Modeling of Hybrid Wind/Photovoltaic Generation System

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Abstract— Renewable energy sources have become a popular alternative electrical energy source where power generation in conventional ways is not practical. In the last few years the photovoltaic and wind power generation have been increased significantly. In this study, we proposed a hybrid energy system which combines both solar panel and wind turbine generator as an alternative for conventional source of electrical energy like thermal and hydro power generation. A simple control technique which is also cost effective has been proposed to track the operating point at which maximum power can be coerced from the PV system and wind turbine generator system under continuously changing environmental conditions. The entire hybrid system described given along with comprehensive simulation results that discover the feasibility of the system. A software simulation model is developed in MATLAB/Simulink.

Key words: MPPT Technique, Solar Energy System, Wind Turbine System

I. INTRODUCTION

Due to the critical condition of industrial fuels which include oil, gas and others, the development of renewable energy sources is continuously improving. This is the reason why renewable energy sources have become more important these days. Few other reasons include advantages like abundant availability in nature, eco-friendly and recyclable. Many renewable energy sources like solar, wind, hydel and tidal are there. Among these renewable sources solar and wind energy are the world's fastest growing energy resources. [1]With no emission of pollutants, energy conversion is done through wind and PV cells. Day by day, the Electricity is rapidly increasing. But the available base load plants are not able to supply electricity as per demand. So these energy Sources can be used to bridge the gap between supply and demand during peak loads. [8]This kind of small scale stand-alone power generating systems can also be used in remote areas where conventional power generation is impractical. In this Paper, a wind-photovoltaic hybrid power generation system model is studied and simulated. A hybrid system is more advantageous as individual power generation system is not completely reliable. When any one of the system is shutdown the other can supply power the entire hybrid system comprises of PV and the wind systems. The PV system is powered by the solar energy which is abundantly available in nature. PV modules, maximum power point tracing systems make the demand for PV energy system.[6][2] The light incident on the PV cells is converted into electrical energy by solar energy harvesting means. The maximum power point tracking system with Perturb & absorb algorithm is used, which extracts the maximum possible power from the PV modules. The ac-dc converter is used to converter ac voltage to dc. Wind turbine, gear box, generator and an AC – DC converter are included in the wind energy system. The wind turbine is used to convert wind energy to rotational mechanical energy and this mechanical energy available at the turbine shaft is converted to electrical energy using a generator. To coerce the maximum power from wind system we used a maximum power point tracing system. Both the energy systems are used to charge a battery using bi-directional converter. Bidirectional converter and the battery form the common additional load to the wind and PV energy system[5][7]

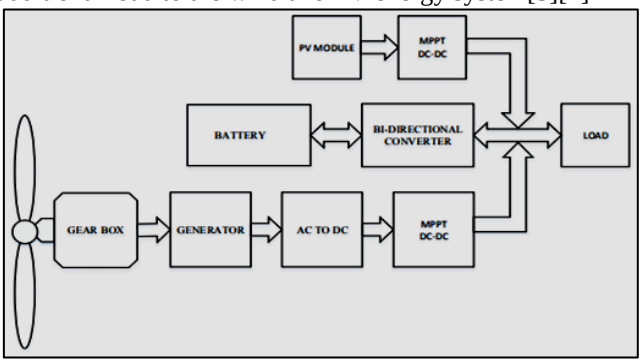

Fig. 1: Block Diagram of Hybrid System

II. PROPOSED APPROACH

The main objective of this paper is to execute a power system that is a hybrid of both Photovoltaic and wind powers. The step by step objectives are to study and model PV cell, PV array and PV panels to study the characteristic curves and consequence of variation of environmental conditions similar to temperature and irradiation on them to study the PV module's presentation under partial shading condition. To trace the maximum power point of operation the PV panel irrespective of the changes in the environmental conditions. To study and simulate the wind power system and track its maximum power point¬ Implement hybrid system

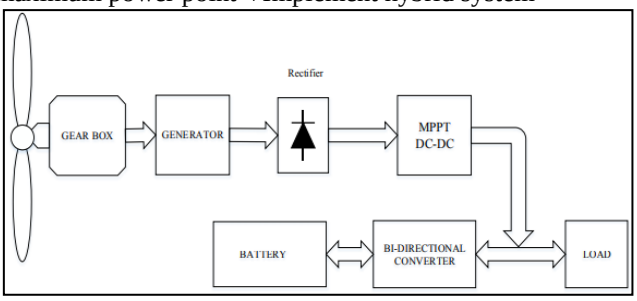

Fig. 2 Overall Block Diagram of Wind Energy System

This system comprises of a wind turbine which transforms wind's kinetic energy into rotating motion, a gear box to match the turbine speed to generator speed, a generator which converts mechanical energy into electrical energy, a rectifier which converts ac voltage to dc, a controllable dc-dc converter to trace the maximum power point, a battery is charged and discharged through bi-directional converter. A wind turbine converts kinetic energy of air i.e. wind power into mechanical power i.e. rotating motion of the turbine that can be used directly to run the machine or generator. Power captured by wind turbine blade is a concomitant of the blade shape, the pitch angle, speed of rotation, radius of the rotor [21]. The equation for the power generated is shown below.

$$Pm = 1/2\pi pCp(\lambda,\beta)R^2V^3$$

Where PM– Power captured by wind turbine –Air densityρ –Pitch angle (in degrees)β R– Blade radius (in meters) V– Wind speed (in m/s) The term λ is the tip-speed ratio, given by the equation

λ=Q/RV

Where - Rotor speed of rotation (in rad/sec)Ω CP can be expressed as the function of the tip-speed ratio (λ)

III. SYSTEM IMPLEMENTATION

The proposed system nearby power-control strategies of a grid-connected hybrid generation system with resourceful power transfer. This hybrid system allows maximum consumption of freely available renewable energy sources like wind and photovoltaic energies. For this, an adaptive MPPT algorithm along with standard perturbs and observes method will be used for the system. Also, this configuration allows the two sources to supply the load separately or simultaneously depending on the availability of the energy sources. The turbine rotor speed is the main determinant of mechanical output from wind energy and Solar cell operating voltage in the case of output power from solar energy. Permanent Magnet Synchronous Generator is coupled with wind turbine for attaining wind energy conversion system. The inverter converts the DC output from non-conventional energy into useful AC power for the connected load. This hybrid system operates under normal conditions which include normal room temperature in the case of solar energy and normal wind speed at plain area in the case of wind energy. The simulation results are presented to exemplify the operating principle, feasibility and dependability of this proposed system.

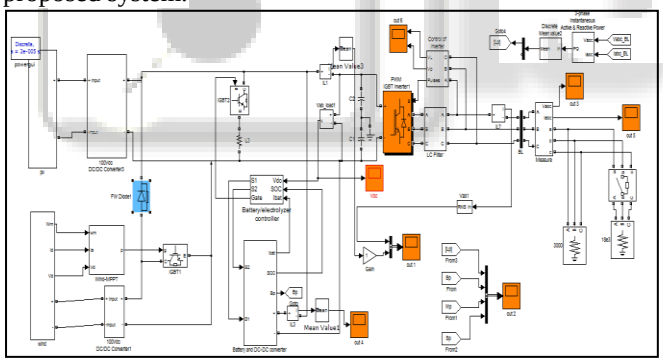

Fig. 3: System implementation

Bi-directional DC-DC converters are called so due to their ability of allowing the power flow in both the directions, depending on the requirement. There are many applications for the bidirectional converter such as

Hybrid Vehicles, Uninterruptable Power Supplies (UPS) and also storage systems powered by Fuel cells and also renewable energy systems

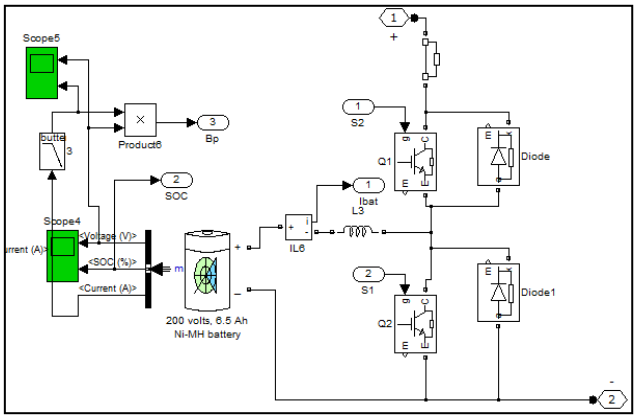

Fig. 4: Battery & DC-DC Converter

A synchronous machine generates power in large amounts and has its field on the rotor and the armature on the stator. The rotor may be of salient pole type or cylindrical type. In the permanent magnet synchronous generator, the magnetic field is obtained by using a permanent magnet, but not an electromagnet. The field flux remains constant in this case and the supply required to excite the field winding is not necessary and slip rings are not required. All the other things remain the same as normal synchronous generator.[3]

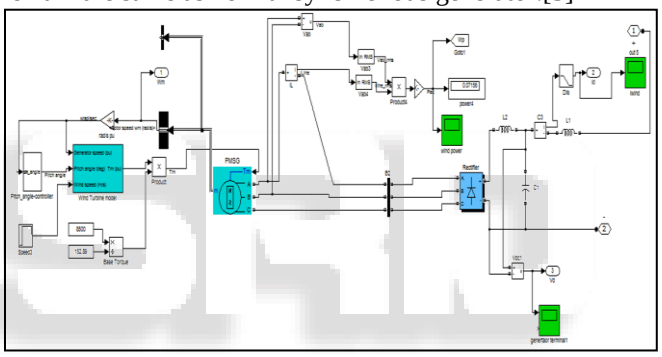

Fig. 5: PMSG Terminal

A. *Battery Charging*

Battery is a storage device which is stores the excess power generated and uses it to supply the load in addition to the generators when power is required. Both PV and wind energy are integrated i.e. connected to a common DC bus of constant voltage and the battery bank is also connected to the DC bus. Any power transfer whether from generator to battery bank or generator to load or from the battery bank to the load takes place via this constant voltage DC bus? As the power flow associated with the battery is not unidirectional, a bidirectional converter is needed to charge and/or discharge the battery in case of excess and/or deficit of power respectively

B. *Generator*

The shaft of the wind turbine is mechanically coupled to the rotor shaft of the generator, so that the mechanical power developed by the wind turbine (by Kinetic energy to mechanical energy conversion) is transmitted to the rotor shaft. This rotor structure has a rotor winding (either field or armature). In both the cases, we get a moving conductor in a stationary magnetic field or a stationary conductor in moving magnetic field. In either case, electric voltage is generated by the generator principle

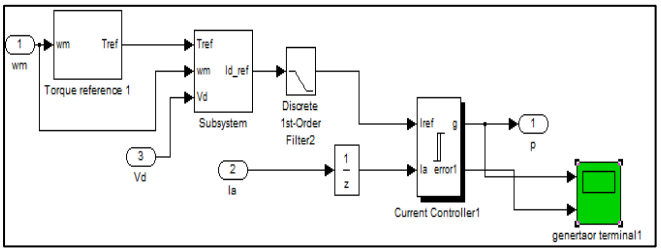

Fig. 6: Generator Terminal

C. Bi-Directional Converter for Battery Charging

As mentioned earlier, the bidirectional converter has many applications and here in the work, the converter is used for charging and discharging the battery based on the surplus and deficit of the power respectively. When there is a surplus of energy, i.e. the supply is greater than demand then the battery is charged, allowing the converter to operate in forward direction. When there is a deficit in power i.e. the supply is less than demand then the battery starts discharging supplying the deficit of power to the load. This requires the converter to operate in reverse direction. Charging/discharging of the battery is done by the help of a bidirectional converter [10].

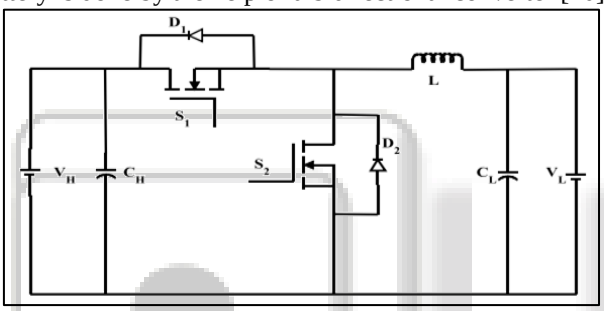

Fig. 7: Circuit Diagram of the Bidirectional Converter

IV. RESULTS & DISCUSSIONS

PMSG output is shown in the fig 6.12.The point of operation of crest power of wind generator output is traced by a maximum power point tracing system is shown in the fig 8 given below. Output Voltage of wind generator at which maximum power is achieved is shown in the fig 10.

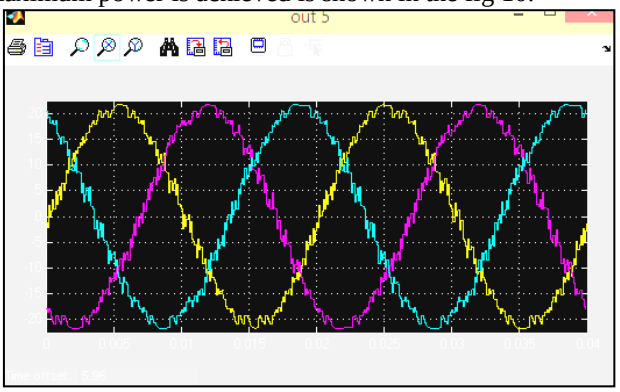

Fig. 8: Three Phase Line Output Voltage of PMSG

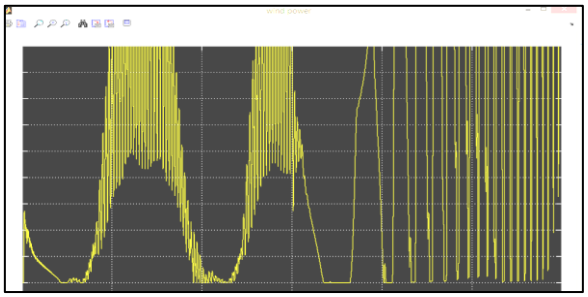

Fig. 9: Output of Wind Power

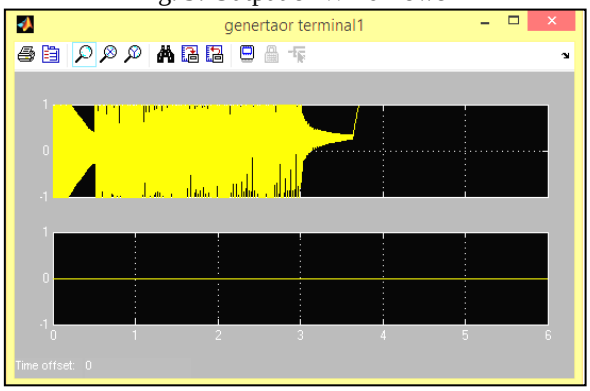

Fig. 10: Output Power of Wind System after MPPT

Output power and output voltage after maximum power point tracing are apparent in the figures 9 and 10 respectively. As we examine from the fig 10 maximum power is achieved at voltage 26.3 volts; from fig 9 we can see we are equal to track the output voltage where we can acquire the maximum power which is about 26.3 volts. From fig 10 we can see the maximum power which is about 200 watts can be tracked.

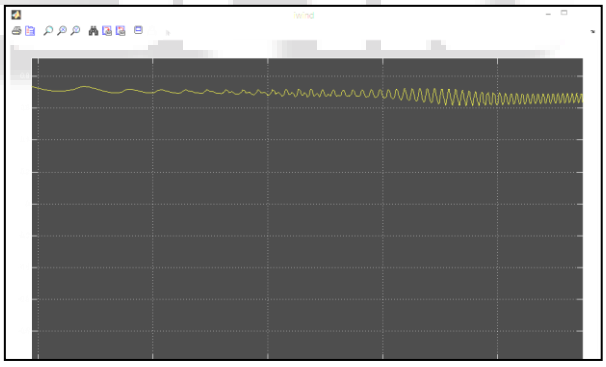

Fig 11 Charging Characteristics of Battery

V. CONCLUSION

Maximum power is achieved at voltage 26.3 volts. We can see we are equal to track the output voltage where we can acquire the maximum power which is about 26.3 volts. The maximum power which is about 200 watts can be tracked. Output from solar and a wind system is converted keen on AC power output by using inverter. In all operating conditions to meet the load the hybrid system is unnatural to give maximum output power. Battery is following to wind or solar organization to meet the load and Also, simultaneous operation for the identical load.

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