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REPRODUCTION AND SIMULATION OF 2 MW PMSG WIND ENERGY CONVERSION SYSTEMS

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Abstract

Wind energy as a substitute to fossil fuels is abundant renewable extensively dispersed clean and produces no greenhouse gas emissions during procedure. The world has enormous resources of wind power that are to be used. It is predicted that if only 1/10 (one tenth) of available resource like storm potential is put to convert wind energy, all the energy requirements of the world would be completed.

In India wind energy production started as previous as 1985. Till now the aggregate established power capacity has accomplished approximately 21,000 MW, saving approximately 935,000 metric tons of coal. In the world wind electrical generation systems are the most cost inexpensive of all the environmentally unsoiled and safe renewable energy sources. The generated wind energy is as powerful as fossil fuel energy and is much cheaper as compared to nuclear power.

By convention, the wind generation systems draw on variable pitch constant speed wind turbines (horizontal or vertical axis) that were coupled to Squirrel cage Induction generators or Self Excited Induction generator or Doubly fed Induction generator Wound-field Synchronous generators Permanent magnet synchronous generator and fed power to utility grids or autonomous loads. Permanent magnet synchronous generator (PMSG) is a Direct Drive form generator; we don't require gear box and excitation current, so PMSG show good performance in WECS. The permanent magnet synchronous generator based wind energy conversion system can be used in two special ways namely: 1. Isolated standalone system 2. Grid connected system

INTRODUCTION

The conventional energy sources are limited and polluted environment. So infinite attention and interest have been paid to the consumption of renewable energy obtain such as Wind Energy or Fuel Cell or Solar Power etc. Wind Energy or airstream is the fastest increasing and most competent renewable energy source among them as it is economically feasible.

In 2008 India was the country that pass online the third largest amount of wind energy [1] after the US and China. The Indian wind energy sector has an establish capacity of 21141.36 MW (as on 13 March 2014). India ranked 5th in the world in terms of wind energy established capacity. Those days India is a chief performer in the global wind energy. The idle resource has the potential to sustain the growth of wind energy in India. A strong domestic manufacturing base has underpinned the development of the wind energy in Indian [2].

India has a great untapped potential for wind energy. India has a large available potential for wind energy as per authorized approximation. The Countries total wind power resource amount 102 GW of installed capacity [3] but some experts believe that this data is on the conservative side and that technological expansion could significantly increase this potential. The optimistic development of wind energy in India has primarily been driven by progressive state level legislation as well as strategy procedures such as renewable portfolio values. This additionally realizes how significantly role wind energy could play in securing India's power security cutting its CO_2 discharge providing new employment and boosting economic development. As can be seen by the Indian Wind power Point of view the wind industry both national as well as worldwide stands geared up to do its part in accomplishing an energy revolution in India.

Wind energy as a renewable non-polluting and inexpensive resource directly avoids dependency of fuel and transport can result to green and pure electricity [4].

Including an installed capacity is 21141.36 MW of wind energy the Renewable power Sources currently accounts for 13.86 % of India's overall installed power capacity is 228721 MW. Wind power grasps the major portion of 66 % (of 31707 GW total RE capacity) among renewable and continued as the largest supplier of clean energy [5]. The Government of India has set a goal of adding approximately 18 GW of renewable energy sources to the generation mix out of which 11 GW is the Wind estimation and rest from renewable sources like Solar 4 GW and other sources 3 GW. The industry have indicate its capability with good policy frame work to achieve a reference goal of 16000 MW pragmatic target of 20000 MW and an inspiring target of 25000 MW in the plan period of 2012-2017.

Wind Farms in India

1. Muppandal Perungudi (Tamil Nadu)

With an aggregate wind power capacity of 450 MW the Muppandal Perungudi region in the neighbourhood of Kanyakumari has the distinction of having one of the largest huddles of wind turbines. Roughly 2500 crores have been invested in wind power in this area.

2. Kavdya Donger Supa (Maharashtra)

A wind farm project has been developed at Kavdya Donger at Supa Pune highway about 100 Kilometres from Pune. These wind farms have 57 machines of 1-MW Power capacity of each machine. Annual utilization capacity of up to 22% has been reported from this spot.

3. Satara district (Maharashtra)

Encouraging policy for private investment in wind power projects has resulted in significant wind power development in Maharashtra located in the Satara district. Wind power capacity of around 340 MW has been established at Vankusawade Thosegarh and Chalkewadi in Satara region with an investment of roughly Rs.1500 crores.

The total ability of wind energy on this earth that can be harnessed is about 72 TW. There are now many thousands of wind turbines operating in different parts of the world with benefit companies having a total capability of 59,325 MW. The energy generation by wind power was around 94.12GW in 2007 which makes up nearly 1% of the total energy generated in the earth. Globally the long term technical potential of wind energy is believed to be 5 times current global energy consumption or 40 times current electricity demand. [6] This would require covering 12.7% of all land area through wind turbines. This land would have to be enclosed with 6 large wind turbines per square kilometer

The power obtains from the wind can be calculating by the given formula:

$$\mathbf{Pw = 0.5\rho\pi\ Cp\ (\lambda, \beta)} \qquad \text{Equation 1}$$

Pw = extracted power from the wind

ρ = air density (something like 1.225 kg/m3 at 20_o C at sea level)

R = blade radius (in m) (it varies between 40-60 m)

Vw = wind velocity (m/s) (velocity can be controlled between 3 to 30 m/s)

Cp = the power coefficient which is a function of both tip speed ratio (λ) and blade pitch angle (β) (Degrees)

Power coefficient (Cp) is defined as the ratio of the output power produced to the power available in the wind.

Types of Wind energy Conversion Devices

A wind turbine is a rotating machine which converts the kinetic energy in wind into mechanical power. If the mechanical power is then transformed to electricity the apparatus is called a wind generator wind turbine wind power unit (WPU) wind energy converter (WEC) or aero generator. Wind turbines can be divided into two types based by the axis in which the turbine Spin. Turbines that spin around a horizontal axis are more familiar. Vertical-axis turbines are less familiar used.

1. Horizontal axis wind turbine

A.)Dutch type grain grinding windmills.

B.) Multi-blade water-pumping windmills.

C.) High speed propeller type windmills.

2. Vertical axis wind turbine

A.) The Savonius rotor.

B.) The Darrieus rotor.

Reproduction and Simulation

This paper presents a number of basic considerations regarding simulations for wind turbines in electrical power systems. However we focus on the modelling of wind turbines the general objective is also to look at the wind turbine as one electro technical component among many others in the entire electrical power system.

This paper starts with a brief overview of the concept of modelling and simulation aspects. This is followed by means of smooth modelling of wind turbines. [7] We will present general elements of a common wind turbine model and some common considerations associated with per unit systems which experience shows are time after time difficult. Mechanical data resolves discussed with a set of typical mechanical data for a current sized wind turbine. These per unit data are representative for a wide range of sizes of wind turbine and are therefore suitable for user applications in a number of electrical simulation programs. Finally, various types of simulation phenomena in the electrical power system are discussed, with special emphasis on what to consider in the different types of simulation.

System configuration

The Wind-Turbine permanent magnet synchronous generator is presented by using a 480 V, 300 KVA synchronous machines, a wind turbine driving a 480 V and 275 KVA. This system can be coupled with Grid. Rated wind speed is considered as 12 m/s. The overall rated power of the wind turbine system is 2 MW.

Wind turbine systems

Various types of wind turbines have been developed. They have different purposes and thus treat different skin texture of the wind turbine system and they span in detail all the aspects relevant to such a device. The purpose of aerodynamic simulations is to verify and optimize blade design, according to prescribed criteria. [8] Examples of such criteria might be maximization of practical forces minimization of unwanted loads and tuning of blade characteristic for a chosen imaginary wind speed etc. Mechanical engineers are mostly disturbed with the safe and economical dimensioning of the whole wind turbine system and a proper mechanical model of the wind turbine will make their task simpler. General purpose models concerned with the electrical properties of wind turbines are widely used. There are also economical models which evaluate the price effectiveness of developed and installing wind turbines. The model of the overall wind turbine system integrates several building blocks.

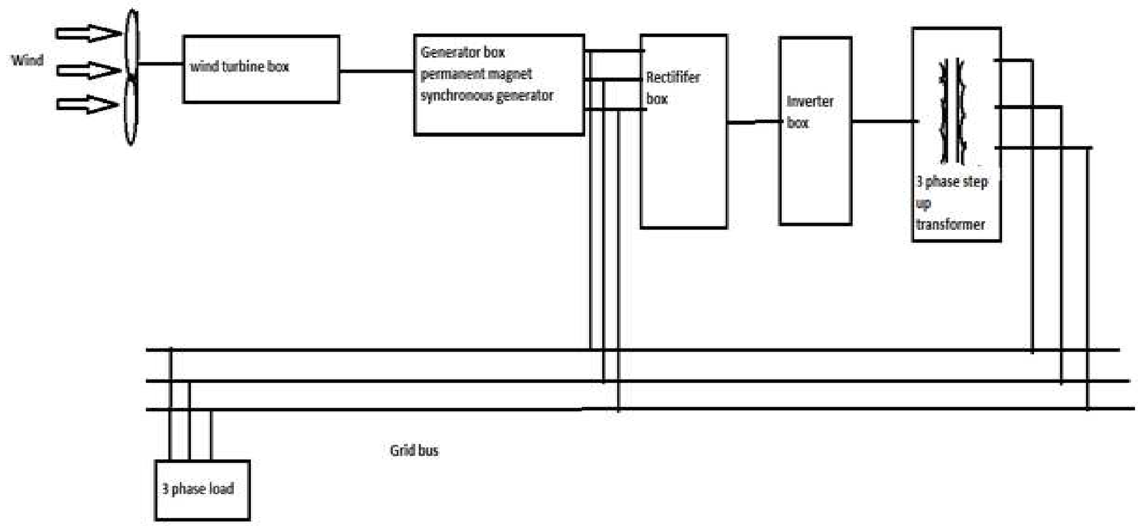

Figure 3 shows a diagram representing the basic structure of the mode

Turbine Modeling

The model is built on the basis of the steady-state power characteristics of the turbine. The stiffness of the drive train is infinite and the friction factor and the inertia of the turbine must be combined with those of the generator coupled to the turbine.

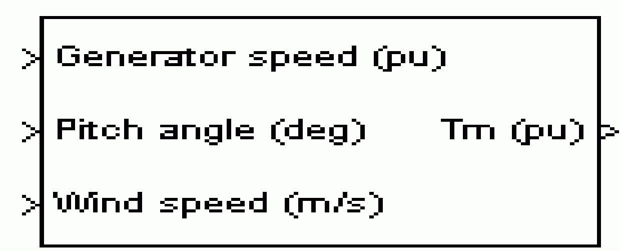

Fig. 4 MATLAB block of wind turbine.

The output power of the turbine is given by:

$$P_m = C_p(\lambda, \beta)\frac{\rho A}{2}V_{wind}^3$$

Where

P_m is mechanical output power of the turbine (W)

ρ is air density (kg/m^3)

C_p is performance coefficient of the wind turbine

A is turbine swept area (m^2)

V_{wind} is wind speed (m/s)
λ is tip speed ratio of the rotor

β is blade pitch angle (deg)

Above Equation can be normalized. In the per unit system and can be written as

$$P_{m\_pu} = k_p C_{p\_pu}(\lambda, \beta)\frac{\rho A}{2}V_{wind\_pu}^3$$

Where

P_{m_pu} Power in per unit of nominal power for particular values of ρ and *A*.

C_{p_pu} Performance coefficient in per unit of the maximum value of C_p .

V_{wind_pu} Wind speed in per unit of the base wind speed. The base wind speed is the stand for value of the expected wind speed in m/s.

k_p Power gain for C_{p_pu}=1 pu and V_{wind_pu}=1 pu, k_p is less than or equal to 1.

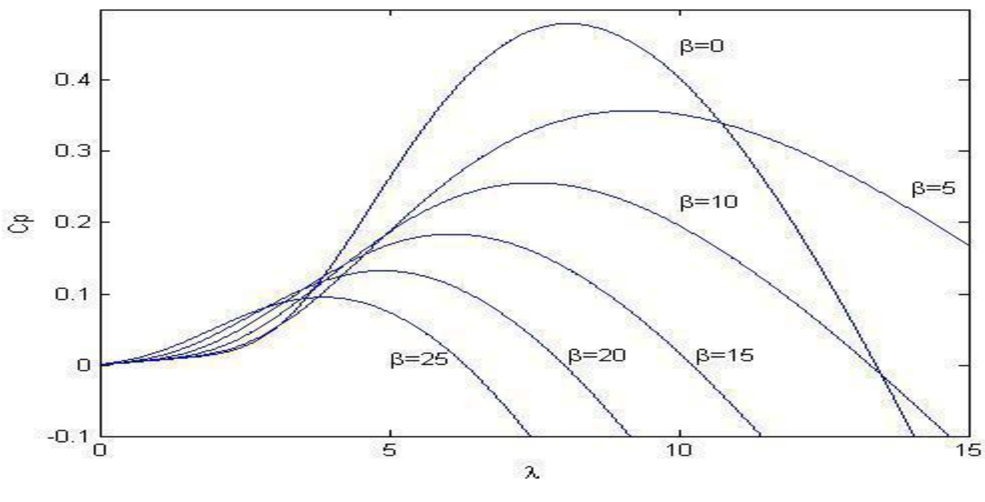

Fig. 5 Power coefficient versus tip speed ratio

From the above graph we can see that maximum value of cp for a particular value of TSR. Based on this proposal the following algorithm be developed which calculates the value of pitch angle for receiving the maximum value of Cp for a specific tip speed fraction. [9]

We calculate TSR (tip speed ratio) in a case where the blade tip speed is almost constant in the case of an unchanging speed turbine. And Cp versus **λ** graph is calculated used for exclusive values of β.

$$\text{TSR(tip speed ratio)} = \frac{\text{tip of blade}}{\text{wind speed}}$$

It converts the mechanical power output of wind turbine into electrical power. Those work on the principle of Faraday's law of electromagnetic induction.

PMSG is used in WECS because of its improvement such as better consistency, lower protection and additional efficient. The model of PMSG is well-known in the d-q synchronous structure.

Matlab model of wind turbine Pmsg

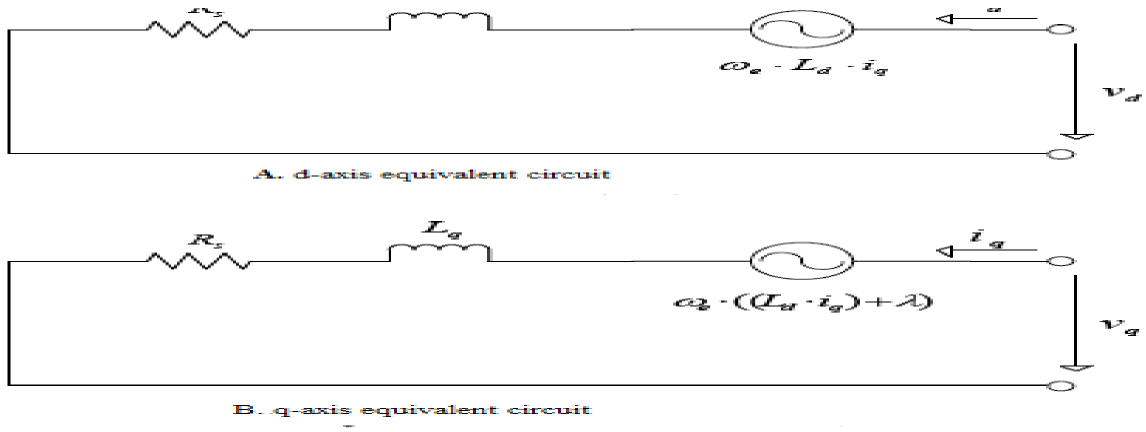

Fig. 6 Equevalent circuit

$$\frac{d}{dt} i_d = \frac{1}{L_d} V_d - \frac{R}{L_d} i_d + \frac{L_q}{L_d} \rho w_r i_q$$

$$\frac{d}{d_t} i_q = \frac{1}{L_q} V_q - \frac{R}{L_q} i_q + \frac{L_d}{L_q} \rho w_r i_d - \frac{\lambda \rho \, w_r}{L_q}$$

Where,

Lq= q axis inductance

Ld = d aixs inductance

iq = q axis current

id = d axis current

R = resistance of the stator winding

Vq = q axis voltage

Vd = d axis voltage

wr = angular velocity of the rotor

λ= amplitude of generated flux

ρ = number of pole pairs

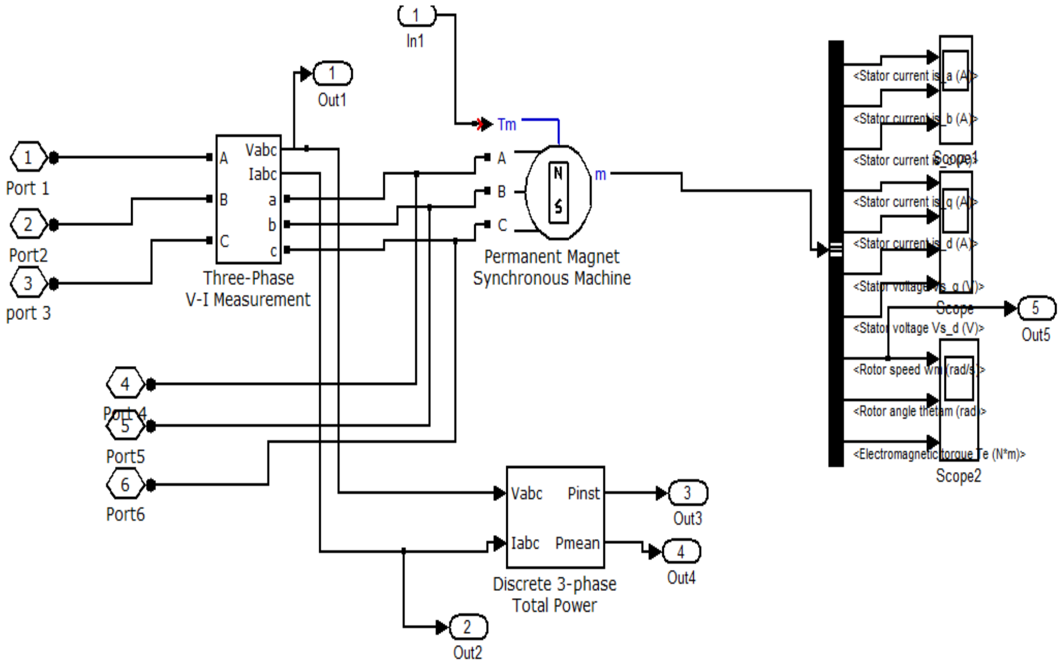

Fig. 7 Model of wind turbine PMSG

Matlab model of Rectifier

Phase controlled AC to DC converters makes use of thyristor is widely used for changing constant AC input voltage to controlled DC output voltage. The configuration does not require any individual transformer. Those converters are works as a 6 pulse rectifier [10].

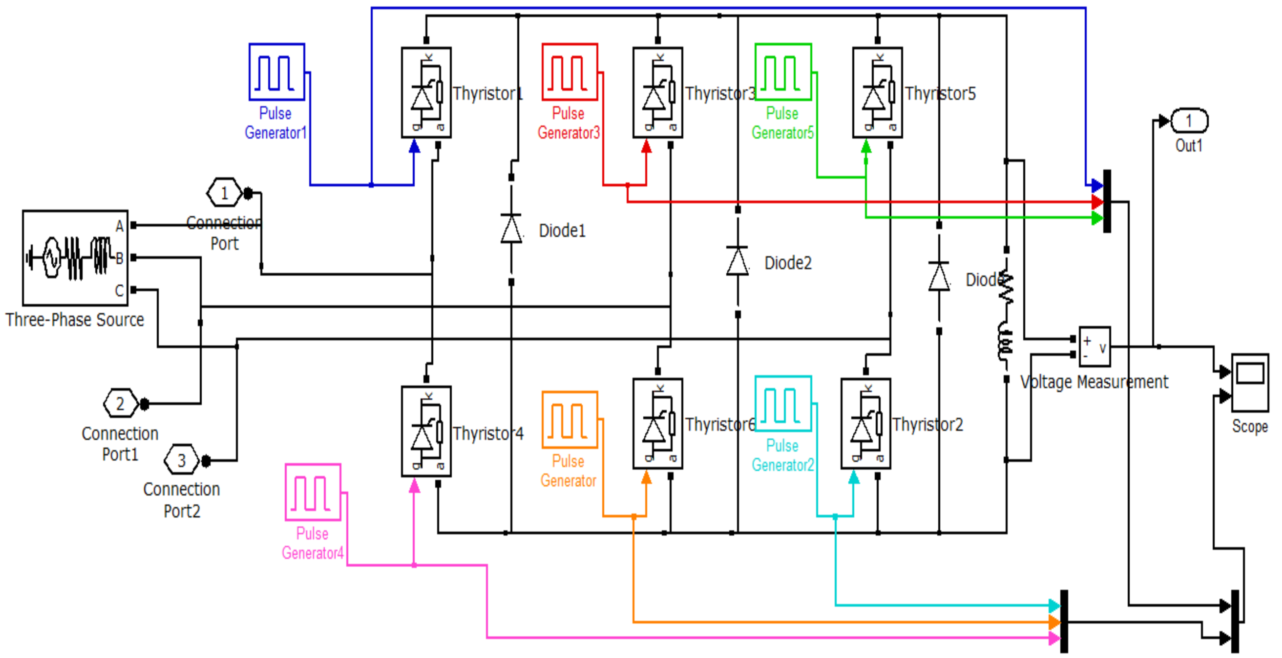

Fig. 8 Simulink model of Rectifier

Inverter converts the DC power into 3 phase AC power. The inverter that we have used at this time an IGBT diode based inverter connected in the bridge configuration. Universal bridge inverter used at this time to present bridge inverter.

Matlab model of Inverter

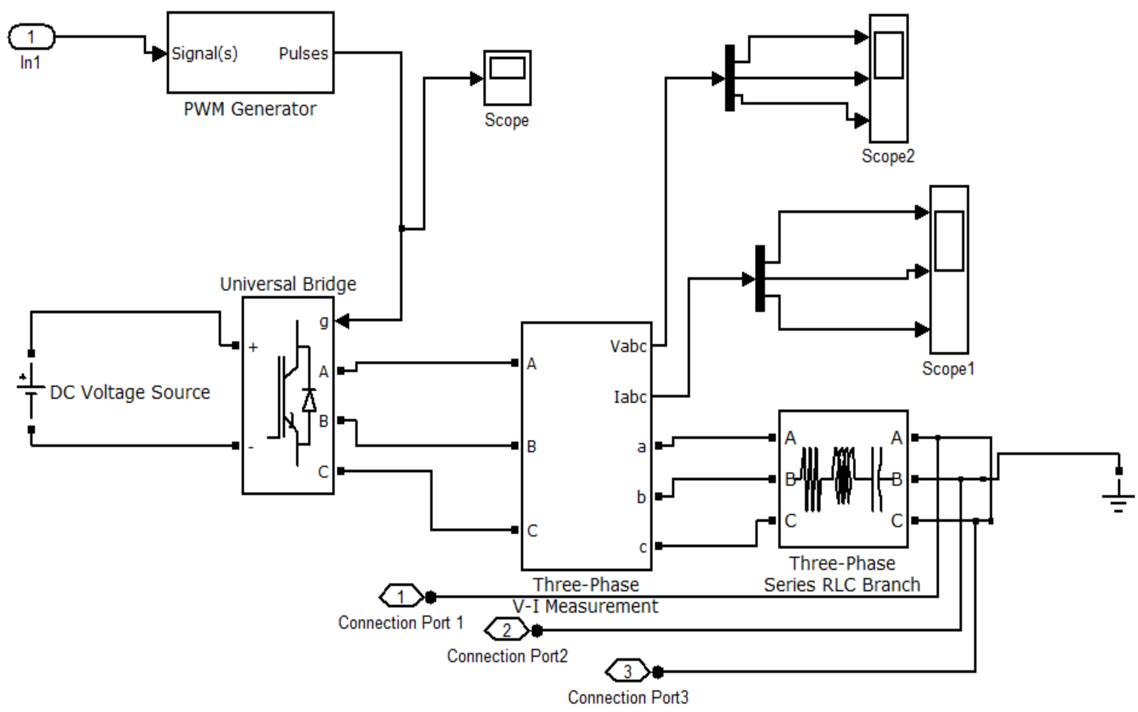

Fig. 9 Simulink model of Inverter

Matlab model of overall system

The consequent model describes our finishing system with all components.

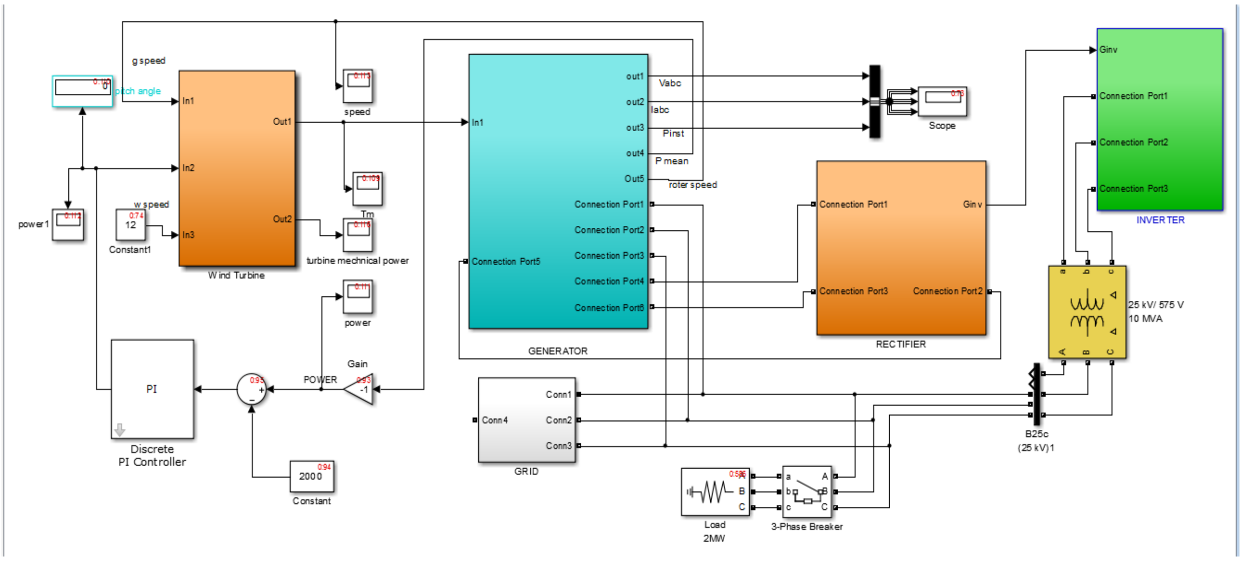

Fig. 10 Simulink model of wind turbine system

SIMULATION RESULT

In wind energy conversion system is built via Matlab/Simulink. In this paper the base wind speed is suppose as 12m/s. Simulation results are given below:

Output current and output voltage of inverter are two stepped square wave. After connecting to the grid results of the output voltage is shown in fig. 11

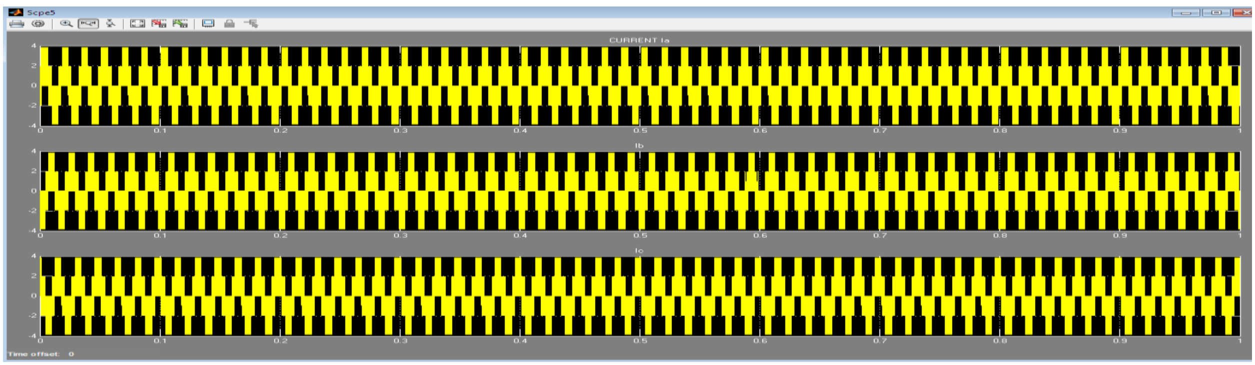

Fig 11 Output voltage of inverter

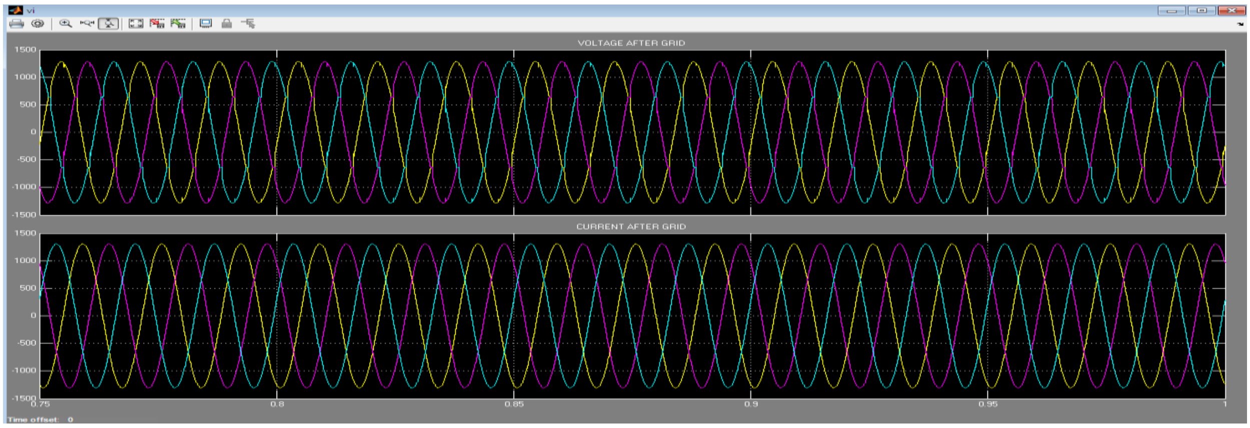

Fig 12 Output voltage of inverter After Grid

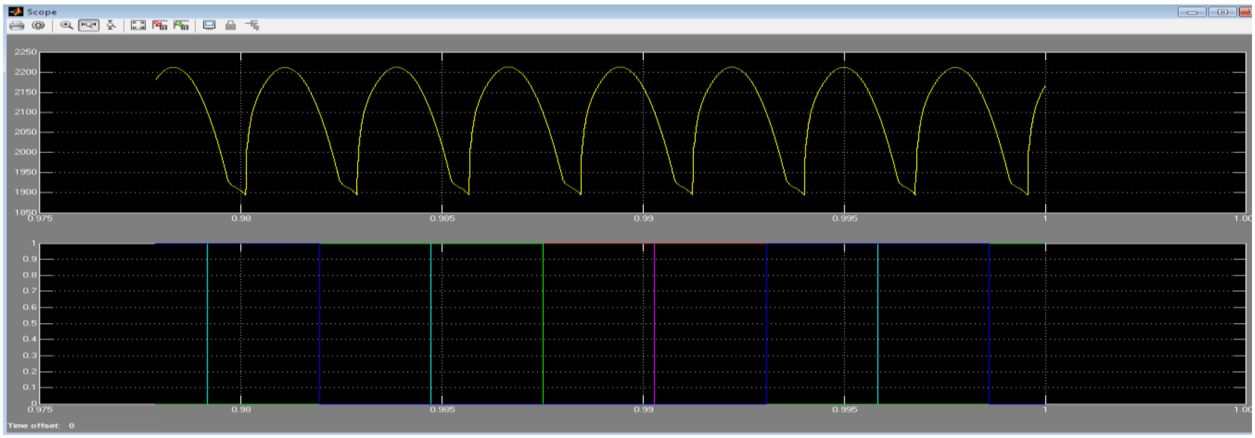

Fig 13 Output voltage of Rectifier

CONCLUSION

The paper tries to optimize and to maximize the yield of a wind turbine by means of permanent magnet synchronous generator (PMSG). First variable speed has been chosen because of the higher energy gain and the reduced stresses.

A gearbox is not necessary when a synchronous PMSG is used. The Rectifier has been added to the system to improve the dc voltage. This allows energy gains even for lesser wind speeds. In the following part a controller is considered. The wind turbine model is changed to a stall wind turbine model by adding a PI controller for the strike angle. One controller are used for the Rectifier voltage has been developed. The developed inverter controller is an all or nothing controller which is a fundamental controller. All results prove that the model developed and controllers demonstrate the effectiveness of adding a controller to obtain the maximum power production.

FUTURE ASPECT

The whole system can be developed for higher level. Conventional PI as well as AI based fuzzy logic controllers can also design for pitch servo system. The fuzzy logic controller provides better performance in terms of settling time.

Neural network controller can also use to control the pitch servo mechanism the results are further improved in all the functioning criteria. The settling point in time found to be good than conventional PI controller. The pitch variation with time and disturbance becomes almost linear and no hint of jerk or mechanical stress is noticed in the result.

REFERENCES

1. D. Mary, Shinosh Mathew, Sreejith K, Modelling and Simulation of Grid Connected Wind Energy System” International Journal of Soft Computing and Engineering (IJSCE), Volume-3, Issue-1, March 2013, 255-259
2. Mirza Mohd. Shadab, performance analysis of permanent magnet synchronous generator connected with wind turbine, Volume 2, Issue 2, May 2012, 46-49
3. P. P. Vinod Kumar 1, L. Venkata Suresh Kumar 2, “Power control of Grid connected PMSG wind energy system” International journal advanced research in Electrical, Electronics engineering, Volume 2, Issue 10, October 2013, 4668-4674.
4. World Wind Energy Report 2010, available at:http://www.wwindea.org/home/images/stories/pdfs/worldwindenergyreport2010-s.pdf, accessed May 2011.
5. J. Verma, et al., Performance, Analysis and Simulation of Wind Energy Conversion System Connected With Grid, International Journal of Recent Technology and Engineering, Volume 2, Issue 6, January 2014, 33-38.
6. S. Samanvorakij, P. Kumkratug, Modeling and Simulation PMSG based on Wind Energy conversion system in Matlab/Simulink Proc. of the Second Intl. Conf. on Advances in Electronics and Electrical Engineering - AEEE 2013, 37-41
7. Z. Chen and E. Spooner, A Modular Permanent Magnet Generator for Variable Speed Wind Turbines in proceedings of IEE EMD, 1995, 453-457.
8. Three-Phase Full wave Controlled Converters (Controlled rectifier) University of Technology Laser and Optoelectronics Engineering Department Laser Engineering Branch Power electronics 2011-2012
9. J. A. Baroudi, V. Dinavahi, A Review of power converter topologies For wind generators, In Proc. IEEE, Vol 8 Issue 4, 83-89