RESEARCH ARTICLE

SAMRIDDHI Volume 14, Issue 2, 2022 Print ISSN: 2229-7111 Online ISSN: 2454-5767

An Innovative Design of Hybrid System Using Wind Turbine and Photovoltaic Panel System

Somesh Srivastava*, Manish Kumar Srivastava

Department of Electrical Engineering, Vaugh Institute of Agriculture, Engineering and Technology. Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Abstract

The electricity demand increases day by day, but fossil fuel has limited reserves. The renewable energy has lots of potential to provide the electricity. Renewable energy has lots of benefits and the main feature is being pollution-free. In last three decades, new research have been done in solar energy and wind energy which improves the efficiency of both systems. Renewable energy has many benefits like it can be reused again and cause very minor or no harm to environment. When solar system and wind turbine are attached together then that system is called hybrid renewable energy system. This research discusses the various aspects of the hybrid renewable energy system (HRES). This paper discusses at resultant on PV panel and Wind turbine. After that there is a simulation on *MATLAB / SIMULINK* and different output waves are analyzed for different conditions.

Keyword: Hybrid renewable energy system (HRES), Renewable energy(RE), Solar systems (SS), Wind turbines(WR).

SAMRIDDHI : A Journal of Physical Sciences, Engineering and Technology (2022); DOI: 10.18090/samriddhi.v14i02.00

Introduction

In last three-decade renewable energy use is increased and seen as a replacement of the conventional energy, as conventional energy cannot be reused. The energy from fossil fuels has limited sources such as coal, oil, natural gases any many more. But Renewable energy resources (RES) can be permanent replacement of conventional energy. RES has a large investment to develop the Renewable energy resources system, but it runs for a long period to become an economically affordable.

Renewable energy resources (solar and wind) utilization improves the country's capacity. It provides clean and economical energy. A hybrid wind and photovoltaic (PV) system for power supply to homes is proposed, consisting of four subsystems: solar panels and wind turbine- generators, a converter for connection of generators to a common DC bus, an inverter DC-AC and a control subsystem that uses PI controllers.

A stand-alone hybrid system was developed by Hashimoto *et al.*[3] He proposed a model consisting of wind turbine generators and photovoltaic modules for a radio station using a backup storage battery.

Hamza Mohammed *et al.*,[2] The proposed renewable energy resource has unlimited resources, and solar PV system is one of them. Electric energy is generated by solar radiation. The PV system is widely associated with recent three decays and grid systems. The PV system can connect to DC-DC boost converter.

Corresponding Author: Somesh Srivastava, Department of Electrical Engineering, Vaugh Institute of Agriculture, Engineering and Technology. Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India, e-mail: somesh.sri95@gmail.com

How to cite this article: Srivastava, S., Srivastava, M.K. (2022). An Innovative Design of Hybrid System Using Wind Turbine and PV Panel System. *SAMRIDDHI : A Journal of Physical Sciences, Engineering and Technology,* 14(2), 1-4.

Source of support: Nil

Conflict of interest: None

PV Panel Model

PV Array

Photovoltaic (PV) Array are a combination of solar cell and solar panel. Solar cell has generated very less amount of power so that improving the power, solar cell connected in series. and in solar array, it is connected series and parallel. PV cell modeling has been combined with a single type of diode i.e. controlling the flow of current. Simple and basic equations come down with series and parallel connections. The basic equation in this circuit can be defined as the generated value of current and many other parameters can be found with this equation. This non-ideal solar cell circuit is shown as shown in Figure 1 i.e. converts solar energy into

electrical energy and this effect is called photovoltaic effect. The basic characteristic circuit has been design below and this this is basic model of the solar cell.
Figure 1 below in the current equation:

$$I = I_{pv} - I_D - I_{sh} \tag{1}$$

Where, the current's solar cell is shown as I, the current PV cell is shown as I_{pv}, the current diode is shown as I_D, Ish is the shunt current flow and the shunt resistor is referred to asR_{sh}.

For solar cell [1]:

$$I_D = I_0\left[\exp^{\left(\frac{V+IR_s}{aV_{th}}\right)} - 1\right] \tag{2}$$

$$I_{sh} = \frac{V + IR_s}{R_{sh}} \tag{3}$$

Equation (1) can now be written as,

$$I = I_{pv} - I_0\left[\exp^{\left(\frac{V+IR_s}{aV_{th}}\right)} - 1\right] - \frac{V + IR_s}{R_{sh}} \tag{4}$$

Where, the reverse saturation current is I_0, the PV cell resistors are connected in series and parallel as represented Rs and R_{sh} respectively, the diode ideality factor is one, the thermal voltage is Vth. It is given here.

$$V_{th} = \frac{KT}{q} \tag{5}$$

Where, K = Boltzmann constant (1.23 x 10 ^ (- 23) J / K), T = cell temperature, q = charge of electron (1.6 x 10 ^ (- 19) C) Find the total number of solar-connected series. N which is by solar panel is given by the current equation:

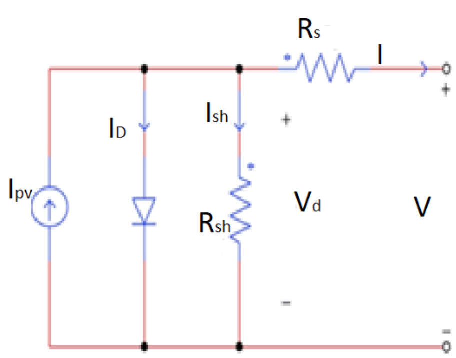

Figure 1: Single diode model of PV cell

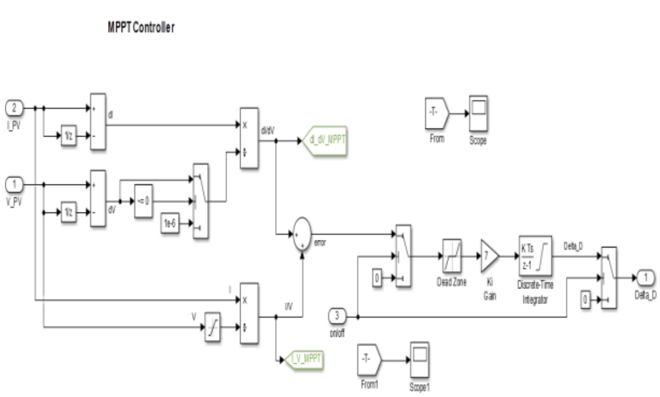

Figure 2: MPPT using incremental conduction

$$I = N_p I_{pv} - N_p I_0\left[\exp\left(\frac{\frac{V+IR_s}{N_s}}{aNV_{th}}\right) - 1\right] - \frac{V + IR_s}{R_{sh}} \tag{6}$$

Maximum Power Point Tracking (MPPT)

Solar PV arrays have a non-linear behavior and due to changes in weather conditions, its output often varies. Maximum power point tracking (MPPT) helps the photovoltaic panel provide maximum power at its output and thus improves the efficiency of the system. It is an insulated-gate bipolar transistor (IGBT) gate pulse device and operates with a set of appropriate duty cycle values, used in the gate boost converter of the switch. The MPPT (incremental conduction) technique has been used in internal control systems. At the maximum power point:

$$\frac{dP}{dV} = 0 \tag{7}$$

Now,

$$\frac{d(V\,x\,I)}{dV} = \frac{dV}{dV}x\,I + \frac{dI}{dV}\,x\,V = I + \frac{dI}{dV} = 0 \tag{8}$$

hence,

$$\frac{dI}{dV} + \frac{I}{V} = 0 \tag{9}$$

The MPPT test should be zero for dI/dV and I/V, which means that no changes have been applied to this system. If the sum is not zero, the system operates and the controller's value improves or decreases. The MPPT controller operates on the output result when the duty cycle is increased or decreased. DC-DC boosters provide how much duty cycle to the converter controller. This MPPT technique has designed in block diagram simulate in software as shown in Figure 2.

Boost Converter

It converts dc to dc and can stabilize the output of dc. Boost converter has most popular technique and it shown in Figure 2. The converter output is given by:

$$V_0 = \frac{V_{in}}{1 - D} \tag{10}$$

This equation shows the inductor and capacitor:

$$L > \frac{V_{in}xD}{fx\Delta t} \tag{11}$$

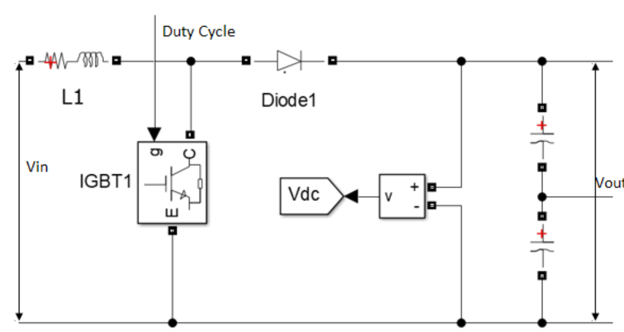

Figure 3: DC to DC boost converter modeling

$$C_1 = C_2 = \frac{V_{out} D}{2f\Delta V_{out} R_{load}} \quad (12)$$

In these equations, the output voltage is shown as V_0, V_{in} is defined as input voltage, Dis defined as Duty cycle, the frequency can be denoted as f, the current waveform can be denoted as ΔI, C_1 and C_2, both capacitances can be denoted like this. output voltage ripple can be denoted as like thisand load resistance can be denoted as R_{Load}, shown as V_{out}/I_{out}.

Turbine Description

This section presents a mathematical model of a wind turbine and its comparison with a predefined block model of MATLAB/SIMULINK. Wind turbines complete a system in three part: rotor blades, shaft and generator. Blades convert the kinetic energy into the mechanical energy and shaft transmit the mechanical energy. And generator convert the mechanical energy into electrical energy. Wind turbines are also called wind power converters or wind power units.

The power generated by the wind turbine is directly proportional to the air density [kg/m3], the full rotation of the rotor blades and the area covered by the wind speed V_W[m/s], the square of Figure 4.Turbines can be used alone to supply electricity or in hybrid systems together with any other renewable source of electricity, such as a solar panel. A known model of wind turbine is presented by Bimayak Bhandari.[3] He also introduced a hybrid system consisting of photovoltaic panels and wind power.

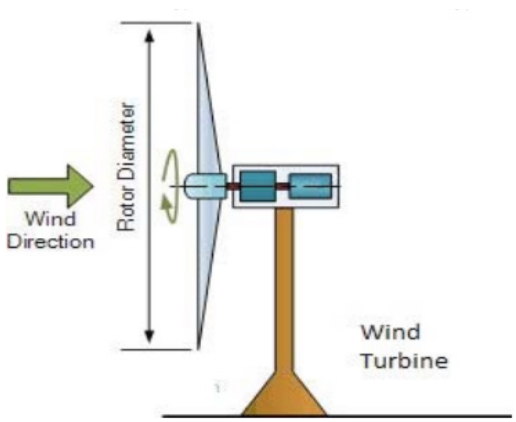

Figure 4: Wind turbine schematic details.

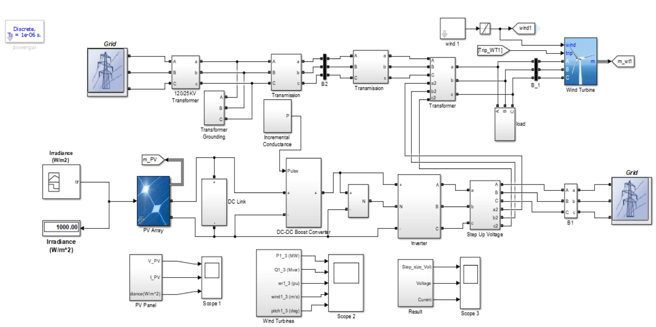

Figure 5: Simulation of hybrid system using wind turbine and PV panel system

Turbine model

From the model presented by Bimayak Bhandari[3] and given the necessary conditions to derive a model for a wind turbine, the following equations were derived: ...

$$\begin{cases} P_w = \frac{\rho}{2} . C_p(\lambda, \beta) . A . v_w^3 \\ A = \pi . r^2 \end{cases}$$

Where Pw = power [W]; = Air density [kg / m3]; CPP = power coefficient; = Tip-speed ratio; = Blade pitch angle; A = area of blade surface [m^2]; R = length of blade; V_W = wind speed [m/s].

Model Simulation Results

The mathematical model was implemented in Matlab 2016a / Simulink. Wind speeds throughout the day (24 hours) were considered variable. The pitch angle was assumed to be constant (45°), be constant. Depicts the modeling diagram for the wind turbine and in Table I the parameters of the model based on the data are given importance.

Result and Discussion

PV panel system controlled incremental conductance with grid is design on MATLAB/SIMULATION. this system provides a result and provide the waveform as required. As shown in Figure A, 120kV grid integrated with Hybrid Photovoltaic and Wind turbine system are simulate and connected system to the PV Panel and Wind turbine is 25kV using feeder line. PV Panel parameters connect with irradiance and temperature at maximum 1000W/m2 and 25°C, respectively. This PV system generate. power of whole system and its initial voltage of the PV system.

the I-V curve and P-V curve give the same and exact value provide as we required as we show that I-V curve provide the remarkable point whose easy to identify the measure the value. The normally it calculates mathematically but this simulation provide the easy interference to the system. The

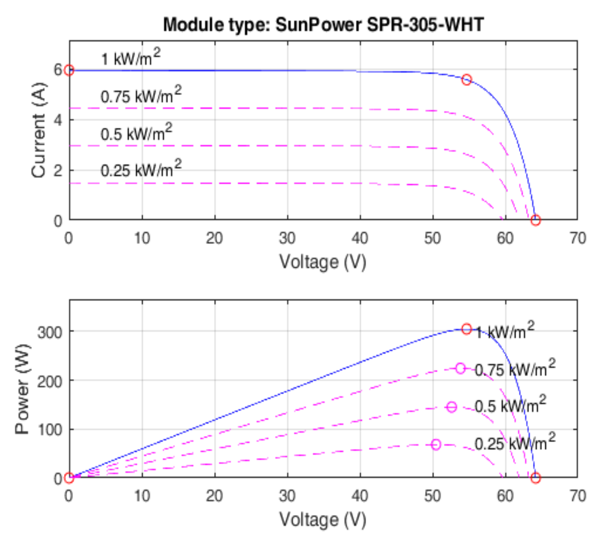

Figure 6: a: Solar Panel Module of I-V and P-V Curve

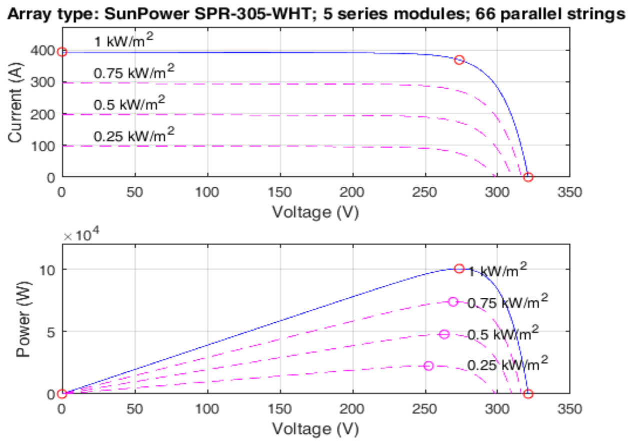

Figure 6: a: I-V Curve and P-V Curve of A PV Array

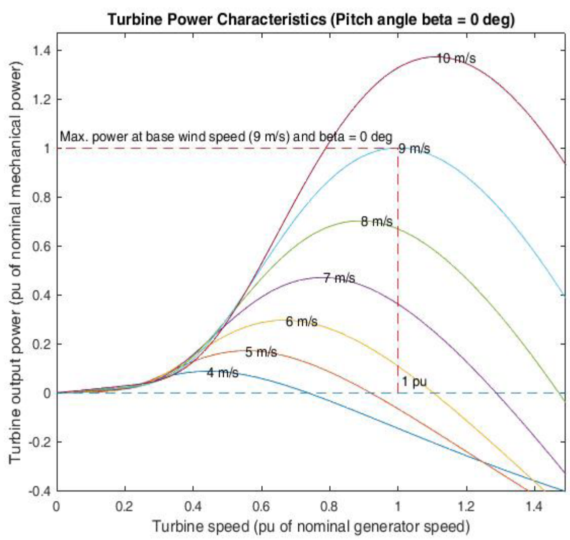

Figure 7: Turbine Power Characteristics

I-V curve has three important remarkable as shown in figure above and we have achieved the point successfully. Fig 6.a shows a single PV Panel module and Fig 6.b Shows the Array of a PV Module.

The base speed of the wind turbine of the system is 9 m/sec. and the output of the wind turbine of the system is 1.5 MWatts. As shown in graph, the simulated result of power characteristic of turbine with respect to speed and output power.

Conclusion

Here, solar PV System and wind turbine both are utilize in the single model so that it is called Hybrid renewable energy system (HRES). The purpose of this paper is to present a comprehensive review of various aspects of HRES. Increment conductance (MPPT) technique utilized the improve the maximum power using incremental conductance. A grid (120KV) integrated with Hybrid Photovoltaic and Wind turbine system are simulate and connected system to the PV Panel and Wind turbine is 25kV using feeder line. PV Panel

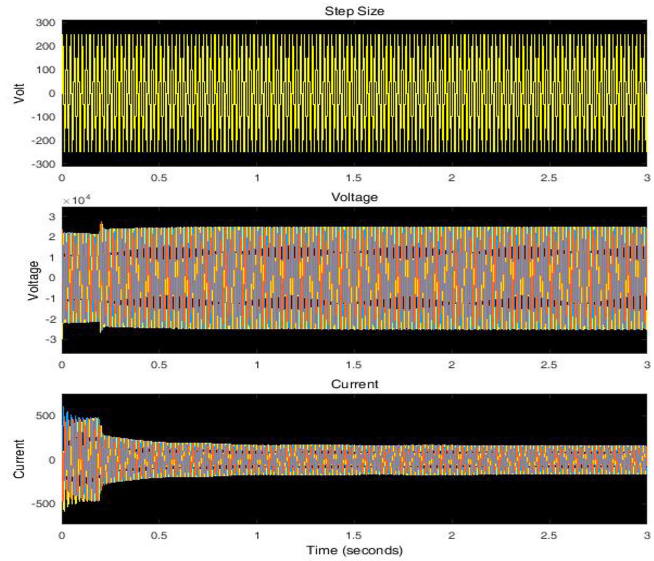

Figure 8: Simulation Output of Hybrid System using Wind Turbine and PV Panel System

has generated maximum efficiency 305W at irradiance and temperature, maximum 1000W/m2 and 25^{0}C respectively. Where wind turbine has generated 575V.This system can reduce the noises near 5%-6% overall.

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