# Stand Alone Solar-Wind System Using MPPT Control

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***Abstract*- A stand-alone hybrid power system is proposed in this thesis. The system consists of solar power, wind power and an MPPT power controller. MATLAB/Simulink was used to build the dynamic model and simulate the system. To achieve a fast and stable response for the real power control, the MPPT controller consist of P&O and pitch angle control for maximum power point tracking (MPPT). The pitch angle of wind turbine is controlled by Pitch angle control, and the solar system uses P&O, where the output signal is used to control the dc/dc boost converters to achieve the MPPT.**

***Keyterms- MPPT, P&O algorithm, Pitch angle control***

## I .INTRODUCTION

One of the major concerns in the power sector is the day to day increasing power demand and the unavailability of enough resources to meet the power demand using the conventional energy sources. Demand has increased for renewable sources of energy to be utilized along with conventional systems to meet the energy demand. Renewable sources like wind energy and solar energy are the prime energy sources which are being utilized in this regard. The continuous use of fossil fuels has caused the fossil fuel deposit to be reduced and has drastically affected the environment depleting the biosphere and cumulatively adding to global warming

Solar energy is abundantly available that has made it possible to harvest it and utilize it properly. Solar energy can be a standalone generating unit or can be a grid connected generating unit depending on the availability of a grid nearby. Thus it can be used to power rural areas where the availability of grids is very low. Another advantage of using solar energy is the portable operation whenever wherever necessary. The use of the newest power control mechanisms called the Maximum Power Point Tracking (MPPT) algorithms has led to the increase in the efficiency of operation of the solar modules and the wind system and thus is effective in the field of utilization of renewable sources of energy. Topologies of the power electronic converter for maximum power point tracking (MPPT) and voltage conversion are studied in this paper. The maximum power point of photovoltaic (PV) array is variational, so a search algorithm is needed according to the current–voltage (*I*–*V*) and power–voltage (*P*–*V*) characteristics of the solar cell. The perturbation and observation (P&O) MPPT algorithm is commonly used, due to its ease of implementation. It is based on the observation that if the operating voltage of the PV array is perturbed in a given direction and the power drawn from the PV array increases, which means that the operating point is moving toward the MPP, so the operating voltage must be further perturbed in the same direction. Otherwise with the operating point moving away from the MPP, the direction of the operating voltage perturbation must be reversed. By using the P&O method, impedance matching is conducted between a boost converter and PV array in order to realize the MPPT function.

## II. PROBLEM FORMULATION

The basic objective would be to study MPPT and successfully implement the MPPT algorithms either in code form or using the Simulink models. Modeling the solar and wind systems and comparing the output power produced from the systems and connecting to the load. To minimize the number of devices used in the circuit and also improve the system efficiency. Modeling of the both solar and wind power plants with MPPT and without MPPT are done to compare the both in their outputs.

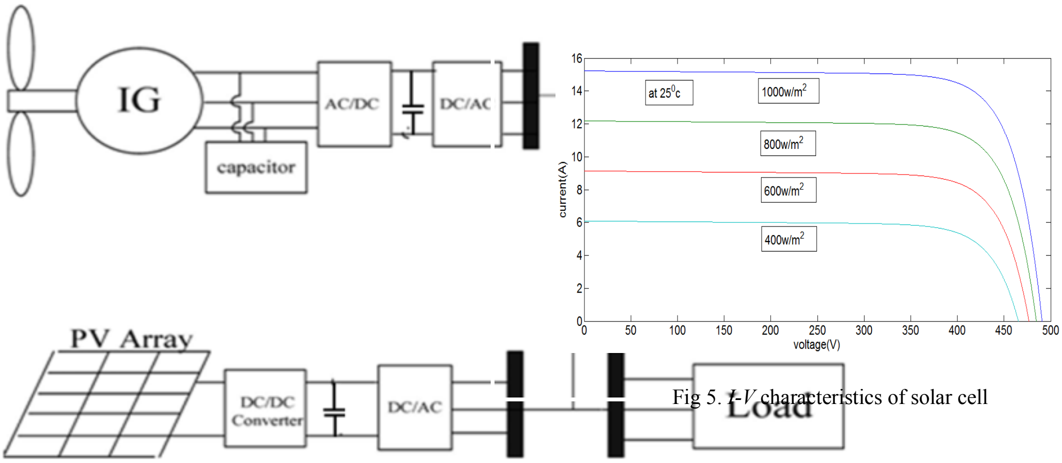


Fig 5. *I-V* characteristics of solar cell

Fig 1 Proposed Solar Wind Hybrid System

## III .SYSTEM OVERVIEW AND MODEL DESCRIPTION

The proposed solar wind hybrid system is shown in Fig 1. Dynamic models of system are developed using MATLAB/Simulink, consisting of

1) Wind Energy Conservation System
2) PV Generation System

### *a) Wind Energy Conservation System*

The input to the wind turbine is wind and the output is mechanical power produced. The mechanical power produced is given by

$$P_m = 0.5\rho A C_p (\lambda, \beta) V^3 \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where ρ and A are the air density and the area of the blades. V is the wind velocity and $C_p$ is the power coefficient with respect to tip speed ratio λ and pitch angle β. Tip speed ratio is given by

$$\lambda = (r\omega_r)/V \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where r is the radius of the wind blades and $\omega_r$ is the turbine speed .

The pitch angle controller plays an important role in the wind turbine working. Fig. 2 shows the groups of *Cp–λ* curves of the wind turbine used in this study at different pitch angles. From the figure it is given that *Cp* is changeable according to the adjustment of the pitch angle β. So output power is regulated by pitch angle control. For each turbine, there is an optimal TSR value that corresponds to a maximum value of the power coefficient (Cp, max) and therefore the maximum power. Therefore, maximum power can be obtained for different wind speeds by controlling the rotational speed of generator.

### *b) PV Generation System*

Solar cell is a p-n junction similar to the characteristics of diodes. Solar cell parameters are shown in the fig.3.The relation between terminal current and voltage

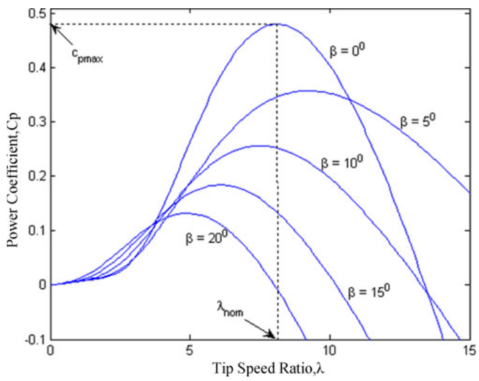


Fig 2.*Cp*–*λ* Characteristics of the WECS at different pitch angle

is given by

$$Vpv = (nkt/q)\ln(\frac{Isc}{Ipv} + 1) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

K is Boltzmann constant ($8.63*10^{-5}$ J/°K) and q is the electronic charges. T is the temperature and *n* is the ideality factor of p-n junction.

$$Ipv = Isc - Ipvo\left[\exp\left(\frac{q(Vpv + IpvRs)}{nKT}\right) - 1\right]$$

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$$-\frac{Vpv + RsIsc}{Rs} \ldots\ldots\ldots\ldots\ldots\ldots. (4)$$

where Rs and Rsh are series and shunt resistance. Isc is the light induced current, Ipvo is the diode saturation current,

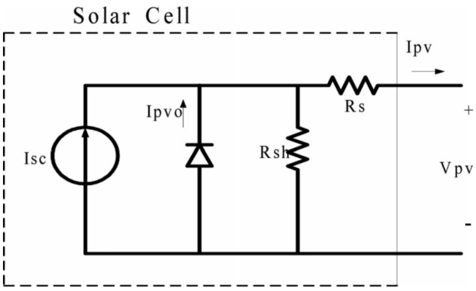



Fig 3. Equivalent circuit of a solar cell

Isc depends on the irradiance level.

The output characteristics of solar cell drastically affected by the irradiance and temperature of sunlight. Equation (3) and (4) shows the output characteristics.
The *P-V* and *I-V* characteristics are shown in fig 4& 5. When output voltage change gets reduced, the change in output current is reduced.

In fig 4 shows the variation between output powers produced and output voltage with different irradiance value. In fig 5 shows the variation between output current and output voltage with the irradiance value.

## IV MPPT ALGORITHM FOR THE SYSTEM

For the combined system there are two algorithms designed for MPPT control. They are *P&O* algorithm and pitch angle controller.

### a) *P&O algorithm*

The most common method used in the PV system is the *P&O* method. It periodically increases or decreases the solar cell's voltage to get the maximum power point. It

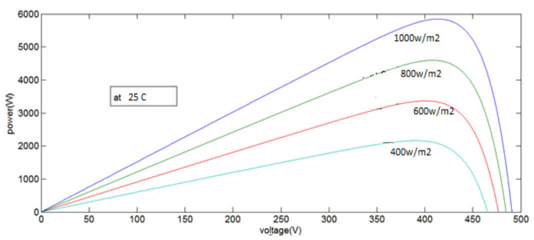
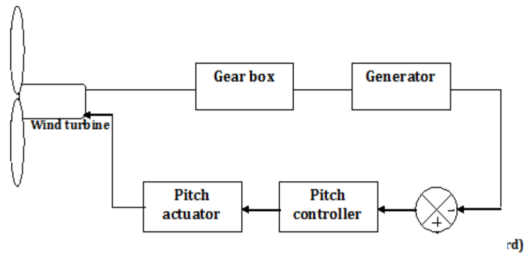



Fig 4. *P-V* characteristics of solar cell

is often referred to as hill climbing method, because they depend on the fact that on the left side of the MPP, the curve is rising (dP/dV> 0) while on the right side of the MPP the curve is falling (dP/dV< 0). Fig 6 shows the control block of the P&O method.

### b) *Pitch Angle controller*

The method used in the wind energy conservation system for maximum power point is pitch angle controlling. The pitch angle of the blades of the wind system is controlled wit



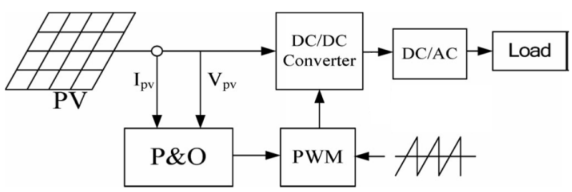




Fig 6.MPPT control of solar PV system using P&O method

maximum power point. The pitch angle of the wind system is adjusted by the controller according to the input wind. The blades are adjusted to get maximum power output from the system.

Fig 7 explains about the power produced in the wind system with respect to the time change. Fig 8 shows the control block of pitch angle controller.

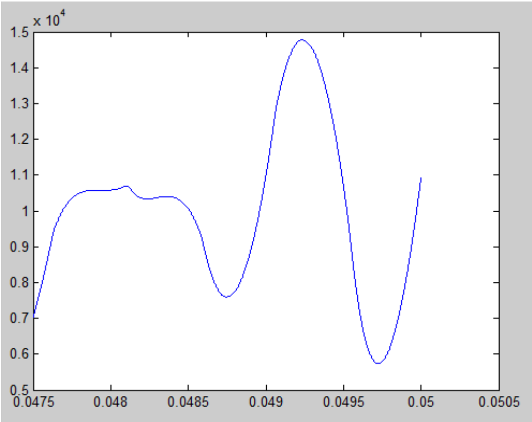



Fig 7.Power Produced With Respect To Time

## V RESULT AND DISCUSSION

So with the help of MPPT controller algorithm in the system we are able to study about the change in power produced from the systems.

| CONTROLLER | IRRADIANCE | OUTPUT POWER (per hour) |
|---|---|---|
| Without MPPT controller | 1000 W/m$^2$ | 3.84 MW |
| With MPPT controller | 1000 W/m$^2$ | 4.5MW |

Table 1 Output comparison of solar system

From the table1 the comparison of the power produced in the solar system with maximum irradiance value from the sun. The power produced in a solar cell changes changes according to the irradiance changes and maximum power is produced from it.

| CONTROLLER | PITCH ANGLE | OUTPUT POWER (per hour) |
|---|---|---|
| Without MPPT controller | 45 | 9.69 MW |
| With MPPT controller | 0.154 | 10.99MW |

Table 2. Output comparison of wind system

From the table 2 the comparison of the power produced in the wind system with change in pitch angle value of the blade is done. The power produced from the wind system is maximum with the MPPT controller (pitch angle controlling) than the other.

The proposed system is made with the MPPT control algorithm in the both solar and wind system for the maximum power production and to compare with the other system according to the power produced. The system is created to produce maximum power for the future as the power consumption is getting increased.

The system is replaced with *Neural Networking System* from *P&O algorithm* and *pitch angle controller* for maximum power output for the system. The existing system produces maximum output but in practical conditions it is not produced. Neural networking helps to produce more power practically as it is human friendly system which helps to produce more power.

## VI CONCLUSION

A hybrid solar-wind energy system has been proposed in this work. When the wind speed or solar power goes low, the stored energy is utilized to maintain load power constant. So that the system can be made more efficient and reliable by inclusion of hybrid system. A single four port converter has been used for connecting solar, wind, battery and load. So the number of devices used in the circuit is reduced. In next phase Perturb & Observe controller and PI controller replaced with neural network for the future grid restructuring process and the load variation studies.

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