BESS BASED DFIG FOR REAL AND REACTIVE POWER CONTROL OF GRID

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Abstract—**The total energy demand and per capita energy demand are increasing day by day. So the dependency on renewable energy sources like wind and solar is also increasing. The wind speed variations causes serious power quality problems during integration of wind turbine with the grid. The power control block consisting of rotor side controller block and grid side control block helps to overcome these problems. The DFIG is capable of producing power in above and below synchronous speed. The power supplied to the grid through stator and rotor. In this paper, a battery energy storing system (BESS) is introduced in between the inverter and converters section. Since the converters and BESS are introduced in the rotor side their rating can be reduced. The system is simulated in MATLAB/SIMULINK and results are presented.**

Keywords—Doubly fed induction generator (DFIG),Battery energy storing system (BESS),Power electronic converters (PEC),Wind turbine

I INTRODUCTION

With high population growth and economic development in the world, the energy demand increasing day by day. Fossil fuel sources like oil, coal are costly and causing serious pollution to the environment. Wind energy generation is under renewable energy source it is a feasible solution to energy shortage. China has the most installed wind energy capacity, followed by the United States, Germany, Spain and India. Wind energy is one of the fastest growing energy production industry at present situation and it will continue to grow worldwide, as many countries have plans for future development. The Indian wind energy sector has an installed capacity of 18.55 GW. In terms of wind power installedcapacity, India is ranked 5th in the World. However the output power of wind generator is fluctuating due to wind speed variations. This will causes serious problems in the distribution network. The utility cannot accept this power fluctuations. Wind turbines can either operate at fixed speed or variable speed. For a fixed speed wind turbine the generator is directly connected to the electrical grid. For a variable speed wind turbine the generator is controlled by power electronic equipment. There are several reasons for using variable-speed operation of wind turbines. Because of the advantages of the DFIG over other generators it is being used for most of the wind power applications. Presently The DFIG wind turbines dominate the market due to cost-effective provision of variable-speed operation. The torque speed characteristics of DFIG is shown

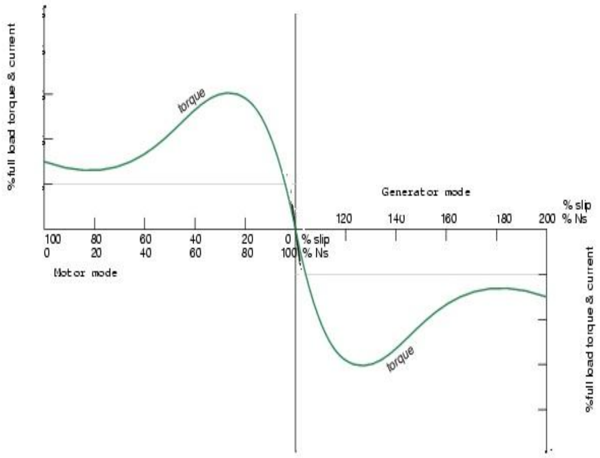


Fig. 1. Induction Generator Torque Characteristics

The DFIG has the ability to control electrical torque and reactive power helps to provide better performance considering the system stability.DFIG is basically an induction generator with the multiple winding that is directly connected to the electrical grid and three phase rotor winding which is also connected to the grid via slip rings.A squirrel-cage induction generator, which has its rotor short-circuited, a DFIG has its rotor terminals accessible. In the DFIG concept,the wound-rotor induction generator is grid-connected at thestator terminals, as well as the rotor terminals through a partially ratedvariable frequency ac/dc/ac converter (VFC), which only needsto handle a fraction (25%-30%) of the total power to achievefull control of the generator. The VFC consists of a rotor-sideconverter (RSC) and a grid-side converter (GSC) connectedback-to-back.[1] The battery energy storing system is introduced in between the inverter and converter sections. The BES would help in storing/releasingadditional power in case of higher/lower wind speed to maintainconstant grid power.Today doubly fed drives are the most common variable speed wind turbine concept.

Types of Wind Turbines

1.Fixed speed induction generator

The first kind of turbines uses one or two asynchronous squirrel cage induction generators. The power produced is made constant by varying the slip slightly. They are called fixed speed wind turbines since their speed variations are only in the order of 1 %. They are self-exiting and no need of slip rings and can be grid connected without the need of the power electronic devices. Due to some advantages like simple design, lower cost and easy maintenance they commonly used in power system. But due to mechanical stresses in the drive train it cannot produce steady output to the grid and reactive power problems hence they not used now a days.

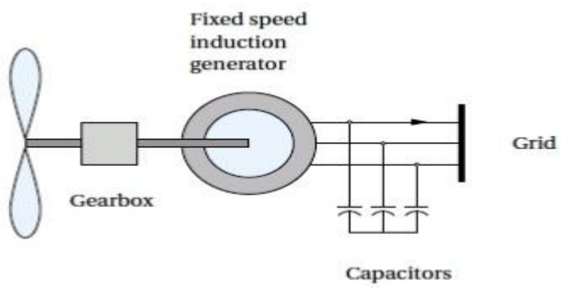


Fig2. Fixed speed induction generator

2.Synchronous generator with full converter

These types of wind turbines uses full scale power electronic equipment’s. They may be either directly connected to the wind turbines or connected with gear box. The generator may be permanent magnet synchronous generator (PMSG) or wound rotor types. Instead of directly connecting the stator they are connected through rated power electronic converters the converter is back to back voltage source converter. The power control can be adjusted by pitch angle control. Due to fully rated power electronic converters they are more costly.

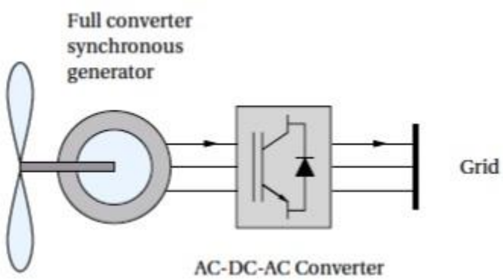


Fig 3. Synchronous generator with full converter

3.Doubly fed induction generator (DFIG)

In DFIG the stator winding is directly connected to the grid and the rotor winding is connected to the grid through power electronic converters. The power electronic converter used is a voltage source converter. The power electronic converters will helps to compensate the difference between mechanical and electrical frequencies by providing rotor voltage with the changing frequencies. Thus the variable frequency of operation is possible. The variable speed of operation will helps to reduce the mechanical stresses in the turbine system. The converters used in the DFIGs are only a fraction of the rated power of the turbine

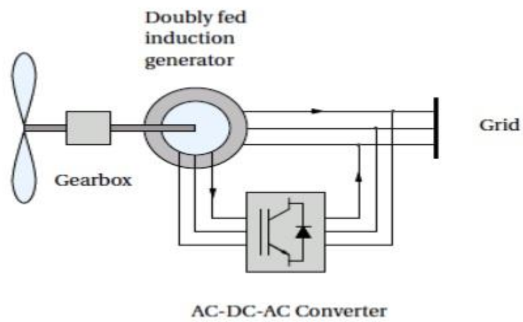


Fig 4. Doubly fed induction generator

II CONTROL STRATEGY

This section describes how the control scheme is implemented in DFIG. The main advantage of the DFIG is that decoupled control of active and reactive power is possible.Here two back to back converters are used so we need to control these two converter sides. These two controllers are known as Rotor Side Converter and Grid Side Converter. Based on the wind speed the power is allowed to flow on both directions in the rotor side.

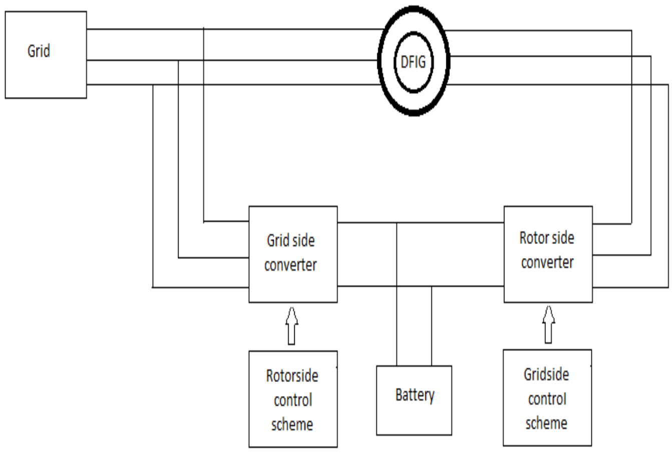


Fig 5. DFIG control scheme

1.Control of Grid Side Converter (GSC)

The ultimate aim of the grid side converter is to maintain constant power in the grid. The power which has to be maintain constant is obtained from the average power based on the wind speed variations calculated earlier. This power is given as reference power to the grid side converter. This reference power is compared with instantaneous value of the grid power. The reference d axis component of the current is obtained as[1]

$$i_{rdref} = (K_{prsc} + \frac{K_{irec}}{S})(Q_{grid} - Q_{ref})(1)$$

$$i_{rqref} = (K_{prsc} + \frac{K_{irec}}{S})(\omega_{rotor} - \omega_{ref})(2)$$

afterdqo to abc transformation it is compared with the the instantaneous values of grid currents clock pulses aregenerated.

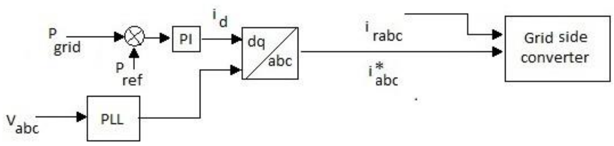


Fig6. Control of Grid Side Converter

2. Control of Rotor Side Converter (RSC)

The DFIG is controlled in the stator flux oriented reference frame. In stator flux oriented reference frame the d axis component of current is oriented along the stator flux position. The RSC is mainly used for extracting maximum power from the wind turbine and maintaining low reactive power in the DFIG. For this the reactive power set point is set to zero. The proportional-integral controller (PI) controller is used for the regulation of reactive power and rotor speed. The reference rotor currents i_{rdef} and i_{rqef} are obtained. Then these reference d-axis and q-axis components are compared with instantaneous values of d-axis and q-axis components of rotor currents [2]

$$i_{dref} = (K_{prsc} + \frac{K_{irec}}{S})(i_{rd} - i_{rdef})(3)$$

$$i_{qref} = (K_{prsc} + \frac{K_{irec}}{S})(i_{rq} - i_{rqef})(4)$$

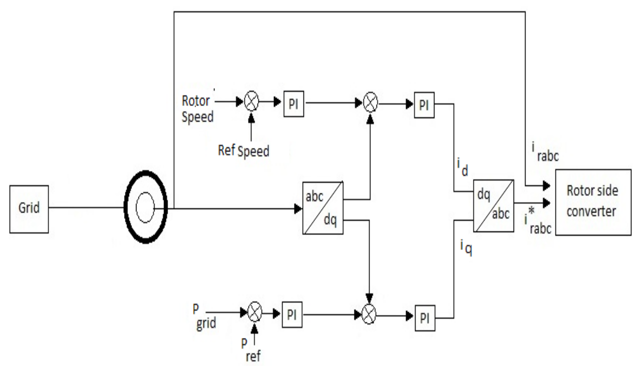


Fig 7.Control of Rotor Side Converter

where$i_{rd}$and I_{rq} are the instantaneous values of d-axis and q-axis components of rotor currents .Then this reference current

is compared with the instantaneous values of rotor currents clock pulses are generated.[4]

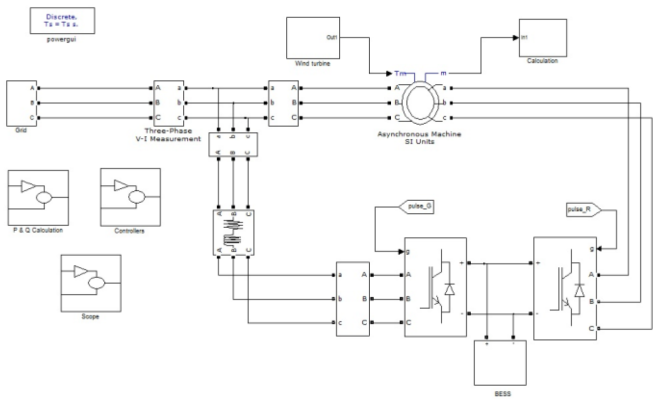


Fig 8.Simulink model

III BATTERY MODELLING

The most commonly used battery model is Thevenin battery model. Thevenin equivalent model consist of an ideal no load battery voltage represented by E_0 . The equivalent resistance of internal and external series and parallel or series combination of battery is represented by R. This equivalent resistance is usually taken as very small value. The R_0 and C_0 represents the capacitance of the parallel plates and non-linear resistance due to contact resistance. R_0 in parallel with the C_0 represents self-discharging of the battery. The self-discharging of the battery is very small so this value is taken as large value. The battery is an energy storing device so it is represented in kilowatt-hour (kWh)[3].The value of capacitance C_0 is determined by

$$C_0 = \frac{\text{kWh} \times 3600 \times 10^3}{0.5({V^2}_{max} - {V^2}_{min})}(5)$$

The $V_{max}$and V_{min} are the maximum and minimum open circuit voltage of the battery when the battery is under fully charged and discharged condition. The lead acid battery is not allowed to discharge below 25%.If the battery discharge is falls below 25% it will affect the life of the battery.

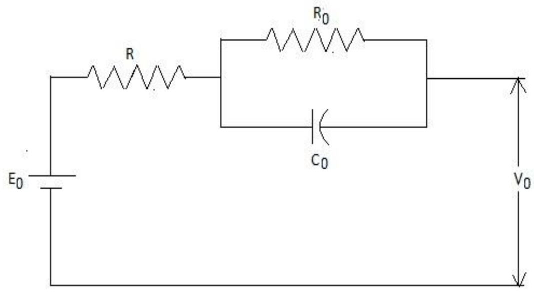
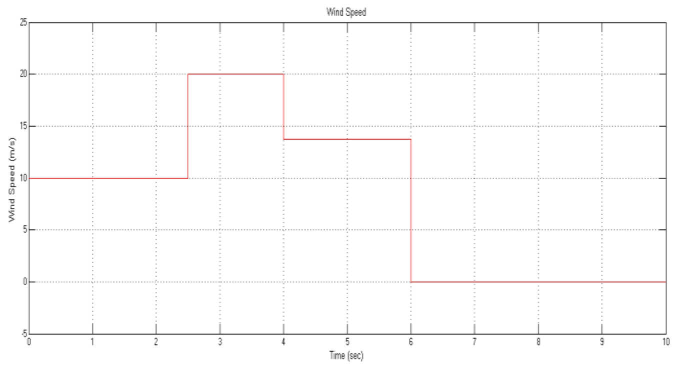
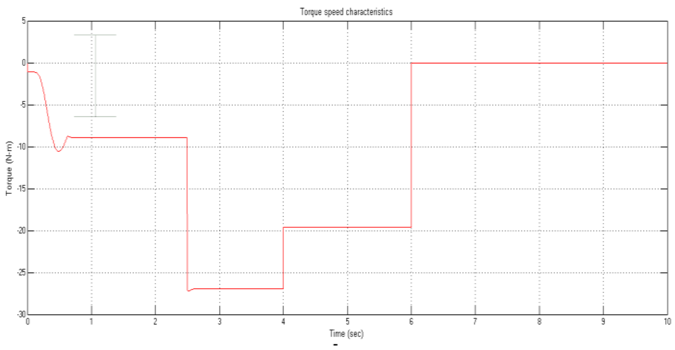


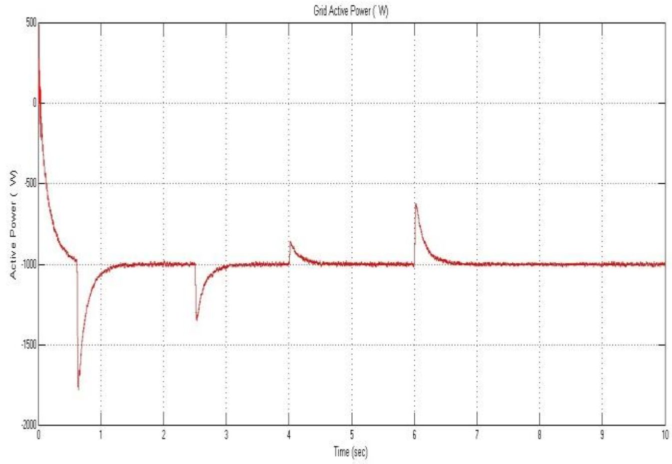
Fig 8. Battery model

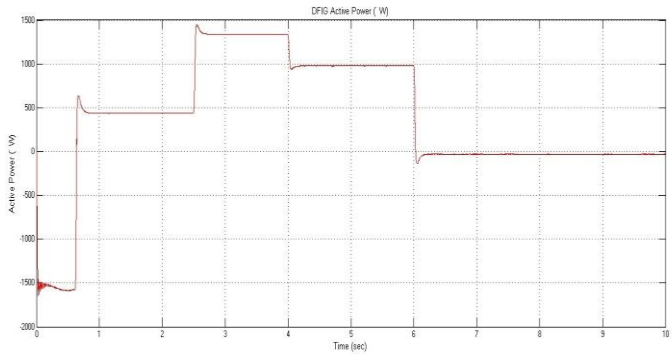
IVSimulation results

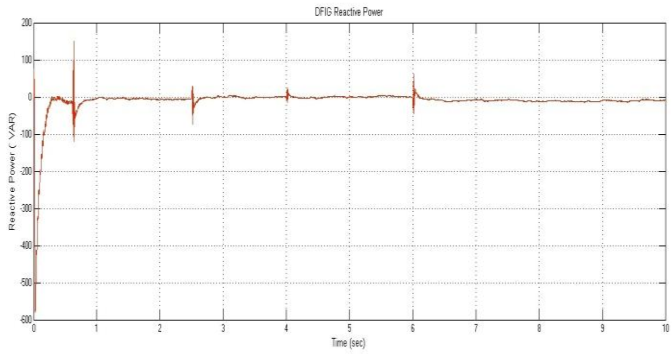
The wind speed is varried from 10 to 20 m/s .Initially the wind speed is 10 m/s Then it is varried to 20 m/s at 2.5 sec. When the wind speed is at 20 m/s the battery will store the additional amout of power available in the grid. This power is represented by negetive value in the battery power from 2.5 ms to 5 ms.Then it is varried to 13.5 m/s at this time the DFIG is capable of producing 1000 w.Then finally the wind speed is made to 12 m/s.

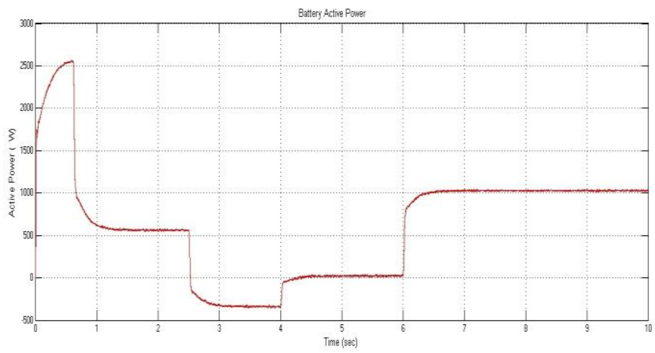


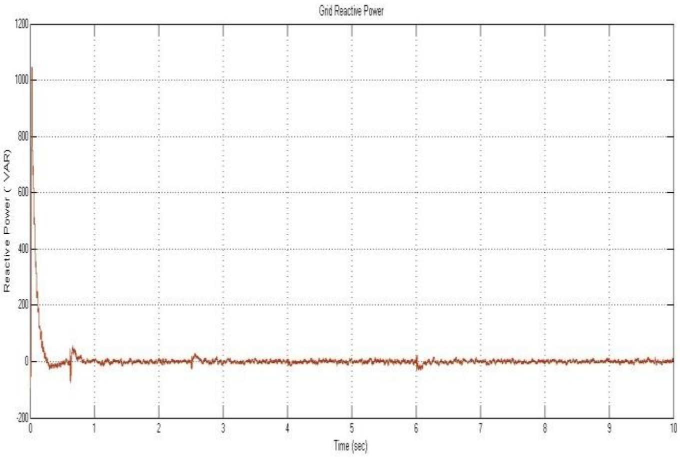












IV CONCLUSION

The wind speed is highly variable and newer technologies are required to make theelectricity output constant. The work presented in this thesis is committed to controland grid-synchronization of the doubly-fed induction generator. A DFIG d-q steady state model isdeveloped to study the real and reactive power control in stator-voltage and stator-flux oriented frame.Modeling of RSC in the stator flux-oriented reference frame was done. Modeling of GSC is also done. Thesimulation results shows that the active power of grid is by using GSC and is independent of varyingwind speed.The machine torque is obtained as negative this shows that the DFIG is operating as generator.If the wind speed is zero then also the BESS is capable of maintain constant grid power. The simulation was done in MATLAB/Simulink

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