

Efficiency Improvement of Partially Shaded PV System

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ABSTRACT: In PV system, the Maximum Power Point Tracking (MPPT) is used for the controlling process. The output of the PV system is obtained with the help of MPPT technique. If the irradiance in PV panel is less the output power will be reduced. To overcome this problem the proposed system is developed using “Distributed” MPPT (DMPPT) technique in which each panel is connected to separate MPPT. To compensate the voltage variation in different PV panel the Buck-Boost converter is used. Finally all the MPPT’s are connected in parallel to each other that increases efficiency of the partially shaded PV system.

KEYWORDS: DMPPT technique, Buck boost converter, Photovoltaic System

I. INTRODUCTION

The solar radiation is converted into electrical energy with the help of the Solar Photovoltaic (PV) cell. In recent day, the power generated from the solar PV system is the most popular method of power generation. Since the lifespan of solar panel is about 20-25 years it should be utilized in an effective manner. The maximum power point tracking (MPPT) technique is used to track the point at which maximum power is obtained in the PV panel of the solar system. Tracking of the maximum power point provides many peak powers at different times which seem to be the real challenging task.

There are different MPPT techniques available for the solar system as Perturb & Observe, Incremental conductance, Current sweep method etc. They calculate the present and past values of voltage and current and compare the values to get the exact maximum power point. This maximum power point generate the duty cycle which is used to drive the buck-boost converter. During the mismatches in the irradiance over the PV panel the conventional MPPT techniques is inefficient and reduce the production of power. This mismatch occurs due to the partially shaded condition which is due to the clouds, shadows of trees, buildings, overhead lines, etc.

During this mismatches, if the PV panels are connected in series with each other the output power of the system is affected which reduces the efficiency. To overcome such problem the Distributed Maximum Power Point Tracking (DMPPT) technique is introduced where each PV panel is connected to separate MPPT to get individual maximum power point. The DMPPT technique will increase the efficiency of the system by increasing the output power of the different PV panels.

II. BLOCK DIAGRAM

Existing System:

The solar system consists of more than one photovoltaic panel connected in parallel and series with each other to generate the power through the solar system. The MPPT is used to track the maximum point where the maximum power is obtained. In the existing system, MPPT is used commonly for all the PV panels which are connected in parallel as well as in series. The panels will provide an efficient output when the radiation from the sun is constant but if the radiation over the panel is changed will reduce the output power. So the final output will not be efficient that will not be helpful for commercial usage because of the fluctuations in the output. This problem will tend to reduce the lifetime of the PV panels.

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Proposed System:

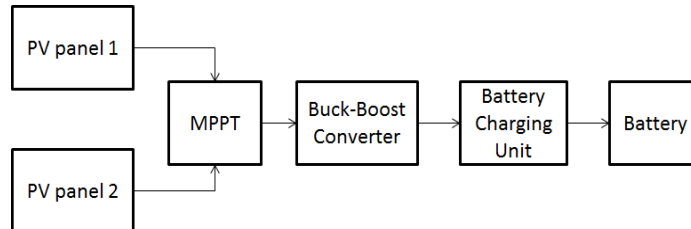


Fig. 1 Block diagram for existing system

The proposed system given in this paper will overcome the problems in the existing system by increasing the efficiency of the system during the change in irradiance. It is done with the help of separate MPPT for each panel along with buck-boost converter. Since we are using separate MPPT the maximum power point for every panel is noted individually and constant output is obtained using the buck-boost converter on any variation in the input. Thus the constant output is generated during difference in irradiance. The output from the buck-boost converter is given as the input to the battery charging unit which gives required voltage to the battery. The response will be faster when the MPPT is connected separately to each panel and provides more accuracy.

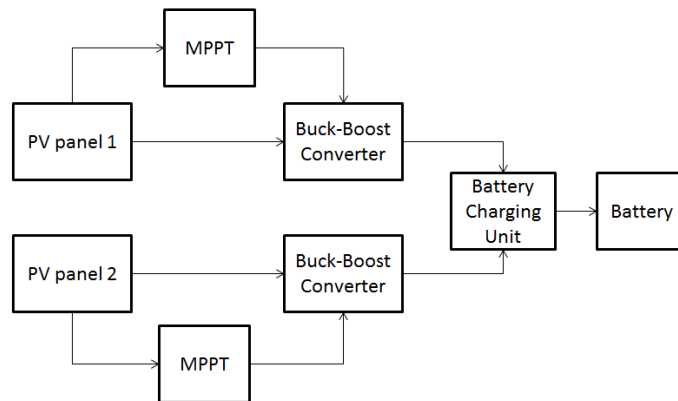


Fig. 2 Block diagram for existing system

III. SEGMENTS USED

In partially shaded condition, the output power reduces when the current generated from the series is reduced which is because of the lower current flow in the partially shaded PV module. This prevents the unshaded module to deliver the full output power. The temperature is increased as the shaded module is reversed biased and produce the local hotspot that damages the PV panel and the efficiency is reduced in the output.

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DMPPT:

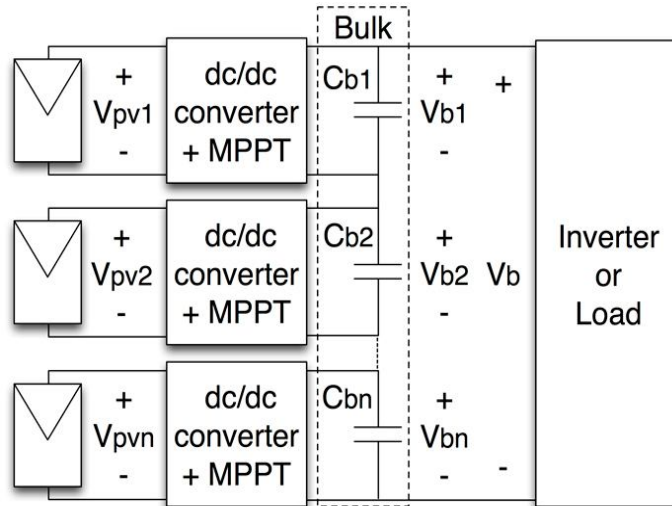


Fig.3. DMPPT for PV System

During the partially shaded condition the maximum power is obtained with the help of Distributed Maximum Power Point Tracking technique. When we are using DMPPT, the output power is depends on the module level instead of array level. In normal operation of PV system, the whole PV panel is connected to single MPPT which reduces the output if the irradiation is less. So the DMPPT is used which is connected to each panel separately that corrects the voltage differences and the output is constant for changes in irradiation. Thus the efficiency of the PV system is increased.

BUCK-BOOST CONVERTER:

The buck-boost converter will either buck or boost the output voltage (i.e.) output voltage will be either lesser than or greater than the input voltage. The buck or boost operation is performed based on the input voltage which is compared with the defined reference voltage.

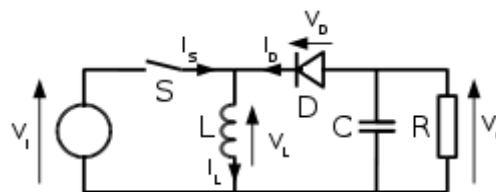


Fig.4. Buck-Boost Converter

The operation of buck-boost converter is as follows. During On-state condition (switch ON), the inductor L is connected directly to the input voltage source, where inductor L will store energy and the load is supplied by the energy which is stored in the capacitor. During Off-state condition (switch OFF), the energy that is stored in the inductor L is transferred to capacitor C and load. The relation between input and output voltage is given as

$$\frac{V_o}{V_i} = \frac{D}{(D - 1)}$$

MPPT Techniques:

There are different algorithms in performing the MPPT Techniques. Few of which is Perturb & Observe (P&O) algorithm, Incremental Conductance algorithm, Current sweep method, Constant voltage, etc., to find the point at which the maximum power is obtained [2].

i. Perturb& Observe:

The Perturb & Observe (P&O) algorithm is one of the algorithms which are used in MPPT techniques. It is also known as “Hill-climbing” technique. In this method, the power is measured and the voltage is controlled in the array.

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As the power varies the adjustment is made so as to reduce the change in power. This method only needs the voltage to calculate the maximum power point. The implementation of this method is easier method to find the maximum power point since it needs only the voltage value [9].

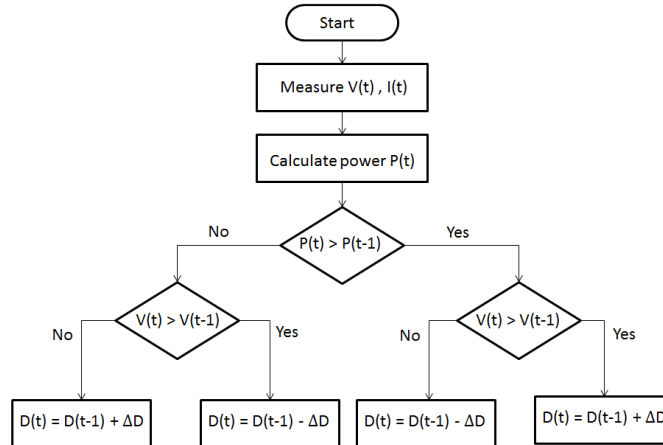


Fig.5. Flowchart of P&O algorithm

If the power is increased, the perturbation should be done in the same direction and if the power decreases, then the next perturbation should be done in the opposite direction. Based on these conditions, the algorithm is implemented. This process is repeated until the Maximum power point is reached. The response for variation in irradiation is little less when compared to incremental conductance method but this method is preferred because of its easier implementation.

ii. Incremental conductance method:

In this incremental conductance algorithm, the changes in array current and voltage is measured by the controller to predict the effective output voltage. More computation is required in this type of MPPT algorithm but its response is faster during the change in irradiance. First it will check whether there is a change in voltage. If there is a change in voltage then this method provides maximum power point by comparing the incremental conductance ($\Delta I / \Delta V$) and the array conductance (I / V). This method needs both the voltage and current to calculate the power and the point at which maximum power is obtained. This method provides more accuracy but the implementation is very complex when compared to the Perturb & Observe method of maximum power point technique.

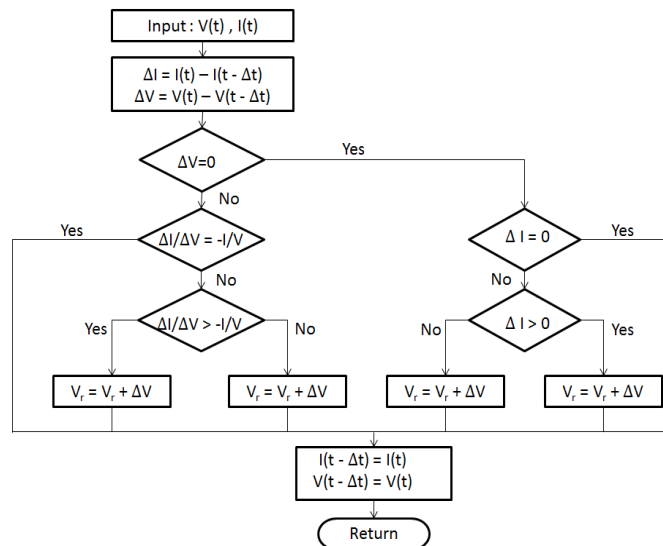


Fig.6. Flowchart of Incremental conductance algorithm

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Battery charger Unit:

It consists of boost converter and the controller in it. The boost converter is used to increase the output voltage which is capable of charging the battery. This maintains the voltage as constant value even there is the change in the voltage from the output of the PV panel.

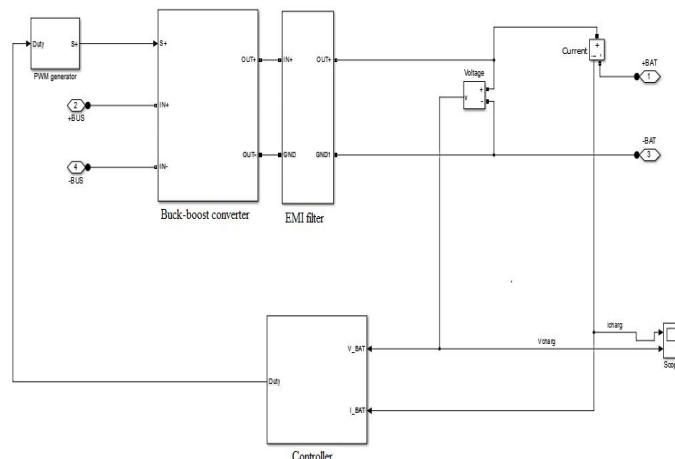


Fig.7. Simulation diagram of battery charging unit

The controller in the battery charging unit collects the output voltage information and kept it as a feedback to control the output voltage. The controller unit gets the current and voltage input and provides duty cycle to drive the boost converter for maintaining the constant output to charge the battery. The PWM generator is generates the pulse that is used to trigger the buck-boost converter. The output is maintained constant with the help of this converter.

IV. SIMULATION DIAGRAMS

Two PV panels are taken and connected in parallel to each other. Each PV panel has been provided with separate MPPT so that the change in irradiation doesn't affect the output of the system. If there is a change in irradiation, each MPPT provides certain duty cycle so as to maintain constant output at both the PV modules. The EMI filter is used to reduce the ripple in the DC output generated from the solar PV panel. The battery charger unit is placed after the EMI filter which is used to provide the required voltage that is needed to charge the battery. The boost converter is used to increase the voltage level of the output in the battery charger unit.

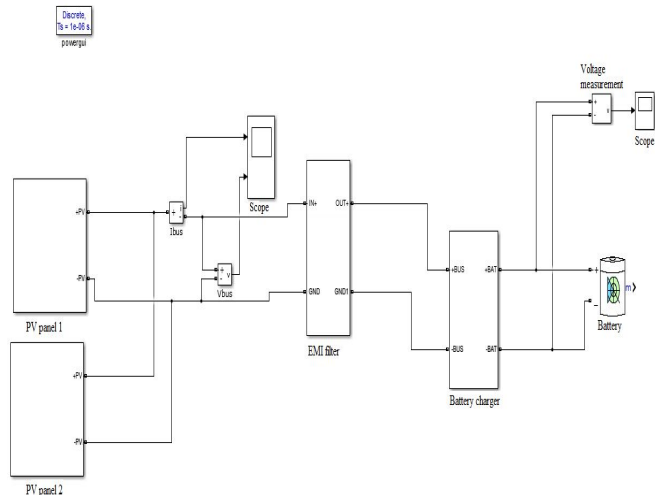


Fig.8. Main simulation diagram

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PV Panel Module Subsystem:

The current is generated from the PV panel while the voltage is produced with the help of the controlled current sensor. Both the current and the voltage value is measured and given to the input to the MPPT which also has the timer input that gives the information to the MPPT about how frequently the voltage and the current has to be measured from the solar panel. Finally by analyzing the voltage and the current value the duty cycle is created so as to trigger the buck-boost converter. This buck-boost converter either increments or decrements the output values which is obtained from the PV panel according to the reference voltage that is defined.

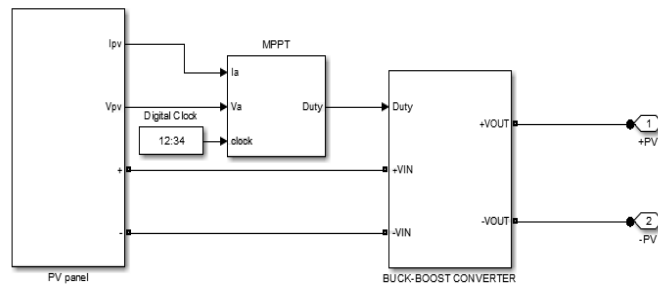


Fig.9. Simulation diagram of PV Panel

Two similar panels are connected in parallel to each other. The output is obtained at each panel. Since each panel are provided with the separate MPPT, during the changes of the irradiation occurs due to natural causes in the different panel the MPPT that is connected separately to each panel will provide duty cycle to corresponding buck-boost converter to produce constant output voltage.

V. SIMULATION RESULTS

The simulation results for the proposed system are obtained as follows. The output voltage is measured across the output terminal. The voltage obtained from it is to be capable for charging the battery. In the proposed system a 48V battery is used. To charge the 48V battery, the required input voltage to the battery has to be about 54V. Thus the battery charging unit is created and the voltage is boosted up to meet the requirement for charging the battery.

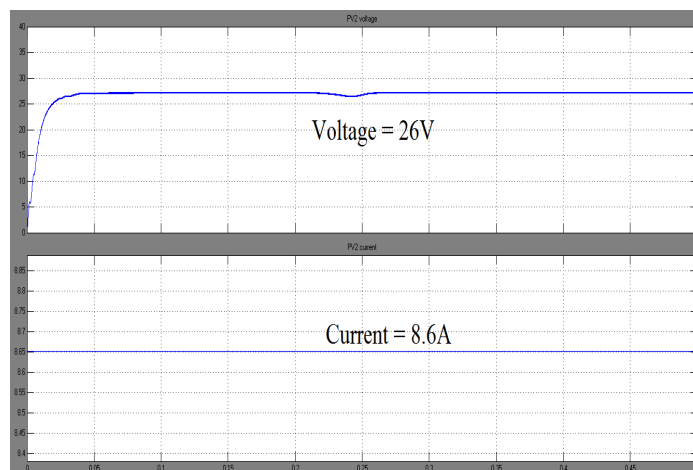


Fig.10.PV panel 1 output

The above output is obtained for the first PV panel which has the irradiation of 1 and temperature of 27°C. The output voltage for this PV panel is obtained of about 26V and the current is obtained as 8.8A. This output is boosted up by the buck-boost converter that is provided to it for getting the constant output voltage even during variation in the irradiance obtained from the sun. The output for the second PV panel is obtained as shown below

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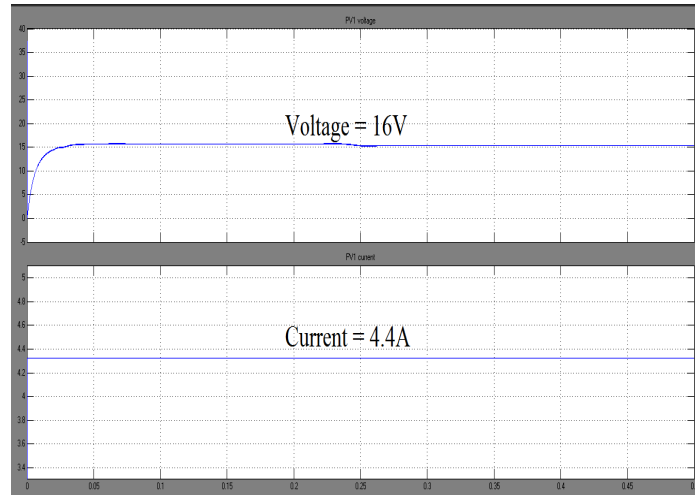


Fig..11. PV panel 2 output

The irradiance of 0.5 and temperature of 27°C is given to second panel and the output voltage is obtained at the range of 16V while the current is obtained as 4.4A. Since the irradiance is less in this panel, the output voltage is reduced according to the variation. These variations will result in the reduction of the efficiency of the system. So the buck-boost converter is used to boost the output voltage to a constant level at both the PV panels. Now the output from both the PV panels is similar to each other. As the panels are connected in parallel to each other they are combined together and the resultant output is obtained as follows.

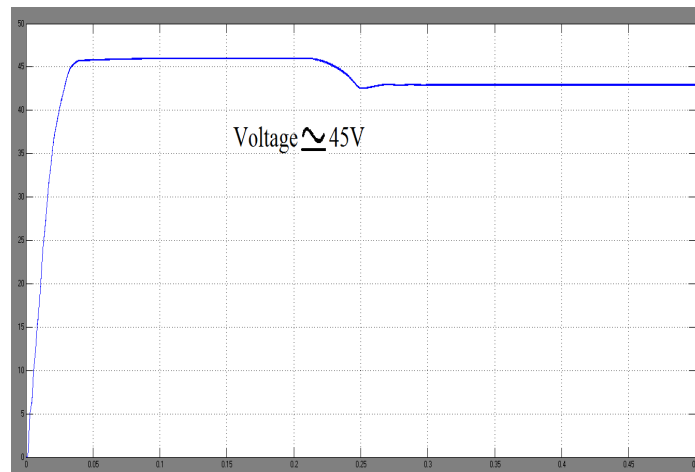


Fig 12. Output voltage of parallel connected PV panel

After connecting both the PV panel in parallel, the output voltage is obtained nearly 45V. But this output voltage is not enough to charge 48V battery, so the battery charging unit is used after the PV panels to regulate the output voltage. The boost converter is used as a part of battery charging unit to increase the output voltage to meet the requirement for charging the battery.

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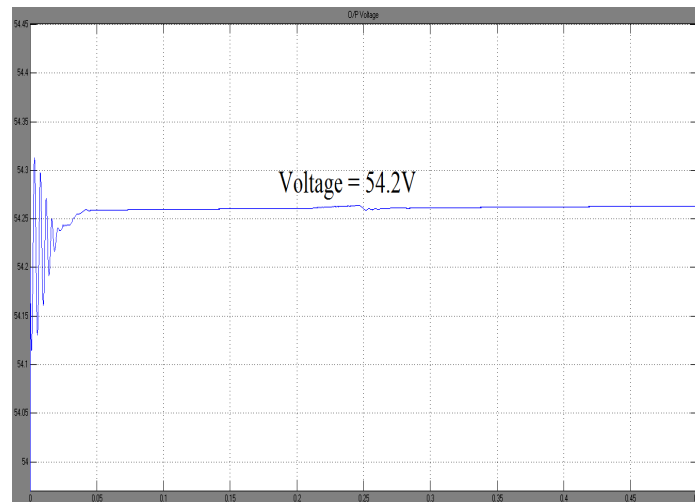


Fig. 13. Overall output voltage

At initial condition, few oscillations occurs due to the switching of the converters for short period of time, after few period the oscillation is reduced and the output is made steady which is useful to charge the battery. The output voltage of about 54V is reached after the boost converter. The output is stable at this range which required for charging the battery.

VI. CONCLUSION

The Distributed Maximum Power Point Tracking (DMPPT) technique is used in this paper which gives more efficiency than the normal MPPT method. The usage of separate MPPT for each and every PV panel will control the output of each PV panel and boost the output to a constant voltage even there is a change in irradiation. Such process provides the same output at all the PV panel which provides stable output. Due to this, the final output can be controlled easily and provides the constant output voltage throughout the process. The battery is used to store the energy that is generated from the PV panel. To charge the battery it requires almost constant output to avoid the damage of battery. The usage of normal MPPT technique will not result in the constant output during partially shaded condition. But the implementation of DMPPT technique yields the constant output voltage to charge the battery.

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