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Implementation of MPPT Algorithm for Solar PV cell using P&O, Incremental Conductance and Constant Voltage Method

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ABSTRACT

The conventional energy source are depleting day by day at an alarming rate. In the present era, there is an acute shortage of energy source for the production of electricity . The feasible alternative is non-conventional energy source. This paper deals with modelling of PV array including the effects of temperature and irradiation. The DC-DC converter is used for boosting low voltage of the PV array to high DC voltage. Since the efficiency of a PV array is around 13% which is low, it is desirable to operate the module at the peak power point to improve the utilization of the PV array.

A maximum power point tracker (MPPT) is used for extracting the maximum power from the solar PV array and transferring that power to the load. Implementation of MPPT technique has been developed using P&O, incremental conductance and constant voltage algorithm has been done using MATLAB based M file programming scheme.

Keywords. Photovoltaic (PV) array, Maximum power point tracking(MPPT), DC-DC converter, Modelling of PV array.

I. INTRODUCTION

As the sources of conventional energy depleting day by day, resorting to alternative sources of energy like solar and wind energy has become need of the hour. A field of photovoltaic solar energy has experienced a remarkable growth for two decades

A photovoltaic system directly converts sunlight into electricity. Due to its low power, it is necessary to combine multiple cells into series or into parallel, forming a PV module and modules are further connected into series or into parallel with the required values of current and voltage to form a photovoltaic array. But this photovoltaic system has two major drawback one is that the conversion efficiency required for electrical power generation is very low especially during low irradiation condition may be the efficiency is around 9 to 17%, the second drawback is that the P-V and I-V characteristics of solar cell is non-linear and it also varies depending upon the temperature and irradiance.

In case of PV and IV characteristics of solar cell there is an unique point called maximum power point at that point entire PV system operates at maximum efficiency and produces its maximum output power. Therefore maximum power point tracking techniques are needed to maintain the PV array's at its maximum power point. Many MPPT techniques have been proposed in literature these techniques varies between them in many aspects including simplicity, convergence, speed, hardware implementation, sensors required, cost range of effectiveness. Perturb and Observe, Incremental conductance and constant voltage are the techniques to be used [1], [2].

In P&O method [3], [4], there is a perturbation in the operating voltage in the PV array. However, the P&O algorithm cannot compare the array terminal voltage with the actual MPP voltage, since the change in power is only consider to be a result of the array terminal voltage perturbation. As a result, they are not accurate enough and it also slows in finding the MPP if the voltage is far away from the MPP. Thus there are some disadvantages with this method where they fail under rapidly change in atmospheric conditions [5].

Incremental conductance method is the method which overcomes the drawback of the P&O method. In this method the array terminal voltage is always adjusted according to the MPP voltage. It is based on incremental and instantaneous conductance of the PV module [6], [5], [7], [8].

The open circuit voltage d is based on observation that the voltage of the maximum power point is always close to a fixed percentage of the open circuit voltage.

II. METHODS AND MATERIAL

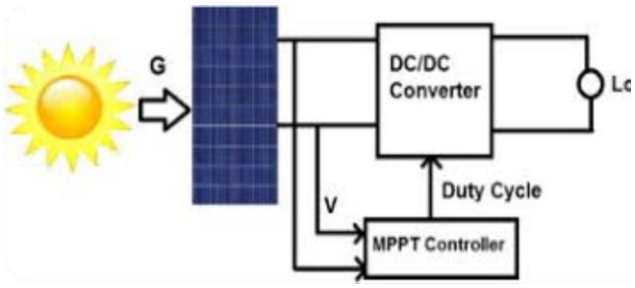

Figure 2.2. Block Diagram of MPPT model.

2.1 MODELLING OF SOLAR CELL

A solar cell is the building block of a solar panel. A photovoltaic module is formed by connecting many solar cells in series and parallel. To understand the Physical behavior of a solar cell, it is useful to create a model which is electrically equivalent, and is based on discrete electrical components whose behavior is well known. This model is known as a single diode model of solar cell.

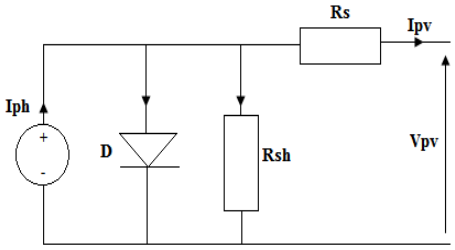

Figure 2.2. Single diode model of solar cell

The I-V characteristics of the equivalent solar cell circuit can be determined by following equations [1]. The current through diode is given by.

$ID = I [\exp (q (V + I RS)/KT) - 1] \ldots(1)$

While, the solar cell output current.

$I = IL - IL - ISH \ldots(2)$

$I = IL - I [\exp (q(V + I RS)/KT)) - 1] - (V + IRS)/ RSH \ldots (3)$

Where.

I = Solar cell current (A)

I= Light generated current (A)

ID= Diode saturation current (A)

q = Electron charge (1.6×10-19 C)

K= Boltzmann constant (1.38×10-23 J/K)

T= Cell temperature in Kelvin (K)

V =solar cell output voltage (V)

RS=Solar cell series resistance (Ω)

RSH=Solar cell shunt resistance (Ω)

The I-V and P-V curves for a solar cell are given in the following figure. It can be seen that the cell operates as a constant current source at low values of operating voltages and a constant voltage source at low values of operating current.

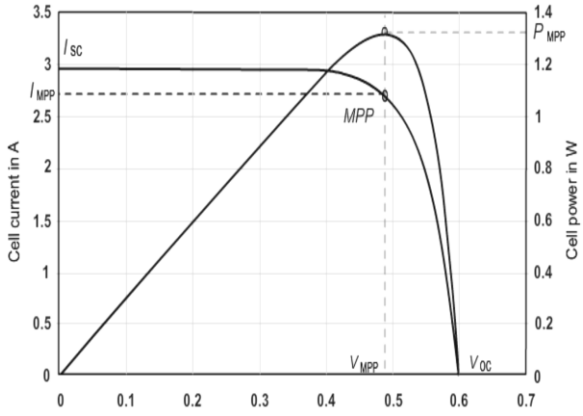

Figure 2.3. P-V I-V curve of a solar cell at given temperature and solar irradiation.

2.2 MAXIMUM POWER POINT TRACKING

The efficiency of a solar cell is very low. In order to increase the efficiency, methods are to be undertaken to match the source and load impedances properly. One such method is the Maximum Power Point Tracking (MPPT). This is a technique used to obtain the maximum possible power from a varying source. In photovoltaic systems the I-V curve is non-linear, thereby making it difficult to be used to power a certain load. This is done by utilizing a dc-dc converter whose duty cycle is varied by using a 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 can produce maximum power is called "maximum power point" (or peak power voltage).

FLOW CHART OF MPPT ALGORITHMS

The most widely used methods for maximum power point tracking are studied here. The methods are

1. Perturb & Observe Method Algorithm

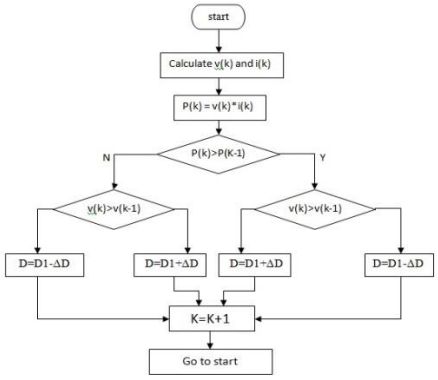

Figure 2.2.1 Flowchart of Perturb & Observe Method

2. Incremental Conductance Method Algorithm

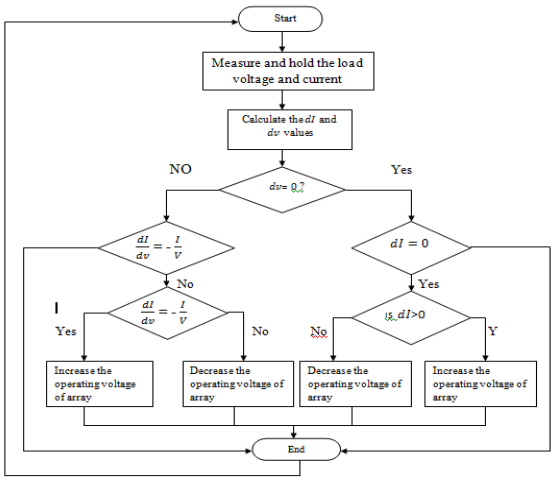

Figure 2.2.2 Flowchart of Incremental Conductance Method

3. Constant Voltage Method

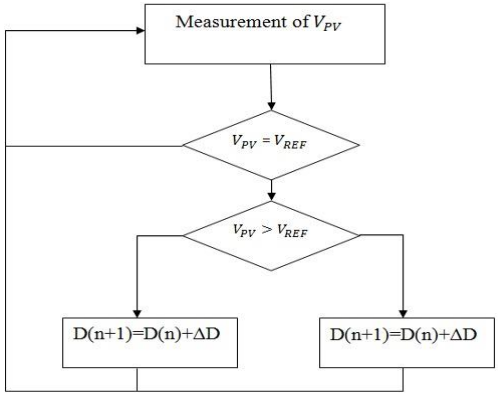

Figure 2.2.3 Flowchart of Constant Voltage Method

III. RESULTS AND DISCUSSION

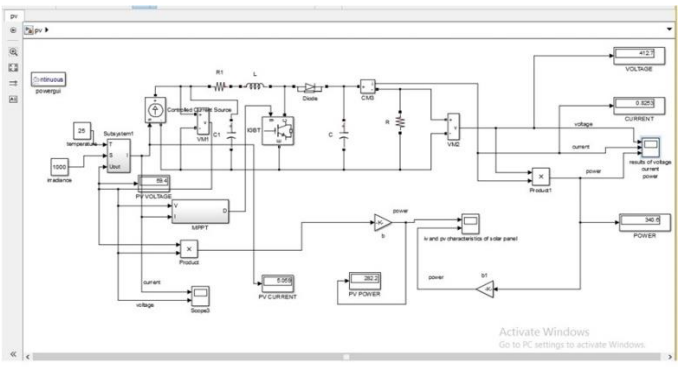

Figure 3.1 Simulink model of P&O Algorithm

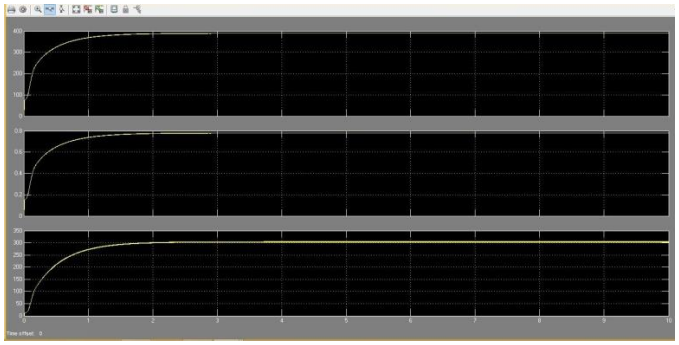

Figure 3.2 result of p&o algorithm method

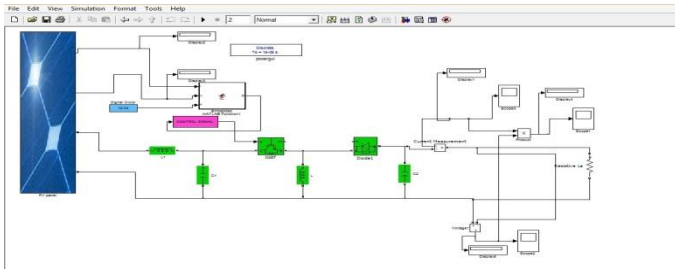

Figure 3.3 Simulink model of Incremental Conductance Algorithm

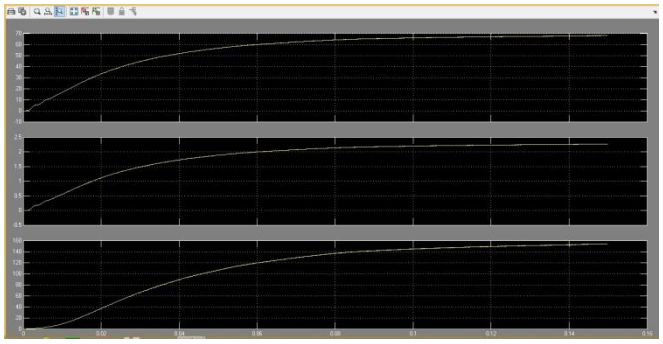

Figure 3.4 result of incremental conductance algorithm method

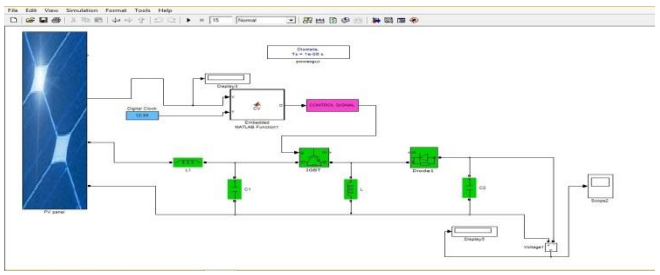

Figure 3.5 Simulink model of Constant Voltage Algorithm

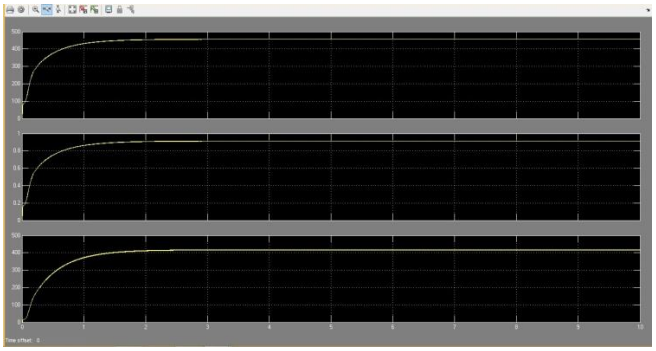

Figure 3.6 result of constant voltage algorithm method

IV. CONCLUSION

P&O and incremental conductance and constant voltage methods are implemented with MATLAB-SIMULINK for simulation. The MPPT method simulated in this paper is able to improve the dynamic and steady state performance of the PV system simultaneously. Through simulation, it is observed that the system completes the maximum power point tracking successfully despite of fluctuations. When the external environment changes suddenly, the system can track the maximum power point

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