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Performance of PV System with IC MPPT Algorithm: A Review

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Abstract: **- Photovoltaic (PV) is a technical name in which radiant (photon) energy from the sun is converted to direct current (DC) Electrical Energy. PV power output is still low, continuous efforts are taken to develop the PV converter and controller for maximum power extracting efficiency and reduced cost factor. The maximum power point tracking (MPPT) is a process which tracks one maximum power point from array input, varying the ratio between the voltage and current delivered to get the most power it can. A number of algorithms have been developed for extracting maximum power. This paper details with the study of PV system with MPPT algorithm. The panel voltage V and its generated power depend on the number of serial modules in a string and the number of parallel strings in a panel. The module reference voltage VREF is obtained from the irradiation density A and the MPPT algorithm in order to extract the maximum power.**

Keywords: **PV Module, MPPT, DC-DC converter, Incremental Conductance (IC) Algorithm**

I. INTRODUCTION

The growing demand for electrical energy throughout the world has caused a great need to consider renewable energy sources as a technological option for sustainable energy supply. Among the renewable energy sources photovoltaic (PV) energy is now becoming one of the fastest growing renewable energy technologies due to continuous cost reduction and technological progress. PV is the field of technology related to the application of solar cells by converting sunlight directly into electricity. Due to the nonlinear relationship between the current and the voltage of the PV cell, it can be observed that there is a unique Maximum Power Point (MPP) at a particular environment, and this peak power point keeps changing with solar illumination and ambient temperature. An important consideration in achieving high efficiency in PV power generation system is to match the PV source and load impedance properly for any weather conditions, thus obtaining maximum power generation. Therefore, the system needs a Maximum power point tracking (MPPT) which sets the system working point to the optimum and increases the system's output power. The main aim of this work is to use the solar power with MPPT technique. An attempt has been made to design solar panel with MPPT controller and DC - DC converter which switches in between buck and boost topology depending upon the input voltage and the switching signals from the MPPT algorithm. In the literature survey show that there will be an increasing percentage of 30- 40 % of energy will be extracted compared to the PV system without solar tracking system.

The author compares and evaluates the percentage of power extraction with MPPT and without MPPT. It clearly shows that when we use MPPT with the PV system, the power extraction efficiency is increase to 97%. The study of developing a PV charging system for Li-ion batteries by integrating MPPT and charging control for the battery is reviewed. The author reviews the various types of non isolated DC-DC converters for the photo voltaic system. Optimal operating performances by different converter topologies are one of the main points which can be summarized in this research work. It concludes that the best type of converter for PV system is the buck boost Dc/Dc converter. The overall block diagram of PV panel with DC-DC converter and MPPT is shown in figure 1.

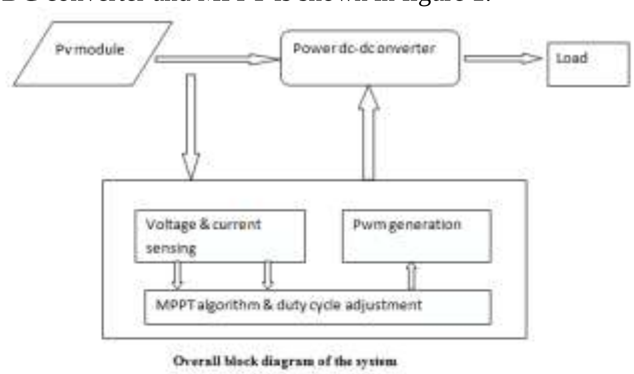

Fig. 1: Overall Block Diagram of a PV System

This paper presents an approach to model and simulate a maximum power point tracker (MPPT) of photovoltaic (PV) system for battery charging application. Firstly, a simulation of Shell SM50-H PV module current-voltage (I-V) and power-voltage (P-V) characteristics at various insolation and temperature levels have been carried out using Matlab

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software. Next, the incremental conductance algorithm is applied for maximum power point (MPP) tracking purpose, which is developed using C programming. This algorithm is selected due to its ability to withstand against any parameter variation and having a very high efficiency. As a result, by variation of the temperature and the insolation, the algorithm still managed to track the MPP successfully. Finally, a model of a boost converter is constructed using Matlab/Simulink, particularly with great utilization of the Power System Blockset, (PSB), in order to verify the performance of proposed MPPT system. MPPT controlling process is developed using a simple voltage based MPPT. As for the consequences, this technique performance tends to give significant efficiency, in addition, it is cost saving and reliable.

II. MODELING OF PV CELL

The solar cell is the basic unit of a PV system. An individual solar cell produces direct current and power typically between 1 and 2 W, hardly enough to power most applications. Solar Cell or Photovoltaic current is *I*sc taken from the datasheet of the reference model. *I*ph for different values of insolation and temperature is shown in Table. PV cell is a device that is made up of semiconductor materials such as silicon, gallium arsenide and cadmium telluride, etc. that converts sunlight directly into electricity. The voltage of a solar cell does not depend strongly on the solar irradiance but depends primarily on the cell temperature. PV modules can be designed to operate at different voltages by connecting solar cells in series. When solar cells absorb sunlight, free electrons and holes are created at positive/negative junctions. If the positive and negative junctions of solar cell are connected to DC electrical equipment, current is delivered to operate the electrical equipment. The equivalent circuit of the PV cell is shown in figure 2.

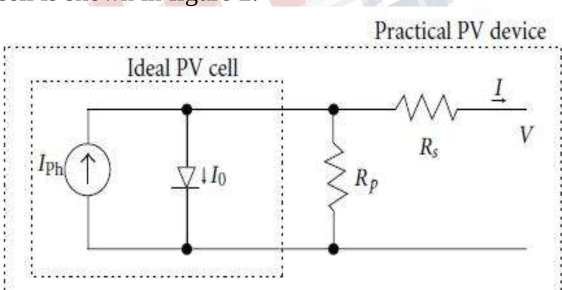

Fig.2: Single diode model of PV cell

For simplicity, the single-diode model of Figure is used in this paper. This model offers a good compromise between simplicity and accuracy with the basic structure consisting of a current source and a parallel diode. In Figure.1, *I*ph represents the cell photocurrent while *R*sh and *Rs* are, respectively, the intrinsic shunt and series resistances of the cell. The module photocurrent *I*ph of the photovoltaic module depends linearly on the solar irradiation and is also influenced by the temperature according to the following equation:

$$Iph = [Isc + Ki\,(Tk - Tref)] * \lambda / 1000$$

Where Iph is the light-generated current at the nominal temperature and nominal weather condition (25◦C and 1000W/m2), *Ki* is the short-circuit current/temperature coefficient (0.0017A/K), *Tk* and *T*ref are, respectively, the actual and reference temperatures in *K*, *λ* is the irradiation on the device surface (W/m2), and the nominal irradiation is 1000W/m2. The value of module short-circuit current is Isc taken from the datasheet of the reference model. Iph for different values of isolation and temperature is shown in table I.

Table I: IPH for different values of isolation and temperature

Sl No	Insolation	Value of Iph at 20 degree temperature	Value of Iph at 30 degree temperature	Value of Iph at 50 degree temperature
1	1000	2.54	2.54	2.59
2	500	1.07	1.27	1.29
3	100	0.24	0.25	0.254

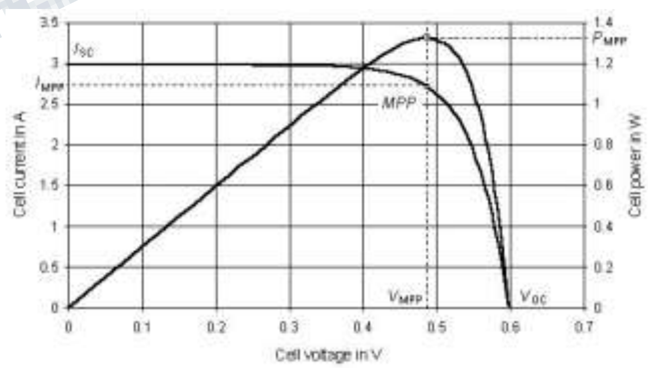

Fig.3: P-V & I-V characteristics of PV cell

III. INCREMENTALCONDUCTANCE MPPT ALGORITHM

MPPT or Maximum Power Point Tracking is algorithm that included in charge controllers used for extracting Maximum available power from PV module under certain conditions. The voltage at which PV module

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can produce Maximum power is called „maximum power point" (or peak power voltage). Maximum power varies with solar radiation, ambient temperature and solar cell temperature. Typical PV module produces power with maximum power voltage of around 17 V when measured at a cell temperature of 25°C, it can drop to around 15 V on a very hot day and it can also rise to 18 V on a very cold day. MPPT checks output of PV module, compares it to battery voltage then fixes what is the best power that PV module can produce to charge the battery and converts it to the best voltage to get maximum current into battery. It can also supply power to a DC load, which is connected directly to the battery. MPPT algorithm can be applied to both buck and boost power converter depending on system design. Normally, for battery system voltage is equal or less than 48 V, buck converter is useful. On the other hand, if battery system voltage is greater than 48 V, boost converter should be chosen. In incremental conductance method the array terminal voltage is always adjusted according to the MPP voltage it is based on the incremental and instantaneous conductance of the PV module. The basic concept of Incremental conductance on a PV curve of a solar module is shown in figure. The slope of the PV module power curve is zero at The MPPT, increasing on the left of the MPP and decreasing on the Right hand side of the MPP. The basic equations of this method are as follows:

$dP/dV=0$ at MPP
$dP/dV>0$ left ofMPP
$dP/dV<0$ right ofMPP
$dP/dV = d(VI)/d(V)= I + V*dI/dV$

The dP/dV is defined as Maximum power point identifier factor. By utilizing this factor, the IC method is proposed to effectively track the MPP of PV array . The following definitions are considered to track the MPP.

$\Delta I/\Delta V = -I/V$ at MPP, $\Delta Vn=0$
$\Delta I/\Delta V > -I/V$ left of MPP, $\Delta Vn= + \delta$ $\Delta I/\Delta V < -I/V$ right of MPP, $\Delta Vn= -\delta$

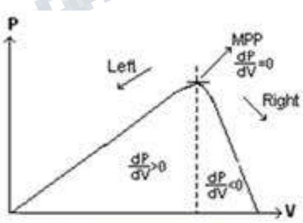

Fig.4: Basic concept of IC algorithm on P-V Curve

The MPPT regulates the PWM control signal of the dc to dc power converter until the condition: (dI/dV) + (I/V) = 0 is satisfied. Consider the nth iteration of the algorithm as a reference, and then n+1 iteration process can be determined by using the above equations. The Flow chart of incremental conductance MPPT is shown in figure 5. The output control signal of the IC method is used to adjust the voltage reference of PV array by increasing or decreasing a constant value ($\Delta V=\delta$) to the previous reference voltage. In this method the tracking of MPP is accomplished by a fixed step size (+ δ) regardless to the gap between the operating point of PV and MPP location. In this method the peak power of the module lies at above 97% of its incremental conductance.The MPP can be tracked by comparing the instantaneous conductance to the incremental conductance, as shown in the flowchart of figure 5. The Vpv and Ipv are taken as the inputs to MPPT unit, duty cycle D is obtained as output.

IV. DC-DC POWER CONVERTER

DC-DC converters can be used as switching mode regulators to convert an unregulated dc voltage to a regulated dc output voltage. The regulation is normally achieved by PWM at a fixed frequency and the switching device is generally BJT, MOSFET or IGBT. There are several different types of dc-dc converters, buck, boost, buck-boost and topologies, have been developed and reported in the literature to meet variety of application specific demands. The important requirement of any DC–DC converter used in the MPPT scheme is that it should have a low input-current ripple.

V. RESULTS DISCUSSION

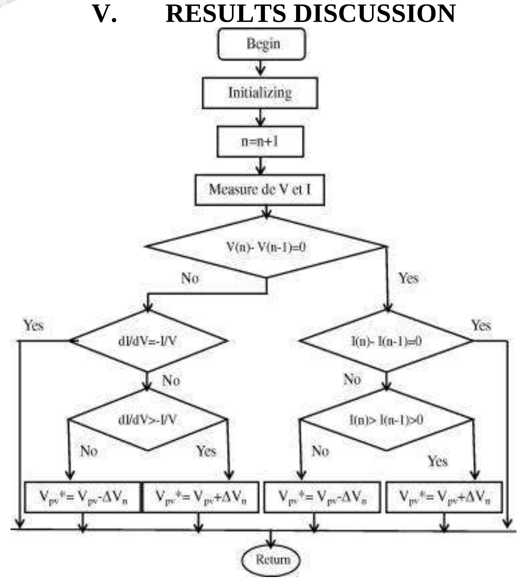

Fig. 5: Flow chart of the MPPT incremental conductance method

The flowchart of the incremental conductance MPPT algorithm has been implemented in Matlab/ Simulink.

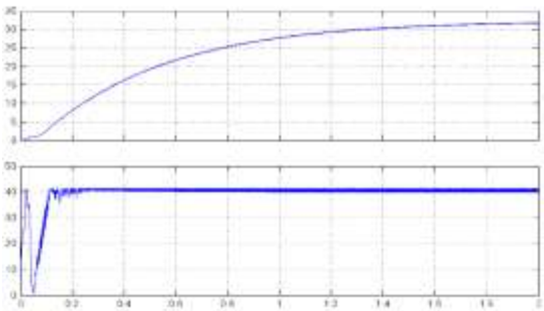

Fig.6: Output power v/s Input power of Boost Converter

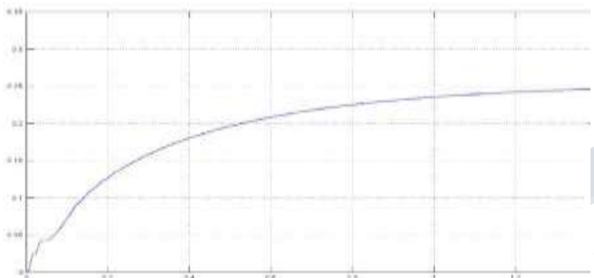

Fig.7: Low ripple o/p current of Boost converter

Comparison of Boost Converter Results with Buck Converter

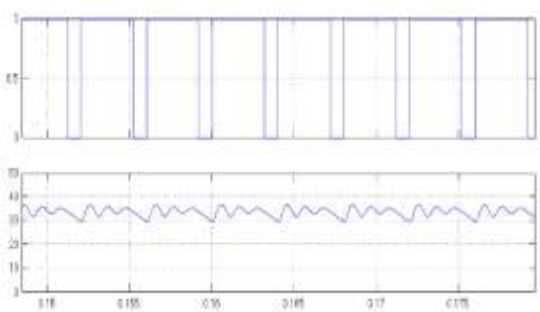

Fig.8: MPPT PWM output and output power of PV Module with buck converter

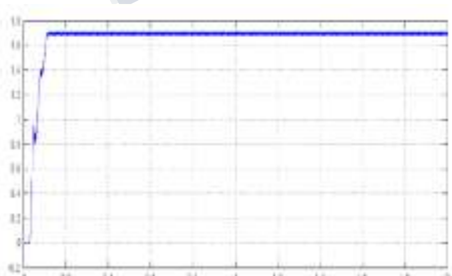

Fig.9: Output current of buck converter

Thus from the simulation results it is seen that Buck converters will produce ripples on the PV module side currents and thus require a larger value of input capacitance on the module side. On the other hand, boost converters will present low ripple on the PV module side.

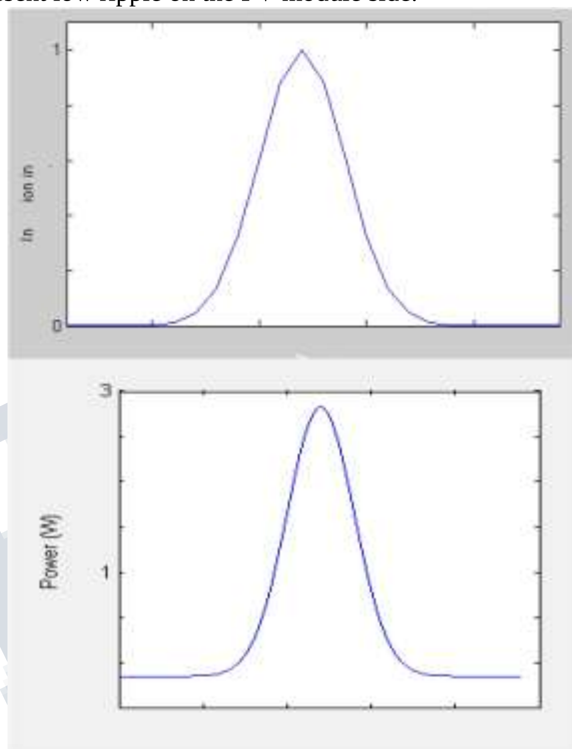

Fig. 10: The PV panels output power depending on the irradiation during a day

VI. CONCLUSION

In this paper, the simulation of the PV system with Incremental conductance MPPT algorithm has been successfully obtained in the Mat lab/Simulink. So that it forces the PV module to operate at close to maximum power operation point to draw maximum available power. The results of the output converter power shows that it is achieving the maximum extracting power and it is constantly working near the maximum operating point of the PV Module This technique has an advantage over the perturb and observe method because it can determine when you reach the MPP without having to oscillate around this value. This study has used to a power flow control strategy simultaneously applied to three kinds of renewable energy components: wind, solar and water storage. The number of activated pumps/turbines is found according to regulation purposes and to wind/solar availability. A static VAR compensator is used in order to maintain reactive power compensation. Both islanded and grid connected modes were considered. In this study, it was considered that transients and dynamic behavior of the network components will not affect the regulation and the network performance. Therefore in a later study, dynamic mechanical and electrical characteristics will be investigated in order to analyze the effect of transients on the frequency and voltage regulation.

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