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Perturb and Observe MPPT Algorithm Implementation for PV Applications

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Abstract: Photovoltaic (PV) panels are devices that convert sun light into electrical energy and are considered to be one of the major ways of producing clean and inexhaustible renewable energy. However, these devices do not always naturally operate at maximum efficiency due to the nonlinearity of their output current-voltage characteristic which is affected by the panel temperature and irradiance. Hence, a high performance maximum-power-point tracking MPPT is the key to keep the PV system operating at the optimum power point which then gives maximum efficiency. Many MPPT controllers and different types of control techniques have been considered in the past. But they do not accurately track the maximum power. This paper primarily considers the MPPT control method or algorithm i.e, perturb and observe (P&O) technique which is widely used due to its low cost and ease of implementation. The proposed method has been evaluated using MATLAB programing.

Keywords: [MPPT] maximum power point tracking, [P&O]Perturb and Observe, [PV] Photovoltaic panel.

I. Introduction

The growing energy demand coupled with the possibility of reduced supply of conventional fuels, evidenced by petroleum crisis, along with growing concerns about environmental conservation, has driven research and development of alternative energy sources that are cleaner, are renewable, and produce little environmental impact. Among the alternative sources, the electrical energy from photovoltaic (PV) cells is currently regarded as a natural energy source that is more useful, since it is free, abundant, clean, and distributed over the Earth and participates as a primary factor of all other processes of energy production on Earth. Moreover, in spite of the phenomena of reflection and absorption of sunlight by the atmosphere, it is estimated that solar energy incident on the Earth's surface is on the order of ten thousand times greater than the world energy consumption.

But a major test in using a PV source is to undertake its nonlinear output characteristics, which vary with solar irradiation and atmospheric temperature. The characteristics get more complex if the whole array does not receive uniform insolation, as in partially shaded (cloudy) conditions, resulting in many peaks.

The presence of many peaks reduces the efficiency. several techniques have been implemented for this maximum power point tracking like, Open Circuit (OC), Short Circuit (SC) and Perturb & Observe (P & O) MPPT are mostly used in PV Array. The OC and SC methods are simple but do not accurately track the maximum power [1]-[5].

In order to overcome the above drawback,P&O method is used. The method operates by periodically changing the output voltage of the solar array and evaluating the corresponding output power. When the maximum of the product I*V is found, the MPP has been located This paper looks at the MPPT for PV system using P&O technique where the immediate value of power are considered each time, and the maximum power point value is reorganized. The main compensation connected with PV module is that it consists of no moving parts. Do not produce any noise and maintenance costs are minimal.

This paper begins with a review of PV characteristics and generation. Subsequently, the tracking of maximum power point of P-V and I-V curves using perturb and observe method is explained.

II. Photovoltaic Characteristics and Generation

Fig. 1 shows the equivalent circuit for a PV cell. The output current of the equivalent circuit, *I*, can be expressed as a function of the PV cell's voltage, *V*.

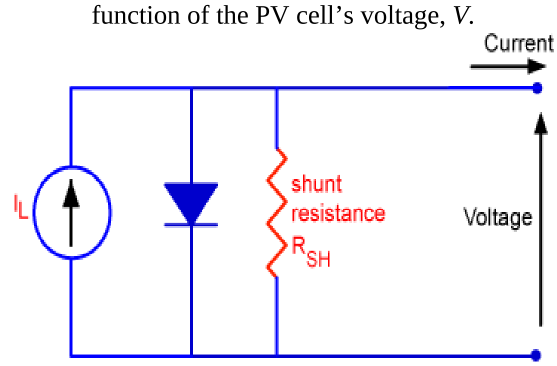
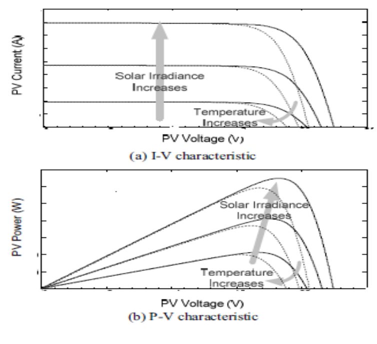


Figure1: Equivalent circuit of PV cell

$$I = I_L - I_D - I_{sh} \quad (1)$$

$$\therefore \; I = I_L - I_o\left[e^{\frac{V + I\cdot R_S}{nV_T}} - 1\right] - \frac{V + I\cdot R_S}{R_P} \quad (2)$$



(a) I-V characteristic
(b) P-V characteristic

Figure2: The effect of solar irradiance and temperature on I-V and P-V characteristics.

Where I_L is the photocurrent, is a function of cell temperature and solar irradiance. The solar irradiance and the PV device's temperature are the two important factors that influence the amount of solar energy harvested by PV modules. The short circuit current increases with the increase of sunlight intensity and the open circuit voltage decreases with the rise of temperature. Thus, the power generated by PV modules is high when the solar irradiance is high under low ambient temperature. The impact of solar irradiance and PV device temperature on the I-V and P-V characteristics are illustrated in Fig. 2.

III. PERTURB & OBSERVE MAXIMUM POWER POINT TRACKER:

The photovoltaic module yields the current-voltage characteristic with a unique point which is known as the Maximum Power Point (MPP). Perturb and Observe (P and O) and Incremental Conductance (INC) algorithms are most widely used, especially for low-cost implementations. The MPP changes as a consequence of the variation of the irradiance level and temperature.

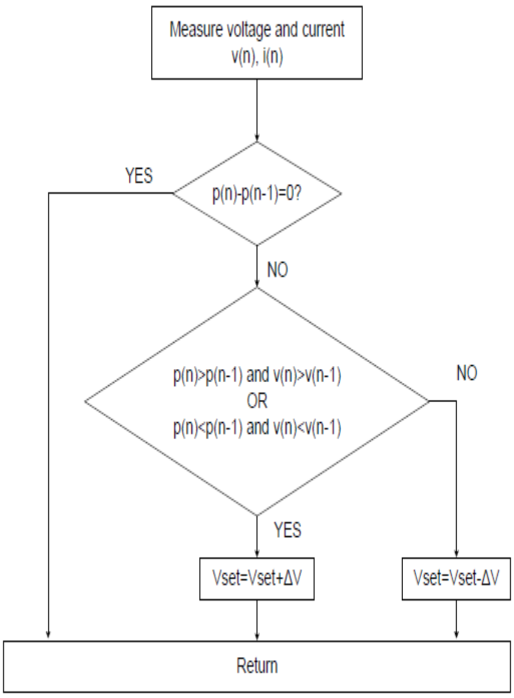


Figure3: Flow chart of P&O MPPT Algorithm

Therefore, it is necessary to ensure that the PV system always operates at the MPP in order to maximize the power harvesting in that prevailing environmental conditions. This compares the power measured in the previous cycle with the power of the current cycle to determine the next perturbation direction. If the power increases due to the perturbation then the perturbation will remain in the same direction. If the operating point exceeds the peak power and deviate to the right side of the P-V characteristic curve, the power at the next instant will decrease. Thus, the direction of the perturbation reverses. When the steady-state is reached, the operating point oscillates around the peak power as the MPP will perturb continuously. The flow chart required for P&O MPPT module (subsystem) is shown in Fig. 1.The electrical characteristics data of solar module is given below.[8]-[12].

Table 1: electrical characteristics data of solar 36w pv module

Rated power	37.08W
Voltage at maximum power(V_{mp})	16.56V
Current at maximum power(I_{mp})	2.25A
Open circuit voltage(V_{oc})	21.24V
Short circuit current(I_{iscr})	2.55A
Total number of cells in series(N_S)	36
Total number of cells in parallel(N_p)	1

IV. RESULTS AND DISCUSSIONS

The output obtained under different conditions of P&O method are-

Case1: MPPT Tracking of P&O method for different irradiation levels and constant temperature i.e,25 ^{0}C

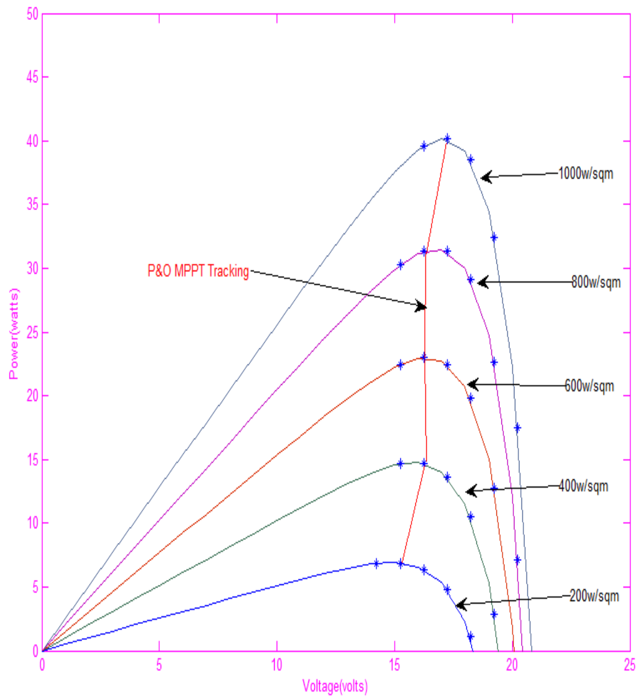


Figure4: P-V characteristics for different irradiation levels at constant temperature of 25 ^{0}C .

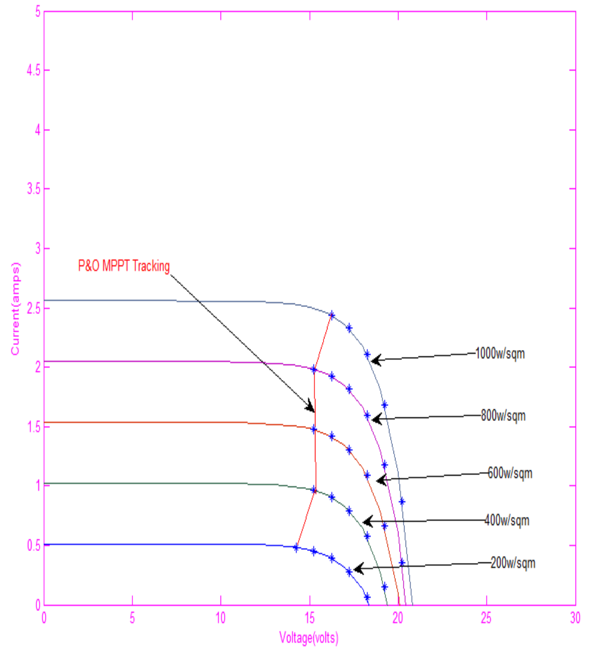


Figure5: I-V characteristics for different irradiation levels at constant temperature of 25 ^{0}C .

Case2: MPPT Tracking of P&O method for different temperature levels and constant irradiation i.e,1000 w/sqm

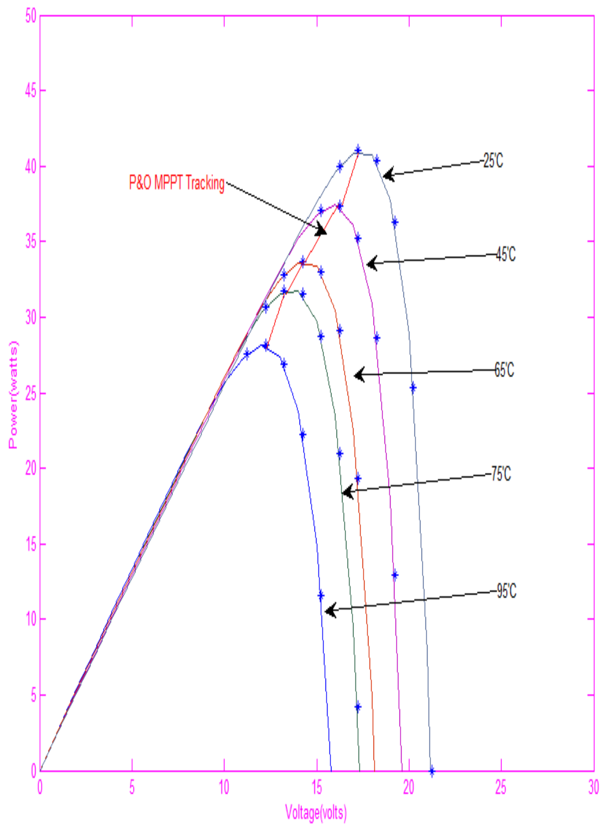


Figure6: P-V characteristic for different temperature levels at constant irradiation of 1000w/sqm

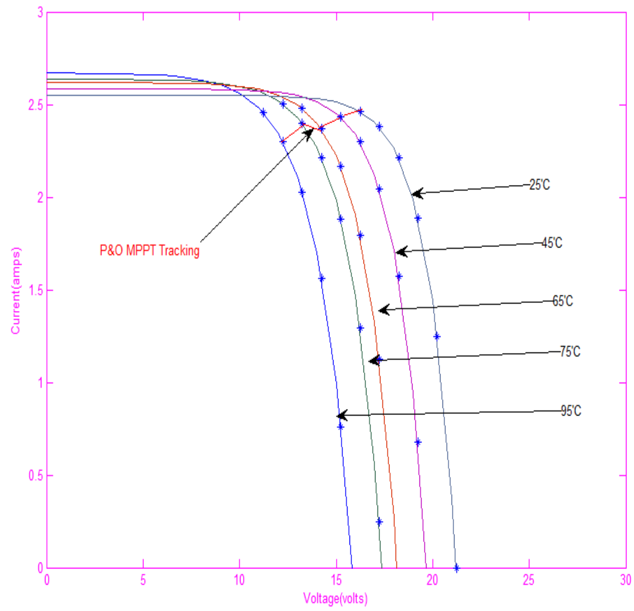


Figure7: I-V characteristic for different temperature levels at constant irradiation of 1000w/sqm

The results show that PV energy conversion system gives more efficiency with maximum power point tracking method i.e., perturb and observe method .

V. Conclusion

In the Present Work, the maximum power point tracking is successfully carried out by this research using perturb and observe method. The PV module working on photovoltaic effect actually improves the system efficiency Compared to other methods of maximum power point tracking, the perturb and observe method seems to be easy for the optimization of the photovoltaic system. It tracks true maximum power, unlike the fractional open circuit voltage and FSCC methods. Also, it does not require a large amount of data (storage) for training and extensive computation to deal various stages, as required by FLC and NN. The results show that the proposed algorithm gives faster response than the conventional algorithms.

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