Scientific Journal of Impact Factor (SJIF): 5.71

e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 5, Issue 04, April -2018

POWER QUALITY IMPROVEMENT FOR GRID CONNECTED WIND SOLAR SYSTEM USING DOUBLY FED INDUCTION GENERATOR

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Abstract — *A wind-solar hybrid system using Doubly Fed Induction Generator (DFIG) is proposed. In this proposal, we will implement a rotor current control strategy. Over the entire period of operation, a solar photovoltaic (PV) unit of appropriate capacity has been augmented with the rotor circuit of the DFIG. A marginal battery backup is also included to supplement the rotor power in order to maintain continuity of power generation. The quality of power and the efficiency can be improved and maintained, as both the solar PV and wind energy complement each other during lean periods of either source. The proposed scheme will be validated in simulation using MATLAB-Simulink which can produce the desired results.*

Keywords-*DFIG, THD, PV, RSC, GSC*

I. INTRODUCTION

Renewable energy sources i.e., energy generated from solar, wind, biomass, hydro power, geothermal and ocean resources are considered as a technological option for generating clean energy. But the energy generated from solar and wind is much less than the production by fossil fuels, however, electricity generation by utilizing PV cells and wind turbine increased rapidly in recent years. This paper presents the Solar-Wind hybrid Power system that harnesses the renewable energies in Sun and Wind to generate electricity. System control relies mainly on micro controller. It ensures the optimum utilization of resources and hence improves the efficiency as compared with their individual mode of generation. Also it increases the reliability and reduces the dependence on one single source. This hybrid solar-wind power generating system is suitable for industries and also domestic areas.Doubly-fed electric machines are electric motors or electric generators where both the field magnet windings and armature windings are separately connected to equipment outside the machine. By feeding adjustable frequency AC power to the field windings, the magnetic field can be made to rotate, allowing variation in motor or generator speed. This is useful, for instance, for generators used in wind turbines.

II. BLOCK DIAGRAM OF HYBRID SYSTEM WITH DFIG

As the concept of wind solar hybrid systems is taking over the world, we are trying to implement something innovative, by the introduction of a Doubly Fed Induction Generator, to a conventional power grid system. The advantage of DFIG is such that, it can be used for the rapid variation of the mechanical input from the wind turbines. In this chapter, we will also discuss about the various components as shown in the block diagram below. The components include:

- Wind turbine
- Rotor side converter (rectifier)
- Grid side converter (inverter)
- Doubly fed induction generator
- Photovoltaic cell
- Boost converter
- Battery(backup)

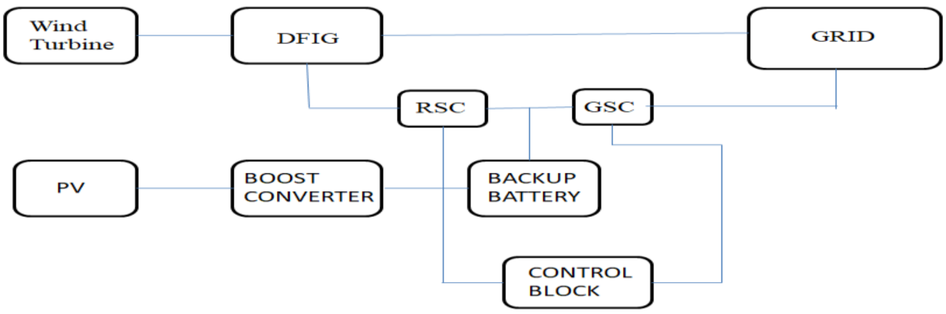

Fig 1: Block Diagram of the wind solar hybrid generation system

2.1 DFIG

Doubly-fed electric machines are electric motors or electric generators where both the field magnet windings and armature windings are separately connected to equipment outside the machine. By feeding adjustable frequency AC power to the field windings, the magnetic field can be made to rotate, allowing variation in motor or generator speed. This is useful, for instance, for generators used in wind turbines.

Doubly fed electrical generators are similar to AC electrical generators, but have additional features which allow them to run at speeds slightly above or below their natural synchronous speed. This is useful for large variable speed wind turbines, because wind speed can change suddenly. When a gust of wind hits a wind turbine, the blades try to speed up, but a synchronous generator is locked to the speed of the power grid and cannot speed up. So large forces are developed in the hub, gearbox, and generator as the power grid pushes back. This causes wear and damage to the mechanism. If the turbine is allowed to speed up immediately when hit by a wind gust, the stresses are lower and the power from the wind gust is converted to useful electricity.

2.2 Wind Turbine

A wind turbine works on a simple principle. This animation shows how energy in the wind turns two or three propeller-like blades around a rotor. The rotor is connected to the main shaft, which spins a generator to create electricity. Wind turbines are mounted on a tower to capture the most energy. At 100 feet (30 meters) or more above ground, they can take advantage of faster and less turbulent wind. Wind turbines can be used to produce electricity for a single home or building, or they can be connected to an electricity grid (shown here) for more widespread electricity distribution.

2.3 Solar Cell

Conversion of light energy in electrical energy is based on a phenomenon called photovoltaic effect. When semiconductor materials are exposed to light, the some of the photons of light ray are absorbed by the semiconductor crystal which causes a significant number of free electrons in the crystal. This is the basic reason for producing electricity due to photovoltaic effect. Photovoltaic cell is the basic unit of the system where the photovoltaic effect is utilized to produce electricity from light energy. Silicon is the most widely used semiconductor material for constructing the photovoltaic cell. The silicon atom has four valence electrons. In a solid crystal, each silicon atom shares each of its four valence electrons with another nearest silicon atom hence creating covalent bonds between them. In this way, silicon crystal gets a tetrahedral lattice structure. While light ray strikes on any materials some portion of the light is reflected, some portion is transmitted through the materials and rest is absorbed by the materials The same thing happens when light falls on a silicon crystal. If the intensity of incident light is high enough, sufficient numbers of photons are absorbed by the crystal and these photons, in turn, excite some of the electrons of covalent bonds. These excited electrons then get sufficient energy to migrate from valence band to conduction band. As the energy level of these electrons is in the conduction band, they leave from the covalent bond leaving a hole in the bond behind each removed electron. These are called free electrons move randomly inside the crystal structure of the silicon. These free electrons and holes have a vital role in creating electricity in photovoltaic cell. These electrons and holes are hence called light-generated electrons and holes respectively. These light generated electrons and holes cannot produce electricity in the silicon crystal alone. There should be some additional mechanism to do that.

2.4 Boost Converter

A boost converter (step-up converter) is a DC-to-DC power converter that steps up voltage (while stepping down current) from its input (supply) to its output (load). It is a class of switched-mode power supply (SMPS) containing at least two semiconductors (a diode and a transistor) and at least one energy storage element: a capacitor, inductor, or the two in combination. To reduce voltage ripple, filters made of capacitors (sometimes in combination with inductors) are normally added to such a converter's output (load-side filter) and input (supply-side filter).

2.5 Rotor Side Converter (Rectifier)

A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as rectification, since it "straightens" the direction of current. Physically, rectifiers take a number of forms, including vacuum tube diodes, mercury-arc valves, stacks of copper and selenium oxide plates, semiconductor diodes, silicon-controlled rectifiers and other silicon-based semiconductor switches. Historically, even synchronous electromechanical switches and motors have been used. Early radio receivers, called crystal radios, used a "cat's whisker" of fine wire pressing on a crystal of galena (lead sulfide) to serve as a point-contact rectifier or "crystal detector".

2.6 Grid Side Converter (Inverter)

A power inverter, or inverter, is an electronic device or circuitry that changes direct current (DC) to alternating current (AC).

The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by the DC source.

A power inverter can be entirely electronic or may be a combination of mechanical effects (such as a rotary apparatus) and electronic circuitry. Static inverters do not use moving parts in the conversion process.

III. LAYOUT OF HYBRID SYSTEM WITH DFIG

As the production of clean energy has been stressed globally, the option of wind-based power generation is gaining more importance. The doubly fed induction generator (DFIG) can be an attractive option as a generator for rapid variation of mechanical input from wind turbines. To harvest maximum energy content of wind energy, the efficient DFIGs with higher power ratings is a natural option for wind energy conversion system (WECS). However, the active power loss during the operation is the major challenge for efficiency optimization and life expectancy of the DFIGs. Different sensor less vector control strategies for DFIGs have been extensively elaborated , where the active power generation both at the stator and the rotor terminals was controlled using rotor side converter (RSC) converter. The main objective of the RSC is to regulate stator side active and reactive power independently. However, the fluctuating power from DFIG-based wind generators in response to wind speed variations would adversely affect the power quality . Also during the low wind speed situations, most of the existing schemes will not succeed to generate rated active power at the generator bus . To enhance the availability of active power at generator bus, different coordinated hybrid generation schemes have been proposed. An appropriate scheme for rated power generation at generator bus is proposed, however, the suggested scheme does not clarify the operation over wide speed range, as regards the storage battery size and prolonged operation in the sub synchronous rotor speed region.

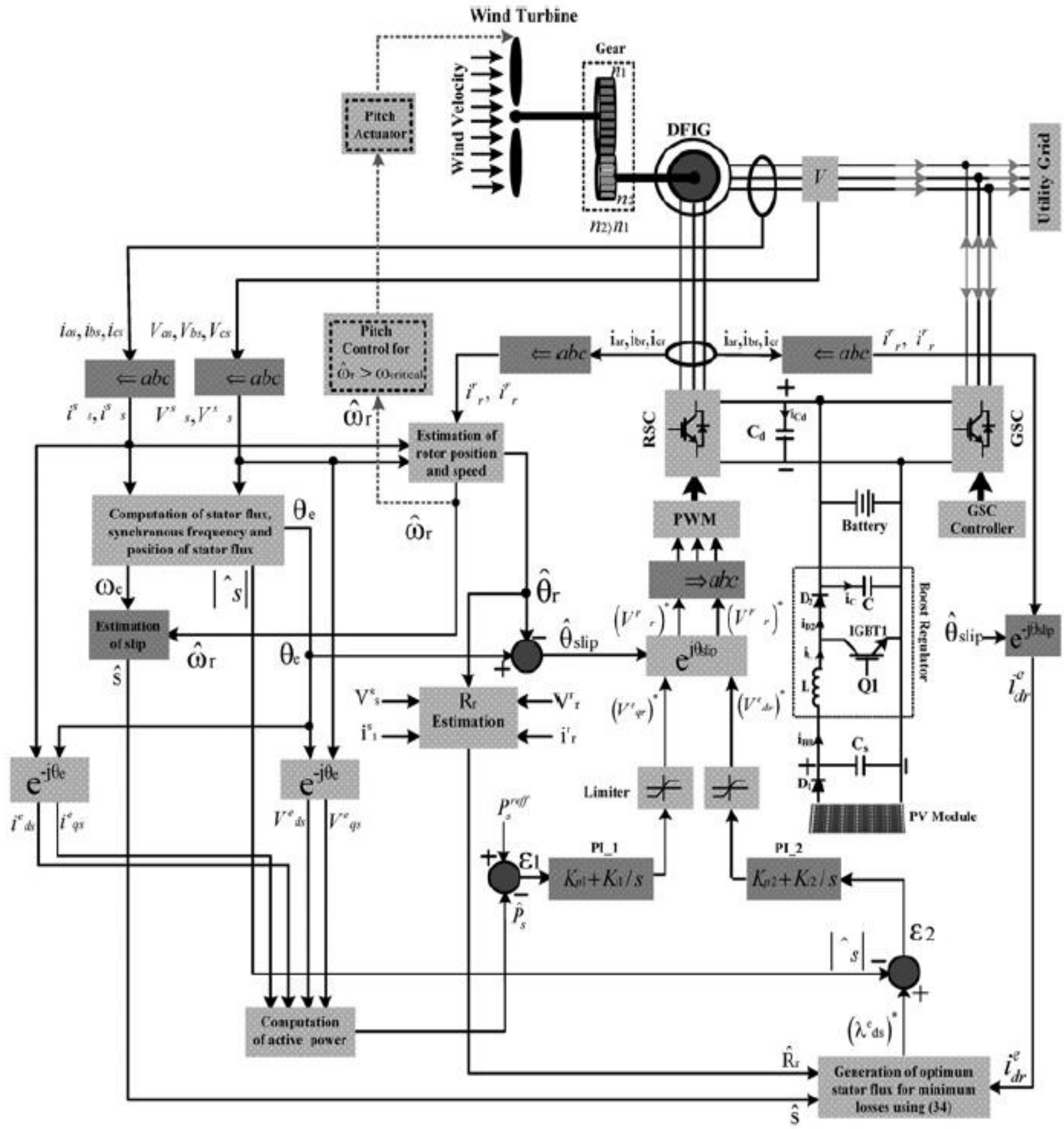

Fig 2: Layout of wind solar hybrid system using DFIG

IV. RESULTS AND DISCUSSIONS

The following graph is the immediate output of the DFIG, after it receives the mechanical input from the wind turbine.

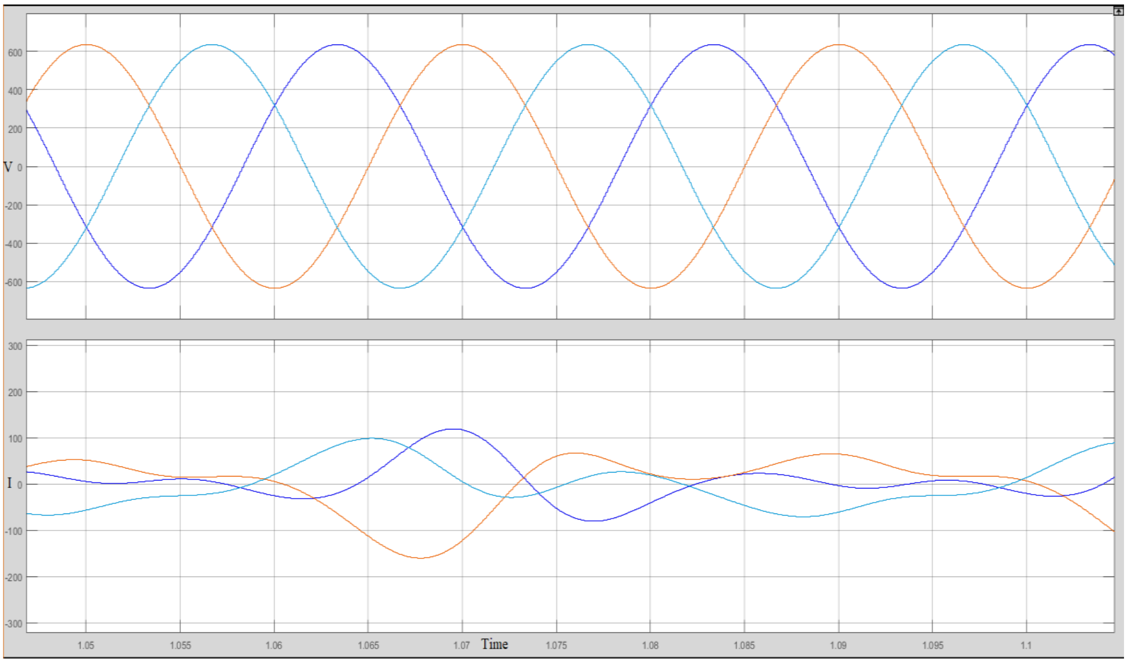

Fig 3: Source voltage and current waveform obtained from DFIG

The following graph is the output of the GSC after the output of the DFIG has been filtered necessarily.

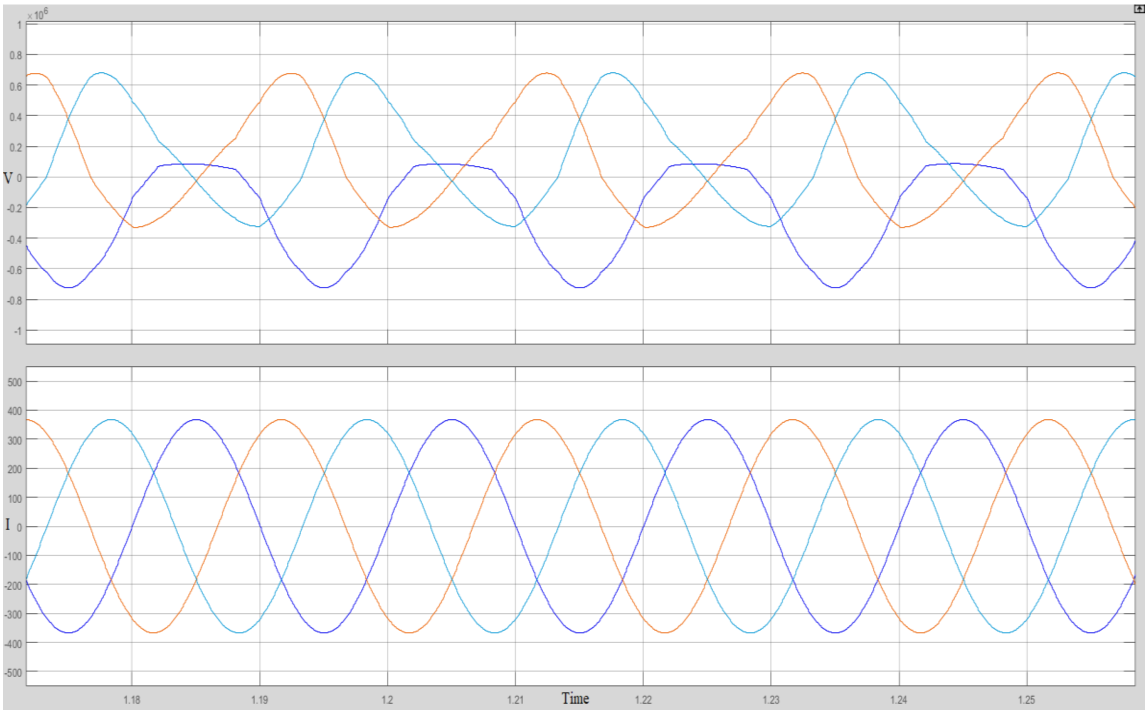

Fig 4: Output of Grid Side Converter voltage and current

4.1 Open Loop Characteristics (First Phase)

This revolves around the first phase of our project. As is evident from the graph shown below, we can see the harmonics in the Y and B phases of the waveforms. We also show the Total Harmonic Distortions, with the help of FFT analysis, which are the figures following the graph below.

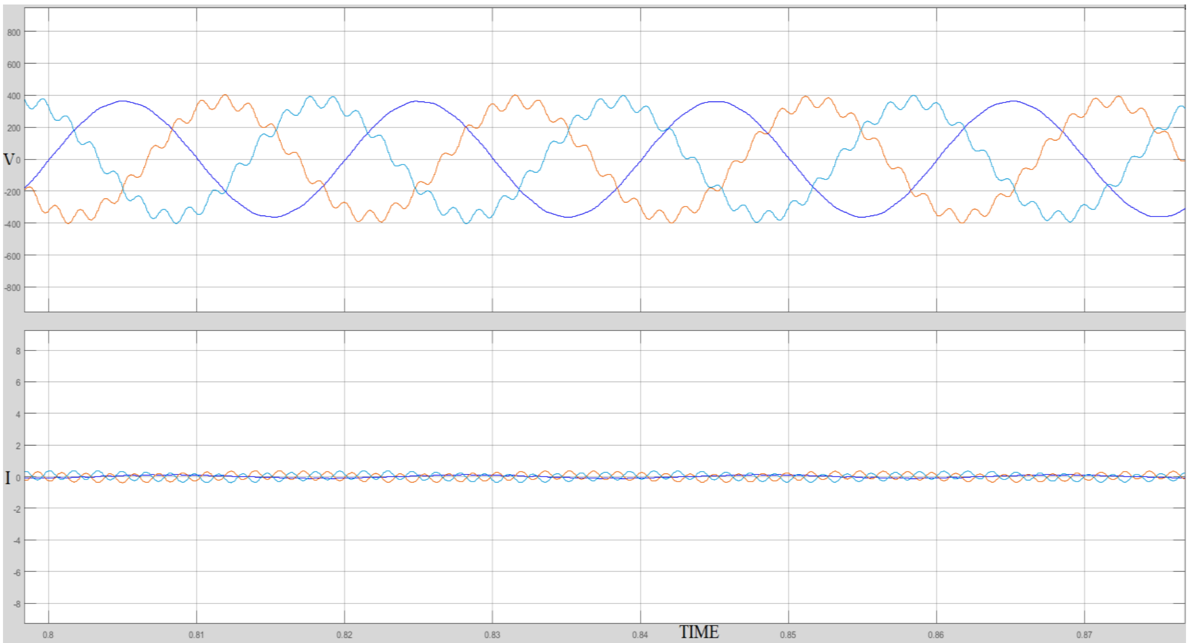

Fig 5: Open loop voltage and current characteristics

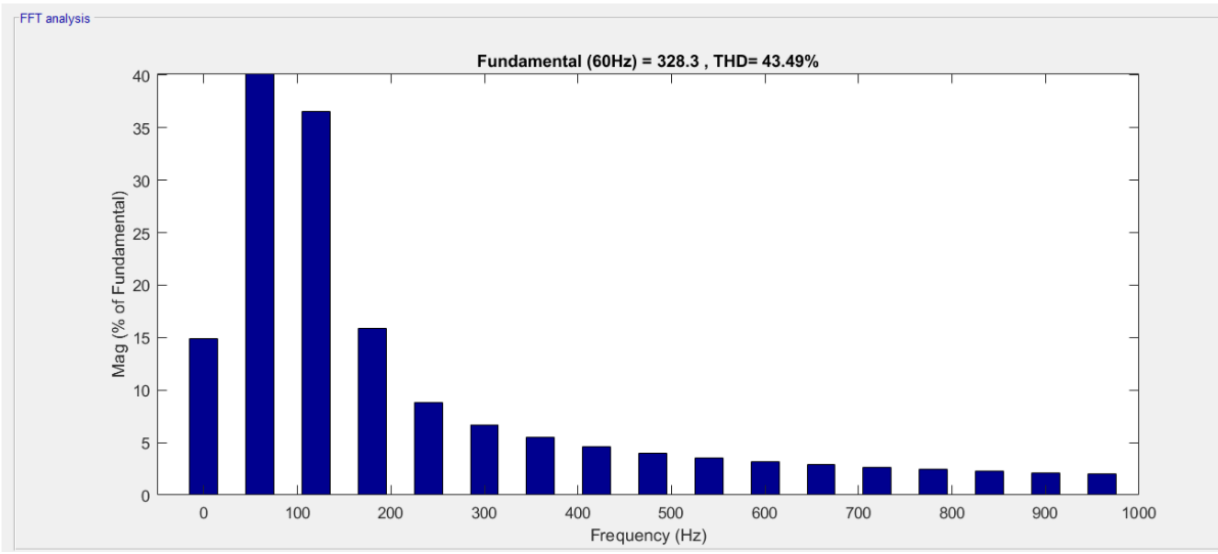

Fig 6: THD for A phase

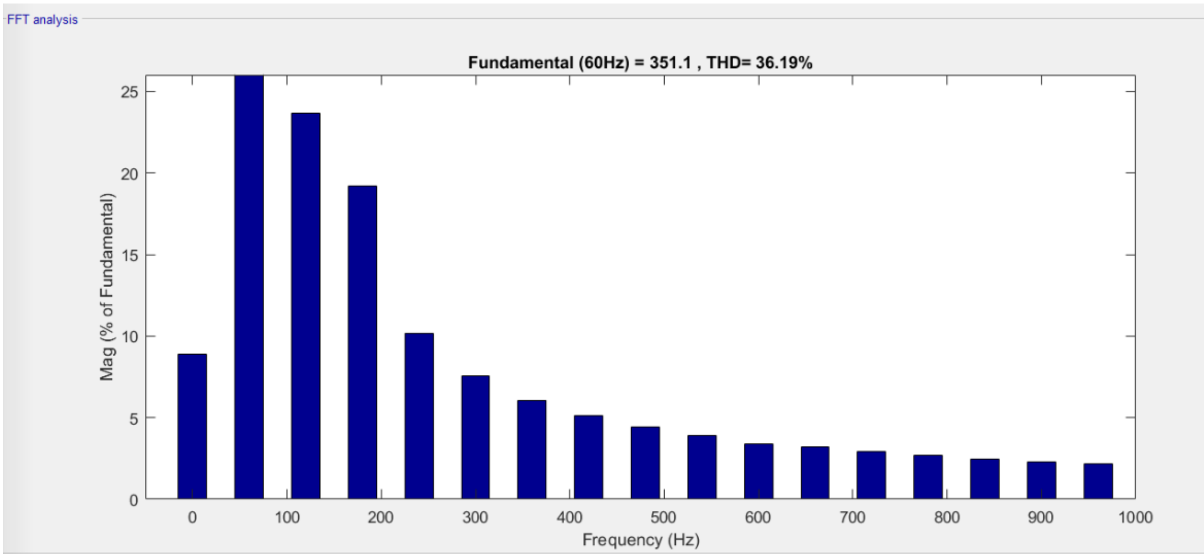

Fig 7: THD for B phase

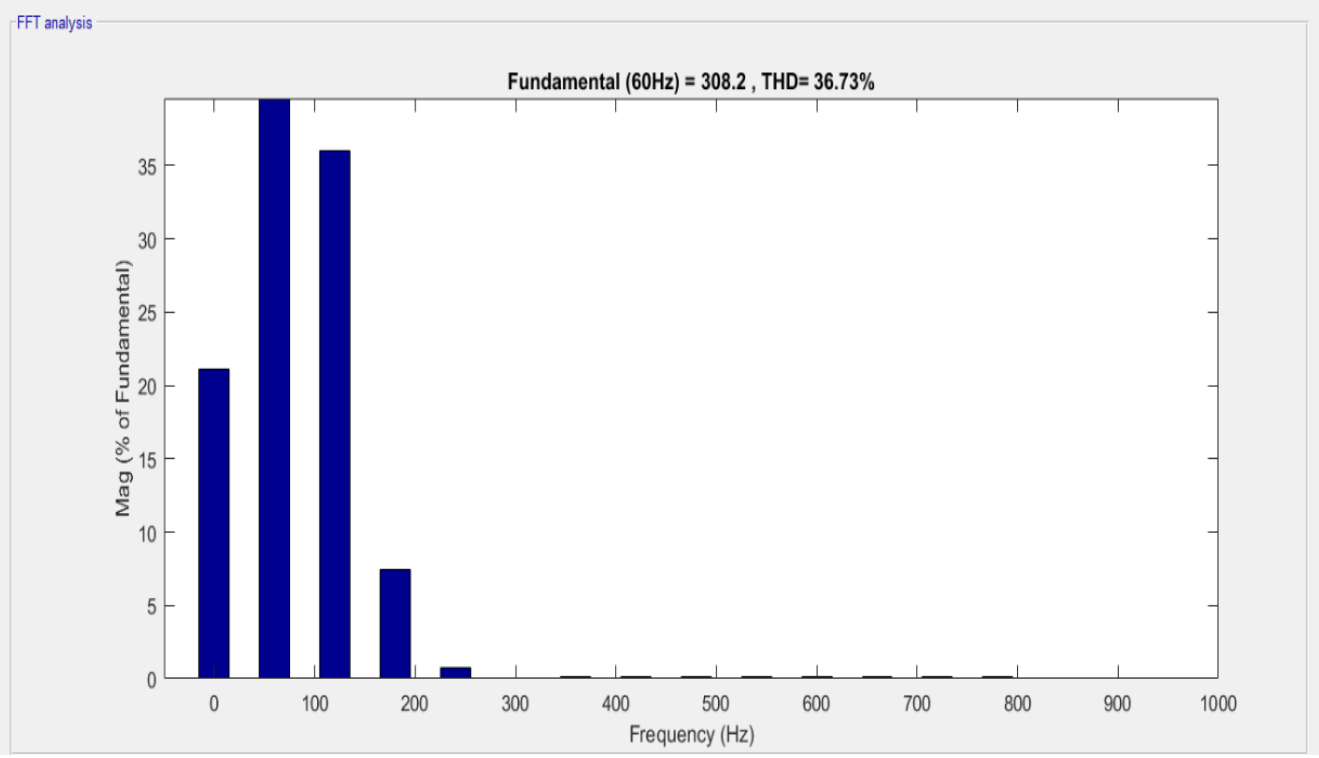

Fig 8: THD for C phase

So from the above three diagrams, we can see the total harmonic distortions in the range of 35% to 45%. So the reduction in these harmonics can be seen in the next section, which is the basis of our next phase.

4.2 Closed Loop Characteristics (Second Phase)

Here, we can see the harmonics have been removed and we can see near sinusoidal waveforms for the R, Y and B phases in the diagram given below. This is the basis of the second phase of our project. We also have total harmonic distortions of the phases, which will show a considerable decrease in the distortions, after the implementation of the control block.

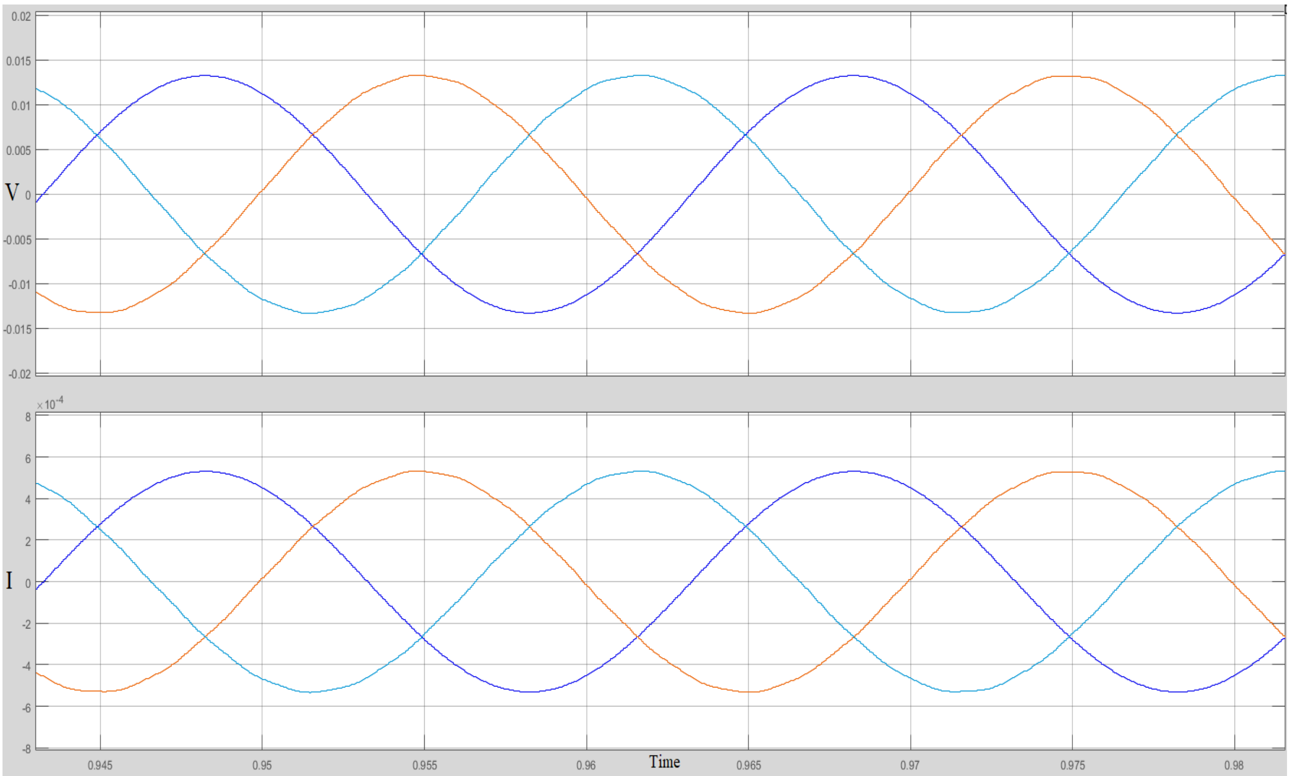

Fig 9: Closed loop voltage and current characteristics

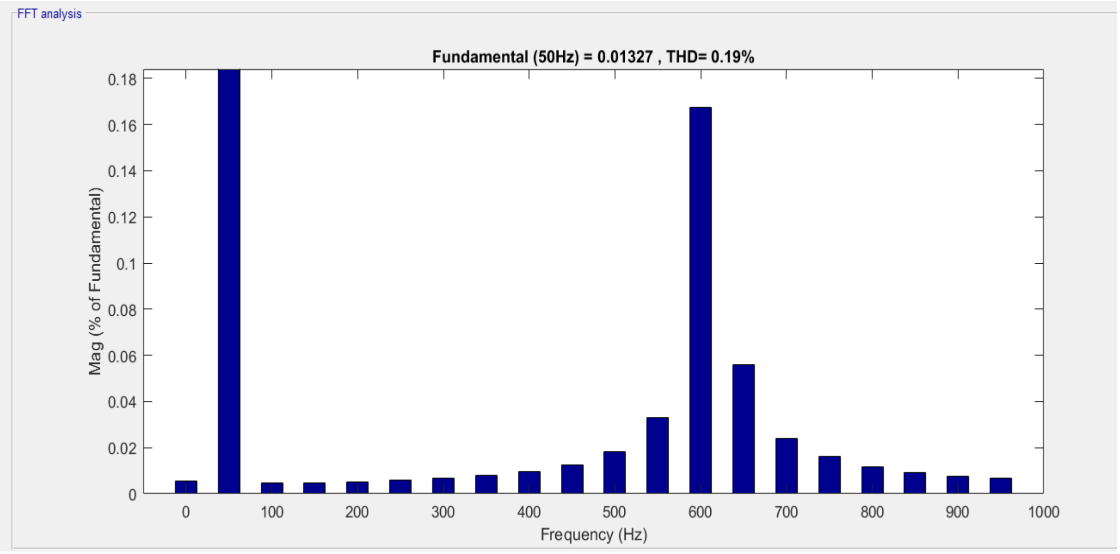

Fig 10: THD for A phase

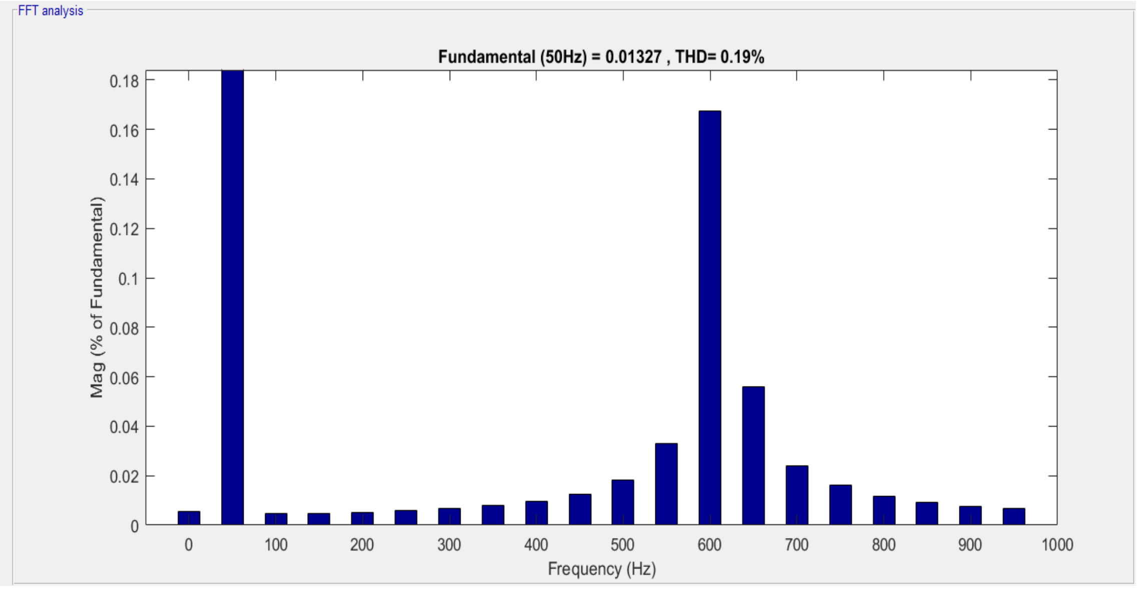

Fig 11: THD for B phase

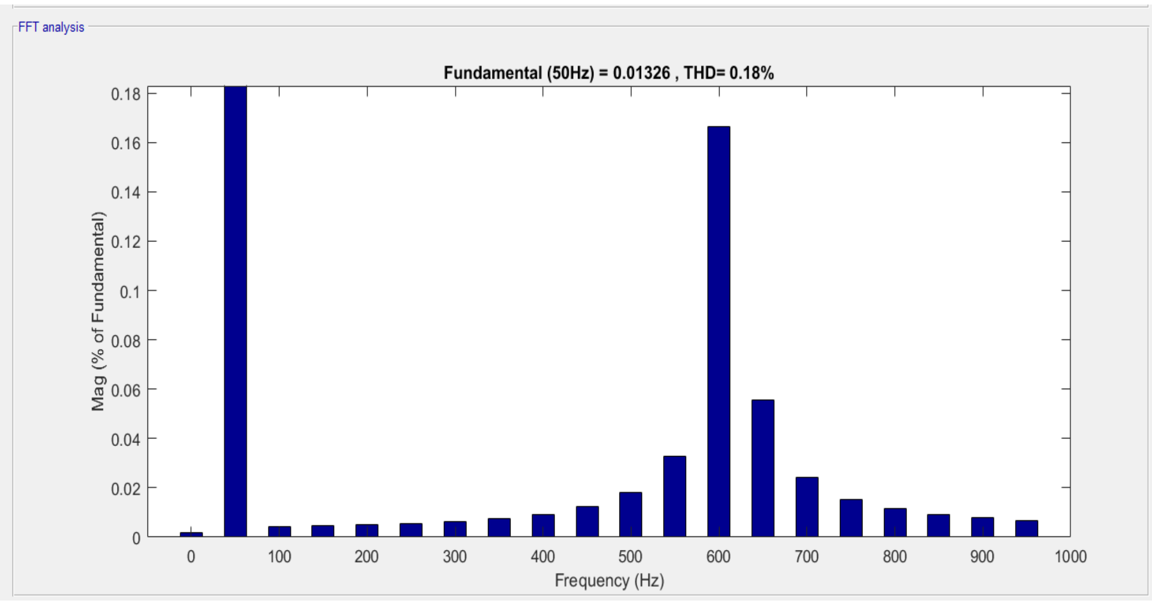

Fig 12: THD for C phase

So from the FFT analysis shown in the above three diagrams, we can see a decrease of about 40% in the distortions, after the implementation of the control block.

The following diagram will give an idea in the increase of power generation and hence, increase in efficiency.

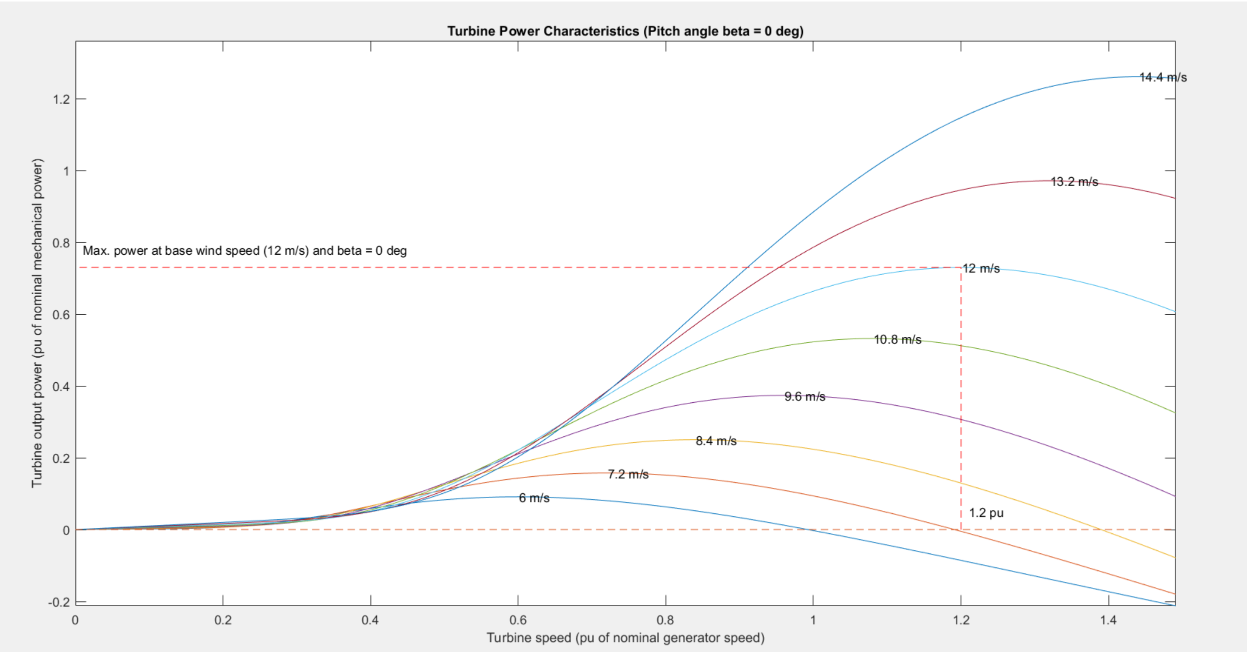

Fig 13: Turbine Power Characteristics

V. CONCLUSION

The method implemented here will help in the improvement of the power quality to a considerable extent. The efficiency will increase as well. As can be seen from the harmonics present in the first phase of work, the distortions were way too much, as is with the general hybrid systems. But after the implementation the mentioned method, the distortions were decreased to a considerable amount, hence improving the quality and efficiency as well. This could lead to a better utilization of the input energy sources. In turn, it would lead to the decrease in the depletion of energy resources which are in limited amounts. The proposal is user friendly, cost effective, and has a scope of implementation in the near future, because of its easy integration into any existing systems.

V. BIBLIOGRAPHY

1. Cardenas, R., Pena, R.: ‘Sensorless vector control of induction machines for variable-speed wind energy applications’, IEEE Trans. Energy Convers., 2004, 19, (1), pp. 196–205
2. Jadhav, H.T., Roy, R.A., Betka, A.: ‘Comprehensive review on the grid integration of doubly fed induction generator’, Int. J. Electr. Power Energy Syst., 2012, 49, pp. 8–18
3. Marques, G.D., Sousa, D.M.: ‘New sensorless rotor position estimator of a DFIG based on torque calculations – stability study’, IEEE Trans. Energy Convers,2012, 27, (1), pp. 196–203
4. Karthikeyan, A., Nagamani, C., Ray Choudhury, A.B., et al.: ‘Implicit position and speed estimation algorithm without the flux computation for the rotor side control of doubly fed induction motor drive’, IET Electr. Power Appi., 2012, 6, (4), pp. 243–252

