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# Wind-PV Hybrid System with MPPT Control

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***Abstract**: Research and development of alternate and eco friendly energy sources have been showing excellent potential as a form of contribution to conventional power systems. The integration of renewable energy sources such as photovoltaic (PV) system and wind energy conversion (WECS) system is an excellent option for distributed energy production. This paper is focused to the development of such a hybrid energy system which is being connected to grid and is being provided with a Maximum power point tracking (MPPT) technique to track maximum power from individual system. The proposed system is connected to grid through an inverter, which can achieve dc bus voltage regulation or stabilization if one or more of the energy sources are degraded.*

***Keywords**: Photovoltaic (PV), Wind Energy Conversion system (WECS), Maximum Power Point Tracking (MPPT)*

## 1. INTRODUCTION

The entire world is facing a challenge to overcome the deficiency of energy. The ever increasing demand for conventional energy sources and need for a safe globe and better life of all living beings, is driving the society towards the research and development of alternate eco friendly energy sources. The renewable energy sources such as photovoltaic (PV) system and wind energy conversion (WEC) system have become two promising alternate sources of energy. A power generating system which combines two or more different sources of energy is called hybrid system. The hybrid power systems exhibit higher reliability and lower cost of generation than those that use only one source of energy. This paper aims at a hybrid wind and photovoltaic power generating system. The wind and photovoltaic are used as energy sources. A simple control method tracks the maximum power from the wind energy source without measuring the wind or generator speed, which is very useful for actual small size wind turbines[1]-[3]. The same control principle is applied to track maximum power point of the photovoltaic system without sensing the irradiance level and temperature [4]-[6]. Integration of the two energy sources, as a storage device placing the huge conventional batteries or super storage capacitors, leads to a non-polluting reliable energy source and reduces the total maintenance costs.

The hybrid system is being provided with a maximum power point tracking controller which tracks the maximum power from each source and which is being provided to grid. Various techniques of MPPT have been considered in renewable energy applications. Although the MPPT efficiency demonstration or comparisons to other methods is beyond the scope of the present work, a voltage based MPPT for PV and WEC systems has been proposed for its simplicity and faster tracking response. This paper is aimed at combining WEC and PV power generating systems to maximize the output energy and reduce the output power fluctuations. The proposed hybrid system can be connected to the grid through an inverter.

## 2. HYBRID SYSTEM MODEL

The hybrid energy system integrating two main subsystems of PV and WEC with two individual control units and a bridge inverter is shown in fig.1.The PV and WEC systems are used as energy sources [7]-[10]. The two subsystems such as PV and WEC systems are connected to individual dc-dc boost converter. The control is being provided using MPPT technique. The output of the hybrid systems are connected to a common dc bus. The DC power available at the dc bus is supplied to the grid inverted using an inverter which also provides voltage regulation. Thus the entire system when connected to the grid will provide a required continuous energy supply even if any one of the energy sources is being diminished.

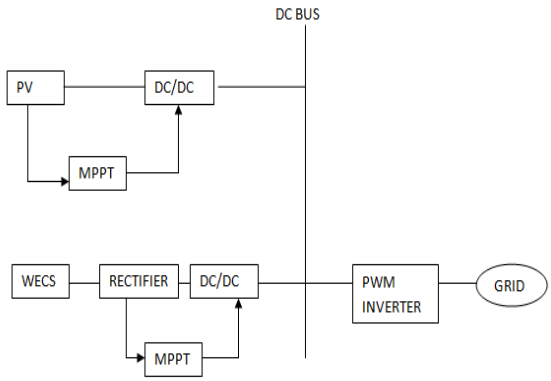


**Figure 1:** Grid connected hybrid energy system

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## 3. SYSTEM DESCRIPTION

### *3.1 Photovoltaic System*

Solar cell is defined as a p-n junction, fabricated on a thin wafer of semiconductor. A number of such solar cells form the building block of a PV array [11]. The electromagnetic radiation of solar energy is directly converted to electrical energy through photovoltaic effect. Photovoltaic generation system are day by day becoming important as renewable energy source since it has no fuel cost, does not pollute, requires less maintenance, no operating noise and so on.

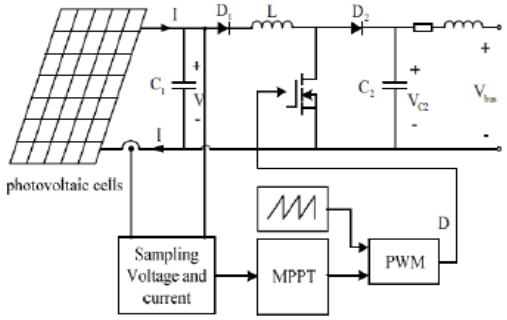


**Figure 2:** Application circuit for PV system

### *3.2 Wind Energy Conversion System*

Wind energy system consists of a wind turbine, permanent magnet generator, a diode bridge rectifier and a dc-dc boost converter as shown in Fig.3

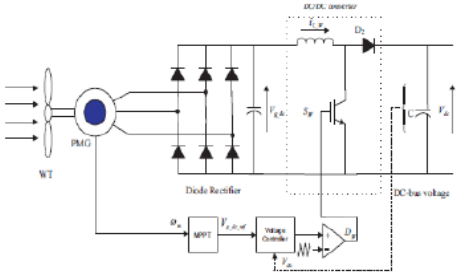

**Figure 3:** Application circuit for WEC system

The WEC system consisting of a wind turbine coupled to a generator and the turbine is rotated by means of wind energy and electricity is being produced by converting the rotation of turbine into electrical power by the generator [12]. The generator is connected to three phase diode bridge rectifier which provides a rectified dc to the input of a dc-dc boost converter. The boost converter is controlled by the MPPT technique same as that of PV system. The fundamental equation governing the mechanical power capture of the wind turbine rotor blades, which drives the electrical PM generator, is given by eqn.1.

$$P=1/2\rho ACpV^3 \quad (1)$$

Where ρ is the air density (kg/m3), A is the area swept by the rotor blades, V is the air velocity (m/s), Cp represents the power coefficient of the wind turbine. Therefore, if the air density, swept area and wind speed are assumed to be constant the output power of the wind turbine will be a function of the power coefficient, Cp. The wind turbine is normally characterized by its Cp–TSR characteristic, where the TSR is the tip-speed ratio and is given by eqn.2.

$$TSR=\omega mR/V \quad (2)$$

R and ωm are the turbine radius and the mechanical angular speed, respectively and V is the wind speed. The power coefficient has its maximum value at the optimal value of the tip-speed ratio (TSR opt) which results in optimum efficiency of the wind turbine and capture of maximum available wind power by the turbine.

## 4. SYSTEM CONTROL MECHANISM

### *4.1 Maximum Power Point Tracking Technique*

Before being provided to grid, Maximum power point tracking controller tracks the maximum power from each source. The dc-dc boost converter in each system is controlled using this MPPT technique. Various MPPT methods that have been developed are perturb and observe method, incremental conductance method ,open and short circuit method, Fibonacci search method to name a few [13]. In wind and PV systems, perturbation and observation (P&O) method, which moves the operation point toward the maximum power point by periodically increasing or decreasing the system voltage, is commonly used[14].

The perturbation and observation (P&O), or hill-climb searching (HCS) method is a mathematical optimization technique used to search for the local optimum point of a given function. It is widely used in wind energy systems to determine the optimal operating point that will maximize the extracted energy. This method is based on perturbing a control variable in small step-size and observing the resulting changes in the target function until the slope becomes zero. As shown in Fig.4, if the operating point is to the left of the peak point, then the controller must move it to the right to be closer to the MPP and vice versa if it is on the other side.

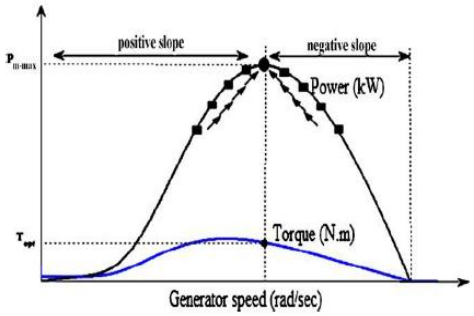


**Figure 4:** Wind turbine output power and torque characteristics with MPP tracking process

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Fig.5 shows the basic form of the P&O algorithm, where C is the step for perturbation.The voltage based P&O algorithm tracks the peak-power on the basis of the past voltages and powers. The operating voltage of the wind energy system is perturbed by a small constant increment and the resulting change of power *P* is observed. If *P* is positive, then it is supposed that it has moved the operating point closer to the MPP. In this case, further voltage perturbations in the same direction will move the operating point toward the MPP. If *P* is negative, then the operating point has moved away from the MPP, and the direction of perturbation should be reversed to move back toward the MPP.

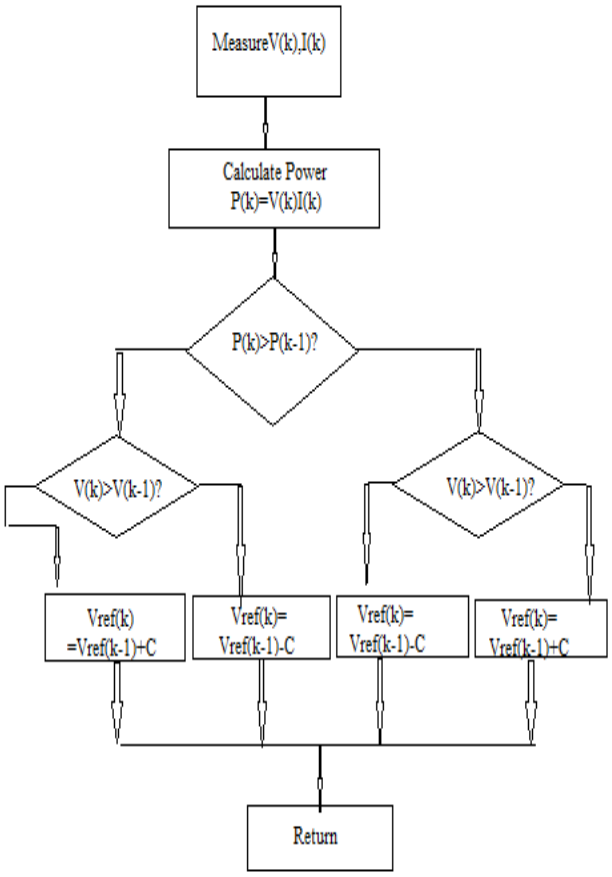


**Figure 5:** Flow Chart for Perturb and Observe method

### *4.2 PWM Inverter*

Fig. 6 shows the circuit configuration for the proposed inverter. The inverter input is being fed with dc bus voltage of the system. The inverter provides a power conversion and supplies the power to the grid, at a particular voltage and frequency [15].

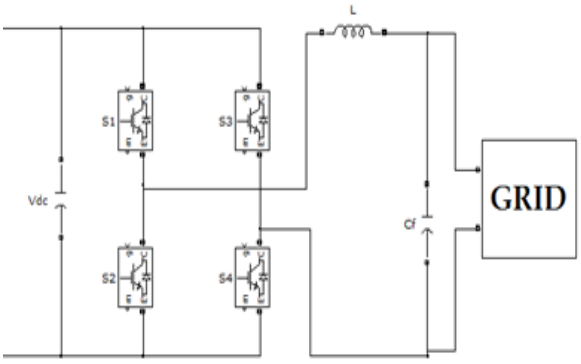


**Figure 6:** Circuit diagram for proposed inverter

The proposed inverter control procedure uses pulse width modulation (PWM) method to generate proper pulses for driving the switches of inverter.

## 5. SIMULATION MODEL AND RESULTS

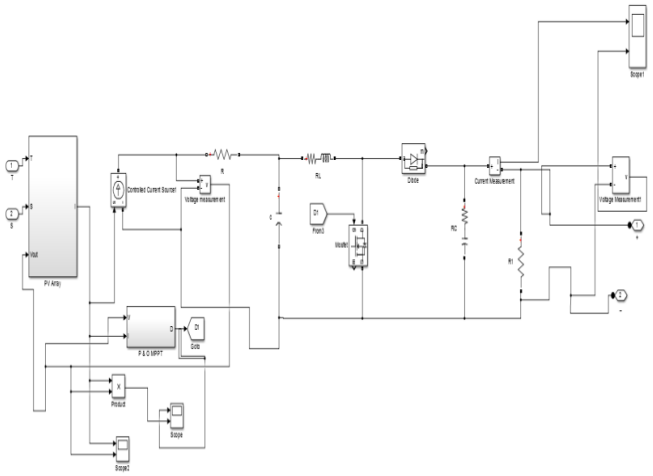

**Figure 7:** PV system with MPPT

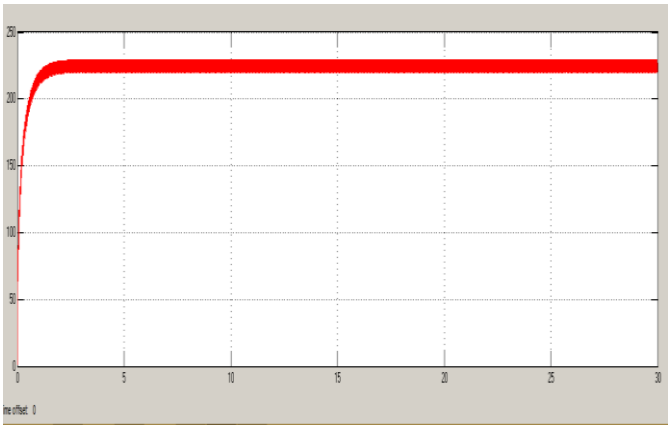


**Figure 8:** DC Output Voltage of PV System

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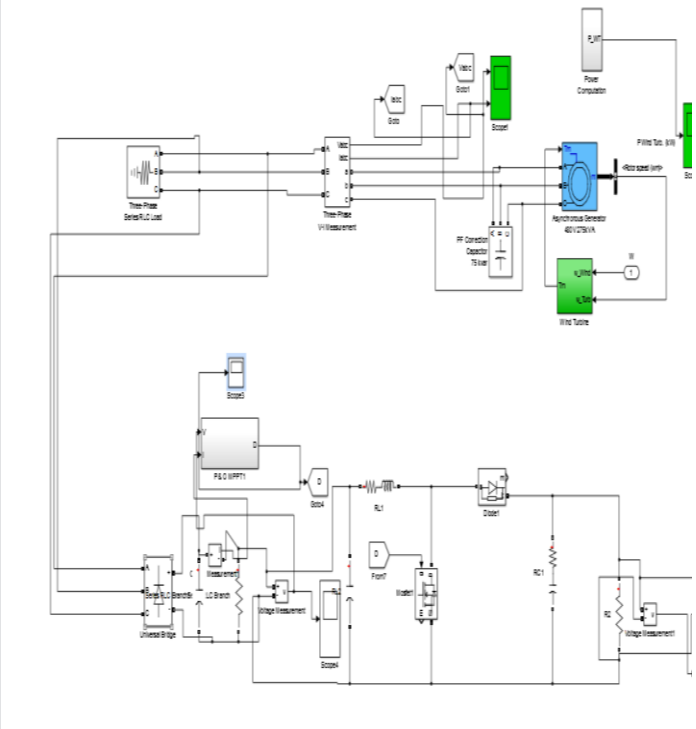

**Figure 9:** WECS with MPPT

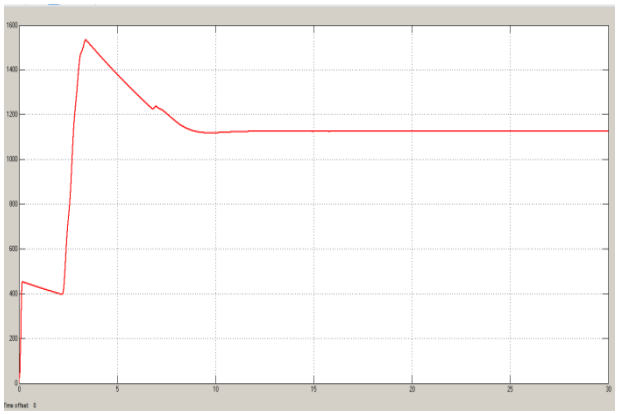

**Figure 10:** DC Output Voltage of WECS

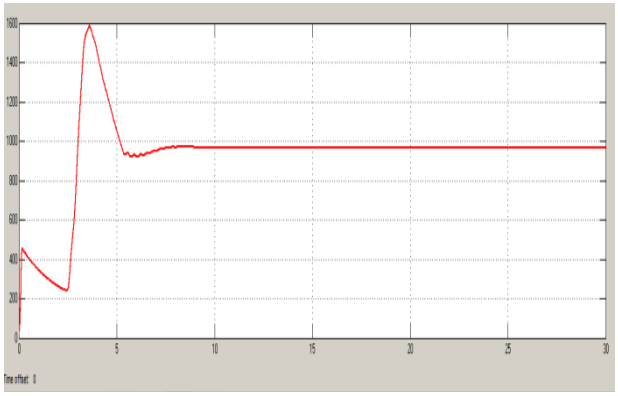

**Figure11:** DC output voltage of Wind-PV Hybrid system

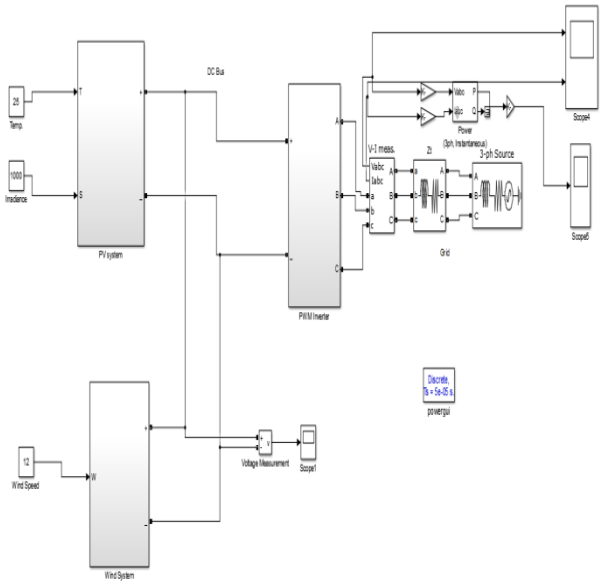

**Figure 12:** Grid Connected Wind-PV Hybrid system

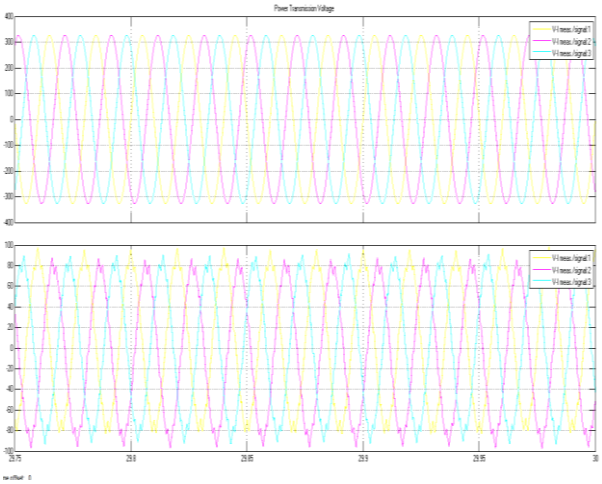

**Figure 13:** Output voltage and current obtained at Grid

The proposed system simulation results are carried out using MATLAB r2013b Simulink software. The model is examined under varying parameters for wind and solar irradiation and maximum power is being tracked from each subsystem components.

Fig.7 shows the simulation model of photovoltaic system along with MPPT control. PV panel converts the light energy into electrical energy. The output power obtained from PV system is fed to the input of a dc-dc boost converter and its performance is controlled using MPPT technique. The output power obtained from PV system before and after employing MPPT technique is shown in Fig. 8.Before employing MPPT a voltage of about 60V is obtained and at the output of boost converter it is boosted up to 250V.

Simulation model of wind energy conversion system along with a bridge rectifier and boost converter is shown in Fig. 9

.1200V is obtained after employing MPPT technique which is shown in Fig. 10.

The individual output of WECS and PV is given to DC bus which gives an output voltage to 1000V shown in Fig.11. Fig. 12 shows the complete grid connected model of WECS & PV system.

Individual systems such as PV and WECS are connected to grid which is designed for 300V.The hybrid system is connected to grid through a PWM inverter. A continuous voltage output of about 300V is obtained across grid as in Fig. 13.

The results obtained from the study shows the concept of a hybrid energy system consisting of three individual energy systems such as PV & WECS system and separately controlled using MPPT technique. The entire system connected to grid is examined and a continuous output is obtained across it.

## 6. CONCLUSION

The paper presents a hybrid energy system with MPPT and dc bus voltage regulation. The entire system can provide a continuous output across the grid. The output power obtained from primary energy sources such as PV and WECS will vary depending on solar irradiance and wind speed variation. The overall system provides a continuous power output across the grid without considering load variation and environmental changes. Therefore the power fluctuation of the hybrid system is less compared to individual system and has been completely achieved using the system proposed in the paper.

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