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MODELING AND ANALYSIS OF MAXIMUM POWER POINT TRACKING ALGORITHMS USING MATLAB/SIMULINK

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ABSTRACT

As the consumption of fossile fuel and the incidental trouble induced by the expected power generation like gasoline, charcoal, and etc., alternative energy sources and between these sources photovoltaic panels and wind-generators are now broadly used. One of the most favorable alternative energy is photovoltaic (PV) energy it is pure, limitless and free from harvesting. Though, two main defects of PV system are the high investing cost and the low regeneration of PV modules efficiency. In this paper work, PV system is analyzed with different maximum power point controlling techniques i.e. Perturb and Observe, Incremental Conductance & Fuzzy Logic Control, to study various parameters like settling time, oscillation around maximum power point tracking and selection criteria of dc-dc converter. The selection criteria of dc-dc converter is important because dc-dc converter decides tracking and non-tracking region.

Keywords: Fuzzy Logic Control, Matlab, Simulink

I. INTRODUCTION

The expected sources of energy are rashly decreasing. Also, the energy amount is increasing and that’s why a maximum favorable alternative is PV system. They are pollution free, plenty delivered all over the earth and reusable. The difficult point is its high investing amount and efficiency of low regeneration. So, the purpose is to enhance the ability and power output of the system. PV arrays are in combination of parallel and series PV cells that are used to reproduce electrical power determined by the atmospheric conditions, like solar radiation and temperature. Thus, it is essential to connect the PV array with a dc-dc converter [1-6]. The energy of photons direct change into electrical energy i.e. called Photovoltaic electrical system. Now there are environmental parameters, such as radiation and temperature, so the output power is highly effective to them. Thus, from a panel the draw out maximum power also changes with change in these parameters. From a PV panel in turn to assure maximal drawing of power under different incidental actions, load must be changed in conformation by changing incidental parameters, hence at the maximum power point, operating point consistently lies on it.

Since, to convert the load at every interval which is not possible practically, so there should be any combine circuit inserted in the PV panel and the load, that can convert the load as noticed from the side of

PV terminals. Commonly switched mode power converters (dc to dc converters) are used as the combine circuit, as the output of PV panel is of DC in nature. Through changing the duty-cycle of these power converters the operating point may be shifted. To discover the maximum power point there are various techniques in paper according to which the duty-cycle of these converters can be changed [1-7].

II. PV ARRAY MODEL

In the formation of masked block PV module there is a one diode equivalent circuit-based simulation model. In this model, it is permissible to evaluate performance of PV module towards changes on radiation avidity, ambient temperature and parameters of the PV module. In addition, in the dynamic simulation of stand-alone PV systems the model can be used which is adept of function of maximum power point tracking (MPPT) [1].In SIMULINK/MATLAB a procedure of modeling and simulation photovoltaic (PV) module is execute. For a PV cell, it is essential to explain a circuit-based simulation model to allow the intercommunication with a power converter. Characteristics of PV cells that are influenced by radiation and temperature are modelled by a circuit model. As a model a simplified PV equivalent circuit with a diode equivalent is employed. With different types of PV module datasheets the simulation results are compared [2]. Mathematical analysis for the single diode model is employed to check out the I-V and P-V characteristics, in which the impact of radiation and temperature is also considered. The analysis is accomplished in MATLAB/SIMULINK environment which is a very flexible to change the parameters of the system [3].

III. MAXIMUM POWER POINT TRACKING TECHNIQUES

3.1. Maximum Power Point Tracking Principle

The effectiveness of a photovoltaic system is lesser, as the output power of the PV array based on different incidental actions like temperature and solar radiation, that's why maximum power point fluctuates with change in radiation and temperature. Therefore, it is essential to modify the output power of the PV array before providing it to the domestic loads there is the need of the system to condition the output power. Fig.1 presents a block diagram which is exhibit the use of a converter for PV energy system. The PV array output after being conditioned by dc-dc converter supplied to the load. An operating point on either I-V or P-V characteristic curve of a PV array is maximum power point (MPP). The power given to the load is maximal at this point of operation. From the theorem of maximum power transfer, when the converter load is steady and the duty cycle of the converter is variable, then the effective load on the PV system varies, from the PV system maximum power can be achieved. To achieve maximum power by modifying the slope of the load line, relocating of operation point and then fixed it at MPP, maximum power can be done. The conception of maximum power point tracking is shown in Fig.1 [18].

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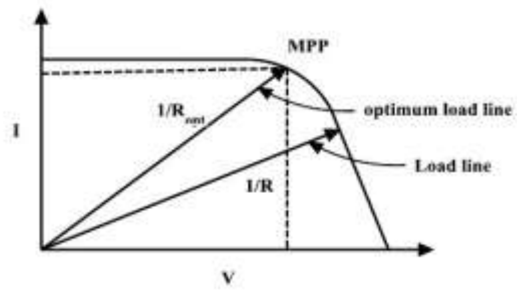

Fig 1: Conception of maximum power point tracking [18]

3.2. Characteristics of PV Cell

An absolute solar is formed through a current source in parallel with a diode, no solar cell is absolute. So to the model shunt and series resistances are joined as shown in PV cell diagram in Fig. 2. Series resistance is R_s whose value is low. The equivalent shunt resistance is R_{sh} which has very large value. To provide clarity and accurateness there is a good connection of single diode model. For power electronics applications, a single diode model is considered to be accurate well as simple to provide effective analysis.

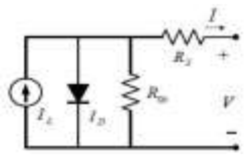

Fig. 2: Model of PV cell [2]

3.3. Variation effect of Solar Radiation

Solar cell curves PV and I-V are extremely depending on the solar radiation values. The solar radiation as the result of incidental changes keeps on oscillating but control apparatus are accessible that can track the interchange and can adapt the working of solar cell to meet the require load demand. If the solar radiation is higher then the solar input would be higher and therefore it is seen that, by varying solar radiance the open circuit voltage almost remains constant but the short circuit current changes and hence maximum power point also changes, i.e. short circuit current increases as solar radiation increases, the effect of variation of solar radiation is shown in Fig. 3.

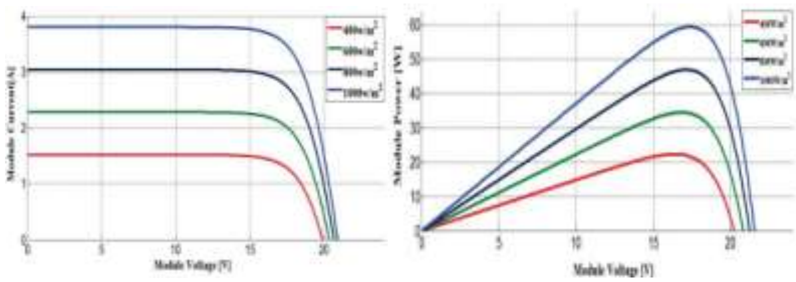

Fig. 3: I-V and P-V Characteristics for different radiation values [6]

3.4. Variation effect of Temperature

Under open circuit conditions, open circuit voltage V_{oc} is given by equation 1

$$V_{oc} = \frac{\alpha KT}{q} \ln\left[\frac{I_L}{I_0} + 1\right] \quad (1)$$

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In above equation reverse saturation current is I_o which doubles for every 10°C rise in temperature. So open circuit voltage decrease with increase in temperature. The effect of increase of temperature has negligible effect on short circuit current but open circuit voltage decreases as temperature is increased as shown in Fig. 4.

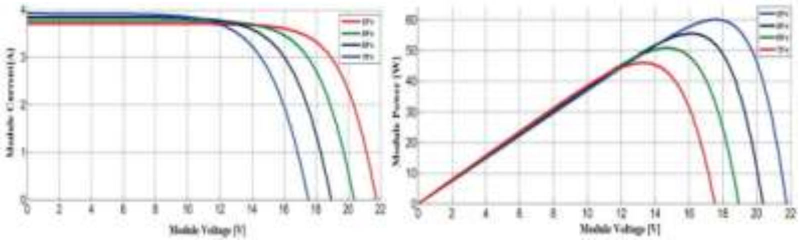

Fig. 4: I-V and P-V Characteristics for different temperature conditions [6]

3.5. Buck-Boost Converter& Operation

Buck-boost converter general arrangement is shown Fig. 5. It includes a dc input voltage source V_1, inductor L, controlled switch Q, diode D, filter capacitor C, and the load resistance R. Buck-Boost converter will function as buck (step down) converter if duty ratio is less than 0.5 and as boost (step –up) converter if duty ratio is greater than 0.5.

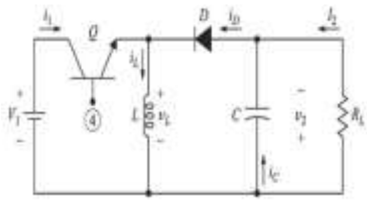

Fig. 5: Configuration of a Buck Boost Converter [14]

The circuit operation can be separated into two modes:

Mode1: At the time of mode 1, the switch Q is becomes on and the diode D is reversed biased. In mode 1 the input current (i_1), which rises then flows through inductor L and switch S_1 [15].

Mode 2: In mode 2, the switch Q becomes off and the current would flow through L, C, D and load which was flowing throughout inductor L. In this mode the energy gathered in the inductor (L) is conveyed to the load and the inductor current (i_L) falls until the switch Q is turned on again in the next cycle. Over complete cycle the average value of voltage across inductor and average current through capacitor is zero [15].

The steady-state voltage and current waveforms are shown in Fig.6.

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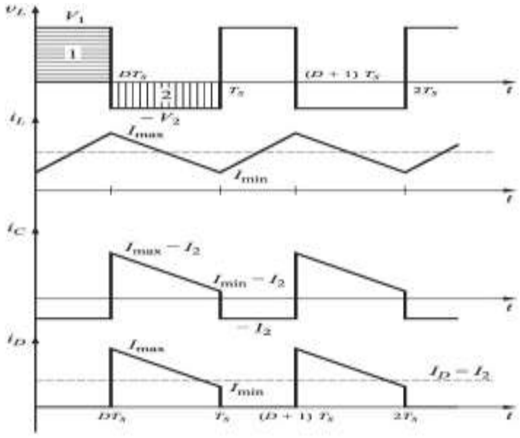

Fig.6: Current and voltage waveforms of Buck Boost Converter [14]

Based on the relation (volt-second balance) that average voltage across inductor over a complete cycle is zero, the relationship between input and output voltage for Buck-Boost converter shown in Fig.5 is:

$$V_2 = V_1 \frac{D}{1-D} \quad (5.8)$$

Where, D is duty ratio of switch varies between 0 & 1.

V_2 is output voltage across load resistance R_L.

V_1 is input source voltage.

IV. SIMULATION & RESULTS

4.1. PV Array Characteristics

In this section I_{PV}-V_{PV} and P_{PV}-V_{PV} characteristics of PV array are plotted for different radiations and performance analysis is done for three different MPPT control techniques namely perturb & observe, incremental conductance &Fuzzy logic Control.

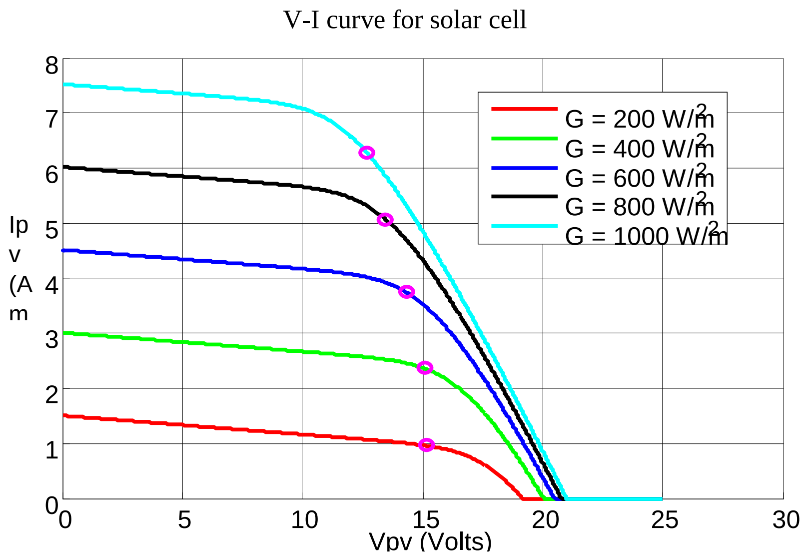

Fig.7: I_{PV}-V_{PV} Characteristics for different radiation values

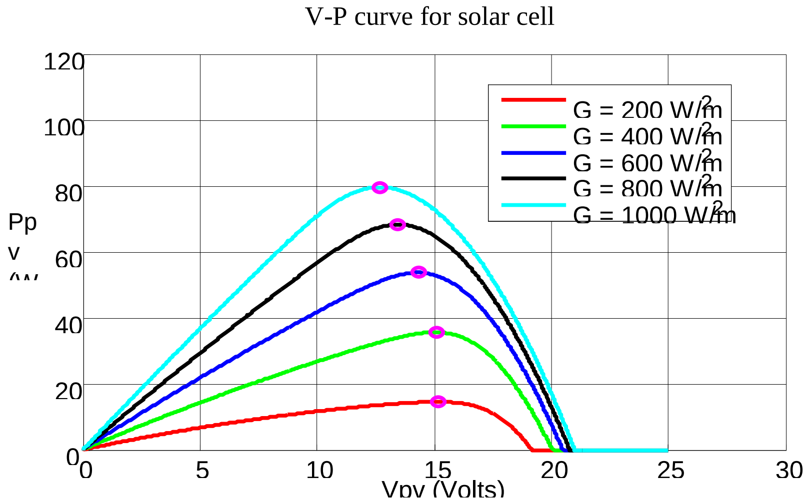

Fig.8: P_{PV}-V_{PV} Characteristics for different radiation values

4.2. Performance Analysis of Different MPPT Techniques

In this section the simulation curves are obtained for different MPPT techniques (perturb & observe, incremental conductance & Fuzzy logic control) for a fixed step size of 0.7 to track maximum power corresponding to radiation of 1000 W/m^2 is shown below.

4.2.1. Perturb& Observe

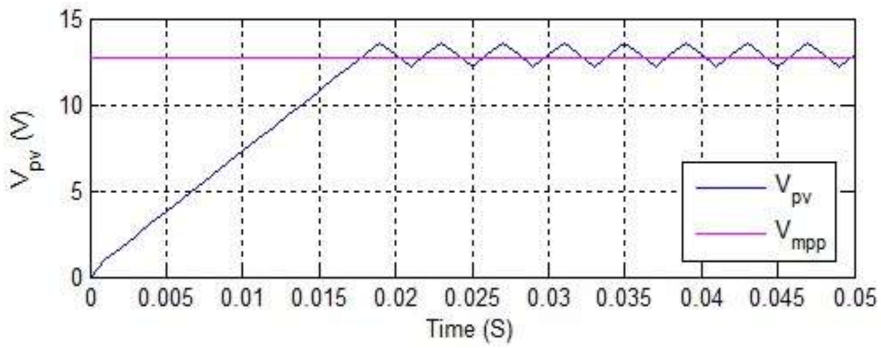

Fig.9: PV Voltage versus time curve produced by Perturb and Observe algorithm for step size of 0.7 and radiation of 1000 W/m^2.

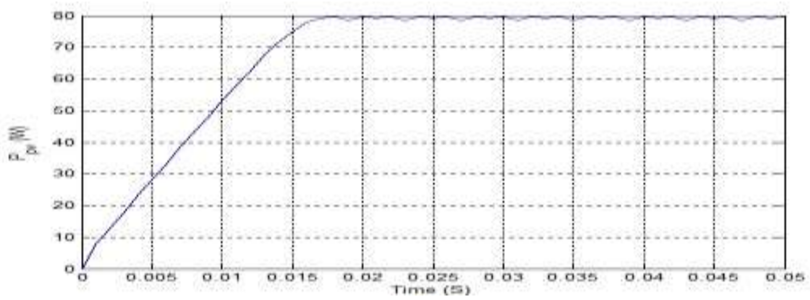

Fig.10: PV Power versus time curve produced by Perturb and Observe algorithm for step size of 0.7 and radiation of 1000 W/m^2

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The tracking time corresponding to Perturb and Observe algorithm is 18 millisecond and the power at maximum power point oscillates between 78.6-79.6W and the corresponding voltage varies between 12.2-13.5V.

4.2.2. Incremental Conductance

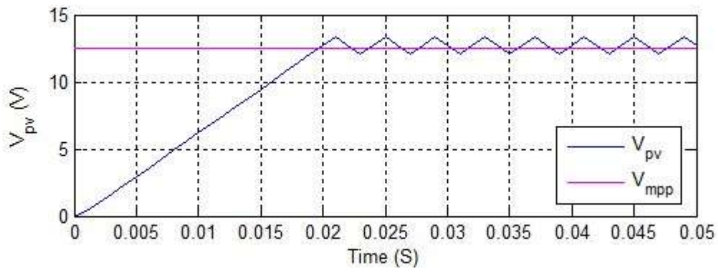

Fig.11: PV Voltage versus time curve generated by Incremental Conductance algorithm for step size of 0.7 and radiation of 1000 W/m^2

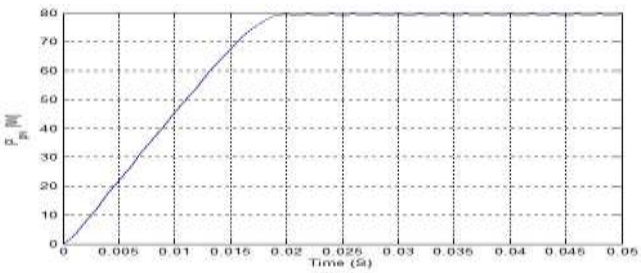

Fig.12: PV Power versus time curve generated by Incremental Conductance algorithm for step size of 0.7 and radiation of 1000 W/m^2

The tracking time corresponding to Incremental Conductance algorithm is 20 millisecond and the power at maximum power point oscillates between 79.1-79.7W and the corresponding voltage varies between 12.1-13.4V.

4.2.3. Fuzzy Logic Control

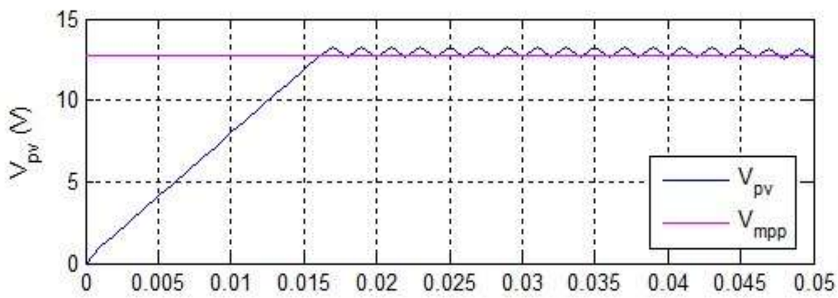

Fig.13: PV Voltage versus time curve generated by Fuzzy Logic Control for radiation of 1000W/m^2

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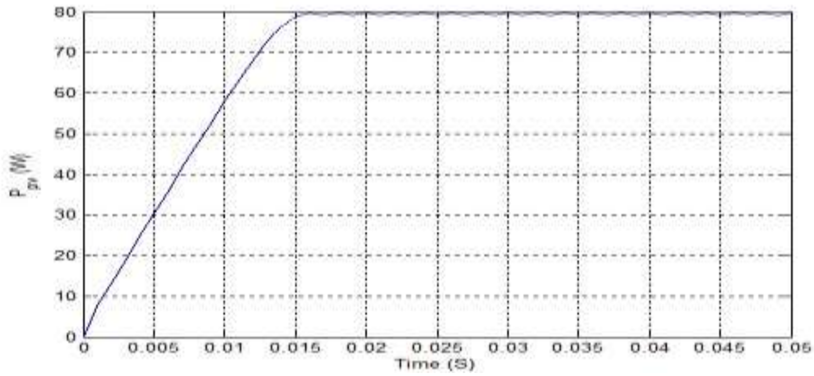

Fig14: PV Power versus time curve generated by Fuzzy Logic Control for radiation of 1000 W/m^2

The tracking time corresponding to Fuzzy Logic Control is 15.7millisecondand the power at maximum power point oscillates between 79.2-79.6Wand the corresponding voltage varies between 12.7-13.3V.

V. RESULTS

From the results obtained by simulation which are depicted in Table 1, clearly highlights that Perturb & Observe MPPT, Fuzzy logic MPPT and Incremental Conductance MPPT can trace the maximum power point.

Table 1 in addition to above, also gives a comparison between various techniques to trace maximum power point for a radiation of 1000 W/m^2.

Table 1- Comparative Analysis of different MPPT techniques

Sr. No.	**MPPT Technique**	**Variation in Power at maximum power point**	**Variation in Voltage at maximum power point**	**Ripple in Power(Watts)**	**Settling time (Millisecond)**
1.	Perturb & Observe	78.6-79.6W	12.2-13.5V	±1W	18 Millisecond
2.	Incremental Conductance	79.1-79.7W	12.1-13.4V	±0.6	20 Millisecond
3.	Fuzzy Logic Control	79.2-79.6W	12.7-13.3V	±0.4	15.7Millisecond

VI. CONCLUSION

From this chapter it is concluded that results obtained using Fuzzy logic control has minimum settling time and variation in power around maximum power point, in contrast to other conventional techniques, such as P&O, INC having more settling time and variation in power around maximum power point.

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