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Design and realization of a photovoltaic system equipped with the analogical and digital MPPT command for better exploitation of solar energy

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Abstract:
In this paper, we present results concerning the design, implementation and modeling of photovoltaic system prototype (PV) equipped with an analog or digital MPPT command. This MPPT command is provided with an analog circuit that detects a dysfunction of the system while ensuring the optimal operation of the PV system without restarting the system. The experimentation of the PV system carried out shows the possibility to following the maximum power point (MPP) of PV panel independently to rapid changes of weather (Solar irradiation…) and load (battery, resistor…). In the case of analog MPPT command, every divergence of the PV system, the circuit detects the perturbation and CDCS circuit reconvergence the system without restarting it to the new PPM.

Keywords: panels and photovoltaic system, analogical or digital MPPT command, circuit (CDCS), DC-DC converter, Pspice simulator, optimum operation, energy loss.

1. Introduction

Energy demand is increasing following the development of industry, transportation and growth worldwide. Photovoltaic (PV) energy is a renewable energy, inexhaustible, clean and does not emit greenhouse gases [1].Currently, much research carried out in order to realized and reliable the PV systems for better use of the PV energy without losses [2-3]. In this paper, we studied the design and optimization of a PV system [4-6] equipped with analog or digital command. In the case of analogical MPPT command, we designed the system so that they converge to the maximum power point (MPP) of the PV panel independently to changes in weather (solar irradiation ...) and load. In the case of analogical MPPT command [7-8], we designed and proposed a detection circuit of dysfunction and reconvergence (CDCS) to the MPP of the PV panel without restarting the PV system. Particular attention is attached to the estimated power losses supplied by PV panels for days of operation of the PV prototypes carried out in this work.

2. Results and discussions

2.1 Photovoltaic system

(Figure 1) shows the block diagram of a PV system that has been the subject of our study. This system is formed by a PV panel (monocrystalline of 75 Wpeak), a Boost DC-DC conveter, an analogical or digital MPPT command and load (Battery, resistor,..)

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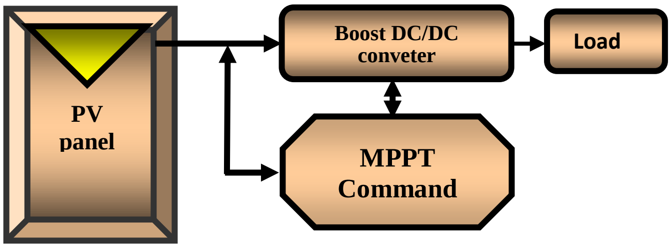

Figure 1: Block diagram of the PV system adapted by the DC-DC converter and an analogical or digital MPPT command.

2.2 PV panel

In (figure 2) we presented experimental characteristics power-voltage and those simulated in the simulator Pspice. It appears in a good agreement between experiment and simulation, and the dependence of the optimal voltage of PV panel with the solar radiation: when the solar radiation varies from 300 to 900 W/m^2, the optimum voltage varies from 14.8 V to 13.2 V (a decrease of 11%).

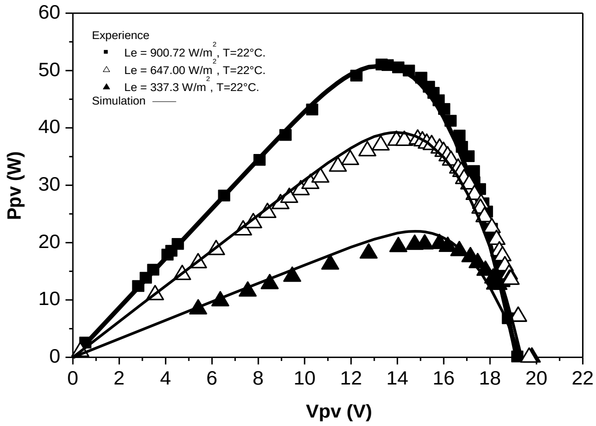

Figure 2: Experimental characteristics power-voltage (■, Δ,▲) and simulated in Pspice (——). T: 22-25°C

2.3. Analogical MPPT command and CDCS circuit

We have shows in (Figures 3 and 4) block diagrams of the PV system equipped with MPPT command and CDCS circuit. On the (figure 5 to 7) the photos of PV panels used, the automatic measuring equipments and the block PV system (Boost DC-DC converter MPPT command and CDCS circuit).

We have experimented the global PV system equipped with MPPT command and CDCS circuit during a cloudy day. In particular, we analyzed the functioning when the sudden changes of solar radiation. The experimental results and those simulated (Optimum) in Pspice are presented in (Figure 8). It appears:

- A very good agreement between experiment and simulation,
- The electrical quantities of PV panel oscillates around those optimal
- Each variation of solar radiation, the CDCS circuit detects the dysfunction and ensures optimum operation.

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In order to validate the operation and performance of the PV system, we followed the operation of the system and carried out during a sunny day in the presence of some clouds. The results obtained (Figure 9), and the good efficiency of the DC-DC converter (about 90%), demonstrate the good operation of the PV system. Throughout the day, the PV panel operates under optimal conditions. For each divergence, the CDCS circuit detects it and reconvergence the global system to the new global PPM. Energy losses of PV are estimated less than 7%.

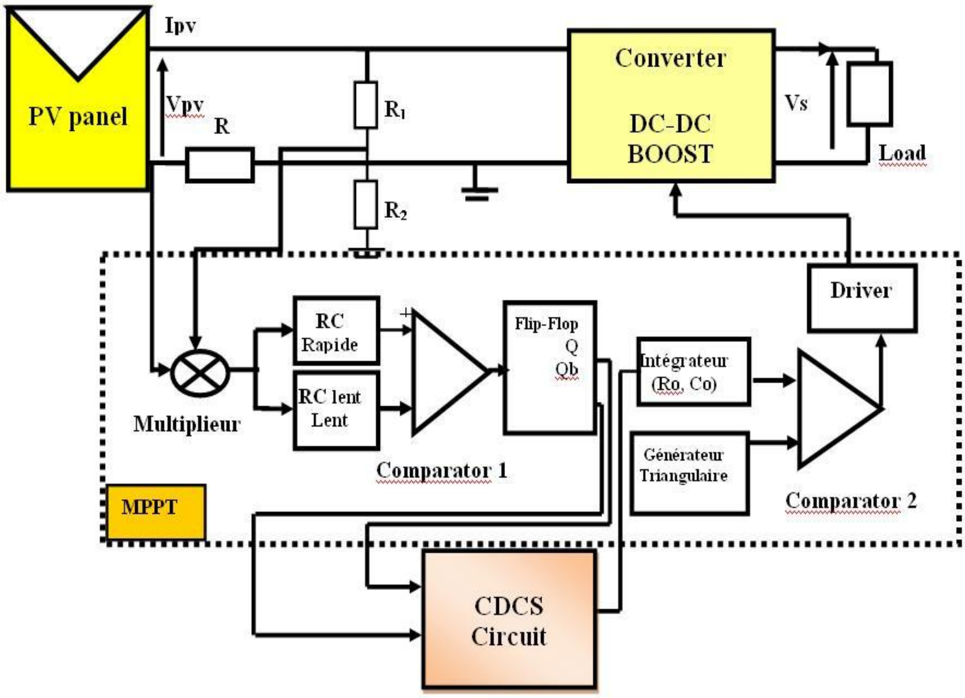

Figure 3: Block diagram of the PV system provided with analogical MPPT command and CDCS circuit.

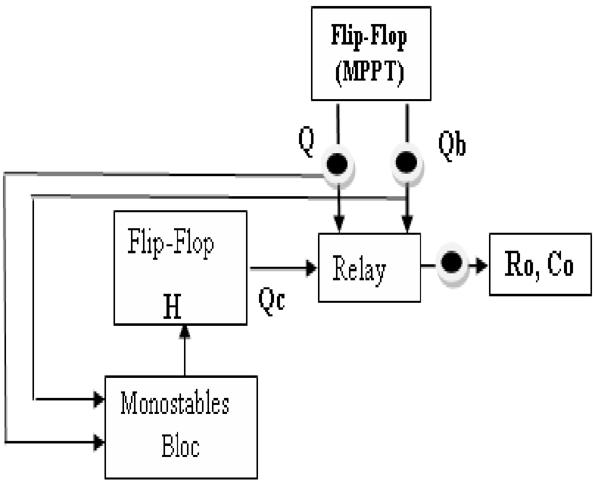

Figure 4: Schematic of the detection circuit of dysfunction and Convergence System (CDCS).

Figure 5: PV panels installed in the laboratory.

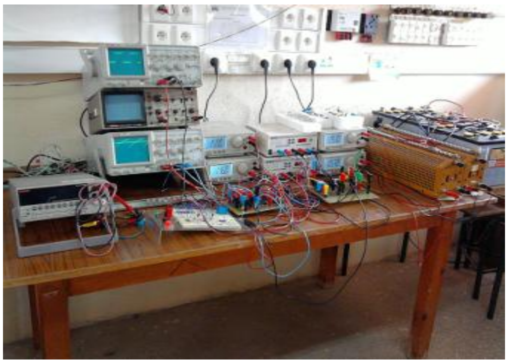

Figure 6: Measuring equipments set up to characterize the PV system.

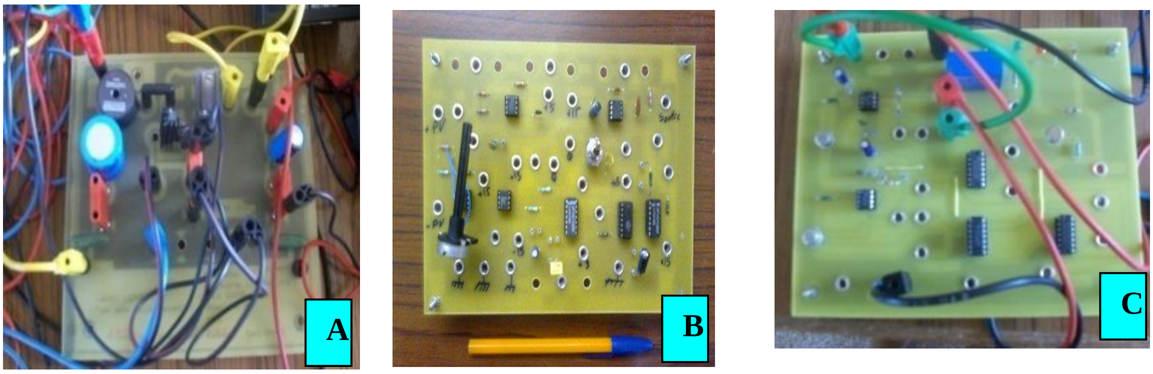

Figure 7: Photos of circuit carried out at laboratory:

(A) DC-DC Converter of Boost type ,
(B) Analogical MPPT command,
(C) CDCS circuit.

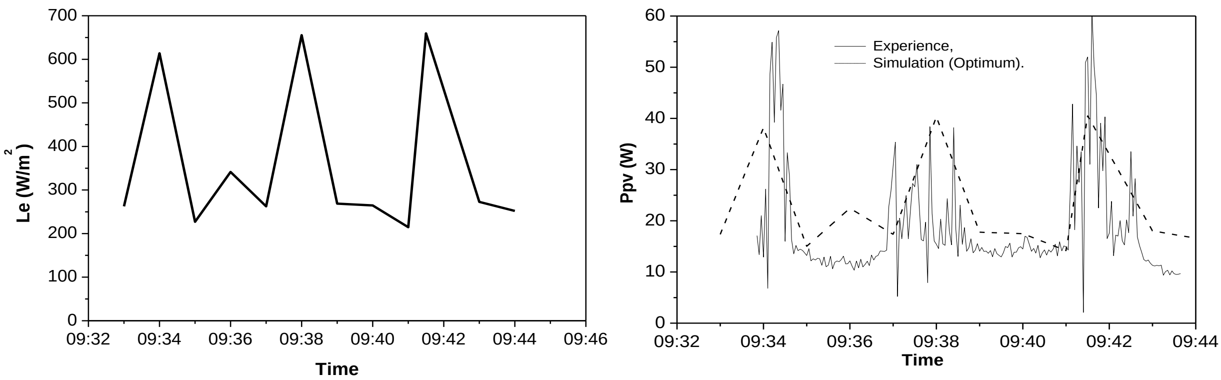

Figure 8: Solar radiation, the PV panel power when the PV system equipped with the MPPT command and the CDCS circuit is undergoing rapid changes in radiation. T = 24 ° C.

2. 4. Digital MPPT Command

In Figure 10 is shown a diagram of PV system equipped with a digital MPPT command [5-9]. This is obtained by implementing an extremal digital MPPT command based on a PIC microcontroller. The role of the MPPT command is to follow the PPM of the PV panel independently to perturbations (variations of solar irradiations, load...).

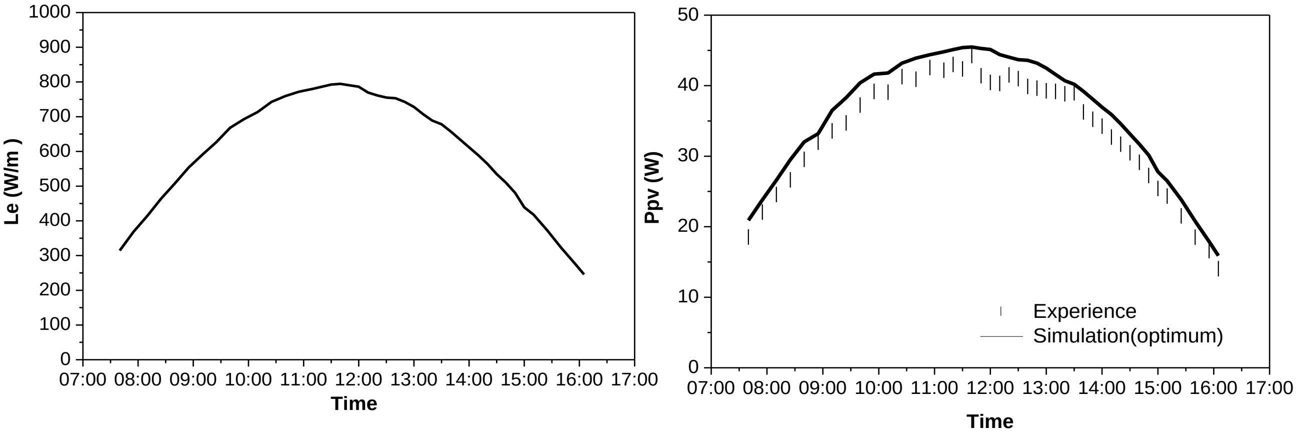

Figure 9: Solar radiation, experimental and simulated (Optimum) power provided by the PV panel of the PV system equipped with the MPPT command and CDCS circuit. T = 24 °C.

We have experimented the PV system carried out (Figure 11) by varying the load, or during cloudy days when the sudden changes of solar radiation. Typical results obtained are shown in Figure 12. It appears very satisfactory results: good agreement between experiment and simulation, the PV system follows the PPM independently to changes in illumination. During operation of the PV system the efficiency of the DC-DC converter is about 90% and losses power supplied by the panel are less than 10%. All these results show the feasibility of the PV prototype provided with the digital MPPT command.

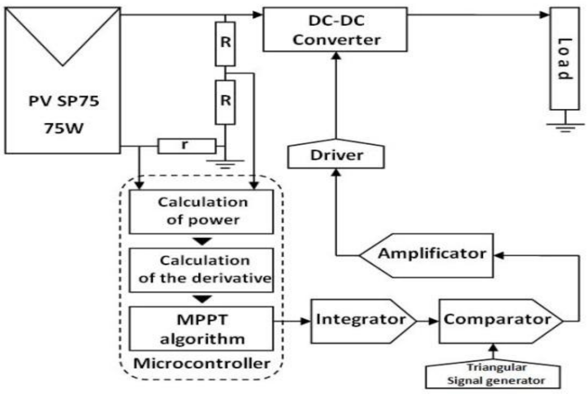

Figure 10: Block diagram of the PV system with a digital MPPT command.

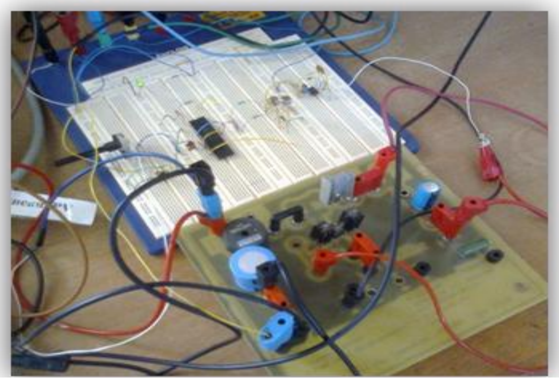

Figure 11: Photo of the PV system provided with a digital MPPT command carried out.

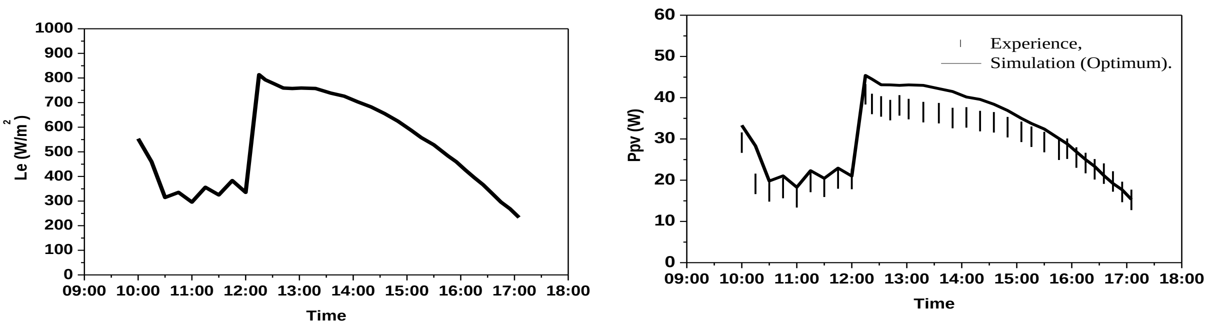

Figure 12: Solar radiation and PV panel power (experimental and simulation in Pspice) during a day.7

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3. Conclusion

In this paper, we showed the feasibility of PV systems, equipped with the analogical or digital MPPT command, for better use of solar energy. The overall results show that PV systems designed, developed and optimized in this work can be used in a PV system to reduce energy losses (due to installations, changes in solar irradiation ...) and consequently the cost of the PV system

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- programme des Nations Unis au Développement, PNUD Art Gold Maroc, 2008 2 ENV OO

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