

Design and modeling of optical reflectors for a PV panel adapted by MPPT control

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ABSTRACT

Due to the highly non-linear electrical characteristics of photovoltaic generators (PVGs), the efficiency of PV systems can be improved by forcing the GPV to operate at their maximum power point (MPP). In this article, we are interested in concentrating Photovoltaic design to improve the output current of the panel while maintaining the DC-DC boost element, after presenting the basic structure of Boost DC-DC converter, which shows the existence of a limitation on the voltage gain for this converter. In order to meet the specifications (high voltage gain and low ripple of the input current), existing structures will be presented that are able to provide a high voltage gain (Photovoltaic concentration) compared to another structure.

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1. INTRODUCTION

Photovoltaic (PV) is the youngest renewable energy; it has the advantage of being non-polluting, flexible and reliable. It then makes it possible to avoid the installation of generators, which pose problems of reliability and supply of fuel. The basic device of a PV system is the solar cell. The solar cell is made of a semiconductor material that absorbs light energy and transforms it directly into electric current. Cells may be grouped to form modules or panels. The voltage and current available on the terminals of a PV device can directly feed small loads such as lighting systems and DC motors. More sophisticated applications require electronic converters to process electricity from the PV device. These converters can be used to adjust the voltage and current of the load, and primarily to track the maximum power point (MPP) of the PV device.

Renewable energy sources such as photovoltaic cells, fuel cells, wind energy, etc., is one of the most reliable remedies for saving electrical energy [1, 2]. These sources require an energy conditioning system. Indeed, the voltages and currents produced by photovoltaic panels need to be improved in terms of ripples quality and efficiency [1]. Boost converters are often used to form a more robust power distribution system and more stable currents. This distribution mode is commonly used for applications requiring currents exceeding tens of amperes [1, 3].

The boost converter is a current depressant it has deferent expressions according to automatic adjustment of duty cycle, the latter allows by a power distribution to reduce the stress endured by semiconductors and thus improve reliability, robustness and reliability. Lifetime of the conversion stage [4].

In this work, we present a solution on the design of a panel by integrating fixed reflectors to improve conversion efficiency. For this, we present the new conversion structures developed within the laboratory of the University of Tahri Mohammed to improve PV performance. This solution is inspired by the methods commonly used for the low voltage at the output of the panel.

For the various boost converter topologies, simulation results have been analyzed in order to validate their use as adaptation stage for PV applications. To finalize the validation of these structures and show their potential, a comparison between a structure without reflectors and with optical reflectors was chosen to evaluate the performance of this type of concept on a photovoltaic conversion chain.

To this end, we are interested in concentrating Photovoltaic design in order to improve the output current of the panel, after having present the basic structure of Boost DC-DC converter, which shows the existence of a limitation on the voltage gain for these converters. In order to meet the specifications (high voltage gain and low ripple of the input current), existing structures will be presented that are able to provide a high voltage gain (SPVC) over another structure.

2. DESCRIPTION OF THE PV SYSTEM WITH REFLECTORS

The dimensions of our panel are 0.9 m and 0.42 m, which gives the surface of 0.3780 m². This panel is mounted on a metal support at the bottom (fixed) and an upper part (mobile) thus allowing the inclination of the sensor relative to the horizontal plane from 0 ° to 90 ° [5]. This systematic diagram of a photovoltaic reflector system can see in Figure 1.

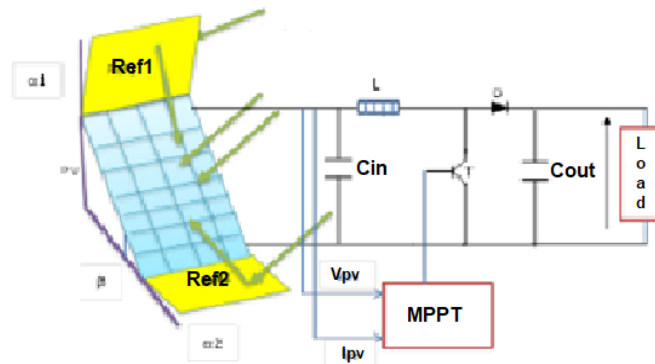


Figure 1. Systematic diagram of a photovoltaic reflector system

The inclination is 31.63 ° with respect to the horizontal plane and has been oriented to the south. Two aluminum foil reflectors made with diffuse solar radiation reflection, whose dimensions are 0.45 m, 0.42 m, giving a surface of 0.189 m² were mounted on the variable position. The principle of PV panel with optical reflectors is for obtaining the highest intensity of solar radiation.

The total solar radiation from the surface of the panel, with the inclined plane angle β is the sum of the direct radiation on the surface, the sky-diffuse radiation, the radiation reflected by the ground, the radiation reflected by the lower reflector which has reached the inclined plane reflector surface with the angle and the radiation reflected by the upper reflector which has reached the sensor surface with an inclined plane angle [5, 6].

The values of the optimal positions of the upper and lower reflectors in the period of May 2018 month for an inclined plane angle 31.63 ° (latitude of the place), This value changes during the day with the variation of the declination angle of the sun .

We have observed that the optimal positions for the upper and lower reflectors are at angles of 30 ° and 10 °, respectively, the measured data include the intensity of the solar radiation, the ambient temperature, the panel temperature; the maximum current and the maximum voltage are measured using an ammeter and voltmeter, the direct solar irradiance on the opening plane of the photovoltaic field is measured using a pyrometer (Silzium-Eistrahlungssensor SOZ-3). The voltage generator is measured directly at its terminals.

The boost converter configuration shown in Figure 2 consists of DC input voltage source V_{in} , boost inductor L, controlled switch K, diode D, filter capacitor C, and load resistance R, and switches (MOSFET) in blocked saturated mode [6, 7].

Where, V_{in} is input voltage, V_{out} is output voltage and d is the duty cycle of a pulse width modulation (PWM) signal used to control the MOSFET. The maximum power point tracking (MPPT) has generated high power from photovoltaic model. The parameter of photovoltaic energy generation such as voltage, power and current has extracted from PV. The incremental conductance has high tracking ability of power from the supply [6, 8].

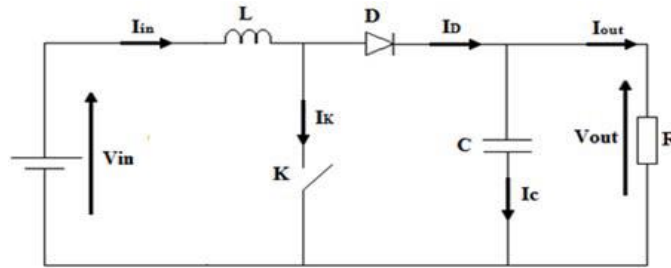


Figure 2. Configuration of DC to DC converter

3. EXPERIMENTAL PROCEDURE

The converter has the problem of the large input current that passes through the inductor so this topology is a disadvantage that we must find another topology that can increase the panel output current. For this, we have proposed a fully autonomous optimal dimensioning solution [9], including the generator, equipped with reflectors and a technical realization with the objective of improving the solar irradiation increase incident on this panel, for a fixed inclination and able to reflect the radiation on the panel. The Figure 3 illustrates our experience.

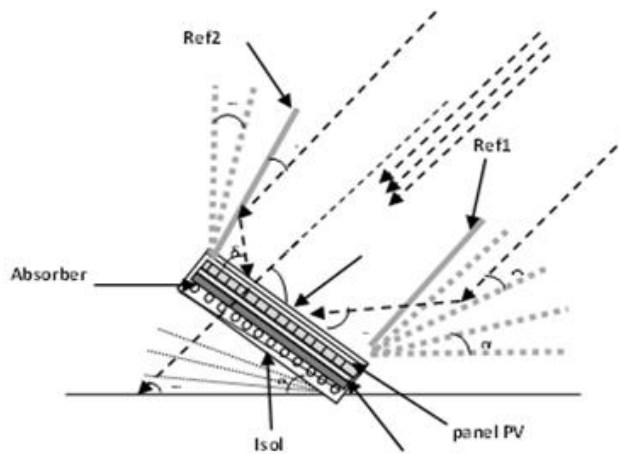


Figure 3. Diagram of the hybrid PV reflector sensor

This system has been improved by a cooling system to reduce the heat at the photovoltaic panel (PV/T system) Experimental results with summers obtained for this panel with reflector gives a very good agreement but for temperatures higher than or equal to 66 ° C, it means that this system can use in the days or the cold season [5, 10].

Most of the research conducted in the Concentration PV field is aimed at evaluating the electrical performance or analyzing the economic aspect of the systems through the estimation of the solar coverage rate. For this, some authors emphasize the development of models or made according to an electrical analogy, and more rarely electric models of photo-conversion in steady state or dynamic. Some of these analyzes also rely on confrontations with experimental studies under controlled conditions or in situ at various sites.

Other research aims to optimize the performance of existing solar components by improving the operating conditions (inclination, orientation of the component ...) or by proposing innovative geometric configurations. Thus, they are based on the modification of the dimensions or the properties of the PV cells materials ...).

We obtained the experimental results for a voltage at an output current and gives us the result of the test (Table 1), we have radiations of about 100W / m² at 7.30 up to 800 at 8.30, the use of reflectors gives good results on global radiation and even on the duty cycle, it has also been shown that the duty cycle values vary between 0.5 and 0.29, which means a great advantage in our system, ie does not exceed 0.5 in order to avoid current consumption at the coil.

Table1.Measurement results of a SPVC (17/04/2018)

Time (20mn)	Voltage (V)	Curent (A)	Power(W)	Cyclical Reprt
7 :50	12	1.2	15	0.5
8 :10	12.2	1.4	17.78	0.49
8 :30	12.7	1.5	19.35	0.47
8 :50	13.2	1.8	23.76	0.45
9 :10	14	2	28	0.41
9 :30	14.6	2.3	33.58	0.39
9 :50	15	2.5	37.5	0.37
10 :20	15.8	2.5	39.5	0.34
10 :50	16	3	48	0.33
11 :10	16	3	48	0.33
11 :30	16.2	3.2	51.84	0.32
11 :50	16.8	3.3	55.44	0.3
12 :10	16.9	3.5	59.15	0.29
12 :30	17	4	68	0.29

We have input and output chemical capacitors at the input to filter the voltage and output variations to filter voltage variations and for the compensation of the energy supplied by the coil to the closing of the transistor. The simulation results determine the behavior of these converter supplying a load $R = 4.8\Omega$ for an output voltage: $V_s = 24V$, and $I_s = 5A$.

During the test campaign of a PWX500 panel, it was found that the electric power will increase when the reflectors exist in the early hours of the day against in a system without reflectors, for $100W / m^2$ radiation, there is a radiation power of about $400W / m^2$.

The Experience results shows that by using the reflectors, the voltage and current at the output of the DC-DC converter increases and the duty cycle decreases [4, 11, 12]. To show the effect of the reflectors on the DC DC converter, using MATLAB Simulink software, we will compare two photovoltaic conversion chains with and without reflectors by using the results from the experiment Figure 4.



Figure 4. Pictures of the experiment (17/04/2018)

Figure 5 shows the configuration of PV system built in Simulink. It consists of a PV module model, a boost converter, MPPT algorithm and PWM generator [3, 13, 14]. The inputs are voltages and experimental currents. The output produced by the PV module is the PV current, which serves as a controlled current source for the input of the boost converter [15].

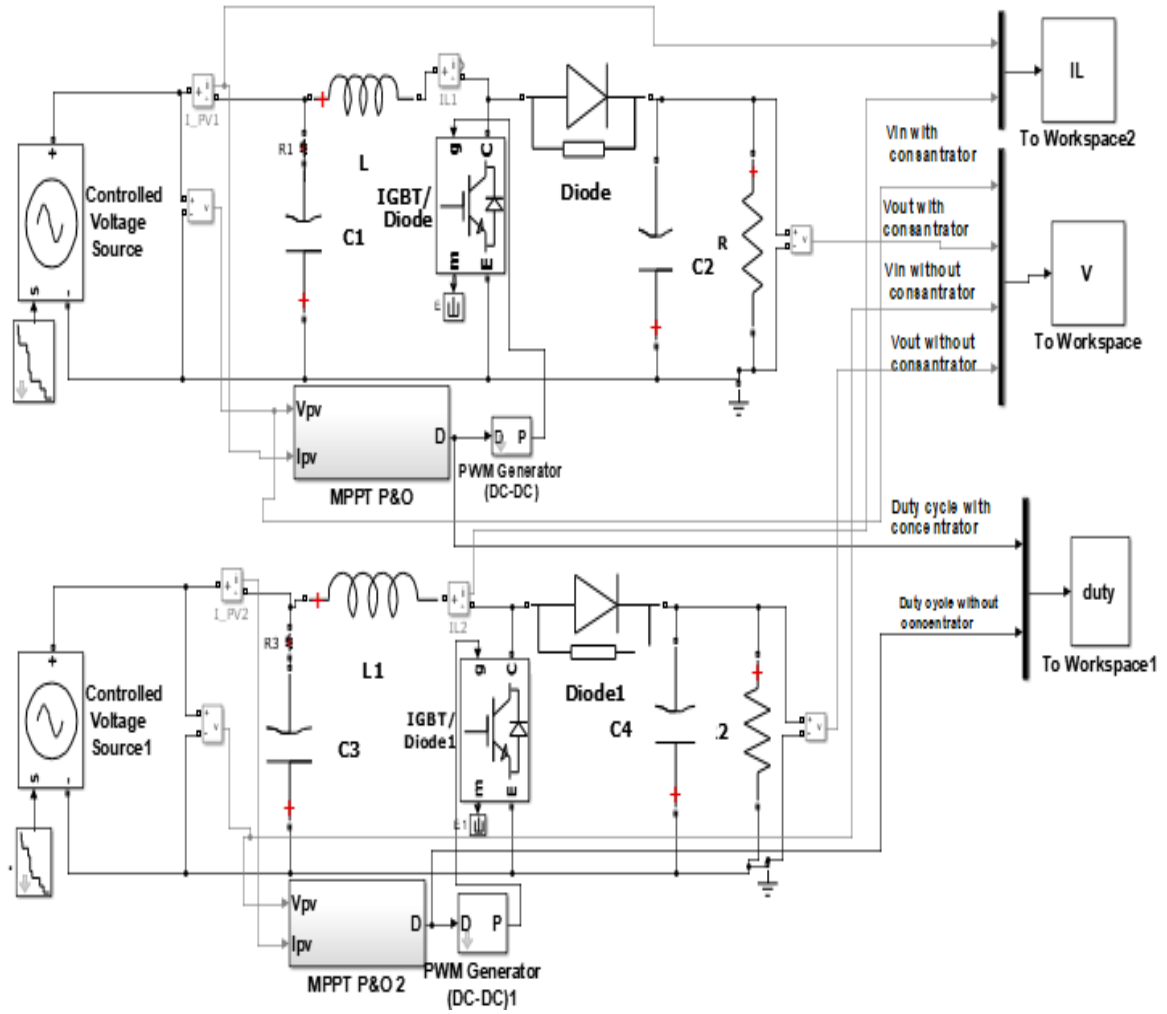


Figure 5. Simulink Program under Matlab of a boost converter controlled in MPPT

4. RESULTS AND DISCUSSION

The simulation results are given in Figure 6, 7, 8 and 9. These figures show the output values of the voltage, the current, the duty cycle, and the current crosses the coil.

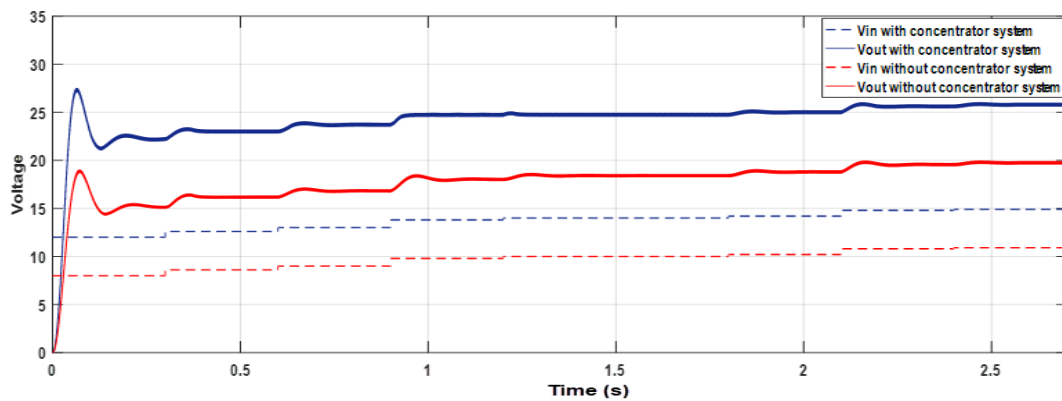


Figure 6. Input and output voltage of the boost chopper with MPPT control with and without concentrator system

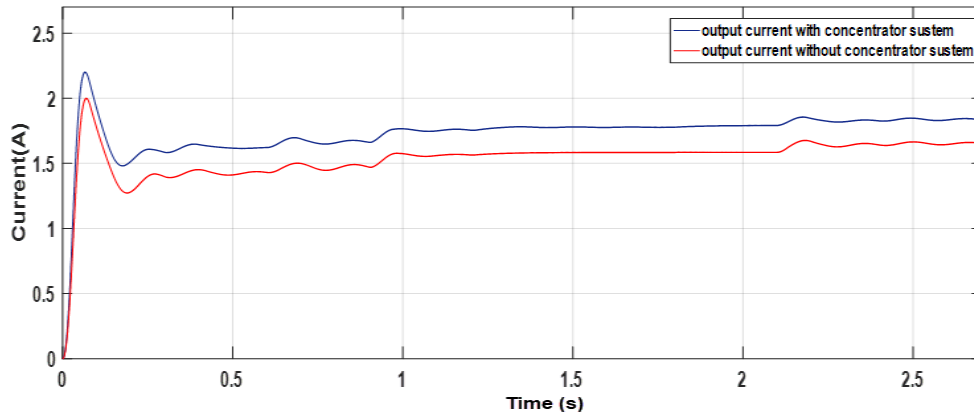


Figure 7. Output current

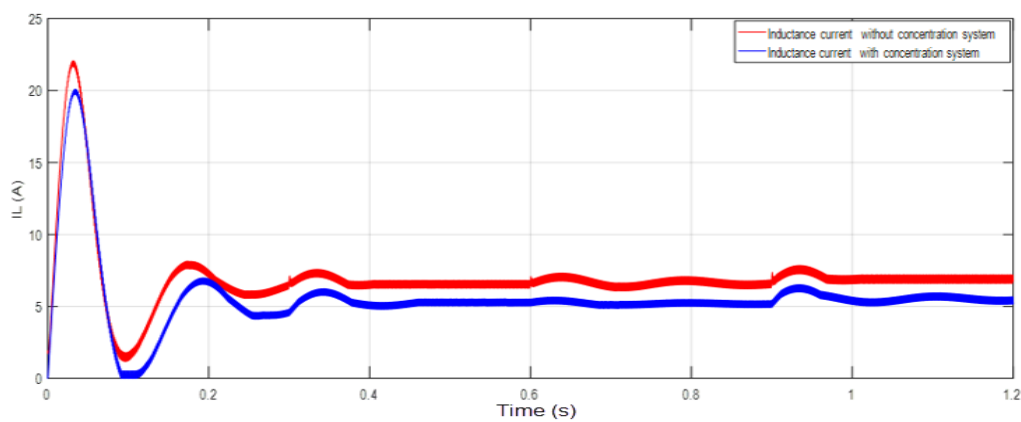


Figure 8. Inductor current

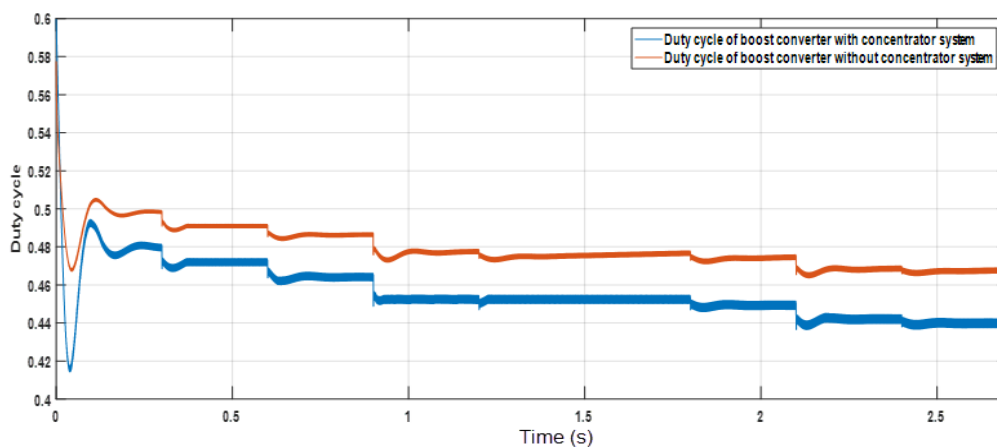


Figure 9. Cyclic report

The voltage at the output of the boost converter with the use of the reflectors is greater than the voltage at the output of the boost converter without the use of the reflectors. In the case of using the reflectors, the current through the coil is less than the current flows through the coil in the case of absence of the reflectors, which explains the intensity of the current at the output of the boost converter with the use of the reflectors is greater than the intensity of the current at the output of the boost converter without using of the reflectors.

This mean that the output current is reduced, and the consumption of the Boost chopper coil is very high or which passes through the inductor L, on the other hand, it is noted in Figure8 that the value of the duty cycle in the case of using reflectors is less than the value of the duty cycle in the case of absence of the reflectors.

5. CONCLUSION

In this paper, we presented the study of effects of photovoltaic panel with reflectors on the dc dcboost converter efficiency. The objective of this prototype is to increase the intensity of the lights on the PV panel and to minimize the current flowing through the coil or decrease the duty cycle.

The role of the DC-DC boost converter is generally to raise the voltage of the PV generator and as little lowered the current supplied to the load by the consumption of the latter into the coil. In order to avoid the current consumption in the coil, were performed Reflectors a side of the panel to increase the radiation on the surface of the panel.

It has been found that by using reflectors, the duty cycle values do not exceed 0.48, then decreases with increased radiation, which means a great advantage in our system, in order to avoid current consumption atthe coil.

This allows makes it possible to increase the voltage and the current supplied to the load, and the value of the duty cycle less important in front of a system PV without reflectors, this is what allow us to get a good efficiency of the DC-DC boost converter.

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