## Chapter 5

# Analysis Study and Design of Optimal Control MPPT Strategy for a Photovoltaic Solar Energy System

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**Abstract** In this paper, we study a comparative problem, analysis, with and without MPPT regulator of autonomous application for Photovoltaic System and estimate of a model of autonomous kit with electrochemical storage and autonomous kit over the sun. Using the parameter which is the maximum power accompanied by the efficiency of the photovoltaic with the architectural phases of the DC-DC converter for the photovoltaic effect. These solar systems present structural modeling using MATLAB/SIMULINK software. Thus, we present the corresponding connection stage between the GPV, the MPPT regulator, the solar battery and the circuit breaker. The new technologies of the future are the use of economic solutions using renewable energies. The only one that allows the execution from the point of view of maximum power of the PV module whatever the irradiance of the temperature, the connection of a DC / DC boost converter in a photovoltaic installation at the output of the panel could be a good solution to boost these characteristics. The progress of power electronics in this energy supply specialty, allows us to better manage our work on isolated site in the environment. The essential parameter is the DC and AC load. We simulated and compared the different transfer topologies to achieve the best optimization and energy produced solution.

**Keywords** Solar system · Maximum power point tracker MPPT · Energy efficiency · Modeling · Simulation

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Y. Chiba et al. (eds.), *Advances in Green Energies and Materials Technology*,
Springer Proceedings in Energy, https://doi.org/10.1007/978-981-16-0378-5_5

## 5.1 Introduction

Renewable energy bases give a positive point because of their enormous load and the depletion of fossil fuels. Renewable floats are environmentally friendly, non-polluting and multi-source from nature sources, hydroelectric and geothermal and biomass energy [1]. The energy supplied by the sun in an hour is equivalent to the amount of energy required by humans in a year [2]. The photovoltaic energy system has made widespread success as one of the renewable energy sources because of the possibility of depletion of conventional energy sources and its high cost as well as its negative effects on the environment. The solution will give good result and energy efficiency as well as a significant difference in cost. For this reason, it is necessary to know the lot of architecture to choose the right PV topology for each PV installation [3, 4]. The effect of partial shade or offset between PV modules in power delivery will also depend on the type of architecture. However, the price and cost of PV also depend on the choice of architecture [5]. The inverters must ensure that the photovoltaic module(s) are working at the MPP, which is the operating condition where the most energy is captured. This is finished with an MPP tracker (MPPT). This gives the ripple across the PV module(s) to be low to work around the MPPT.

### 5.1.1 *Problem Formulation*

The circuit study of the PV cell consists of a source, which is the sun, and circuit component, which contains the series and parallel diode resistors, presented in Fig. 5.1.

The electrical characteristic of PV cell under solar irradiance (G) is presented in relation with the output current of PV cell (I) and voltage of PV cell (V). Refer to figure one and refer to Kirchhoff's first law, the basic equations which describe the electrical data of the PV cell model [6]. The relationship between current and voltage across the table is as follows:

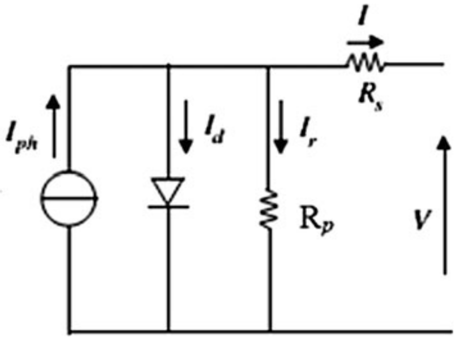


**Fig. 5.1** General model of PV cell in a single diode model

$$I = I_{ph} - I_D - \frac{V + IR_S}{R_P} \tag{5.1}$$

$$I = I_{ph} - I_0\left[e^{\frac{q(V+IR_S)}{nKT}} - 1\right] - \frac{V + IR_S}{R_P} \tag{5.2}$$

$$I_{ph} = I_{SC}\frac{\phi}{1000} \tag{5.3}$$

where V and I are the output current and the output voltage of the photovoltaic cell, Iph is the generated photocurrent, Io is the reverse saturation current of the diode, in the ideality factor of the diode, Rs and Rp the series and parallel resistance (respectively), and T is the absolute temperature in Kelvin. The equation also composes the elementary charge constant q (1.602.10-19C) and the Boltzmann constant k (1.380 × $10^{-23}$ J/K). DC converters. DC-DC switching power converters are widely used in photovoltaic systems to transform direct current between one voltage and another, and used in maximum power point scheduling (MPPT).

In this work, it is about a converter with switched mode Si-IGBT (Insulated Gate Bipolar Transistor) able to produce a continuous output voltage higher than the direct input voltage [7] (Fig. 5.2).

The step-up converter is one of the most successful DC-DC converters. In a DC transformer, the transformation relationship can be electronically controlled by changing the converter operating phase between [0, 1]. The relations used for the design are the conventional relation between the output voltage, the signal input and the duty cycle [8]:

$$V_{OUT} = \frac{1}{1-\alpha}V_{in}$$

Study of the continuous state: By changing the signals derived by zeros, we can replace the signals of the converter by their average values, and this will modify the system of equations: Conversion and performance ratio: By calculating the relations

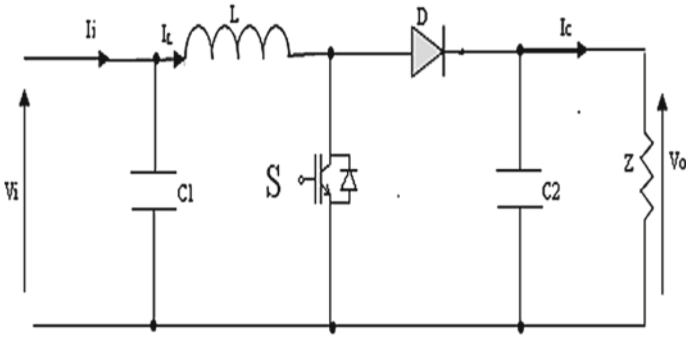


**Fig. 5.2** Electric structure of the boost power converter

(5), we can evaluate the conversion percentage [9].

$$\frac{V0}{Vi}$$

$$M(\alpha) = \frac{V0}{Vi} = \frac{1}{(1-\alpha) + \frac{r_L I_L}{V0}} = \frac{1}{1 + \frac{r_L I_0}{(1-\alpha)^2 V0}} \frac{1}{1-\alpha}$$
$$= \frac{1}{1 + \frac{r_L}{(1-\alpha)^2 Z}} \frac{1}{1-\alpha} = \eta \frac{1}{1-\alpha}$$

Represents the robustness of the converter; Note that the performances η do not only depend on the complex load Z of the converter and the parasitic resistances of the components, but they also depend on the duty cycle α. Thus, it recommended that the Boost offer good results, not to exceed the operating point α greater than a fixed value, which results in the quality of the inductance and the load operated.

## 5.2 Results and Discussions

In the first architecture, the application of our study of this type of solar model configured by the AC load is multiple, especially in isolated sites.

The frequency of the source and load currents then becomes double the switching frequency of the switches. In addition, the ripple of the input current is reduced compared to the current ripple in the inductors due to the interlacing of the currents of each of the phases. Finally, the value of the output capacitance is reduced with respect to the increase in the frequency of the current in the load. An inverter controlled by three-phase PWM command and a measure the voltages of AC inverter load applied in a three-phase asynchronous machine (Fig. 5.3).

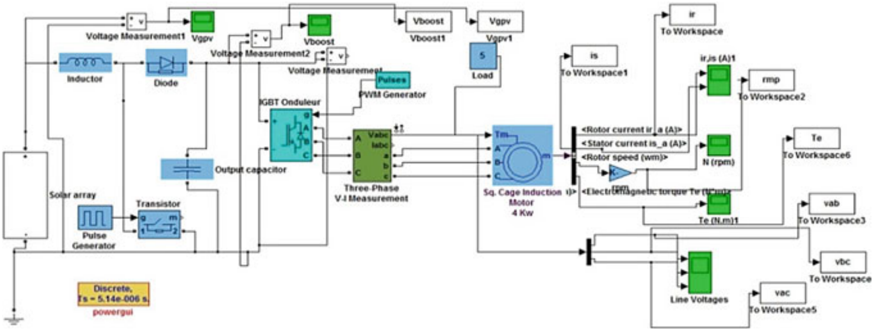


Fig. 5.3 Simulation of AC loads supply

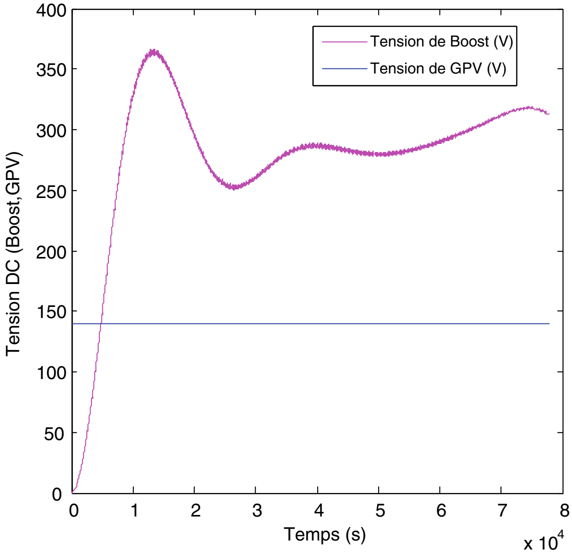


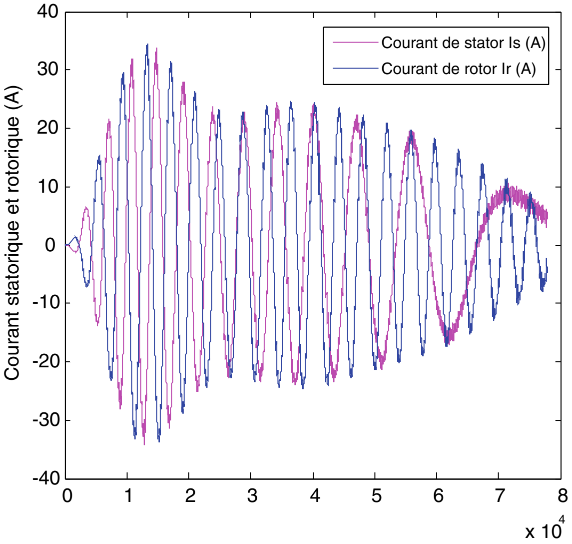
**Fig. 5.4** Voltage of DC (boost)

We modeled with the Matlab/Simulink software a DC field of a direct voltage source first directly flickered to the load, then when the boost converter is connected. It appears that the desired amplification could improve the dynamic state characteristics of the DC voltage source GPV. We must therefore enrich the study by adding an inverter that converts the DC boost current into an alternating current that can be used to supply the AC loads. Figure 5.4, shows the DC voltage of the step-up converter, we can see that the output voltage of the step-up converter has increased the car it is used as much as the voltage step-up, for a good design of a step-up converter capable of seeking the power maxi -mum for any variation in sunshine thanks to its MPPT control. Figure 5.5 respectively represents the curves of the stator and rotor current, of the rotor speed and of the electromagnetic torque. Figure 5.6 shows the result of the output voltage of the inverter, simulate voltage applied (three-phase asynchronous machine). Used PV panels and a converter. The converter is ordered with an MPPT controller, Figs. 5.7, 5.8 shows the simulation of the DC load in Simulink / MATLAB.

## 5.3 Conclusion

In this paper, the different topologies of photovoltaic system were examined, a comparative study, an analysis, with and without MPPT regulator of autonomous application for photovoltaic system and an expertise of a model of autonomous kit with electrochemical storage and autonomous kit with the thread of the sun by exploiting the maximum power point. Monitoring the efficiency of photovoltaic in

**Fig. 5.5** Stator and Rotor Current



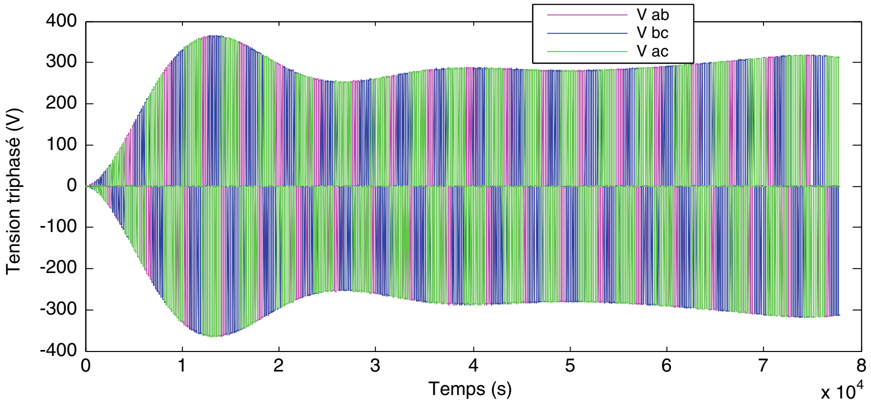


**Fig. 5.6** Simple Voltages Va, Vb, Vc

configuration of DC-DC converter for photovoltaic use. It gives the various for model configuration.

In our study, we focused on the simulation results for two models of an autonomous system. First goal, we presented a single kit for chemical storage by public lighting, so topology of 80 W photovoltaic generator ensures the load even varied irradiation, and we also concluded as in the favorable values of radiation (1000 W/m$^2$), it can light four lamps at the same time. Second goal present by autonomous kit above the sun without electrochemical storage.

**Fig. 5.7** Gpv voltage

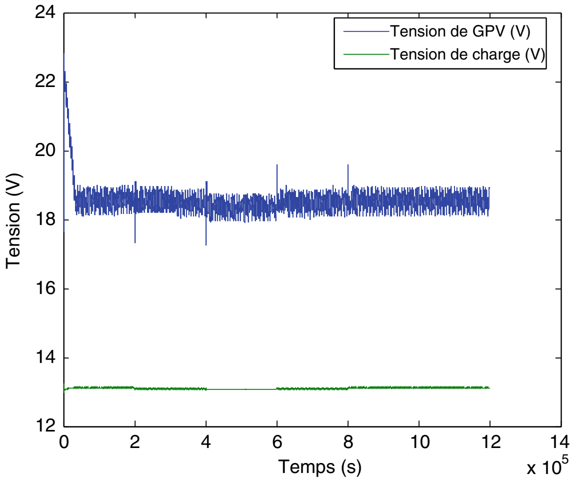
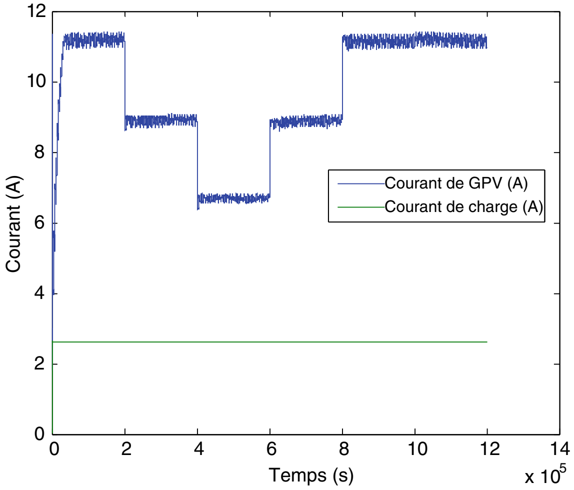


**Fig. 5.8** Gpv curre



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