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MATLAB MODELING OF PHOTOVOLTAIC CELL BY USING MPPT TECHNIQUE

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ABSTRACT

In this paper, MATLAB software is used for controlling the photovoltaic power using Maximum Power Point Tracking (MPPT) .The main objective of this paper is to provide the conditioning system of solar-PV using a Maximum Power Point Tracking (MPPT) control mechanism and design simulation. This simulation scheme Applicable for I-V & P-V characteristics of the PV array due to partial shading under observation. This paper gives overview about best technique for power point tracking & provides 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 PMAX 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.

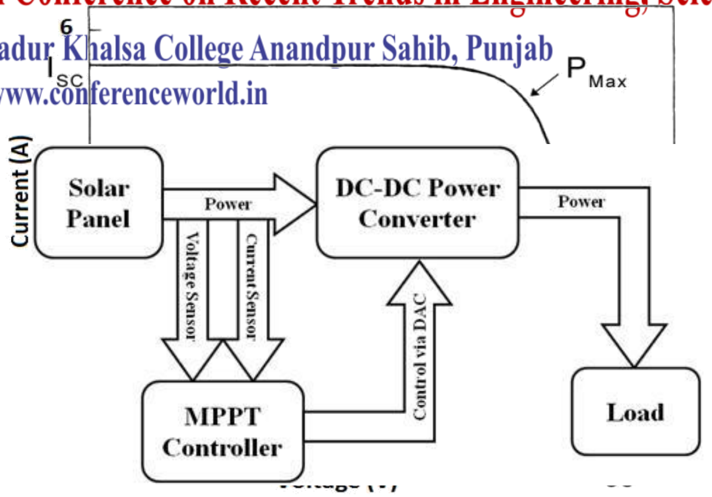

Fig 1: Block Diagram for PV System with MPPT Command

II. PHOTOVOLTIC EQUIVALENT MODEL

A PV is array mainly consists of several photovoltaic cells which are arranged series and parallel connections shown in fig. 2. 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.

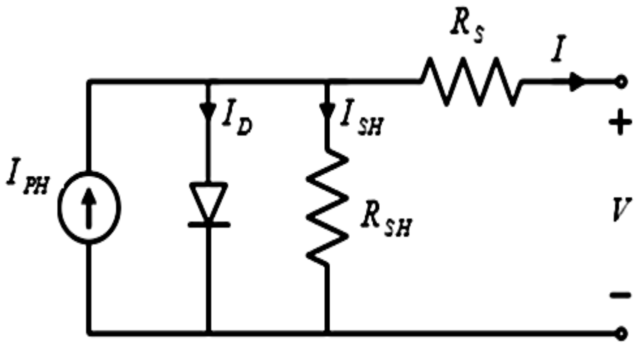

Fig 2: Equivalent circuit of PV cell

In 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.

Equation (1) shows simple PV output current: (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 fig. 3 and fig. 4 the variation of current and voltage with respect to voltage.

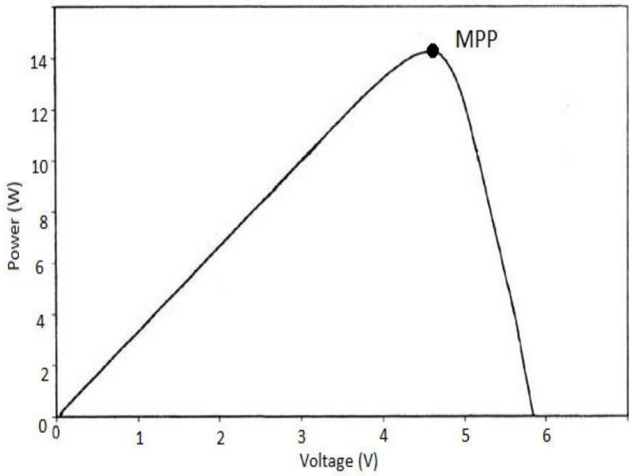

Fig. 3: I-V characteristics of a solar Cell

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 critical 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 evaluating 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 different 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 allows on the maximum usable power under partially shaded conditions

VI. MPPT TECHNIQUE

The P-V and I-V curves of a solar cell are highly dependent on the solar irradiation values. The solar irradiation is a result of the environmental variations keeps on shifting, but control tools are available that can track this change and can alter the working of the solar cell to meet the required load demands. In fig. 5 shows with increase in the solar irradiation the open circuit voltage will be increases. This is due to the point that, when more sunlight incidents on to the solar cell, the electrons are supplied with higher excitation energy, thereby increasing the electron movement and thus more power is generated.

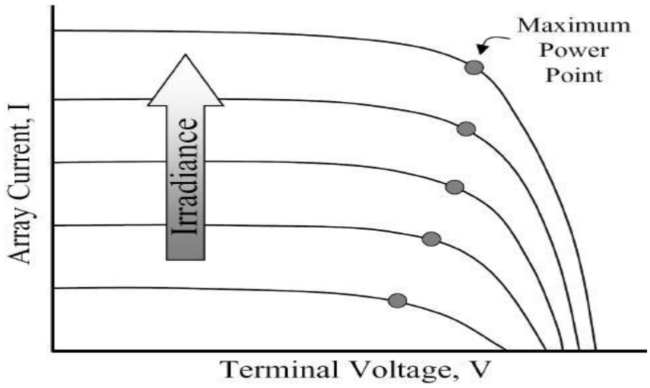

Fig. 5: I-V curve of a PV cell at irradiation.

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 5 is a simulation for the case where we obtain a varying voltage output.

B. Illustration

Boost Converter

As stated in the introduction, the maximum power point tracking is basically a load matching problem. In order to change the input resistance of the panel to match the load resistance (by varying the duty cycle), a DC to DC converter is required. 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 plan 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 shown in fig. 6.

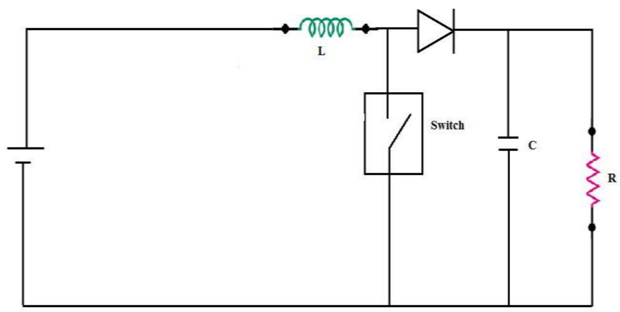

Fig. 6: Circuit diagram of a Boost Converter

If the switch is closed then the inductor will be charged through the battery and stores the energy. In this case inductor current increases but for easiness we assume that the charging and the discharging of the inductor are linear. The diode lumps the current flowing and so current of load remains constant which is being complete due to the discharging of the capacitor. When the switch is open and so the diode becomes short circuited. The inductor gets discharged through reverse polarities which charge the capacitor. The load current rests 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:

1) Perturb and Observe (hill climbing method)
2) Incremental Conductance method
3) Fractional short circuit current
4) Fractional open circuit voltage
5) Neural networks
6) 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.

V. SIMULATION BLOCK DIAGRAM

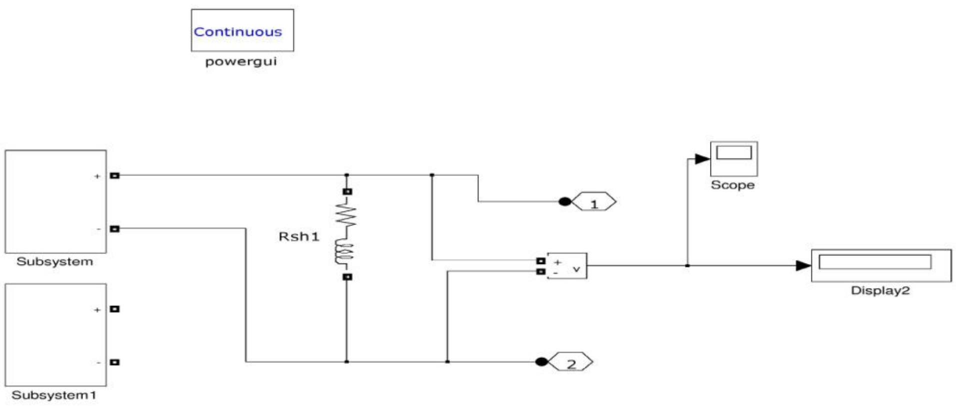

Fig.7: Simulink Model of PV System

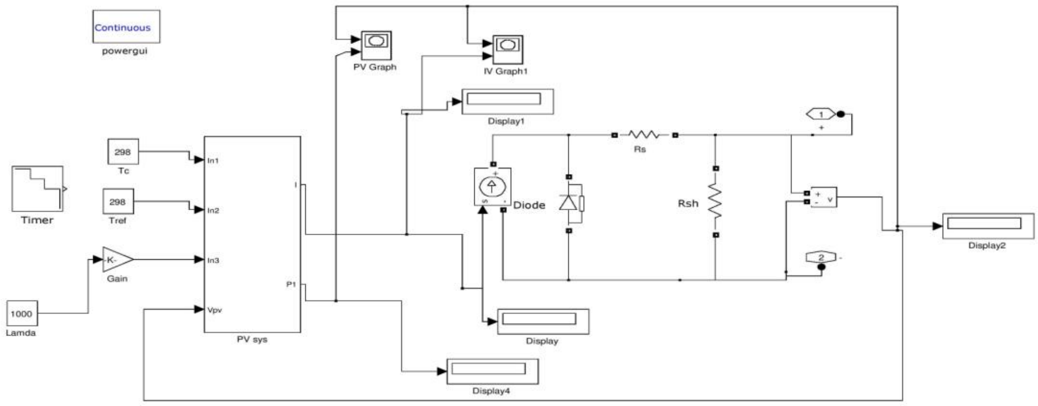

Fig.8: Block Diagram Model of solar PV System

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VI. SIMULATION RESULTS

The output of the model is as shown in fig. 9 and fig. 10. These two characteristics I-V (V on X-axis and I on Y-axis) and P-V (V on X-axis and P on Y-axis) are evaluate with irradiance is 900 W/m^2 and temperature of 25^{0}C. And simulate the PV cell model at Maximum Power Point shown in output characteristics.

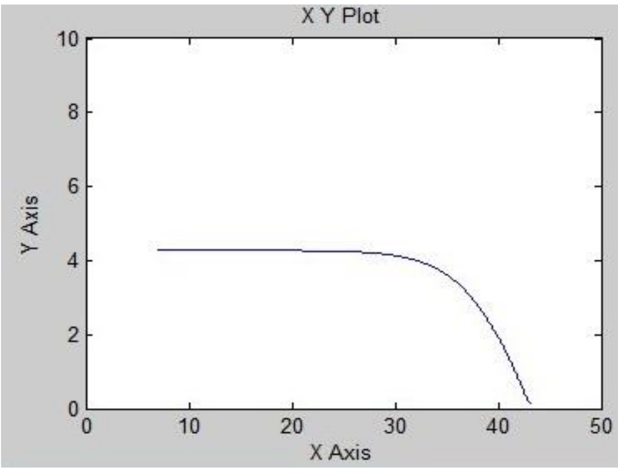

Fig. 9: I-V Characteristics of Solar PV system

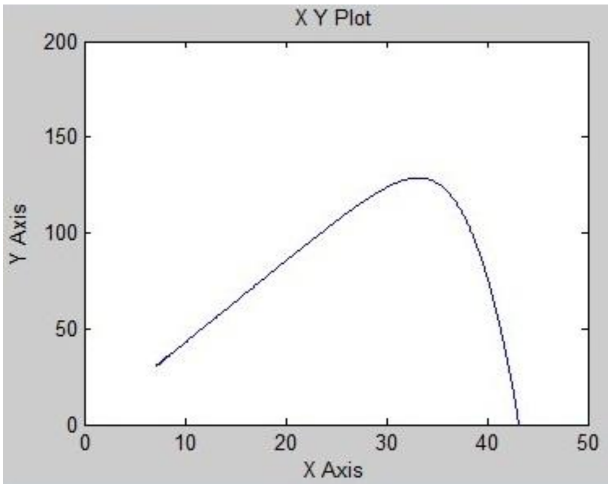

Fig. 10: P-V Characteristics of Solar PV system

The output of the model is as shown in fig. 11 and fig. 12. These two characteristics I-V (V on X-axis and I on Y-axis) and P-V (V on X-axis and P on Y-axis) are evaluate with irradiance is 1260 W/m^2 and temperature of 25^{0}C. And simulate the PV cell model at Maximum Power Point shown in output characteristics

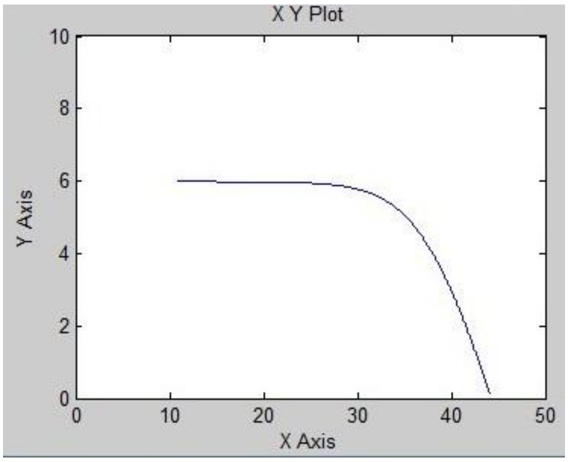

Fig. 11: I-V Characteristics of Solar PV system

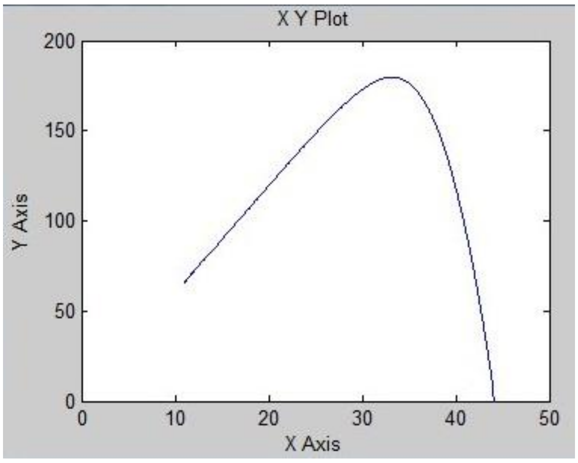

Fig. 12: P-V Characteristics of Solar PV system

VII. CONCLUSION

The partial shading conditions are having huge numbers of connected PV modules, which are used for obtaining I-V and P-V characteristics of PV array. By using MPPT technique obtained characteristics is of Maximum Power point curve in nature. The performance of PV array can be obtained by using standard condition at 1240 W/m^2 and 25^0 C. The simulation model is design to obtain most minimum configuration of PV array to get maximum power point curve. The above characteristics results are found by using MATLAB/SIMULINK model design for PV array at different shading condition. Also DC-DC boost converter model is simulated which is the key for changing the PV's terminal voltage to track the maximum power.

VIII. FUTURE WORK

Development to this PV cell model can be finished by tracking the maximum power point in changing environmental atmospheres. Environmental consequence can be variation in solar irradiation or change in ambient temperature or even together. This can be done by using Simulink models to become out MPPT in its place of writing it code in Embedded MATLAB functions. In this Simulink models the solar irradiation and the temperature can be definite as changeable inputs in its place of continuous values as done here.

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