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Active Reactive Power Control & Solid Ground Faults compensation of a DFIG for Variable Speed Wind Energy Conversion System using AFCL

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Abstract - One of the necessities for safe, stable, maintainable, and productive task of doubly fed induction generators (DFIGs)- based wind energy change systems (WECSs) is the accurate and reliable protection against electrical faults, specifically, ground faults. The execution of protective devices utilized to accomplish this necessity is profoundly reliant on the establishing design of the DFIG-based WECS. This paper examines effects of the establishing design on the execution of defensive devices used to protect DFIGs-based WECSs from electrical ground faults. Examined grounding setups incorporate solid grounding, low-resistance grounding, high-resistance grounding, and no grounding. This paper additionally examines the utilization of a capacitor in parallel with a low resistance, as an establishing setup, to restrict ground possibilities, decrease ground currents, and limit impacts on response of ground protective relay. The effects of the grounding arrangements on defensive devices are seen through their capacity to recognize faults, and in addition their speed to react to identified faults. Simulation and experimental outcomes uncover that enough designed low-resistance establishing offers the base effects on protective devices utilized for ground protection of DFIG-based WECSs.

Keywords - Faults compensation, Wind Energy Conversion System, Active Reactive Power Control, AFCL. DFIG.

I. INTRODUCTION

Alternate to fossil fuels and non renewable sources, wind power emerged as a powerful renewable energy resource for generation of electric power. Wind power plays a vital role for electrical power transmission network compared to other renewable sources. Wind turbines extract wind power from air flow to produce mechanical power. Induction Generators connected to wind turbines convert mechanical power into electrical power. Wind power is clean, renewable, produces no green house emissions, available plentiful, widely distributed and uses little land with almost zero environmental problems. Wind farms are broadly classified as on-shore and off-shore wind turbines. Small onshore wind farms provide electricity to isolated off-grid locations and some energy into the grid. Wind power significantly varies and inconsistent from year to year, therefore wind power is used in conjunction with the other electric power sources to meet the requirements of grid and for reliable supply of electric power.

Wind Energy Conversion System (WECS) is the overall system for converting wind energy into useful mechanical energy that can be used to power an electrical generator for generating electricity. The WECS basically consists of three types of components: aerodynamics, mechanical, and electrical as shown in Figure 1.1.

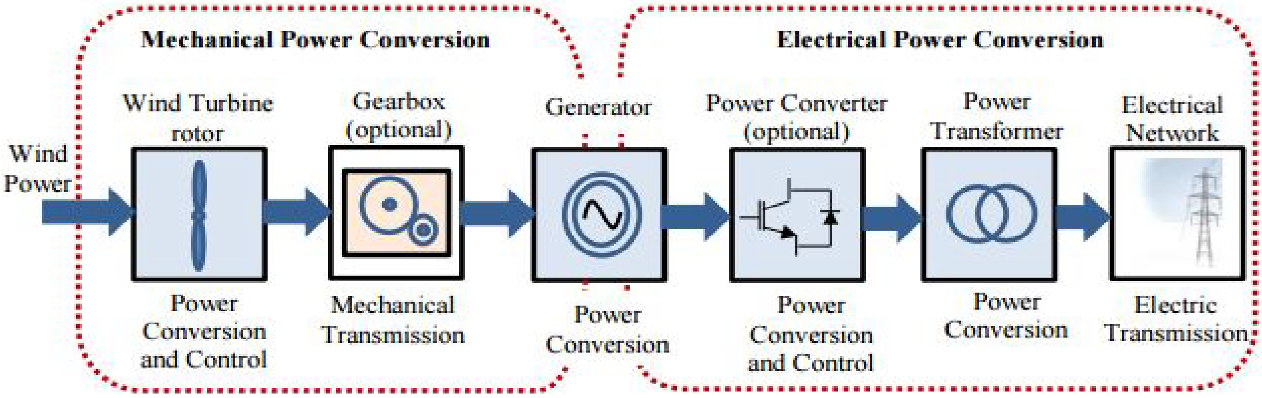

Figure 1.1 Block diagram of component of WECS connected to grid.

Small capacity wind turbines are operated as stand-Alone units in farms, islands and villages where grid is not accessible or costly. Now-a-days majority of wind farms are connected to the grid, so wind turbines with large capacity are directly connected to the grid. Since the wind turbine generators are capable of withstanding low voltage(typically 690V), transformers are utilised for stepping up the voltage to 35kV, further this voltage is stepped up with the substation transformer.

On-land wind farms are installed where wind speed is adequate. On-land wind farms have advantages such as access is convenient, erosion is less, capital cost and maintenance cost is less, and energy production is good. Offshore wind farms are installed where wind speed is higher and steadier and there is no limit for land/area. But in these firms capital cost and maintenance are very high.

II. DOUBLY FED INDUCTION GENERATOR

In wind energy conversion systems (WECSs), the kinetic wind energy is converted to electrical energy through doubly-fed induction generators (DFIGs) and then fed into the grid. In order to examine the power quality issues of variable speed wind turbine- generator systems, such as their interaction with the grid and different control scheme configurations, a proper model of the grid-connected variable speed WECS should be established first.

Typically wind generation equipment is categorized in three general classifications:

1) Utility scale- Corresponds to large turbines (900kW-3.5MW) used to generate bulk power for energy markets.

2) Industrial Scale- Corresponds to medium sized turbines (50kW-250kW) mainly used by industries for remote grid production to meet local power requirement.

3) Residential Scale- Corresponds to small sized turbines (400 watts-50kW) mainly utilized for battery charging. In conjunction with solar photovoltaic, it can be utilized for remote power requirement where normal power distribution lines do not exist.

Unlike a conventional power plant that uses synchronous generators, a wind turbine can operate as fixed-speed or variable-speed. In a fixed-speed wind turbine, the stator of the generator is directly connected to the grid. However, in a variable-speed wind turbine, the machine is controlled and connected to the power grid through a power electronic converter. There are various reasons for using a variable-speed wind turbine. (1) Variable-speed wind turbines offer a higher energy yield in comparison to constant speed turbines. (2) The reduction of mechanical loads and simple pitch control can be achieved by variable speed operation. (3) Variable-speed wind turbines offer acoustic noise reduction and extensive controllability of both active and reactive power. (4) Variable-speed wind turbines show less fluctuation in the output power. The permanent magnet synchronous generator (PMSG) and doubly-fed induction generator (DFIG) are the two machines on which the variable-speed wind turbines are based.

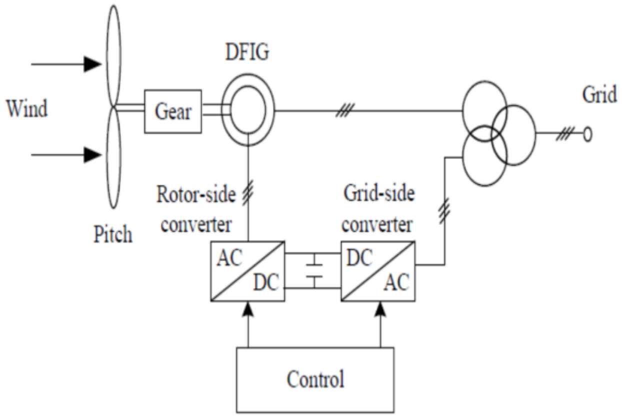

Figure 2.1 DFIG wind turbine configuration.

A variable speed wind turbine-generator system (WECS) schematic is shown in Figure 2.1. The stator phase windings of the doubly-fed induction generator (DFIG) are directly connected to the grid, while the rotor phase windings are connected to a bidirectional power converter via slip rings. The bidirectional power converter consists of two converters, i.e., grid side converter and rotor side converter, and between the two converters a dc-link capacitor is positioned. The main objective for the grid-side converter is to keep the variation of the dc-link voltage small. With control of the rotor side converter, it is possible to control the torque, the speed of the DFIG as well as its active and reactive power at the stator terminals.

III. PROPOSED SYSTEM

Proposed system DFIGs-based WECSs utilizing AFCL advanced fault current control limiter has been implemented and simulated on MATLAB. The Impacts of the establishing design on the execution of defensive devices used to protect DFIGs-based WECSs from electrical ground faults. Researched establishing arrangements incorporate strong establishing, low-protection establishing, high-protection establishing, and no establishing figure 3.1 exhibited in figure 3.1 Proposed System Design with FCL extension. AFCL is a standout amongst the most novel alternate for maintains a strategic distance from the issue of expanding fault current. It enhances power system reliability and stability by diminishing the fault current promptly. It has had extensive impedance in fault conditions and has low impedance in ordinary conditions and also instantaneous recovery to zero impedance post fault clearance. Superconducting materials have a very non-straight conduct which is perfect for the application as FCLs.

The Fault Current Limiter (FCL) presents unique attributes acquired from the properties of superconductors. This presents fundamental components of superconductivity that are utilized to show the cause of the electrical resistance occurring in the flux-flow regime in high temperature superconductors. Superconductivity is a state of the issue portrayed by a weak attractive communication between conduction electrons. In this specific state, that occurs for some components of the periodic system, this weak interaction diminishes the system entropy and permits the in-phase motion of corresponded electrons over essential distances.

If the current rise above the critical current esteem the resistance increments rapidly. The disseminated losses because of the rapid raise in resistance warms the superconductor over the basic temperature and the superconductor changes its state from superconducting to Normal state and fault current is decreased promptly. This phenomenon is called quench of superconductors. At the point when the blame current has been decreased.

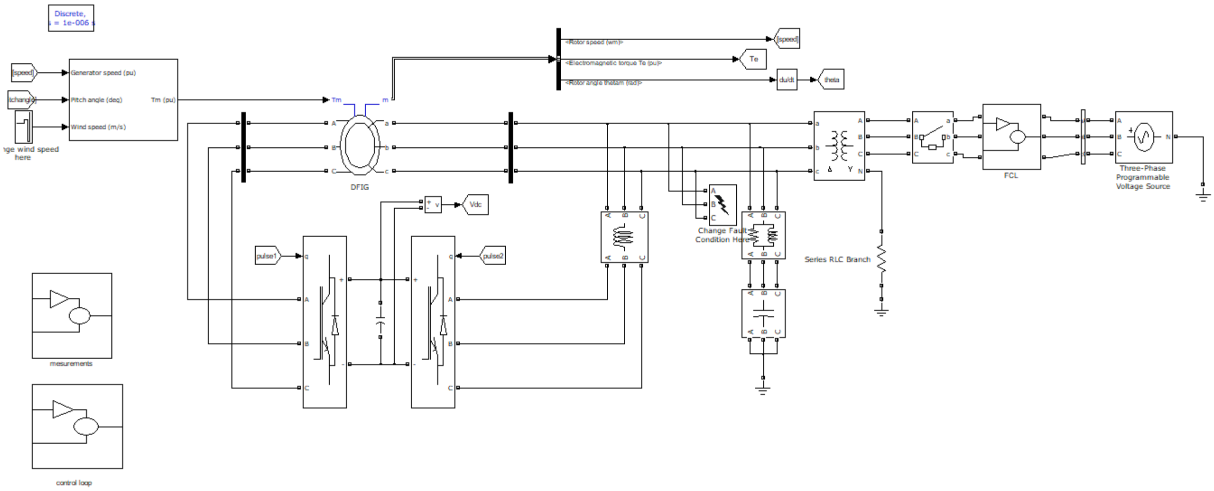

Fig. 3.1 Proposed System Design with FCL extension.

Before the advancement work of the fault current limiter, the fundamental region of research was to soften the circuit during fault in order to spare the costly equipment at power frameworks from huge fault currents occurred during fault. Keeping in mind the end goal to deal with substantial fault currents electrical switch with expansive rating were produced. But, the issue with the circuit breakers is that they have a constrained life period, and can't break the circuit until the point that the primary current cycle goes to zero.

Figure 3.2 shows the subsystem of proposed FCL system implemented on Matlab. There are three connections as illustrated in figure i.e. conn1, connn2 and conn3 connected to DFIG. to perform operation a pulse generator is utilised to generate pulse signal parallel three series RLC branch and two thyristor , thyristor and thyristor 1 are configured.

Matlab implementation circuit of proposed control loop for DFIG WECs has been shown in figure.

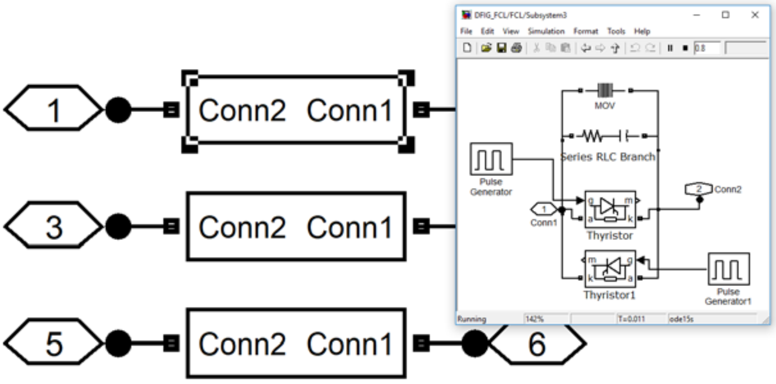

Figure 3.2 Proposed FCL Subsystems.

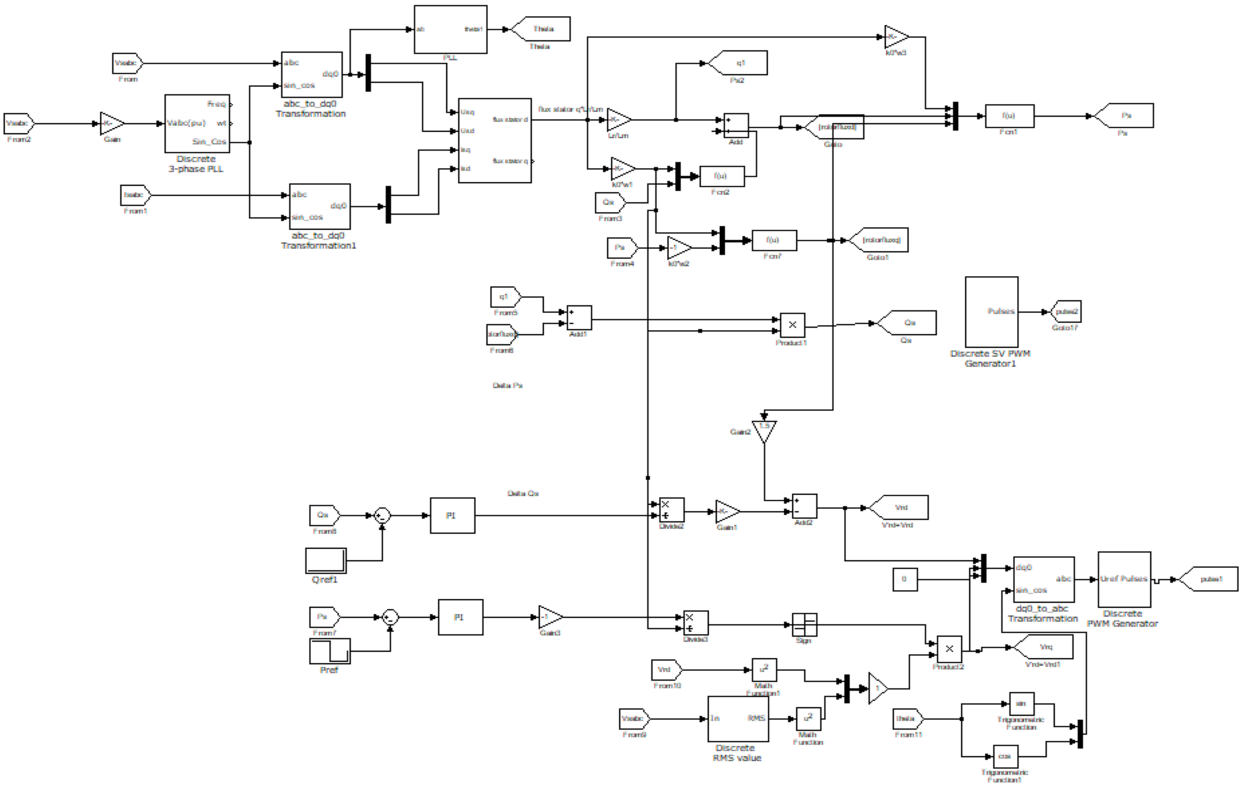

Figure 3.3 Proposed Control Loop.

IV. SIMULATION RESULTS

AFCL advanced fault current limiter controller has been connected for active and reactive power control accomplished the steady state stability and zero consistent state error in face of transient unsettling influences, in DFIG WECS. The stator active and reactive power has been controlled by utilizing Sliding Mode Control. Prattling because of switching capacity is dispensed with utilizing low pass filter likewise strong ground faults has been compensated of a DFIG for variable speed wind energy transformation system. Simulations have been pursued after for controlling active and reactive power by AFCL utilizing MAT-LAB/SIMULINK. Controlling active and reactive power assumes an essential part for power trans-mission and dispersion. The graphical portrayal of results has been given in figure underneath.

Figure 4.1 shows the waveform taken from simulation scope9 Rotor Currents and figure 4.2 shows the simulation waveform of stator currents. The waveform of active and reactive power has been shown in figure 4.3. The waveform of wind speed and torque of WECs has been shown in figure 4.4 and 4.5 respectively.

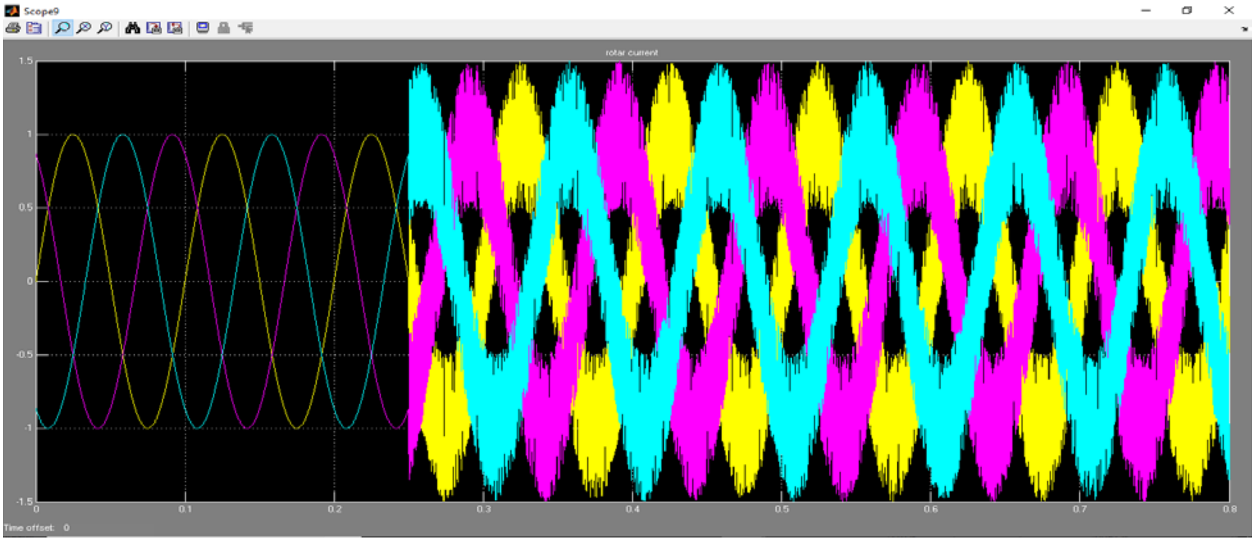

Figure 4.1 Rotor Currents.

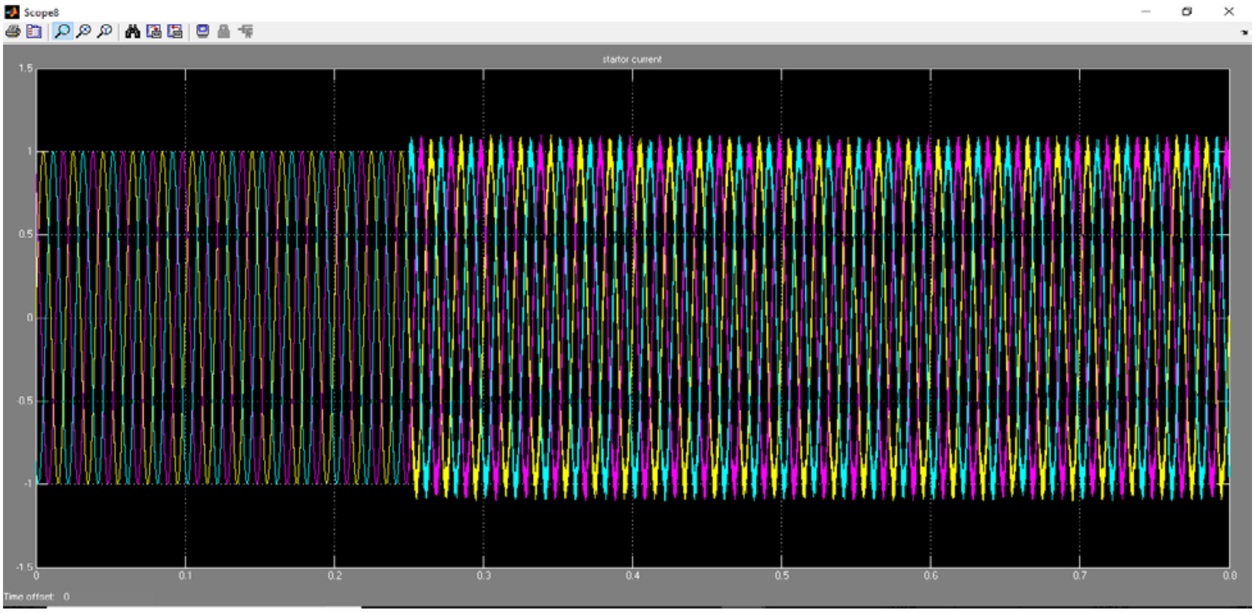

Figure 4.2 Stator currents.

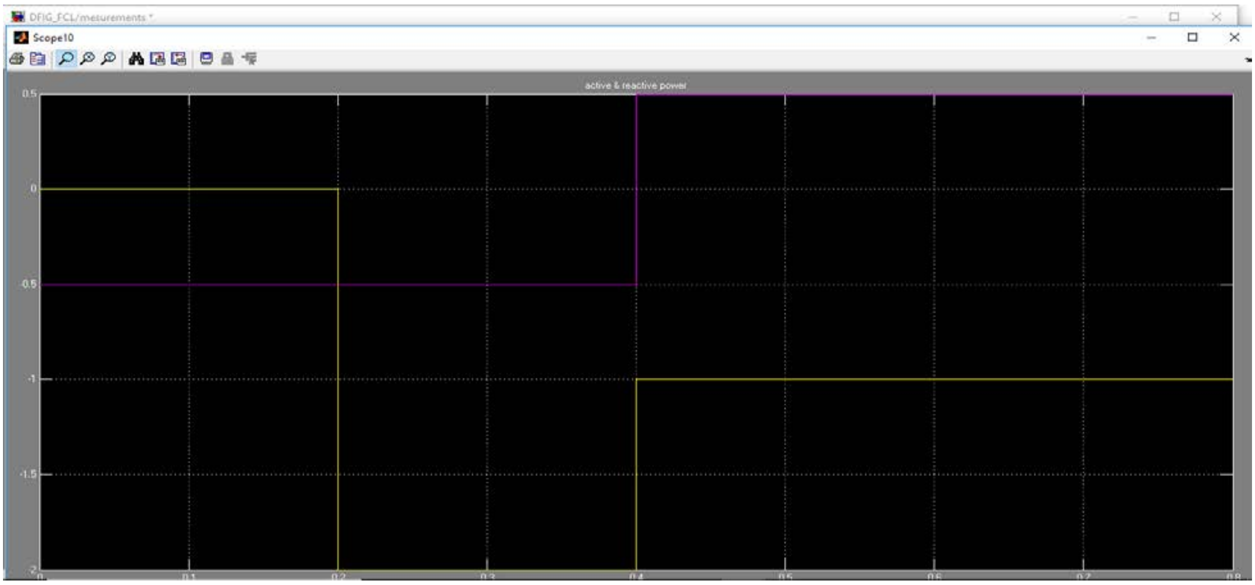

Figure 4.3 Active and Reactive Powers

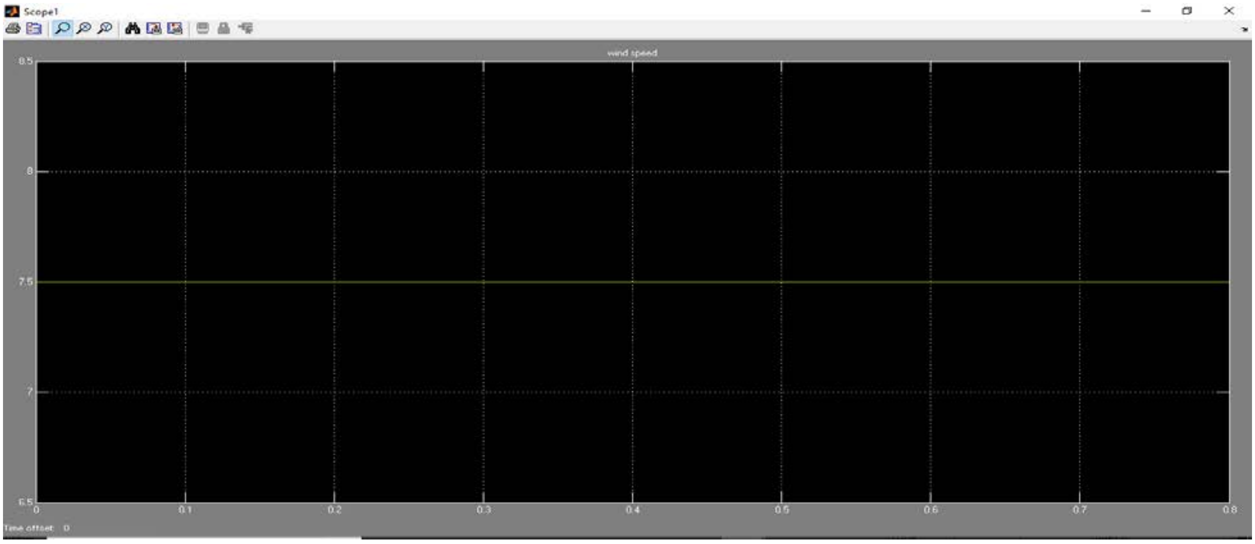

Figure 4.4 Wind Speed.

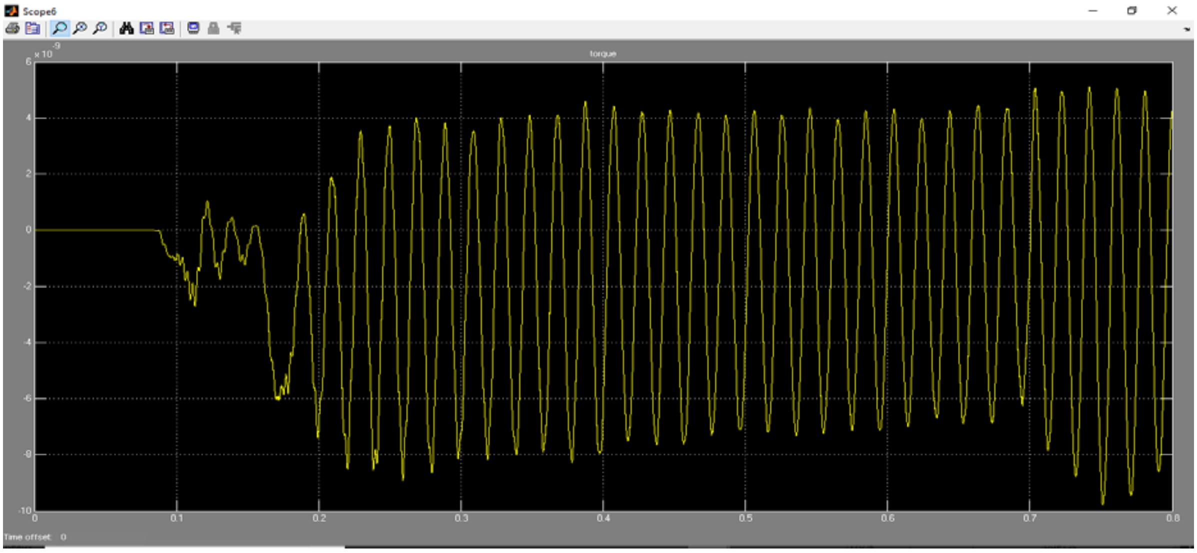

Fig.4.5 Torque

V. CONCLUSION AND FUTURE SCOPE

The modelling and control of a doubly-fed induction generator based wind turbine-generator system have been considered. All the more particularly, the demonstrating of various segments, the control techniques for the back-to-back converter, the advanced modulation innovation and novel kind of converters have been considered and briefed in detail. As a premise of the exploration, the model of a wind turbine-generator system designed with a doubly-fed induction generator was developed in a Matlab/Simulink software based simulation environment, which simulate the function of the system from the turbine rotor, where the kinetic wind energy is changed over to the mechanical energy, to the generator, which changes the mechanical power to electrical power, and then to the grid connection point, where the electric power is fed into the grid. The model of the wind turbine system aerodynamic models of the wind turbine, the drive prepares system models, the consecutive converter models, and the doubly-fed induction generator models. Active reactive power control and Solid Ground Faults compensation of a DFIG for Variable Speed Wind Energy Conversion System has been accomplished by utilizing AFCL.

Although numerous improvements have been carried out in this work, a few conceivable future examinations are interesting. A few subjects for future investigations are considered as follows higher order models of the drive train system and the doubly-fed induction generator demonstrate with saturation effect ought to be considered in wind turbine systems. Wind speed sensorless control systems ought to be examined, because of the way that the anemometer may not precisely measure the wind speed.

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