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Simulation Model of Hybrid Wind-Solar Energy System using MPPT Algorithm using a Converter Topology

Grusha Vinod Dongre[1*], Romi Jain[2]

[1]Department of Electrical Engineering, UIT-RGPV, Bhopal
[2]Department of Electrical Engineering, UIT-RGPV, Bhopal

Corresponding Author: shikhar.k.dubey@gmail.com

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Abstract— The proposed system presents power-control strategies of a grid-connected hybrid generation system with versatile power transfer. This hybrid system allows maximum utilization 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.

Keywords:- Fuel cell, Photovoltaic, Wind energy conversion, Wind Turbines, Z- source converter

I. INTRODUCTION

Recent developments and trends in the electric power consumption indicate an increasing use of renewable energy. Virtually all regions of the world have renewable resources of one type or another. By this point of view studies on renewable energies focuses more and more attention. Solar energy and wind energy are the two renewable energy sources most common in use. Wind energy has become the least expensive renewable energy technology in existence and has peaked the interest of scientists and educators over the world [1]. Photovoltaic cells convert the energy from sunlight into DC electricity. PVs offer added advantages over other renewable energy sources in that they give off no noise and require practically no maintenance [2]. Hybridizing solar and wind power sources provide a realistic form of power generation.

Many studies have been carried out on the use of renewable energy sources for power generation and many papers were presented earlier. The wind and solar energy systems are highly unreliable due to their unpredictable nature. In [3], a PV panel was incorporated with a diesel electric power system to analyze the reduction in the fuel consumed. It was seen that the incorporation of an additional renewable source can further reduce the fuel consumption. Several hybrid wind/PV power systems with Maximum Power Point Tracking (MPPT) control have been proposed earlier [4]. They used a separate DC/DC buck and buck-boost converter connected in fusion in the rectifier stage to perform the MPPT control for each of the renewable energy power sources. These systems have a problem that, due to the environmental factors influencing the wind turbine generator, high frequency current harmonics are injected into it. Buck and buck-boost converters do not have the capability to eliminate these harmonics. So the system requires passive input filters to remove it, making the system more bulky and expensive [5]. In this paper, a new converter topology for hybridizing the wind and solar energy sources has been proposed. In this topology, both wind and solar energy sources are incorporated together using a combination of Cuk and SEPIC converters, so that if one of them is unavailable, then the other source can compensate for it. The Cuk-SEPIC fused converters have the capability to eliminate the HF current harmonics in the wind generator. This eliminates the need of passive input filters in the system. These converters can support step up and step down operations for each renewable energy sources. They can also support individual and simultaneous operations. Solar energy source is the input to the Cuk converter and wind energy source is the input to the SEPIC converter. The average output voltage produced by the system will be the sum of the inputs of these two systems. All these advantages of the proposed hybrid system make it highly efficient and reliable.

II. MPPT ALGORITHM

Because of the lesser efficiency of photovoltaic array most of the energy, impacting over array gets wasted. The algorithm known as maximum power point tracking may be helpful to enhance the performance of solar panel. The MPPT algorithm works on principal of Thevenin, according which the power output of a circuit is maximum when impedance of circuit matches with the load of impedance. So now we have to match the impedance instead of tracking maximum power point.
There are different techniques used to track the maximum power point. Few of the most popular techniques are:

- Perturb and observe (hill climbing method)
- Incremental Conductance method
- Fractional short circuit current
- Fractional open circuit voltage

Perturb and observe

The P&O algorithm and “hill-climbing”, both names refer to the same algorithm depending on how it is implemented. The basic difference between these two is that Hill-climbing involves a deviation of the duty cycle of the power converter and in P&O anxiety on the operating voltage of the DC link between the PV array and the power converter takes place [3]. The deviation of duty cycle of the power converter is the modification of the voltage of DC link between the PV array and the power converter refer as Hill-climbing, so both names refer to the same technique. What should be the next perturbation is decided by considering the sign of the last perturbation and the sign of the last increment in the power.
The perturbation will remain in the same direction if power is incremented, and if power is decreased then next perturbation will be in the opposite direction. The process will be repeated until the point of maximum power will be reached. Then the operating point oscillates around the MPP.

Incremental conductance

The slope of the curve between power and voltage of PV module is the deciding factor in incremental conductance algorithm, if it is zero it shows point of MPP positive (negative) on the left of it and negative (positive) on the right.

- $\Delta V/\Delta P = 0$ at the MPP
- $\Delta V/\Delta P > 0$ on the left
- $\Delta V/\Delta P < 0$ on the right

The change of MPP voltage is identified by comparing the change of the power to increment of the voltage of current curve.

Fractional short circuit current

Fractional short circuit current method states that the ratio between array voltages at maximum power V_{MPP} to its open circuit voltage V_{OC} is nearly constant.

$$V_{MPP} \approx k_1 V_{OC}$$

The constant K_1 is having value between 0.71 to 0.78. Now the value of V_{MPP} can be calculate by periodically measuring V_{OC}. This method is simple and cheap to implement but its efficiency is relatively low due to the utilization of inaccurate values of the constant k1 in the computation of V_{MMP}.

III. METHODOLOGY

Photovoltaic cell

To convert the light energy supplied by sun the semiconductor solution is the photovoltaic cell it converts light energy to electrical energy by photovoltaic effect. The energy photons are available with light, if there energy is greater than the energy gap of atomic electronics, than the outer most electrons of atoms are get emitted because of the impact of these photon. These electrons get flow freely and cause current.
The construction of photovoltaic cell is similar as the construction of p-n junction diode. A photovoltaic cell is composed of two different layers of silicon one is P-type layer where negative ions are there with one less valence electron and other is N-type layer with positive ions with one extra valence electron. At the junction of these two layers extra electrons of N-layers get diffused with less electron space of P – layer and leave region with positive and negative ions only. This space is known as diffusion layer, the diffusion layer act as a protective layer and stops the transfer of electron across the junction when equilibrium is reached. When solar energy is imposed the energy of electrons available will increase and again transfer of electron get start. This will cause flow of current and convert solar energy into electric energy.

MATLAB Modelling -

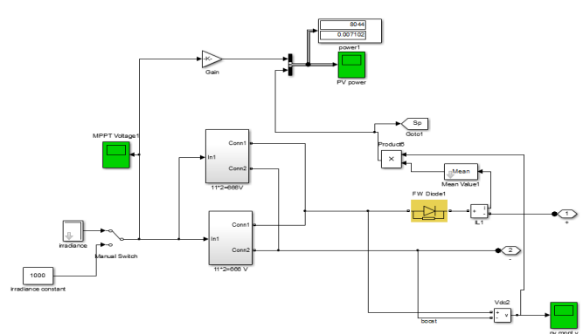


Figure 1: MATLAB Model for PV System

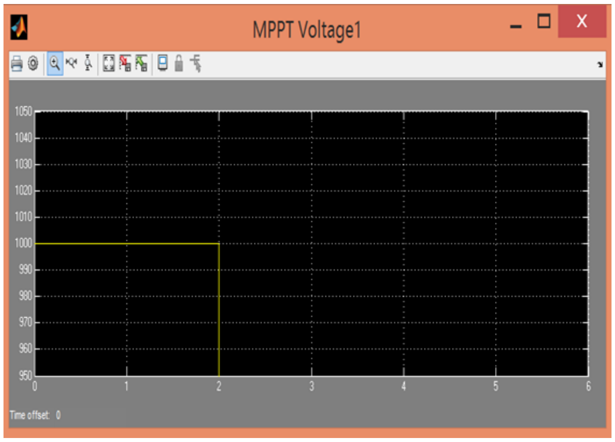


Figure 2: Output Voltage of Maximum Power Point Tracking

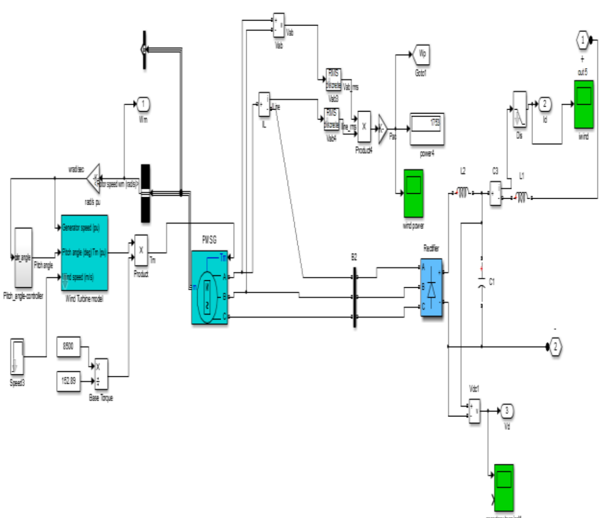


Figure 3: MATLAB Model for Wind System

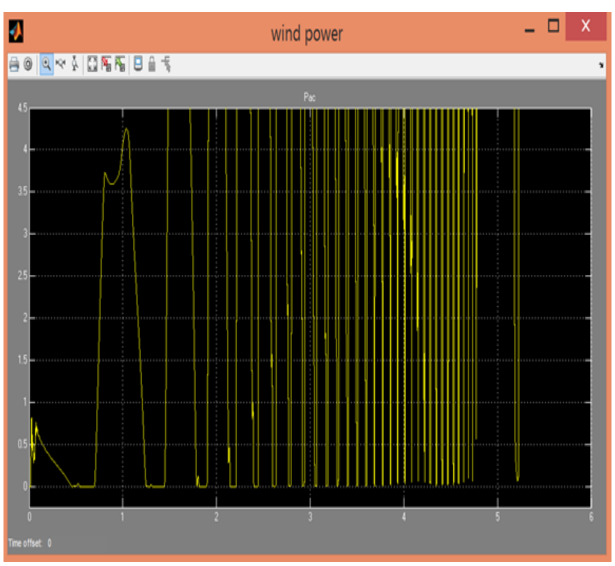


Figure 4: Output Voltage of Wind Power

IV. SIMULATION MODEL

The proposed system presents power-control strategies of a grid-connected hybrid generation system with versatile power transfer. This hybrid system allows maximum utilization 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.

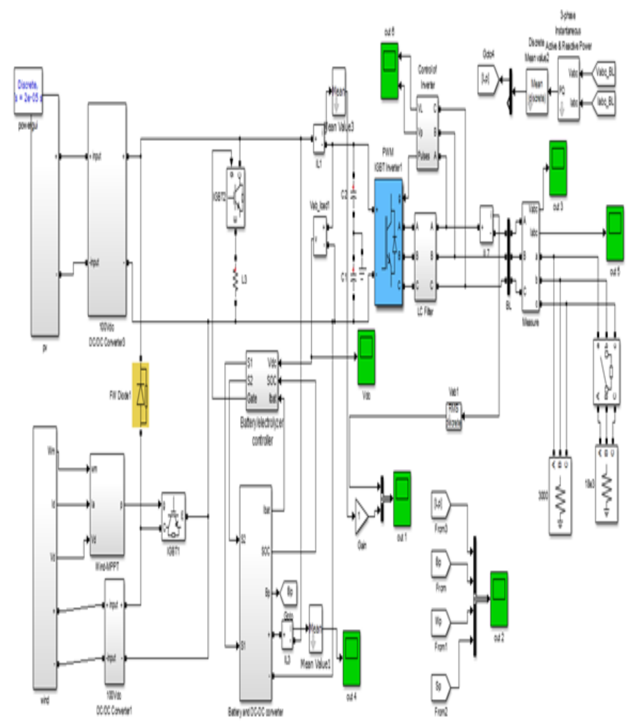
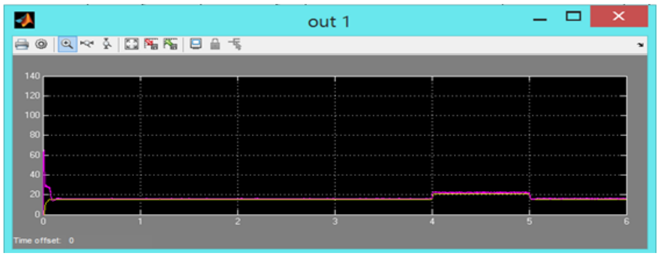
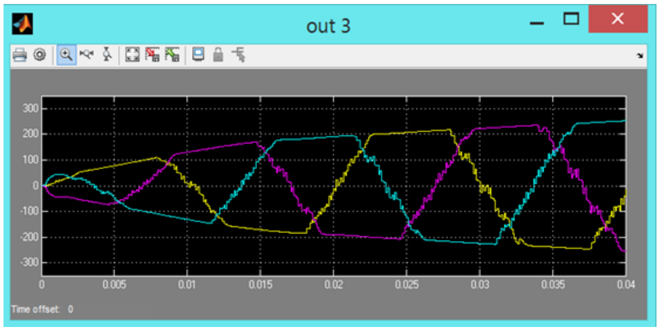
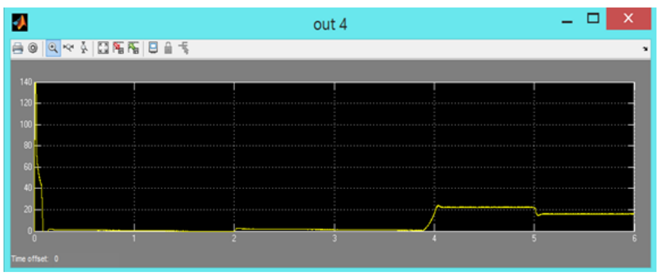


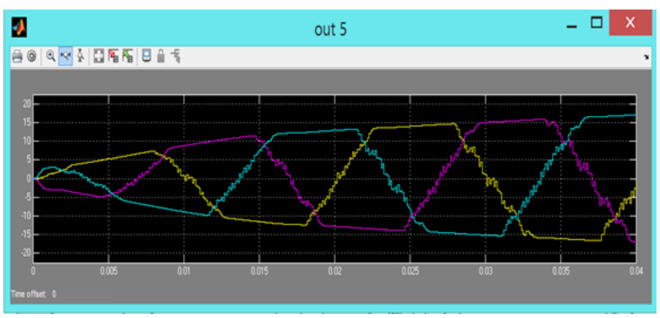
Figure 5: MATLAB Simulink Model of Hybrid Wind-Solar Energy System using MPPT Algorithm

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 illustrate the operating principle, feasibility and reliability of this proposed system.









V. CONCLUSION

Renewable energy sources also called non-conventional type of energy are continuously replenished by natural processes. Hybrid systems are the right solution for a clean energy production. Hybridizing solar and wind power sources provide a realistic form of power generation. Here, a hybrid wind and solar energy system with a converter topology is proposed which makes use of Cuk and SEPIC converters in the design. This converter design overcomes the drawbacks of the earlier proposed converters. This topology allows the two sources to supply the load separately or simultaneously depending on the availability of the energy sources. MPPT control is done for PV and wind energy so that maximum power is tracked and system work more reliably and efficiently. This system has lower operating cost and finds applications in remote area power generation, constant speed and variable speed energy conversion systems and rural electrification. MATLAB/ SIMULINK software is used to model the PV panel, wind turbine, DC-DC converters, MPPT controller and proposed hybrid system.

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