e-ISSN: 2278-8875
p-ISSN: 2320-3765

International Journal of Advanced Research

in Electrical, Electronics and Instrumentation Engineering

Volume 10, Issue 7, July 2021

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.282

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 7, July 2021 ||

| DOI:10.15662/IJAREEIE.2021.1007026 |

P&O Algorithm Based MPPT Technique for Isolated PV System with Varying Weather Conditions

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ABSTRACT: The PV cells are used to convert incident solar energy into electrical energy. The PV panels are important power sources as they operate on renewable resources, produces clean energy. However, due to change in environmental conditions less power output is generated. In this paper the conventional MPPT algorithm, with P&O technique under varying weather conditions by using MATLAB simulation software is discussed and its findings is presented.

KEYWORDS: PV cell, MPPT, P&O, Photovoltaic, Solar energy, MATLAB/simulink.

I.INTRODUCTION

Energy demand is growing day by day and so is environmental pollution. So switching on renewable sources of energy is the need of the hour not only because it produces clean energy and at an affordable price per unit but also helpful in achieving social equity. By using the clean and affordable source of energy the economy can be boosted up and brings out new ideas and innovations. Also dependency on oil imports is reduced by using renewable sources of energy. But in using solar panel the efficiency is disturbed by the environmental factors like temperature and the insolation level. To get the maximum output power efficiency at every time instant the MPPT system is used. [6-7]

Basics of MPPT

At a time there is only a single operative point in PV modules at which the system can generate power or maximum power. By using the MPPT system, the operating point which gives maximum power is tried to reach or near the maximum power operating point.

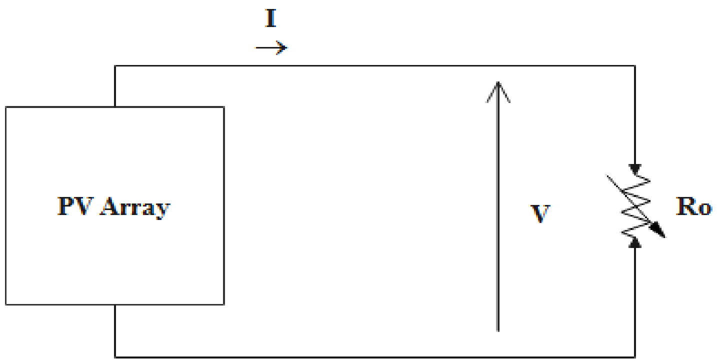

Fig. 1 PV Array with Load, R_O

So, MPPT is the system in which the operating point which gives the maximum power is continuously tried to reach and sustained at that value till any further change in maximum power point.

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II.MATHEMATICAL MODELING OF A PV CELL

A Photovoltaic (PV) cell transforms the incident solar radiationsinto electricity by a phenomenon called Photovoltaic effect. Several PV cells are joined together to get the desired power output. The semiconductor material is used for the manufacturing of solar cells. Solar cell's equivalent circuit model is shown in Fig 2. It consists of a current source, a diode connected in shunt and two resistors, resistor connected in series (Rs) and a resistor connected in shunt (Rsh).[1], [9], [11], [13-14]

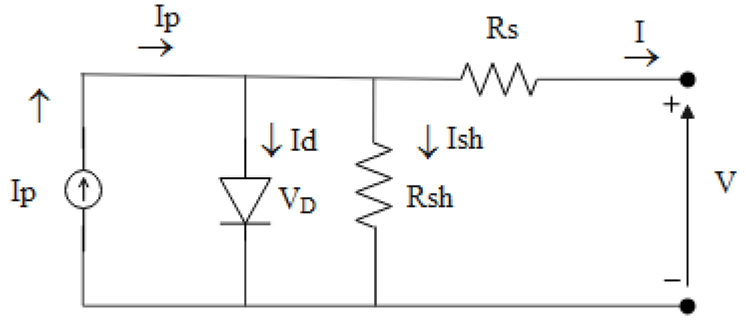

Fig. 2 PV solar cell equivalent circuit

By using the Kirchoff's current law, the PV cell generated current, i.e. Ip can be given as, [4]

$$Ip = Id + Ish + I \quad (1)$$

Where,
I_P= Photo-generated current (A) or Photo-diode current or photo current or current generated by photons
Id = Diode saturation current (A)

The current Ip is sum of the diode current (Id), the current through the shunt resistance Rsh and the terminal current, I.[2], [7]
As the voltage across Rsh is equal to $V + IR_S$, the current through Rsh can be given by the Equation 2 [5],

$$Ish = \left(\frac{(V + IRs)}{Rsh} \right) \quad (2)$$

Where,
V = PV cell output voltage (V)
I = PV cell output current (A)

Where, [4]

$$I = Ip - Id - \left(\frac{(V + IRs)}{Rsh} \right) \quad (3)$$

From PN junction theory,

$$Id = NpI0\ (e^{(V+IRs)/nV_T} - 1) \quad (4)$$

So this is the current equation for the diode.

Then, inserting Equation 4 into Equation 3 results in

$$I = Ip - NpI0[e^{(V+IRs)/(nV_T)} - 1] - \left[\frac{V + IRs}{Rsh} \right] \quad (5)$$

Equation 5 shows the characteristic curve of the PV module. [3], [5], [14], [16], [19-21]

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Where,
I0 represents reverse saturation current of the diode.
V_T is the voltage equivalent of temperature of the diode
n represents diode ideality factor.

To calculate Isc, Short-circuit current (Rs<<Rsh)

So, output current, I is equal to Isc, i.e. short circuit current and the voltage output, i.e. V is equal to 0, which means the terminal voltage is short circuited. If we apply these constraints to the Equation 5 we get,

$$Isc = Ip - I0\ (e^{\frac{(0+IscRs)}{nV_T}} - 1) - \left(\frac{0 + IscRs}{Rsh}\right) \tag{6}$$

Now Rs is very very small compared to the shunt resistance Rsh, therefore Isc Rs is tending towards 0, because of a very small value of Rs. The portion, Isc Rs by nV_T will tend to 0 so e^0 is 1 and therefore this entire diode current portion is removed from the Equation 6.

$$Isc = Ip \tag{7}$$

Therefore, Isc is equal to Ip, the photocurrent which is proportional to the incident solar power or insolation.

To calculate Open-circuit voltage, i.e. Voc (Consider Rsh>>Voc)

Now the output current I is equal to 0 and the terminal voltage, Vis equal to Voc. If we put these values in Equation 5 then we get,

$$0 = Ip - I0\ (e^{\frac{V_{oc}}{nV_T}} - 1) - \left(\frac{V_{oc}}{Rsh}\right) \tag{8}$$

Rsh is much greater numerically compared to Voc. And therefore we could remove this from the Equation 8 without loss of generality.

After rearrange these variables,

$$V_{OC} = nV_T\ ln\left(\frac{Ip + I0}{I0}\right) \tag{9}$$

Voc is related to Ip the insolation but in a logarithmic way. So if Ip increases due to increase in the solar radiation Voc will increase logarithmically.

III. MPPT CONTROL TECHNIQUE

Conventional P&O method

In conventional method the PV voltage output (V) and current output (I) are considered as the control inputs in the MPPT controller. The controller algorithm gives the control signal for the converter accordingly.

Let's understand how this method works. Let initially, the PV output voltage is increased by using the control signal for the converter. Then calculate the output power which is calculated by using V and I, then compare it with the previous power. At the start initial power is set at zero value.

If the power is increased then the algorithm is designed such that it continuously increasing the PV output voltage till the generated power starts decreasing. If the power starts decreasing then the voltage is reduced by the control signal to reach the MPP again.If due to reduction in the output voltage value, the power is decreased from the previous iteration then the voltage is further increased to reach the MPP to generate maximum power.[6], [9-10], [14]

Flow chart for Conventional P&O: The flowchart for the Conventional P&O, i.e. fixed change in voltage or step-size (ΔV) algorithm is portrayed in fig 3.

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The present voltage output (V) and current output (I) of the PV system are computed, and calculate the present power output (P) by using the product block in the simulink model. The present power is matched up with the previous power and according to the P&O principle the algorithm works and reaches the maximum power point.

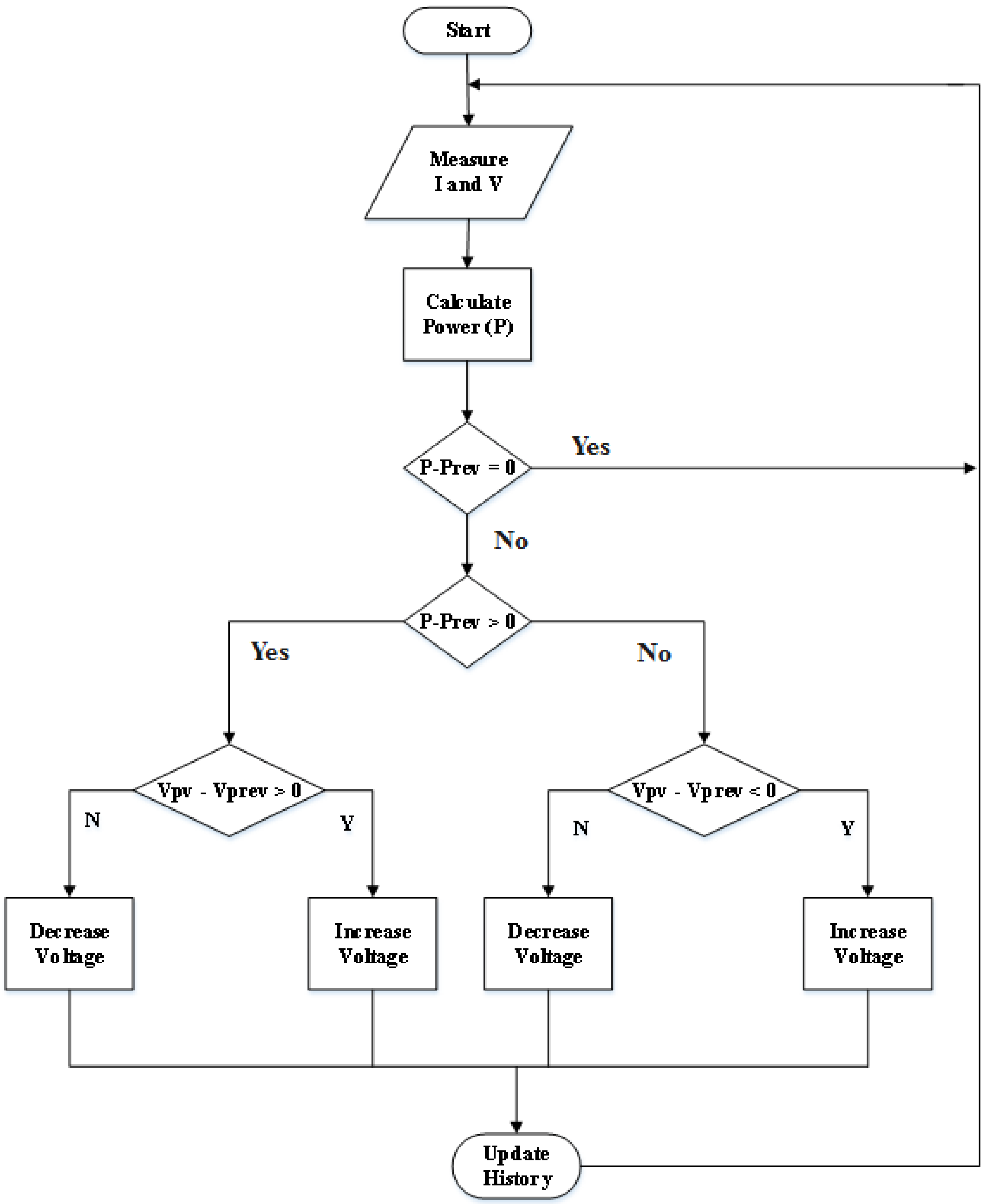

Fig. 3 Flow chart of Conventional P&O algorithm[6],[8], [11-12]

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Table 1: P&O algorithms operation methodology [5]

Serial No.	Constraints	Action Perform
1	ΔP< 0 & ΔV< 0	Voltage increase
2	ΔP> 0 & ΔV> 0	Voltage increase
3	ΔP> 0& ΔV< 0	Voltage decrease
4	ΔP< 0 & ΔV> 0	Voltage decrease
5	ΔP= 0 & ΔV= 0	No change in voltage

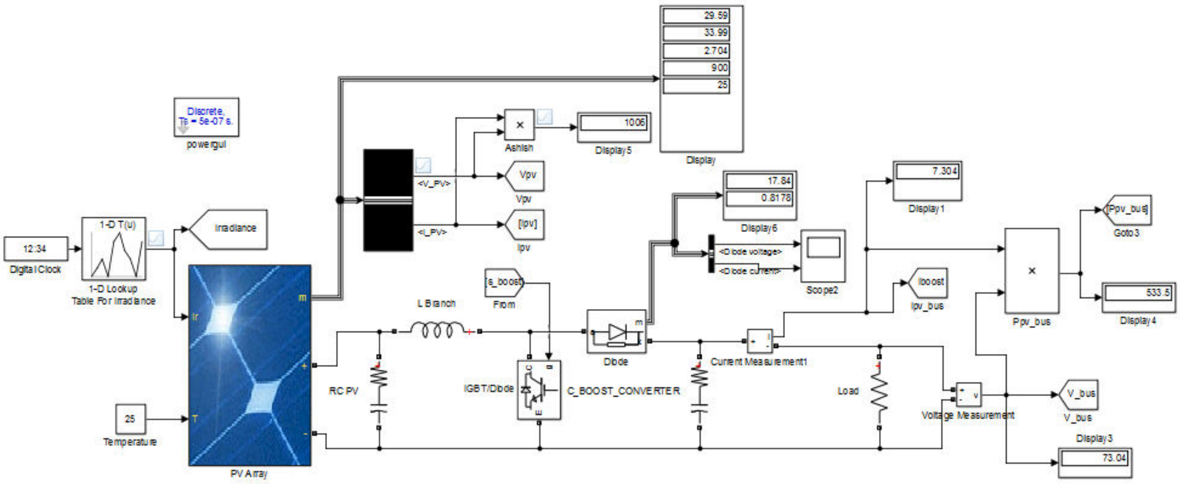

Fig. 4MATLAB/Simulink model of PV panel with ConventionalP&O MPPT system

IV. RESULT AND DISCUSSION

PV Output voltage (V) vs Time (s) graph of the PV panel in case of Conventional MPPT with P&O technique is shown in fig 5.

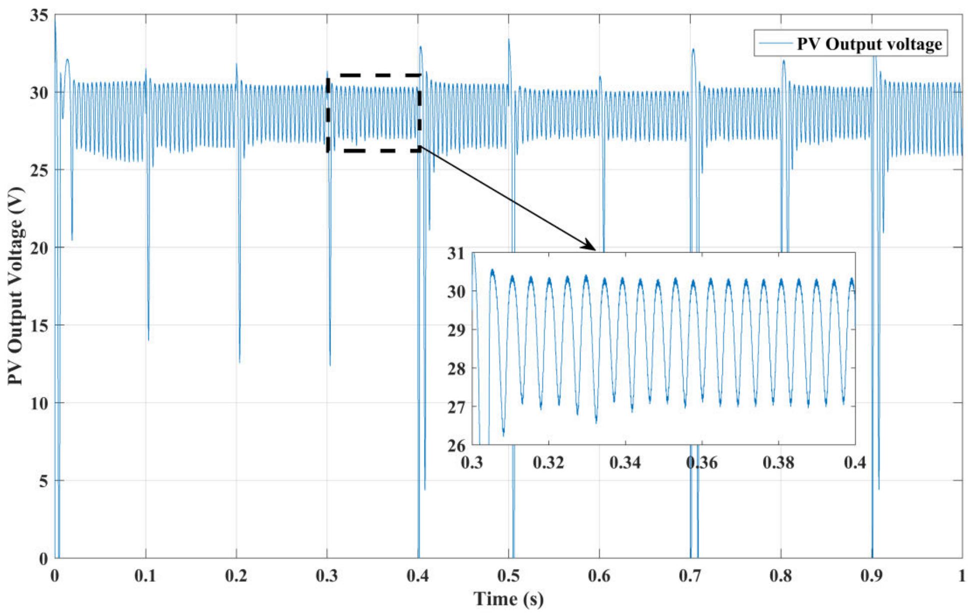

Fig. 5 Graph of PV Output Voltage vs time

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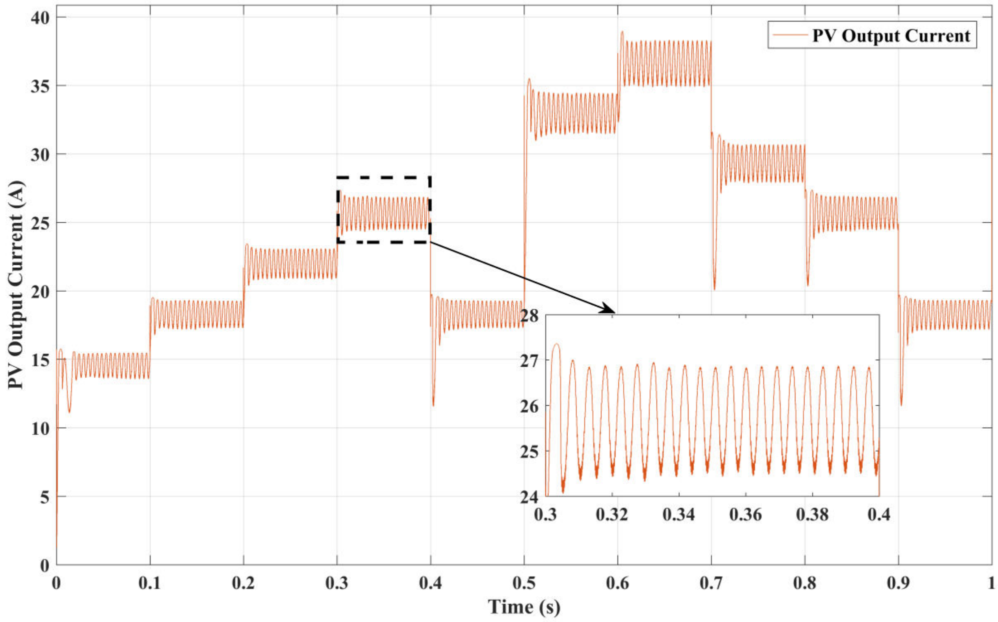

Fig. 6 Graph of PV Output Current vs Time

Fig 6, shows the graph between the PV output current (A) vs Time (s) of the PV panel in Conventional P&O MPPT technique.

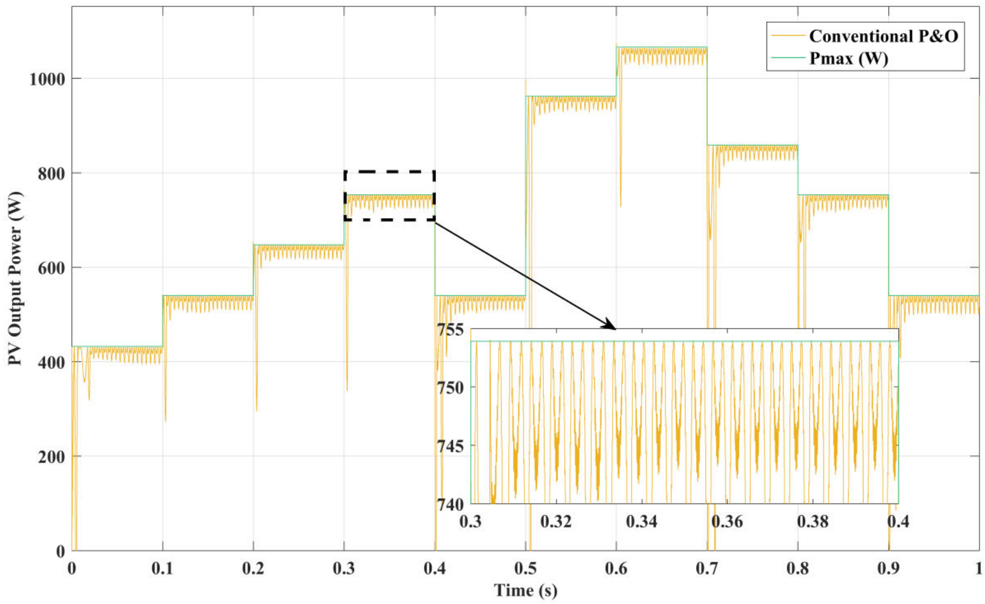

Fig. 7 Graph of PV Output Power (W) vs Time

The PV output power (W) vs Time (s) graph generated by the PV panel in Conventional P&O technique is shown in Fig 7. It also incorporates the theoretical power calculated by using the system model.

Table 2: Conventional P&O MPPT algorithm output parameters chart

MPPT Algorithm	Voltage Ripple (V) (Peak-to-peak)	Current Ripple (A) (Peak-to-peak)	Power Ripple (W) (Peak-to-peak)	Average Tracking Efficiency (%)
Conventional P&O	3 V	2.5 A	15 W	97.51%

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V.CONCLUSION

In this paper, the performance of conventional P&O MPPT algorithm is studied and verified by using MATLAB simulation software. The voltage ripple, current ripple, power ripples and the PV output power tracking efficiency are the quality parameters. In the Conventional P&O MPPT algorithm the voltage ripples(peak-to-peak) are 3V, current ripples(peak-to-peak) are 2.5A, power ripples(peak-to-peak) are 15W and the average tracking efficiency of the PV system is 97.51%.

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