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Maximum Power Point Tracking Control for PV Systems

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Abstract: The world has shifted to cleaner sources of energy to meet the growing demands of energy and to adhere to the sustainable development goals with environment protection as the top priority. Solar power is one such cleaner sources of energy which meets the human needs of electricity and power. Photovoltaic cells or PV cells are used to convert sun's energy into electricity. PV cells work on the principle of photoelectric effect. The power output of PV cells is dependent on various conditions. Maximum power output of PV cell is decided by MPPT, Maximum Power Point Tracking. The maximum power which can be produced in a PV cell due to voltage is the peak power voltage called as Maximum Power Point. This paper is the overview of Maximum Power Point Tracking by use of Matlab software of study and analysis. The maximum power output of PV cells varies with intensity of solar rays, temperature, humidity, current flow etc.
Keywords: pv cells, mppt, solar energy, matlab

I. INTRODUCTION

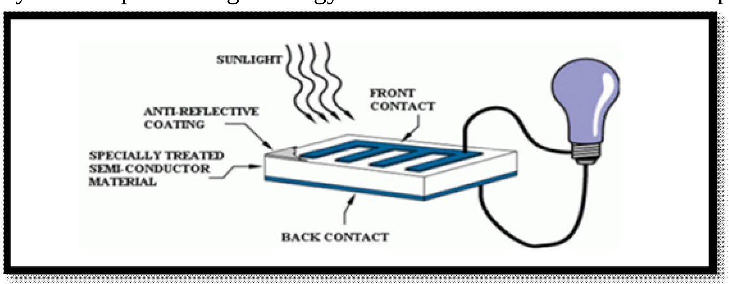
Solar energy is one of the most abundant forms of energy present on Earth whose efficient utilization can reduce the burden of the fossil fuels. Solar energy is pollution free thus it has no negative effect on the solar system.

Photovoltaic cells or solar cells are used to convert sun's heat and light into electricity. Solar cells work on the principle of photoelectric effect. The photovoltaic cells are made of semiconductor materials like Silicon. These semiconductor materials emit electrons when hit by the solar light consisting of protons. These free electrons when captured result into electricity.

MPPT **or** Maximum Power Point Tracking is the method which is used for obtaining the maximum power from PV cell at specific conditions. The peak voltage which produces the maximum power in a PV module is called maximum power point. Maximum power varies with solar radiation, ambient temperature and solar cell temperature.

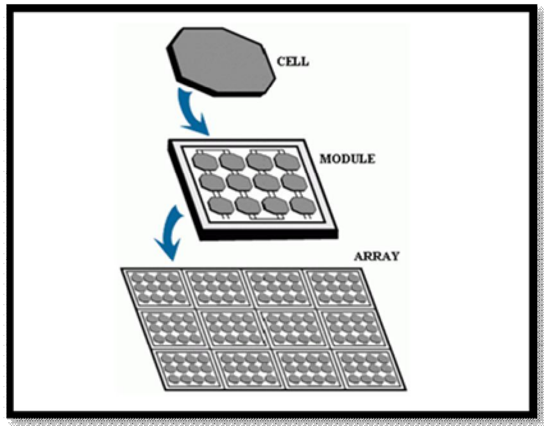
II. PHOTOVOLTAICS

The conversion of sun's light into electricity is called as Photovoltaics. This photovoltaic is exhibited by some materials like Silicon . these materials absorb energy from the sun , photons of light and release electrons. These electrons are then captured and tuned to give electric current. This property of absorption of light energy and release of electron is called as photoelectric effect.



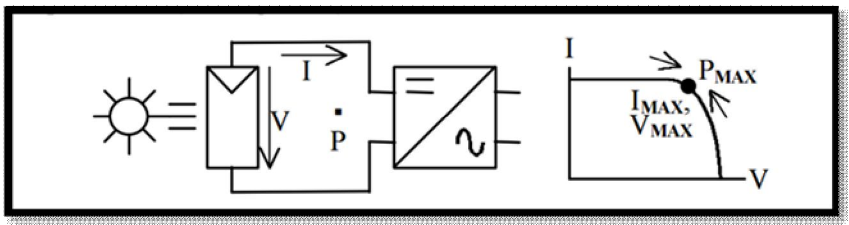
A simple photovoltaic cell or a solar cell is shown in the figure above. Solar cells are built some special kind of materials called as semiconductor materials. Examples of semiconductor materials are silicon, germanium etc as per specific requirements. The solar cells have a thin semiconductor wafer which forms an electric field, with both positive and negative sides. When sun's energy hits the solar cell, free electrons are released from the atoms in the semiconductor material. The released electrons are captured with the conductors completing the circuit of positive and negative and the electrons flow as electric current , constituting the flow of electricity . This generated electricity from sun's energy can be used to power the load, or light the house appliances, water heaters etc.

Multiple solar cells which are electrically connected to each other and mounted in a support structure or frame is called a photovoltaic module. Modules are designed to for specific requirements and voltages for generation of electricity, such as a common 12 volts system. The current produced is directly dependent on how much sun's light strikes the module.

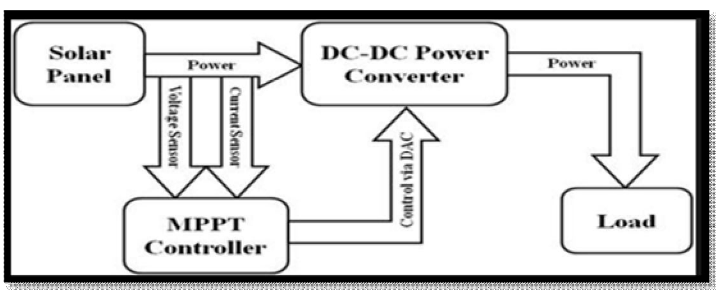


MPPT Algorithms

Maximum power point tracking (MPPT) is the algorithm which is performed by some battery charge controllers and by most grid connected PV inverters. The governing condition is the adjustment of the operating voltage of the pv cell to produce maximum and optimum power output closely related to theoretical value of pmax.



There are different methods – direct and indirect method for the tracking of maximum power point . the direct methods uses the calculated values of AC output power values or DC input voltage and current and by varying the operational points of the Pv cells , actual maximum power point is determined. There could be continuous or intermittent Mpp adjustments and the algorithms may or maynot include mpp which is artifical for search. The methods which use an external signal to measure and calculate mpp are the indirect methods. The measurement of radiance, cell temperature, current in short circuit condition or voltage in open circuit conditions are such outside or external signals. Mpp set point is calculated and monitored under a given set of physical parameters. The simple block diagram shows the solar panel, mppt controller, dc-dc power converter and supply of power to load through the solar energy conversion mechanism with mppt in consideration.



MPPT Principle

The mppt works on the principle of derivation of maximum power from pv cell or pv module by allowing the operation of pv module at the optimum voltage. The ouput of pv module is checked by the mppt and then compared to the battery voltage and then analysed the maximum power pv module can produce at the voltage which supplies battery maximum current. The mppt can be used to power a dc load which is connected to the battery.

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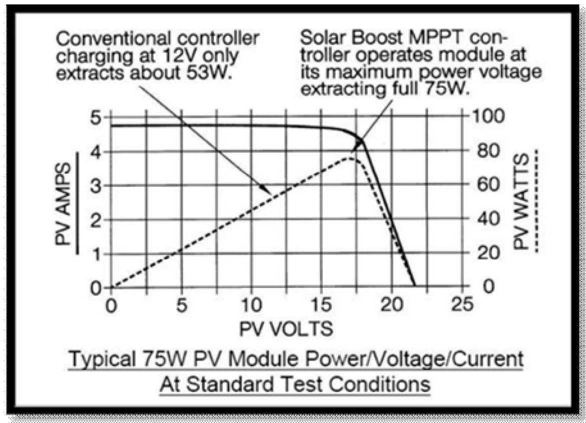
To ensure that maximum current reaches the battery from pv module, mppt has an addition charge controller embedded in it.. MPPT takes dc input from the pv cell , converts it to ac and the reconverts the ac to different dc voltage and current to ensure maximum supply of pv cell power to the battery. These mppt solar charge controllers are useful in various applications in home or offices etc be it water system, light system etc.



III. CHARACTERISTICS OF MPPT

A. The features of MPPT solar charge controller are-

1) Accuracy in variations of I-V characteristics of solar cell.
2) To obtain maximum power from PV module.
3) Use of higher voltage output than battery voltage.
4) Complexity of system reduced.
5) High efficiency output.
6) Extended to other renewable energy sources.

IV. MPPT METHODS

There are various MPPT methods to optimize the power output of pv cells. The various methods are listed below and some of the methods are discussed further.

A. Constant Voltage

The constant voltage method is the simplest method. This method simply uses single voltage to represent the VMP. In some cases this value is programmed by an external resistor connected to a current source pin of the control IC. In this case, this resistor can be part of a network that includes a NTC thermistor so the value can be temperature compensated. Reference 1 gives this method an overall rating of about 80%. This means that for the various different irradiance variations, the method will collect about 80% of the available maximum power. The actual performance will be determined by the average level of irradiance. In the cases of low levels of irradiance the results can be better.

B. Perturb and Observe

Perturb and Observe (P and O) searches for the maximum power point by changing the PV voltage or current and detecting the change in PV power output. The direction of the change is reversed when the PV power decreases. P and O can have issues at low irradiance that result in oscillation. There can also be issues when there are fast changes in the irradiance which can result in initially choosing the wrong direction of search. The designer has a choice of either changing the PV voltage or current. Figure 8 shows that changes in VMP are closely related to ln(irradiance) and Figure 9 shows that IMP is proportional to irradiance. Tracking PV power by changing the PV voltage is less sensitive to changes in irradiance. This becomes more of an issue as the irradiance decreases as shown in Figure 10. So finding IMP will better locate the maximum power point particularly at lower insulation. Choosing the proper step size for the search is important. Too large will result in oscillation about the maximum power point and too small will result in slow response to changes in irradiance. To reduce the response to noise, averaging the PV power value is important when making a direction decision. Keep in mind that whenever the system is not at the maximum power point, it is not operating at the optimal point.

C. Incremental conductance

In the incremental conductance method, the controller measures incremental changes in PV array current and voltage to predict the effect of a voltage change. This method requires more computation in the controller, but can track changing conditions more rapidly than the perturb and observe method (P&O). Like the P&O algorithm, it can produce oscillations in power output. This method utilizes the incremental conductance (dI/dV) of the photovoltaic array to compute the sign of the change in power with respect to voltage (dP/dV). The incremental conductance method computes the maximum power point by comparison of the incremental conductance (I_Δ / V_Δ) to the array conductance (I / V). When these two are the same (I / V = I_Δ / V_Δ), the output voltage is the MPP voltage. The controller maintains this voltage until the irradiation changes and the process is repeated. The incremental conductance method is based on the observation that at the maximum power point dP/dV = 0, and that P = IV. The current from the array can be expressed is a function of the voltage: P = I(V)V. Therefore dP/dV = VdI/dV + I(V). Setting this equal to zero yields: dI/dV = -I(V)/V. Therefore, the maximum power point is achieved when the incremental conductance is equal to the negative of the instantaneous conductance.

V. CONCLUSION

The maximum power point tracking of solar cells or pv modules differ with the varied algorithms followed and different methods used for the calculation of output power. The output power efficiency also varies with different conditions of temperature and humidity and other atmospheric conditions. The mppt solar controller is a tool for simplifying the solar system and increases the output power efficiency. This calculations can be analysed in various software tools like matlab, labview etc.

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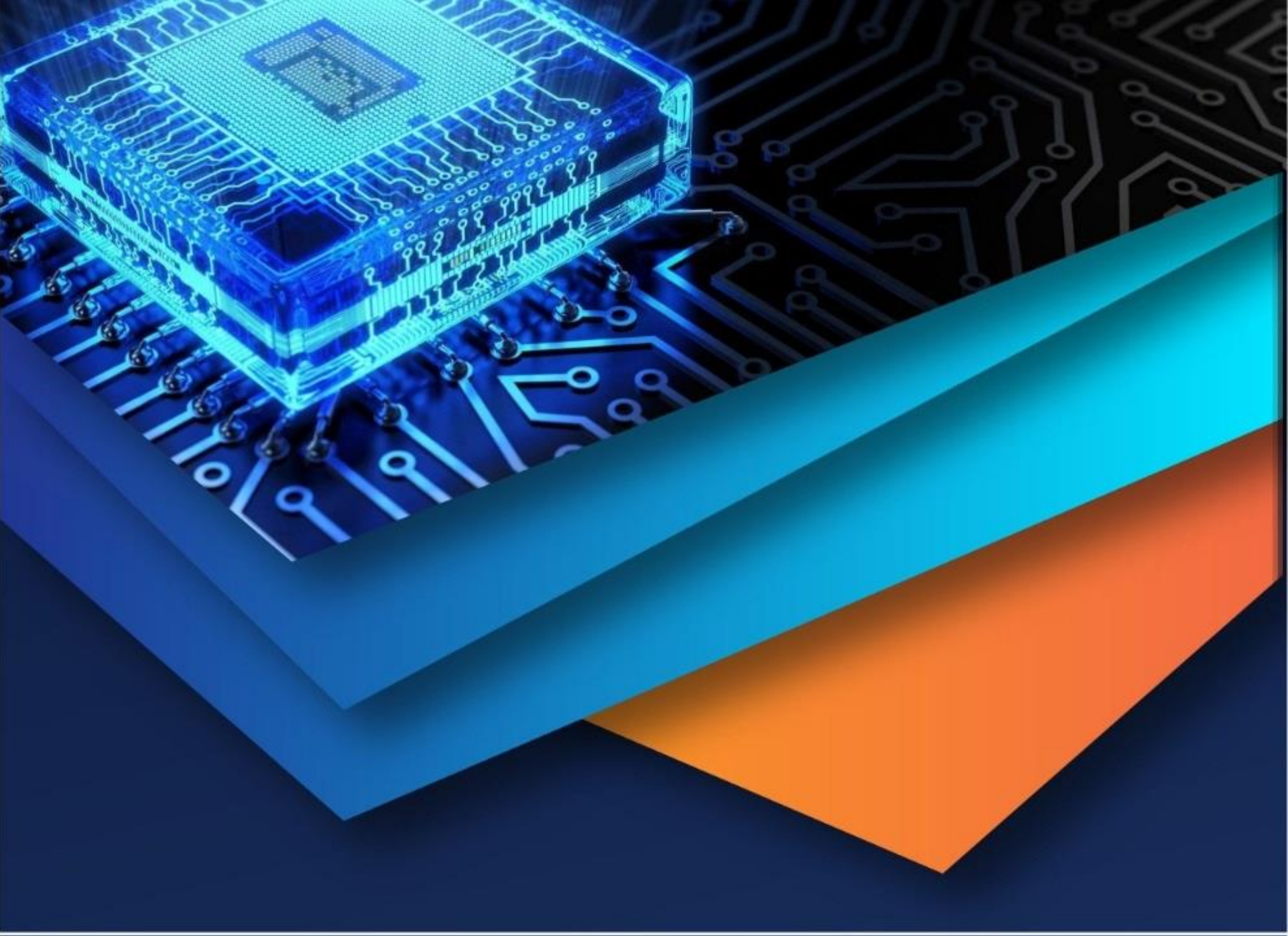

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