

MATLAB Modeling to Study the Effect of Partial Shading on PV Array Maximum Power Point - Review

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Abstract— In this review paper utilization of MATLAB software for control of photovoltaic power using Maximum Power Point Tracking (MPPT) The main aim of the paper is the conditioning system of solar-PV using design simulation along with a Maximum Power Point Tracking control mechanism. The PV module under various condition simulated using matlab. This simulation scheme suitable for I-V & P-V characteristics of the PV array due to partial shading under insolation. This paper give overview about used technique for power point tracking & provide brief discussion of their characteristics.

Keywords— PV modeling, MPPT techniques, Partial shading, Matlab simulation.

I. INTRODUCTION

Specific commands laws existing to bring devices to operate at maximum points of their characteristics without neither the knowledge in advance of these points nor the knowledge when they have been changed or what are the reasons for this change. This type of control is often referred to as maximum power point tracking (MPPT). The principle of these commands is to conduct a search of the point of maximum power while ensuring a perfect matching between the generator and load. Figure 1 shows a block diagram for an elementary photovoltaic system with an MPPT control. The system is based on a solar array, a DC-DC converter and a load. In our case the power supplied by the photovoltaic generator corresponds to the maximum power P_{MAX} generated and then transferred to the load.

The constant increase in the development of the solar cells manufacturing technology would definitely make the use of these technologies possible on a wider basis than what the scenario is presently. 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 thus is effective in the field of utilization of renewable sources of energy. There are many different approaches to maximizing power from PV cell, this range from using simple voltage relationship to more complex multiple base analysis. Depending on the application the dynamics of the irradiation, the power conversion needs to evaluate the various option.

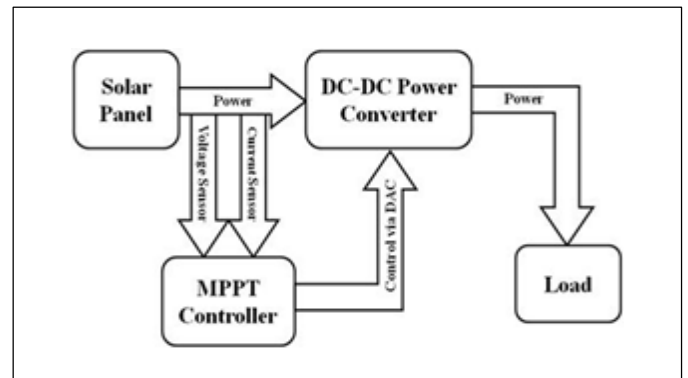


Fig. 1. Block Diagram for PV System with MPPT Command

II. PHOTOVOLTAIC EQUIVALENT MODEL

A PV is a array mainly consists of several photovoltaic cells which are arranged series and parallel connections. Series connections are accountable for increasing the voltage of the module whereas the parallel connection is responsible for increasing the current in the array. It is observed that a solar cell can be modeled by a current source and an inverted diode connected in parallel to it. It has its own series and parallel resistance. Series resistance is because of hindrance in the path of flow of electrons from n to p junction, parallel resistance is due to the leakage current.

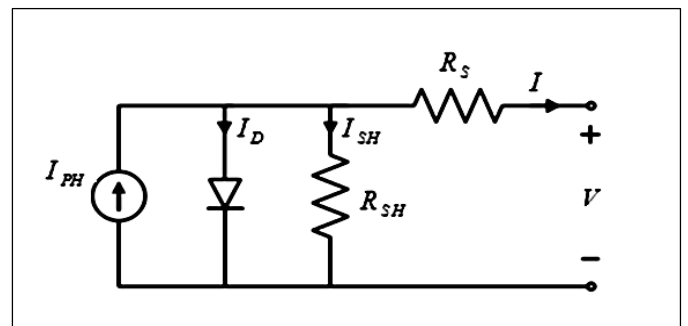


Fig. 2. Equivalent circuit of PV cell

In this model shown in fig. 2. we consider a current source (I_{PH}) along with a diode and series resistance (R_S). Here shunt resistance (R_{SH}) is in parallel and its value is very high, it has a negligible effect and can be neglected.

Simple PV output current:

$$I = I_{PH} - I_S \left[\left(\frac{V + IR_S}{K T_C A} \right) - 1 \right] - \frac{V - IR_S}{R_{SH}} \tag{1}$$

R_{SH} is parallel leakage resistance is typically large in PV cell model. This component can be neglected in many application excepted for low light condition. For accurate modeling of the solar panel, two diode circuit could have been used. But our scope of study is limited to single diode model. Following are the ideal characteristics of a solar array which show in fig. 3 and fig. 4. the variation of current and power with respect to voltage.

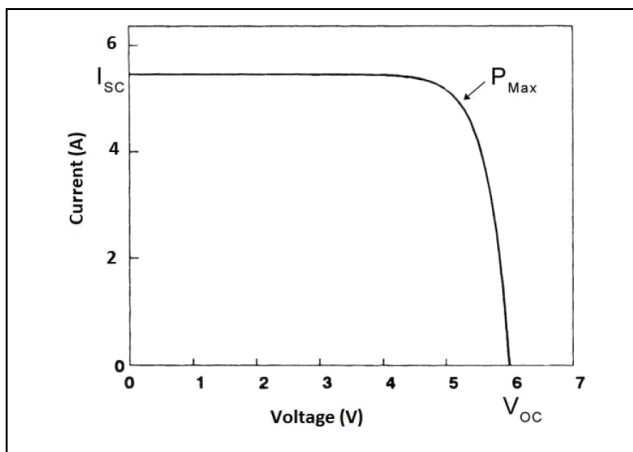


Fig. 3. I-V characteristics of a solar Cell

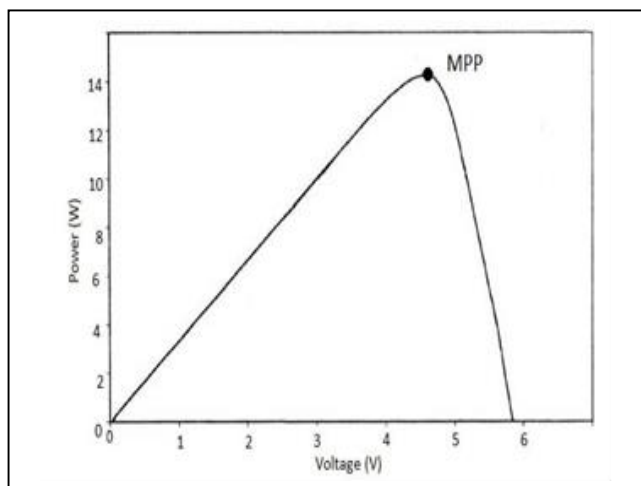


Fig-4 P-V characteristics of solar Cell

III. EFFECT OF PARTIAL SHADING ON PV

The functioning of a photovoltaic array is impacted by temperature, solar irradiance, shading, and array configuration. Frequently, the PV arrays get shadowed, wholly or partially, by the moving clouds, adjacent buildings and towers, trees, utility and telephone poles. The situation is of especial interest in case of big PV installations such as those used in distributed power generation systems. Under partly shaded conditions, the photovoltaic characteristics get more complex with more than one peaks. Yet, it is very

crucial to understand and predict them in order to draw out the maximum possible power. Here, we present a MATLAB-based modeling and simulation scheme desirable for studying the I-V and P-V characteristics of a photovoltaic array under a non- inhomogeneous insolation due to partial shading. It can also be used for acquiring and assessing new maximum power point tracking methods, especially for partially shaded conditions. It can also be used as a means to study the effects of shading patterns on PV panels having dissimilar forms. It is followed that, for a set number of PV modules, the array configuration (refers to the number of series and parallel connections) importantly bears on the maximum usable power under partially shaded conditions

IV. MPPT TECHNIQUE

The P-V and I-V curves of a solar cell are highly dependent on the solar irradiation values. The solar irradiation as a result of the environmental changes keeps on fluctuating, but control mechanisms are available that can track this change and can alter the working of the solar cell to meet the required load demands. Higher is the solar irradiation, higher would be the solar input to the solar cell and hence power magnitude would increase for the same voltage value. With increase in the solar irradiation the open circuit voltage increases. This is due to the fact that, when more sunlight incidents on to the solar cell, the electrons are supplied with higher excitation energy, thereby increasing the electron mobility and thus more power is generated.

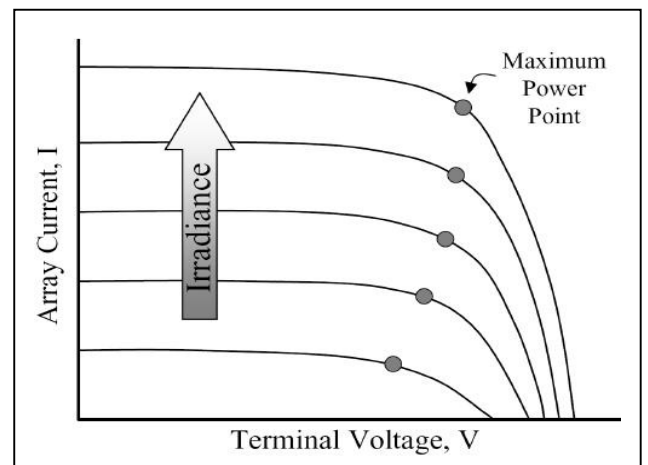


Fig. 5. I-V curve of a PV cell at irradiation.

A. Illustration

The PV system under study is shown in figure (1). A photovoltaic array is mainly used for conversion of sunlight into DC current. The output of the array is connected to a boost DC converter which is used to perform MPPT functions, increase the array terminal voltage to a higher value so it can be interfaced to the distribution system grid at 230 V. The DC converter controller is used to perform these two functions. A DC link capacitor is used after the DC converter and it acts as a temporary power storage device which is used to provide the voltage source inverter

through a steady flow of power. The controlled voltage source and the current source inverter have are used to interface the modeled panel with the rest of the system. The boost converter which are built using the SimPowerSystems is module of MATLAB. The block diagram for the model shown in Figure 2 is a simulation for the case where we obtain a varying voltage output. This model is used to highlight the difference between the power obtained on using an MPPT algorithm and the power obtained without using an MPPT algorithm.

**B. Illustration
Boost Converter**

In order to change the input resistance of the panel to match the load resistance, a DC to DC converter is required. From Fig. 5. it has been studied that the efficiency of the DC to DC converter is maximum for a buck converter, then for a buck-boost converter and minimum for a boost converter but as we intend to use our system either for tying to a grid or for a water pumping system which requires 230 V at the output end, so we use a boost converter.

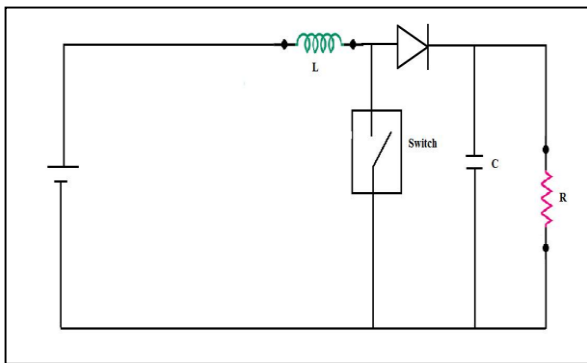


Fig. 5. Circuit diagram of a Boost Converter

When the switch is closed the inductor gets charged through the battery and stores the energy. In this mode inductor current rises (exponentially) but for simplicity we assume that the charging and the discharging of the inductor are linear. The diode blocks the current flowing and so the load current remains constant which is being supplied due to the discharging of the capacitor. When the switch is open and so the diode becomes short circuited. The energy stored in the inductor gets discharged through opposite polarities which charge the capacitor. The load current remains constant throughout the operation.

Different MPPT techniques

There are different techniques used to track the maximum power point. Few of the most popular techniques are:

- Perturb and Observe (hill climbing method)
- Incremental Conductance method
- Fractional short circuit current
- Fractional open circuit voltage
- Neural networks
- Fuzzy logic

The choice of the algorithm depends on the time complexity the algorithm takes to track the MPP, implementation cost and the ease of implementation.

MPPT technique	Convergence speed	Implementation on complexity	Periodic tuning	Sensed parameters
Perturb & observe	Varies	Low	No	Voltage
Incremental conductance	Varies	Medium	No	Voltage, current
Fractional V_{oc}	Medium	Low	Yes	Voltage
Fractional I_{sc}	Medium	Medium	Yes	Current
Fuzzy logic control	Fast	High	Yes	Varies
Neural network	Fast	High	Yes	Varies

Table 1. Characteristics of different MPPT techniques

I. CONCLUSION

This paper is an effort to review the main points presented in this work with suggested future research on the proposed method of maximum power point tracking. This paper has presented a literature review on the renewable energy resources and then highlighted the photovoltaic energy and its types and characteristics which is the main topic of this paper. A PV simulator is also developed using MATLAB/SIMULINK software which if supplied by the required data can simulate the behavior of any PV array. Also DC-DC boost converter model is simulated which is the key for changing the PV's terminal voltage to track the maximum power.

II. FUTURE WORK

Improvement to this model can be made by tracking the maximum power point in changing environmental conditions. Environmental effect can be change in solar irradiation or change in ambient temperature or even both. This can be done by using Simulink models to carry out MPPT instead of writing it code in Embedded MATLAB functions. In the Simulink models the solar irradiation and the temperature can be given as variable inputs instead of constant values as done here

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