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Small Unit of Stand Alone Wind Based Energy Storage System and Reliable Power Supply

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Abstract: ***The use of wind energy for Electric power generation provides a clean and renewable source. The quality power deliver by the structure of wind turbine system with variable speed permanent magnet Synchronous Generator (PMSG) and system to store the energy. The entire model of the system is achieved, including the PMSG, the boost converter, and the storage system. The absorbed power by the connected load can be delivered efficiently and supplied to the proposed wind turbine and energy storage systems and subject to an opposite control method. Permanent magnet Synchronous Generator have the potential to be a robust and highly efficient electrical conversion system for variable speed wind application. An PID control method implemented to deliver the power for the connected variable load.This work provides a detailed methodology to assess the impact of wind generation on the voltage stability of a power system. In order to verify the presented model and the control strategy, simulation MATLAB/Simulink software have been conducted. Simulation results prove the stabilize power supply.***

Keywords: Wind Energy Conversion System (WECS), Permanent Magnet Synchronous Generator (PMSG), Energy Storage System, Wind Power.

1. Introduction

A renewable energy source is most attracting as alternative energy sources for the conventional energy sources. With increasing the attraction of renewable energy sources, because of environmental 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 economically 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 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 dedicated to horizontal axis wind turbine. Excitation field of the synchronous generator is provided by the diode rectifier. By using diode rectifier and ac voltage converter into an dc voltage fed 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 oversized, if the chances of without battery bank and the power also deliver in the peak load. These ensure the uncompetitive against large power stations. This means that larger battery 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. This study represents the wind turbine converter the mechanical power in the rotor shaft to electrical energy by connecting to the permanent magnet synchronous generator. Further supplied to the variable load.

2. Proposed System Model

The model of the entire WEC system can be divided into several interconnected subsystem model as shown in figure 1. These subsystem models are the WT, the PMSG, Rectifier bridge, Boost converter, Energy storage system, Mosfet inverter and Variable load.

2.1 Wind Turbine Model

The method used only to measure the optimum tip speed ratio, the wind speed and angular velocity. The operating point in the positive slope and maximum point of curve obtain. If the operating point in the positive slope and the operating point is to be maximum. This can be achieved by reducing the current of load. Decreasing in the load current the torque will be reduced and difference between torques will accelerate.

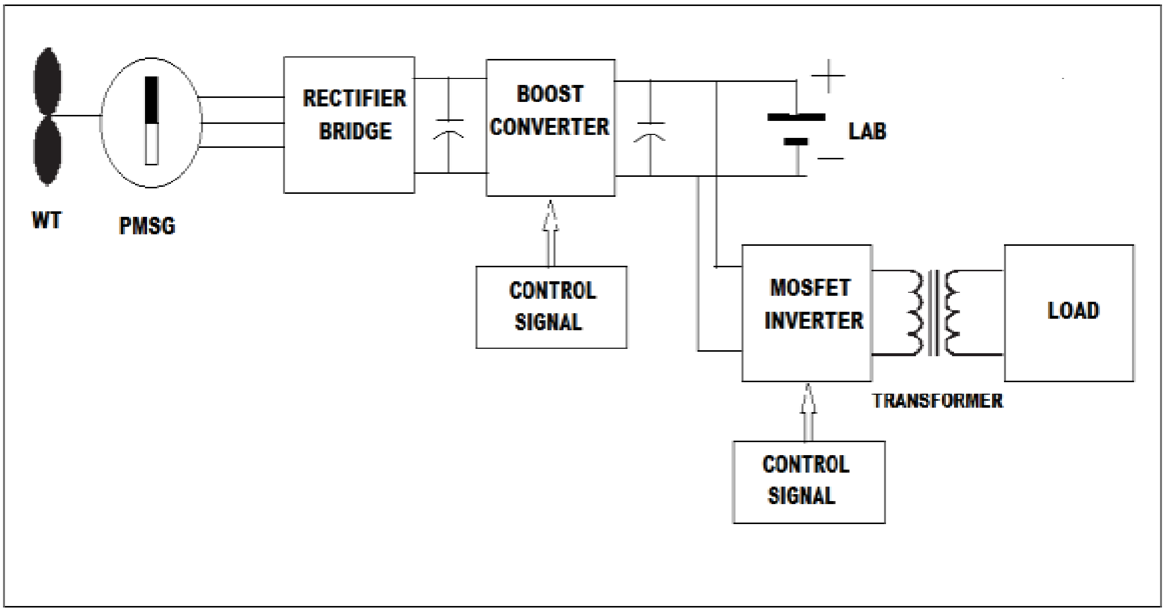

Figure 1: Proposed stand alone WEC system

The wind turbine model designed in MATLAB/SIMULINK. This block implements a variable pitch wind turbine model. The performance coefficient Cp of turbine is the mechanical output power of the turbine divided by wind power and a function of wind speed, rotational speed, and pitch angle (beta). Cp reaches its maximum value at zero betas. The wind-turbine power characteristics display the turbine characteristics at the specified pitch angle. The first input is the generator speed in per unit of the generator base speed. For a synchronous generator, the base speed is the synchronous speed. For a permanent-magnet generator, the base speed is defined as the speed producing nominal voltage at no load. The second input is the blade pitch angle (beta) in degrees.

The tip speed ratios are:

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

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:

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

2.2 Dynamic Model of PMSG

Permanent magnet machines have been widely used. Indeed, this technique can replace the field winding of synchronous machines and has more well known advantages of compact size, the higher power density, the loss reduction, high reliable and good robustness. Addition to this simple design of the rotor and without field excitation also increases the efficiency of the machine.

The dynamic model of PMSG can be represented in the Park's system using the following equations [3]:

$$V_d = -R_S i_d - L_d \frac{di_d}{dt} + \omega L_q i_q$$

$$V_q = -R_S i_q - L_q \frac{di_q}{dt} - \omega L_d i_d + \omega \lambda_m$$

The electromagnetic torque equation of the rotor is given by:

$$T_e = \frac{3}{2} p \lambda_m i_q$$

2.3 Boost Converter Model

The boost converter acts as an interface between the battery and rectifier capacitor and transfer the rapid power. The

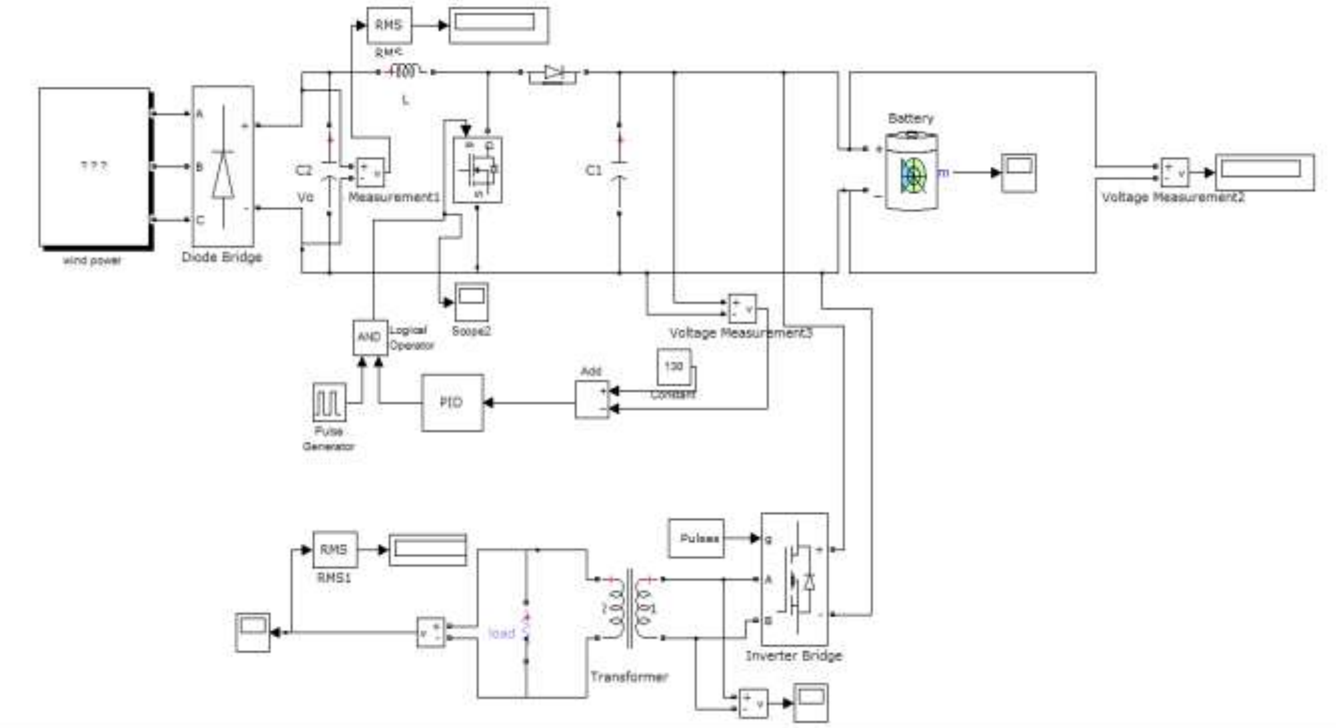

Figure 3: Block diagram of simulation

Voltage and current relation between the primary and secondary of the converter is given by

$$V_b = \frac{V_{\mathrm{dc}}}{1 - D}$$

Where *D* is the pulse-width modulation pulse modulation factor.

When *Vdc* ≥ *Vb*, the boost converter is not working, and the current provided by the generator is channeled through the bypass Schottky diode *Ds*.

The input and output response of the boost converter is modeled by two controlled current source. A PID controller has the controlling dynamics including the steady state error, fast response and higher stability. The PID controller block diagram as shown in the figure 2 . It shows the processing of PID controller action by setting its gain value to give better response to the boost converter.

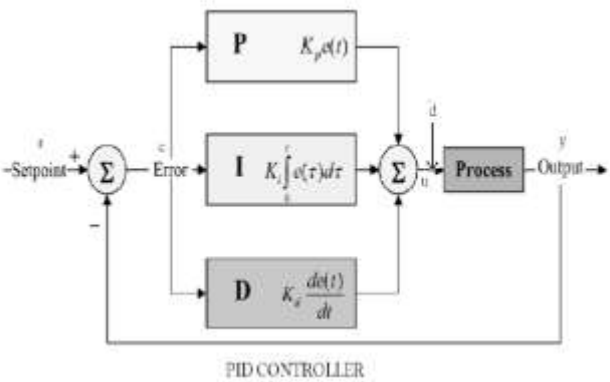

Figure 2: PID Controller

2.4 Energy Storage System and MOSFET Inverter Model

An energy storage system is modeled with a single phase mosfet inverter and lead acid battery. Its 12V each connected in series to provide the required output value of the inverter. The lead acid battery is used to supply the power during wind turbine condition at low.
The equivalent electrical model of the LAB contains a controlled voltage source (*Eb*), connected in series with the internal resistance (*R*int) and the LAB voltage (*Vb*).It is known that the *Eb* voltage depends on the state of charging and temperature, and it is expressed by the following relationship

$$E_b = E_{b0} - \frac{K \cdot Q}{Q - \int_0^t I_b dt}$$

Where *Eb*0 is the no-load battery voltage.
K is the polarization voltage
Q is the capacity of battery
I_b is the battery current

The state of charge of lead acid battery is defined as follows.

$$SOC_{[\%]} = SOC_{0[\%]} + \left(\frac{1}{Q_n} \int_0^t I_b dt \right) \cdot 100$$

3. Simulation and Result

The proposed system has been modeled and simulated using the Matlab/Simulink. Figure 3 shows the Simulink modeling 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 voltmeter connected across the load shows the output across the load.

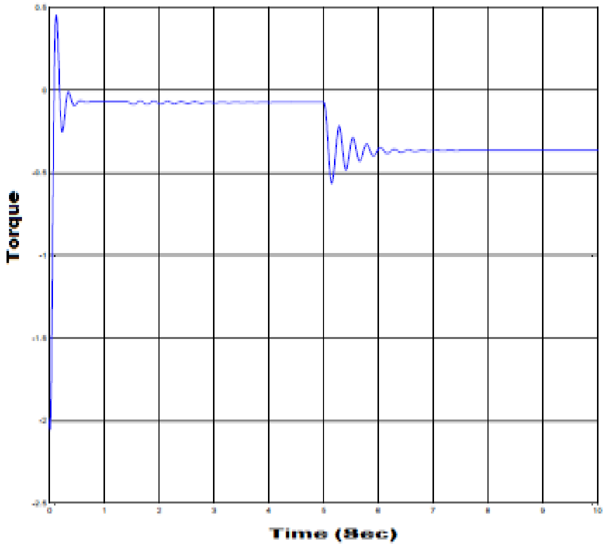

Figure 4: PMSG Torque

The PMSG belongs to real wind turbine and the PMSG torque are shown in the figure 4.

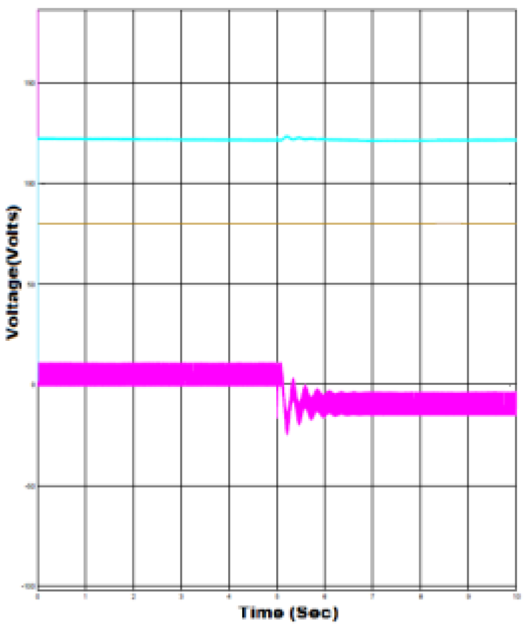

Figure 5: Status of the battery

The simulation results of the lead acid battery is shown in figure 5. It shows the voltage level and current in the battery. The charging and discharging decreases in order to ensure the stable supply of the loads.

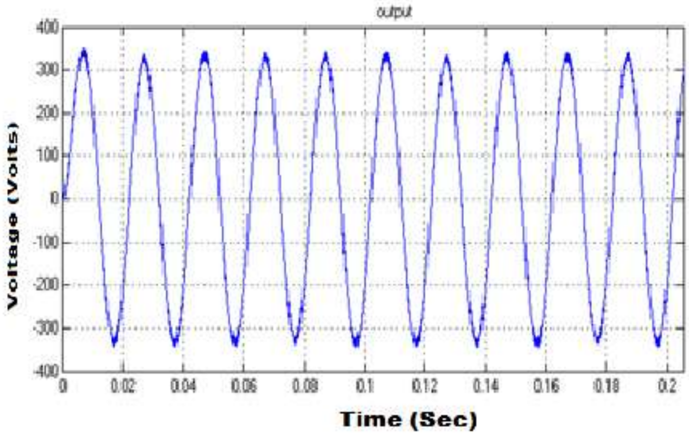

Figure 6: RMS output voltage across the load

The figure 6 shows the stabilize output voltage for the domestic appliance.

4. Conclusion

The proposed control method was simulated with a model of the variable speed wind turbine with PMSG that is scheduled to connect through an boost converter and mosfet inverter supply to the variable load. At the same time, the paper addresses control schemes of the wind turbine in terms of pitch angle and generator rotational speed. The pitch angle control is actuated in high wind speeds and uses wind speed signals and electric power as the inputs. The simulation result shows that the maximum power point tracking control is absolutely necessary to obtain acceptable performances. A system with an maximum power point track with all the wind speed and work efficiently. An PID control method implemented to deliver the power for the connected variable load. The advantages of proposed PID controlled method and it needs the optimal tip speed ratio and maximum Cp, fast response time, simple controller. This having an associated energy storage system, to stabilize the output voltage for the domestic application. The Lead acid battery always ensures the supply of the loads (households). The battery is switching between the charging and discharging modes to the wind speed and load variations.

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