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Performance Analysis of DFIG Wind Turbine Grid Connected System under various Fault Condition

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***Abstract:** Wind generated energy systems have some distinctive challenges for protection and control engineers. The short circuit behavior of the first generation wind turbines depends on the physical characteristics of the machines. Typical protection schemes can be applied to produce protection to those wind farms. Wind turbines were used with SCIG which can be used only under fixed speed. In a while PMSG was used and presently selection in wind speeds influences the vitality transformation, all things thought-about. For greatest vitality transformation to happen, the generator speed should be controlled. A relative investigation among SCIG and DFIG shows that DFIG is superior to SCIG. Different types of even and unsymmetrical shortcomings are actuated in the framework where in DFIG is associated and also the reaction is detected. To ensure the DFIG during such issues, crowbar usage is implemented. The voltage and current in the framework thought-about through such flaws is likewise estimated. A replica study is depicted utilizing MATLAB/SIMULINK relying upon flows, voltages, power and speed.*
***Keywords:** Wind Farm-Doubly Fed Induction Generator (DFIG), Wrecking bar (Crowbar) Protection, L-L-L Fault, L-G Fault, L-L-G Fault, Line to Line Fault*

I. INTRODUCTION

Nowadays, renewable energy systems have attracted interest, as a result of the standard sources of energy have become restricted. Many various energy sources such as wind generation, alternative energy and tiny hydro-electric power are investigated. Wind generation could be a style of alternative energy. The uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the world cause winds. Wind flow patterns are modified by the earth's terrain, bodies of water and vegetation to get electricity.

The terms wind energy or wind generation describes the method by that wind is employed to get mechanical power or electricity. Wind turbines convert the mechanical energy with in the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator will convert this mechanical power into electricity.

Due to its numerous advantages wind energy holds a greater prospective for development during this space. Wind turbines were used with SCIG which may be used solely beneath fastened speed. Soon PMSG was used and presently DFIG with variable speed is getting used. Fastened speed induction generator based mostly WECS offered many disadvantages like increased convertor rating, value and increased losses that resulted in reduced potency. All these disadvantages were overcome by using DFIG as it can operate with variable speed. Such operation will increase the entire energy output and reduces the general value of energy. Wind energy has become the frontrunner among all other renewable energy technologies over the last decade. Variation in wind speeds affects the energy conversion to a good extent.

II. SYSTEM DESCRIPTION

A. *Wind Farm*

A wind farm or Wind park could be a cluster of wind turbines within the same location used for production of electrical power. A oversized wind farm might incorporates many hundred individual wind turbines distributed over an associated degree extended space, however the land between the turbines could also be used for agricultural or alternative functions. Wind farms incorporates several individual wind turbines, that area unit connected to the electrical power transmission network. Fig 2.1(a) shows the overall wind park layout. Wind turbines have the power to be settled off shore and send energy back to land. Wind turbines will be as tall as 200 meters and have blades that may move at a speed of up to 200mph. Some countries utilize wind turbines to produce up to 20% of their electricity needs. Wind farms area unit giant teams of Wind turbines.

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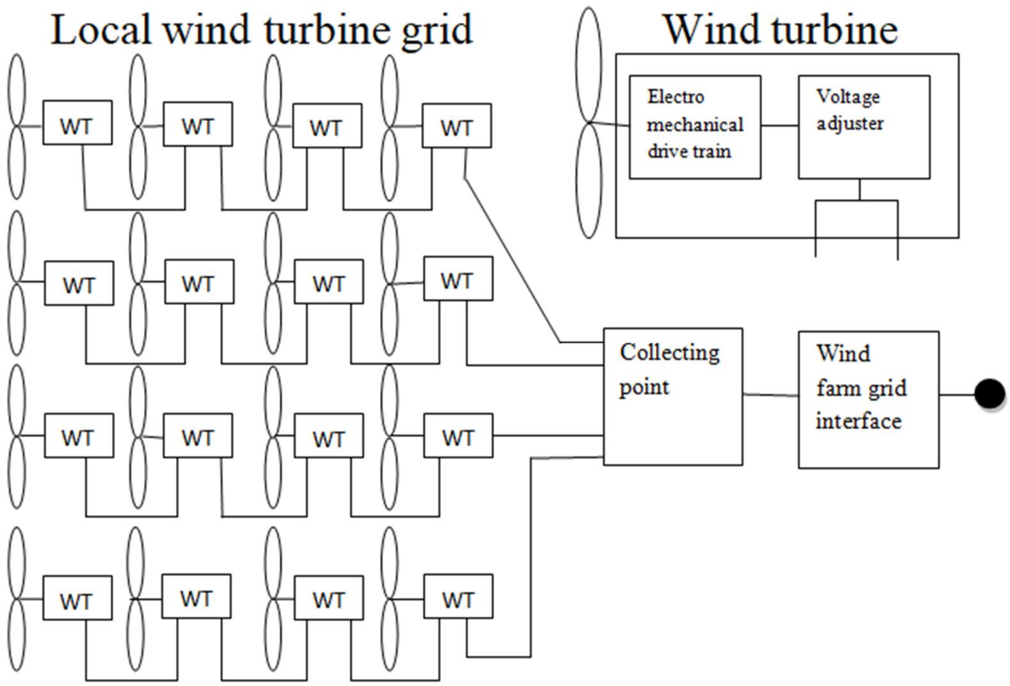

Fig 2.1(a) General Wind Farm Layout

B. Doubly Fed Induction Generator

The Doubly-Fed Induction Generator (DFIG) system is also a popular system inside that the power electronic interface controls the rotor currents to comprehend the variable speed necessary for optimum energy capture in variable winds. As a results of the power physics only methodology the rotor power, typically however 25% of the general output power, the DFIG offers the advantages of speed management with reduced value and power losses. The system model includes a mechanical model of the blades, hub and shaft, a consecutive converter along side thermal loss calculations, a magnetic model of the three-phase electrical device and also additionally the line and grid.

1) A double-Fed induction generator may be a common place wound rotor induction generator with its mechanical device windings directly connected to the ability grid and rotor connected to the power grid through a back to back convertor .
2) The convertor that's connected to the rotor known as "rotor side converter" and also the alternative named "grid side converter".
3) Vector management is one of the most common ways applied to DFIG to regulate the flow of active and reactive power between the mechanical device and also the grid. It can be applied on each rotor side converter (RSC) and grid side converter (GSC).
4) The objective of the RSC is to manipulate each the stator-side active and reactive powers severally, whereas the target of the GSC is to stay the dc-link voltage constant inspite of the magnitude and direction of the rotor power.

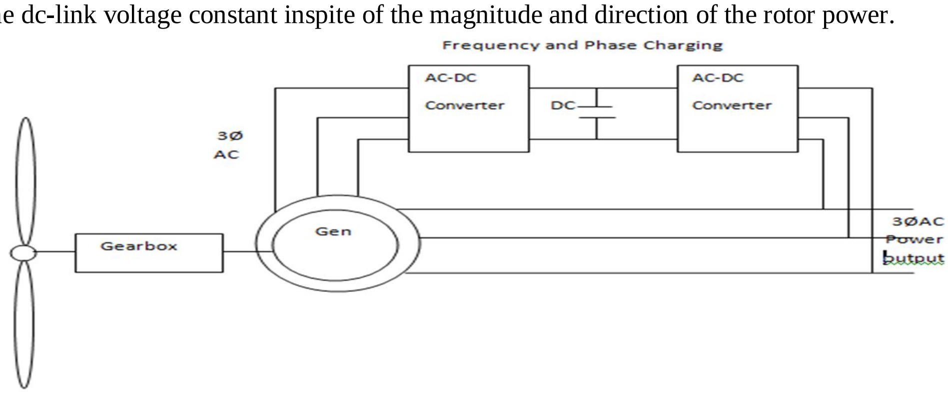

Fig 2.2(a) DFIG Wind Turbine

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The Induction generator is connected directly to the grid through slip rings. A back to back converter is present which connects the rotor windings and the grid. The converter helps to control the active and reactive power fed to the grid by controlling the rotor currents injected into the rotor windings. However, when faults occur the converter may be subjected to high currents. In order to bypass these high currents a crowbar setup is used. This setup consists of resistors connected through thyristors switches. When these switches are triggered using a suitable pulse, they limit the rotor voltage and provide additional path for rotor current.

C. Wrecking Bar Protection

A Wrecking bar circuit is an associate in nursing circuit used for preventing an overvoltage condition of a power supply unit from damaging the circuits hooked up to the facility offer. It operates by golf stroke a brief circuit or low resistance path across the voltage output (V_0), quite like were one to drop a crowbar across the output terminals of the facility. Crowbar circuits are frequently implemented using a thyristor, TRIAC, trisil or thyratron because the shorting device. Once triggered, they rely upon the current-limiting electronic equipment of the facility offer or, if that fails, the processing of the road fuse or tripping the breaker.

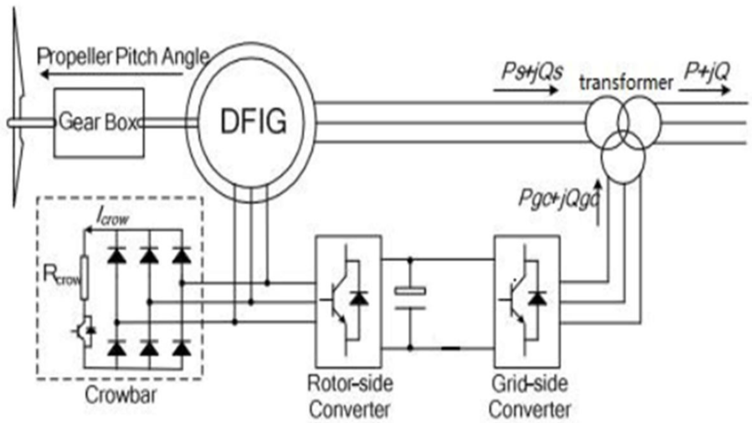

Fig.2.3 (a) Crowbar Implementation in DFIG

III. SIMULATION METHODS OF THE DFIG

Depending on the vary of frequencies to be delineated, three simulation strategies are presently out there in Specialized Power Systems to model VSC based mostly energy conversion systems connected on power grids.

The detailed model (discrete) includes careful illustration of power electronic IGBT converters. So as to achieve an appropriate accuracy with the 1620Hz and 2700Hz switching frequencies used during this instance, the model should be discretized at a comparatively tiny time step (5 microseconds). This model is comparable temperament for perceptive harmonics and control system dynamic performance over relatively short periods of times (typically hundreds of milliseconds to one second).

The average model (discrete) The model of IGBT voltage-sourced converters (VSC) are described by equivalent voltage sources generating the AC voltage averaged over one cycle of the switching frequency. This model doesn't represent harmonics however the dynamic ensuring from control system and power System interaction is preserved. This model permits using much larger time steps (typically 50 microseconds), thus permitting simulations of many seconds.

The phasor model (continuous) This model is healthier tailored to simulate the low frequency electromechanical oscillations over long periods of time (tens of seconds to minutes). With in the phasor simulation technique, the sinusoidal voltages and currents are replaced by phasor quantities (complex numbers) at the system nominal frequency (50Hz to 60Hz). This is often a technique that is employed in transient stability code.

A. Description

A 9MW power station consisting of six 1.5 MW wind turbines connected to a 25kV distribution system exports power to a 120kV grid through a 30km, 25kV feeder.

Wind turbines employing a doubly-fed-induction generator (DFIG) accommodates a wound rotor induction generator and an AC/DC/AC IGBT-based PWM converter. The stator coil winding is connected directly to the 60Hz grid whereas the rotor is fed at variable frequency through the AC/DC/AC converter.

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The DFIG technology permits extracting maximum energy from the wind for low wind speeds by optimizing the rotary engine speed, whereas minimizing mechanical stresses on the rotary engine throughout gusts of wind.
Here, the wind speed is maintained constant at 15m/s. The control system uses a torque controller so as to take care of the speed at 1.2pu. The reactive power made by the wind turbine is regulated at 0 Mvar.

B. Simulation

Throughout this instance you'll observe the steady-state operation of the DFIG and its dynamic response to voltage sag making certain from a remote fault on the 120kV system.
Initially the DFIG power house produces 9MW. The corresponding rotary engine speed is 1.2 pu of generator synchronous speed. The DC voltage is regulated at 1150V and reactive power is kept at 0Mvar.
At t=0.03s the positive sequence voltage suddenly drops to 0.5 pu inflicting an oscillation on the DC bus voltage and on the DFIG output power.
Throughout the voltage sag the control system tries to manage DC voltage and reactive power at their set points (1150V, 0 Mvar).
The system recovers in approximately 4 cycles.

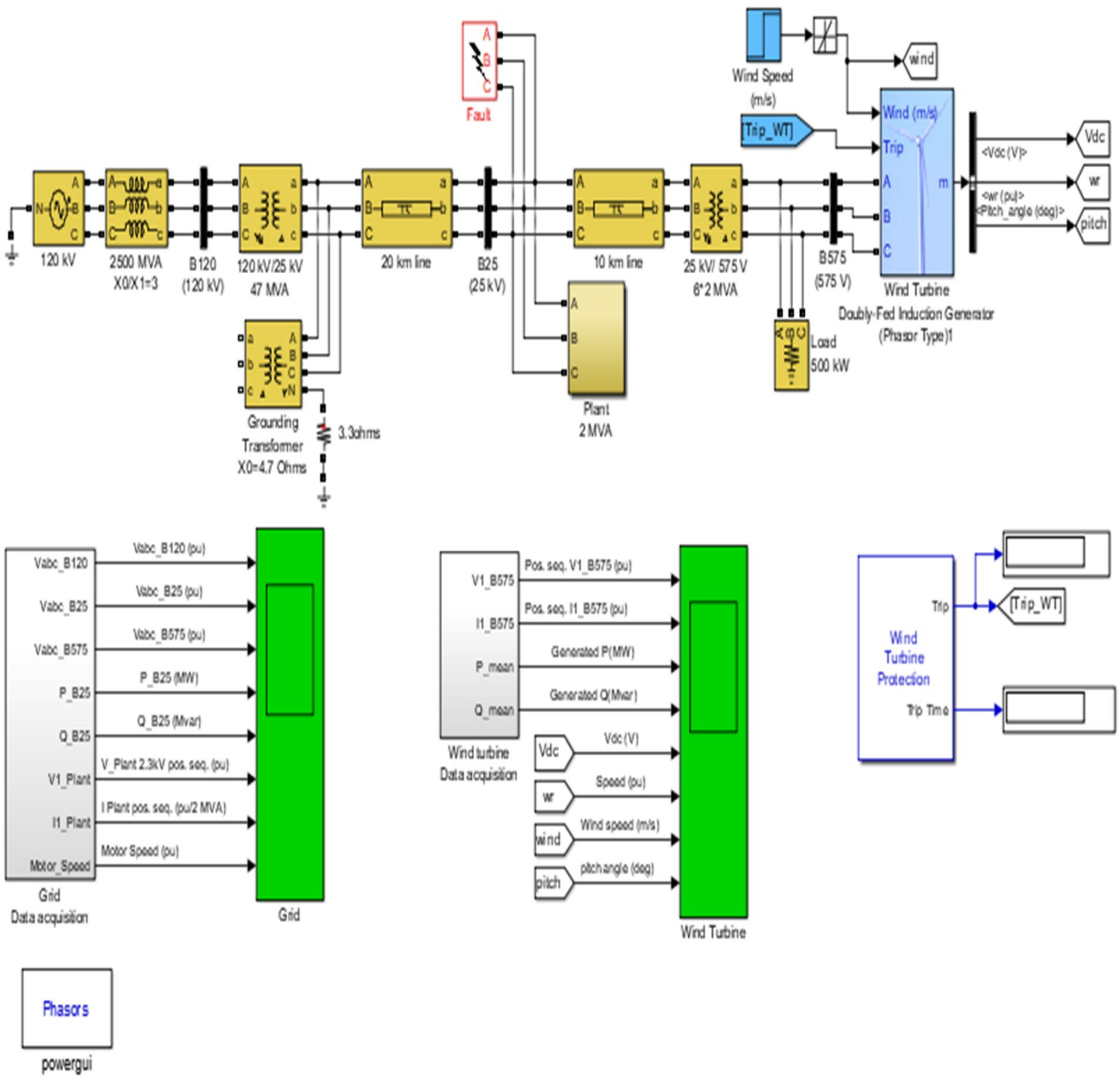

Fig 3.2(a) Model of DFIG Wind Farm

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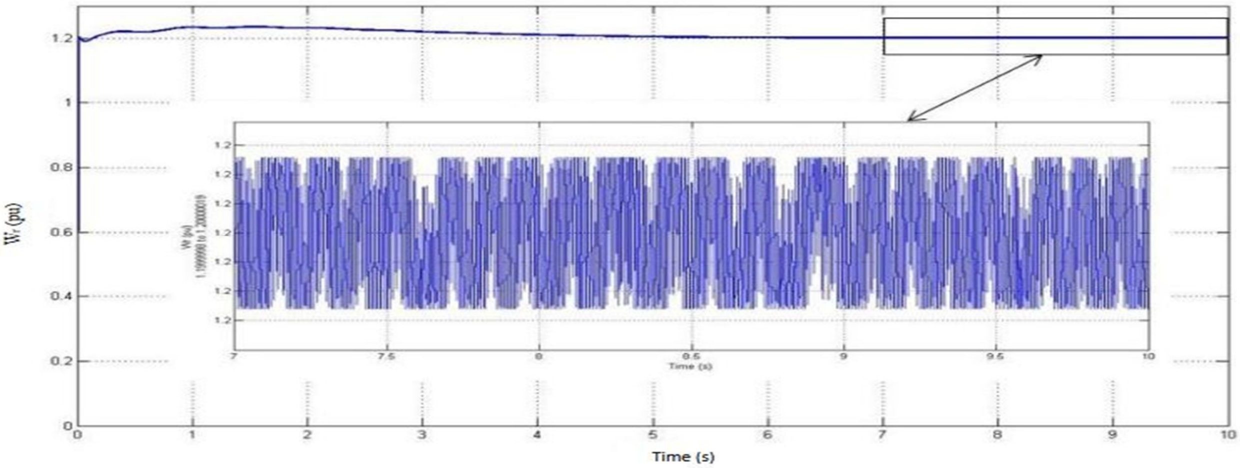

Fig 3.2(b) Turbine Speed

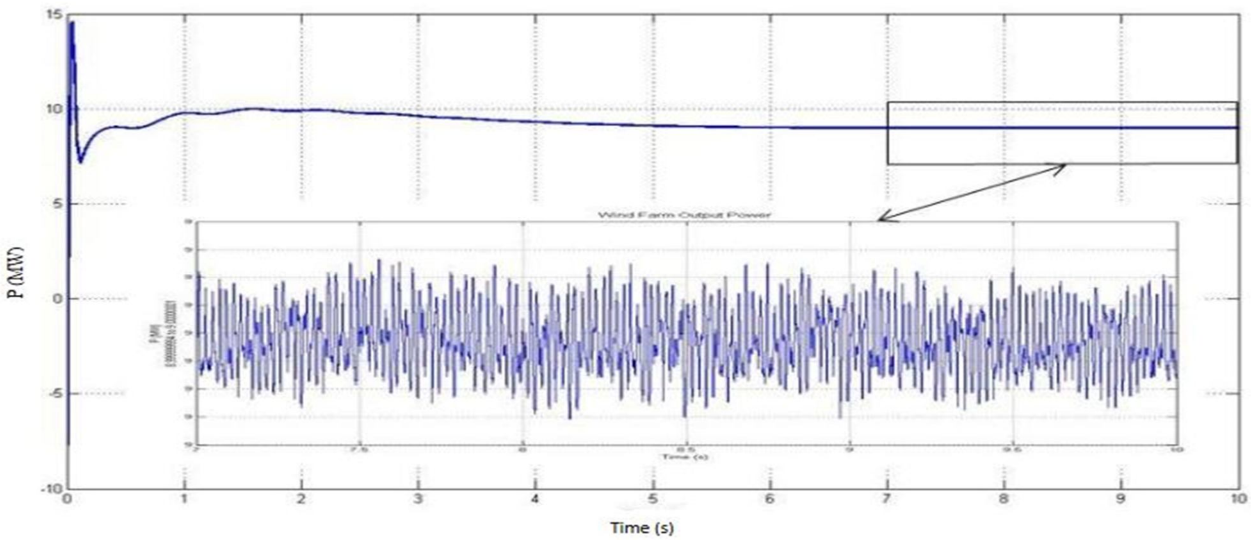

Fig 3.2(c) Active power of Wind Farm

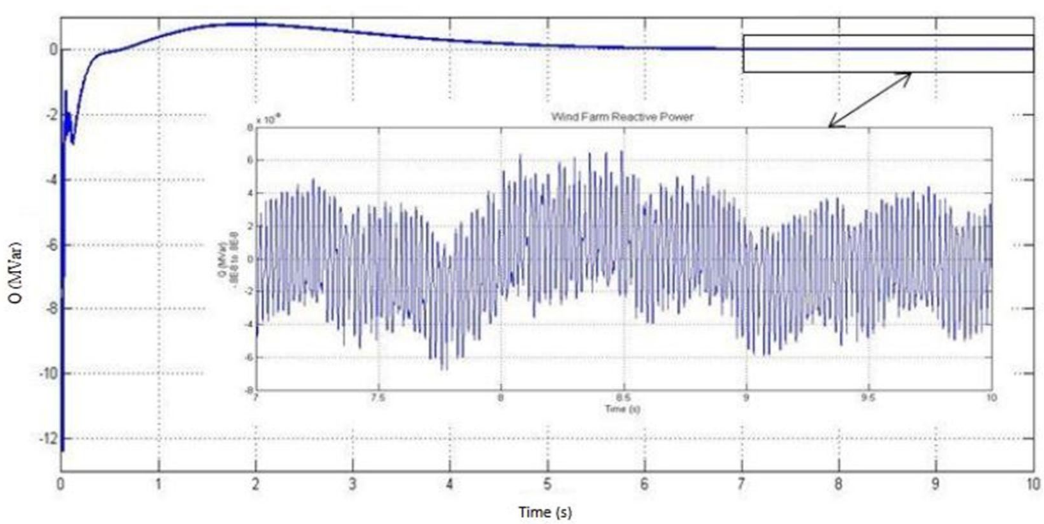

Fig 3.2(d) Reactive power of Wind Farm

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Wind farm parameters under steady state operation Fig 3.2 (a) Wind farm DFIG derailed model (b) Turbine speed (c) Active power of wind farm (d) Reactive power of Wind farm

Wind speed (m/s)	Output power (MW)
2.000	0.000
3.000	0.000
4.000	0.016
5.000	0.077
6.000	0.015
7.000	0.288
8.000	0.423
9.000	0.595
10.000	0.813
11.000	1.073
12.000	1.377
13.000	1.500
14.000	1.500
15.000	1.500
16.000	1.500
17.000	1.500
18.000	1.500
19.000	1.500
20.000	1.500

1) *L-L-L Fault:* It is induced within the mechanical device aspect of the generator. During the time of fault incidence the voltage in all the three phases becomes zero. Since no controller is enclosed within the system to implement the crowbar setup, the voltage and current output cannot be maintained at its nominal value.
2) *L-G Fault:* In this case two line to ground faults are introduced. Only two lines are affected for a specific period of time period. The output isn't maintained within the case while not controller. However within the case with controller the output is maintained throughout the time period of time once fault happens within the system.
3) *L-L Fault:* Line to line fault happens between two phases for a specific period of time. Fault incidence is clearly indicated because the output voltage isn't maintained within the two phases in the case without controller. Harmonics are less during this case in comparison to different cases.
4) *L-L-G Fault:* Double line to ground happens between the two lines a, b and therefore the ground. Phase b remains unaffected.

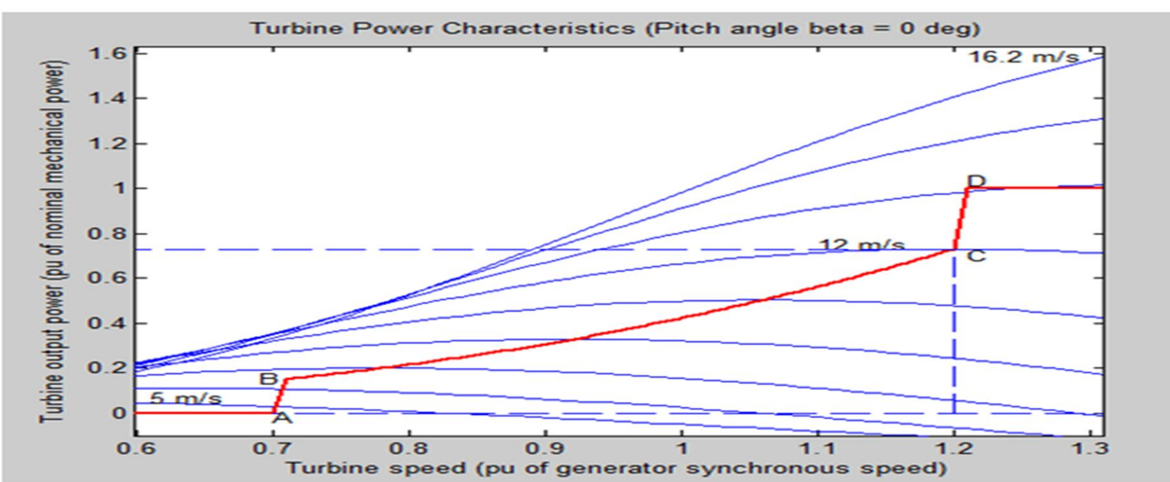

Fig 3.2(d) Turbine power curve

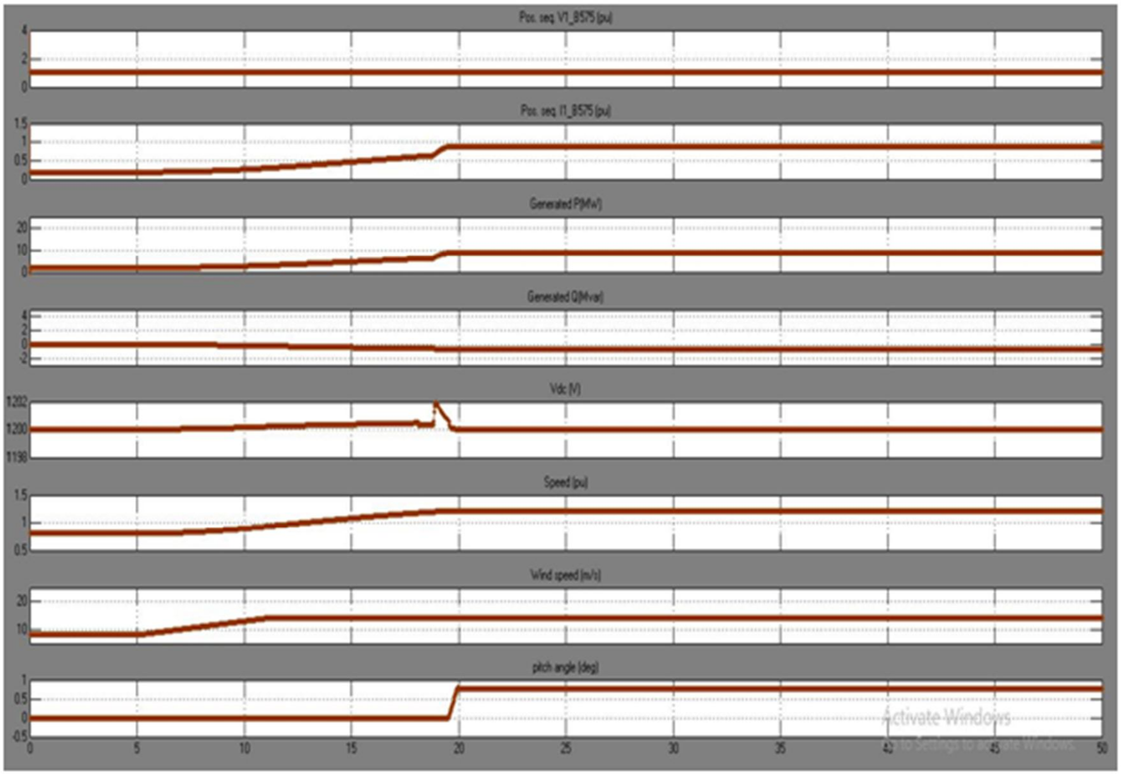

Fig 3.2 (e) Output of Wind Turbine

IV. CONCLUSION

The simulation results are obtained using MATLAB/SIMULINK tool the variation of stator current, rotor current, generated active power, DC link voltage and electromagnetic torque are investigated during fault period. DFIG has the ability to remain connected to grid during large variation of wind speed and also supply power at all power factors. When disturbances occur voltage and frequency of the system must not be compromised. The wind turbine must remain connected to the grid and at the same time no damage should occur to the converter setup.

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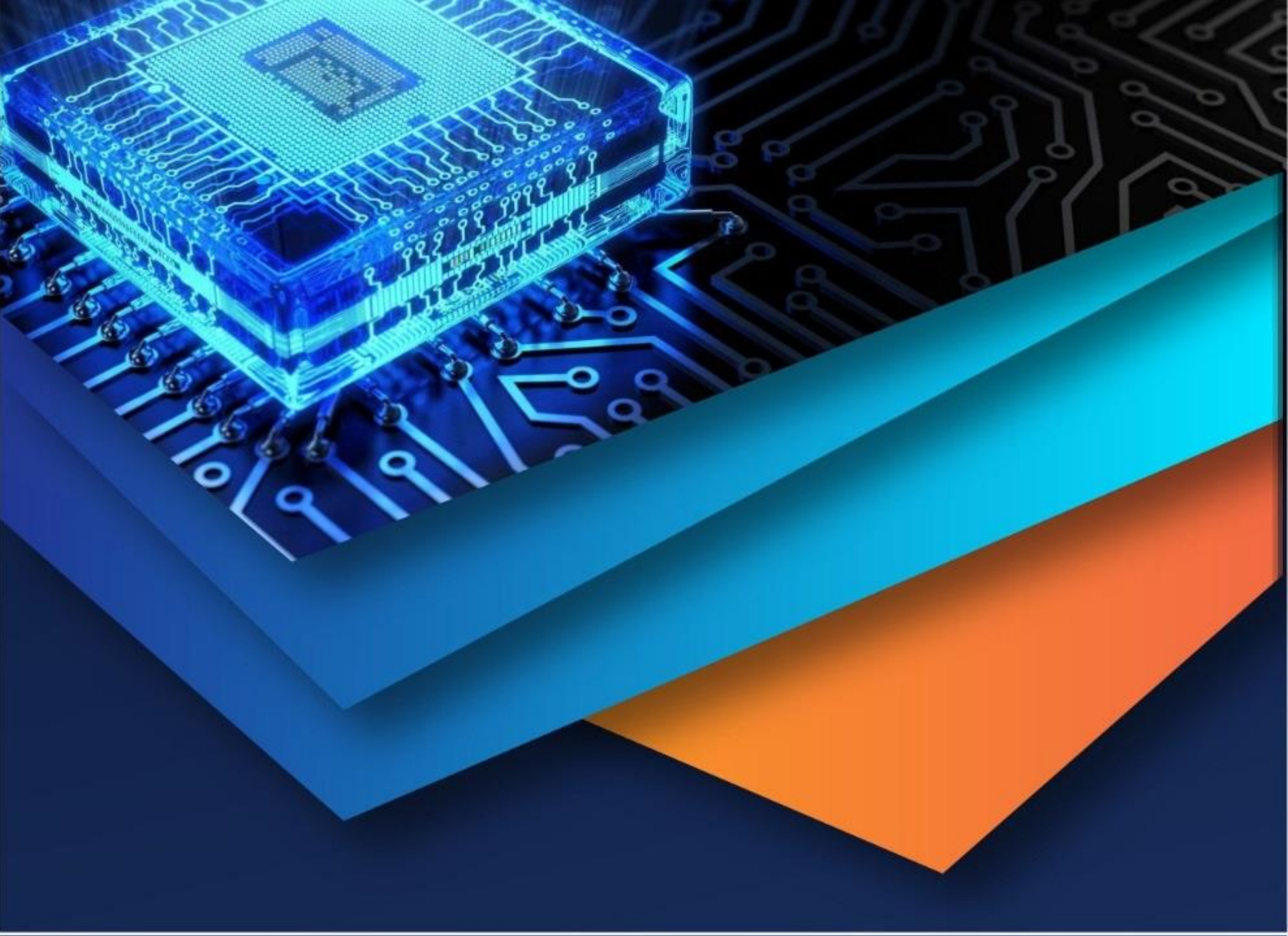

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