INCREMENTAL CONDUCTANCE BASED MPPT FOR INCREASING SOLAR PANEL EFFICIENCY

Prof. Ajay Mendhe[1], Alambabu Siddiqui[2], Bhavana D. Bobde[3], Nikhil A. Bawane[4], Prathmesh S. Giradkar[5] Rucha P. Kawde[6]

[1]*Assistant Professor, Department of Electrical Engineering, PJLCOE, Nagpur, Maharashtra, India*
[23456] *U G Scholar, Department of Electrical Engineering, PJLCOE, Nagpur, Maharashtra, India*

ABSTRACT

Till now we have been continuously using the fossil fuels and other resources provided by the nature. But now this is depleting day by day and soon will have to depend on renewable sources for our need of energy. So the most adopted option is the solar energy that can be conveniently converted to useful form. Also India is located in the tropical region with sufficient sunshine condition. Many firms, industries and residential utilize this power but the main obstacle is to utilize this solar power at maximum efficiency of panel. The efficiency of this panel is increased by mechanical mean or electrical mean but was having scope of improvement. Focusing on electrical methods and overcoming the drawbacks of perturb and observe method, this paper explains about the incremental conductance technique with the help of the incremental conductance algorithm that helps to track the maximum power point of the PV panel more efficiently than other available methods. Without the use of battery in between and scope of direct grid connection leads to its implementation in future applications.

Keywords: *MPPT, Incremental conductance, Perturb and Observe.*

1. INTRODUCTION

Renewable energy sources will be the most preferable sources in the upcoming future. Among all these sources the solar energy is widely used source for electricity. Although the solar panel is used for trapping of the energy, not all the available energy is utilised but the most important factor is to increase the amount of energy converted through it, i.e. it should extract the maximum power at all the available time. Since the intensity of the light is more at the mid-day as compared to that of at dusk and at dawn, we get maximum power at the mid-day only. This reduces the efficiency of the solar panel. To overcome this problem a concept was invented that tracks the maximum power point of the panel characteristics called as maximum power point tracker (MPPT). Under this concept the tracking hours of the panel can be increased. Till now the most widely adopted method of MPPT is the Perturb and Observe (P&O) method since it is simple to implement than others. P and O method is having some drawbacks such as it simply oscillates around the maximum power point and in sudden change in the weather condition this method undergo misjudgment phenomenon [1]. So we shift toward the new technique i.e. Incremental conductance technique. This technique can track the rapid increase and decrease in the irradiance condition with higher accuracy. This paper is based on the maximum power point tracking method of incremental conductance without the use of battery [4]. We can continuously track the maximum power point by the algorithm resulting in the action of bucking and boosting of the output voltage of the panel. This constant output causes the uninterrupted supply to load without any battery storage in between.

2. SOLAR PHOTOVOLTAIC PANEL

A simple solar PV panel consists of several p-n junction that on interaction with the solar radiation release electrons which is called as photovoltaic effect. For the perfect study of method to improve efficiency of PV panel it should be modelled as the equivalent circuit for calculation purpose shown in fig 1. It can be ideally

modelled as the current source in parallel with forward biased diode. But practically the panel also produce losses, so the representation is added with a series resistance Rs which is very small indicates the ohmic contact between the metal and semiconductor internal resistance. Also paralleled resistor Rp is added indicating the surface quality along the module's periphery. It also represents impact of shading and is generally very high. Commercially, value of Rp is much greater than forward resistance of diode.

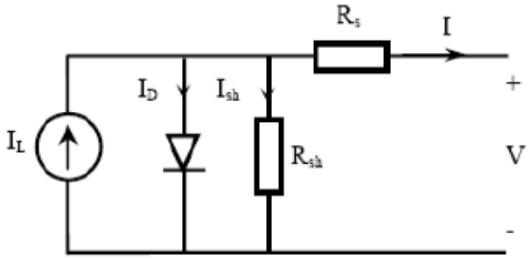

Fig. 1: Equivalent circuit diagram of a solar PV panel [2]

The mathematical model of a PV cell is described by following equation:

$$I = I_{sc} - I0\left(e^{\frac{qV}{kT}} - 1\right) \quad (1)$$

$$V_{oc} = \frac{kT}{q}\ln\left(\frac{Isc}{I0} + 1\right) \quad (2)$$

$$P = V \times I = VI_{sc} - VI_0\left(e^{\frac{qV}{kT}} - 1\right) \quad (3)$$

where,
I – current in solar PV cell (A)
V – voltage in solar PV cell (V)
P – power in solar PV cell (W)
Isc – short circuit current of solar PV cell (A)
Voc – open circuit voltage of the solar PV cell (V)
Io – reverse saturation current
q – electron charge ,q=1.602×10-19I
k – Boltzmann's constant, k=1.381×10-23(J/K)
T – absolute temperature (K)

So following equation guides the V-I characteristics of PV module.

$$I = Isc - Io\left(e^{\frac{q(V+Irs)}{kT}} - 1\right) - \left(\frac{V+Irs}{Rp}\right) \quad (4)$$

where, Rs and Rp represent the impact of shading and losses.

Table 1: Parameters of 75 watts solar panel

Maximum Power Output	75V,+/-5%
Short Circuit Current	4.76A
Maximum Power Current	4.41A
Maximum Voltage	17V
Open Circuit Voltage	23.48V

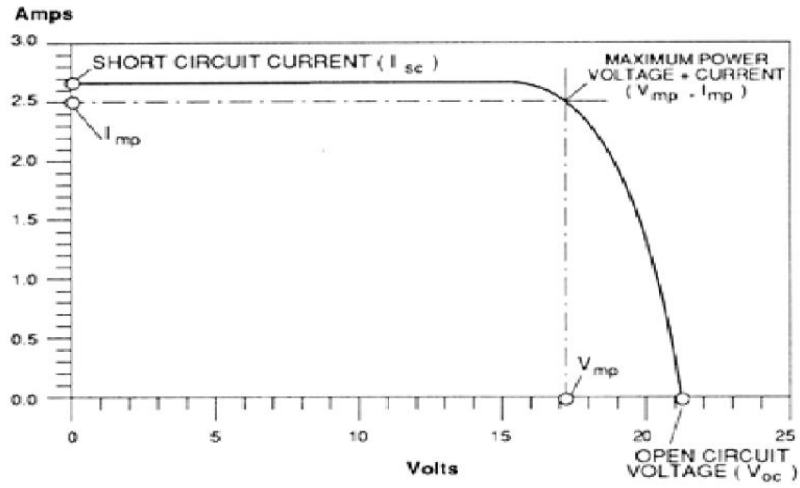

Fig 2: V-I characteristics of 75 watts solar panel

Fig 2 shows the V-I characteristics of 75 Watt PV panel in which two parameter is of large importance Isc, the short circuit current, Voc, the open circuit voltage and MPP, maximum power point can be find at a particular value of this parameter at constant irradiance and temperature. Parameters of 75 Watt panel is given in above table 1.

Power generated at point of Voc and Isc is zero. Since at Voc the current is zero of the PV panel and at Isc the voltage of solar panel is zero. So there exist a point of voltage and current for which maximum power is generated through the PV panel. Along with voltage and current two more parameters on which the power output depends are irradiance (G) and the temperature (T).

This point on the V-I curve for which maximum power is generated by the PV panel is called the Maximum Power Point (MPP). Practically the irradiance and the temperature is not constant but vary the whole day and so the MPP. To increase the efficiency of the solar panel this point has to be tracked continuously to get most of the panel output power and the device which perform this function is called the Maximum Power Point Tracker (MPPT).

3. MAXIMUM POWER POINT TRACKER (MPPT)

A maximum power point tracker is an electronic device that is used to track the maximum power point of the PV panel. Figure 3 below shows the block diagram of solar panel with MPPT. The Voltage-current (V-I) characteristics of PV module is non-linear. To eliminate the unwanted condition MPPT are used. A normal MPPT system is mainly consist of current and voltage driver circuit. It has mainly a DC to DC converter. This can be achieved by various methods such as direct or indirect method through various parameters such as current and voltage. Perturb and observe is one of the widely used methods for MPP tracking because of its simplicity of implementation [2-8].

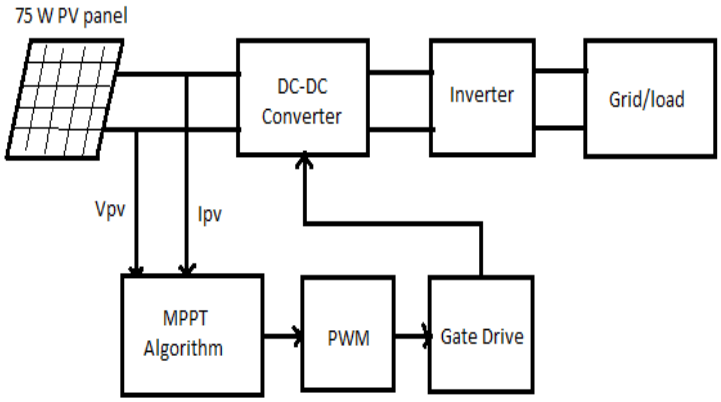

Fig 3: Block diagram of solar panel with MPPT [2]

Shortcomings of P and O leads to move ahead for a new technique that is Incremental conductance due to its advantageous feature explained in detail below.

4. INCREMENTAL CONDUCTANCE

MPPT plays a very crucial role in PV system. Use of MPPT decreases the PV array cost by decreasing the number of PV panels for the same output. In this we use an algorithm for the steps to be followed for the process. Various algorithms have been developed for obtaining the maximum power point but in this paper we will discuss about the Incremental conductance based algorithm. This algorithm overcomes the disadvantages of the P and O method. Objective of this algorithm is to satisfy the condition of dI/dV should be equal to negative of I/V, so as to let the PV array operate at its operating point of MPP. If the condition of required operating point is not meet then the way in which MPPT is operating must be disturbed [4].
This method calculates the slope of the P-V characteristic as follows:

$$\frac{dP}{dV} = \frac{d(VI)}{dV} = I + \frac{dI}{dV}V \quad (5)$$

$$\text{At the MPP: } \frac{dP}{dV} = 0 \quad (6)$$

$$\text{So: } \frac{dI}{dV} = -\frac{I}{V} \quad (7)$$

Using this relationship between dI/dV and -I/V the algorithm is generated as follows in fig 4.

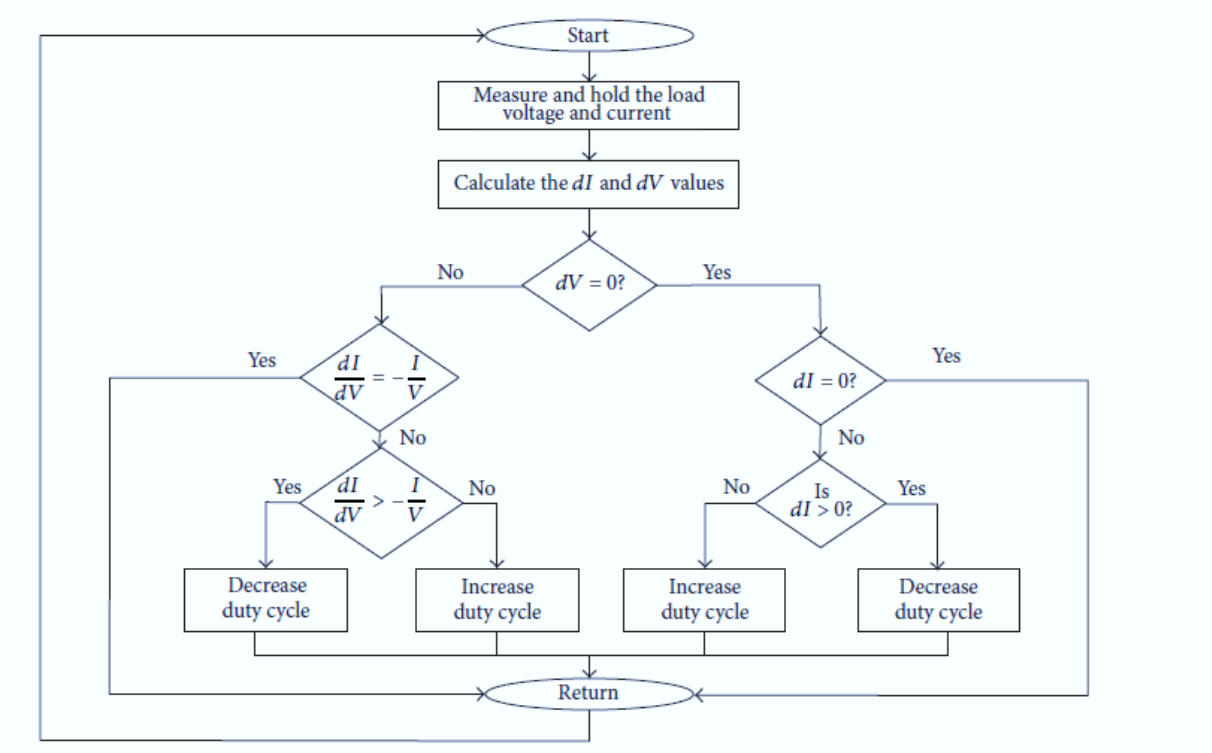

Fig 4: Flow chart of incremental conductance algorithm [6]

In this algorithm first step is to set a reference value for the voltage and current at which the MPP occurs. Now the output of solar or the load voltage and current are compared with the reference to take action for the increase or decrease in duty cycle. Increase or decrease in the voltage is achieved by the buck-boost dc-dc converter [5]. Comparison of the voltage is done by voltage divider circuit and current by hall-effect sensor [7]. Through this

the MPP point is achieved and can be easily understood by the flowchart in fig 4 and fig 5 showing the I-V and P-V characteristics.

The advantages of incremental conductance are:

- It has High steady state accuracy.
- Good tracking efficiency.
- Response is high.
- Adaptable to frequent changes in the environmental conditions.
- Increased time period of energy conversion in a day.
- Able to locate exact MPP.

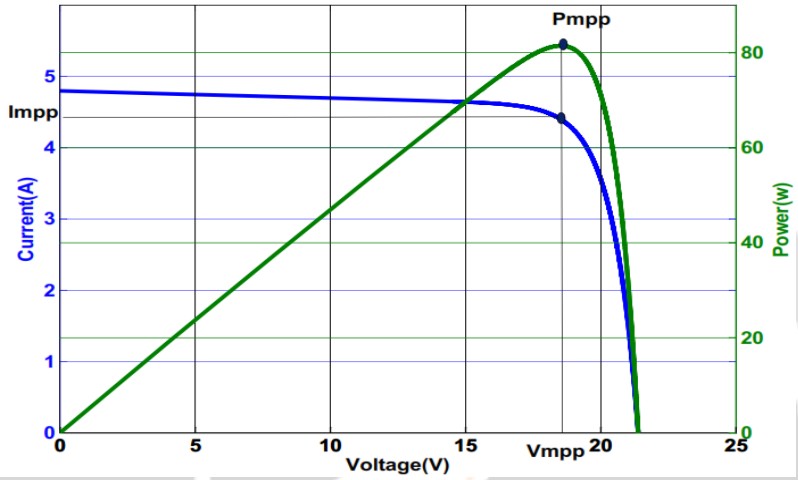

Fig 5: Figure showing the MPP in I-V and P-V curve characteristics of PV panel [3]

5. CONCLUSION

This paper proposes about the mathematical model of the PV panel of 75 Watt with implementation of Incremental Conductance algorithm of Maximum Power Point Technique. Here the tracking of PV panel power is high by this algorithm is seen to be more effective than Perturb and Observation Technique. This algorithm helps to track the MPP in case of partially shaded condition or non-uniform irradiance condition. Varying the duty cycle by Buck-Boost converter, the source impedance is matched to adjust the load impedance which improves the efficiency of our system [8].

6. REFERENCE

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