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EFFICIENCY OF PERTURB AND OBSERVE MPPT FOR PV SYSTEM WITH BOOST CONVERTER

MERABET LEILA, OURICI AMEL & TOURAB WAFA

Department of Electrotechnical Engineering, BadjiMokhtar University, Annaba, Algeria

ABSTRACT

In this work, simulation is conducted with Matlab /Simulink to validate the Perturb and Observe technic for tracking the MPP from Photovoltaic system. The MPP change with irradiation and variations in temperature. For this reason, a boost converter is employed to validate the P&O MPPT. The output power of PVpanelis simulated at various atmospheric conditions. Simulation results demonstrated the efficiency of the MPPT method.

KEYWORDS: Photovoltaic System, MPPT, Boost Converter, P&O & Efficiency

1. INTRODUCTION

Nowadays, researchers are oriented towards renewable energy as result of the great use of fossil fuel. However, the photovoltaic power system is the most important renewable energy. This kind of energy is without any pollution of air with the dioxide gas and without any noise.

In reality, PV system characteristics depend on irradiation and temperature. In this reason, the point of maximum power change. The output power of the PV system deteriorates with the increase in temperature irradiation [1].

The tracking of the MPP is detected using various methods. Maximum Power Point Tracking (MPPT) techniques are necessary to extract the (MPP) [2] to the PV arrays. Several MPPT methods are mentioned in the literature. The conventional methods such as the perturbation and observation (P&O) method [3-4], the incremental conductance method [5-6], ripple correlation control [7], short circuit current (SCC) method [8], and open circuit voltage [8]method. There are also those based on intelligent algorithms, as; Fuzzy Logic [9], Artificial Neural Network (ANN) [10], particle swarm optimization [11] and genetic algorithm [12]. Each technique have advantages and disadvantages. Although they are quick to track MPP, but the disadvantage remains in their complex implementation.

Some of these methods present more complexity than the other methods. Cost, time response, number of sensors, hardware, and efficiency are the parameters used for judging the complexity of each method. Due to the different MPPT techniques, many researches in PV systems has conducted a comparative study validating with simulations, and experimentations. Other researche reviewed them [8]. The efficiency of the MPPT techniques is tested according to the either uniform and partial shading insolation underfast or constant changing atmospheric conditions.

2. PV SYSTEM MODELING

It composed of a PV panel connected to a load through a chopper controlled by MPPT controller. Figure.1 shows the synoptic structure of a photovoltaic system.

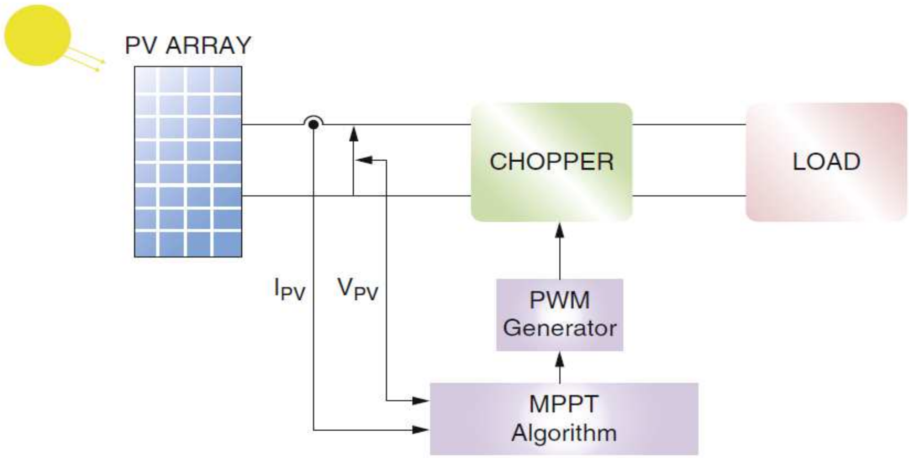

Figure 1: Block Diagram of the PV System.

2.1 Model of the PV Panel

The PV solar panel used in SUNPOWER SPR-305E WHT-D consists of 96 solar cells per module, one module and one string. Table 1 gives the electrical parameters of the PV solar panel. Equation (1) gives the mathematical model [2] of the PV panel. Figure 2 shows the equivalent model of the PV cell. In order to increase, the voltage or the current or the voltage and the current simultaneously of the panel, the PV cells are associated in series, parallel, or series-parallel.

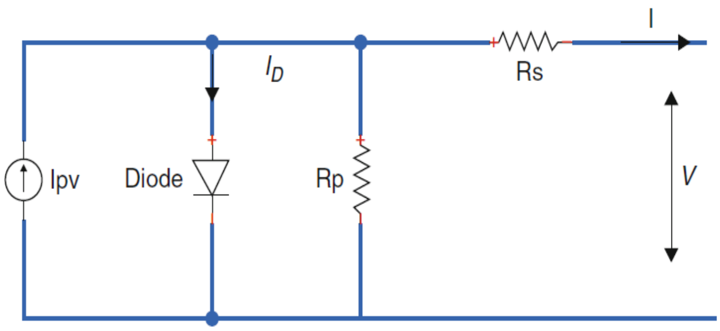

Figure 2: Equivalent Model of Cell.

$$I = I_{pv} - I_0\left[exp\left(\frac{V+R_sI}{aV_t}\right) - 1\right] - \frac{V+R_sI}{R_p} \quad (1)$$

If the Temperature and irradiation are different to the standard condition (T_n= 25 ◦C and G_n= 1000 W/m2);

I_{pv} and I_0 are calculated from equations (2) and (3):

$$I_{pv} = (I_{pvn} + K_i\Delta T)\frac{G}{G_n} \quad (2)$$

$$I_0 = \frac{I_{scn} + K_i\Delta T}{exp\left(\frac{V_{ocn}+K_v\Delta T}{aV_t}\right)-1} \quad (3)$$

The parameters of the model are mentioned in [2]

Table 1: Electrical Parameters of the PV Panel under Standard Conditions

P_{MPP}	305 W
V_{MPP}	54.7V
I_{MPP}	5.58A
V_{OC}	64.2V
I_{SC}	5.96A

The equivalent model of the PV generator is simulated with Matlab Simulink as represented in figure 3.

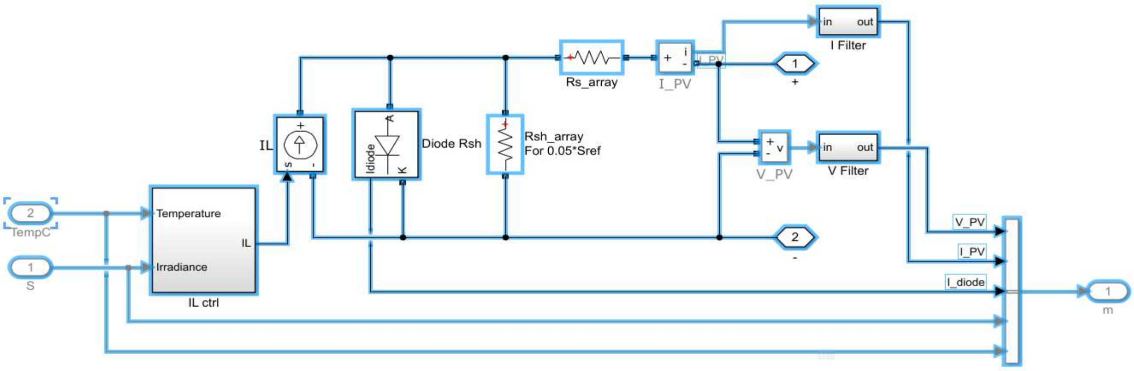

Figure 3: PV Generator with MATLAB/Simulink.

2.2 DC-DC Converter

The method of adapting the PV panel to the load is very important to obtain maximum energy as well as high efficiency from the PV module. This is accomplished by DC-DC power converter, and controlled by the MPPT method. The control strategy, which causes the voltage change simply lies in adjusting the duty cycle appropriately.

In this study, the DC-DC converter is a boost which increases the input voltage. It is modeled with Matlab/ Simulink as shown in Figure 4.

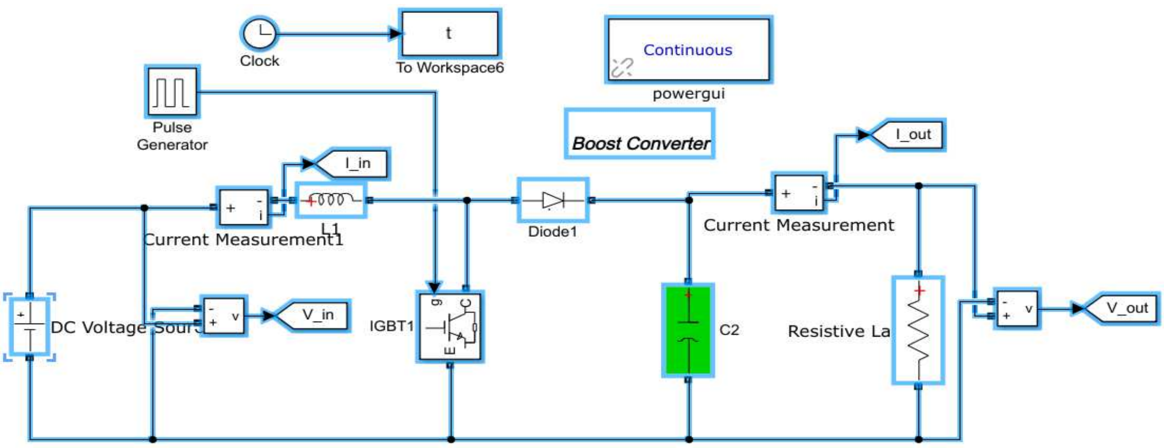

Figure 4: Model of Boost Converter with Matlab Simulink.

The relation between the input and output voltages and currents of the boost converter can be written as [13]:

$$\frac{V_{out}}{V_{in}} = \frac{I_{in}}{I_{out}} = \frac{1}{1-D} \quad (4)$$

D is the duty cycle

$$D = \frac{t_{on}}{t_s} \quad (5)$$

Where;

t_{on} is the on-state time of the IGBT while T_S is the switching time.

f_s is the switching frequency: $f_s = \frac{1}{t_s}$

V_{out}, V_{in} are the output and the input voltages respectively.

I_{out}, I_{in} are the output and the input currents respectively.

2.2.1 Dimensioning of the Inductor

The inductor is calculated based on the current deviation as mentioned in [13] following inequality (6)

$$L \geq \frac{V_{out}}{4 f_s \Delta I_{Lmax}} \quad (6)$$

2.2.2 Dimensioning of the Capacitor

The capacitor Cis calculated based on the ripple voltage. Its value is determined by the following inequality [13]:

$$C > \frac{D_{max} V_{out}}{R f_s \Delta V_{out}} \quad (7)$$

2.3 MPPT Algorithm

Maximum power point tracking (MPPT) method detect the maximum power from the PV panel under temperature and irradiation variations [14, 15, 16, 17]. This is possible by action on the duty cycle of the boost converter. If the point of maximum power is not reached (shows figure 5), great power losses increase.

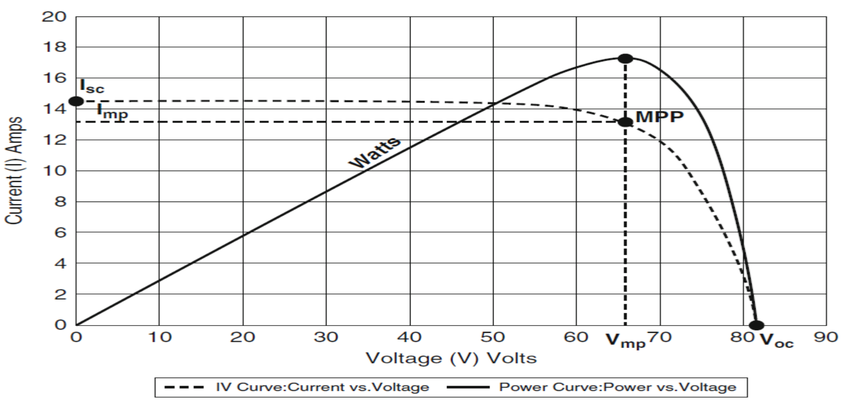

Figure 5: MPP Position.

An efficient MPPT technique shall provide:

- An accurate MPPT
- A high tracking speed

- Efficiency both in constant and partial shading insolation
- Efficiency underfast changing atmospheric conditions
- Efficiency for differentPV systems
- A simplicity
- No oscillation around MPP

2.3.1 Perturb and Observe (P&O) Principle

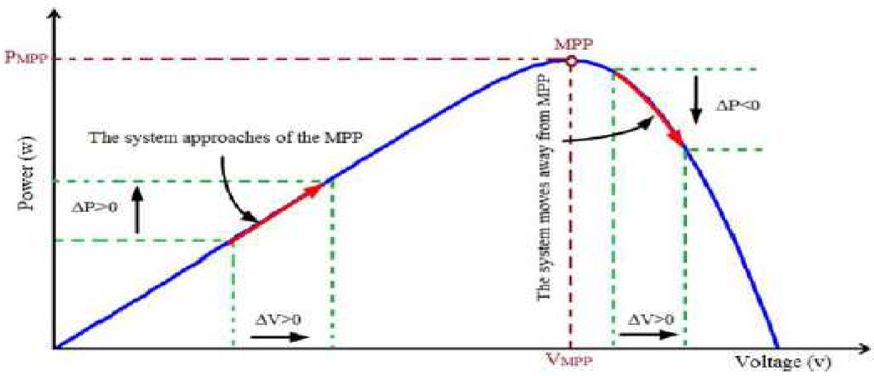

Figure 6: MPPT Tracking with P&O.

Perturb and Observe algorithm is easy to implement because the knowledge of the PV panel characteristics is not required [3-4]. The principle of tracking consists on perturb voltage by decrease or increase the duty cycle of the IGBT and observing the change of the PV output power (show figure). It is resumed as follows:

- If $dp\,dv > 0$;then; the voltage should be increased, according to $d(k) = d(k-1) + dD$,($dD$is an accretion constant)
- If $dp\,dv < 0$, then; the voltage should be decreased according to$d(k) = d(k-1) - dD$.

The principle of Perturb and Observe technique is detailed in Figure 7. To simulate this P&O algorithm, a boost chopper, which described in section B, is used.

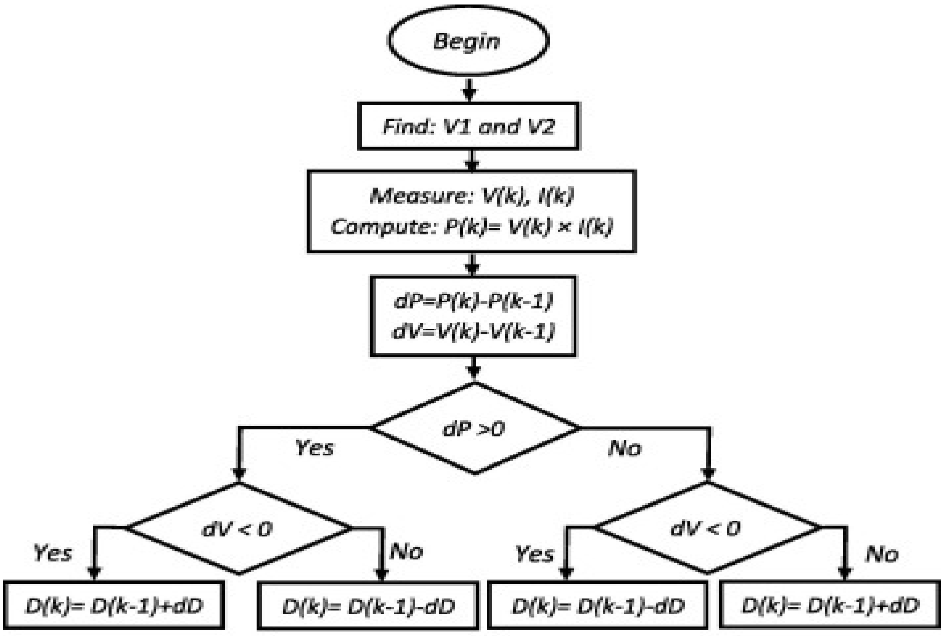

Figure 7: Perturb & Observe Flowchart.

2.4 Efficiency of Tracking

The accuracy of a tracking method is estimated by the correct extraction of the MPP. Efficiency [18] of a MPPT is given by equation (8).

$$\eta = \frac{tracked\ power}{V_{mp} I_{mp}} \quad (8)$$

Where;

$$p_{max} = V_{mp} I_{mp} \quad (9)$$

The efficiency of tracking method is a very important factor in case of fast variation in climatic conditions.

3. SIMULATION RESULTS

To validate the P&O MPPT strategy and judge the efficiency of the system the PV model was validated by simulation using Matlab Simulink, as shown in Figure 8.

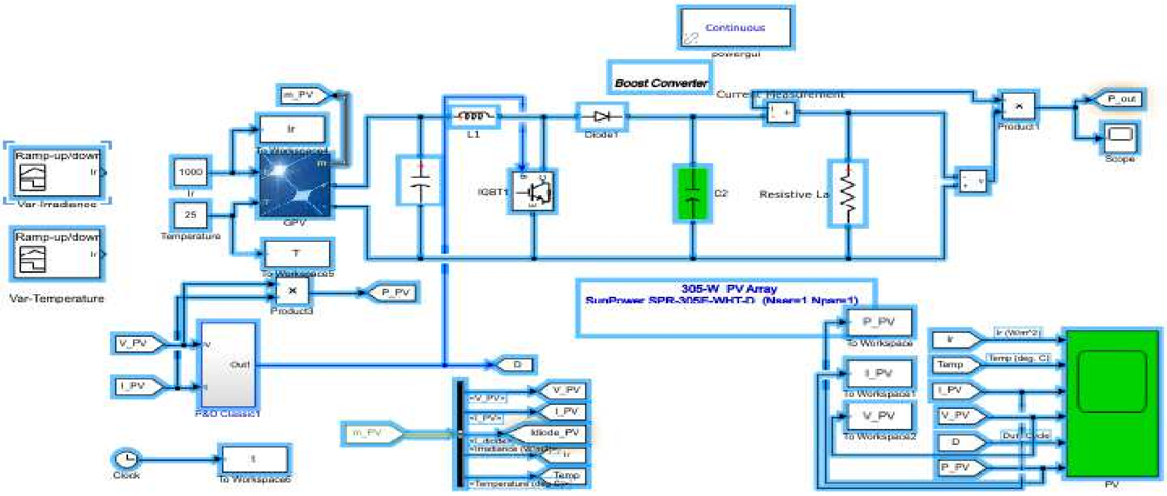

Figure 8: Global Model of PV system with P&O MPPT.

4.1 Influence of Irradiation on PV

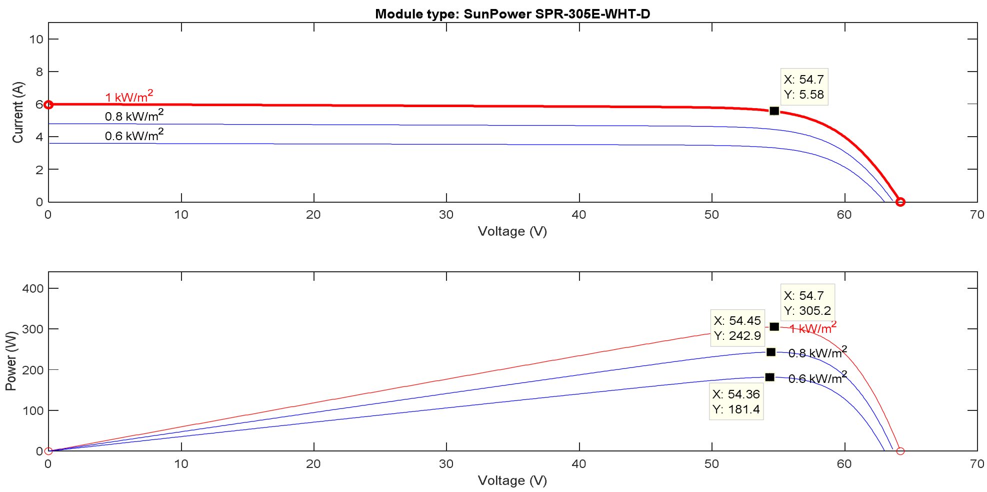

Figure 9: Irradiance Effects on the PV Curves. (T = 25 ◦C)

Figure 9 shows the behavior of the PV solar panel when the irradiation is variable. When the radiation increases, the MPP increases.

4.2 Influence of Temperature

Figure 10 shows the behavior of the I-V and P-V curves in case of variation in temperature.

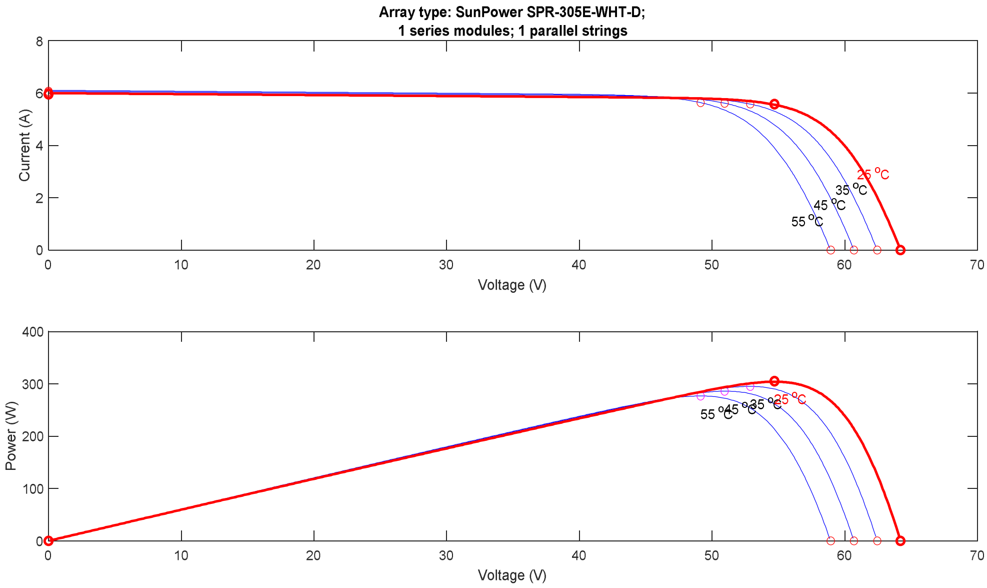

Figure 10: Temperature effect on the PV Curves (at 1000 W/m^2).

The curves show that when the temperature increases, the point of MPP decreases. For this purpose, the MPPT method must tracking the new point of MPP corresponding to the change of temperature and/or insolation.

4.2.1 Test of Boost Converter

In order to test the boost converter, we use an inductor L=300mH an output capacitor equal to 1000µF and a duty cycle D=0.5. If the input voltage is *V-in*= 200V the output voltage is *V-out*= 400V. Simulation results, as demonstrated in figure 11 shows that the output voltage is higher than the input voltage.

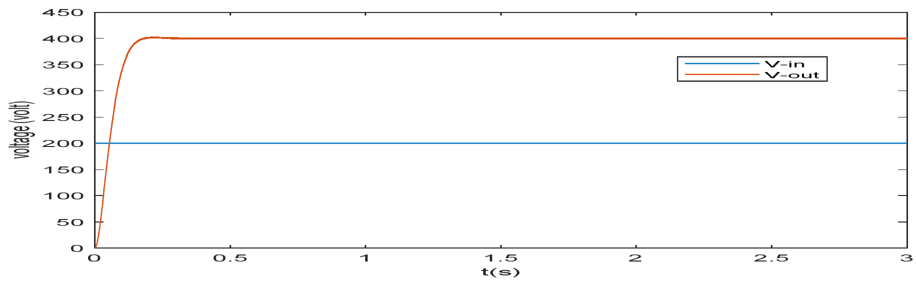

Figure 11: Simulation Results of Boost Converter.

4.3 Test of P&O method

Results with temperature = 25°C and Irradiation = 1000W/m^2

Figure 12 illustrates the output power, corresponding to the standard conditions. The power converge towards the optimal value with less oscillations with time response around 0.25s.

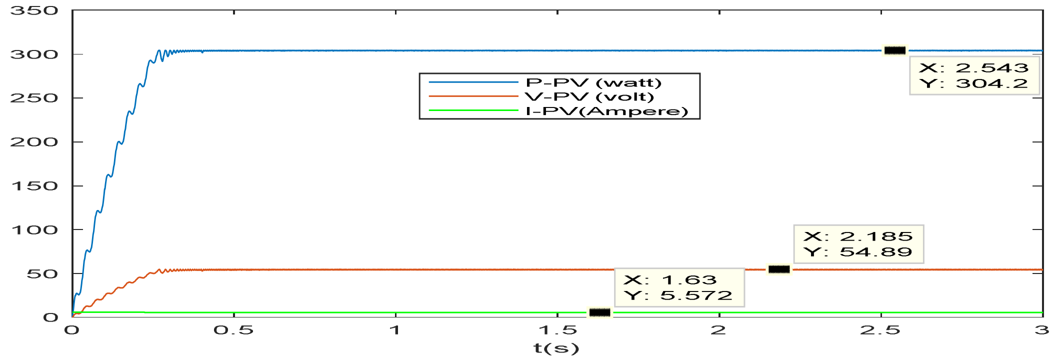

Figure 12: Output PV Power, Voltage and Current under 25°C and 1000 watts/m².

Results with temperature = 25°C and change in irradiation

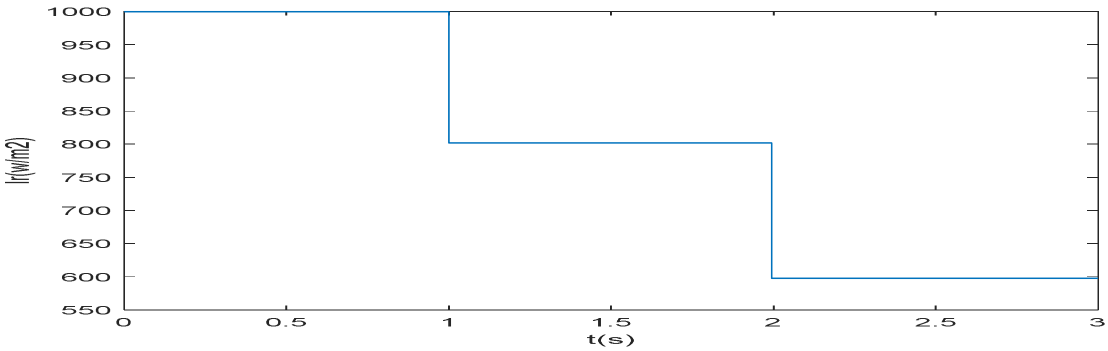

Figure 13: Variation in Irradiation.

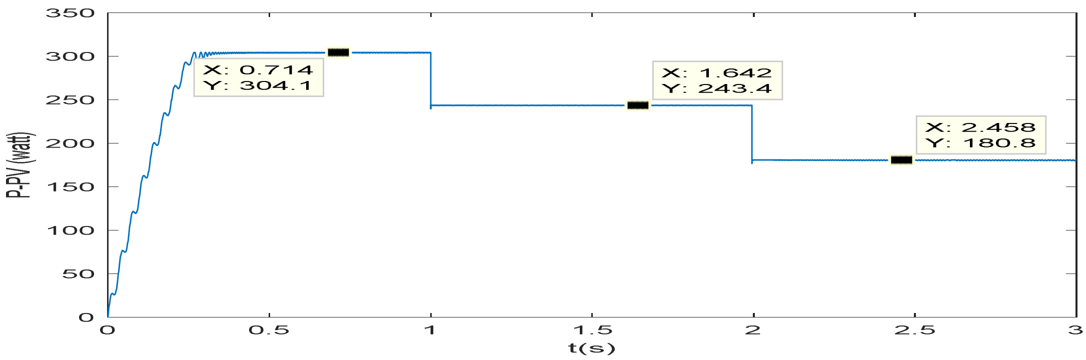

Figure 14: Output PV Power with MPPT Corresponding to the Change in Irradiance.

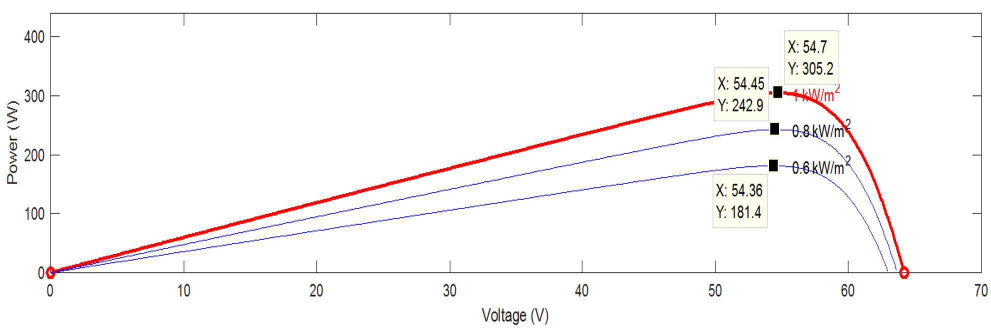

Figure 15: P-V Characteristics for change in Irradiance.

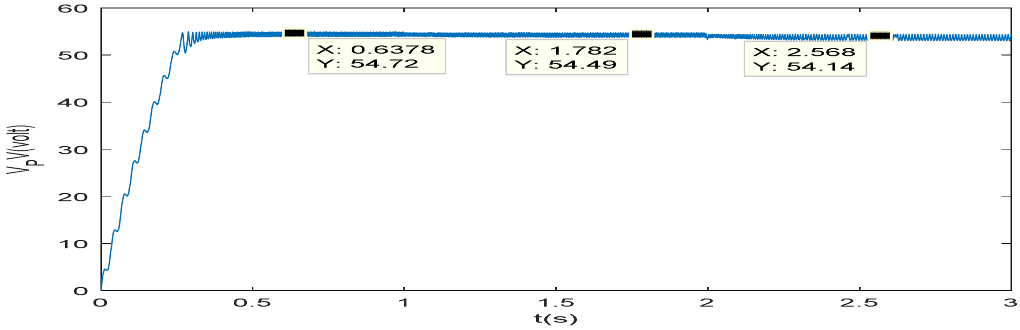

Figure 16: Output PV Voltage with MPPT for Change in Irradiance.

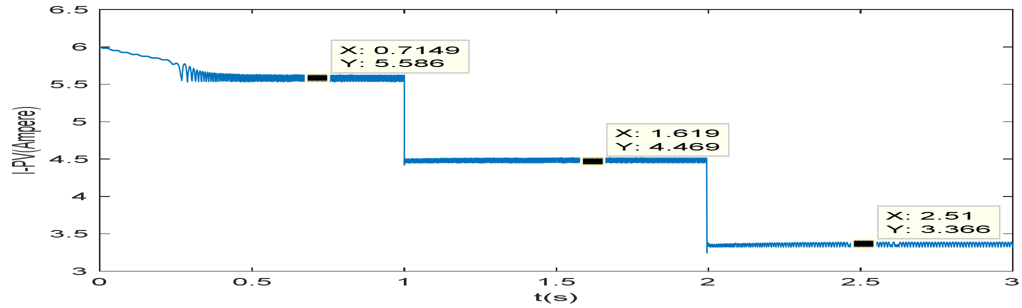

Figure 17: Output PV Current with MPPT for Change in Irradiance.

Figure14, 16 and17 show the PV output power, voltage current for variation in irradiance and constant temperature. The powers converge towards the optimal values at each irradiation; Figure 15. It is case the MPP PV panel increases with increasing solar irradiance.

Results with irradiation =1000W/m2 and change in temperature

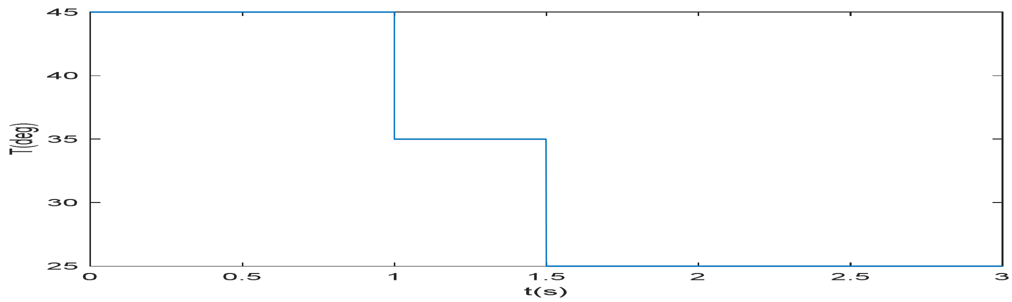

Figure 18: Temperature Variation.

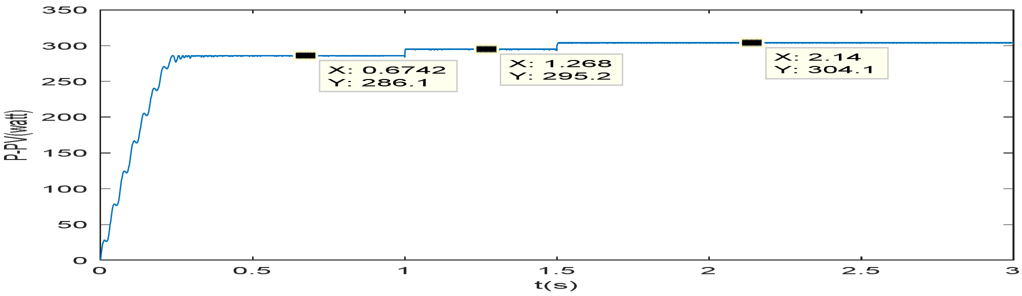

Figure 19: Output PV POWER with MPPT at different Temperature.

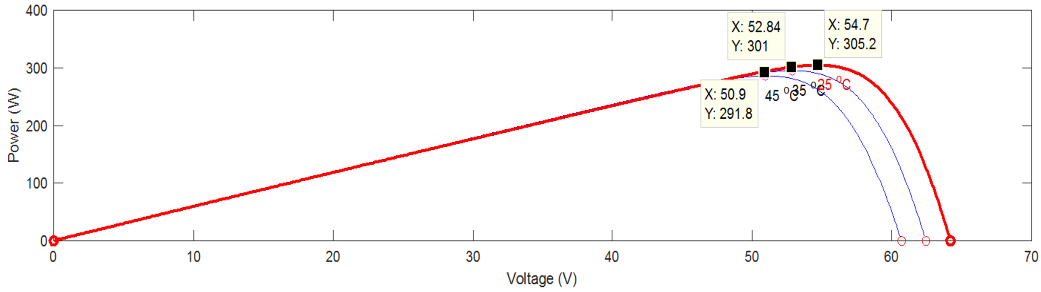

Figure 20: Curves PV power for Change in Temperature.

From these various simulation results as show in Figure 19 for constant solar irradiance and change in temperature (figure.18) it results that the MPP the PV panel increases with decrease in temperature. In Figure 20, it is reported the P-V characteristics in order to compare the MPP to powersat the output of the PV panel with MPPT method. We note that the powers converge to the value of MPP at steady state.

However, when the irradiation varies rapidly controller has a slow time response.

Table 3 resumes the differences between the MPP of the PV panel and the MPPT with P&O algorithm under change in temperature and solar irradiance. The speed of tracking is judged by the efficiency η in case of variable solar irradiation and variable temperature as mentioned in Table 3.

Table 3: Comparison of MPP of PV panel and MPPT with P&O method

Solar irradiance	MPP	MPPT with P&O	η	temperature	MPP	MPPT with P&O	η
1000W/m^2	305.2	304.1	0.996	**45**	291.8	286.1	0.980
800W/m^2	242.9	243.4	1.002	**35**	301	295.1	0.980
600/m^2	181.4	180.8	0.966	**25**	305.2	304.1	0.996

5. CONCLUSIONS

In this paper, a PV system used a P&O method to track the MPPT and is validated with simulation in order to judge the efficiency of this technique. Several simulation with Matlab/Simulink environment are carried out under climatic variations. The simulation results show that:

- The Point of MPP of PV panel decreases in case of increase in temperature and it increases when the irradiation increases.
- The tracking with P&O method is accurate when the irradiation and temperature changes.

- •The good choice of the value of inductance and the value of the capacitance of the boost components can minimize the oscillation around the MPP; which is necessary for dimensioning these elements before proceeding to execute the MPPT controller.
- •The P&O method is not complex to implement and requires two sensors to capture the power.

In the other hand, this method of tracking presents oscillations around the point of MPP in steady state and a slow response time. For resolving these problems, we suggest using the Intelligent MPPT techniques based on: fuzzy logic, artificial neural network, particle swarm optimization and genetic algorithm or even adapt the hybrid methods.

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