ANALYSIS OF SOLAR BASED DC-DC CONVERTER WITH MPPT

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Abstract

The solar photovoltaic power is one of the most widely used renewable source of energy in developed as well as developing nations. Producing electrical energy from solar energy doesn't cause any environmental pollution. Due to serious energy crisis and environmental pollution, solar power has attained great attention. With the same rate of use of the fossil fuels, they would get extinct in about 100 years. Considering the availability, world has turned to solar energy to meet the increasing demand. The purpose of this paper is to study the performance of PV arrays under varying weather conditions, taking the irradiance and temperature into consideration. The main purpose of this PV system is to reduce the amount of electricity that is being imported form the electrical network. The PV arrays receive the sunlight in the form of DC and this is converted into AC and injected into the grid through an interfacing inverter. The controller of this system implements MPPT (Maximum Power Point Tracking). The MPPT method used I here is Incremental Conductance method. The efficiency of the solar cells has been improved through MPPT algorithm.

I. INTRODUCTION

Electricity is one of the most essential needs for humans in the present. With the focus on greener sources of power, PV systems have become important source of power for a wide range of applications. Improvements in converting light energy into electrical energy as well as the cost reductions have helped create this growth. This conversion not only improves the generation of electricity but also reduces the pollution due to fossil fuels. The output of solar panel depends on solar irradiance, temperature and the load impedance. As the load impedance depends upon the application a DC-DC converter is used for improving the performance of solar panel. In this paper, the converter used is Dc-DC Boost Converter.

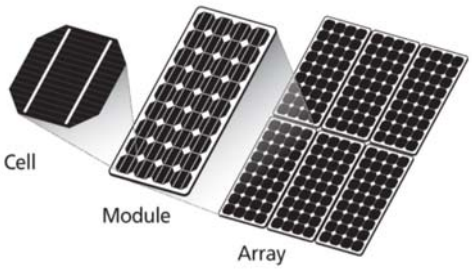
The conversion efficiency of electric power generation is low, especially under low irradiation conditions, and the amount of electric power generated by solar arrays changes continuously with weather conditions. The I-V characteristic of solar cell is non-linear and varies with irradiation and temperature. There is a unique point on the I-V or P-V curve called the MPP (Maximum Power Point), at which the entire PV system operates with maximum efficiency and produces its maximum output power. The location of the MPP is not known, but can be located, either through calculation methods or search algorithms. Therefore, MPPT techniques are needed to maintain the PV array's operating point at its MPP.

II. PHOTOVOLTAIC CELL

Conversion of light energy to electrical energy is based on a phenomenon called photovoltaic effect. Photovoltaic cell is the basic unit of the system where photovoltaic effect is utilized to produce electricity from light energy. Silicon is the most widely used semiconductor material for constructing photovoltaic cell. In a solid crystal, each silicon atom shares each of its valence electrons with another nearest silicon

atom, hence creating covalent bond between them. In this way, silicon crystal gets a tetrahedral lattice structure. While light ray strikes on the material some portion of light is reflected, some portion is transmitted through the material and the rest is absorbed by the material. If the intensity of incident light is high enough, sufficient amount of photons are absorbed by the crystal and these photons in turn excite some of the electrons of covalent bonds. These excited electrons then get sufficient energy to migrate from valance band to conduction band. As the energy level of these electrons is in conduction band they leave from the covalent bond leaving a hole in the bond behind each removed electron. These are called free electrons. These free electrons and holes have vital role in creating electricity in photovoltaic cell. These electrons and holes are hence called light generated electrons and holes respectively. These alone can't degenerate electricity. So, a pentavalent impurity such as phosphorous is added. Four valance electrons create covalent bond and the fifth electron is loosely bond to the parent atom. These loosely bond electrons conduct current in semiconductor.

The PV cells are wired in series and parallel. The number of cells in series indicates the voltage of the panel. While in parallel indicates the current. Bypass diodes are connected anti-parallel to the solar cell to avoid destruction of the shaded cell or of the lamination.



To understand the electronic behavior of a cell, it is useful to create a model which is electrically equivalent and is based on discrete ideal electrical components whose behavior is well defined.

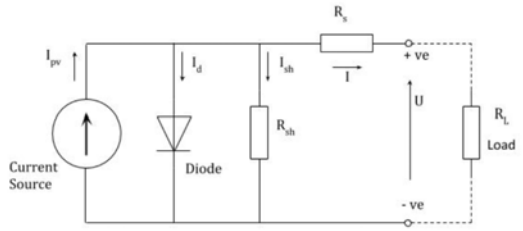
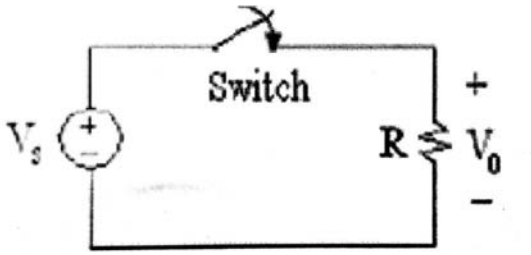


Figure 1: Equivalent circuit of PV Cell

III. DC-DC CONVERTER

A DC-DC converter is used to change the DC voltage from one level to another.



A basic DC-DC converter takes the current and passes it through a switching element, which turns the DC signal into an AC square wave signal. The wave is, and then passes through another filter which turns it back into a DC signal of required voltage.

In this paper we use a boost converter.

IV. MPPT (MAXIMUM POWER POINT TRACKING)

In case of the PV modules, there always exists a single operating point, at any point of time, where maximum power can be drawn. That point is to be tracked or located and it has to be seen that the operating point of the PV module is always at that point of hovering near that point. This point is called MPP. To increase the efficiency of the system it is important to operate PV system always at its MPP.

MPPT is a technique used to extract maximum available power from PV module. This is done with the help of DC-DC converter which operates in such a way that the output of converter always gives the maximum power that is produced by module in specific environment.

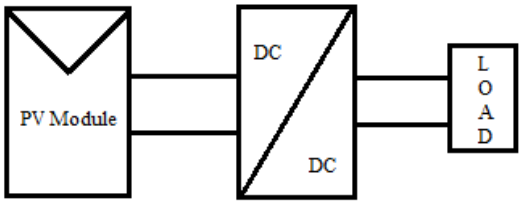


Figure 2: Block diagram of MPPT

The weather and load changes cause the operation of a PV system to vary almost all the times. A dynamic tracking technique is important to ensure maximum power is obtained from the photovoltaic arrays. The following algorithms are the fundamental MPPT algorithms, and they can be developed using micro controllers. However, the most widely used MPPT algorithms are considered here. They are:

1. Perturb and Observe method (P & O)
2. Incremental Conductance method
3. Constant voltage method (CV)
4. Short circuit pulse method (SC)
5. Current sweep method.

Among these P & O and IC are the most commonly used algorithms.

V. INCREMENTAL CONDUCTANCE METHOD

This method uses the incremental conductance method dI/dV to compute the sign of dP/dV. When dI/dV is equal and opposite to the value of I/V the algorithm knows that maximum power has reached and there it ends and returns the corresponding value of operating voltage for MPP.

The power of the panel is,

$$P = V * I \qquad \ldots\ldots(1)$$

Differentiating with respect to voltage,

$$dP / dV = d(V * I) / dV \qquad \ldots\ldots.(2)$$

$$dP / dV = 1 + V * (dI/dV) \qquad \ldots\ldots(3)$$

When the maximum power point reaches zero then the condition will be:

$$dP / dV = 0$$

substitute equation (2) in (3)

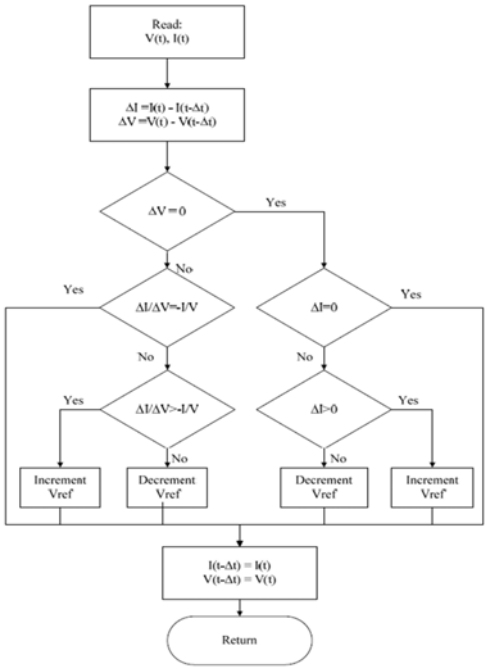
$$1 + V * (dI/dV) = 0 \qquad \ldots\ldots.(4)$$

$$dI/dv = -1/V \qquad \ldots\ldots.(5)$$

The problem with Incremental Conductance method is that the operating point keeps on oscillating for larger increment and for smaller increment time to track MPP is longer.

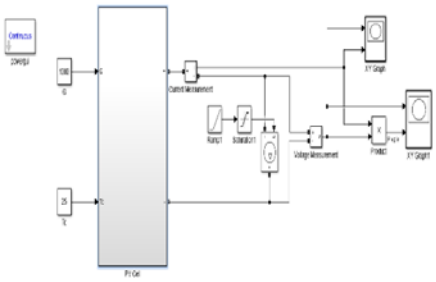
Algorithm of Incremental conductance method:

The following figure represents the algorithm of incremental conductance method. In this case, both the voltage and current values are changes to obtain the MPP. So, here he oscillating condition of the MPP is not observed and is very accurate.

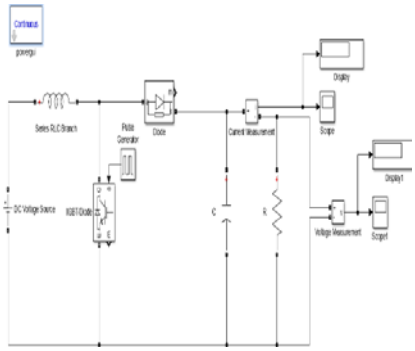


VI. SIMULATION MODELS

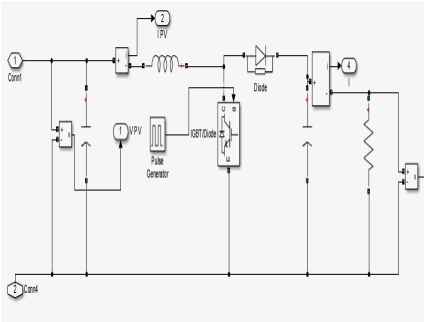
A. Simulink model of single PV cell



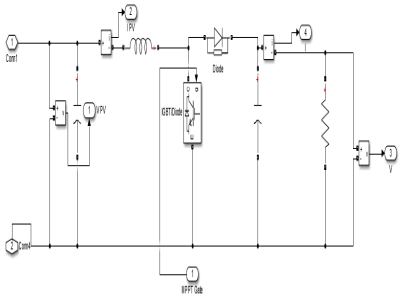
B. Simulink model of DC-DC converter



C. Simulink model of PV and Boost converter with PG

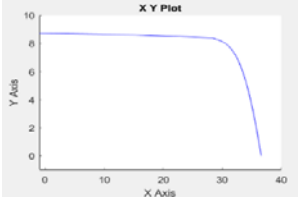


D. Simulink model of PV and Boost converter with MPPT

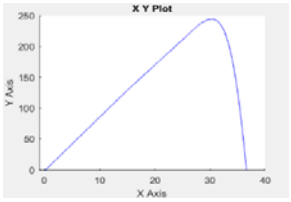


VII. SIMULATION RESULTS

A. IV and PV characteristics of single PV cell

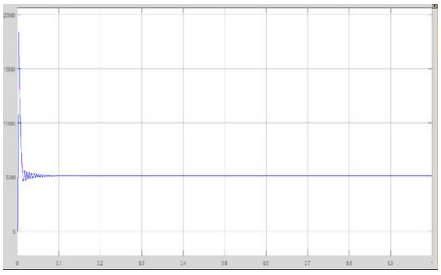


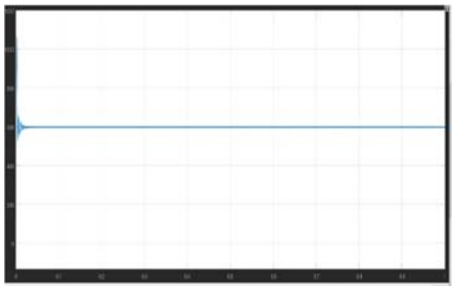
IV characteristics



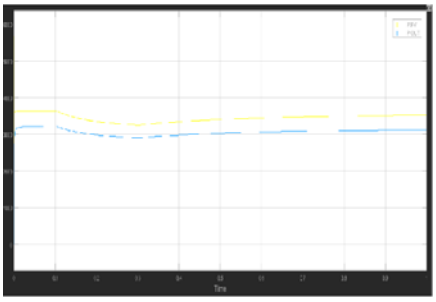
PV characteristics

B. Ouput power and voltage curves of Boost converter

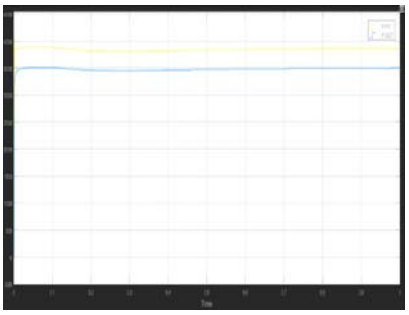




C. Results of Boost converter with Pulse generator



D. Result of Boost converter with MPPT



VIII. CONCLUSION

The major drawback of the solar energy has been the low efficiency in solar cells. To improve the efficiency, we have employed the PV module with boost converter using MPPT algorithms. Various simulation results have been found. Few MPPT techniques have been discussed out of which Incremental conductance method played a vital role. This method computes the maximum power and controls directly the extracted power from PV cells. After implementing MPPT controllers, the ouput power and voltages are improved.

IX. FUTURE SCOPE

Maximum power point tracking of solar panel can also be done using fuzzy neural network control which improves the efficiency of the MPPT controller compared to incremental conductance control. But it increases the complexity of the system, creasing in the recent years. Grid connected PV generator so a trade-off has to be made. Change in the solar power due to wind energy can also be considered during the design of solar panel.

X. REFERENCES.

[1]Muhammad H. Rashid,"Power Electronics: Circuits, Devices and Application", THIRD EDITION.

[2]"A survey of maximum PPT techniques of PV systems" Faculty of Engineering, Alexandria University, Alexandria, Egypt.

[3] Effect of partial shading on characteristics of PV panel using simscape by Amardeep Chaudhary Int. Journal of Engineering Research and Applications ISSN: 2248-9622, Vol2,Issue 5, May 2013.