

# Performance Analysis of Doubly Fed Induction Generator Coupled With Wind Turbine

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## ABSTRACT

Renewable power generation can help countries meet their sustainable development goals through provision of access to clean, secure, reliable and affordable energy. There are many generators available for wind energy. As far as DFIG is concerned, it is very important to make DC-link voltage stable for doubly fed induction generator wind energy conversion system. The advantage of DC-link voltage is that it provides an extra spinning reserve capability for the wind system, which can be used for sink or source of active power. This paper focuses on analysing the performance of wind power in conventional system under various scenarios. Here wind power in a power generation and transmission system alongside the conventional 3-phase sources, is introduced and have simulated its working and performance. While analysing the performance of DFIG it becomes important to explore the effects of DC-link voltage under various cases: (i) effect of load variation on dc link voltage  $V_{dc}$  at fixed speed (ii) effect of load variation on dc link voltage  $V_{dc}$  at variable speed. These cases are compared with fixed and variable DFIG wind energy conversion system. All these systems have been simulated with the help of the inbuilt components provided in SIMULINK library of MATLAB.

**Keywords:** Gear Box, Power Quality, Dynamic Performance, DC Link Voltage

## I. INTRODUCTION

According to the ministry of New and Renewable Energy, wind power accounts for almost 70% of the total installed capacity in the renewable energy sector and the government has a target of doubling renewable energy output to 55 GW by March 2017.

wind. This relies heavily on growth in the wind sector. In the current year, India has installed 19,662 megawatts of wind power according to the Ministry of New and Renewable Energy. Wind energy is used for hundreds of Years for pumping water, milling grains, and sailing the seas. The use of windmills to generate electricity can be traced back to the late nineteenth century with the development of a 12kW dc windmill generator. It is, however, only since the 1980s that the technology has become sufficiently mature to produce electricity competently and consistently. Over the past two decades, a variety of wind power technologies have been developed, which have improved the conversion efficiency and reduced the costs for wind energy production. The size of wind turbine has increased from a few kilowatts to several megawatts each.

The power of an air mass flowing at speed  $V$  through an area  $A$  can be calculated by:

$$P = \frac{1}{2} \rho A v^3 \dots \dots \dots (1)$$

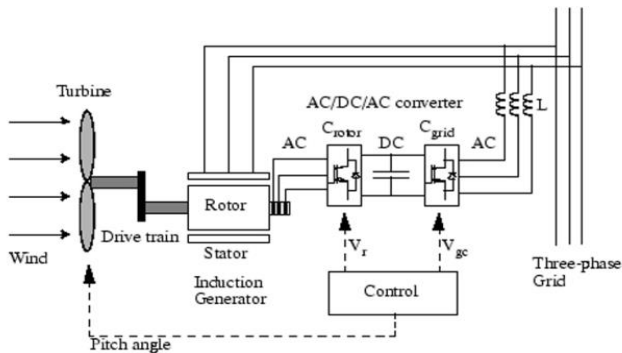
Where,  $P$  is power in watts (W),  $\rho$  is the air density in kilograms per cubic meter ( $\text{kg/m}^3$ ),  $A$  is the swept rotor area in square meter ( $\text{m}^2$ ),  $V$  is the wind speed in meter per second ( $\text{m/s}$ ).

## II. METHODS AND MATERIAL

### Doubly Fed Induction Generator

Doubly fed electric machines are generators or motors are those that have windings on both stationary and rotating parts, where both windings transfer significant active power between shaft and electrical system. Usually the stator winding is directly connected to the three-phase grid and the three-phase rotor winding is fed from the grid through a rotating or static frequency converter. The DFIG is an attractive and popular option for large wind turbines (multi-MW) due to its flexibility in variable speed range and the lower cost of the power. In the DFIG configuration, the generator rotor operates at a variable speed in order to optimize the tip-speed

ratio. Therefore the generator system operates in both a sub-synchronous and super-synchronous mode, typically between  $\pm 30\%$  of synchronous speed. The rotor winding is fed through a variable frequency power converter, typically based on two AC/DC/IGBT based linked voltage source converter through a dc bus. The variable frequency rotor supply from the converter enables the rotor mechanical speed to be decoupled from the synchronous frequency of the electrical network, thereby allowing a variable speed operation of the turbine.



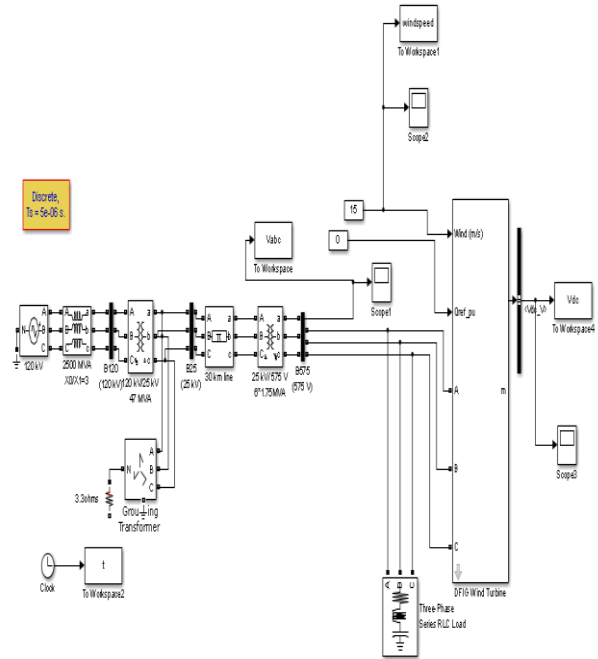
**Figure 1:** Working Principle of DFIG

The rotor winding is fed through a variable frequency power converter, typically based on two AC/DC/IGBT based linked voltage source converter through a dc bus. The variable frequency rotor supply from the converter enables the rotor mechanical speed to be decoupled from the synchronous frequency of the electrical network, thereby allowing a variable speed operation of the wind turbine.

#### A. Power flow in the DFIG

There are multiple aspects to the power flow that must be understood to fully grasp the DFIG operation. The first to be described here is the rotor circuit. In the rotor circuit, active power flows in one direction, either to the rotor or from the rotor, thereby either absorbing or injecting active power to the grid. In either case, the active power flows in only one direction through both converters. The converter arrangement allows for a variable frequency (associated with the variable rotor speed) to maximize active power extraction. As the two converters are decoupled via the DC-link, the connection to the grid can be maintained at the grid frequency and the voltage controlled to synchronize with the grid. The basis for injecting or absorbing active power is the varying operation of the DFIG when it goes from sub-synchronous speed to super-synchronous speed. Active power flows as a function of slip.

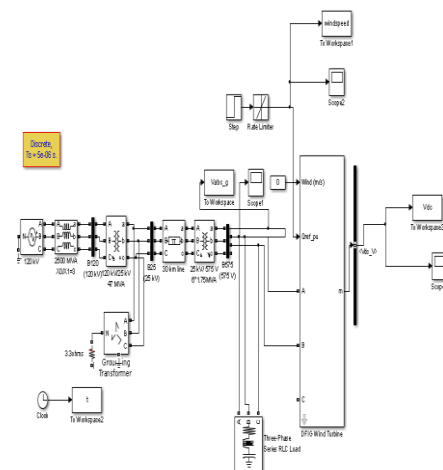
### III. Performance Analysis with fixed speed



**Figure 2 :** Simulink Diagram during Loading at Bus B575 at Fixed Wind Speed

Figure shows DFIG wind model simulation in MATLAB/SIM-POWER SIMULINK. The three phase programmable source is generating power at 120 kV, which is stepped down to 25 kV by the two winding transformer and then transmitted by the 30 km transmission line for stepping down the voltage level to the 575 V at the point of common coupling between the grid and the DFIG wind energy conversion systems. The DFIG wind energy conversion system is generating power of 1.5 MW.

### IV Performance Analysis with variable speed



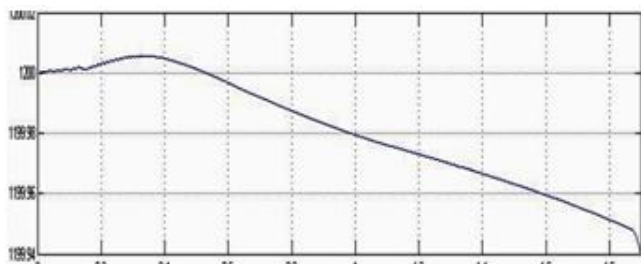
**Figure 3:** Simulink Diagram during Loading at Bus B575 for a Variable Wind Speed

### III. RESULTS AND DISCUSSION

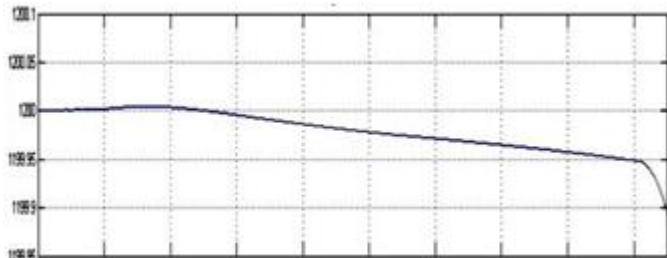
### IV. CONCLUSION

#### A. Effect on DC Link Voltage at fixed speed

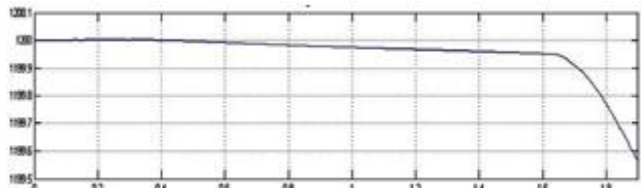
It can be seen that when DFIG wind system is operated without load at both fixed and variable speed the DC-link voltage are almost constant. But when the DFIG wind system are loaded with different load at grid-side for fixed wind speed, then it can be seen that as the load of the system is decreases the DC-link voltage remains constant more time than it was in the higher load. However in case of increase in load there in very nominal effect on the load link voltage profile. It is observed that dc link voltage is very much constant for variable wind speed in comparison to fixed wind speed. The main difference between fixed and variable wind speed is that when the load goes lower beyond certain level the dc link voltage stability gets affected while in fixed speed there is no effect on the stability. So it can be concluded that whenever DFIG system is operated, there should a minimum load on the system for getting constant DC link voltage.



**Figure 4:** Effect on DC Link Voltage when the load is 0.5 MW

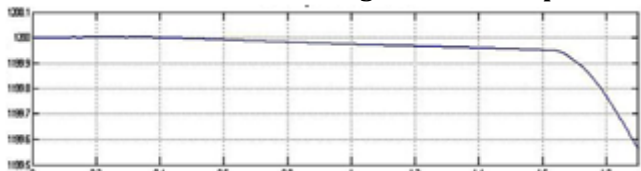


**Figure 5:** Effect on DC Link Voltage when the load is 1 MW

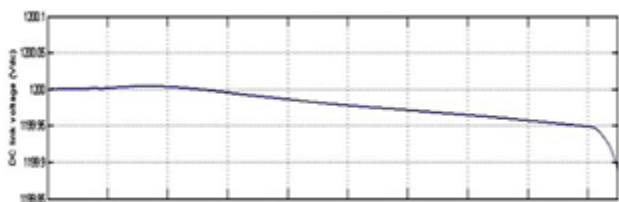


**Figure 6:** Effect on DC Link Voltage when the load is 1.5 MW

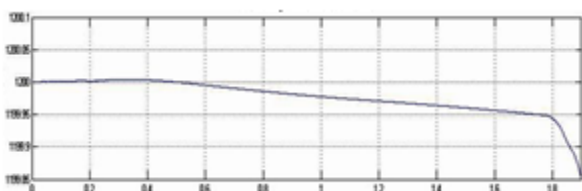
#### B. Effect on DC Link Voltage at variable speed



**Figure 7:** Effect on DC Link Voltage when the load is 0.5 MW



**Figure 8:** Effect on DC Link Voltage when the load is 1 MW



**Figure 9:** Effect on DC link voltage when the load is 1.5 MW

### V. REFERENCES

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