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Performance of maximum power point tracking MPPT controller in photovoltaic system

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Abstract

Modeling and simulation of a photovoltaic system for improving and optimizing the performance of its control, by the method of continued maximum power point tracking (MPPT) is presented in this work. For this characterization of the photovoltaic system including the MPPT based on the method of perturbation and Observation "P&O", the power interface is the boost converter (DC-DC) is carried. Of that same, their models are developed in MATLAB/Simulink. The results obtained under different conditions confirm the proper functioning of the MPPT Controller for photovoltaic systems with the algorithm of perturbation and observation "P&O".

"Keywords: Photovoltaic system; MPPT; Perturbation and observation; boost;"

1. Main text

This work is part of the commitment to the use of renewable natural resources and clean and increased mobilization efforts of research/development for the control technologies used in the installations of renewable energy conversion power [1]. The PV (photovoltaic) system consists of eight modules, photovoltaic power interfaces and filler. A simple circuit DC-DC converter (boost) is used as an interface between the PV and load. A PV model was developed using MATLAB/ Simulink, and the model of the converter, interfaced with the simulation of a DC-DC controller ordered with a P&O (perturb and Observe), which shows oscillations around the MPP (maximum power point) in seeking the maximum power point. The order proposed MPPT is an approach widely used in research because of the MPPT is simple and requires only measurements of voltage and current of the photovoltaic panel V_{pv} and I_{PV} respectively, he gave very good performances and he improved photovoltaic system responses, it not only reduces the response time for the pursuit of maximum power point but it also removed the fluctuations around this point.

Nomenclature

I_{ph}, I_{S1} and I_{S2} : the photo-current, saturation currents of the diodes 1 and saturation currents of the diodes 2.

V_{pv} and I_{PV} : voltage and current photovoltaic respectively.

n_1, n_2 : factors purity of the diodes.

R_S, R_{Sh} : the series resistance and the parallel resistance.

T : the absolute temperature in Kelvin.

q : the elementary charge constant =$1{,}602.10^{-19}$ C.

k : the Boltzmann constant =$1{,}380.10^{-23}$J/K.

2. Photovoltaic system

The photovoltaic conversion is produced by subjecting the solar cell to sunlight. The energy received causes a chaotic movement of the electrons inside the material. The current collection is via the metal contacts (electrodes). If these electrodes are connected to an external circuit, a DC current flows. The cells are connected in series by welding the front contact of each cell to the rear contact of the next. These sets of cells are encapsulated in sealed modules that protect them from moisture, shock and noise: this is the photovoltaic module [2]. The electric model closest to the photovoltaic generator is a model of two diodes with different form factors and laws of behavior, in relation to temperature, different, Figure1.

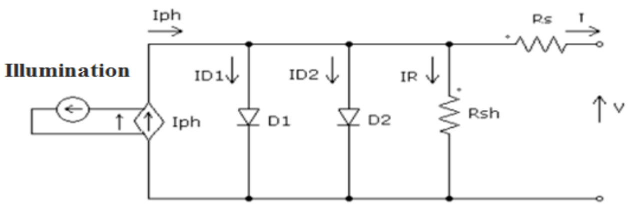

Fig. 1. Modèle électrique équivalent du générateur PV.

3. $$I = I_{ph} - I_{S1}\left[e^{\frac{q(V+IR_S)}{n_1KT}} - 1\right] I_{S2}\left[e^{\frac{q(V+IR_S)}{n_2KT}} - 1\right] - \frac{V+IR_S}{R_{sh}} \quad (1)$$

We have in this equation; the current is a function of temperature, the voltage across the cell, and the illumination itself. The model is therefore implied. The simplest solution to avoid this problem is to neglect the series resistance at this level in the cell model and then include that as wiring resistance R_S in the complete simulation model [3]. Another option is to implement an iterative algorithm that can calculate the current by successive approximations. This gives a classical modeling and performance of a cell PV [4], [5]. The current-voltage characteristic is highly dependent on the insolation and temperature. The temperature dependence is further amplified by the properties of photo-current I_{ph} and reverse saturation currents of the diodes which are given by [6]. In this work we simulated the "Shell SP75" module comprising 36 silicon solar cells connected in series to 125.125mm. The electrical characteristics of photovoltaic module "Shell SP 75" in standard test conditions are shown in Table 1.

TABLE 1. *Electricals characteristics of "Shell SP 75".*

Electricals parameters of the panel in the STC: Illumination E = 1000W/m^2, temperature T = 25°C.	
Maximum peak power, P_m.	75 W
Maximum voltage, V_m.	17 V
Maximum current I_m.	4.4 A
Open circuit voltage, V_{oc}.	21.7 V
Short-circuit current, I_{sc}.	4.8 A

The Fig 2 present the characteristics I(V) and P (V) of the photovoltaic module "Shell SP75" after simulation with MATLAB/Simulink.

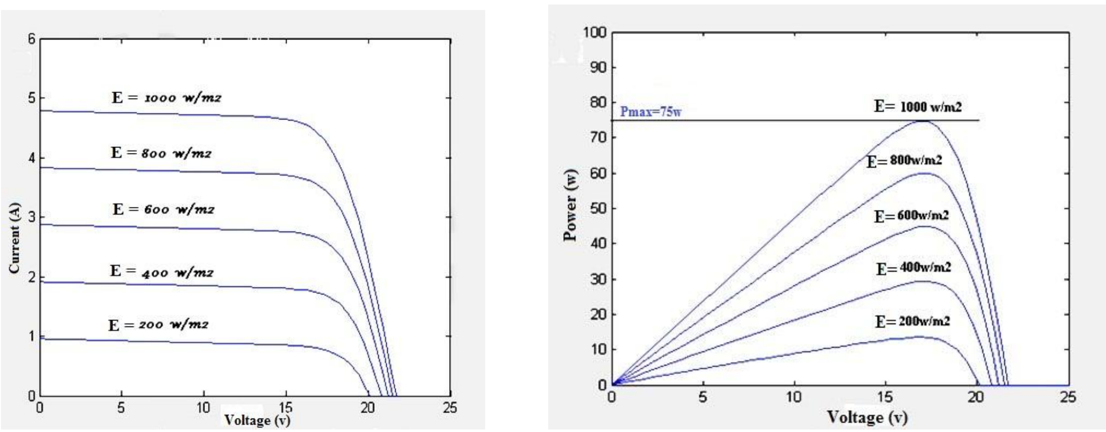

Fig. 2. a) Characteristics I (V) of the photovoltaic module. b) Characteristics P (V) of the photovoltaic module.

4. DC-DC converter

It is necessary to control the supply of electricity using a system of energy storage and regulation of the stock. It is also sometimes necessary to change the nature of the current for some applications (converting DC to AC using an inverter) [6]. Choppers are DC-DC converters for generating a variable DC voltage source from a fixed DC voltage source. The chopper consists of capacitors, inductors and switches. All these devices in the ideal case do not consume power that is why the choppers have good yields. Usually the switch is a MOSFET which is a semiconductor device mode (stuck-saturated) [7].

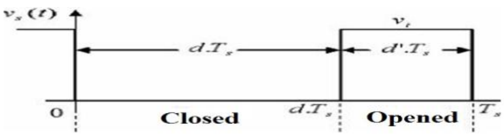

Fig. 3. Voltage v_S (t) of the ideal switch, duty cycle d and switching period T_S.

If the semiconductor device is blocked, its current is zero when its power dissipation is zero. If the device is in the saturated state, the voltage drop across it will be almost zero and therefore the power loss is very small [8].

As shown in Fig 3 during operation of the chopper, the switch is closed with a closing time equal to d.T_S, and opened in an opening time = (1-d) T_S, where:

- Ts is the switching period which is equal to 1/f_S.
- Of the duty cycle of switch (d $\in$[0,1]) [9].

5. Maximum Power Point Tracking (MPPT)

The maximum power that corresponds to the optimum operating point is determined for different insolation from sunlight, and for different temperature variations. We use the type converter DC-DC in the control of the photovoltaic system because it is easier to control, by their reports using a cyclic signal.

In this paper we propose a concept based on fuzzy logic. More than thirty tracking method for PPM was proposed, but the most prominent is the famous P&O algorithm predominates [10].

This continuation of the PPM algorithm is the most used, and as the name suggests it is based on the perturbation of the system by increasing or decreasing V_{ref} which by acting directly on the duty cycle of the DC-DC, then observation of the effect on the output power of the panel. If the current value of the power P (k) of the panel is greater than the previous value P (k-1) then we keep the same direction of previous disturbance if we reverse the disruption of the previous cycle. Fig 5 shows this algorithm.

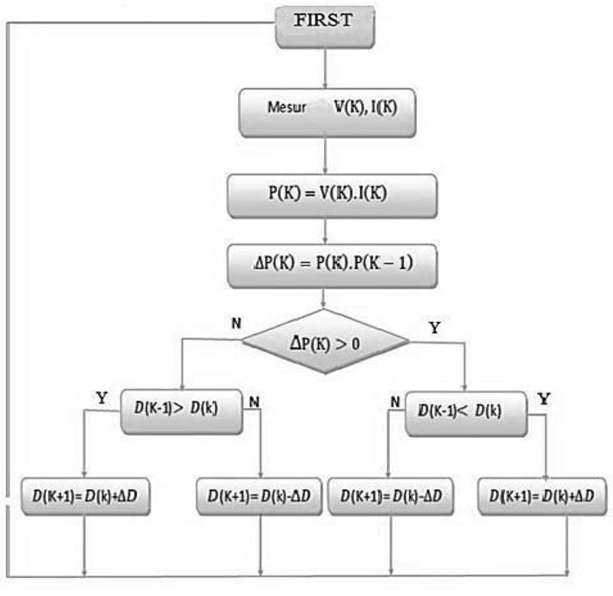

Fig. 4. Algorithm of Perturbation and Observation (P&O).

6. Results and comments

In this section we will simulate a solar system that contains eight photovoltaic modules and a boost chopper with the simulation tool MATLAB/Simulink included in the software Math works MATLAB, and the MPPT tracking control of perturbation and observation.

The system is simulated under stable environmental conditions and many changes of weather conditions: (change in sunlight slow and fast). Fig 5 shows the block diagram Simulink General PV system.

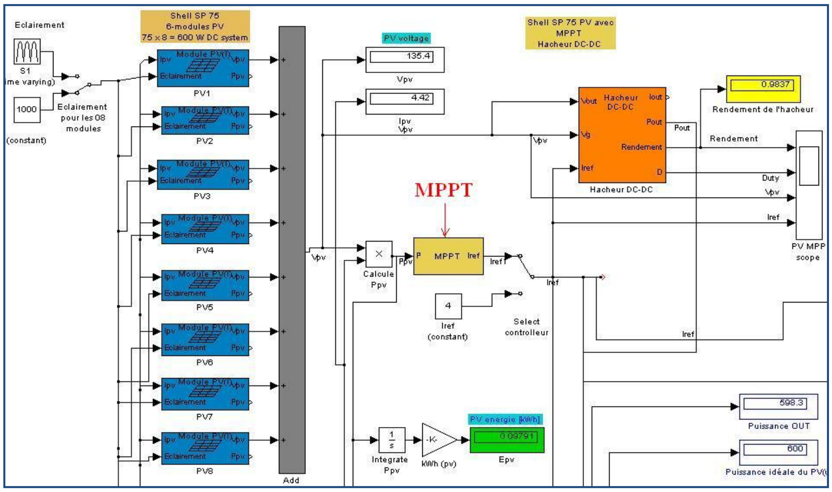

Fig. 5. Simulink block of photovoltaic system with MPPT.

5.1 Operation under constant conditions

In this test the temperature and sunshine are held constant. It takes the values of standard conditions: T=25°C and illumination E=1000W/m^2. The purpose of these simulations is to visualize the shift of operating point from point MPP. It is also used to assess losses due to oscillations around this point that is close to 600 watts from Fig 6.

5.2 Behavior of the system to a change in the illumination

To evaluate the response time of the tracking mechanism, it is subject to varying conditions of sunlight. To see how the system reacts to changes in illumination we will make him suffer first slow changes of sunshine, (Fig 7) from 0 to 250 seconds of illumination reached 1000 W/M^2 going after that time the light going back to 0, second is going to apply a quick change of sunshine at time t=1000 seconds 1000 to 500W/m^2 (Fig 8 and 9) in a very short time which is rarely done except for the mobile stations (solar vehicle) when out of a tunnel for example.

The temperature is kept constant at 25°C. Under these conditions, the controller for MPPT (P&O) we see the effect of the rapid increase in power caused by an increase in sunlight. In this case this technique continues to disrupt the system in the same direction while it is in the wrong direction, causing a deviation from the operating point of the true MPP. This deviation stabilized once the sun takes some time to be recovered, and cause a delay of t=20 seconds (Fig 7).

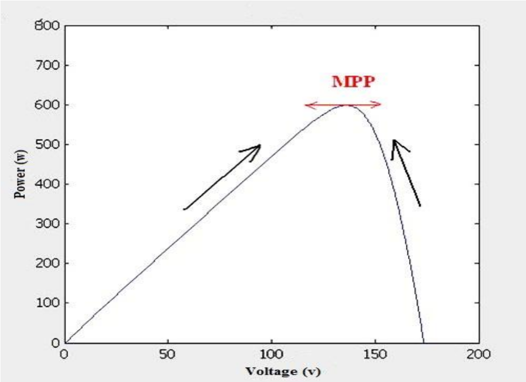

Fig. 6. Curve P (V) of the eight modules.

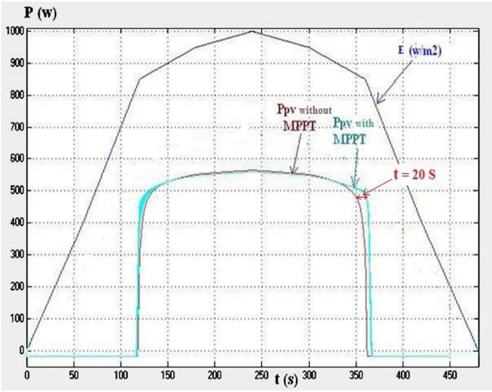

Fig. 7. Power of system with and without MPPT.

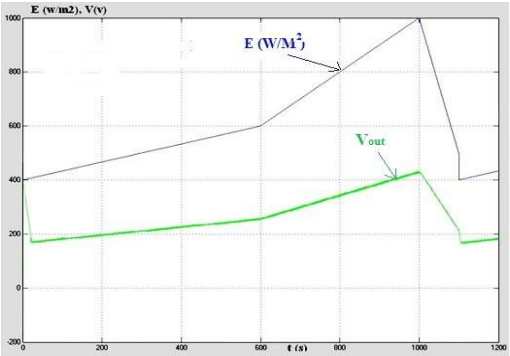

Fig. 8. The out voltage V_{out} of the boost V(t).

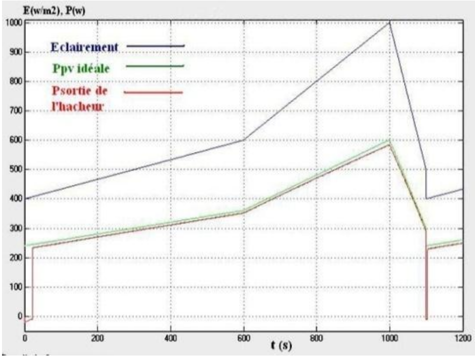

Fig. 9. Power of system at the output of the chopper.

7. Conclusion

In this study, the results obtained show the efficiency of the MATLAB/Simulink for simulation of photovoltaic modules, this is confirmed by the good results of the simulation characteristics of the module «Sharp SP75» and the performance of the MPPT controller used with the perturbation and observation algorithm, which forces the PV system to work around its maximum power. This controller has proven to have better performance, fast response time and steady state error very low, and it is robust to various changes in atmospheric conditions.

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