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Research Article

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Performance Analysis of Permanent Magnet Synchronous Generator and Introduction of Doubly fed Induction Generator Driven by wind Turbines

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Abstract—

The aim of the paper is to analyse performance of permanent magnet generator connected with wind turbine under varying wind speed. Above the rated wind speed pitch angle controller becomes active and limits the power and the speed to their rated values. There are different types of synchronous generator but the multipole PMSG is chosen as its offer better performance due to higher efficiency and less maintenance since it does not have rotor current and can be used without a gearbox, which also implies a reduction of the weight of the nacelle and a reduction of the cost. Simulation of the work is carried out in MATLAB/Simulink.

Keywords: PMSG, SCIG, WRIG, DFIG

I. INTRODUCTION

The wind turbine transforms the kinetic wind energy into mechanical energy through the drive train and then into electrical energy by means of the generator. There are different wind turbine configurations. They can have or not gearbox, the generator can be synchronous or asynchronous. Different modes of operation can be used depending on the wind turbine configuration. They are classified in variable-speed and fixed-speed. For fixed-speed operation, the system is very simple and thus the cost is usually low. As a drawback, the conversion efficiency is far from optimal. Normally an asynchronous generator is used and it is directly connected to the grid. For the variable-speed operation, maximum efficiency is obtained; the system is controlled to maximize the power extracted from the wind. Among all these configurations, the trend is to use variable-speed wind turbines because they offer more efficiency and control flexibility which is becoming very important to comply with the grid requirements Permanent Magnet Synchronous Generator, (PMSG), is an interesting solution which is based on variable-speed operation. With permanent magnets there is no need for a DC excitation system. With a multipole synchronous generator it is possible to operate at low speeds and without gearbox. Therefore the losses and maintenance of the gearbox are avoided.

II. PERMANENT MAGNET SYNCHRONOUS GENERATOR

In order to operate with low speeds, a high number of poles is used in PMSG wind turbines. Instead of electrical DC excitation the magnetic rotor field is provided by permanent magnets. Due to the equal distribution of the surface mounted magnets and a permeability of the magnet material μm approximately as big as the air gap . permeability the reactance's in d- and q-axis differ by only a few percent [4], so that surface mounted PMSGs can be considered as round rotor machines (xd = xq). Because the multipole PMSG is a converter connected low speed application (in contrast to high dynamic drives) no damper winding is necessary. The use of permanent magnets eliminates the DC excitation system, which means a reduction of losses (high field ampere turns in multipole generators) and the omission of slip rings and thus maintenance requirements. [5]

In variable speed wind turbines equipped with a pitch mechanism the mechanical system of the wind turbine can be controlled by means of blade pitching. For wind speeds below rated wind the absorbed aerodynamic power is optimized. According to Figure 1, this is done by adjusting the tip speed ratio l to achieve the maximum power coefficient *c*p. The pitch angle is kept constant while the turbine's rotational speed is adapted, when the wind speed changes.

III. PERMANENT MAGNET SYNCHRONOUS GENERATOR

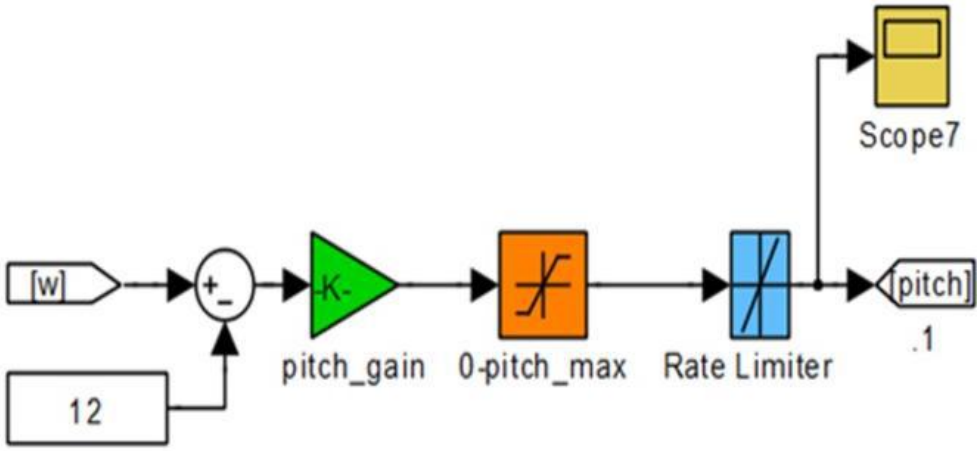
The major types of AC generators that are possible candidates in wind turbine systems are as follows:

- Squirrel-Cage rotor Induction Generator (SCIG)
- Wound-Rotor Induction Generator (WRIG),
- Doubly-Fed Induction Generator (DFIG)
- Synchronous Generator(With external field excitation)
- Permanent Magnet Synchronous Generator (PMSG).

IV. PITCH ANGLE CONTROL

In variable speed wind turbines equipped with a pitch mechanism the mechanical system of the wind turbine can be controlled by means of blade pitching. For wind speeds below rated wind the absorbed aerodynamic power is optimized.

According to Figure 1, this is done by adjusting the tip speed ratio l to achieve the maximum power coefficient *c*p. The pitch angle is kept constant while the turbine's rotational speed is adapted, when the wind speed changes.[6]



The pitch angle is kept constant at zero degree until the speed reaches rated speed. Beyond rated speed the pitch angle is proportional to the speed deviation from rated speed. The SIMULINK model for the pitch angle controller is illustrated in the following figure.

Table 1. Parameters of Wind Turbine and PMSG

	Parameter	**Value**
Wind turbine	Rating	20 KW
	Air density	1.225 kg/m3
	Blade radius	3.7 m
	Rated wind speed	12 m/s
	Inertia constant	0.6s
Permanent magnet synchronous generator	Rating	25 KVA
	Rated phase volt	300 V
	Pole number	42
	Inertia constant	0.4 s

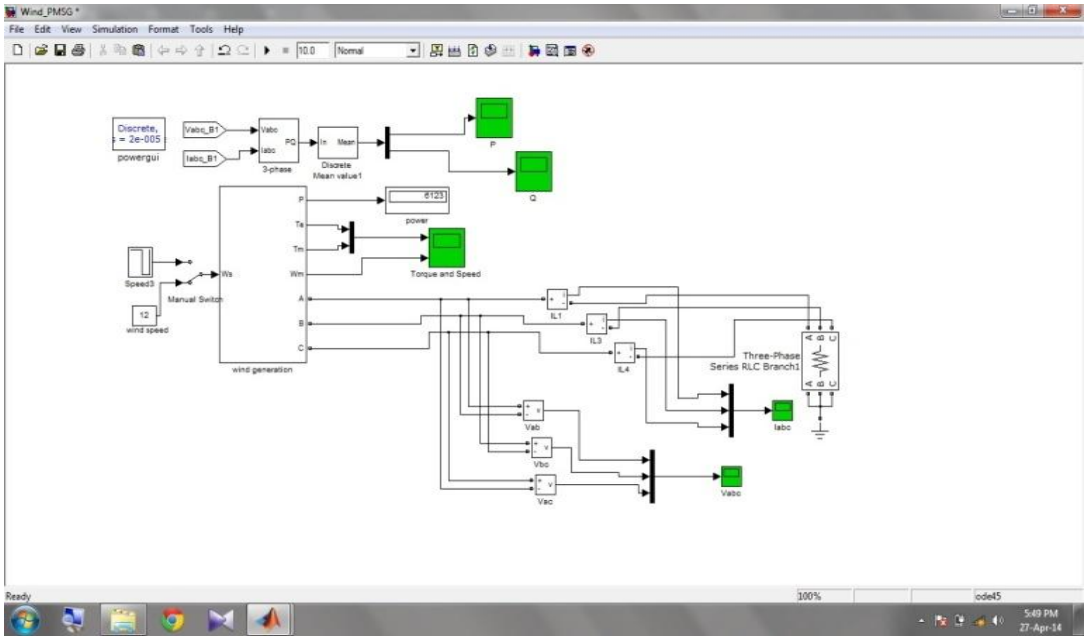


Figure2.Simulink Model for wind System

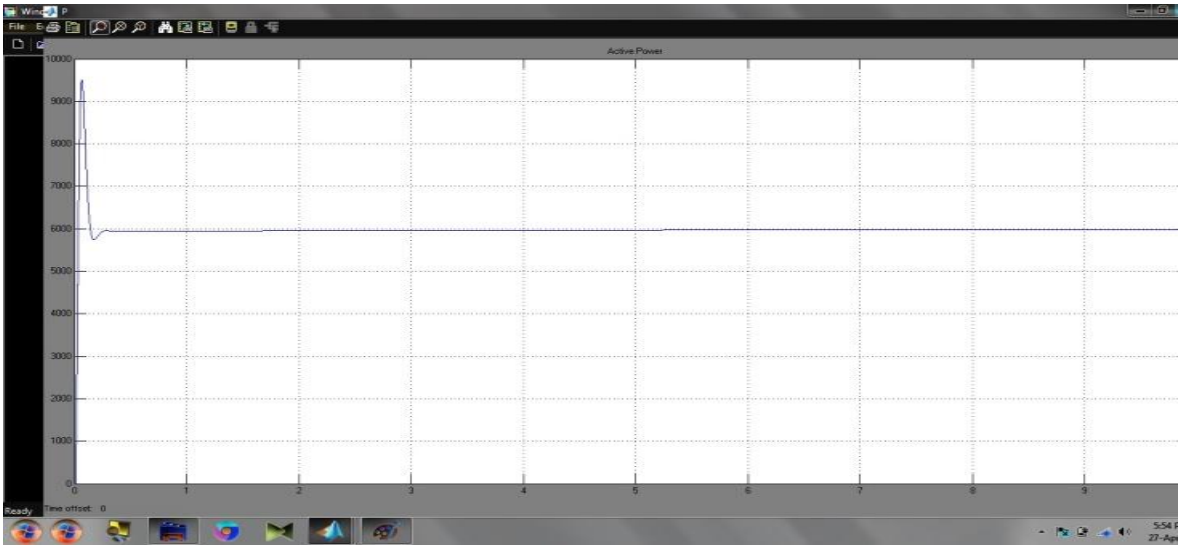


Figure3.Graph of active Active power of PMSG.'

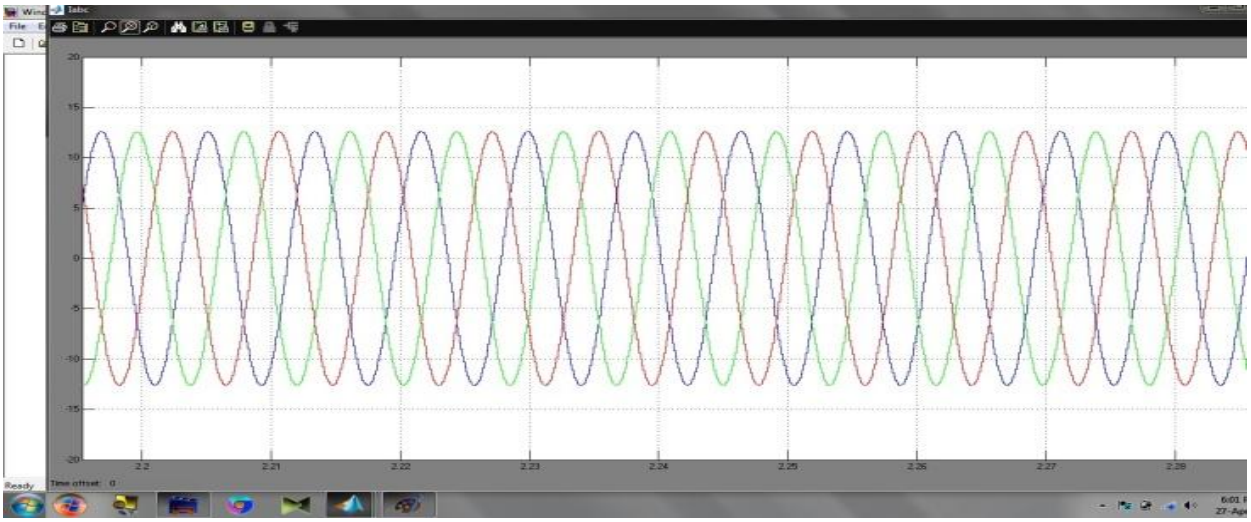


Figure4.Graph of I_a I_b I_c three phase currents from PMSG.

The three phase current from the model is taken and x axis is time and y axis is ampere.

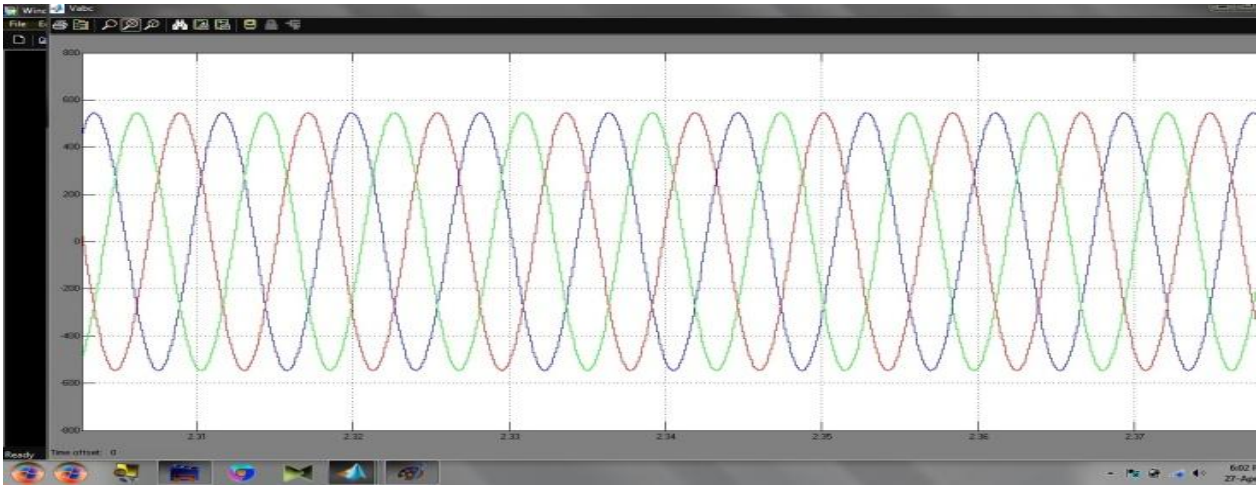


Figure5.Graph of V_a V_b V_c three phase voltages from PMSG.

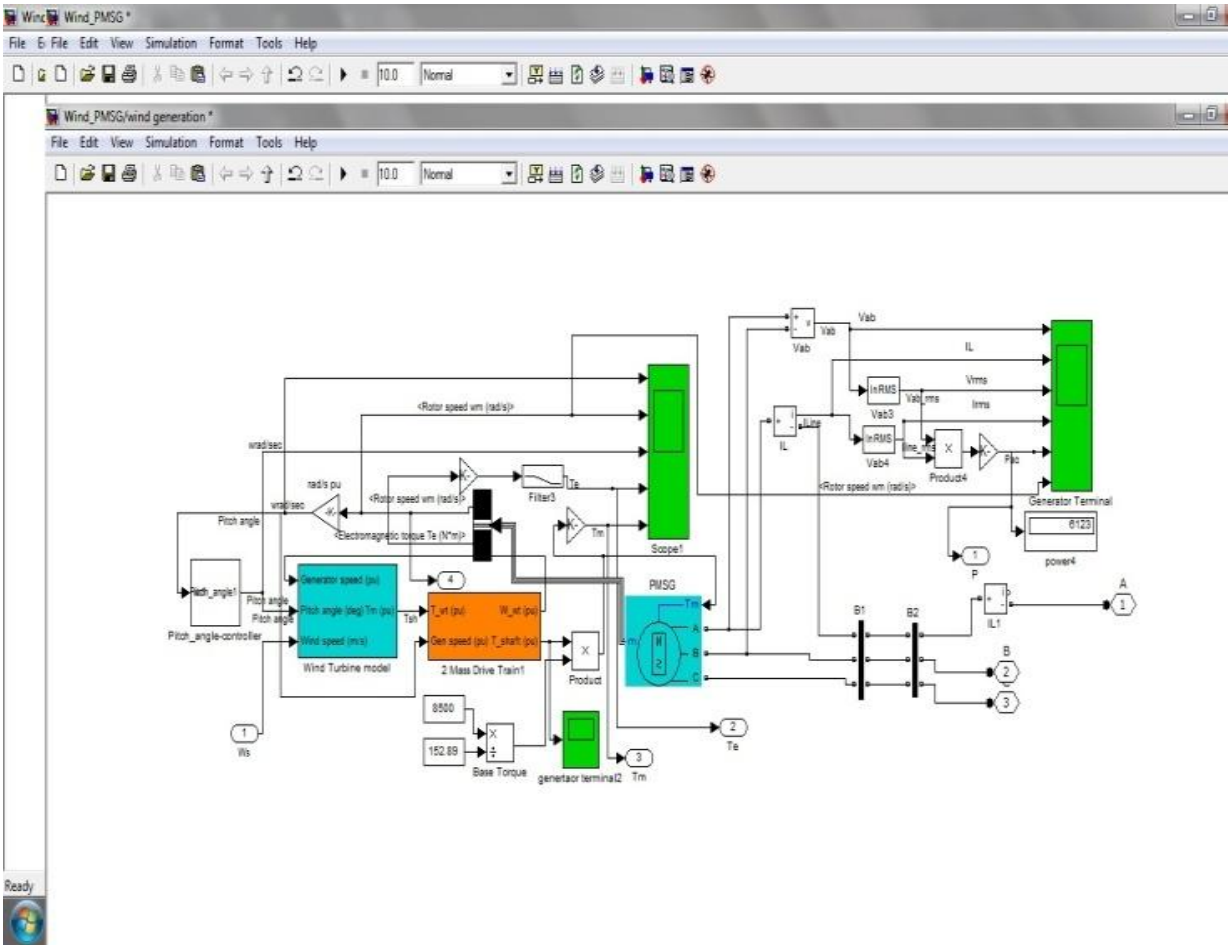


Figure6. Simulink Model inside wind generator block containing permanent magnet synchronus generator block.

The simulink model consist of PMSG block a coupler type block taken from DFIG model of matlab library and PMSM block taken from simpower tool box and in subsystem machines from simulink library.

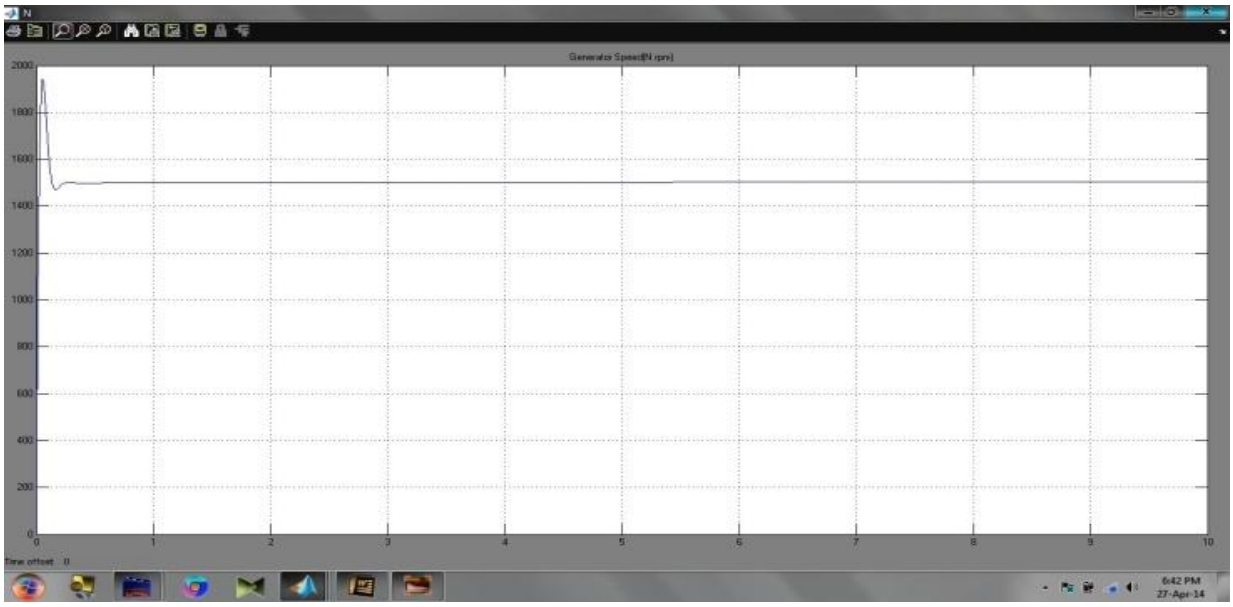


Figure7.Graph of Generator speed of PMSG.

The graph show the generator speed the speed variation with the time is shown.

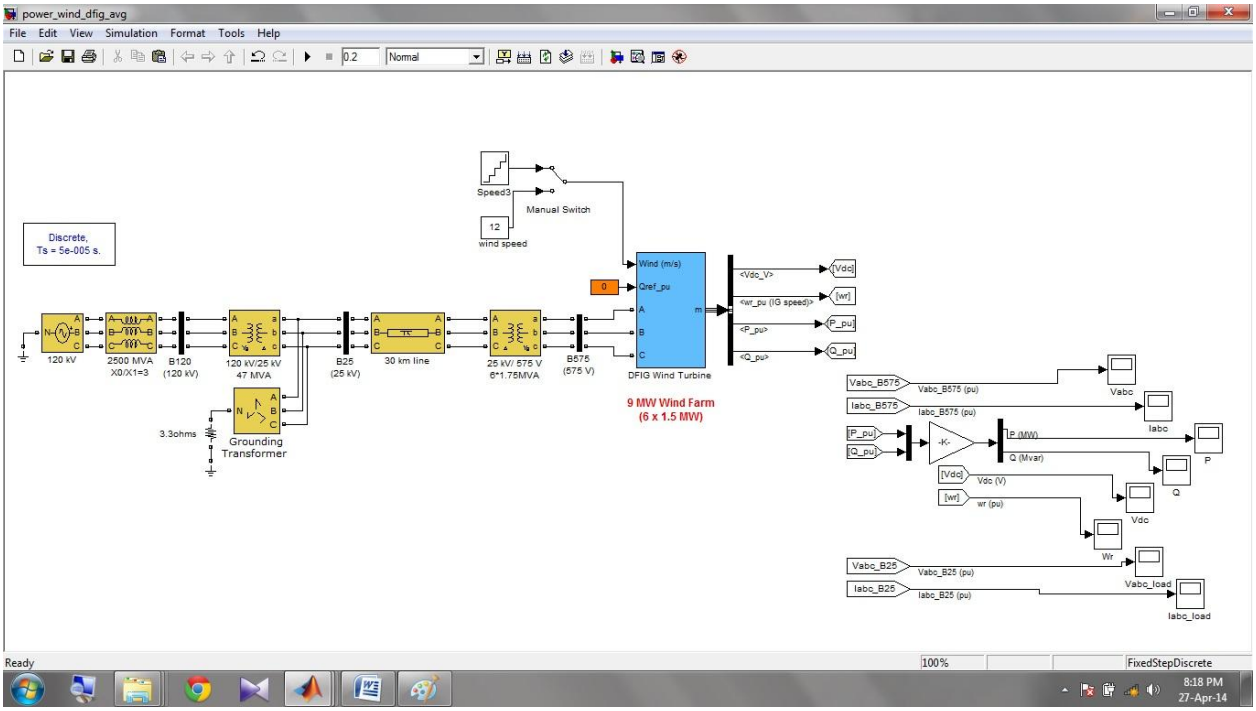
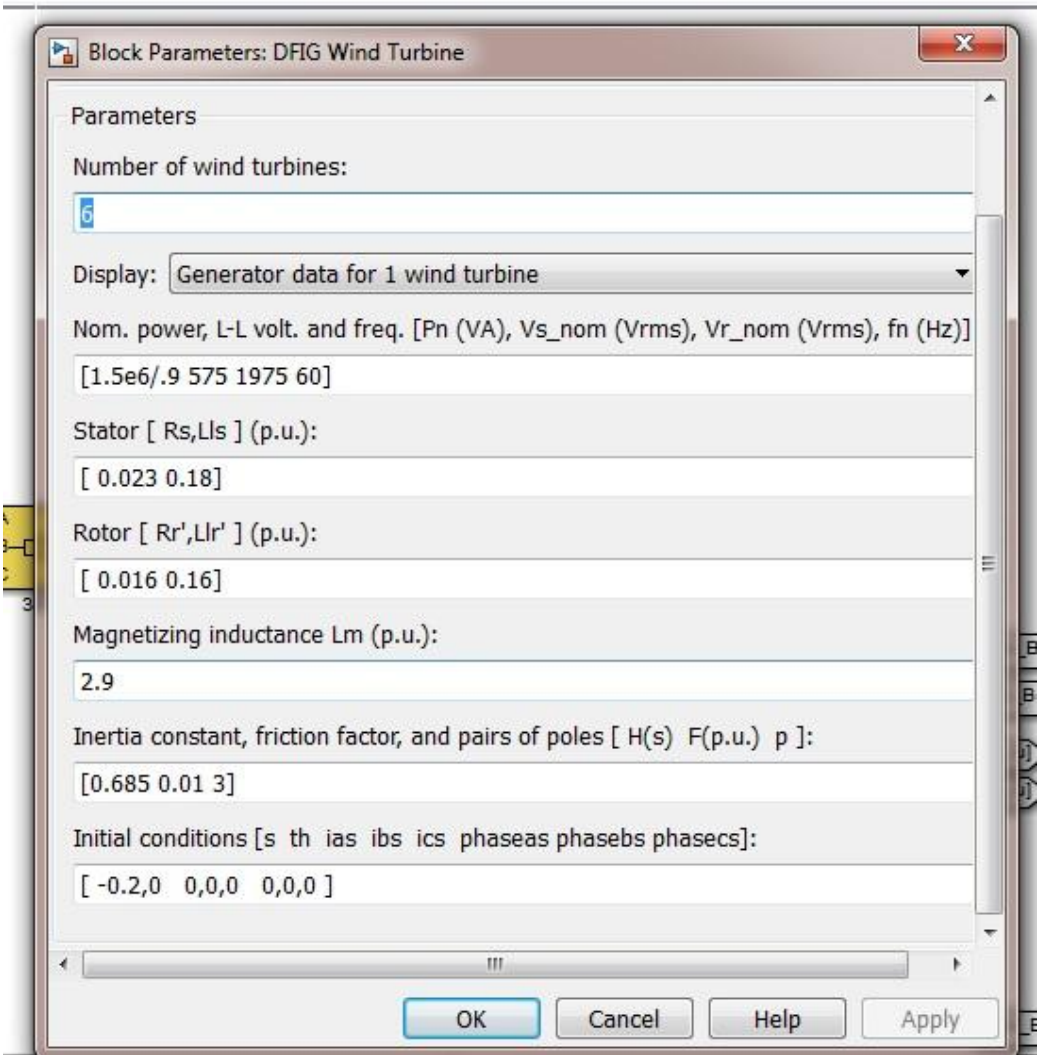


Figure8 Simulink model of wind farm model of containing doubly fed induction generators .



V. CONCLUSION

In this paper simulation based mathematical model of permanent magnet synchronous motor is implemented using MATLAB. The simulation results shows the performance characteristics of permanent magnet synchronous machine, i.e. speed of machine .variation of load torque. The stator currents and electromagnetic torque magnitudes are also obtained in the graphs. The rotor position found out at every instant and is shown in the graph.

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