Research Article

Artificial Neural Networks Controlled DFIG-Based Wind Turbine

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ABSTRACT

In this work, Artificial Neural Network (ANN) control technique has been produced for Doubly Fed Induction Generator (DFIG) based wind energy age framework and the exhibition of the framework is contrasted and fuzzy and NN control techniques. With the expanding utilization of wind power age, it is required to incite the dynamic execution examination of Doubly Fed Induction Generator under different working conditions. In this work, ANN control techniques have been proposed. To supplement different sorts of contamination free age wind energy is a feasible alternative. Already wind turbines were worked at steady speed. The natural selection of wind systems technology has led to the formation of a generation of speed wind turbines with many advantages over fixed speed wind turbines. The DFIG phasor model is used here and provides a survey of a double-fed induction generator powered by a battery-connected wind turbine controlled by an ANN controller. The presentation of the proposed control techniques is shown through the outcomes, dictated by utilizing MATLAB/Simulink. From the outcomes it is seen that the dynamic execution of the DFIG is improved with the Hybrid control technique.

KEYWORDS

DFIG, MATLAB/Simulink, ANN, Wind Turbine.

1. INTRODUCTION

In recent years, the ecological contamination has turned into a noteworthy worry in individual's day by day life and a conceivable energy emergency has driven individuals to grow new innovations for creating perfect and renewable energy. Wind power alongside solar based energy, hydropower and tidal energy are conceivable answers for an ecologically well-disposed energy creation. Among these renewable energy sources, wind power has the quickest developing velocity in the power business.

Wind power generation operates on the principle of energy conversion in air mass particle movement with linear kinetic energy which is converted from mechanical energy into electrical energy using wind turbines and electrical generators. Wind power generators are mainly asynchronous machines which have the advantage of being cheaper, low maintenance, and is highly suitable for large scale wind applications for its variable speed operation i.e., Doubly Fed Induction Generators (DFIGs). There are several reasons for using variable-speed operation of wind turbines; among those are possibilities to reduce stresses of the mechanical structure, acoustic noise reduction and the possibility to control active and reactive power.

A wind turbine extracts the maximum amount of energy from the wind when operating at an optimal rotor speed, which again depends on speed of wind. The optimal rotor speed varies due to the variable nature of the wind speed. Research shows that variable speed operation of the rotor results in a higher energy production compared to a system operating at constant speed. A wind turbine model consists of blades, a generator, a power electronic converter, and power grid. Blades are used to extract power from the wind. By operating the blades at optimal tip speed ratio, maximum amount of energy can be extracted from the variable speed wind turbine. The maximum power point tracking (MPPT) control of variable speed operation is used to achieve high efficiency in wind power systems. The MPPT control is operated using the machine side control system. The function of pitch angle control scheme is to regulate the pitch angle by keeping the output power at rated value even when the wind speed experiences gusts. The double fed induction generator is associated with AC-to-AC converter, where generator is directly grid connected through the stator windings, keeping into account the grid voltage and frequency fixed. While the rotor windings are fed by rotor side converter at variable frequency through slip rings.

Other segments of a wind turbine-generator framework are wind vane, cooling fan and distinctive sensors. These sensors incorporate the anemometer, speed or position sensors just as voltage and current sensors. The wind vane is utilized to gauge the wind bearings and after that choose the activity of the yaw control framework. Electric cooling fans are utilized to cool the gearbox, generator, power converters and the on-board controllers. The anemometer is utilized to quantify the wind speed for following the most extreme power or security purposes. For instance, when the wind speed encounters blasts, the wind speed signal detected by the anemometer will be sent to the on-board controllers, which will make the wind turbine close down through the brake for wellbeing contemplations. Different sensors, for example, speed sensors and current sensors in wind turbine frameworks are utilized for control purposes, and ought to be indicated by the control plans.

The DFIG comprises of stator winding and the rotor winding outfitted with slip rings. The stator is given three-stage protected windings making up an ideal post plan and is associated with the network through a three-stage transformer. Like the stator, the rotor is additionally developed of three-phase protected windings. The rotor windings are associated with an outer stationary circuit by means of a lot of slip rings and brushes. By methods for these parts, the controlled rotor current can be either infused to or retained from the rotor windings.

The stator and rotor windings are typically covered with protection and are mechanically amassed to shape a shut structure to shield the machine from residue, moist, and other undesirable interruptions guaranteeing appropriate attractive coupling among rotor and stator windings. In wind energy change framework, this generator is mounted in the nacelle of the wind turbine framework as appeared in Figure.

For variable-speed frameworks with restricted variable-speed extend, for example ±30% of synchronous speed, the DFIG can be a fascinating arrangement. As referenced before the purpose behind this is power electronic converter just needs to deal with a division of the complete power. This implies the misfortunes in the power electronic converter can be diminished contrasted with a framework where the converter needs to deal with the absolute power. Moreover, the expense of the converter moves toward becoming lower. The stator circuit of the DFIG is associated with the lattice while the rotor circuit is associated with a converter by means of slip rings, see Fig. 1.1.

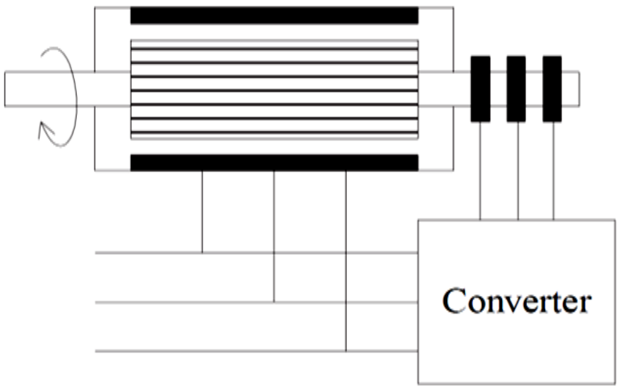

Fig. 1.1 Principle of the doubly fed Induction Generator.

2. ARTIFICIAL NEURAL NETWORK

Artificial Neural Network (ANN) models are a new computing approach applicable in so many areas like pattern recognition, speech recognition, image processing, medical diagnosis, prediction etc. Studies proved that ANN are very powerful computational tools for solving complex problems related to pattern recognition, prediction, optimization, associative memory, and control.

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In its most general form, an artificial neural network is a machine that is designed to model the way in which the brain performs a particular task or function of interest. To achieve good performance, neural networks employ a massive interconnection of simple computing cells referred to as.

- Simple and easy network structure.
- Capability of doing parallel processing operations.
- Contains long term distributed memory.
- Have fault tolerant capability.
- Collective output.
- Learning according to adaptive learning

In the case of neurons, the output can be calculated as a function of inputs. Similarly Figure 2.1 shows an artificial neural network which consists of various nodes which perform the input and output functions. The nodes in the ANN are interconnected together using weighted connection lines. During the training process, the weights are adjusted according to the input giving the system. The inputs are summed together and applying activation function to produce the output.

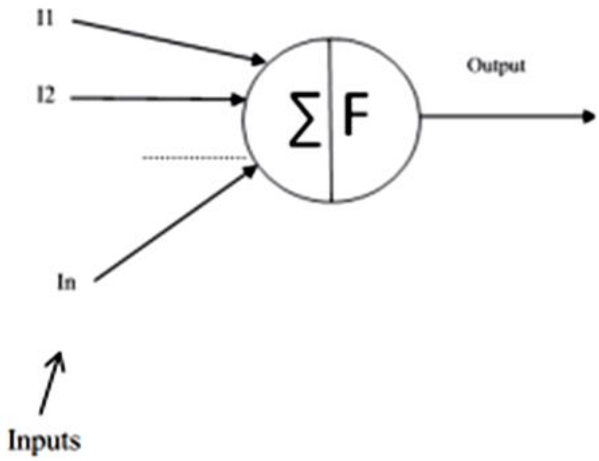

Fig. 2.1 Artificial Neural Network.

3. PROPOSED WORK

The proposed model has been executed and recreated on MATLAB Simulink the basic DFIG model of proposed work has showed up in Fig. 3.1. The square outline for the general control procedures of DFIG dependent on the wind energy is appeared in Fig.3.1, including two sections: the initial segment is the electrical control arrangement of DFIG, which incorporates control of the Fuzzy logic. The target of the Artificial Neural Network (ANN) control method has been created for Doubly Fed Induction Generator (DFIG) based wind energy age framework and the presentation of the framework is contrasted and fuzzy and NN control strategies. is to permit the DFIG wind turbine for decoupled control of dynamic and receptive power or speed, though the target of the Speed is to keep the DC-interface voltage at given an incentive in disobedience of the size and heading of the rotor power. The subsequent part is the mechanical control arrangement of the wind turbine having the principal goal to be the catch of wind power boost and minimization of transient low speed shaft loads.

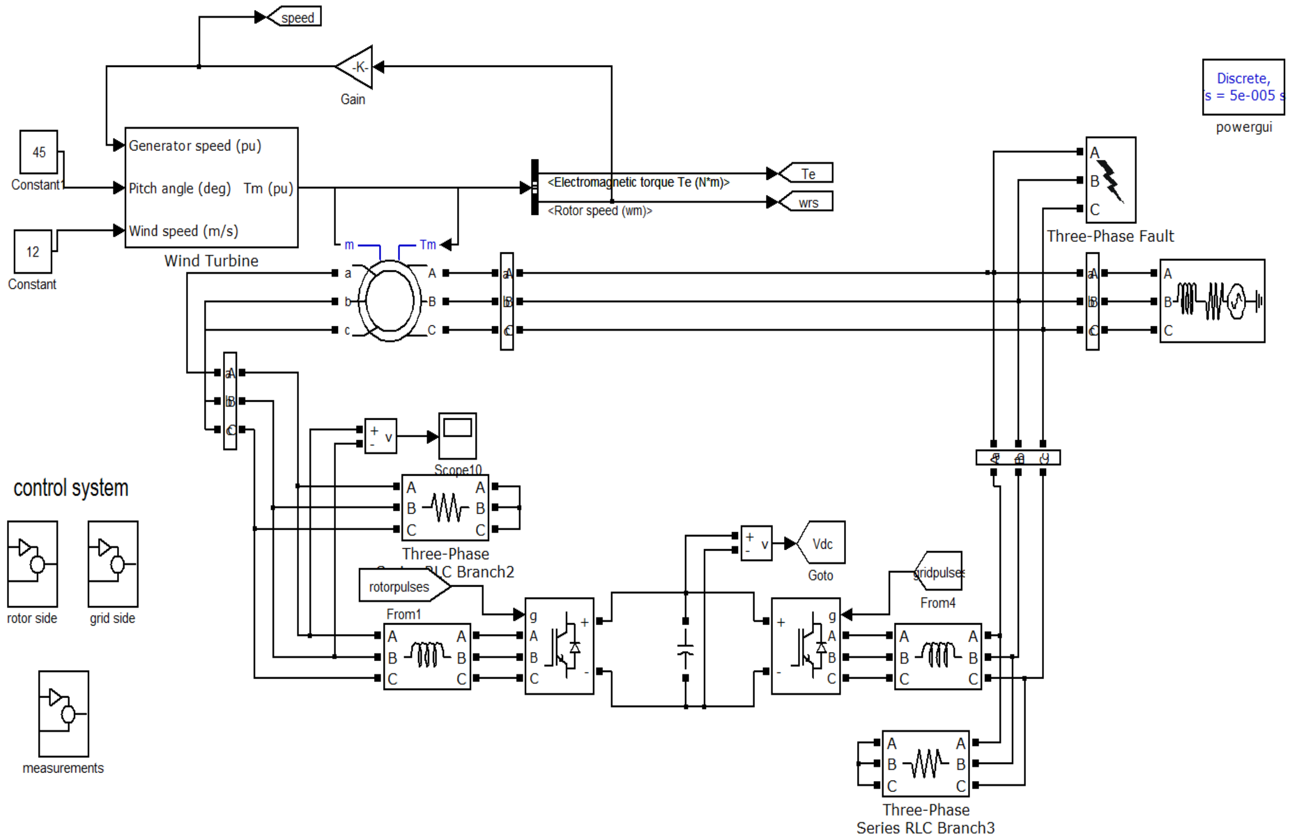

Fig. 3.1 Proposed Model of DFIG based Wind Turbine.

Fuzzy Logic controller

The PI controllers constantly have a very basic activity concerning the consistency of the power system. In any case the execution of the twofold fed induction generator phenomenally depends upon the suitable choice of the control gain parameters of the PI. The issue concerning the PI controller gain is the altering of the controller so as to achieve the perfect movement of the task. The critical drawback of the PI controller is stood up to when the system is nonlinear and moreover when the structure is having movements. Contemplating all of these substances, a fuzzy logic controller was executed. The ideal position concerning fuzzy controller is the systematic method to manage control a non straight assembled methodology depending regarding the data and experience based of individual. A fuzzy controller can use various data sources and different output factors. The assignment of fuzzy controller.

Fuzzification

The purpose of word fuzzification is to fuzzify data. This is done by changing to fuzzy set over the traditional set. For this procedure, we need distinctive fuzzifiers like Triangular, Trapezoidal, Singleton and Gaussian. With the help of these fuzzifiers, we relegate some ability for involvement to each individual data and transform it into a fuzzy set.

Deffuzification

It is a procedure of changing over a fuzzy set into traditional set. It is the opposite procedure of fuzzification. It is of much significance as by deffuzification process we convert the fuzzy qualities once more into the established or fresh qualities. There are diverse strategies for deffuzification, for example, the centroid technique, bisector strategy, biggest of most extreme, center of greatest lastly the littlest of most extreme. Among the majority of this the most proficiently utilized defuzzification strategy is the centroid technique. A fuzzy controller can work in an expansive scope of activities alongside the variety of the parameters and load presence when contrasted with PI controllers. Contingent upon the control prerequisites and operational states of the DFIG, a fuzzy PI control system is planned. Contribution to the fuzzy PI controller is the mistake, which is ceaselessly followed and consequently amended by the dynamic execution.

The Input values are normalized before the proposed ANN controller is fed into the Neural Network Controller. The suggested artificial neural network model is intended with the required parameters as shown in Fig 3.2 and the controller's learning method is performed to achieve the methods suggested. The controller was originally intended by contemplating discrete weights in the ANN module and then the suggested DFIG-based wind turbine was taken to adjust the constructed ANN controller's weight numbers..

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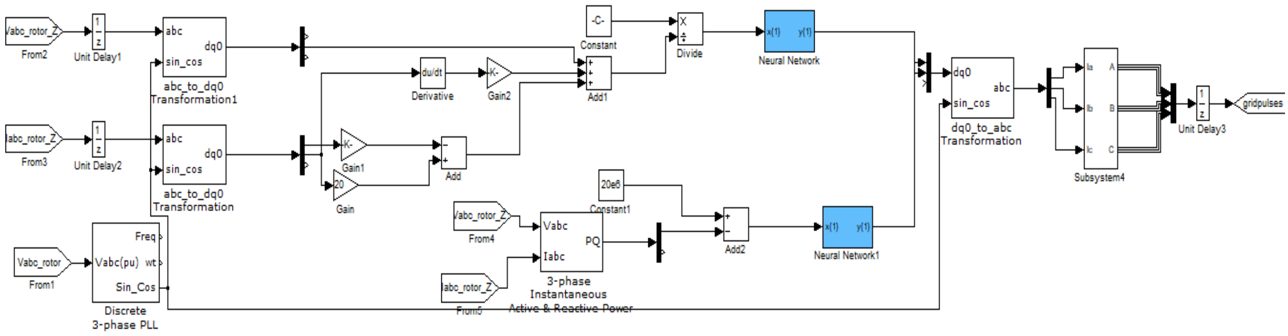

Fig. 3.2 Proposed ANN Controller

The controller was originally intended by contemplating discrete weights in the ANN module and then the suggested DFIG-based wind turbine was taken to adjust the constructed ANN controller's weight numbers. in Fig. 3.2

4. SIMULATION RESULTS

The check of proposed model has done in view of Simulation. Reproduction of proposed show has finished in MATLAB Simulation condition. Different testing parameters of waveforms are pictured and examined on MATLAB Scope. The central target of proposed work is to decrease mutilation in current and voltage to accomplish better Speed quality. As the market for little scale sustainable power source frameworks is quickly expanding, the requirement for control electronic converters likewise increments. In Fig. 4.1 are available the different parameters of source wind speed, electromagnetic torque, Constant Mechanical Speed.

Figs. show the Performance of the suggested DFIG-based WECS setup at sub-synchronous velocity, super-synchronous velocity, and at synchronous speed, respectively, during transformation. The waveforms for battery power are presented for different wind speeds. The engine energy scheme is selected as adverse if the computer releases any energy to the turbine and good if the sample is retained.

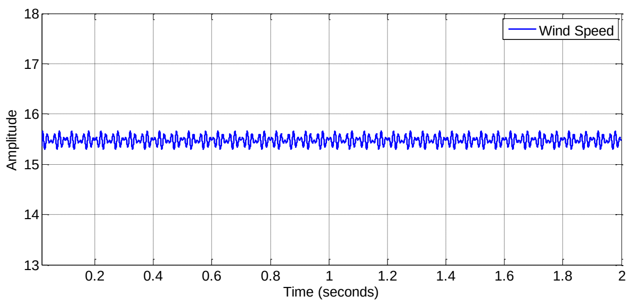

Fig. 4.1 Constant Wind Speed

However, this is kept up by either charging or releasing the battery in the comparing locale of activity. The receptive power is kept up at a steady estimation of zero, exhibiting a solidarity power factor activity. The examination has been performed at variable wind speeds and the system power is kept up to be consistent at the reference esteem. The reference matrix power can be picked to be the normal power provided by the forceful time of activity. Thus, the speed power reference is picked to be Speed as determined and tasteful outcomes are acquired as appeared in Figures.

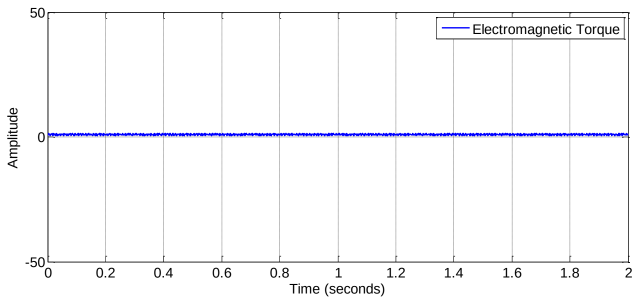

Fig. 4.2 Constant Electromagnetic Torque

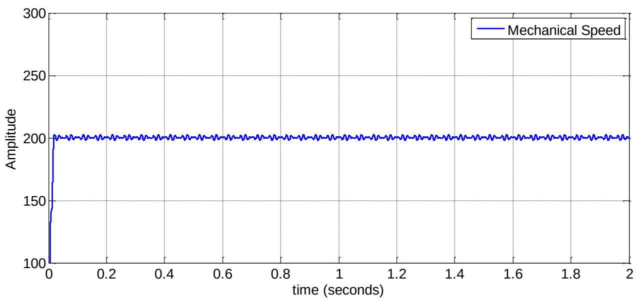

Fig. 4.3 Constant Mechanical Speed

Fig. 4.2 shows a single line graph of an example framework with a steady electromagnetic speed WT. the torque of mechanical trademark has been gotten, and is appeared in Fig. 4.2. In the ordinary working condition, the electrical and mechanical torques will be equivalent; henceforth, the WT will work at slip s0 (point Q). At the point when a serious shortcoming happens near the WT, the terminal voltage of the WT falls definitely. This will diminish the electrical torque to right around zero. Therefore, the rotor will waver, and the slip of the WT will increment.

With the help of Fuzzy control, the info mechanical torque of a constant speed wind turbine can be diminished. During a framework unsettling influence, the framework voltage speeds, and consequently, the dynamic power provided by the wind turbine diminish. Accordingly, the wind speed increments and the wind turbine draws a constant speed, as appeared in Figs. 4.3 and 4.4.

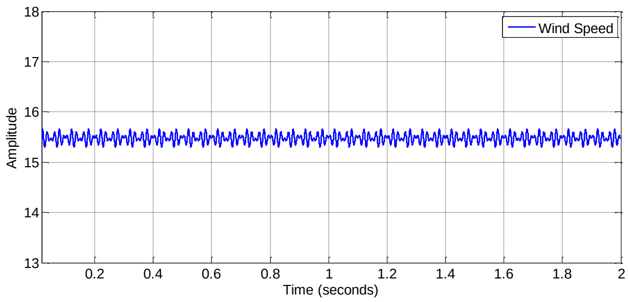

Fig. 4.4 Constant Wind Speed Profile

For this situation, the wind power yield is constant wind speed. Utilizing DFIG controller, the wind power will stay stable despite the fact that the flaw is cleared. That is on the grounds that the mechanical information power, and henceforth, the dynamic power produced is diminished by controlling the contribute edge negative bearing. These outcomes into decrease in mechanical info torque. Therefore, the speed and thus, from the outcomes it is seen that the dynamic execution of the DFIG is improved with the Half and half control system, as appeared in Figures.

Figure 4.5 shows the waveforms of the control pulse used to control the system. Figure 4.6 shows the three-phase load voltage profile. The waveforms is sinusoidal without and distortion, that evident for smooth operation od the system.

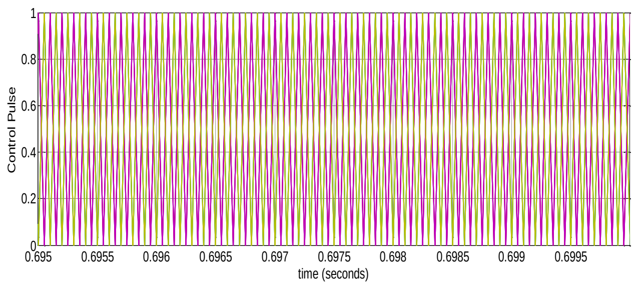

Fig. 4.5 Control Pulse

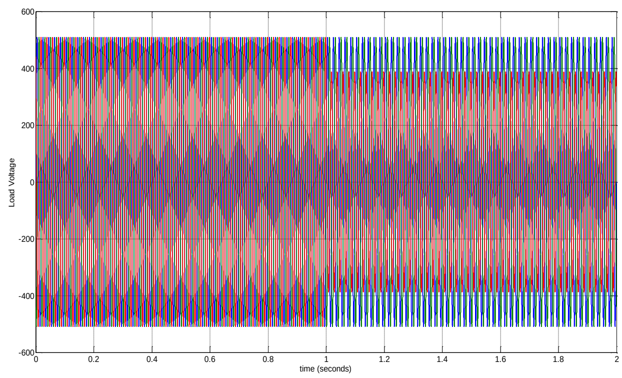

Fig. 4.6 Three Phase Load Voltage

Similarly, Figure 4.7 and 4.8 also shows the waveforms of the three-phase generator voltage and grid voltage respectively. The waveforms are smooth and sinusoidal in behavior and thus good for the proper functionating of the system.

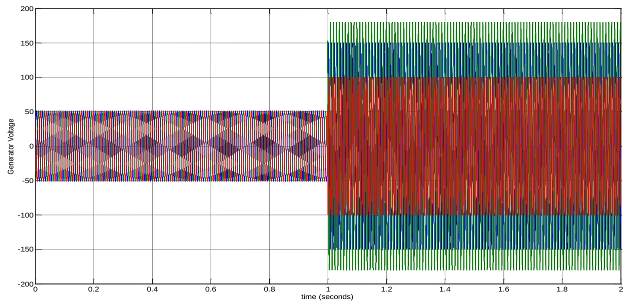

Fig. 4.7 Three Phase Generator Voltage

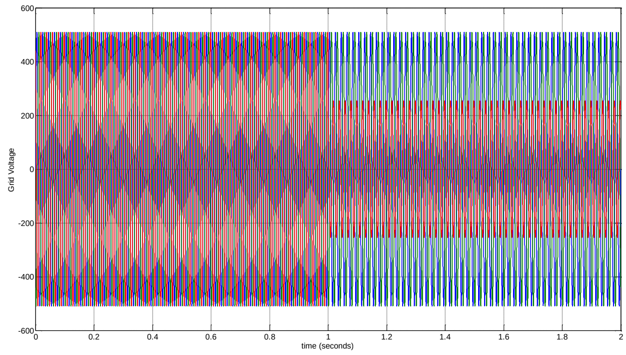

Fig. 4.8 Three Phase Grid Voltage

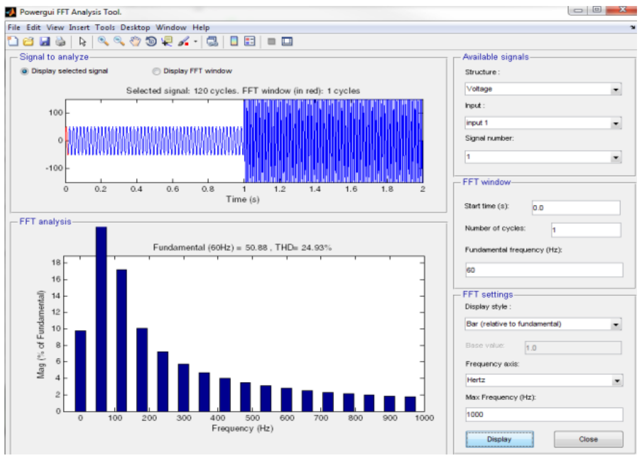

Fig. 4.9 FFT Analysis Generator Voltage

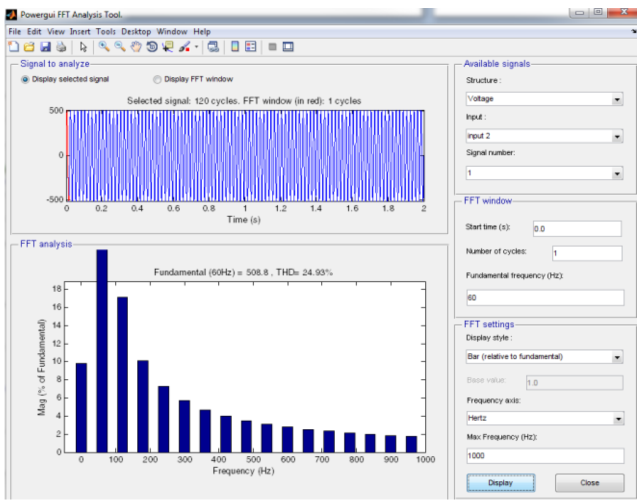

Fig. 4.10 FFT Analysis Grid Voltage

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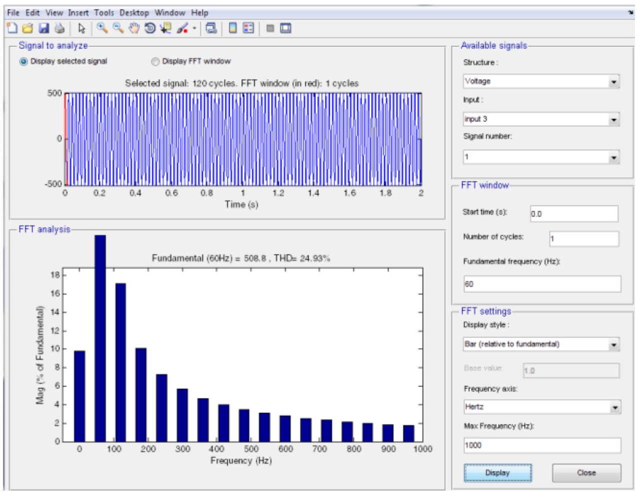

Fig. 4.11 FFT Analysis Load Voltage

Figure 4.9, 4.10 and 4.11 shows the Fast Fourier Transform (FFT) analysis of the generator voltage, grid voltage and load voltage respectively. The following analysis shows the total harmonic distortions in different electrical quantities. The THD percentage of generator voltage is 24.93% which is good enough for system to operate. The THD percentage of grid voltage is 24.93% which is good enough for system to operate. The THD percentage of load voltage is 24.93% which is good enough for system to operate.

5. CONCLUSION AND FUTURE SCOPES

This study is the control strategy for the Twofold Fed Induction Generator (DFIG) determined sunlight-based power stockpiling plan was made for the Artificial Neural Network (ANN) and the accomplishment of the plan is diverged from the Fuzzy and NN observing strategies. We're condensing the essential outcomes and a portion of the essential things of this work. As recently expressed, the goal of the work is to display DFIG dependent on wind turbine in the proposed work for direct control of the stator dynamic and responsive power of fuzzy associated DFIG.

The practical and ecological factors additionally add to the innovative work on investigating different methods for expanding the presentation of wind turbine. Most of the business wind energy transformation frameworks in India are furnished with flat node, upwind designed WTG because of their different points of interest. The exhibition of the proposed control strategies is shown through the outcomes, dictated by utilizing MATLAB/Simulink. From the outcomes it is seen that the dynamic execution of the DFIG is improved with the hybrid control technique.

REFERENCES

[1]. S. Elkhadiri, P. L. Elmenzhi and P. A. Lyhyaoui, "Fuzzy logic control of DFIG-based wind turbine," 2018 International Conference on Intelligent Systems and Computer Vision (ISCV), Fez, 2018, pp. 1-5.

[2]. M. J. Morshed and A. Fekih, "A Terminal Sliding Mode Approach for the Rotor Side Converter of a DFIG-Based Wind Energy System," 2018 IEEE Conference on Control Technology and Applications (CCTA), Copenhagen, 2018, pp. 1736-1740.

[3]. A. Ashouri-Zadeh, M. Toulabi, S. Bahrami and A. M. Ranjbar, "Modification of DFIG's Active Power Control Loop for Speed Control Enhancement and Inertial Frequency Response," in IEEE Transactions on Sustainable Energy, vol. 8, no. 4, pp. 1772-1782, Oct. 2017.

[4]. Singh and S. K. Jain, "Mitigation of subsynchronous resonance in DFIG based wind farms using fuzzy controllers," 2016 7th India International Conference on Power Electronics (IICPE), Patiala, 2016, pp. 1-6.

[5]. R. Bhavani, N. R. Prabha and C. Kanmani, "Fuzzy controlled UPQC for power quality enhancement in a DFIG based grid connected wind power system," 2015 International Conference on Circuits, Power and Computing Technologies [ICCPCT-2015], Nagercoil, 2015, pp. 1-7.

[6]. K. Boulâam and A. Boukhelifa, "A fuzzy sliding mode control for DFIG-based wind turbine power maximisation," 7th IET International Conference on Power Electronics, Machines and Drives (PEMD 2014), Manchester, 2014, pp. 1-6.

[7]. L. Wang and D. Truong, "Stability Enhancement of DFIG-Based Offshore Wind Farm Fed to a Multi-Machine System Using a STATCOM," in IEEE Transactions on Power Systems, vol. 28, no. 3, pp. 2882-2889, Aug. 2013.