

Incremental Conductance Based Maximum Power Point Tracking (MPPT) for Photovoltaic System

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Abstract--- Photovoltaic (PV) energy is the most important energy resource since it is clean, pollution free, and inexhaustible. In recent years, a large number of techniques have been proposed for tracking the maximum power point (MPP). Maximum power point tracking (MPPT) is used in photovoltaic (PV) systems to maximize the photovoltaic array output power, irrespective of the temperature and radiation conditions and of the load electrical characteristics the PV array output power is used to directly control the dc/dc converter, thus reducing the complexity of the system. The method is based on use of a Incremental conductance of the PV to determine an optimum operating current for the maximum output power.

Keywords--- Photovoltaic System, Modeling of PV Arrays, Incremental conductance Algorithm, Boost Converter and Simulation Results

I. INTRODUCTION

Renewable sources of energy acquire growing importance due to its enormous consumption and exhaustion of fossil fuel. Also, solar energy is the most readily available source of energy and it is free. Moreover, solar energy is the best among all the renewable energy sources since, it is non-polluting. Energy supplied by the sun in one hour is equal to the amount of energy required by the human in one year. Photo voltaic arrays are used in many applications such as water pumping, street lighting in rural town, battery charging and grid connected PV systems.

As known from a Power-Voltage curve of a solar panel, there is an optimum operating point such that the PV delivers the maximum possible power to the load. The optimum operating point changes with solar irradiation and cell temperature. This paper deals with Incremental conductance MPPT algorithm method due to its simple approach [1].

II. PHOTOVOLTAIC CELL

Photovoltaic cell generates electricity from the sun. PV panel works under the phenomenon of photoelectric effect. It directly converts sunlight into electricity. The diagram of PV based system is shown in Fig. 1.

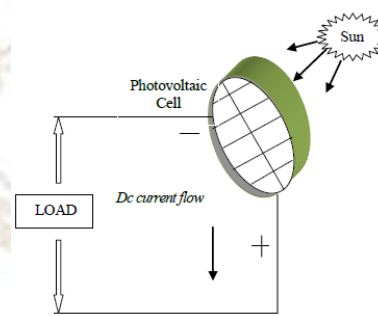


Fig-1: Photovoltaic Cell

III. PV EQUIVALENT CIRCUIT

Solar cells are connected in series and parallel to set up the solar array. Solar cell will produce dc voltage when it is exposed to sunlight. Fig. 2 shows the equivalent circuit model for a solar cell. Solar cell can be regarded as a non-linear current source. Its generated current depends on the characteristic of material, age of solar cell, irradiation and cell temperature.

Fig. 3 and 4 shows the P-V and V-I characteristics of solar panel for various irradiance at a cell temperature of 25°C.

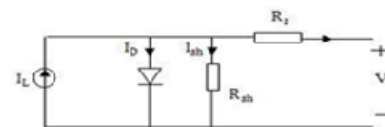


Fig-2: Equivalent Circuit of Solar Panel

Equation (1) describes the I-V characteristics of the PV model,

$$I = I_L - I_0 \left(e^{\frac{q(V+IR_s)}{KT}} - 1 \right) \quad (1)$$

$$I = I_L - I_0 \left(e^{\frac{q(V+IR_s)}{KT}} - 1 \right) - \frac{V+IR_s}{R_{sh}} \quad (2)$$

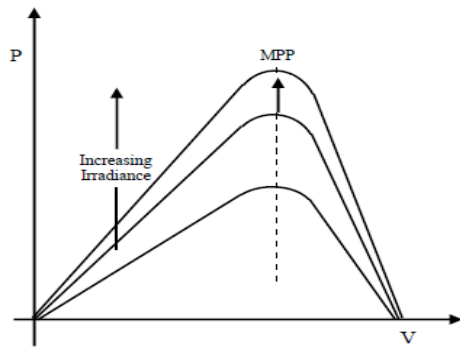


Fig-3: P-V Characteristics of Solar Panel for Various Irradiance S at a Temperature of 25 ° C

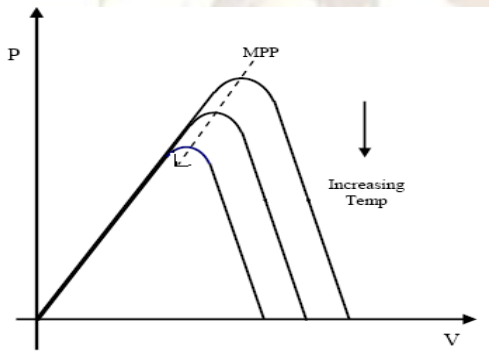


Fig-4: I-V Characteristics of Solar Panel for Various Irradiance S at a Temperature of 25°C

IV. SYSTEM DESCRIPTION

The circuit diagram of Photovoltaic system [7],[8] is shown in Fig 5. The PV system is modeled using Power System Block set under Matlab/ Simulink. The MPPT algorithm is modeled using mat- lab function System

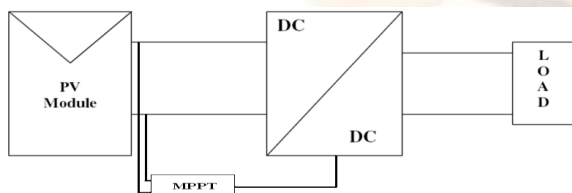


Fig-5: Block of Photovoltaic System

V. INCREMENTAL CONDUCTANCE MPPT

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.

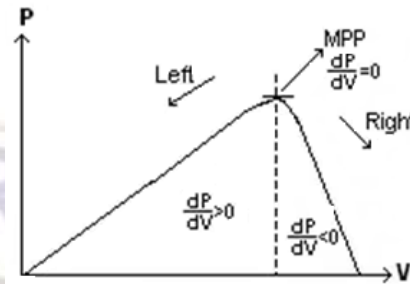


Fig-6: Basic idea of incremental conductance method on a P-V Curve of solar module

Fig-6 shows that the slope of the P-V array power curve is zero at The MPP, 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.

$$\frac{dI}{dV} = -\frac{I}{V} \quad \text{At MPP} \quad (3)$$

$$\frac{dI}{dV} > -\frac{I}{V} \quad \text{Left of MPP} \quad (4)$$

$$\frac{dI}{dV} < -\frac{I}{V} \quad \text{Right of MPP} \quad (5)$$

Where I and V are P-V array output current and voltage respectively. The left hand side of equations represents incremental conductance of P-V module and the right hand side represents the instantaneous conductance. When the ratio of change in output conductance is equal to the negative output conductance, the solar array will operate at the maximum power point.

VI. INCREMENTAL CONDUCTANCE MPPT ALGORITHM

This method exploits the assumption of the ratio of change in output conductance is equal to the negative output Conductance Instantaneous conductance. We have,

$$P = V I \quad (6)$$

Applying the chain rule for the derivative of products yields to

$$\partial P / \partial V = [\partial (VI)] / \partial V \quad (7)$$

$$\text{At MPP, as } \partial P / \partial V = 0 \quad (8)$$

The above equation could be written in terms of array voltage V and array current I as

$$\partial I / \partial V = - I / V \quad (9)$$

The MPPT regulates the PWM control signal of the dc – to – dc boost converter until the condition: $(\partial I / \partial V) + (I / V) = 0$ is satisfied.

In this method the peak power of the module lies at above 98% of its incremental conductance. The Flow chart of incremental conductance MPPT is shown below.

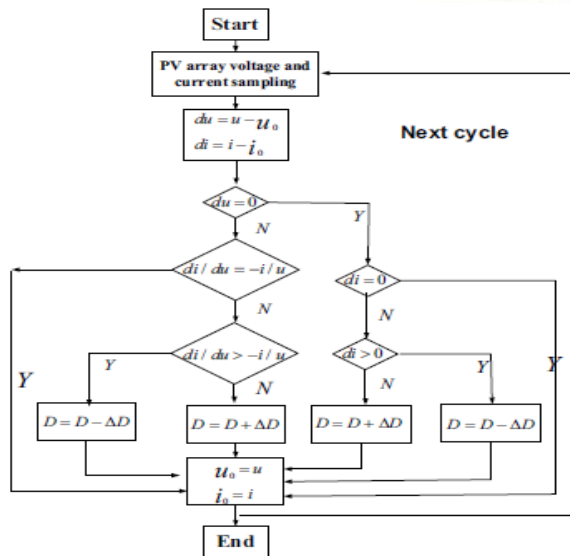


Fig-7: Incremental conductance MPPT Flow chart

VII.SIMULATION CIRCUIT

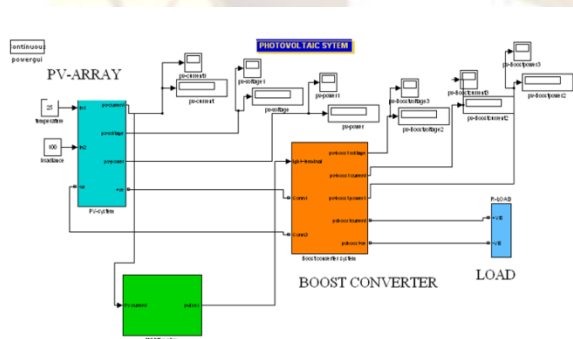


Fig-8: Simulink Model for Incremental conductance MPPT

VIII.SIMULATION RESULTS

Fig.15 shows the power of the photovoltaic panel under 1000W/m2 insulation and load conditions in open loop. The maximum power obtained at 1000W/m2 insulation was 780W in the open loop condition. The Fig. 15 shows the

maximum power tracked under 1000W/m2 insulation and load conditions [4] using MPPT controller in closed loop which is implemented using mat lab function. Here the insulation is 1000W/m2. According to the results, computed P_{max} is 1132W, so the tracking efficiency is 96.8%. the proposed method attempts to tracked 1132W out of available maximum power 1169W at 250c and irradiance of 1000w/m2 (750W for without MPPT) the proposed method attempts to tracked 1132W out of available maximum power 1169W at 25⁰c and irradiance of 1000w/m2 (750W for without MPPT). PV-output current, voltage, power wave forms are shown in below.

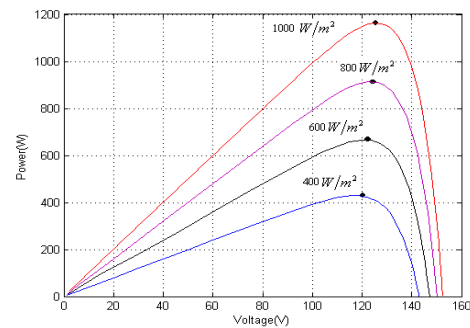


Fig-9: P-V Characteristics for Variation due to Irradiance Change

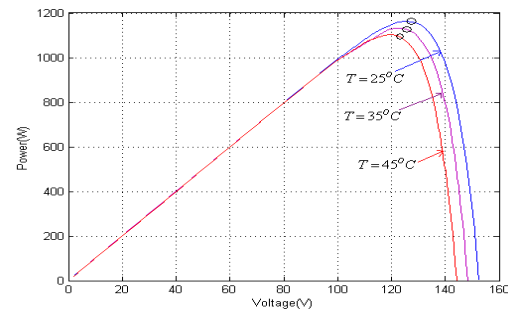


Fig-10: P-V Characteristics for Variation due to Temperature Change

P-V Characteristics of PV system for variation of irradiance from 400w/ m2 to 1000w/m2 and temperature from 25⁰c to 45⁰c is shown in fig 6 and fig 7.the maximum available power at irradiance of 1000w/m2 and temperature of 25⁰c is 1169w Shown in fig 8,V-I characteristics is also shown in fig 9.

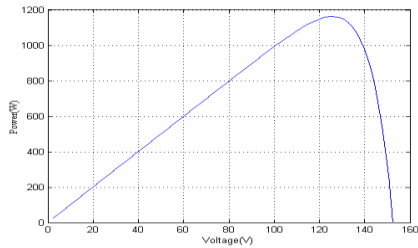


Fig-11:P-V Characteristics for 1000w/m2 Irradiance and 25°C

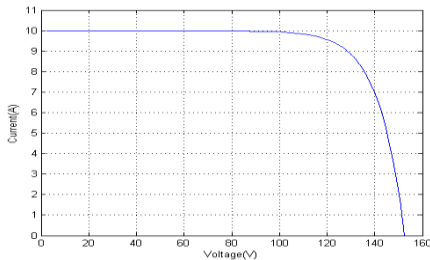


Fig-12: I-V Characteristics for 1000w/m2 Irradiance and 25°C

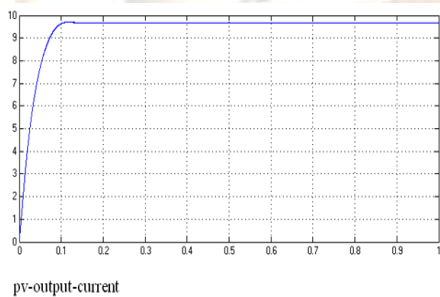


Fig-13: PV-Output Current

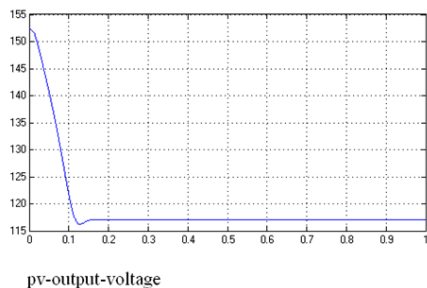


Fig-14: PV-Output Voltage

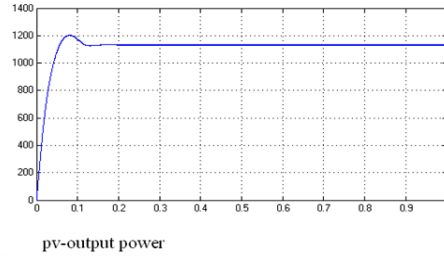


Fig-15: PV-Output Power

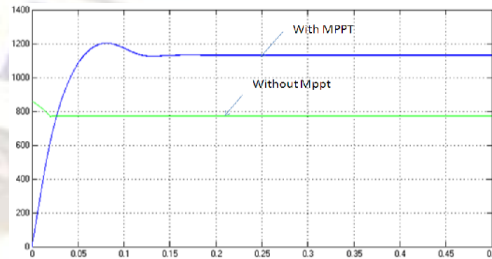


Fig-16: PV-Output Power of with and without MPPT

IX. CONCLUSION

The paper proposes a simple MPPT method that requires only measurements of Incremental conductance. The proposed MPPT algorithm is called Incremental conductance Method. However, by using this MPPT method we have increased efficiency by 44%. This method computes the maximum power and controls directly the extracted power from the PV. The proposed method offers different advantages which are: good tracking efficiency, response is high and well control for the extracted power.

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