Energy Efficiency Enhancement of Wind Power Plant by using P&O MPPT

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Abstract

Globally, Renewable Energy Resources (RER) are playing vital role for generating electrical energy due to conventional fossil fuel based power plant are harms environment. Also, availability of fossil fuels is going to run out. The primary resources for RER are sun, wind, hydro and tidal. Among energy harnessing rate has been rapidly increased in solar PV and wind power plants. Since sun and wind energy are abundant in nature. Nevertheless, natural resources are seasonable which are varying with respect to the climatic condition. Therefore, sun and wind power generator are produced fluctuating electrical energy which causes stability issue.It can be compensated by MPP tracking technique. At present, MPPT technique is incorporated with RER for generating maximum electrical energy based on available resources. In this manuscript a wind power plant withPerturb and Observer based MPPT model has been developed by using MATLAB/Simulink for analyze the significance of MPPT. From the simulation results show that, wind power plants are capable of generating constant power with the help of Perturb and Observer MPPT. Furthermore, the wind power out is significantly enhanced with the accurate designed boost converter.

Keywords. Photovoltaic, Rural, MPPT

1 INTRODUCTION

Due to rapid growth of urbanization and industrialization, the requirement of electrical energy has been increased. Accordingly, power industries are enhancing the electrical energy generating capacity by capacity addition program. During capacity addition, fuels are playing key role. Because of conventional thermal based power plants are fossil fuels are used as primary resource for generating thermal energy. It is used to generate required steam. The fossil fuels are namely coal, diesel, and petrol. Among, over 60% power plants using coal as a primary fuel for generating required thermal energy. The fossil fuel-based power plants faced two challenges such as availability of fossil fuels are going to run out in near further. In addition, the fossil-based power plants are harming the environment. The coal-based power plants are releasing the carbon dioxide, carbon mono oxide and NO etc. These are harming the environment as well as living organism. Therefore, power sectors are concentrating ecologically friendly resources for generating electrical energy. In addition, availability also consider for generating electrical energy [1],[2].

Globally, renewable energy resources are playing a key role for extracting electrical energy. The renewable energy resources (RER) are solar, wind, tidal, and hydro etc. Among them electrical energy generation has been increased from solar and wind power plants. By using suitable energy conversion device, it is possible to convert available RER into electrical energy. For an example, solar PV system, solar PV array are used to convert available irradiations into electrical energy. The photovoltaic cells are connected in series which forms the solar module. Then number of solar cell modules is connected to form a solar PV array. The basic principle behind the solar PV system is photovoltaic effect. The PV cells are received, irradiations form sun. The solar cell made upon two different layers of silicon. Such as P and N type semiconductor materials. By nature, N type semiconductor materials release the electron when sun irradiation is hit on the materials. While P type materials are received the extra electrons. It is a simplest principle behind the solar PV arrays. The output of solar PV array is strongly depending on the environmental conditions such as available irradiations, irradiation received by the solar PV array, cell temperature. The received irradiations by the solar PV cell are high generating electricity also high whereas low number of irradiations are hit in the solar PV which yields the less energy. Therefore, solar PV array yield potential has been varied with respect to the irradiations [2]-[4].

The sun continuously moving therefore received irradiation by the solar PV array has been varied with respect to time. So, electrical energy harnessing rate is varied with respect to time. For an example mid of the solar PV generate high energy, while morning and evening yield potential has been low that of mid of the day. Therefore, extracting maximum energy is challenge task which is achieved by keeping solar PV working on MPP. It is made by the MPPT technique. The role of MPPT is track the maximum power from available irradiations. Traditional MPPT such as Incremental Conductance, Perturb and observation, Hill

climbing is able to track the maximum power steady under climatic condition. Whenever, rapid climatic change occurs at instant soft computing based MPPT technique are capable of tracking maximum power from solar PV system such as ANN, Fuzzy etc [5],[6].

Furthermore, electrical energy extraction rate is significantly increased from wind power plant. The wind power plants are tracking electrical energy from wind. The wind is referring to the movement of air due to uneven heating of earth surface by sun. From wind electrical energy has been extracted by blades. Globally total install capacity of wind power plant is 300 GW which is rapidly increased every hour. According to the International Energy Agency Report, wind power has been contributing 18% of power sharing by 2050. However, wind power plants are doesn't produced constant electrical energy since wind output energy is depends on the available wind speed. Suppose wind speed is high which produced high energy yield otherwise vise-versa. In addition, wind power yield potential has been varied with respect to temperature, pressure and humidity, respectively. Therefore, extracting maximum power from wind power plants is challenge task [7]-[9].

In this paper, wind power plant with MPPT is modelled and analysed with the help of MATLAB Simulink block set. Also, an accurate design has been developed for enhancing voltage form generation to desired level. The manuscript has following section such as in section 2 dealt with proposed model block diagram description followed by section 3 discussion about P&O MPPT and section 4 is simulation results and analysis, and section 5 is concluding the main findings.

2 PROPOSED WIND MODEL

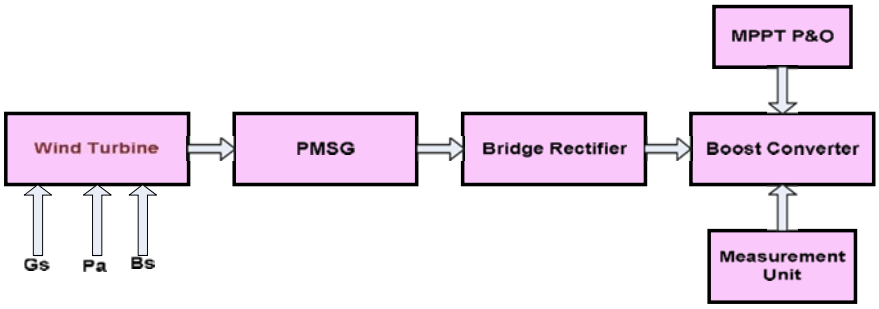

Figure 2.1. Proposed Wind Model

As shown the above figure, it shows the entire unit of proposed model. The first block represents the wind turbine. It received three input such as generator speed (Gs), Pitch Angle (Pa) and Generator Base Speed (Bs), respectively. The turbine is generating required kinetic energy for permanent magnet synchronous generator. Here salient pole synchronous generator has been used. Due to it seed torque characteristics is comparable to the non- salient pole synchronous generator. The PMSG is generating electrical energy depends on the received mechanical energy from wind turbine. Subsequently, the generated electrical energy is fed to thebridge rectifier. It is used to rectifier the given input power from AC to DC. It is fed to the input of boost converter. The boost converter boosts the voltage at desired level according to the L and C and Switching sequence. The voltage level increases, or a decrease depends on the duty cycle of switch. The duty cycle generation is depending on the generator output voltage and rectifier voltage and power [10], [11].

3 WIND ENERGY CONVERSION SYSTEMS

Traditionally, squirrel cage induction motor is used to generate electrical energy which working based on the Danish concept, respectively. It is directly connected to the grid. The speed of such a motor is content such as fixed speed. Perhaps, at the instant of heavy wind hitting on the wind blades subsequently generating electrical energy is also high. Later on adjustable speed control technique has been incorporated with existing squirrel cage induction motor. This is restricting high wind pressure on wind tower. In wind power plants, Double Filed Induction Generator (DFIG) are popularly used which coupled to the turbine with help of gear box. Due to aging phenomena the gear gets damaged. Therefore, it is required frequent maintenance for smooth mechanical coupling between generator and turbine. However, the rotor of PMSG is directly coupled to the wind turbine, so there is no need for gear system. So, cost wise PMSG is lower that of DFIG. The significance of PMSG is low excitation loss, reasonable efficiency, power density is high and so low maintenance cost [2-3]. However, wind power plants are introduced power quality issue

on the transmission and distribution system. To compensate the power quality issue at present dynamic voltage resistor(DVR), a thyristor switched series capacitor (TSSC) has been incorporated with the existing system for enhancing the power quality. In addition with, to reduced voltage sag and swell issues by using DVR. Moreover, wind power plants are causes following impacts on the power systems such as short and long duration effects. The first effect time duration is marginally is very low that is milliseconds to hours which is responsible for system unbalancing. Whenever, generated powers is transferred to the grid which causes the power quality problem, voltage sag and swell and so reactive power problems, respectively. Suppose, required compensating devices are we are not included which continue until wind power get off. Since, wind power plants never run at constant speed. The main classification of voltage variations are voltage sag and swell, short and long voltage irruptions, respectively. It can be rectified by suitable compensator such as STATCOM. It is synchronous condenser which is connected parallel to the AC system, respectively. Now a day's, STATCOM is incorporated with harmonics filter to attain effective control. Other hand, power has been enhanced by SVS. The primary role of SVS is automatically matches the impedance with the required system. For an example, power system load is capacitive that of other, by using reactor SVS consumes the VAR from the power systems. Nevertheless, capacitor bank of SVS get enable when power system is more inductive. Due to absence of excitation, PMSG is popularly used in the wind power plants, so machine cost is low as well maintenance cost is low. Perhaps, it has low speed characteristics. Therefore, DVR system has been incorporated to the wind energy system for maintaining the system consistency and reliability, respectively. The DVR has switching devices such as thyristor, MOSFET or IGBT and voltage source inverter with a low pass filter. The Pulse Width Modulation Technique has been used for triggering VSI. The role of low pass filter is suppressing the harmonics content which is developed during voltage conversion from DC to AC, respectively. Modern power system has separate control unit for match the voltage phase angle and frequency [12]-[14].

4 PERTURB AND OBSERVE MPPT

The wind power plant are cant able to generate constant power since the out electrical energy obtained from wind power plant is strongly depends on the available wind speed. The wind speed on depends on the atmosphere conduction. Therefore wind speed is continuously varying therefore extracts maximum power from crucial task. Due to fluctuation output, these power generation units are interconnected with the utility grid is difficult issue. To rectifying such a problem, the wind power plants incorporated with MPPT. Traditionally, MPPT techniques are enhancing energy yield potential of solar PV system. The same MPPT technique has been incorporated with the wind power system for enhancing energy yield potential [15].

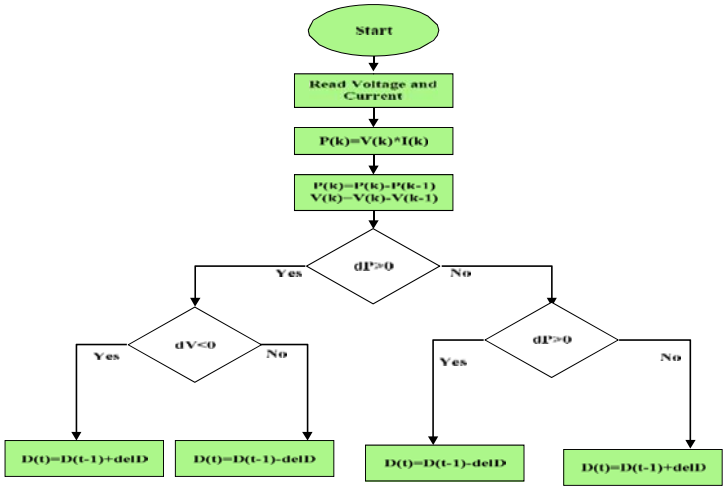

Figure 4.1 Flow Chart for P & O MPPT

Figure 4.1 shows the flow chart for P&O MPPT. At first the voltage and current has been measured by suing suitable sensor. It is used to estimate the power. Next, instantaneous voltage and current has been measured. This is used to estimate instantaneous power. Then, change in power is grater then zero or not has been checked. If yes change in voltage is zero or not has been checked. At this moment, condition is true then duty cycle is increased while duty cycle is get reduced. Nevertheless, change in power is greater than zero then duty cycle of the switching device is reduced. Otherwise, duty cycle is increased.

5 SIMUATION RESULTS AND ANALYSIS

The proposed wind model has been developed in the MATLAB Simulink for analyse the significance of proposed P & O MPPT.

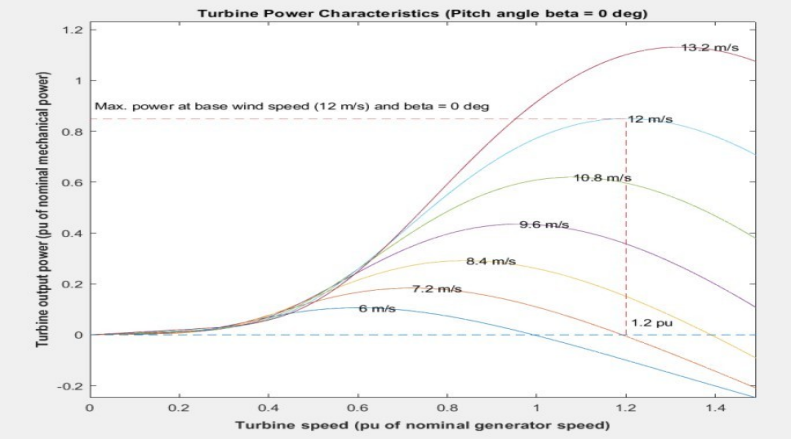

Figure 5.1. Turbine speed Vs Turbine output power

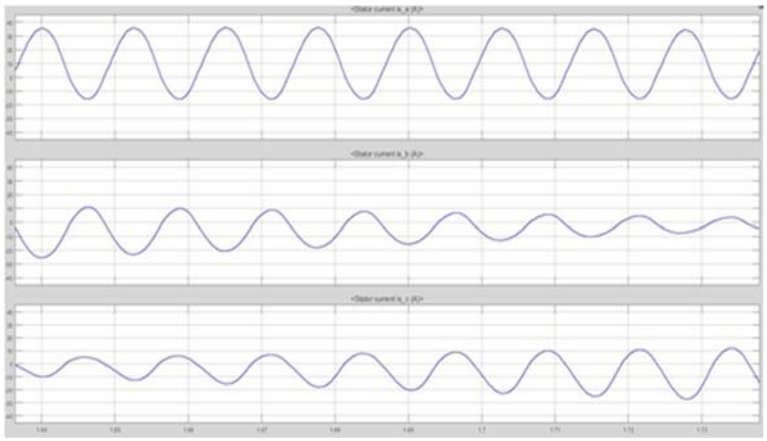

Figure 5.2. Three phase stator current Vs time

As shown the figure its shows the relationship of three phase current of PMSG. From the figure observe thateach phase current has 90-degree phase shit each other.

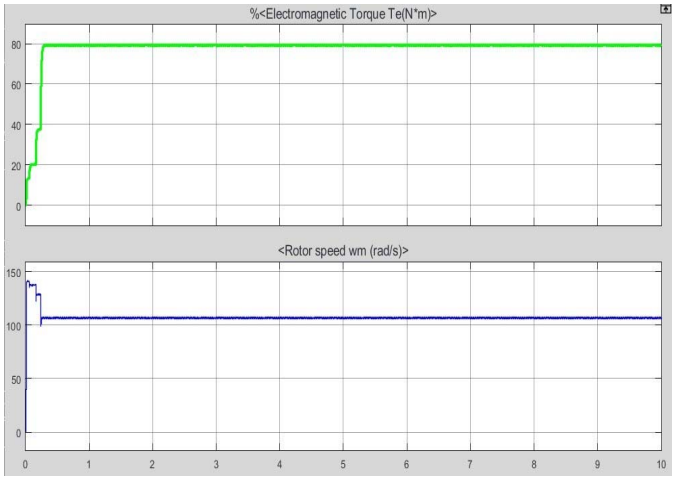

Figure 5.3. Mechanical Characteristics Vs Time

As shown the figure 5.3 It showed the relation between mechanical characteristics of PMSG, such as rotor speed and electromagnetic torque. Initially, electromagnetic torque and rotor speed fluctuation however it will reach a stable value within fraction of seconds. Which infers that motor attain smooth speed very soon.

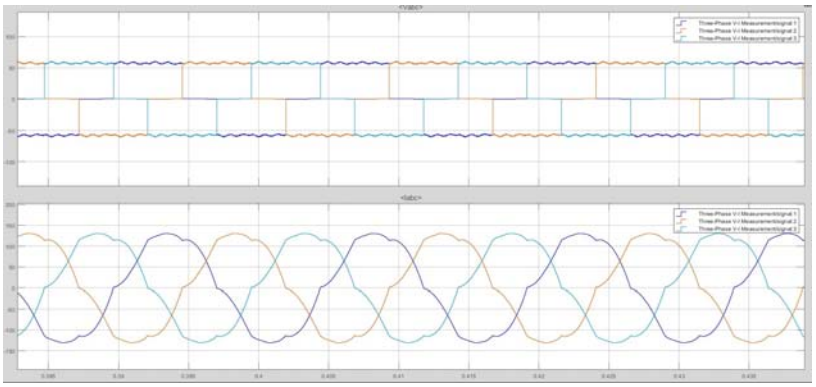

Figure 5.4. Three phase and Three Phase Relationship

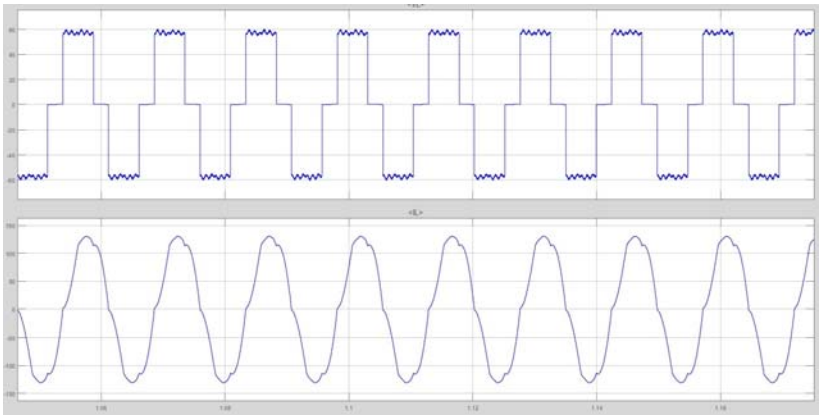

Figure 5.5. Line Voltage and Line Current Relation

Figure 5.4 shows the output of three phase voltage and three phase current respectively. It is the output ofPMSG. The output of PMSG is almost perfect three phase voltage and current, respectively. From figure 5.5 observed that line voltage and current are in phase and so peak of line voltage a small fluctuation is presents. This generated voltage is fed to the input of universal bridge rectifier. The bridge rectifier made by non-gate device such as diode.

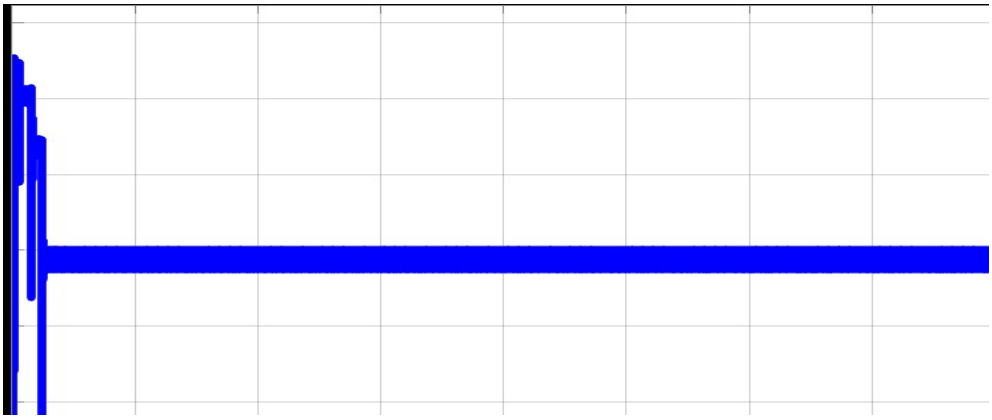

Figure 5.6. Universal bridge Rectifier output

Figure 5.6 Shows the universal bridge rectifier output, from the figure observed that the output of universal bridge rectifier is initially vary but very short time it will reach to 60V for entire duration. The output of universal bridge rectifier is lower than that of input supply which is due to loss.

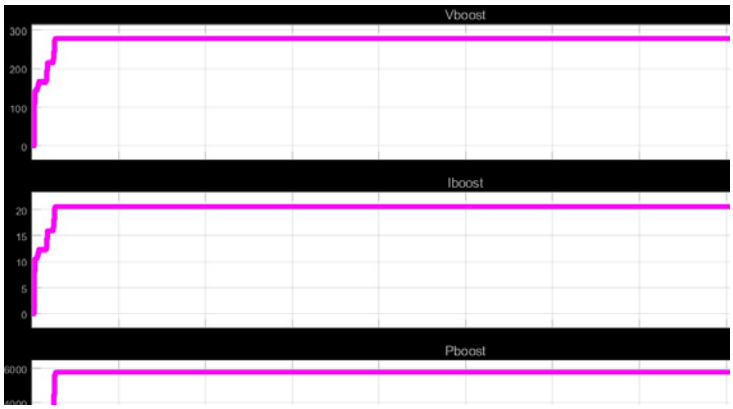

Figure 5.7 Relation between boost converter output

Above figure 5.7 shows the relation between output quantities such as boost voltage (Vboost), boost current (I boost) and boost power (Pboost). It is observed that boost converter output is higher than the input voltage. In addition, observe that, due to perturb and observe the load voltage remains constant, it is maintain by the adjusting duty cycle by P&O. Basically wind power plants are installed far away from the city Centre. Therefore, generated alternating electrical energy has been converted into direct current and transmits to the city Centre. Furthermore, the role of boost converter is step up the voltage level with the help of low ratting L and C so cost wise cheaper than the transformer. Since, step-up transformer is used to step-up the voltage from lowlevel to higher level. The role of P&O MPPT is maintaining constant electrical energy by adjusting duty cycle ofswitching devices. The duty cycle adjustment depends on the generated electrical quantities and previous measured quantities.

6 CONCLUSION

From the literature found that, wind power plant not produced continuous and constant output**.** Therefore, it causes power quality issues on the power system. It rectified by the suitable compensating devices. On compared to all other compensating technique, hybrid compensating technique is costly but it suppress all types of harmonics issues as well as maintains the system voltage at desirable level. The wind power plant with MPPT is modelled and analysed by using MATLAB simulink. From the simulation found that, with P&O MPPT, the developed model has produced constant power for entire duration. Furthermore, with the help of boost converter, step-up the voltage which is suppress the transmission loss since wind farms are installed far away from the city centre. In future, the proposed MPPT technique compared with other MPPT technique to finding effective MPPT for Wind power plants.

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