



POWER CONTROL OF GRID CONNECTED PMSG WIND ENERGY SYSTEM

PP.vinod Kumar¹, L.Venkatasureshkumar², Ravipudi.sudhir³

PG student, Dept. of EEE, GMRIT, Rajam, Srikakulam, AP-532127, India¹

Assistant Professor, Dept. of EEE, GMRIT, Rajam, Srikakulam, AP-532127, India²

Engineer, Dar engineering, Dammam, Saudi Arabia³

ABSTRACT: At present days, wind energy is a very useful energy source. Then the wind power penetration is increasing, the improvements of the manufacturers in order to comply with the grid interconnection requirements. This paper focus on the maximization of the output power, and the generator side converter is controlled. Then the maximum power is obtained from the wind, and this is depending on the velocity of wind. The wind turbine grid side converter which let the full controllability of the active and the reactive power delivered to the grid. Modelling and simulation of the power control of grid connected PMSG wind energy system implemented by using MATLAB/Simulink.

Keywords: wind turbine, PMSG, PI Controller, Back to back converter etc.

I. INTRODUCTION

The renewable energy sources are mostly used in the world wise. The cost of oils is increasing day by day and fossil fuels are very less, and less solution is attracted. The wind energy is free and not pollution. The wind turbine transforms the wind energy into the mechanical energy and mechanical energy into the electrical energy it is also called generator. Although the advantages of wind turbines are simple, high efficiency, less cost, production maintenance is easy. Wind turbines [7] are two different types of speeds i.e Fixed speed, and variable speed, the PMSG is mostly depending on variable speed why because of efficiency is high and maximum power is obtained by the wind. Then fixed speed operation the efficiency is very less. The generator is directly connected to the back-to-back converter. The generator side converter is mainly used to control the generation of the speed and the output power is maximize at low wind speeds. The grid side converter is mainly used to dc link capacitor constant and reactive power delivered to the grid.

II. WIND TURBINE

There are different winds turbines are currently in use: the fixed speed wind turbine with Squirrel Cage Induction Generator (IG), the variable speed wind turbine with Doubly Fed Induction Generator (DFIG), and the variable speed wind turbine with Permanent Magnet Synchronous Generator (PMSG) [1]. The manufactures are developing new larger wind turbines. The power of wind turbines built in 1980 was 50 kW and the diameter of rotor was 15 m long. In 2003 they had the power of 5 MW and the size of diameter of rotor was 124m. The wind turbine transforms the wind energy into mechanical energy then the wind turbine of a rotor is by the various forces acting on the wind turbine of tower and on the blades (e.g. centrifugal, gravity and varying aerodynamic forces acting on blades, gyroscopic forces acting on the tower), then introducing the effects of mechanical the energy of influencing conversion. The mechanical effects have been modelled by eigenswings mainly due to the following phenomena: asymmetry in the turbine, vortex tower interaction, and mechanical eigenswings in the blades. The wind turbine designed to manufacture was low cost, and simple construction. Several countries has available wind speeds are very low, this turbines is used in several places why because maintenance is easy and generate power in wind speeds are very low in unsteady conditions. The turbines of benefits are existing structures can be mounted, therefore installation costs are lowering and tower structures are eliminating. The smaller turbines can be used for store energy for batteries, and grid power is eliminated.

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 10, october 2013

III. MODEL OF PMSG

The PMSG of model was developed by the dq synchronous reference frame, where q-axis is phase shifted of 90 degrees ahead of the d-axis then depending on the direction of rotation. In order to simplify the system the generator was assumed to be a PMSG with surface mounted magnets then field currents are absent. The model of PMSG is given by the following equations.

$$V_{sd} = R_s i_{sd} + L_d \frac{di_{sd}}{dt} - \omega_e L_q i_{sq}$$

$$V_{sq} = R_s i_{sq} + L_q \frac{di_{sq}}{dt} + \omega_e L_d i_{sd} + \omega_e \psi_{PM}$$

$$T_{em} = \frac{3}{2} n_{pp} \psi_{PM} i_{sq}$$

$$T_{em} - T_L = J \frac{d\omega_m}{dt}$$

Where V_{sd}, V_{sq} represents the voltages of direct and quadrature components stator, i_{sd}, i_{sq} represents the currents of direct and quadrature components of stator, L_d, L_q represents the inductances of direct and quadrature components of stator. R_s Represents the resistance of stator, ω_m represents the mechanical speed of the rotor, ω_e represents the electrical speed of the rotor, ψ_{PM} represents the permanent magnet of the flux linkages, T_{em} represents the electromagnetic torque, n_{pp} represents the number of polepair.

The advantages of PMSG are high efficiency, easier controllability, smaller in size then compared to the DFIG. The disadvantages of PMSG are fixed excitation.

IV. BACK TO BACK POWER CONVERTER

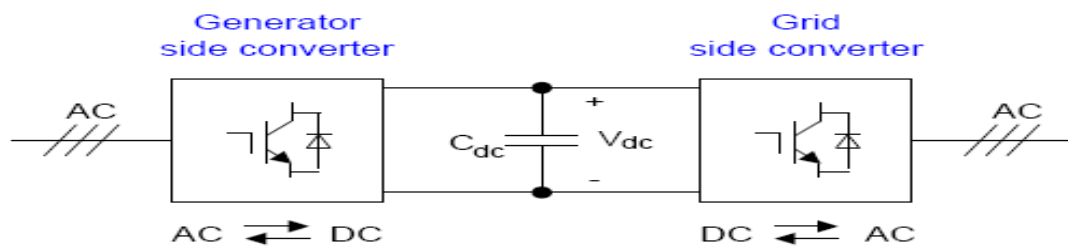


Fig1. Back to back power converter

The above diagram is back to back converter [3]. The power flow can be bi-directional, either generator side or grid side. In the diagram generator side AC is converted to the DC this acts like a rectifier. In the grid side DC is converted to the AC this acts like an inverter. Here DC link capacitor is constant. The capacitor acts like a filter. This eliminates the ripples of the harmonics. The back to back converter is widely used in wind turbine applications. In the diagram two identical voltage sources are connected between the capacitor.

V. PERTURB AND OBSERVE MPPT TECHNIQUE

There are different types of MPPT techniques available, but in this project Perturb and Observe method is used. Perturb & Observe (P&O) is the simplest method. In this we use only one sensor, that is the voltage sensor, to sense the PV array voltage and so the cost of implementation is less and hence easy to implement. The time complexity of this algorithm is very less but on reaching very close to the MPP it doesn't stop at the MPP and keeps on perturbing on both directions. When this happens the algorithm has reached very close to the MPP and we can set an appropriate error limit or use a wait function which ends up increasing the time complexity of the algorithm.

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 10, october 2013

VI.TRANSFORMER

The basic principal of transformer is faradays law of electromagnetic induction. Then the features of transformer are Constant frequency device, Constant power device, Electromagnetic energy conversion device, Complete transform, Transformer is a coupled circuit, Transformer is single excited device, Transformer is a phase shifting device, Transformer is a constant flux device, Transformer is a negative feedback circuit, Two port network.

Where two types of transformers i.e step up or step down transformers is used. Here step up transformer is used because of the level of voltage has to be increased connected in order to be a transmission line i.e. a transformer is used and it is connected to the pcc(point of common coupling).

VII.BLOCK DIAGRAM OF PMSG

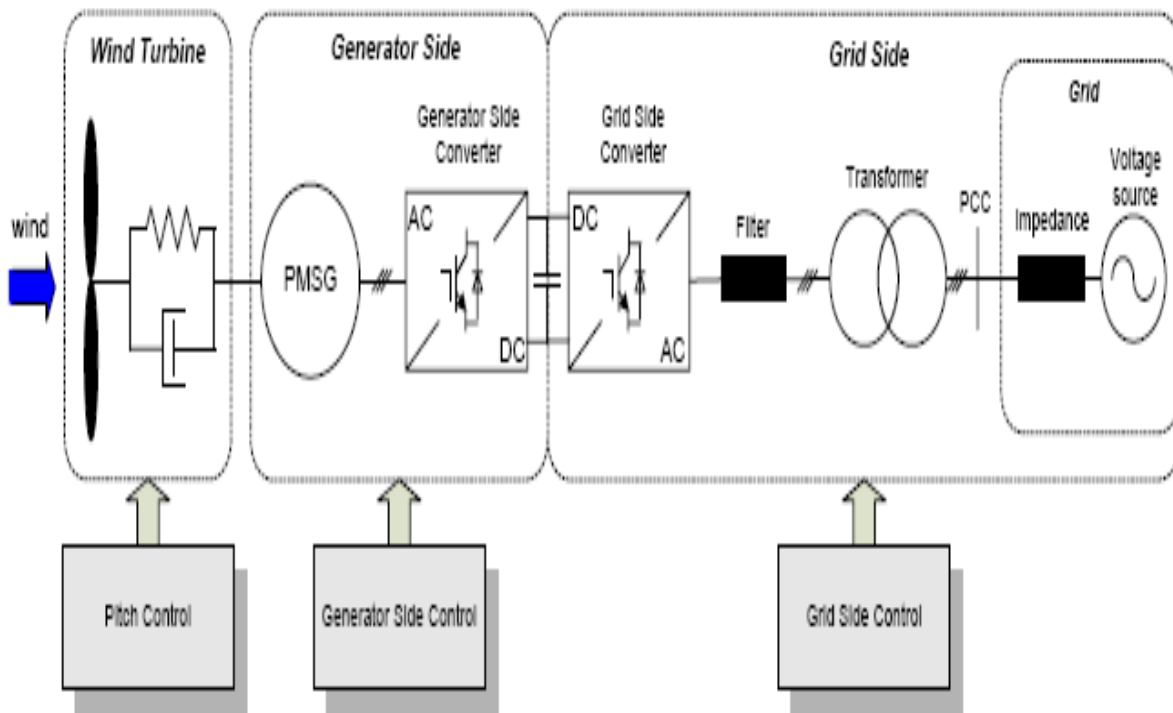


Fig2.Block Diagram of PMSG

In the above block diagram consisting of the wind is given to the wind turbine ,in the wind turbine gear box is available ,gear box and the PMSG is decoupled with a shaft. Then the wind turbine transforms wind energy into the mechanical energy.The mechanical energy is given to the PMSG then it is converted to the electrical energy,then electrical energy is given to the back toback converter.where filter is eliminates the harmonics.Then the transformer is the improves the level of voltages i.e is step up the voltages.where wind turbine controls the pitch angle control(β),the generator side converter controls the speed of the generator and the speed of the torque and maximum output power at low wind speeds.Then the grid side converter controls the dc-link capacitor constant and reactive power delivered to the grid.

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 10, october 2013

VIII.PI CONTROLLER

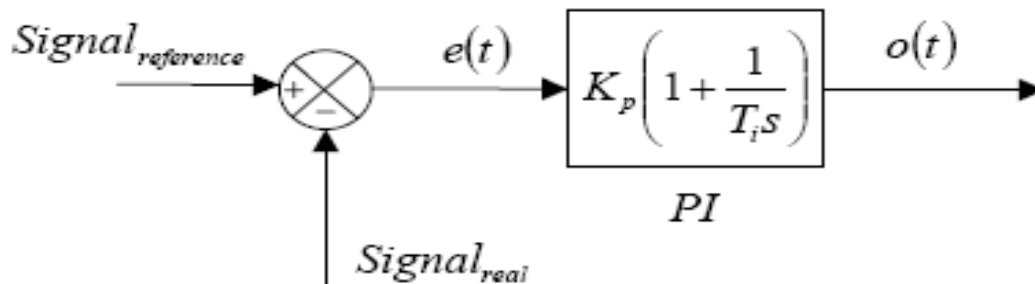


Fig3.General Scheme of PI Controller

The PI controller computes and transfer a signal which is desired to the controlled. The output signal $O(t)$ is computed. The PI controller depends on the parameters is proportional gain (K_p), integral time (T_i), output signal $O(t)$, error $e(t)$ and etc. The change to the output of proportional gain K_p i.e the proportional to the current error value. The proportional gain K_p value is high the system become unstable. On the other hand a small value is given of the K_p , a small output response is obtained. The PI controller eliminates its steady state error. The advantages of PI controller is design is simple, and fast response, improves the steady state response. In the PI controller is obtained by K_p, K_i , values. The disadvantages of PI controller is eliminates its steady state error and peak overshoot.

IX.SIMULATION RESULTS

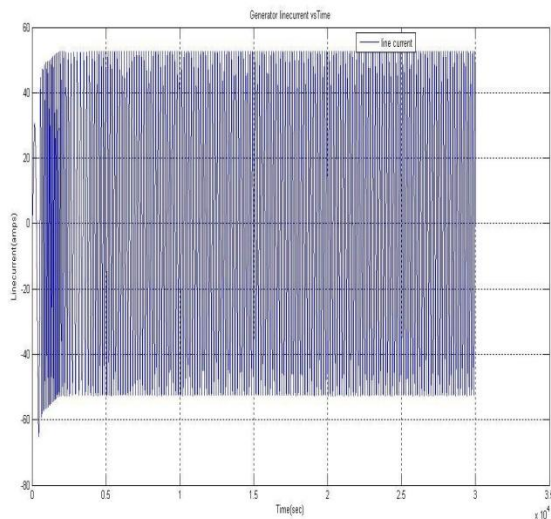


Fig4

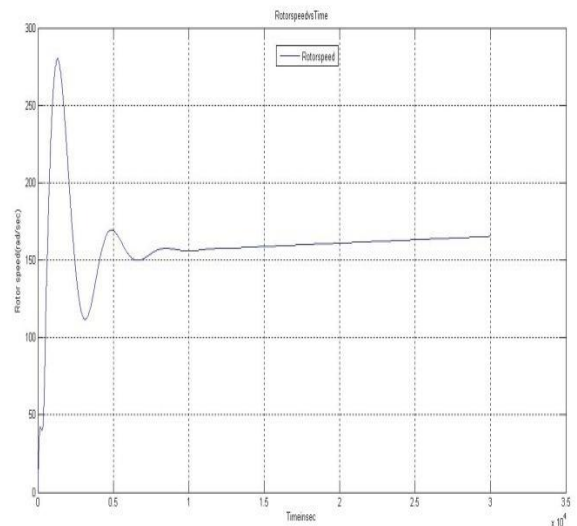


Fig5

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 10, october 2013

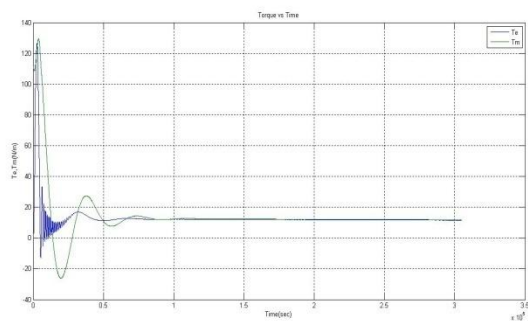


Fig6.

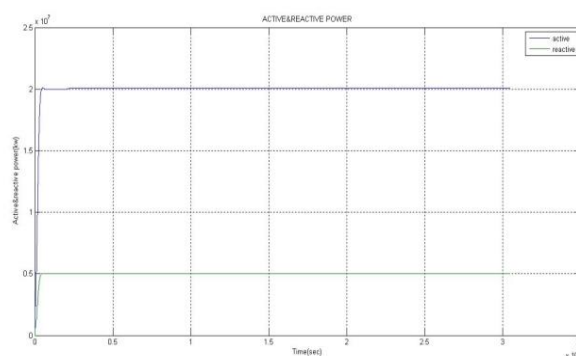


Fig7.

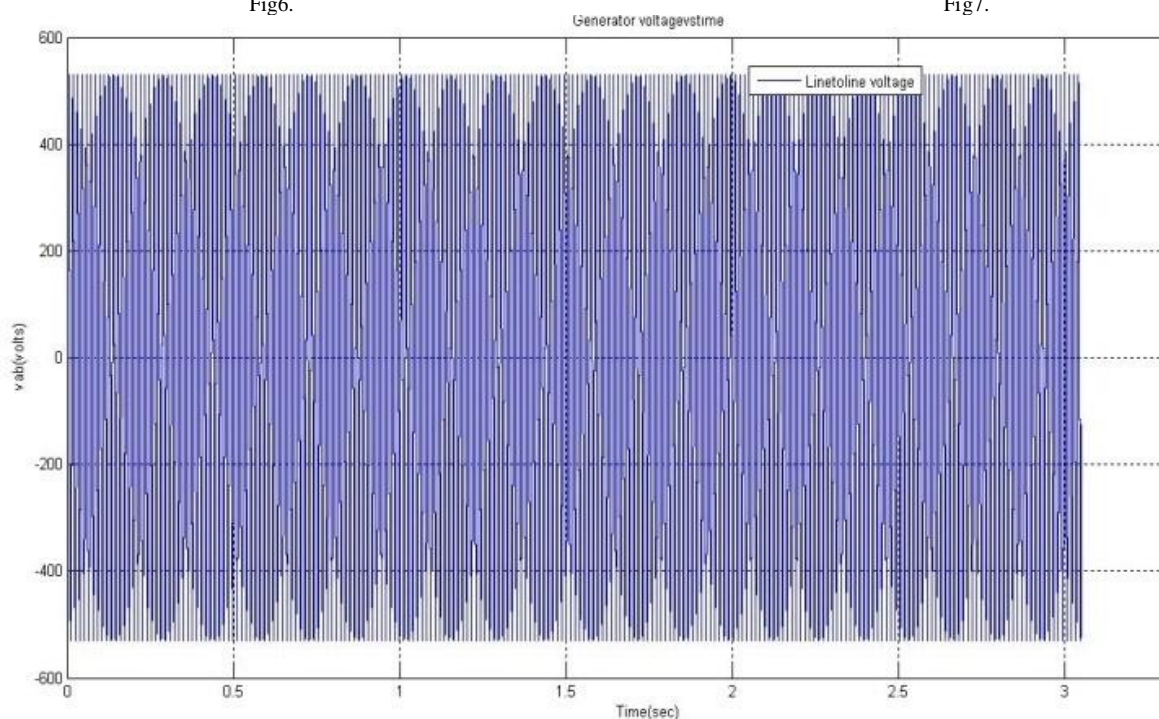


Fig8

In the above fig4 Generator line current vs time is shown. So during the power oscillations damping in the generator up to a 0.25secs the oscillations is reduced at 0.25secs and it's maintain the line current is 54amps.

In the above fig5 the rotor speed vs time is shown.generator speed changes and oscillate during the sudden load changes and fault conditions it is going to damped and settle down at 0.8secs.

In the above fig6 T_e , T_m is electrical torque and mechanical torque. So during the power oscillations in the damping in the generator torque is settle down at 0.8secs and also mechanical torque is 0.8secs i.e. $T_e=T_m$.

In the above fig7 active and reactive power vs. Time is shown. Active power increases and reactive power decreases at the 0.25secs the active power is maintain 220MW and the reactive power is maintain 5MW.Then observe both the curves are maintain 1.5MW.In the above fig8 generator voltage vs time is shown. Then the line voltage is maintained at 520v constant magnitude and constant frequency in the line.



International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 10, october 2013

X. TABULAR FORM

Speed of rotor (ω_e)	260rad/sec
Electrical torque (T_e)	12N-m
Mechanical torque (T_m)	12.2N-m
Line to line voltage (V_{ab})	500V
Line current (I_{line})	50A
Rms voltage (V_{ab-rms})	375V
Rms current ($I_{line-rms}$)	37A
Ac power (P_{ac})	2.5MW
Rectifier ac voltage	500V
Rectifier dc voltage	225V
Transformer output voltage	530V

XI.CONCLUSION

It is possible to state that the main objectives of the project have been achieved. The main objective to implement the control system of the grid side converter for a large wind turbine system connected to the grid. Therefore good knowledge about control systems has been necessary. Besides, to perform the simulations, the models of the components have been prepared and therefore good skills about power control of grid connected PMSG wind energy system by using MATLAB/Simulink. Where finally speed of rotor, electrical torque, Mechanical Torque, line to line voltage, line current, Rms voltage, Rms current the different types of results are observed. Power systems connected to the grid have to comply with the grid requirements. In the case of the wind turbines, considering that the amount of wind energy penetrating to the grid is increasing considerably, it is very important to develop reliable and quality control systems. In this project also used by P&O MPPT method and PI controller is used. The laboratory tests are very important. In this way it is possible to verify the results of the simulations. Besides that, the experimental work is useful to familiarize with the real components and have a better understanding of the systems.

XII. APPENDIX

The parameters of the PMSG used in the listed below

Rated power	2MW
Rated wind speed	12m/s
Resistance R_a	0.10hm
Inductance L	0.005H
Gear ratio ng	77
Number of pole pairs n_p	2
Radius of wind turbine rotor R	41m
Equivalent inertia J	8000kg. m^2
Rotational damping B	0



International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 10, october 2013

REFERENCES

- [1] A. Abedini and A. Nasiri, "Pmsg wind turbine performance analysis during short circuit Faults," IEEE Canada Electrical Power Conference, pp. 160–165, 2007.
- [2] F. Blaabjerg, R. Teodorescu, M. Liserre, and A. V. Timbus, "Overview of control and grid synchronization for distributed power generation systems," IEEE Transactions on Industrial Electronics, vol. 53, pp.1398–1409, 2006.
- [3] A. Carlsson, "The back to back converter," May 1998.
- [4] E. Ceanga, C. Nichita, L. Protin, and N. A. Cutululis, Théorie De La Commande Des Systems. Editura Tehnica, 1997, no. ISBN: 973-31-2103-7.
- [5] M. Chinchilla, S. Arnaltes, and J. Burgos, "Control of permanent-magnet generators applied to variable-speed wind-energy systems connected to the grid," IEEE Transactions on energy Conversion, vol. 21, p. 6, 2006.
- [6] V. Gosbell, S. Perera, and V. Smith, Voltage Unbalance, October 2002.
- [7] F. Iov, "Wind turbine system technology," Lecture at AAU, 2008.
- [8] F. Iov and F. Blaabjerg, "Advanced power converters for universal and flexible power Management in future electricity network," Tech. Rep., 2007.
- [9] F. Iov, A. D. Hansen, P. Sørensen, and F. Blaabjerg, Wind Turbine Blockset in Matlab/Simulink: General Overview and Description of the Models. Aalborg University, 2004, no. ISBN 87-89179-46-3.
- [10] V. Kaura and V. Blasko, "Operation of a phase locked loop system under utility conditions," IEEE Transactions on Industry Applications, vol. 33, 1997.

BIOGRAPHY

PP. Vinod Kumar received B.Tech (EEE) degree, JNTU, Hyderabad in May 2008. At present he is pursuing his M.Tech (Power & Industrial Drives) at GMR Institute of Technology, Rajam, Affiliated to JNTU, Kakinada, A.P, India.

L.Venkatasuresh Kumar received B.Tech (EEE) degree, from JNTU Hyderabad in 2008 and M.TECH (power and energy system) from college of National Institute of Technology Karnataka Surathkal in 2010. Presently working as Assitant professor in GMR institute of technology, Rajam, AP, India.

Ravipudi.sudhir received B.Tech (EEE) degree, from JNTU Hyderabad in 2007 and M.TECH (power and energy system) from college of National Institute of Technology Karnataka Surathkal in 2010. Presently working in Dar engineering, Dammam, Saudi Arabia.