CONTROL OF A DC/DC CONVERTER BY MPPT CONTROL FOR TO POWER A MOTOR-PUMP SYSTEM

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ABSTRACT
We study in this paper a way to transfer all the power output of the PV generator a motor-pump. The characteristics of photovoltaic systems depend on several environmental factors, so a maximum power point tracking MPPT technical is necessary for optimum power. This technical (MPPT) plays an important role in photovoltaic (PV) power systems because they maximize the power output from a PV system for a given set of conditions, and therefore maximize their array efficiency. We chose to use the technology research MPPT maximum power point based on the algorithm "Perturbed and Observation" controlled by signals in pulse width modulation. The obtained energy is used to power the Motor-Pump. The complete model is implemented in Matlab-Simulink environment.

KEYWORDS: *Solar Energy, PV Module, Chopper, MPPT, INVERTER, PWM Control, Motor.-Pump.*

I. INTRODUCTION

In our Arabian nation peopled areas is very small comparing to total area because fresh water resources concentrate in these areas. Now, the existing fresh water almost enough for our needs, but in the near future with increasing in people numbers it will be huge problem. On the other hand we have shining sun all the year, so we can use stand-alone PV-powered water pumping system [1] to get water in non-peopled areas. Unfortunately the actual energy conversion efficiency of PV module is rather low. So to overcome this problem and to get the maximum possible efficiency [2], the design of all the elements of the PV system has to be optimized.
In order to increase this efficiency, MPPT controllers are used. Such controllers are becoming an essential element in PV systems. A significant number of MPPT control have been elaborated since the seventies [3], starting with simple techniques such as voltage and current feedback based MPPT to more improved power feedback based MPPT.
In this paper, a control technique using perturbation and observation (P&O) control is associated to a motor-pump in order to improve energy conversion efficiency.
In a first part, we present the proposed system, after a brief modelling of the PV module, the model and the simulations of the I-V and P-V characteristics with different levels of illuminations and temperatures. In a second part modelling the converter and algorithm P&O presented after that modelling the asynchronous machine. The simulations are carried out to verify the proposed P&O method. Finally, concluding and future work.

II. THE PROPOSED SYSTEM

The studied system consists of the PV generator, the DC-DC converter (chopper booster type), the inverter, synchronous motor and pump centrifuge. The DC-DC converter is controlled by a signal pulse width modulation with a research strategy point of MPPT maximum power.

The figure below shows the block diagram of the entire system:

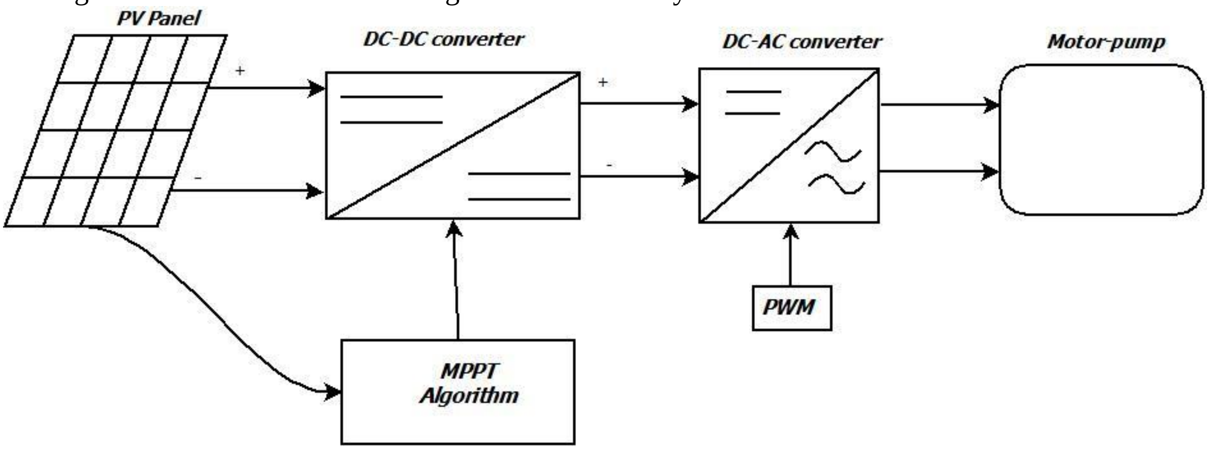

Figure 1 Block diagram of PV system controlled by MPPT

III. MODEL OF SOLAR MODULE

Several mathematical models are used to simulate the operation of a photovoltaic generator. These models differ in the method of calculation and the number of parameters involved in the current - voltage characteristic.

In our work, we implemented the five parameter model. This model can be summarized as follows:

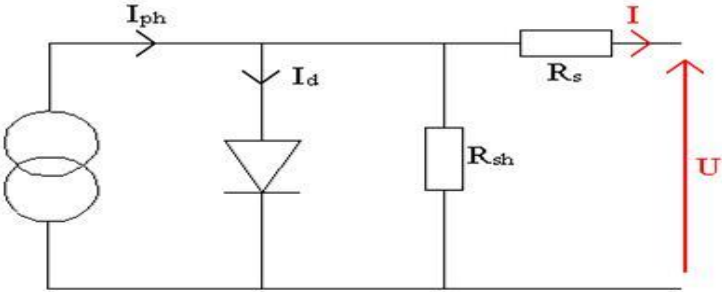

Figure 2 Circuit diagram of a real photovoltaic cell.

The I-V characteristics of the equivalent solar cell circuit can be determined by following equations. The current through diode is given by: [4, 5]

$$I_D = I\,[\exp(q\,(V + I\,.R_S)/K.T)) - 1] \quad (1)$$

While, the solar cell output current:

$$I = I_L - I_D - I_{sh} \quad (2)$$

$$I = I_L - I\,[\exp(q\,(V + I.R_S)/K.T)) - 1] - (V + I.R_S)/\,R_{sh} \quad (3)$$

Where:

I: Solar cell current (A);

I_{sh}: Light generated current (A) [Short circuit value assuming no series/ shunt resistance];

I_D: Diode saturation current (A);

q: Electron charge (1.6×10-19 C);

K: Boltzmann constant (1.38×10-23 J/K);

T: Cell temperature in Kelvin (K);

V: solar cell output voltage (V);

R_s: Solar cell series resistance (Ω);

R_{sh}: Solar cell shunt resistance (Ω).

Kyocera Solar KC200GT PV module is chosen for a MATLAB simulation model. The module is made of 54 multi-crystalline silicon solar cells in series and provides 200.143W of nominal maximum power.

IV. Influence of the Illumination and Temperature on the Operation of a PV Module

From these equations, the characteristics of solar module I = f (V), with a variable illumination, have the following forms (for a junction temperature of 25 ° C and spectral distribution of the radiation says AM 1.5). Note that the voltage V_{oc} varies very little function of the illumination, which unlike the current I_{sc} increases strongly with the illumination.

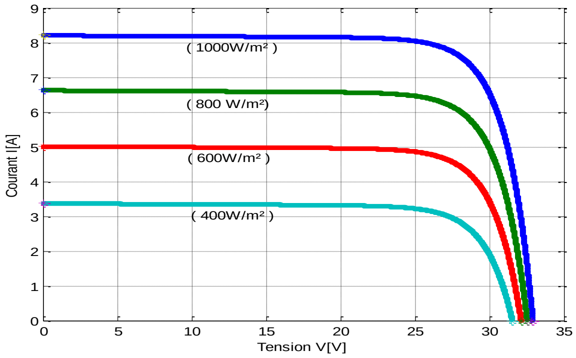

Figure 3 Influence of the sun on the curve I = f (V).

Similarly, the characteristics of the solar module I = f (V) for a variable temperature will be as shown in Figure following (for a constant solar irradiation 1000 W/m^2 and spectral distribution of the radiation says AM 1.5).
Note that the current I_{sc} varies very little function of temperature, unlike that voltage V_{oc} meanwhile increases strongly with the temperature.

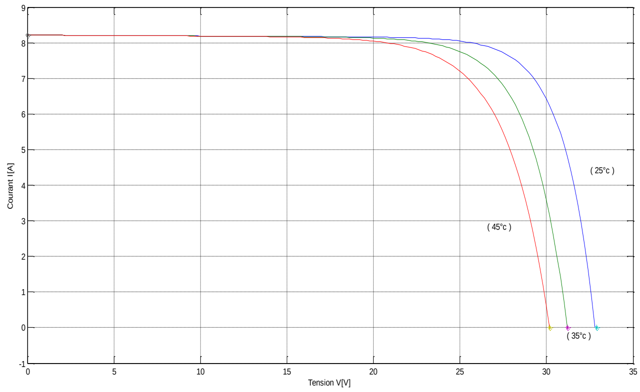

Figure 4 Influence of temperature on the characteristic I = f (V) of a photovoltaic generator.

V. Converter DC-DC (DC / DC)

Boost converter steps up the input voltage magnitude to a required output voltage magnitude without the use of a transformer. The main components of a boost converter are an inductor, a diode and a high frequency switch. These in a co-ordinated manner supply power to the load at a voltage greater than the input voltage magnitude. The control strategy lies in the manipulation of the duty cycle of the switch which causes the voltage change [6] and [7].

$$\frac{V_0}{V_s} = \frac{1}{1-D} \quad (4)$$

Where V_O = output voltage, Vs = source voltage, D = duty cycle.

The critical values of the inductance and capacitance can be calculated using the following equations, [8]

$$L = \frac{(1-D)^2.D.R}{2.f} \quad (5)$$

$$C = \frac{D}{2.f.R} \quad (6)$$

Here, f = frequency 10 MHz. The inductance and capacitance are calculated as L = 120uH, C=100 uF.

5.1 Modelling Boost Chopper

The DC-DC converter is a chopper transistor therefore parallel type voltage booster. Boost chopper can be modelled using the following ordinary differential equations: [6, 7]

$$V_0=\frac{RVc}{R+Rc}+\frac{RRc}{R+Rc}[(1\text{-}D)\ i_L\text{-}i_0] \quad (7)$$

$$i_L=\frac{1}{L}\int(V_s-(1-D)V_o-R_L i_L)dt \quad (8)$$

The block "PWM" generates the PWM signal required to control the switch. His description is shown schematically in Figure

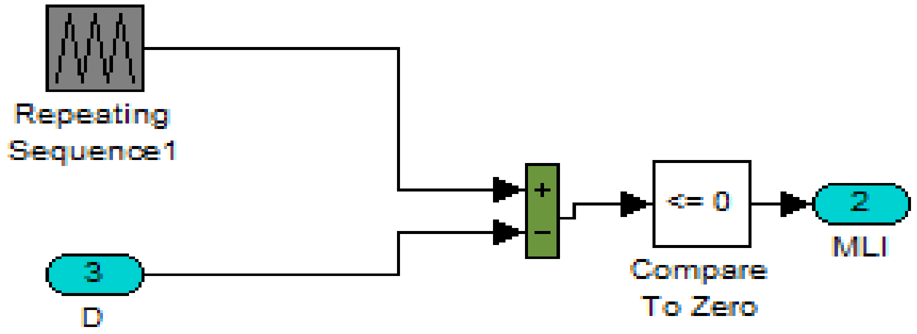

Figure 5 Simulink model to generate the PWM signal

5.2 Maximum Power Point Tracking Controller

When a PV module is directly coupled to a load, the PV module's operating point will be at the intersection of its I–V curve and the load line which is the I–V relationship of load. In general, this operating point is seldom at the PV module's MPP, the optimal adaptation occurs only at one particular operating point, called Maximum Power Point (MPP).

MPPT (Maximum Power Point Tracking) controller is a functional body of the PV system and allows you to search the optimal operating point of the PV generator in weather. Whether analogue or digital control, the control principle is based on the automatic variation of the duty cycle D [9] to the appropriate value so as to maximize the power output of the PV panel. MPPT controller is an electronic system that plays a vital role in operating the PV modules in a manner that it produces its maximum power according to the situation [10].

The adaptation floor is usually implemented with a DC-DC converter and connected between the solar panel and a load as shown in Figure. 1 [10, 11]. An MPPT controller is usually implemented together with a boost converter and connected between the PV panel and load.

5.3 Perturbation and Observation Method

Several techniques for tracking MPP have been proposed. Two algorithms are commonly used to track the MPPT - the P&O method and Inc.-Cond method [3]. The P&O method has been broadly used because it is easy to implement. Figure 7 presents the control flow chart of the P&O algorithm. The MPP tracker operates by periodically incrementing or decrementing the solar array voltage [12].

If a given perturbation leads to an increase (decrease) the output power of the PV, then the subsequent perturbation is generated in the same (opposite) direction. In Figure 6, set Duty out denotes the perturbation of the solar array voltage, and Duty and Duty^{-} represent the subsequent perturbation in the same or opposite direction, respectively.

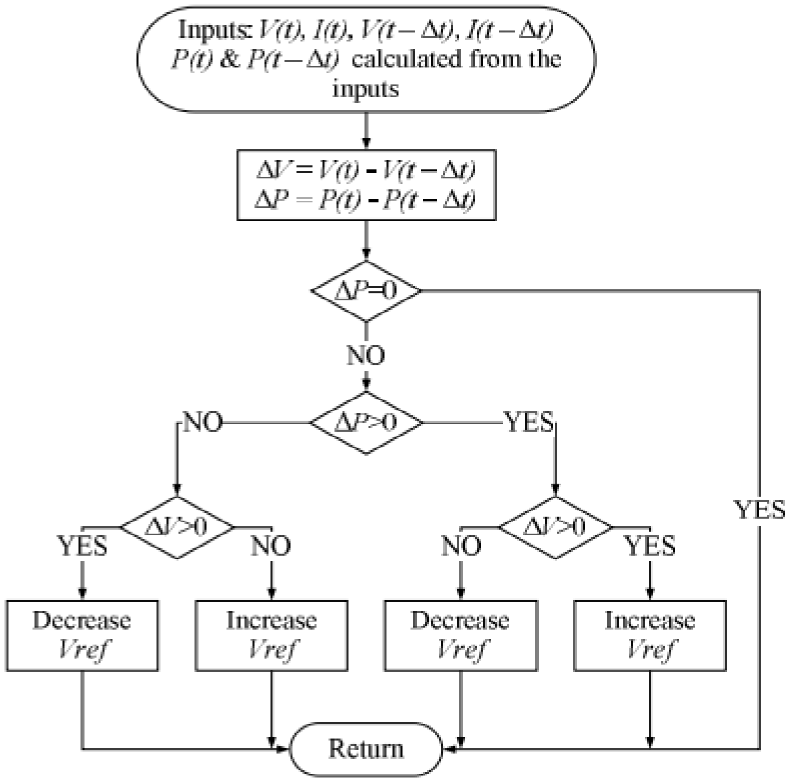

Figure 7 Organization of the disturbance and Observation (P and O) algorithm.

The operation of the P & O algorithm:

First, the voltage V and current I are measured to calculate the power P (k). This value P (k) is compared to the value of power obtained in the last measurement P (k-1). If the power supplied by the panel has increased since the last measurement, the increment or increments of the cyclical relationship will continue in the same direction as in the last round and this is done by testing dV.

If dV> 0, this means that a V increments during the last cycle that is to say, D (k +1) = D (k) + α.

If dV <0 it means we decrements V during the last cycle that is to say we're going to

D (k +1) = D (k)-α so it ends in the path or P continues to increase.

If the power supplied by the panel has decreased since the last measurement, the increment or increments of cyclic to be in the opposite direction from the last cycle and this report is also the test of dV.

With this algorithm the operating voltage V is disrupted with each cycle.

Once the MPP is reached, V oscillates around the ideal operating point (V_{mp}). But this causes a loss of power that depends on the width of not a single disturbance α.

If the step size is large, the MPPT algorithm will respond quickly to sudden and rapid changes in operating conditions but will incur losses slowly changing conditions and stable states.

If the step size is very small losses in states stable or slowly changing conditions will reduced, but the system has a slow response to rapid changes in temperature or exposure.

The ideal value for the width of the system cannot be determined experimentally or by simulation, thus meet a compromise between rapid response and loss power in stable state.

VI. INVERTER

The inverter is a power converter ensuring DC-AC conversion. There are several types; one used in this work is an autonomous three-phase inverter variable frequency commutated PWM Type (Pulse Width Modulation) operated in source voltage.

The purpose of modelling is to find a relationship between the control variables and the electrical variables and alternative portion of the inverter. Thus, as the control variables acting on the switches controllable, we can define the switching function Next to set the state of the switches k = (a,b,c) .

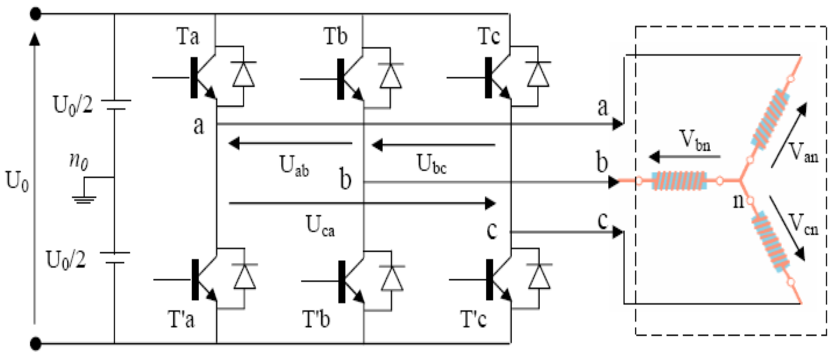

Figure 8 Diagram of the three-phase inverter.

The load was modelled from simple voltage we notes V_{an}, V_{bn} and V_{cn}.
The inverter is controlled from logical variables Si Called Ti and Ti 'transistors (assumed switches ideals), we have:
If $S_i = 1$, then T_i and T_i is passing is open
If $S_i = 0$, then T_i and T_i is open is from

The expression which defines the relationship between the magnitudes of and controls the electric quantities is: [13]

$$\begin{bmatrix} V_{an} \\ V_{bn} \\ V_{cn} \end{bmatrix} = \frac{1}{3} U_0 \begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix} \begin{bmatrix} S_a \\ S_b \\ S_c \end{bmatrix} \quad (9)$$

6.1. Pulse Width Modulation PWM

The pulse modulation is to adapt a frequency higher switching frequency of variables Release and forming each of a succession of alternating niches suitable width.

6.2 Modulated Sine-Triangle

The principle of operation of the PWM is to compare a triangular signal (carrier) with a reference wave generally called sinusoidal modulating each interaction of the two signals; the control sends an electrical ignition or extinction order to transistors constituting a phase inverter which produces the signal. [14]

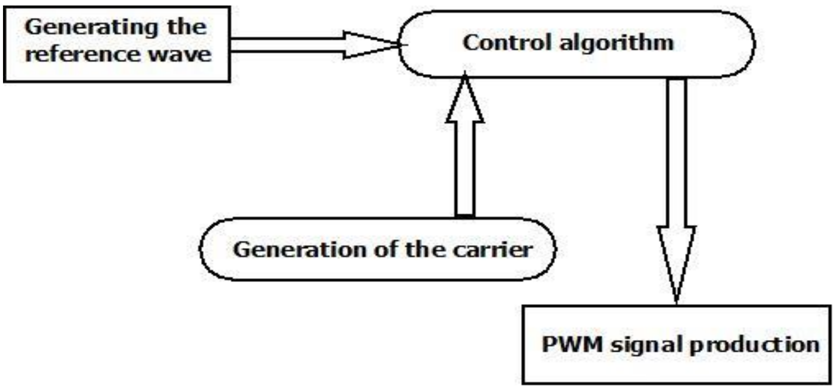

Figure 9 PWM controls algorithm sine-triangle.

VII. MODELING OF THE ASYNCHRONOUS MACHINE

MAS are provided with six phase windings. The stator the machine is composed of three windings (A, B, C) fixed offset by 120 ° in space and through which three streams variables.
The rotor can be modelled by three windings (a, b, c) identical spatially offset by 120 °, these coils are short-circuited and the voltage at their terminals is zero.
Note that we chose the repository related field turn, after the transformation of Park "Transformation Park is to replace the three stator phases by a two-phase rotor d-axis and q "system, we find following equations [13]

$$\begin{bmatrix} \phi d_s \\ \phi q_s \\ \phi d_r \\ \phi q_r \end{bmatrix} = \begin{bmatrix} L_s & 0 & M & 0 \\ 0 & L_s & 0 & M \\ M & 0 & L_r & 0 \\ 0 & M & 0 & L_r \end{bmatrix} \cdot \begin{bmatrix} Id_s \\ Iq_s \\ Id_r \\ Iq_r \end{bmatrix} \qquad (10)$$

$$\begin{bmatrix} I d_s \\ I q_s \\ I d_r \\ I q_r \end{bmatrix} = \frac{1}{L_s L_r - M^2} \begin{bmatrix} L_r & 0 & -M & 0 \\ 0 & L_r & 0 & -M \\ -M & 0 & L_s & 0 \\ 0 & -M & 0 & L_s \end{bmatrix} \cdot \begin{bmatrix} \phi d_s \\ \phi q_s \\ \phi d_r \\ \phi q_r \end{bmatrix} \qquad (11)$$

Was V_{dr} and V_{qr} = 0 = 0, because the rotor is short-circuited.

$$\begin{bmatrix} V_{ds} \\ V_{qs} \end{bmatrix} = \begin{bmatrix} R_s & 0 \\ 0 & R_s \end{bmatrix} \begin{bmatrix} I_{ds} \\ I_{qs} \end{bmatrix} + \frac{d}{dt} \begin{bmatrix} \phi_{ds} \\ \phi_{qs} \end{bmatrix} + \begin{bmatrix} 0 & -\omega_s \\ \omega_s & 0 \end{bmatrix} \begin{bmatrix} \phi_{ds} \\ \phi_{qs} \end{bmatrix}$$

$$\begin{bmatrix} V_{dr} = 0 \\ V_{qr} = 0 \end{bmatrix} = \begin{bmatrix} R_r & 0 \\ 0 & R_r \end{bmatrix} \begin{bmatrix} I_{dr} \\ I_{qr} \end{bmatrix} + \frac{d}{dt} \begin{bmatrix} \phi_{dr} \\ \phi_{qr} \end{bmatrix} + \begin{bmatrix} 0 & -\omega_{sr} \\ \omega_{sr} & 0 \end{bmatrix} \begin{bmatrix} \phi_{ds} \\ \phi_{qs} \end{bmatrix} \qquad (12)$$

VIII. RESULTS OF SIMULATIONS

Figure 9 shows the evolution of the output voltage of GPV:

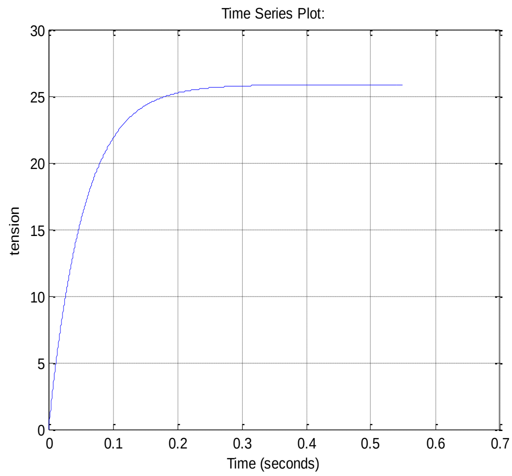

Figure 10 Curve of the chopper output Voltage.

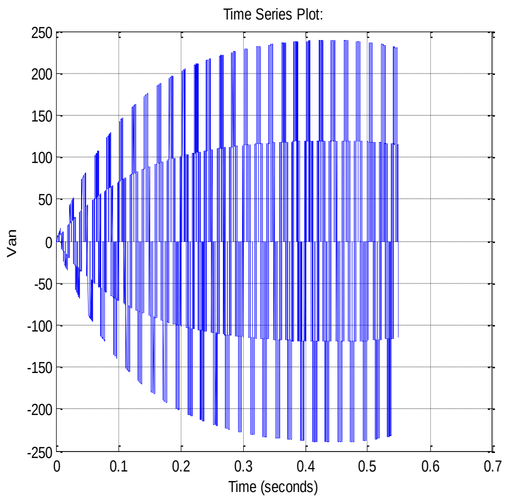

Figure. 11 curve output voltage of the Inverter V_{an}.

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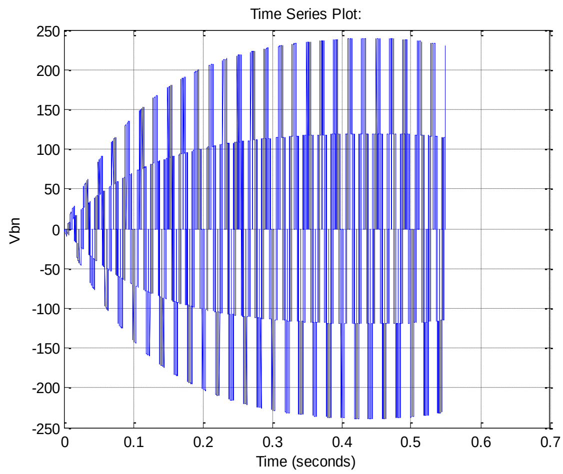

Figure. 12 curve output voltage of the inverter V_{bn}

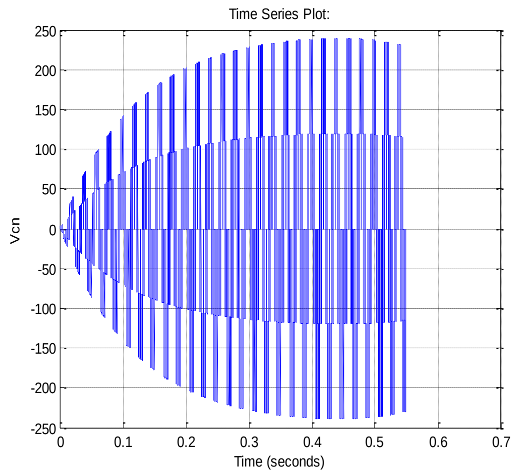

Figure. 13 curve output voltage of the inverter V_{cn}.

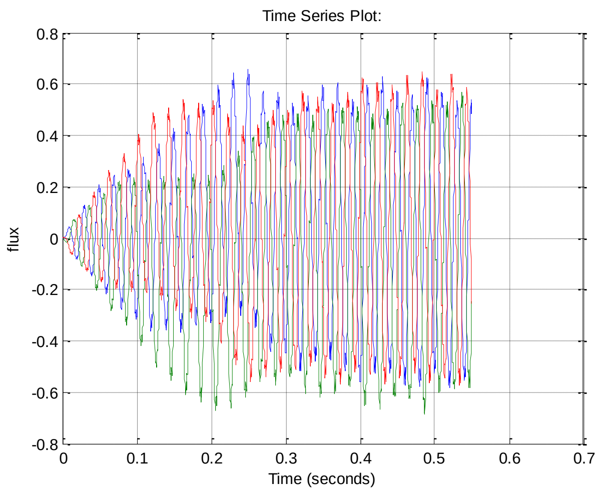

Figure. 14 show the flow curve of asynchronous motor.

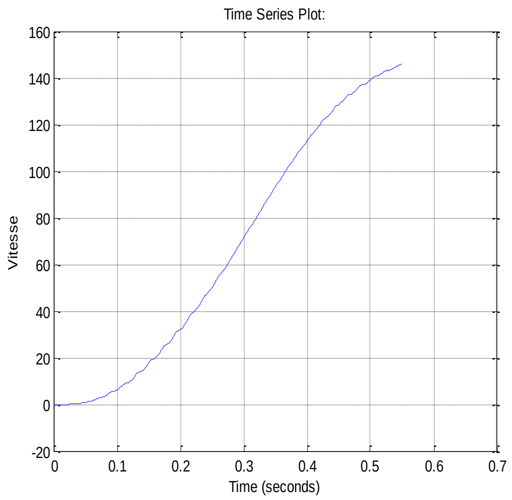

Figure. 15 curves represent the speed asynchronous motor

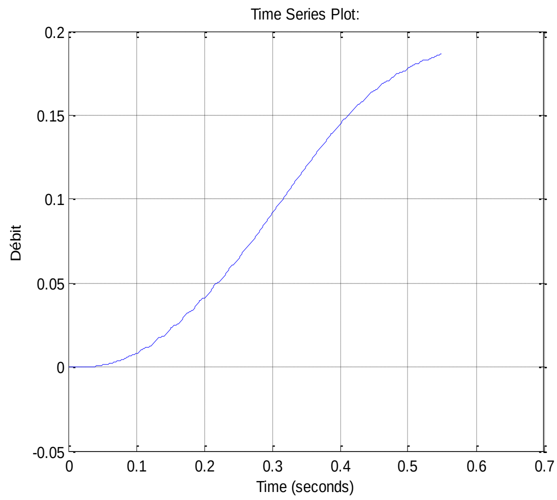

Figure. 16 curve representing pump flow

INTERPRETATION OF RESULTS

In this section we present simulation results obtained. The Research maximum power point based on P & O algorithm shows that: "The optimal point is reached for a voltage of 25.82 V modules with a government transient short 0.18s for illumination of 1000 W/m^2 and a constant temperature".
For power point 195.5W optimum is achieved with the same response time, giving a yield 97.75%. The main role if the inverter converting DC power to the energy alternative for feeding the motor-pump.

IX. FUTURE WORK

Improvement to this project can be made by tracking the maximum power point in changing environmental conditions. Environmental change can be change in solar irradiation or change in ambient temperature or even both. This can be done by using Simulink models to carry out MPPT instead of writing it code in Embedded MATLAB functions. In the Simulink models the solar irradiation and the temperature can be given as variable inputs instead of constant values as done here.

X. CONCLUSION

The study presented in this paper concern, in general, the modeling and simulation of systems of electricity generation from renewable resources photovoltaic. This purpose leads us to achieve many goals, which can be summaries as follow:
Simulate a PV array in MATLAB/SIMULINK, which give us the performance of the PV array (I–V curve and P–V curve) under any atmospheric conditions (irradiance and Temperature).
Simulate DC–DC boost converter and Pulse Width Modulator in MATLAB/SIMULINK and simulate a MPPT controller using P & O algorithm.
Finally, this paper presents a simple but efficient photovoltaic water pumping system. It models each component and simulates the system using MATLAB/SIULINK. Simulations use Sim-Power Systems in SIMULINK to model a DC pump motor. It performs simulations of the whole system and verifies functionality and benefits of MPPT. Simulations also make another comparison with the system without MPPT in terms of energy produced and flow rate of water pumped using atmospheric conditions for one day.
The results validate that MPPT can significantly increase the efficiency of energy production from PV and the performance of the PV water pumping system compared to the system without MPPT. This increasing could bring large savings if the system is large

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