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INNOVATION OF THE PHOTOVOLTAIC SYSTEM, GENERAL AND MAXIMUM POWER POINT TRACKING DEVICE FOR SMART CITIES

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ABSTRACT

Photovoltaic solar energy becomes more and more a solution that promises to replace fossil fuels, thanks to these benefits that we can mention abundance, the absence of pollution and availability of more or less important amounts at all. Points on the earth's globe. It is also a reliable energy (no moving mechanical parts), flexible (adaptable size of the facilities) and which can be produced as close as possible from the consumption site. Photovoltaic solar systems have power generation directly depending on weather conditions (temperature, irradiation). Thus, sizing and optimum use of the energy produced by these generators requires the use of appropriate control methods. Recovery efficiency photovoltaic system requires the recovery of maximum power PV generator to establish proper control to receive maximum power in these generators. The objective of this article is to study the performance of a photovoltaic installation injected into the grid, to meet the energy needs of a building, to then make athe implementation of two algorithms which are the MPPT P&O algorithm and the algorithm Incremental conductance.

Keywords: *Photovoltaic solar, performance, energy needs, MPPT*

1. INTRODUCTION

The production of energy is a challenge of great importance for the years to come. Nowadays, a large part of the world's energy production is ensured from fossil sources (petroleum, natural gas, coal, etc.). The consumption of these sources gives rise to greenhouse gas emissions and therefore an increase in pollution [1]. Photovoltaic energy is an important source of renewable energy that could be an alternative to other conventional sources in order to meet the large energy needs in the future [2]. Indeed, the word photovoltaic comes from the Greek "photo" which means light and from "voltaic" which takes its origin from the name of an Italian physicist Alessandro Volta who contributed a lot to the discovery of electricity [3-5]. This energy is available in abundance over the entire surface of the earth [6]. It is of the order of 1000 W / m² in temperate zones and reaches 1400 W / m² in zones where the atmosphere is slightly polluted with dust or laden with water.

Photovoltaic: is the term relating to the transformation of light into electricity. In the rest of my report the abbreviation "PV" is used to designate the term "photovoltaic".

PV cell: Fundamental PV device capable of generating electricity when subjected to solar radiation.
PV module: the smallest set of interconnected solar cells completely protected from the environment.

PV chain: circuit in which PV modules are connected in series to form sets so as to generate the specified output voltage: it is more common to use the English equivalent "string" to designate a string.

PV group: set of chains constituting the unit for producing electrical energy in direct current.

Junction box: Box in which all PV groups are electrically connected and where any protection devices can be placed.

Inverter: device that transforms direct current and voltage into alternating voltage and current.

Direct current part: it is the part of a PV installation located between the PV modules and the direct current terminals of the inverter.

Alternating current part: it is the part of the PV installation located downstream of the AC terminals of the inverter.

Monitoring: monitoring consists of monitoring and carrying out measurements relating to the monitoring of a PV installation.

Irradiance: instantaneous power of solar radiation in $W.m^{-2}$.

Irradiation: it is the energy of solar radiation. It corresponds to the quantity of energy received during a defined period expressed in. $kWh.m^{-2}$.

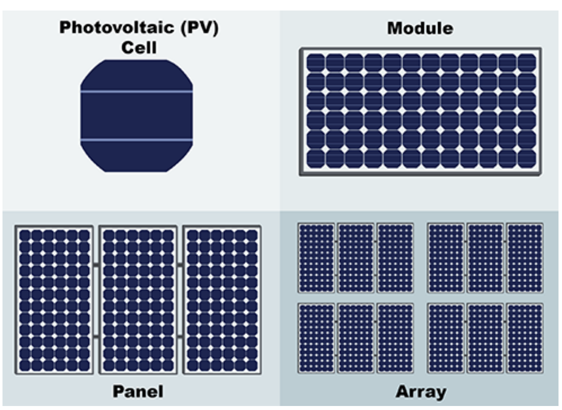

Figure 1: Components Of A Field Of Photovoltaic Modules

2. MATERIALS AND METHODS:

1. PRINCIPLE OF OPERATION:

For the maximization of power of the PV source, interposed a matching quadrupole which is a DC-DC energy converter between the PV source and the load and with the rigorous control of the duty cycle of the latter [7] as shown in the Figure (2) This type of converter is intended to adapt the apparent impedance of the load at any time to the impedance of the PV field corresponding to the maximum power point. The adaptation stage has a command (MPPT) which makes it possible to search for the (PPM) that a photovoltaic solar panel can provide [8]. The search algorithm (MPPT) can be more or less complex depending on the type of implementation chosen and the performance sought. However, in the end, all efficient algorithms must play on the variation of the duty cycle of the associated power converter [9]. (Walker, 2001).

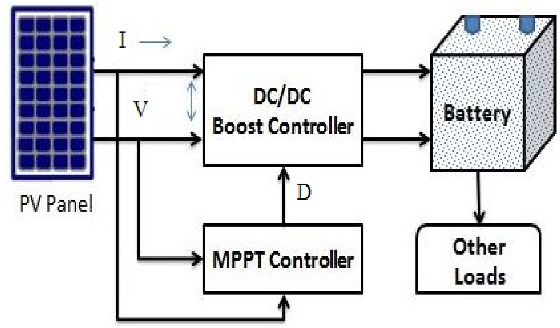

Figure 2: Block Diagram Of The PV System By An MPPT Control

Due to the non-linearity of the IV characteristic, the MPPT circuit forces the system to operate continuously on the point at maximum generator power, once the illumination or the temperature changes. The chopper then captures the electric power absorbed according to a sampling period, and begins to increment or decrement the duty cycle D to cancel the power gradient [10].

2. COMPOSITION OF A PV CELL:

a. P-type semiconductor layer:

The semiconductor material contains external atoms which have a lower amount of free electrons. A positive excess of charge carriers (electron holes) is thus obtained in the semiconductor material. These layers are called p-type conduction semiconductor layers.

b. N-type semiconductor layer:

The semiconductor material contains external atoms which have a greater amount of free electrons. This results in a negative excess of charge carriers (electrons) in the semiconductor material. These layers are called n-type conduction semiconductor layers.

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c. Anti-reflection layer:

The purpose of the anti-reflection layer is to protect the PV cell and to reduce the reflection losses at the surface of the cell.

3. TECHNOLOGY:

Typically, solar cells are made from silicon, the second most common element in the earth's crust. A silicon atom has four valence electrons. In a silicon crystal, two electrons from adjacent atoms form an electron pair. In this state, the silicon crystal is not an electrical conductor [11], because it does not have any free electrons to carry the charge.

An electric field separates the electrons from the holes. In semiconductors, the input of disturbing atoms makes it possible to generate an electric field. For this purpose, [12], atoms with five electrons are placed in a region. This region is an n or n-doped semiconductor because, compared to the pure silicon crystal lattice, it has a slightly negative charge.

Three electron atoms are placed in another region. This region is a p or p-doped semiconductor because, compared to the pure silicon crystal lattice, it has a slightly positive charge. If the semiconductors n and p are adjacent, it forms at their limit the pn junction, from which an electric field originates.

A pn junction is obtained by combining p and n semiconductor layers. At the boundary between the two layers, electrons move from the n shell to the p shell and recombine there with the holes.

3.1 Monocrystalline silicon

Monocrystalline silicon cells represent the first generation of photovoltaic generators. To manufacture them, we melt silicon in the form of a bar. During slow and controlled cooling, silicon solidifies forming only one large crystal. The crystal is then cut into thin slices which will give the cells. These cells are usually a uniform blue.
Lifespan: 20 to 30 years.

Advantage:

- ✓ Good yield, from 12% to 18%
- ✓ Good ratio (around 150 which saves space if necessary $W_c/m^2 Wc/m^2$)
- ✓ High number of manufacturers

Disadvantages:

- ✓ High cost
- ✓ Low performance in low light.

3.2 Polycrystalline silicon:

As the silicon cools in an ingot mold, several crystals are formed. The photovoltaic cell is bluish in appearance, but not uniform, we can distinguish patterns created by the different crystals.

Advantages:

- ✓ Square cell (with rounded corners in the case of monocrystalline Si) allowing better expansion in a module, less expensive than a monocrystalline cell.

Disadvantages:

- ✓ Efficiency less good than a monocrystalline cell: 11 to 15%
- ✓ Ratio less good than for monocrystalline (around 100) $Wc/m^2 W_c/m^2$
- ✓ Low performance in low light.
- ✓ These are the cells most used for electricity production (best value for money). Lifespan: 20 to 30 years.

3.3 Amorphous silicon

Silicon during its transformation, produces a gas, which is projected onto a sheet of glass. The cell is a very dark gray color. It is the cell of so-called "solar" calculators and watches.

Advantages:

- ✓ Operates in low or diffused lighting (even on cloudy days)
- ✓ A little cheaper than other technologies.

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- ✓ Integration on flexible or rigid supports.

Disadvantages:

- ✓ Low yield in full sun, 6% to 8%
- ✓ Need to cover larger areas than when using crystalline silicon (lower ratio, around 60 Wc/m^2 Wc/m^2
- ✓ Performance that decreases over time (around 7%).

Table 1: Comparative Table Of The Different Technologies

Material	Yield	Longevity
Monocrystalline silicon	12 to 18% (24.7% in laboratory)	20 to 30 years
Polycrystalline Silicon	11 to 15% (19.9% in laboratory)	20 to 30 years
Amorphous	5 to 8% (13% in the laboratory)	
Monocrystalline composite	18 to 20% (27.5% in the laboratory)	
Polycrystalline composite	8% (16% in the laboratory)	

Material	Characteristics	Main uses
Monocrystallin silicon	High performance Production stability. Expensive and laborious production method	Aerospace. Module for roofs, facades, ...
Polycrystalline Silicon	Suitable for large-scale production. Production stability. It occupies more than 50% of the world market	Modules for roofs, facades, ...
Amorphous	Can work under fluorescent light. So low light. Operation in cloudy weather. Operation in case of partial shade. The output power varies over time: At the start of its life, the power delivered is 15 to 20% higher than the nominal value and stabilizes after a few months.	Electronic devices (watches, calculators, ...). Integration into the building.
Monocrystallin composite	Heavy, sensitive	Aerospace (Satellites)
Polycrystalline composite	Requires few materials but some contain polluting substances.	Electronic appliances. Integration into the building.

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3.1 Constitution of a photovoltaic generator

The power produced by a single PV cell is low. The association of several photovoltaic cells in series / parallel gives rise to a photovoltaic generator in order to increase the voltage and intensity of use.

3.2 Parallel association

In an array of cells connected in parallel, the cells are subjected to the same voltage and the resulting characteristic is obtained by adding the currents at a given voltage as shown in figure (3):

$$I_{scc} = N_p . I_{cc} \text{ And } V_{soc} = V_{OC}$$

N_p : The number of PV cells connected in parallel.

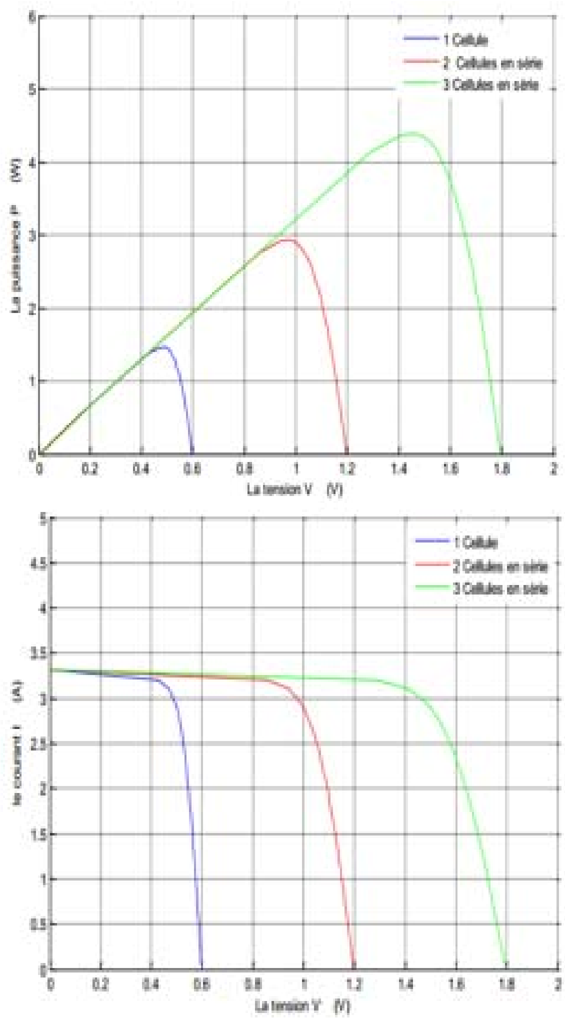

Figure 3: PV And IV Characteristics Of A PV Cell Array In Parallel

3.1 Serial association

In the series connection, shown in figure (7), all the PV cells are traversed by the same current. On the other hand, the output voltage is equal to the sum of the voltages of the assembly.

$$I_{scc} = I_{cc} \text{And} V_{soc} = N_s V_{oc}$$

Ns: being the number of PV cells connected in series

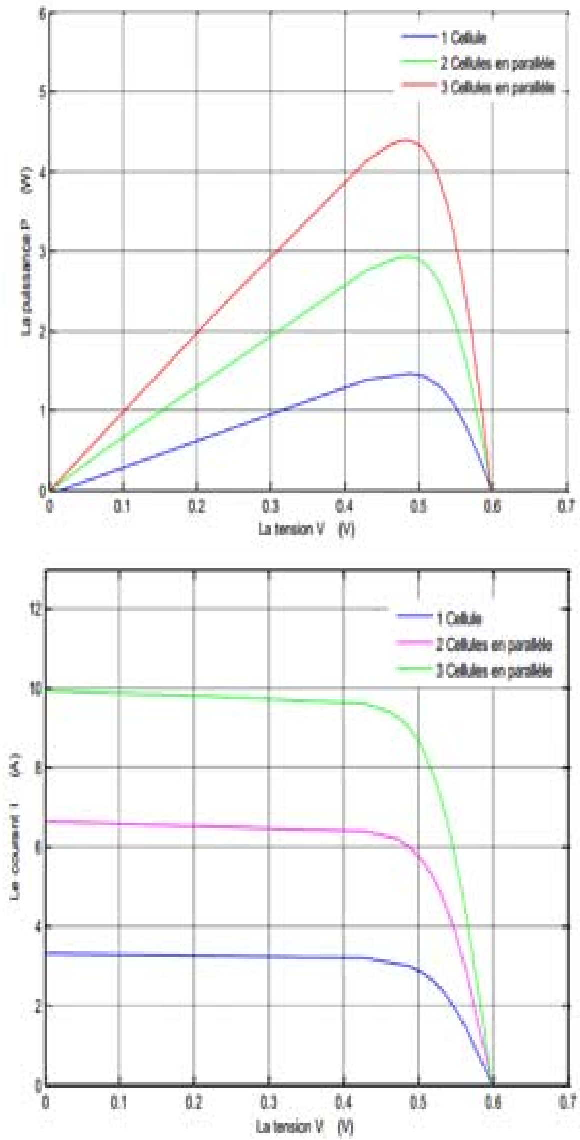

Figure 4: PV And IV Characteristics Of An Array Of PV Cells In Series.

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4. INFLUENCE OF PARAMETERS ON CHARACTERISTICS

4.1 Series resistance

The series resistance acts on the slope of the characteristic in the area where the cell operates as a constant voltage generator as shown in figure (5):

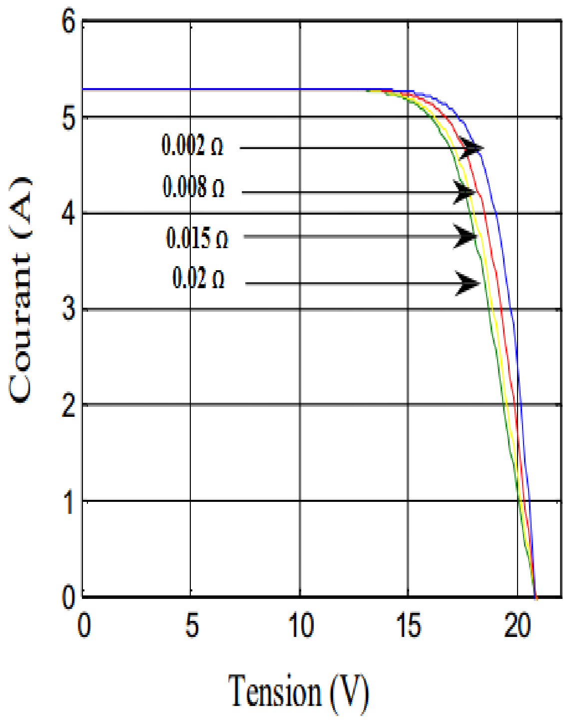

Figure 5: Influence Of Series Resistance On Characteristic IV

4.2 Temperature

A rise in the temperature of solar cells causes a significant increase in their current. Since the PV current is equal to the subtraction of the photo-current and the diode current, there is a slight increase in current accompanied by a sharp decrease in voltage and therefore a shift of the maximum power point (PPM) towards the lower powers. I_{cc} V_{co}

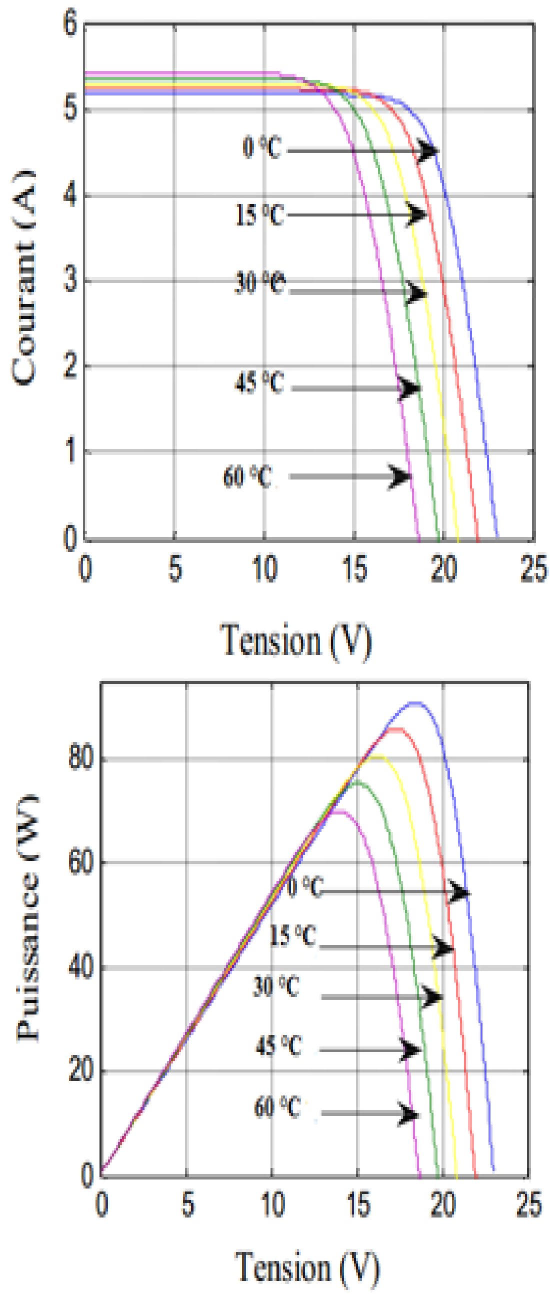

Figure 6: Influence Of Temperature On IV And PV Characteristics

4.1 Sunshine

The figure (7) shows the influence of illumination on the IV and PV characteristics. At a constant temperature, it is observed that the current undergoes a significant variation, but on the other hand the voltage varies slightly. Because the short-circuit current is a linear function of the illumination while the open circuit voltage is a logarithmic function.

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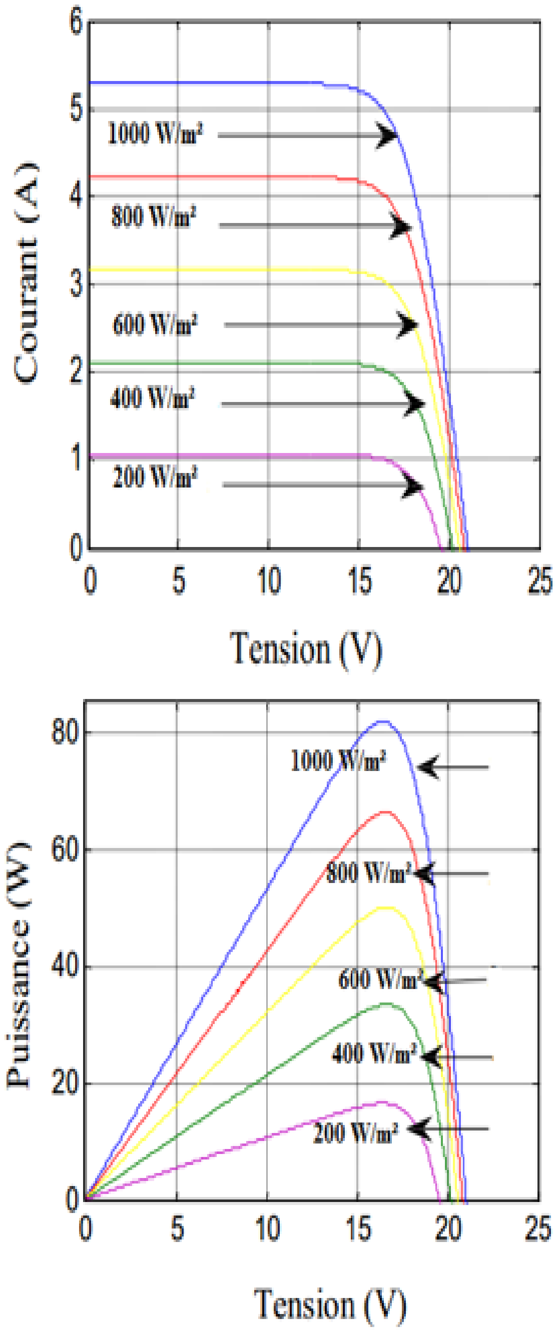

Figure 7: Influence Of Illumination On IV And PV Characteristics

3. RESULT:

1. Control (MPPT) of dc / dc converters

Photovoltaic solar systems have an electricity production directly dependent on meteorological conditions (temperature, irradiation). Thus, the sizing and optimal use of the energy produced by these generators requires the use of appropriate management methods. Improving the efficiency of the photovoltaic system requires extracting the maximum power from the PV generator which allows the proper control to be established in order to obtain the maximum power from these generators.

By definition, an MPPT command, associated with an intermediate adaptation stage, makes it possible to operate a PV generator so as to continuously produce the maximum of its power. Thus, whatever the weather conditions, the converter control places the system at the maximum operating point.

2. The pursuit of maximum power point

To obtain better efficiency in the operation of photovoltaic generators, the technique called maximum power pursuit (MPPT) which consists in optimally transferring all the electrical power to be extracted from this source of the photovoltaic energy to the load to be supplied. It must be used in any application using these generators, and will become necessary and even essential according to the theory of optimal power transfer.

Various works on controls ensuring MPPT type operation have appeared regularly since 1968, the date of publication of the first control law of this type adapted to a renewable energy source of the PV type. In literature, the most used power maximization techniques are:

- ✓ The perturbation and observation (P&O) method.
- ✓ The conductance increment method.

3. Disturbance and observation

It is the most widely used PPM tracking algorithm [13]. As its name suggests it is based on the disturbance of the system through the increase or decrease of or by acting directly on the duty cycle of the DC-DC converter, then by observing the effects of these disturbances on the power. panel output. If the value of the current power P (k)

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of the panel is greater than the previous value P (k-1) then keep the same direction of previous disturbance otherwise the disturbance of the previous cycle is reversed [14]. Figure (9) shows the P&O algorithm as it should be implemented in the control microprocessor. V_{ref}

With this algorithm, the operating voltage V is disturbed at each cycle of the MPPT. [15] As soon as the MPP is reached, V will oscillate around the ideal operating voltage. This causes a loss of power which depends on the step width of a single disturbance. If the step width is large, the MPPT algorithm will respond quickly to sudden changes in operating conditions, but losses will be increased relative to stable or slowly changing conditions. If the step width is very small the losses under stable or slowly changing conditions will be reduced [16], but the system will no longer be able to keep up with rapid changes in temperature or insolation. V_{mpp}

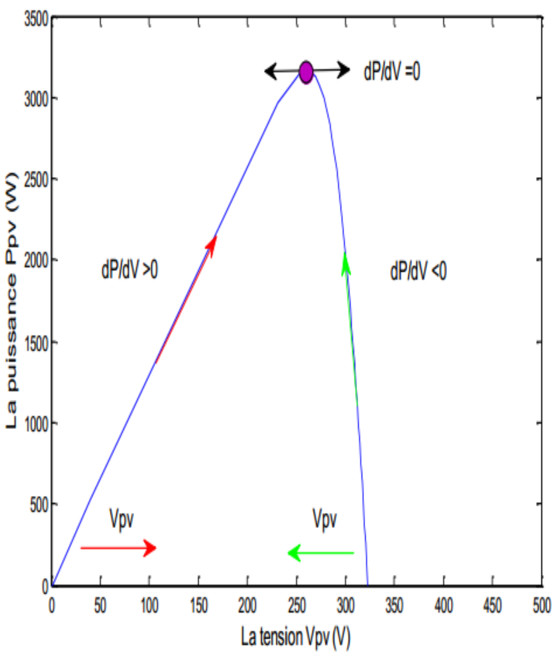

Figure 8: Operating Characteristics Of The P&O Method

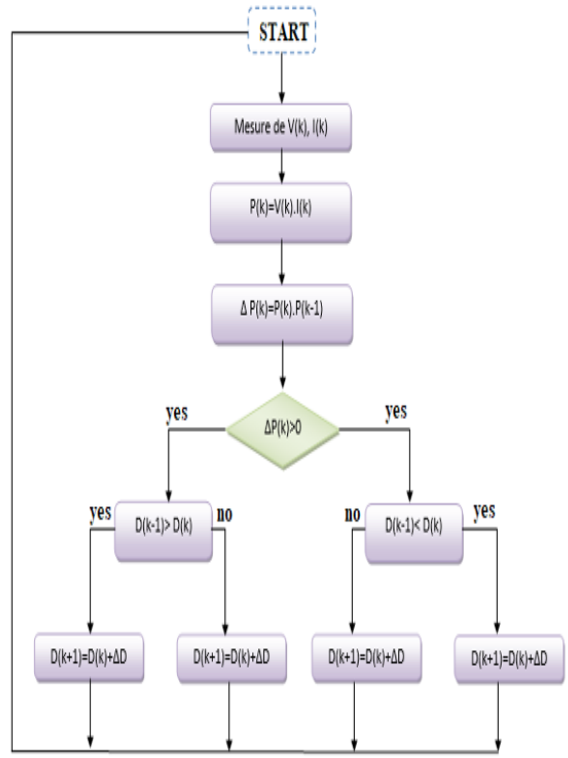

Figure 9: MPPT Algorithm (P&O)

4. The conductance increment

The conductance incremental algorithm Figure (10); results in deriving the power of the photovoltaic panel with respect to the voltage and setting the result equal to zero. The conductance is a relatively well-known physical quantity: it is the quotient of the intensity by the voltage (G = I / V) The incremental conductance is much more rarely defined, it is the quotient of the variation, between two instants, of the intensity by that of the tension (). By comparing the conductance G to the incremental conductance ΔG, we will find the point of cancellation of the derivative of the power. This can be described by the following equations: $G = \frac{dI}{dV}$

$$\frac{dP}{dV} = \frac{d(V.I)}{dV} = I + V\frac{dI}{dV}$$

$$\frac{dI}{dV} = \frac{-I}{V}, (\frac{dP}{dV} = 0)$$

$$\frac{dI}{dV} > \frac{-I}{V}, (\frac{dP}{dV} > 0)$$

$$\frac{dI}{dV} < \frac{-I}{V}, (\frac{dP}{dV} < 0)$$

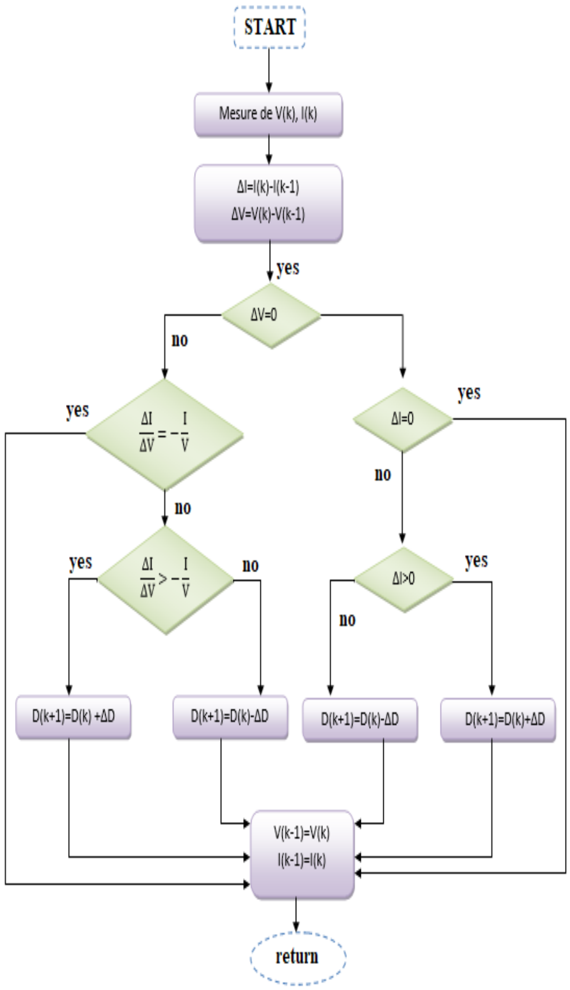

Figure 10: The Incremental Conductance Algorithm

4. CONCLUSION

In this article we have presented some definitions and concepts relating to photovoltaic systems, and AC / DC converters and on the various classical methods for the search for the maximum power point (MPPT), we have cited the example of two maximization methods PV array power, (P&O) method and incremental conductance. The characteristic curves of the panels showed good performance in terms of pursuit of the maximum power supplied by the photovoltaic panel and a strong dependence of the performance of the photovoltaic module as a function of the irradiation and the temperature. And also the implementation of two algorithms which are the MPPT, P&O algorithm and the algorithm Incremental conductance.

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