

An Investigation of Perturb and Observe Based MPPT Algorithm for PV System

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Abstract:-Renewable energy is one of the most available and exploitable forms of energy of the various renewable energy sources photovoltaic energy has emerged as the most viable source of electric power and is economically competitive with conventional sources. With the increasing demand on electricity and rising prices of conventional sources, photovoltaic energy is a promising alternative; it is freely available and less operational and requires low maintenance. Maximum power point tracking techniques (MPPT) are used in photo voltaic (PV) systems to maximize the PV array output power by tracking continuously. Among all the different techniques Perturb and Observe (P&O) technique is most extensively used in commercial MPPT systems because it is straight forward and low cost to implement.

1. INTRODUCTION

Energy is a primary and most universal measure of all kinds of work by human beings and nature. In the world, everything that happens is the expression of flow of energy in one of its forms. Electrical energy, among all special types of energy is one of the most important that people require every day. Increasing energy demand and environmental issues over the non- renewable energy sources have significantly developed the interest in renewable energy sources to replace non-renewable energy sources. The electrical power generation awareness based on different renewable energy sources are reviewed in this chapter. Among all the renewable energy sources the photovoltaic (PV) are gaining more popularity due to their ease of installation, low maintenance and in isolated mode of power generation these are proven as an effective solution for feeding energy demand in rural areas. A photovoltaic system with Maximum power point tracking (MPPT) algorithm is presented which increases the system efficiency.

A solar cell in the PV system has the non-linear characteristics and the output power of the PV system mainly depends on irradiance or insulation and temperature. Thus, the PV system due to these non linear characteristics produces less efficiency in the output power. To increase the efficiency of the PV system, maximum power point tracking techniques are introduced. There are various MPPT techniques that are used in the recent days to produce high tracking efficiency and good performance of PV system. Some of the MPPT techniques used for PV system to track

maximum power are curve fitting technique, open-circuit voltage technique; short-circuit current technique,

Incremental conductance technique, perturbation and observation technique and other techniques. Among these techniques perturbation and observation technique is most commonly used.

This paper shows PV modeling with MATLAB/SIMULINK maximum power point tracking by using P&O technique. Then the results are compared and the performance of the PV system is evaluated.

2. SYSTEM CONFIGURATION

The system consists of a PV module, DC/DC converter, P&O MPPT block and load. Let us see the each block in detail.

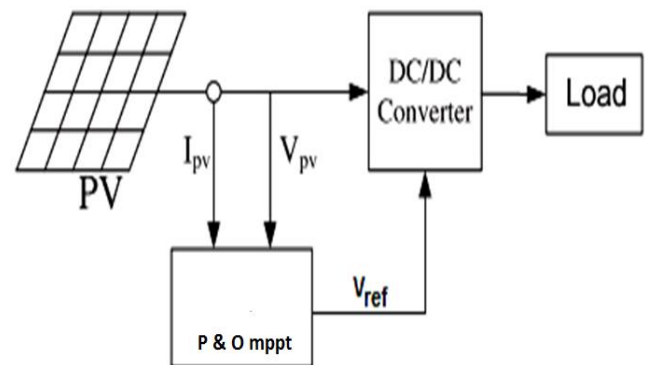


Fig.1. Block diagram of proposed system configuration

Fig.1. shows that PV module consists of multi solar cells. The characteristic of a PV module is same as that of a

solar cell expect with the change in the magnitude of current and voltages. A solar module normally provides with 36 or 72 individual cells [6] - [7]. Multiple PV modules connected in series and or parallel to form an array.

PV cells in nature shows nonlinear I-V and P-V characteristics which differ with irradiation and temperature of cell. The typical I-V and P-V characteristics of PV cell are shown in Fig.2.

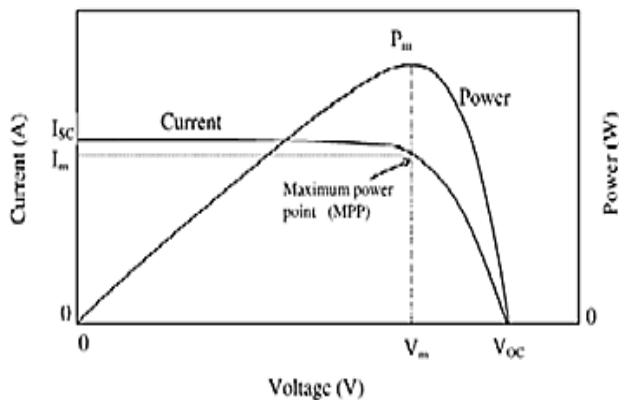


Fig. 2.Characteristics of PV cell

The I-V Characteristics of PV array is nonlinear, which make it difficult to find the MPP. From the I-V curve and P-V curves at fixed irradiance, open circuit voltage decreases with increase in temperature.

A DC-DC converter converts directly from DC-DC and is simply known as a DC converter. A DC converter can be considered as an ac transformer with a continuously variable turn ratio and it can be used to step down or step up a DC voltage source as transformer. DC converters can be used as switching-mode regulators to convert a DC voltage to a regulated DC output voltage. The regulation is normally obtained by PWM at a fixed frequency and the switching device is basically BJT, MOSFET or IGBT.

3. PERTURB AND OBSERVATION ALGORITHM

P&O algorithms are extensively used in MPPT because of their simple structure and the few precise parameters which are required. In this technique, a small perturb is introduced, it makes the power of PV module changes. If the power is increases, then perturbation will go in the same path in the next sequence, otherwise the perturb path will be reversed. Therefore, when the steady state is reached, the P&O algorithm will oscillate around it resulting in a loss of PV power, after that perturbation reverses in cases of constant or slowly changing atmospheric conditions. In turn

to decrease the power loss size of perturbation is kept very little. [11].

In this topology,P&O method is measured by adapting the step size. When the system operating far from the MPP then the size of perturbation is improved, and when the real operating point starts to oscillate close to the MPP, the algorithm changes the reference voltage in order to reduce step size, so the fluctuation is reduced to a large extent. By reducing the step size oscillations at MPP is reduced but tracking speed will be very low. The P&O block diagram shown in below Fig.3.

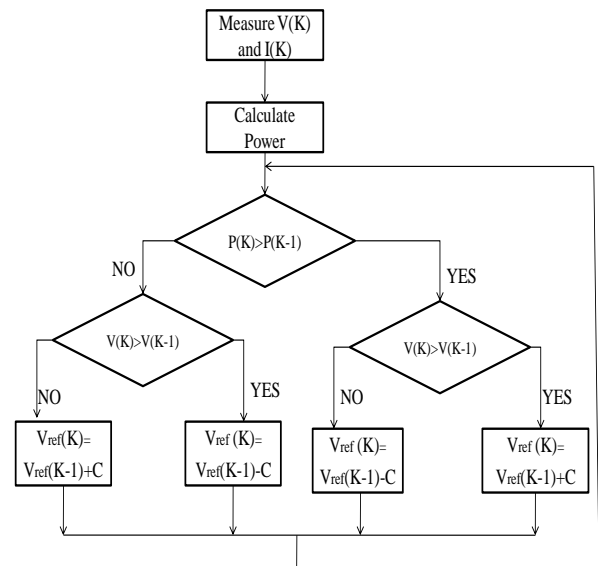


Fig 3.Perturb and Observe (P&O) algorithm

Further evaluating the voltage and power equations, MPPT controller may track the accurate direction to achieve MPP of PV array. The maximum power operating point rapidly tracks by considering derivative of power and voltage(dp/dv) equate to zero with varying cell temperature and solar irradiance.

Power slope dp/dv will be evaluated digitally by sampling the PV array current and voltage at consecutive time intervals (k-1) and (k) as follows.

$$dp / dV (k) = P(k) - P(k-1) / V(k) - V(k-1)(1)$$

Where,

P(k) = Present value of power

P(K-1)= Previous value of power

V(k) = Present value of voltage

V(K-1) =Previous value of voltage

In order to achieve the maximum power the present value and the previous value should be same then the numerator becomes zero and it is given in Eqn (2).

$$dp(k)/dv(k-1) = 0 \quad (2)$$

4. RESULT ANALYSIS

A. Simulation Diagram of Photovoltaic System:

The mathematical model of PV array is designed in MATLAB/Simulink to be compatible with a given load to achieve maximum power transfer from solar arrays, is shown in Fig.4. When the temperature constant and varies irradiance then power gradually minimum to maximum. Similarly when the temperature varies and irradiance constant then power gradually maximum to minimum respectively.

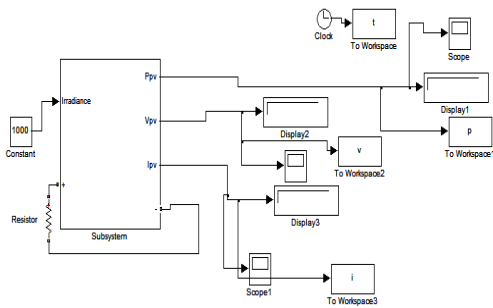


Fig 4. Simulation Diagram of Photovoltaic System

The Current vs. Voltage (I-V) characteristics and the Power vs. Voltage (P-V) characteristics of the photovoltaic system at rated values of solar irradiance (1kw/m²) and temperature (25°C) is shown in below Fig.5. and Fig 6.

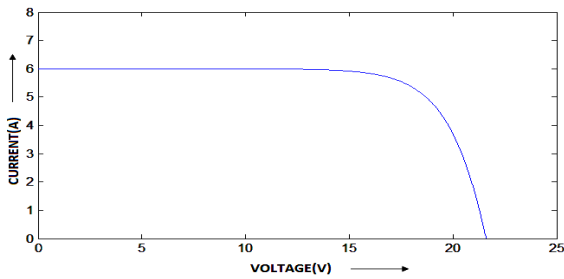


Fig.5. I-V Characteristics

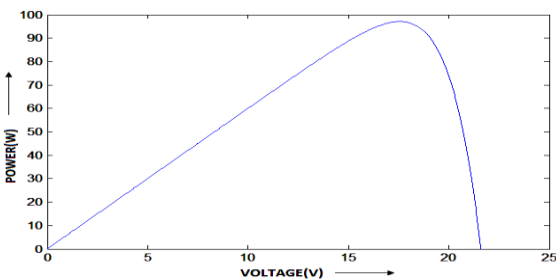


Fig.6. P-V Characteristics

If there is any changes in solar irradiation or in temperature or in both, the V-I characteristics and P-V characteristics will also changes, this will also effects the PV system output power. The I-V and P-V curves for changes in the solar irradiation are shown in Fig.7 and Fig.8.

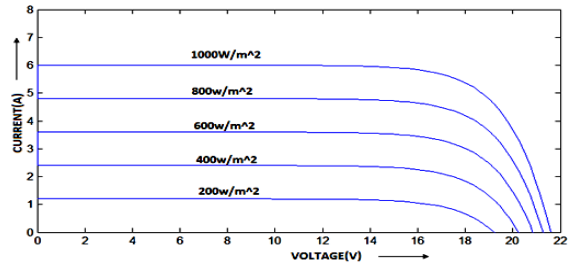


Fig.7 I-V Characteristics for Different Solar Irradiation

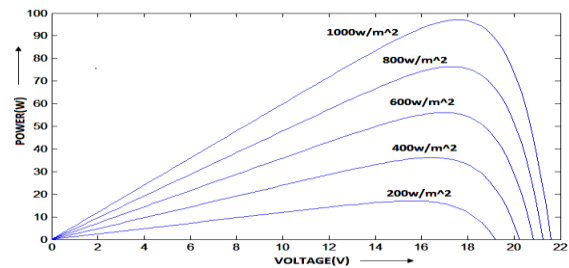


Fig.8 P-V Characteristics for Different Solar Irradiation

From Fig 7 and Fig 8 it shows that, as solar irradiation increases from minimum to maximum, power increases from minimum to maximum at constant temperature of 25°C. Similarly as the temperature changes power will also changes. The V-I and P-V characteristics for changes in temperature is shown in Fig 9 and Fig 10.

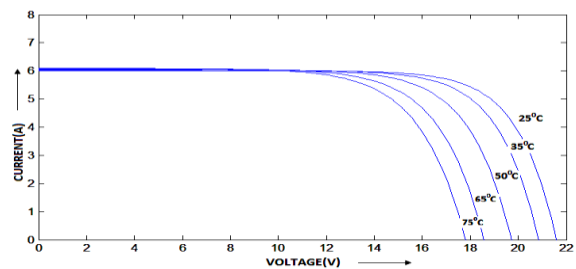


Fig.9 I-V Characteristics for Different Temperature

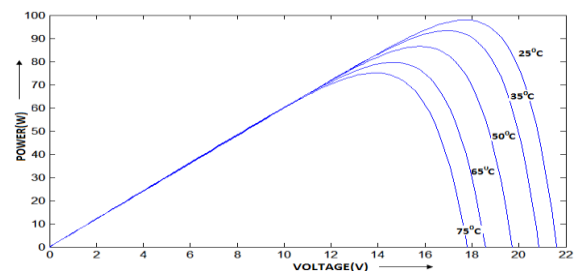


Fig.10 P-V Characteristics for Different Temperature

From Fig 9 and Fig 10 it shows that, as temperature increases power decreases at constant solar irradiation of 1000w/m^2 .

B. Simulation diagram of P&O MPPT Controller

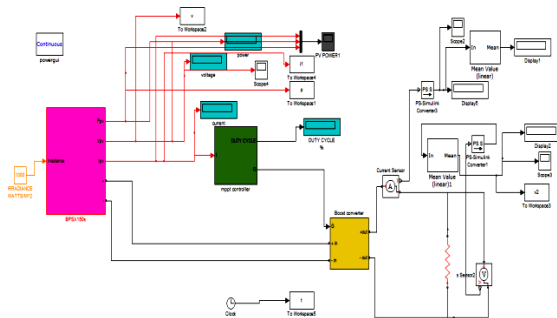


Fig.11. Simulink Diagram of P&O MPPT control

The Fig.11 shows the Simulink diagram of P&O MPPT controller. The irradiance input block and the Duty cycle block where different duty cycles are given to the system and the another block is the Boost converter.

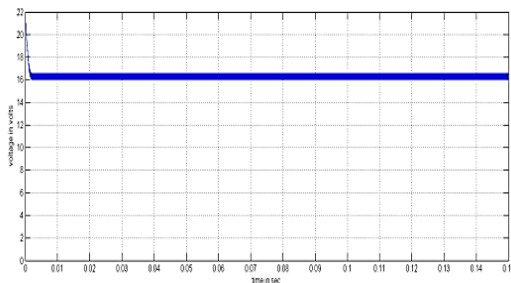


Fig.12 Output Voltage of P&O

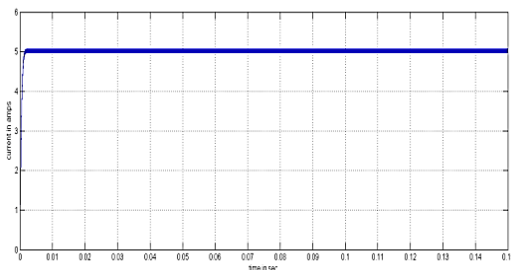


Fig.13 Output Current of P&O

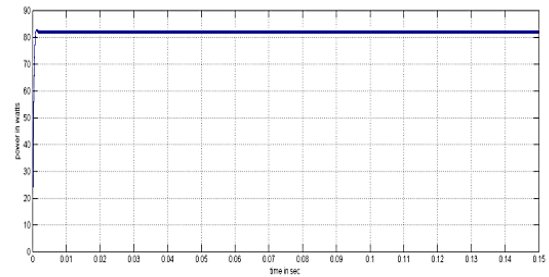


Fig.14 Output Power of P&O

Fig 12, Fig 13 and Fig 14 shows the Output voltage, Current and power respectively at $T = 25^\circ\text{C}$ and $\lambda = 1000\text{W/m}^2$. The output voltage, current and power of the boost converter for the Perturb & Observe based maximum power point tracking of PV system are shown in Fig 15, Fig 16 and Fig 17 respectively.

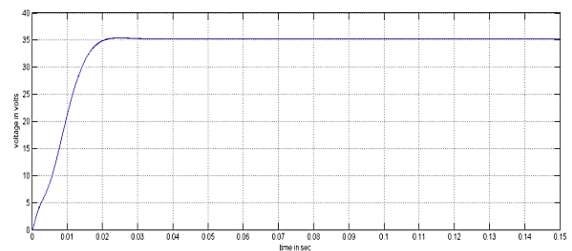


Fig.15 Output Voltage of Boost converter

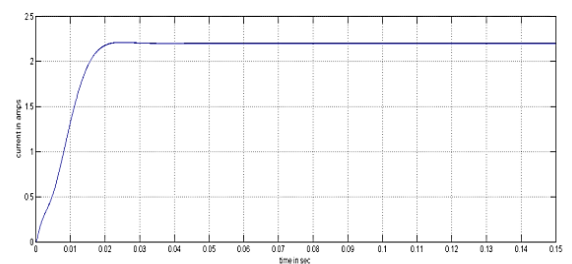


Fig.16 Output Current of Boost converter

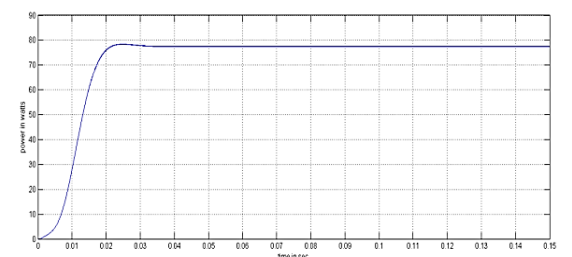


Fig.17 Output Power of Boost converter

Boost converter output voltage, current and power of P&O at $T=25^{\circ}\text{C}$ and $\lambda=1000\text{W}/\text{m}^2$. The values of PV power, voltage and current for different irradiance at constant temperature with P&O based MPPT are measured and the changes in maximum voltage and maximum current and maximum power are shown in Table.1 It shows that power gradually decreases due to decrease of irradiance. So that the oscillations are increases and the stability goes down.

The performance of the system with P&O and without P&O is tabulated for different irradiance values. The temperature is fixed at $T = 25^{\circ}\text{C}$ and $\lambda=1000\text{W}/\text{m}^2$ is also fixed.

Table 1
ANALYTIC ASSESSMENT OF P&O MPPT CONTROL ALGORITHM BASED PV SYSTEM

Irradiation (W/m^2)	Temperature ($^{\circ}\text{C}$)	V_{PV} (volts)	I_{PV} (Amps)	P_{PV} (Watts)	Tracking Efficiency (%)
200	25	11.2	1.05	11.5	11.5
400	25	13.35	2.15	27.9	27.9
600	25	14.26	3.17	44.6	44.6
800	25	14.89	4.23	61.69	61.69
1000	25	16.63	5.08	82.4	82.4

From the table 1 it is evident that the tracking efficiency at irradiance $1000\text{W}/\text{m}^2$ is high (82.4%) and it is lowest at the irradiance $200\text{W}/\text{m}^2$ (11.5%).

5. CONCLUSION

The maximum power point tracking is a technique used with PV system to improve its conversion efficiency. To eliminate mismatch between the load line and V-I characteristic, an MPPT control algorithm is necessary. Perturbation and Observation method is relatively simple and easily of implementation could be realized easily with simulation. P&O method has dramatic fast tracking capability; a better response for the system under rapid atmospheric condition variations can be obtained by increasing the execution speed. The P&O method gives high efficiency about 82.4% and performs well with changing irradiation and temperature.

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