

## EVALUATION OF POWER PERFORMANCE OF PV MODULE USING MODIFIED PERTURB AND OBSERVE MPPT ALGORITHM

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### ABSTRACT

The paper concerns about power performance of PV module considering MPPT technique. From the observation, it is seen that the average power is sharply increased to around 33% at the initial stage, whereas this level increases gradually up to approximately 41% only due to the utilization of MPPT technique. The whole evaluation process has been investigated by MATLAB\_Simulink.

**Keywords:** Power, Temperature, MPPT, module, Perturb and Observe, Algorithm.

### 1. INTRODUCTION

The solar energy treated as clean energy holds a vital role in making high life span and good reliability. That's why it is treated as one of the most valuable renewable sources. The major advantage of photovoltaic energy system is that it can be installed at any places near about the consumer region having the facility of no transmission loss and no emission of CO<sub>2</sub> gas (Hernanz et al., 2010). The excessive utilization of fossil fuel causes reduction of fuel (fossil) deposit seriously and pollutes the atmosphere depleting the biosphere as well as rising to global warming. For the abundance of solar energy, it is easy to implement it as the alternate source of fossil fuel. And this photovoltaic energy may be operated as a standalone or as a grid connected generation system considering presence of a public grid nearby. In this way rural areas may be covered with power where grid is not available (Patel & Sharma, 2013). For the non linearity characteristics of PV module, it is necessary to figure out it for design criteria as well as for simulation to find out maximum power point tracking (MPPT) of photovoltaic application. Photovoltaic model utilized in MATLAB simulation has been prepared for over last four decades (Anngrist, 1982; Wasynczuk, 1983; Phang et al., 1984).

The paper tries to represent the average power output of the solar module integrating MPPT criteria. The comparison between PV module with MPPT and without MPPT solution has been observed by simulation of MATLAB simulink model.

### 2. PV CELL MODELLING

Figure 1 represents the equivalent diagram of photovoltaic cell. Root equation which illustrates I-V characteristics of photovoltaic cell is given in equation (1) (Tsai et al., 2008):

$$I = I_{ph} - I_s \left[ \exp\left(\frac{q(V + IR_s)}{kT_c A}\right) - 1 \right] - \frac{V + IR_s}{R_{sh}} \quad (1)$$

Where I<sub>ph</sub> = light produced current, I<sub>s</sub> = dark current saturation in cell, q = charge = 1.6 × 10<sup>-19</sup> C, k = (1.38 × 10<sup>-23</sup> Joule/k), T<sub>c</sub> = working temperature of the cell, R<sub>sh</sub> = resistance in parallel and R<sub>s</sub> = resistance in series, A = ideality factor.

Light produced current which is relying on solar irradiation and temperature of cell is illustrated by equation (2) (Tsai et al., 2008):

$$I_{ph} = [I_{sc} + K_I (T_c - T_{ref})] \frac{G}{G_n} \quad (2)$$

Where I<sub>sc</sub> = Cell short circuit current at 25°C, T<sub>ref</sub> = reference temperature of the cell, K<sub>I</sub> = short circuit current temperature coefficient of cell, G<sub>n</sub> = nominal solar irradiation at STC in kW/m<sup>2</sup>, G = the solar irradiation in kW/m<sup>2</sup>. On top of this, saturation current of cell is affected by temperature which is shown in equation (3) (Tsai et al., 2008):

$$I_s = I_{RS} \left(\frac{T_c}{T_{ref}}\right)^3 \exp\left[-\frac{qE_G \left(\frac{1}{T_{ref}} - \frac{1}{T_c}\right)}{kA}\right] \quad (3)$$

Where E<sub>G</sub> = band-gap energy of semiconductor material used in photovoltaic cell, I<sub>RS</sub> = reverse saturation current of cell at a particular reference temperature.

The reverse saturation current of cell which is dependent on short circuit current and open circuit voltage is denoted by equation (4) (Villalva et al., 2009).

$$I_{RS} = \frac{I_{sc} + K_I \Delta T}{\exp\left(\frac{V_{oc} + K_V \Delta T}{AV_t}\right) - 1} \quad (4)$$

Where V<sub>oc</sub> = open circuit voltage for photovoltaic cell, ΔT = the difference in temperature between the actual and reference temperature (°C), K<sub>V</sub> = voltage coefficient and V<sub>t</sub>

= thermal voltage of photovoltaic cell. Thermal voltage is expressed in equation (5).

$$V_t = \frac{kT_c}{q} \quad (5)$$

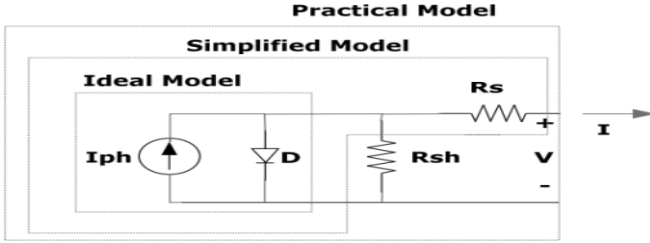


Figure 1: Equivalent circuit diagram for photovoltaic cell (Durago, 2011).

### 3. PV ARRAY MODELLING

Photovoltaic array is referred as the parallel or series arrangement of modules. Photovoltaic module which is considered for MATLAB simulation shows maximum power output is 100W. For obtaining power with expected current and voltage, parallel and series combination of photovoltaic modules must be examined first. The equation of current of the photovoltaic array with  $N_s$  and  $N_p$  is provided in equation (6) (Tsai et al., 2008):

$$I = N_p I_{ph} - N_p I_s \left[ \exp\left(\frac{V}{N_s} + \frac{IR_s}{N_p}\right) - 1 \right] - \frac{N_p V}{N_s} + IR_s \quad (6)$$

### 4. ALGORITHM FOR MPPT

Most frequently utilized algorithm for MPPT is the Perturb and Observe (P&O), since it has easy operation and implementation.

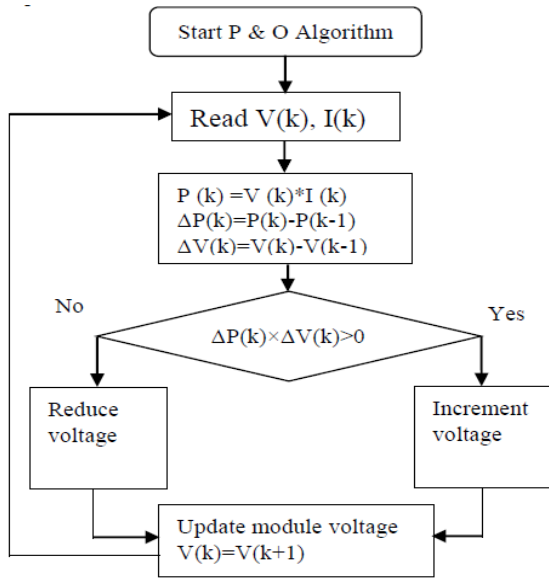


Figure 2: Proposed Perturb and Observe algorithm flow chart.

The valuable merit of the Perturb & Observe process is that it is simple to operate. Nevertheless, with some constraints like low response speed, oscillations around MPP in the operation of steady state and incorrect tracking way with immediately varying atmospheric state (Hohm & Ropp, 2000; Femia et al., 2004a, b; Brambilla et al., 1999; Kuo et al., 2001; Liu & Lopes, 2005).

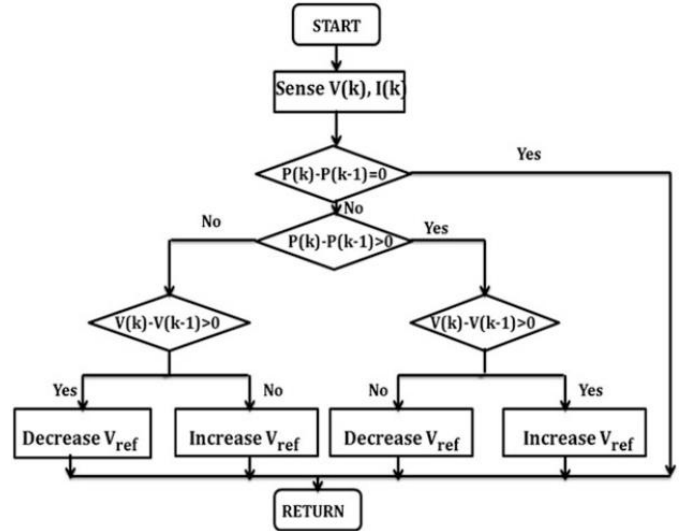


Figure 3: Commonly used flowchart of Perturb and Observe method.

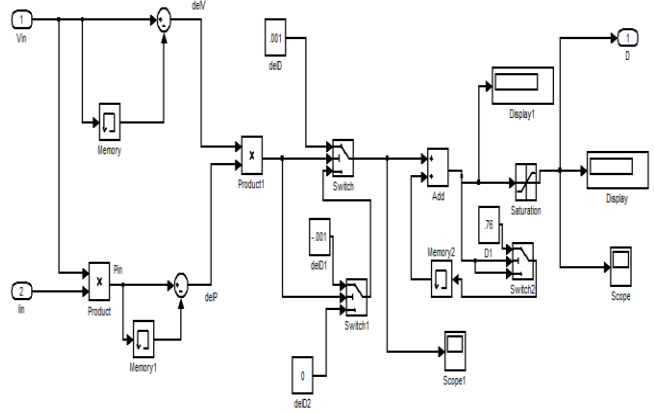


Figure 4: Simulink model of Modified P & O algorithm.

To make comparison between proposed modified algorithm and commonly used algorithm of Perturb and Observe method, both algorithms are provided in figure 2 & figure 3 respectively. Fig. 2 shows modified algorithm of Perturb and Observe method. In this modified algorithm a good number of calculating stages have been reduced which can diminish the cost of implementation. And increment and decrement of module voltage according to the requirement is done by changing the duty cycle. This measurement of duty cycle is handled by MPPT following the P & O method. The implementation for P & O algorithm is depicted in figure 4.

## 5. RESULTS AND DISCUSSION

For simulation purpose, CSS-MSP-100M-36 is taken as PV module. From figure 5 and figure 6, it is observed that at moment of 20 volt, the PV module provides its maximum power whereas fig. 7 shows that the operating voltage is varying from around 17 V to 22 V due to the implementation of MPPT. Again fig. 8 explains that the average output power rises to around 64 W, whereas the fig. 9 exhibits that this average power level develops to around 90 W due to addition of MPPT technique. On top of this, the fig. 10 and fig. 11 represent the power increment behaviour due to the MPPT solution. From the observation, it can be said that on average maximum 26 W more power can be extracted from a single PV module if MPPT solution is executed.

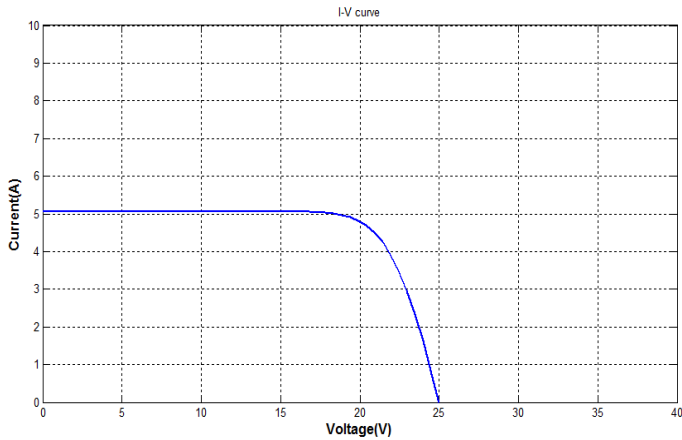


Figure 5: V-I characteristic curve of photovoltaic module without MPPT solution.

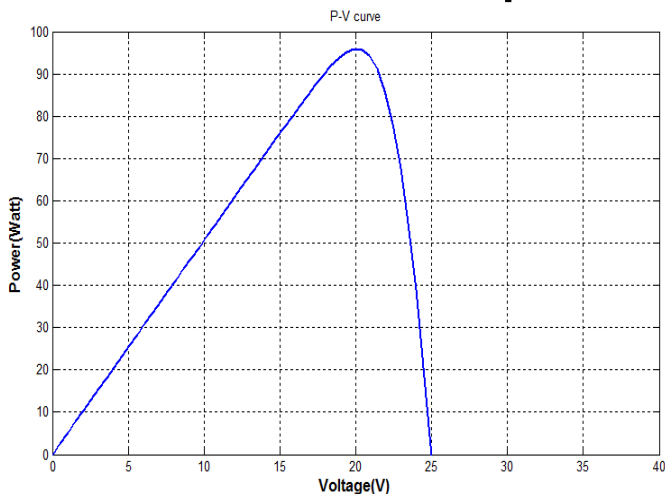


Figure 6: Power versus voltage curve of PV module without MPPT solution.

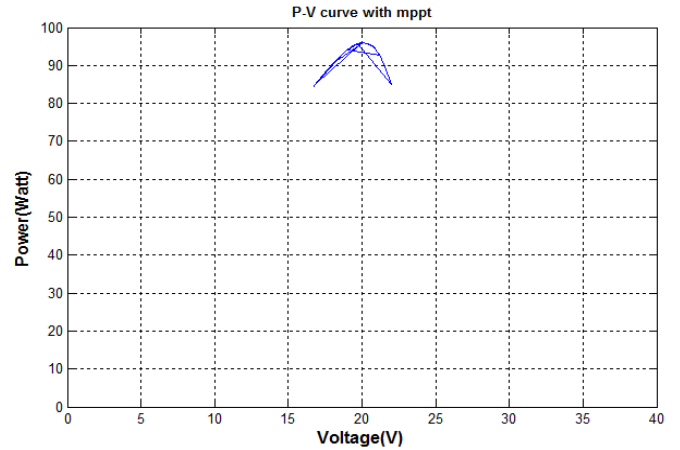


Figure 7: Power versus voltage curve of photovoltaic module using MPPT solution.

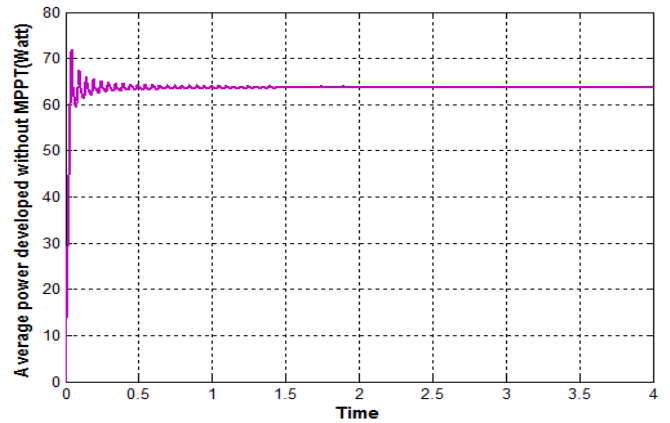


Figure 8: Average power of photovoltaic module void of MPPT solution.

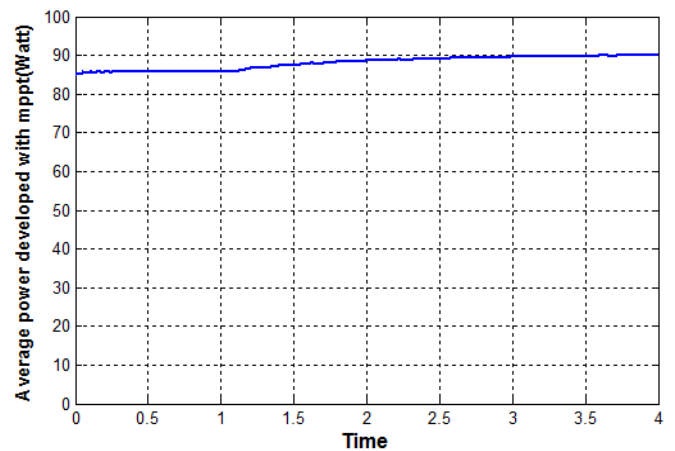


Figure 9: Average power of photovoltaic module using MPPT solution.

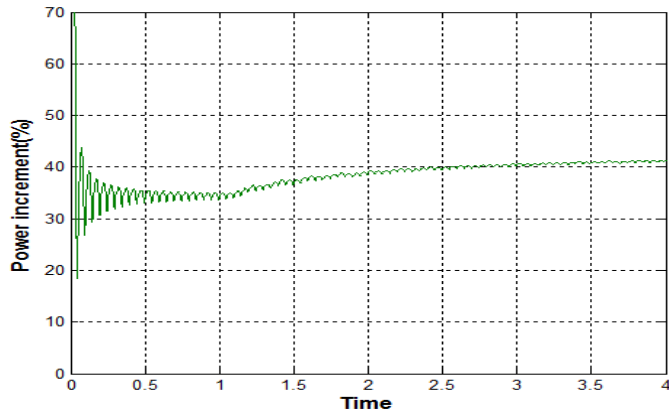


Figure 10: Output power increment of PV module due to MPPT solution.

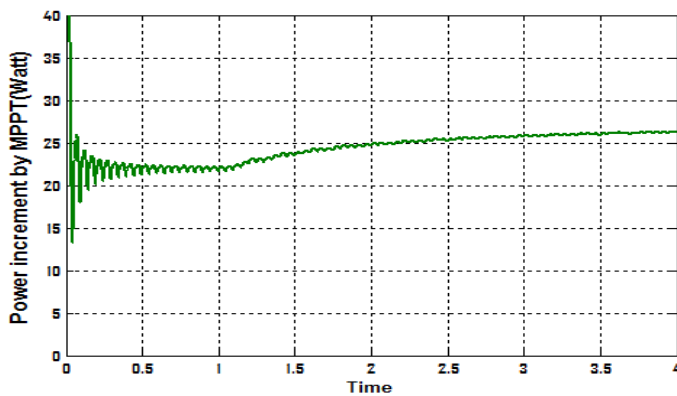


Figure 11: Percentage power increment of PV module due to MPPT solution

## 6. CONCLUSION

The MPPT solution using modified P & O algorithm is inherited with PV module for exhibition of characteristics of output power. The performance analysis shows that the positive output difference power could be obtained on average from 22-26 W around from a single PV module only by integration of MPPT technique. On top of this, more analysis is needed to observe the power performance with MPPT solution considering shading effect, solar irradiance, temperature, ideality factor etc.

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