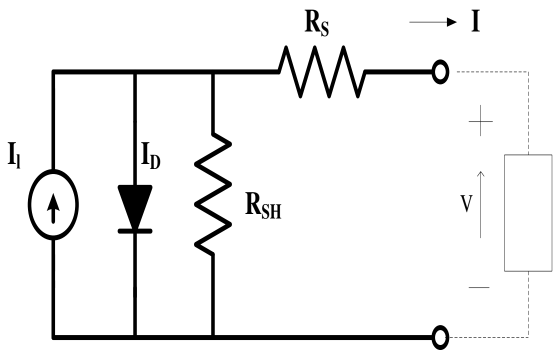

Figure 8: Equivalent circuit of PV Module

Power output of solar cell is P = V * I

Artificial Neural Networks:

The structure of an ANN, in which a circle indicates a fixed node, whereas a square indicates an adaptive node, is shown in Figure 9. In this structure, there are input and output nodes, and in the hidden layers, there are nodes functioning as membership functions (MFs) and rules. This eliminates the disadvantage of a normal feed forward multilayer network, which is difficult for an observer to understand or to modify. For simplicity, we assume that the examined FIS has two inputs and one output. In this network, each element of the input vector p is connected to each neuron input through the weight matrix W. The ith neuron has a summer that gathers its weighted inputs and bias to form its own scalar output n(i). The various n(i) taken together form an S-element net input vector n.

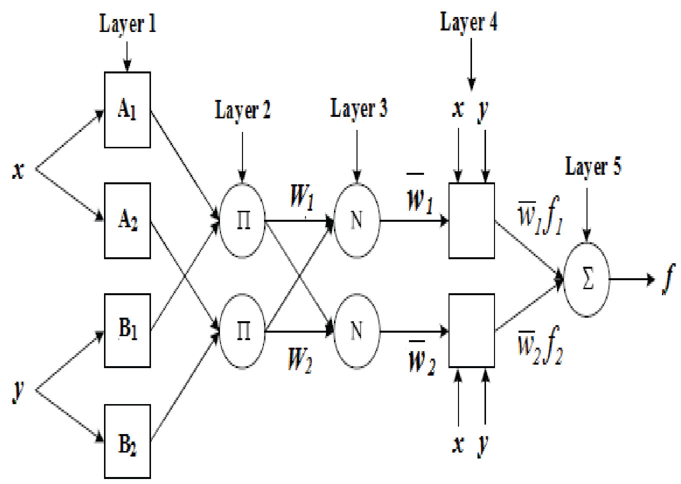

Figure 9: ANN architecture for a two-input multi-layer network

Simulation Case Study:

In this section we have simulated three different microgrids namely PV-Battery system, DFIG system, Hybrid (PV, Wind, and Battery) system which is shown in figure 1.

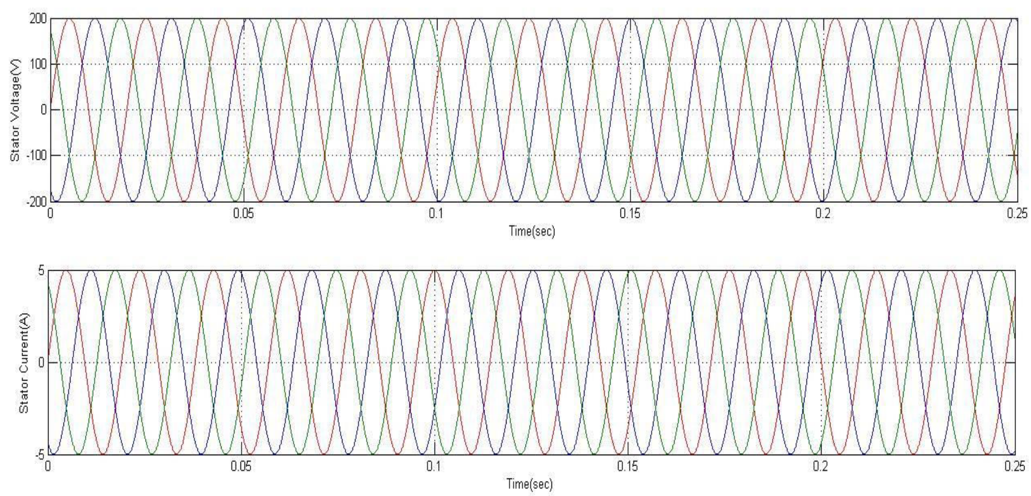

Figure 10: Simulation Result for Stator Voltage and Current Waveforms for DFIG System with PI Controller

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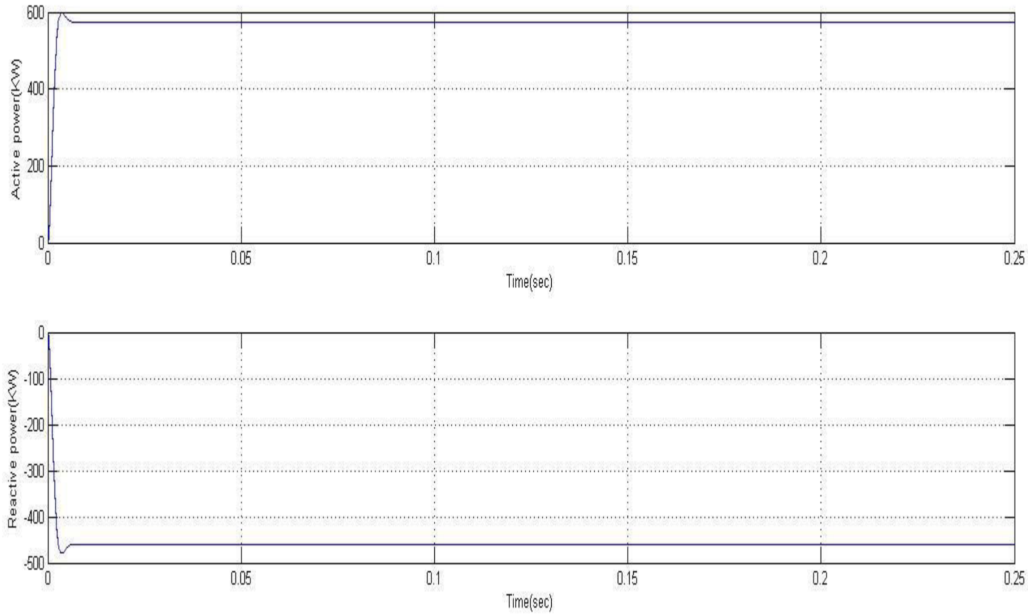

Figure 11: Simulation Result for DFIG Stator Powers with PI controller

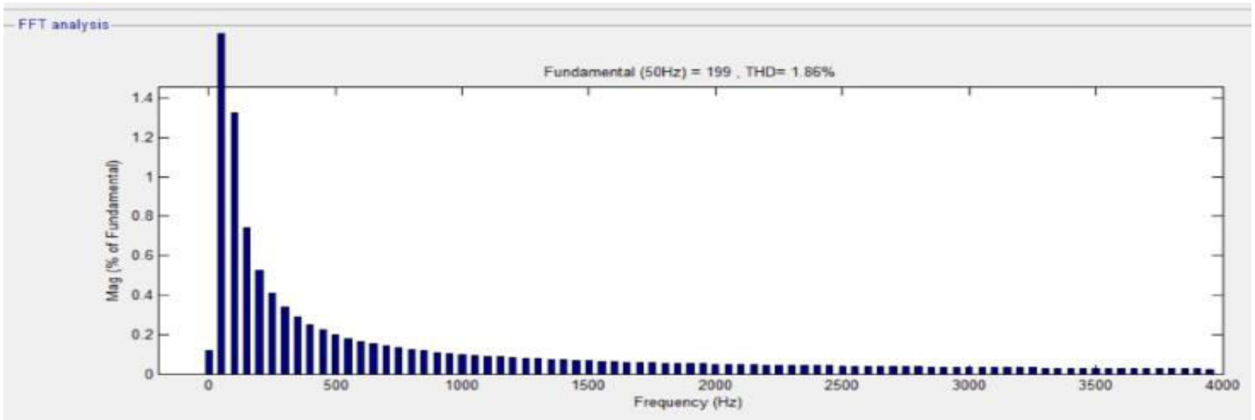

Figure 12: Voltage THD for DFIG with Conventional Controller

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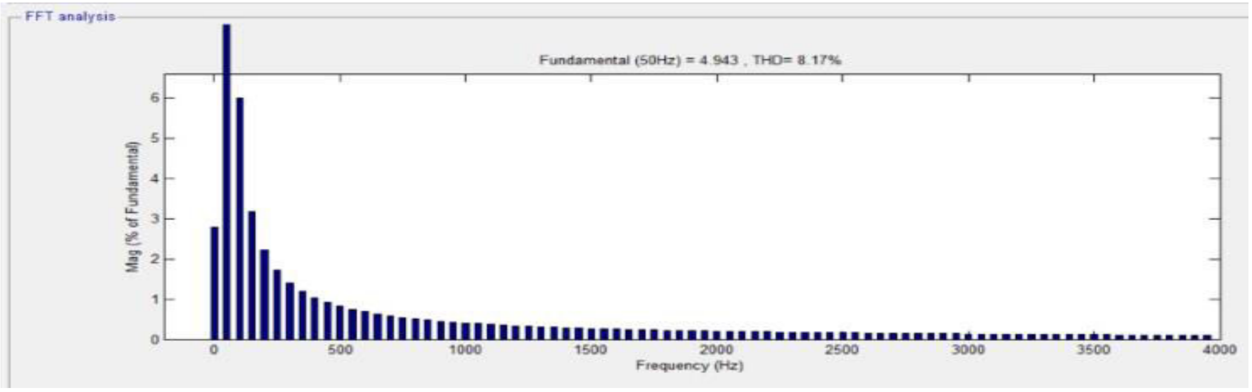

Figure 13: Current THD for DFIG with Conventional Controller

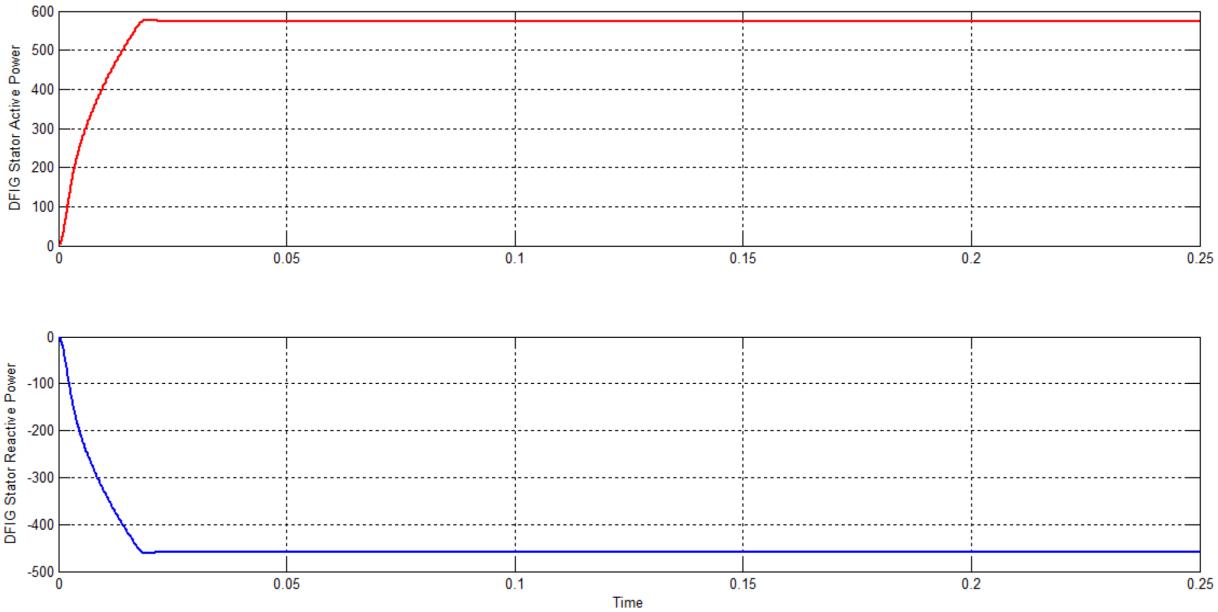

Figure 14: Simulation Result for DFIG Stator Powers with ANN controller

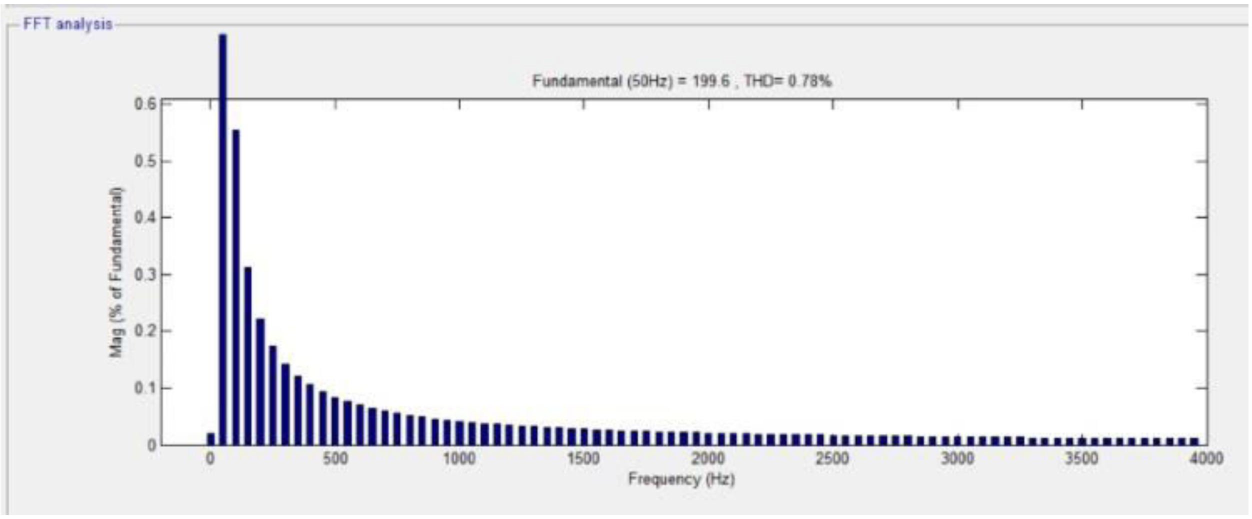

Figure 15: Voltage THD for DFIG with ANN Controller

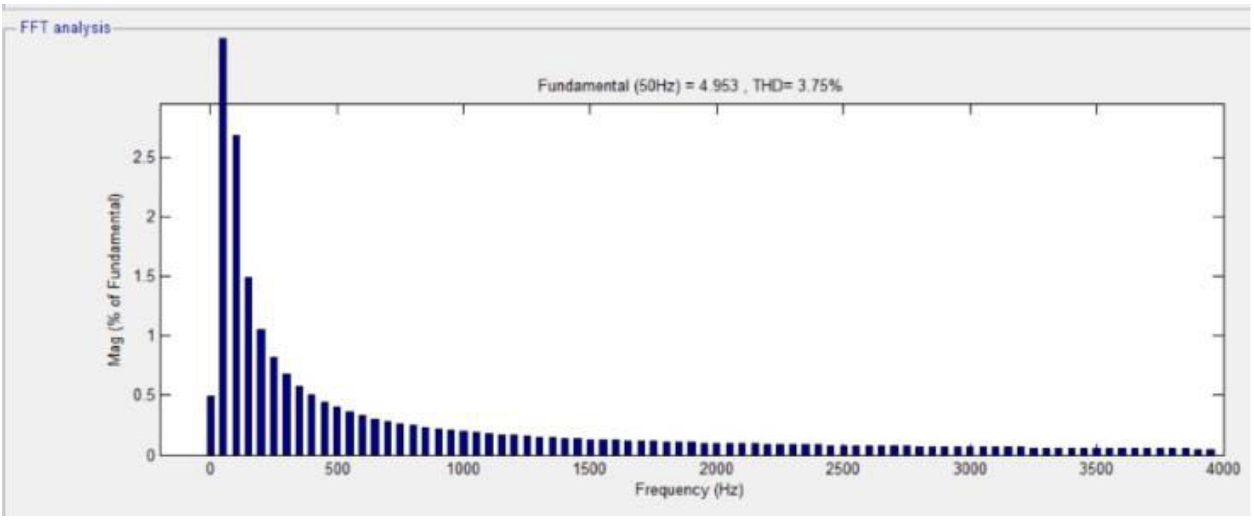

Figure 16: Current THD for DFIG with ANN Controller

CONCLUSION

This paper proposes an application of ANN controller to RSC and GSC of DFIG converter provides better reduction of THD in hybrid system as comparative with MLI. It has been also proven that, the DFIG grid converter can also be used in PV-Battery system, which eliminate the need of converter in PV-Battery system and hence power quality is improved. The performance of ANN based DFIG Controller provides better performance as compared with Conventional Controller.

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