A NOVEL P&O MAXIMUM POWER POINT TRACKING METHOD FOR SOLAR PV SYSTEM

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***Abstract*- a new approach is proposed in this paper to improve the efficiency of solar PV system compensating the effect of irradiance or temperature using MPPT concept (Maximum Power Point Tracking Method). The PV voltage intentional flustering to the changes in PV power which is one of the techniques of MPPT known as Perturb and Observe. And hence we can diagnose the PV characteristics, this unveil MPP position. However the altering temperature (or irradiance) stimulates swing in PV power and a substantial divergence of MPP. The advances for consideration contains an algorithm to reduce the steady state moments and further minimize probability of losing tracking direction of P&O hinged MPPT for PV system. The refashioned program retains conventional P&O, but with unique for swing size. At the same time a dynamic divisions are set to avoid divergence. This work was performed using MATLAB and observed results**

Keywords— Photovoltaic (PV), maximum power point tracking (MPPT), perturb and observer method (P&O).

I. INTRODUCTION

The environmental problems and exhaust of fossil fuels make the people more concerned and motivated to move towards renewable energy resources. Among the renewable energy resources PV panels and the wind-generators are used widely. Renewable energy are more advantageous because of maintenance free and pollution free. The problem with these resources is high installation cost and in some cases their need power conditioners (dc/ac or dc/dc converters) to interface the load with the supply.

Since the overall efficiency of conversion of the PV module is low, high efficiency power conditioners are used and also to extract maximum power from the photovoltaic panel. The point at which maximum power can be obtained is the maximum power point and the techniques used to extract maximum power point from the panel are called maximum power point tracking techniques [1].

An essential part in the PV systems is to trace maximum power point and is ensured to stay at that point. At present plenty of methods are developed and implemented these method vary in sensors required, complexity, convergence speed, effectiveness rang cost, hard implementation, and other aspects [2]. Among all those it became difficult to find which method exists or newly proposed.

In general the most common method to extract maximum power point under atmospheric conditions is by comparing the voltage (or current) measured value to the constant reference values of voltage (or current) [3].presentation of different MP point schemes as well as comparative study is presented in [4], [5]. To date, MPPT techniques reported are of numerous in literature [6]. These techniques are extensively classified into two type's namely conventional and soft computing approaches. In the conventional MPPT the most popular techniques are perturb and observer (P&O) [7], incremental conductance [8], and hill climbing techniques [9]. Fussy logic [10], artificial neural techniques, differential evolution [11], particle swam optimization [12], cuckoo search [13] are the MPPT algorithms based on soft computing are more versatile and flexible.

II. MODELING OF PV

The modelling of the PV modules purpose is to emulate module behaviour; from this it will be ease to integrate the electrical based software (such as MATLAB/Simulink). The two diode model is used in this work [14].

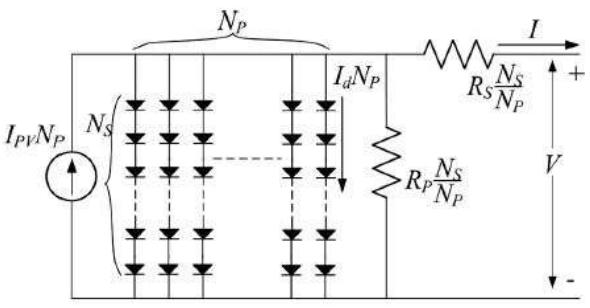


Fig.1. Equivalent circuit of two diode model and combination of series and parallel cells

The governing equations for the above equivalent as follows,

$$I = I_{PV} - I_D - I_P \quad (1)$$

Where the I is the output current, I_{pv} is the current generated by light, I_D is the current lost due to recombination, I_P shunt resistance current loss.
I_D is modelled using the Shockley equation.

$$I = I_{PV}N_P - I_{D1} - I_{D2} - \frac{V+NIR_S}{NR_P} \quad (2)$$

Above (2) is current draw from the system, V is the PV voltage and $N=N_S/N_P$,

$$I_{D1} = I_{D1}N_P\left[\exp\left(\frac{V+NIR_S}{a_1V_{T1}N_S}\right)\right] \quad (3)$$

$$I_{D2} = I_{d2}N_P\left[\exp\left(\frac{V+NIR_S}{a_2V_{T2}N_S}\right)\right] \quad (4)$$

Series resistance and parallel resistances are R_S and R_P ideality factors are a_1 and a_2 [26], terminal voltage is V_T.

$$I_{PV} = \left(I_{PV\_STC} + K_I(T - T_{STC})\right)\frac{G}{G_{STC}} \quad (5)$$

G is irradiance while T is temperature. STC is standard test conditions. K_I short circuit current coefficient, usually provided by manufacturer.

$$I_{d1} = I_{d2} = \frac{I_{SC+}K_I(T-T_{STC})}{exp\left((V_{OC+}K_V(T-T_{STC}))/V_T\right)-1} \quad (6)$$

Above equation results in the saturation current of the diode SC current and OC voltage under STC. K_V variable is the coefficient of temperature of voltage. [15] Gives detailed information regarding the PV module.

TABLE 1. PV Module specifications are as given in tabular form

Label	Parameters	Value
I_{SC}	Short Circuit current	3.8A
V_{OC}	Open circuit voltage	21.1V
I_{MPP}	Current at Pmax	3.5 A
V_{MPP}	Voltage at Pmax	17.1V
P_{MPP}	Maximum power	59.85 W
K_V	V_{OC} coef. of temperature	-0.08V /°C
K_I	I_{SC} coef. of temperature	3e-^{3} A/ °C
n	cell in series per module	36

III. CONVENTIONAL P&O

In the convention P&O method programming and the implementation is ease so the at present the application of this method is spread widely .But the utilization efficiency of this method is very low.

This process is as shown in figure (2).

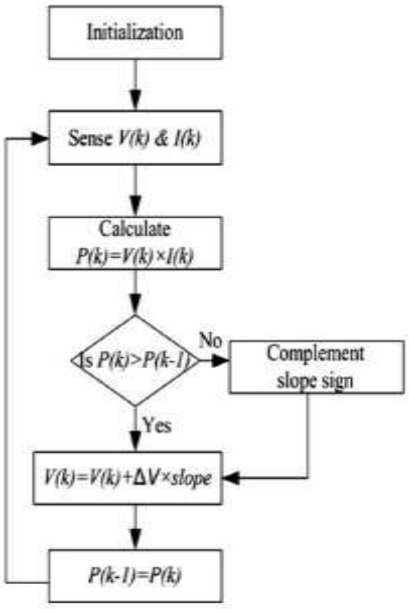


Fig.2.Block diagram for conventional P&O method

The perturbation of the maximum power point varies according to the change of irradiance and the temperature. Even though the change in the irradiance and the temperature is of very negligible the output power extracted from the panel changes. This perturbation can be controlled by using the perturbation size to drag the operating point to the maximum operating point.
The perturbation is based on change in Pas given below

$$X_{new} = X_{old} + \Delta X \times \Phi \quad (7)$$

Major drawbacks that causes hindrance to the application of the conventional method is that conversion efficiency of the system is very low and also oscillations occurred under steady state leads to low output power.

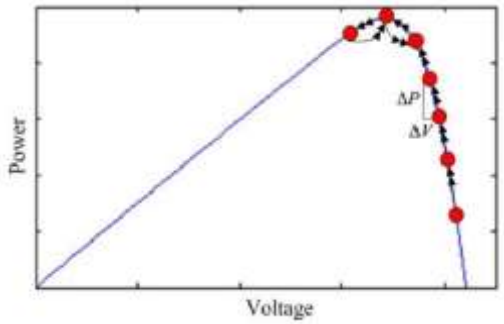


Fig.3. Change of operating point

The loss of tracking direction in this method is also a major issue.

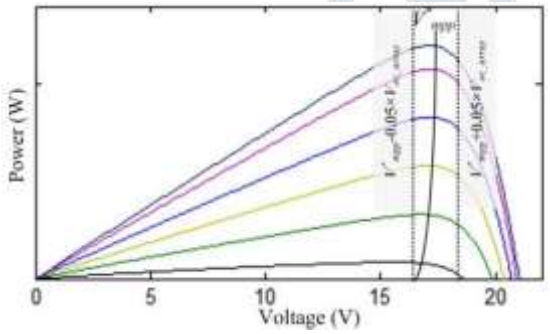
IV. THE NOVEL P&O METHOD

In the novel technique the main aspect is to reduce the steady state oscillation and to improve the tracking efficiency of the system [16],[17]. Initially the changes in the irradiance and the temperature are tracked and then based on the changes the values of the perturbation size is also varied.[18]-[21].

In this new technique the power recorded at this instant is compared to the previous secured value. Based on the calculations the perturbation size is varied is the difference is more the size of perturbation is also more.the size is less if the difference is less. Also the tracking of maximum point is based on the boundary conditions. Limits are included in the axis of the voltage so that the operating point is maintained to operate at maximum point. After some time the irradiance value settles to a particular value then the perturbation size is reduced to minimal [22].

Based on numerous research it is concluded that the MP point lie s in the proximity of 0.8x $V_{oc\text{-}array.}$ The initial to trace the accurate direction, five consecutive values of gradient are summed. During the comparison if the gradient sum is equal to the five then it is said to be converged to steady state is not achieved, in other hand if the value obtained is less than five then it is concluded that MPP tracking converged to steady state.

Initial perturbation size is started at 2% of open circuit array output voltage. The size of perturbation is continuously changed until it reaches the value of 0.5% of the array output voltage and also it is crucial to maintain the perturbation size at minimum value rather than zero.



point is place slightly away from this value. This is because to calculate the gradient of the PV curve. That is either positive or negative further the process is carried out based on the calculated slope. The gradient is the multiplication of sign of voltage and power quantities and normalised to (1) unity.

This concept is supported by the given table.

Table II. Tabulated Φ values

P	***V***	***ϕ* value**
+1	+1	+1
+1	-1	-1
-1	+1	-1
-1	-1	+1

The summation of the slope values of the PV curve can be evaluated using the above tabular form then the obtained value is compared with the value 5

Fig .5.Depending on irradiance level the position change of V_{MPP}

From the figure.5 it is illustrated that the voltage values are restricted within the boundaries of V^{*}_{mpp}-0.05 * V_{oc_array} to V^{*}_{mpp}+0.05 * V_{oc_array} i.e. within the 5% margin it is forced to remain operating point near MPP within imposed boundary thus the locus of loss of tracking is avoided.

The process carried out in the proposed method is as shown in the block diagram below. At starting the maximum point is searched according to the obtained values. Next the oscillation reduction and the perturbation size also reduced to minimum level, this process of tracking is continued [23]-[25]. The measured values are compared to the threshold values and then further calculation of perturbation size is adjusted according to the difference in the secured values and the present values drawn at that instant of time. Further boundary limits are applied and the maximum point is intentionally operated at the maximum power output point.

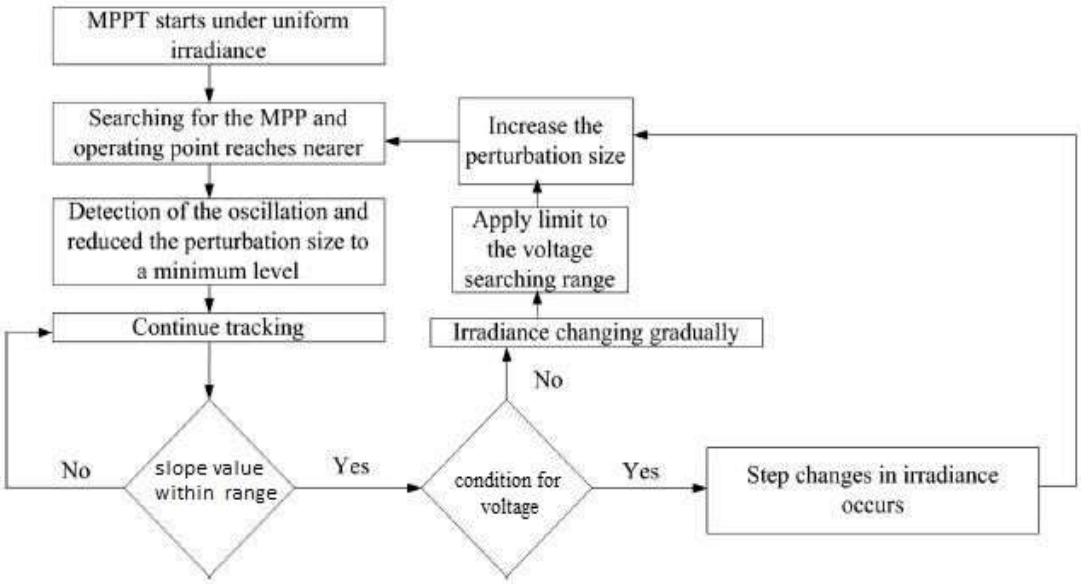


Fig.6. Block diagram for the proposed method

Different inputs of irrsdiance are given as input 250W/m^2, 550W/m^2, 750W/m^2, 950 W/m^2 respectively. the reference temperature of the PV panel is 25^{o}c.

V. SIMULATION RESULTS AND ANALYSIS

The panel output characteristics curves performances are observed for different values of irradiation and temperature as follows under different conditions.

A. Fixed temperature, variable irradiation

Fig 7. (a) and fig . 7. (b) shows the P-V module characteristic output using I-V and P-V curves.

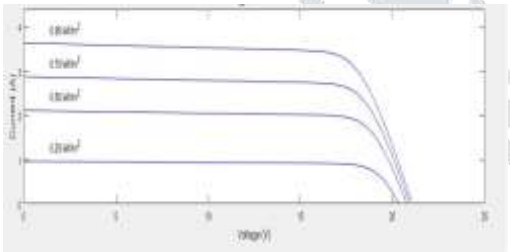
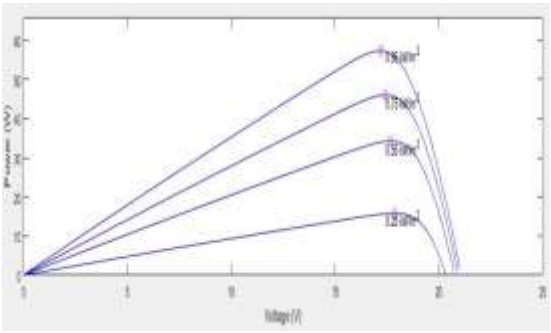


Fig.7. (a) Panel output I-V curve for constant temperature and variable irradiance



B. Fixed irradiation, variable temperature

Fig 8. (a) and fig . 8. (b) shows the P-V module characteristic output using I-V and P-V curves. different temperature values of 25^{o}c, 45^{o}c, 85^{o}c are aplied and constant irradiance of 100W/m^2.

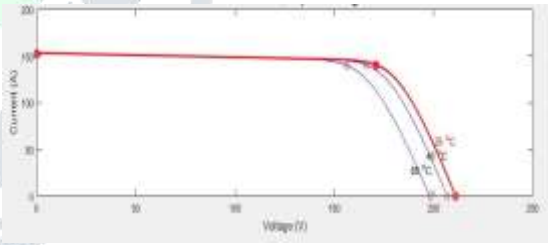


Fig.8. (a) Panel output I-V curve for constant irradiance and variable temperature

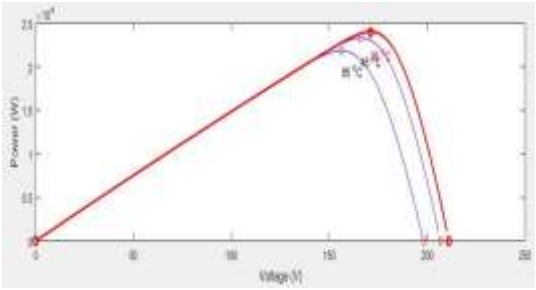


Fig. 8. (b) Panel output P-V curve for constant irradiance and variable temperature

Performance of MPPT:

Below curves are acquired before and after the implementation of the MPPT algorithm to the conventional perturb and observer method.

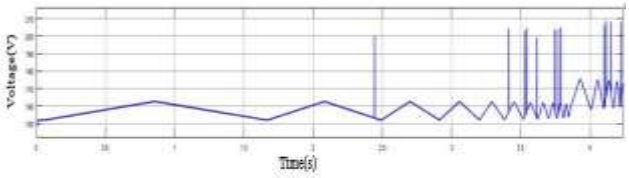


Fig.9 (a). Voltage curve of P&O method before MPPT

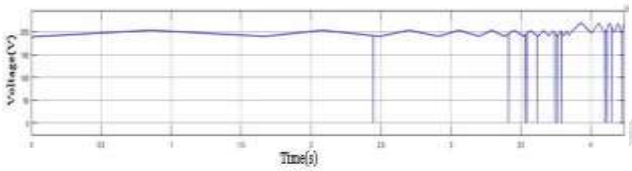


Fig.9 (b). Voltage curve of conventional P&O method after MPPT

Fig .9. (a) and fig. 9.(b) shows that with the application of the MPPT the oscillations in the curves are reduced and he system is operated near the MPP.

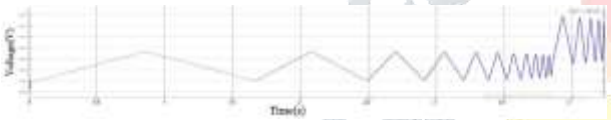


Fig.9 (c). Voltage curve of modified P&O method after MPPT

From the fig.9.(c) it can be concluded that oscillation obtained from the modified method is reduced compared to existing method

Performance evaluation

The MPPT algorithm effectiveness is measured using the efficiency formula of MPPT is,

$$\eta_{MPPT} = P_{OUT}(t)/ P_{IN}(t) \qquad (8)$$

Average efficiency is calculated using

$$\eta_{MPPT,\ avg} = [\int P_{OUT}(t)\ dt]/ [\int P_{IN}(t)\ dt\ ] \qquad (9)$$

Using (2)-(6) the power achievable through theoretical calculations are computed. P_{out} is the extracted power from the PV array by the algorithm, ability to operate close to the MPP depends on the MPPT. The η_{MPPT} is not related to the physical efficiency of the converter is to be noted.

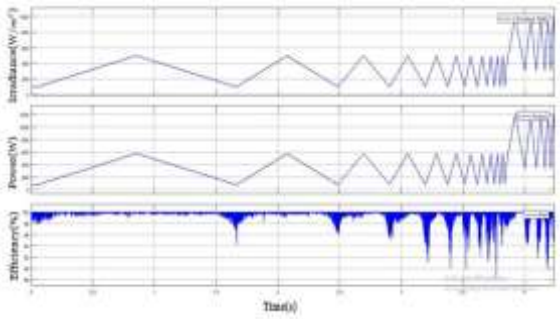


Fig.10 (a). Simulation results of modified P&O method

From the obtained results compared to the traditional method the efficiency is improved from 86% to 98% using modified P&O method. This can be achieved by using the slope calculation.results shown in fig10 are the improved efficiency using modified method.

VI. CONCLUSION

This paper presents a modified method of P&O the obtained reduced steady state oscillations and the improved tracking efficiency is noticed with respect to the conventional method is achieved with the addition of the calculation of the slope values for certain range and also inclusion of the boundary limit in the axis of the voltage. As the voltage values are within the range the MP point operates at maximum power point thus the operating point is said to be operating at the maximum power point.

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