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An Investigation Of Incremental Conductance Based Maximum Power Point Tracking 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. The output power of PV arrays is always changing with weather conditions, i.e., solar irradiation and atmospheric temperature. Therefore, a MPPT control to extract maximum power from the PV arrays at real time becomes indispensable in PV generation system. 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 resulting system has high-efficiency; lower-cost this paper proposes a maximum-PowerPoint tracking (MPPT) method with a simple algorithm for photovoltaic (PV) power generation systems. The method is based on use of an Incremental conductance of the PV to determine an optimum operating current for the maximum output power. This work proposes on Investigation of Incremental conductance Based maximum Power Point Tracking for Photovoltaic System, to have the advantages of low frequency switching.

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Keywords: Photovoltaic System; Modelling of PV Arrays; Incremental conductance Algorithm; Boost Converter

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1. 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 [1, 2].

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. Therefore, maximum power point tracking is essential for PV panel. A variety of maximum power point tracking (MPPT) methods is available. This paper deals with Incremental conductance MPPT algorithm method due to its simple approach [3].

1.1 Photovoltaic Cell

Photovoltaic cell generates electricity from the sun. PV panel works under the phenomenon of photoelectric effect [6]. It directly converts sunlight into electricity. The diagram of PV based system is shown in Fig. 1.

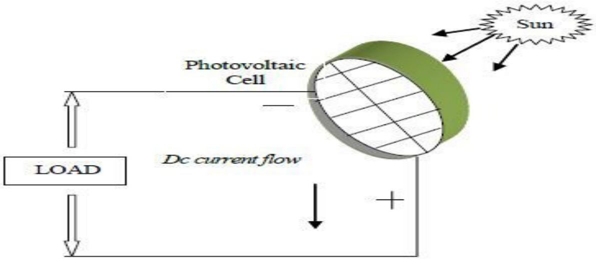

Fig. 1: Photovoltaic Cell

1.2 Photovoltaic Cell 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 [3, 4].

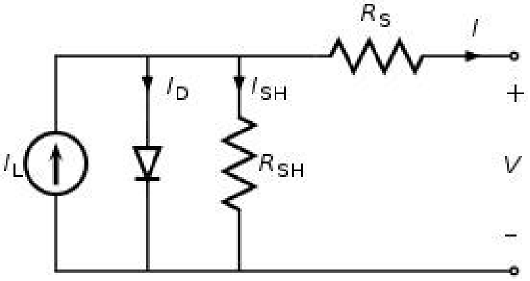

Fig. 2: Equivalent Circuit of Solar Cell

From the equivalent circuit it is evident that the current produced by the solar cell is equal to that produced by the current source, minus that which flows through the diode, minus that which flows through the shunt resistor,

$$I = I_L - I_D - I_{SH} \tag{1}$$

Where

I = output current (ampere)

I_L = photo generated current (ampere)

I_D = diode current (ampere)

I_{SH} = shunt current (ampere)

The current through these elements is governed by the voltage across them:

$$V_j = V + IR_s \qquad (2)$$

Where
V_j = voltage across both diode and resistor R_{SH}
(volt) V = voltage across the output terminals (volt)
I = output current (ampere)
R_S = series resistance (Ω).

By the Shockley diode equation, the current diverted through the diode is:

$$I_D = I_0\{\exp[\frac{qV_j}{nkT}] - 1\} \qquad (3)$$

Where

I_0 = reverse saturation current (ampere)

n = diode ideality factor (1 for an ideal diode)

q = elementary charge

k = Boltzmann's constant

T = absolute temperature

At 25°C, $kT / q \approx 0.0259$ volt

By Ohm's law, the current diverted through the shunt resistor is:

$$I_{SH} = \frac{V_j}{R_{SH}} \qquad (4)$$

Where

R_{SH} = shunt resistance (Ω)

Substituting these into the first equation produces the characteristic equation of a solar cell, which relates solar cell parameters to the output current and voltage:

$$I = I_L - I_0\{\exp[\frac{q(V + IR_S)}{nkT}] - 1\} - \frac{V + IR_S}{R_{SH}} \qquad (5)$$

Fig. 3 and 4 shows the P-V and V-I characteristics of solar panel for various irradiance at a cell temperature of 25^0C.

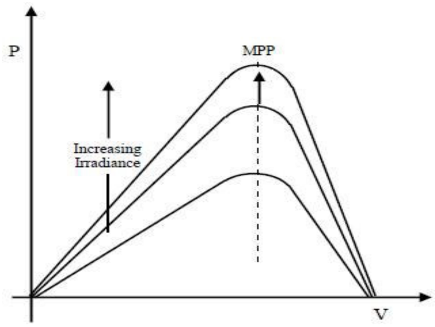

Fig. 3: P-V Characteristics of Solar Panel for Various Irradiance S at a Temperature of 25^0c

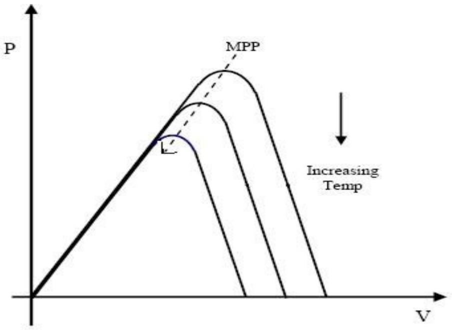

Fig. 4: I-V Characteristics of Solar Panel for Various Irradiance S at a Temperature of 25^0c.

1.3 System Description

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

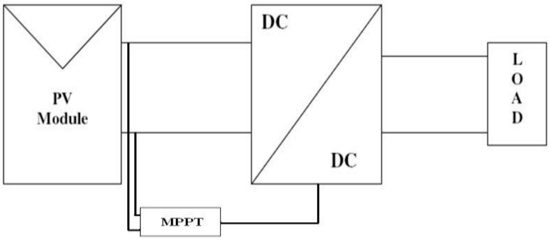

Fig. 5: Photovoltaic System

1.4 Incremental Conductance Maximum Power Point Tracking

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 [5, 9].

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.

$$\frac{dI}{dV} = -\frac{I}{V} \quad \text{At Maximum Power Point} \qquad (6)$$

$$\frac{dI}{dV} > -\frac{I}{V} \quad \text{Left of Maximum Power Point} \qquad (7)$$

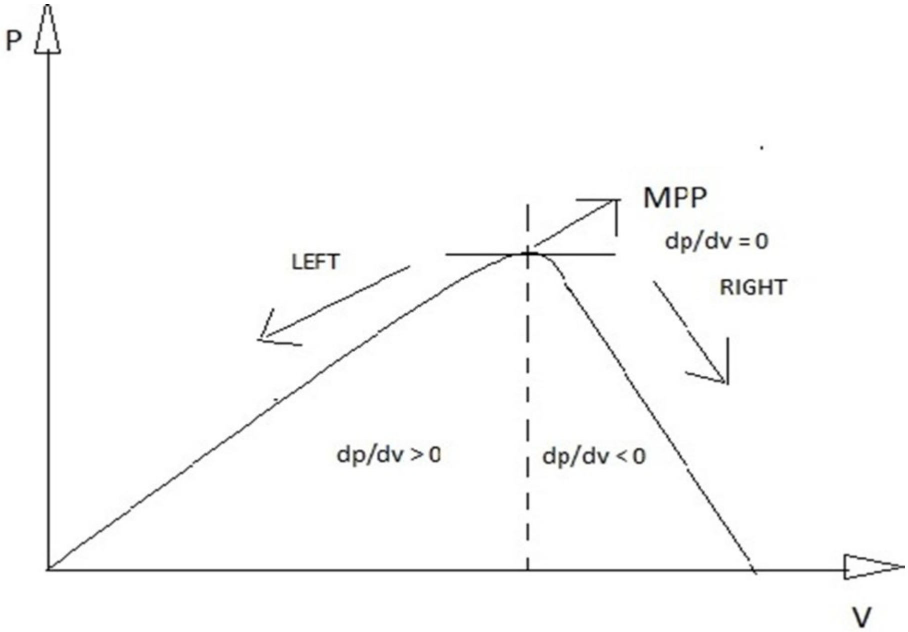

Fig. 6: Basic idea of incremental conductance method on a P-V Curve of solar module.

$$\frac{dI}{dV} < -\frac{I}{V} \quad \text{Right of Maximum Power Point} \qquad (8)$$

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 [11].

1.5 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,

$$P = V\,I \qquad (9)$$

Applying the chain rule for the derivative of products yields to

$$\partial P/\partial V = [\partial\,(VI)]/\,\partial V \qquad (10)$$

At MPP, as

$$\partial P/\partial V=0 \qquad (11)$$

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

$$\partial I/\partial V = -\,I/V \qquad (12)$$

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 [12]. The Flow chart of incremental conductance MPPT is shown below.

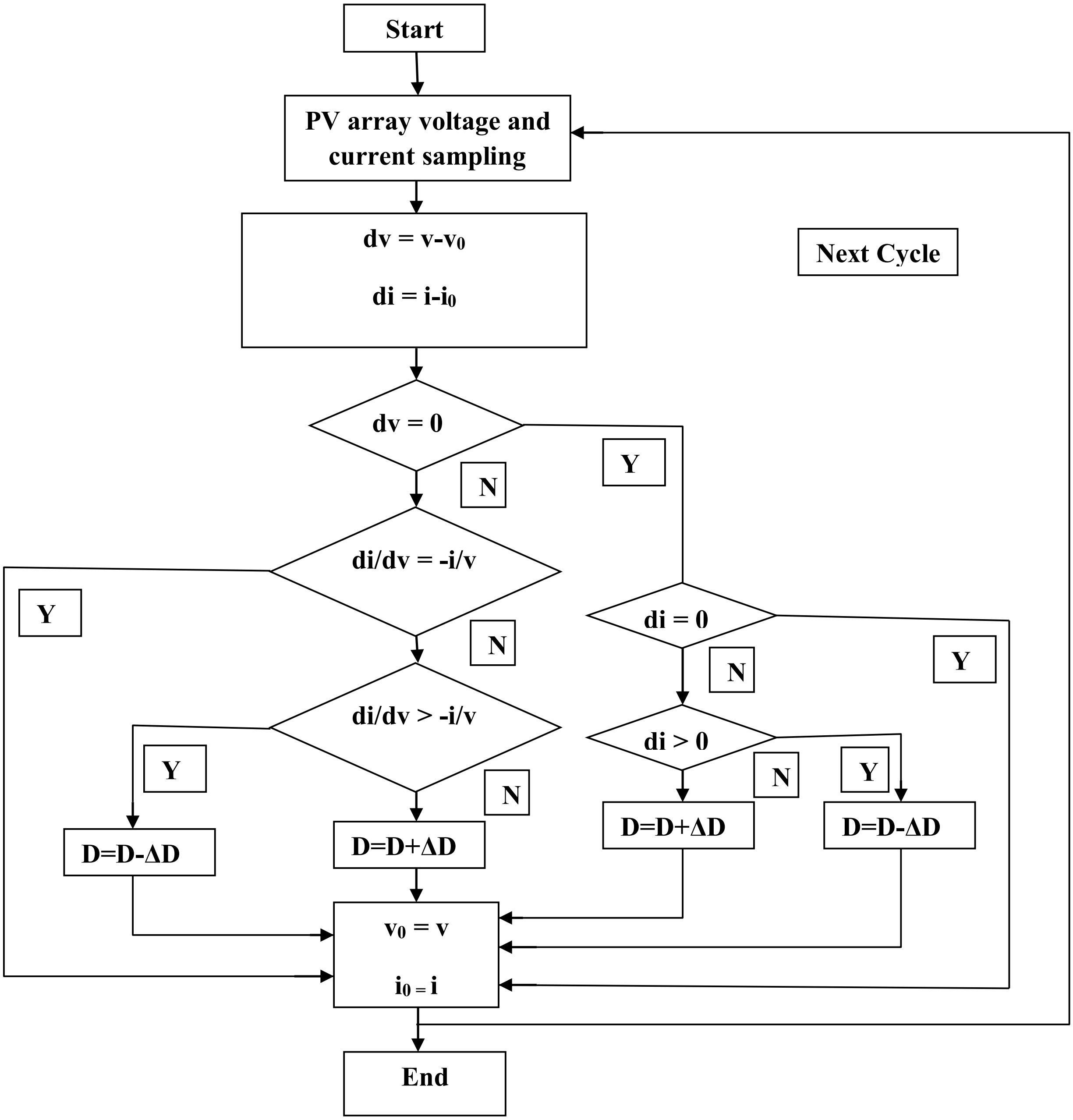

Fig. 7: Incremental Conductance MPPT Flow chart

1.6 Simulation Circuit

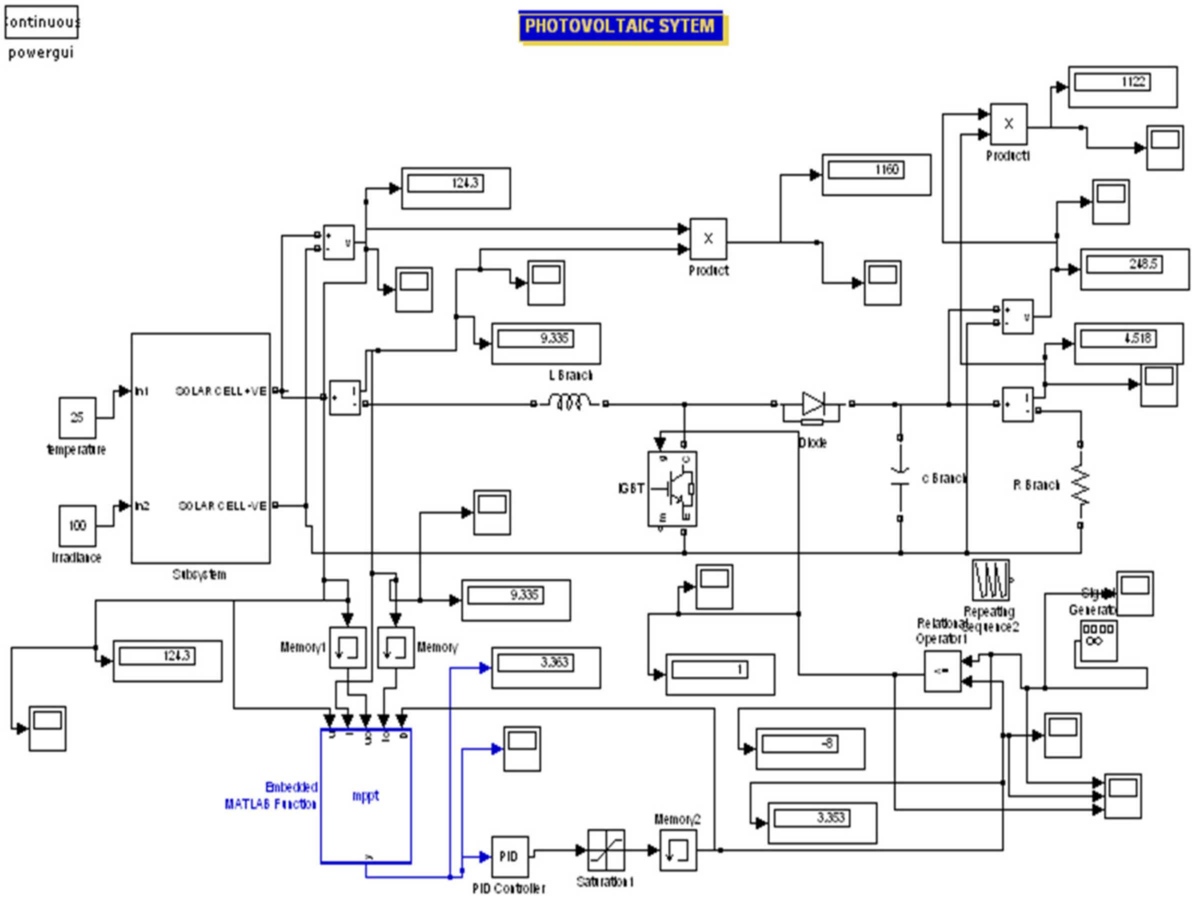

Fig. 8:Incremental Conductance MPPT

1.7 Simulation Results

Fig. 14 shows the power of the photovoltaic panel under 1000 W/ m^2 insulation and load conditions in open loop. The maximum power obtained at 1000 W/ m^2 insulation was 780W in the open loop condition. The Fig. 15 shows the maximum power tracked under 1000 W/ m^2 insulation and load conditions [4] using MPPT controller in closed loop which is implemented using mat lab function [14]. Here the insulation is 1000 W/ m^2 . According to the results, computed Pmax is 1132 W, so the tracking efficiency is 96.8%. the proposed method attempts to tracked 1132 W out of available maximum power 1169 W at 250c and irradiance of 1000 W/ m^2 (750 W for without MPPT) the proposed method attempts to tracked 1132 W out of available maximum power 1169 W at 250 $^{\circ}C$ and irradiance of 1000 W/ m^2 (750 W for without MPPT).

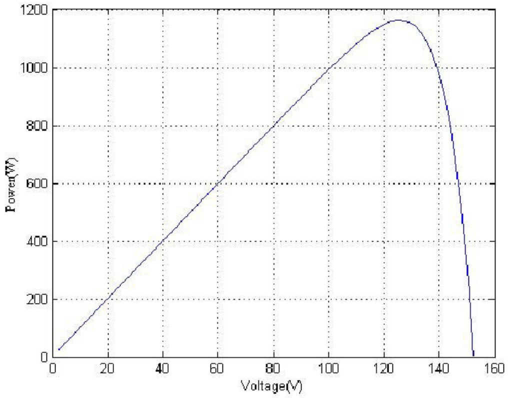

Fig. 9: P-V Characteristics for 1000 W/ m^2

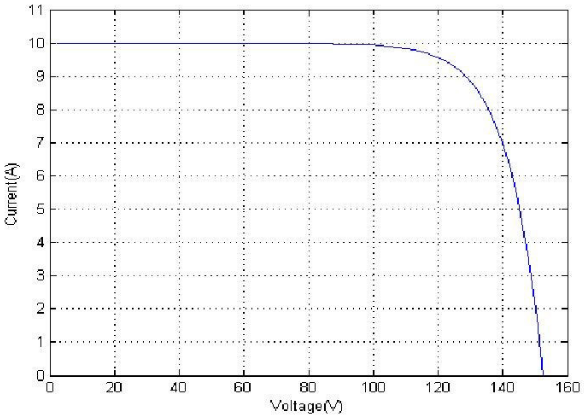

Fig. 10: I-V Characteristics for 1000 W/ m^2

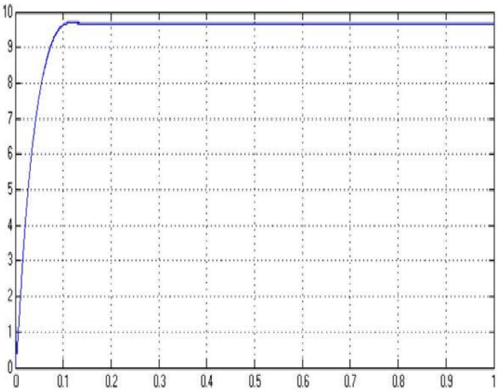

Fig. 11: PV-Output Current

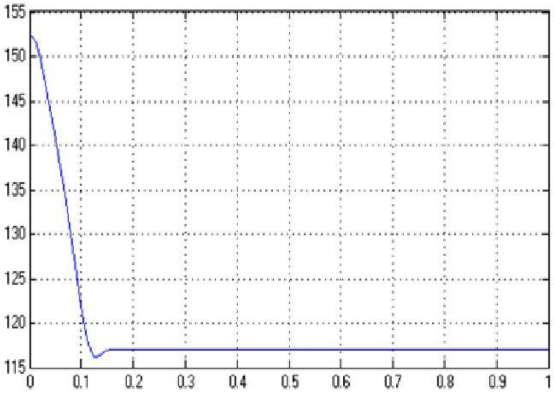

Fig. 12: PV-Output Voltage

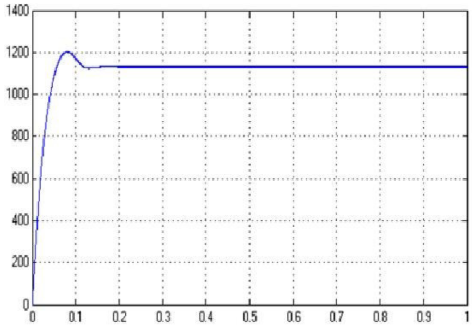

Fig. 13: PV-Output Power

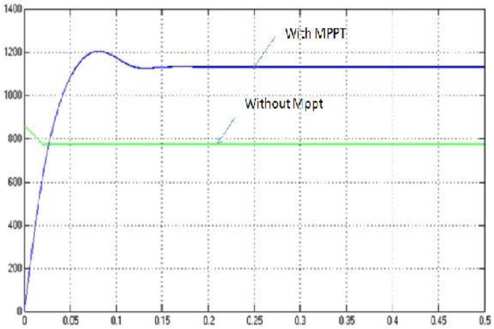

Fig. 14: PV-Output Power of with and without

1.8 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 [17, 18].

1.9 Acknowledgment

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