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Performance of Wind Energy Conversion Systems

[1] R.Gunasekari [2] N.H.Umashree [3] Nethravathi.J [4] Kavya Neela [5] Namratha.R
[1][2][3][4]Student [5] Assistant Professor
[1][2][3][4][5] EEE Department, Sri Sairam College of Engineering, Bengaluru

Abstract: -- **A renewable energy source is most attracting as substitute energy sources for the conservative energy sources. With growing attraction of renewable energy sources, because of ecological problem and clean electrical power generation. This is not only due to the diminishing fuel source and due to environment pollution and global warming problems. The wind energy conversion systems (WECS), interest is focused on a small unit of wind turbine to provide electricity supply in the remote areas. Small stand alone renewable based power supply systems are marketable in the remote places. Where the grid is not connected cost-effectively and electricity is not available. The wind power is the main sources of a renewable energy and maximum power can be generated during the wind variations. Permanent magnet synchronous generator (PMSG) is used with the wind turbine for power generation and it has better reliability, lower maintenance and efficiency is more. A synchronous generator is needed to extract all the power in peak power situation as high wind and to store the enough energy for periods to the renewable source is no available. The generator is committed to horizontal axis wind turbine. Excitation field is provided to the synchronous generator by the diode rectifier. By using diode rectifier and ac voltage converter into a dc voltage supplies to and boost converter. Supplies the single phase supply to the connected by an MOSFET inverter and the storage system is used to provide the supply during the low wind condition. The generator is extra-large, if the chances of without storage bank and the power also deliver to the peak load. These ensure the uncompetitive against huge power stations. This proves that larger storage banks are needed to ensure power all the time. The high power load appears for short period and storage system ensures the sufficient power. The cost of total energy including the capital cost of the power system and maintenance is huge compare to the hybrid system with battery bank is small than the conventional power supply.**

Keywords – **Wind Energy Conversion Systems, Permanent Magnet Synchronous Generator, MOSFET, Boost Converter**

I. INTRODUCTION

The wind energy conversion systems (WECS), interest is focused on a small unit of wind turbine to provide electricity supply in the remote areas. Small stand alone renewable based power supply systems are marketable in the remote places. Where the grid is not connected cost-effectively and electricity is not available. The wind power is the main sources of a renewable energy and maximum power can be generated during the wind variations.

Permanent magnet synchronous generator (PMSG) is used with the wind turbine for power generation and it has better reliability, lower maintenance and efficiency is more. An synchronous generator is needed to extract all the power in peak power situation as high wind and to store the enough energy for periods to the renewable source is no available. The generator is committed to horizontal axis wind turbine. Excitation field is provided to the synchronous generator by the diode rectifier. By using diode rectifier and ac voltage converter into an dc voltage supplies to and boost converter. Supplies the single phase supply to the connected by an MOSFET inverter and the storage system is used to provide the supply during the low wind condition.

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II. WIND TURBINE SYSTEM

Wind turbines harness the power of the wind and use it to generate electricity. Horizontal axis wind turbines (HAWT) are most common type of wind turbines. Its design is taken from the design of windmills, which have blades that rotate and spin around a horizontal axis. The horizontal axis mainly is the rotor shaft that is considered the electrical generator shaft.
Horizontal axis wind turbine has three blades around a rotor. The rotor is connected to the generator shaft. The electrical generator shaft rotates and the generator

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generates electricity. The electrical power produced passes through a power conversion system. The stored energy from the wind is a low quality form of wind energy. So many factors influence the factor of the wind speed and its modulated as source intermittent variable energy. It's characterized as variable in the magnitude of wind energy and direction.
Wind energy as random variable given by

$$u = u_0 \left[1 + \sum_n A_n \sin(\omega_n t) \right]$$

The wind energy of mechanical energy conversion passed to the rotor of a wind turbine and factors influenced between the tower of wind turbine and energy conversion. Mechanical effects have been modelled by Eigen swings mainly due to the asymmetry in the wind turbine, tower interaction of vortex and mechanical Eigen swing in the blades. The mechanical power passed over the wind turbine rotor has been modelled. The amount of power in the wind is a function of the wind density, swept area of the blades Ab, the coefficient of performance, Cp that has to be less than 0.59 which is Betz limit and proportional tp cube of wind speed, Vw, Betz limit is the upper limit of power that we can extract from the wind. The wind power equations is

$$P_w = \frac{1}{2} \cdot \rho \cdot A_b \cdot v_w^3$$

The mechanical power, Pm, extracted from the wind can then be expressed as

$$P_m = \frac{1}{2} \cdot \rho \cdot A_b \cdot v_w^3 \cdot C_p(\lambda, \beta)$$

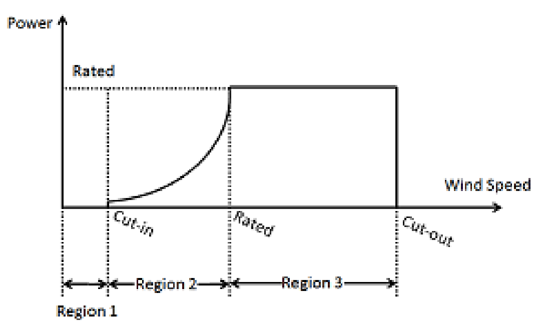

Fig.1: Power-Wind Speed Curve for Variable-speed Pitch-regulated Turbine

III. WIND TURBINE CONTROL SYSTEMS

From the power flow perspective, control of wind turbine can be divided into two stages. The first stage is to control the turbine to convert aerodynamic power into the mechanical (rotor) power (i.e. the product of rotor torque and rotor speed), while the second stage is to control the generator to convert the mechanical power into the electrical power (i.e. grid power for most occasions). Fig. 3.2 shows the power vs. wind speed curve for variable speed pitch regulated turbine.

There are different configurations for wind turbines. For utility wind turbines, the most popular and efficient is the variable-speed and variable-pitch turbine. With different wind speed and control objectives, the control of variable-speed variable-pitch wind turbine can be categorized into three control regions. The wind speed below the cut-in speed (usually 3-5m/s) is classified as Region 1. Turbine operation is not started yet in this region. The wind speed between the cut-in speed and rated wind speed is classified as Region 2. The objective for Region 2 control is maximizing the capture of mechanical rotor power. Above rated wind speed is Region 3, the turbine operates at the rated power of the generator, and pitch is used to reduce the mechanical load. When the wind is above the cut-out speed, the turbine will shut down to protect turbine. The control development for wind power generation always focuses on Region 2 and Region 3 operations. For Region 2, the challenge is in order to achieve maximize power operation, controller needs to find out the optimal rotor speed and blade pitch under variable wind.

For Region 3, the control objective is to regulate the power output at the rated level and minimizing the turbine load at the same time to ensure the reliability. As more and more wind turbines have been and will be installed in medium to low wind areas, i.e. more frequently operated in Region 2,enhancing power capture in this region is an critical issue for wind power development. Wind power capture can be enhanced with better turbine design and/or advanced control strategy

Developing advanced control strategies is often a more cost-effective way for energy capture enhancement and also can be applied easily to those turbines already installed.

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IV. PROPOSED SIMULINK MODEL

The proposed system has been modelled and simulated using the Matlab/Simulink. Fig. shows the Simulink modelling of the wind turbine with the permanent magnet synchronous generator. Vw represents the input to the wind speed and the power at the PMSG. The battery is used to provide real power to the system.

The wind turbine used to measure the optimum tip speed ratio, the speed of wind and angular velocity. The operating point in the positive slope and maximum power point of curve attain. If the functioning point in the positive slope and the operating point is to be maximum.

This can be achieved by reducing the current of load. declining the load current and the torque will be reduced and difference between torques will accelerate. The wind turbine model designed in MATLAB/SIMULINK.

This block incorporates a variable pitch wind turbine model. The performance coefficient Cp of turbine is the mechanical output power of the turbine alienated by divided by wind power and a function of wind speed, rotational speed, and pitch angle (beta). Cp reached its value at the zero betas. The wind turbine characteristic displays the wind turbine characteristics at the particular pitch angle. The first input is the generator speed in per unit of the generator base speed. The synchronous generator base speed is the synchronous speed. The permanent magnet synchronous generator, the base speed is defined as the speed producing nominal.

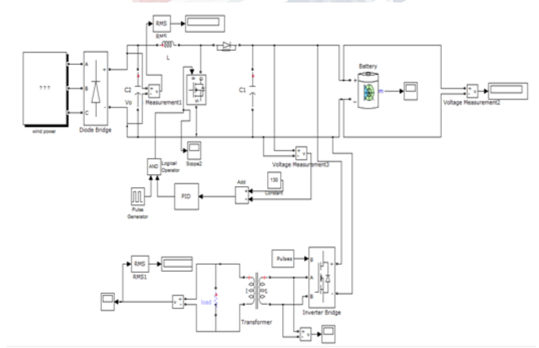

Fig.2: Complete Simulink Model of Wind Energy Conversion System

voltage at no load. The another input is the blade pitch angle in degrees.

The tip speed ratio is

$$TSR = \frac{wr}{v_w} = \lambda$$

The mechanical power, Pm, extracted from the wind can be expressed as

$$P_m = \frac{1}{2} \cdot \rho \cdot A_b \cdot v_w^3 \cdot C_p(\lambda, \beta)$$

The output torque of the turbine is calculated

$$T_m = \frac{P_m}{\Omega} = \frac{1}{2}\frac{C_p \rho \pi R_{turbine}^2 v_{wind}^3}{\Omega}$$

V. SIMULATION RESULTS

The simulation results of proposed Simulink model are shown as below:

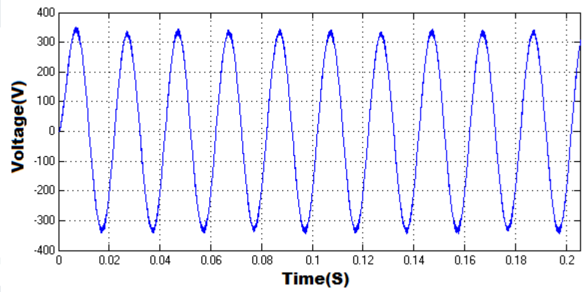

Fig.3: Output Voltage Waveform of Inverter

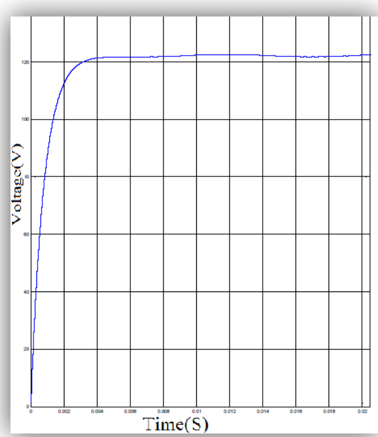

Fig.4: Output of Boost converter

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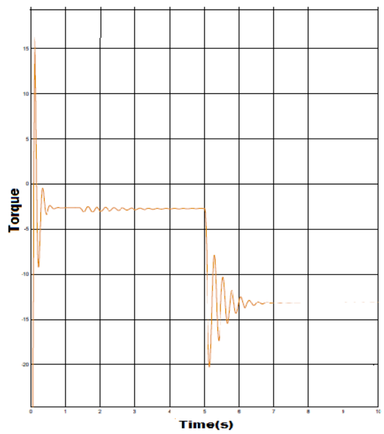

Fig. 5 : Torque of Permanent Magnet Synchronous Generator

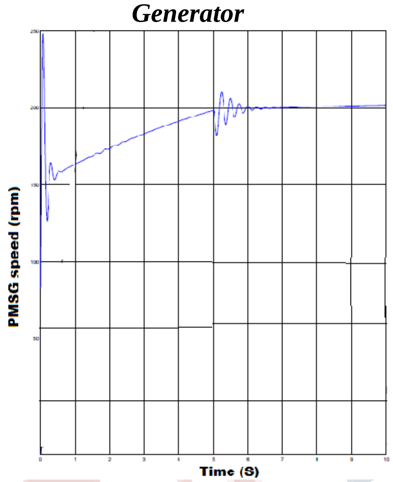

Fig.6: Speed of Permanent Magnet Synchronous Generator

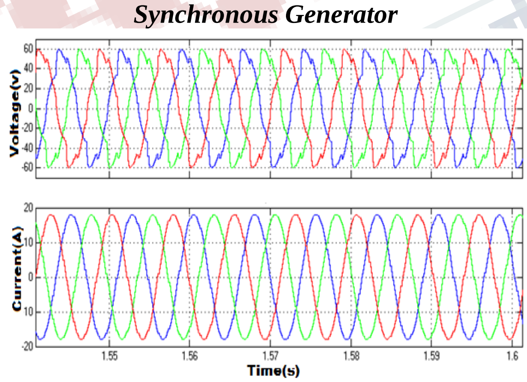

Fig.7: Output Voltage and Output Current Waveforms Permanent magnet synchronous generator

VI. CONCLUSION

The proposed control method was simulated with a wind turbine and a permanent magnet synchronous generator is connected through boost converter and mosfet inverter to supply the reliable power supply to the load. A control scheme incorporated pitch angle control and generator rotational speed. The pitch angle control is actuated at high speed of wind and sends wind speed signals as the inputs. The simulation results shown maximum power extractions control is absolute necessary to obtain the performance. A system with a maximum power extraction with all wind speeds and works efficiently. A PID control method incorporated to deliver the reliable power to the connected variable load. The compensation of proposed PID controller method and the optimal tip speed ratio, maximum Cp, fast response time, simple controller. Also an associated energy storage system of model, to stabilize the output voltage for the domestic applications. The lead acid battery always delivers the reliable supply to the households. The battery is switching linking the charging and discharging method to the wind speed and load variation.

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