

Improving the incremental conductance control method of a solar energy conversion system

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1. Introduction

In general, the Earth has two global movements that affect the reception of the solar energy to its surface: the rotation that it does once on itself per day and the yearly revolution that it does around the sun. The combination of these movements implies daily changes in the receipt of the solar light to particular places [1]. The reason for which the energizing flux received to soil hardly passes 1000 W/m^2 is that the atmosphere modifies in an important way the direct radiance of the sun [2], [3].

Our goal is to maximize the output power produced by the solar panel. Notice that this problem has attracted the interest of several authors [4],[5],... Thus, the paper is organized as follows. Section 2 is devoted to present the system under considerations. Section 3 shows the difference between photovoltaic cell and solar panel. In the fourth section, an analysis of the output power and condition of its maximizing value are given. Simulation results are presented in section 5. Finally, conclusions are given in section 6.

2. The process under considerations

Our system is achieved in the Faculty of Engineering of the Lebanese University in Lebanon. It is constituted of two solar panels (50 W each one), the first stationary and the second mobile. The control of the last one took place so that its surface is always perpendicular to the solar rays (Figure 1). The using of a microcontroller on the whole system has permitted the interconnection between the two solar panels and the computer in order to archive the values of the produced powers. Another role was to turn the electric motor of the support carrying the mobile panel. In addition, our system contains a weather station in order to manage better the produced power. In this paper, we are interested in the modeling and control of the solar panel in order to maximize the produced power.

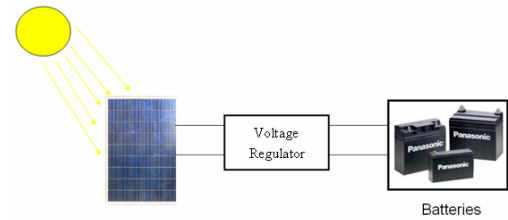


Fig. 1. The solar conversion system

3. The solar generator

A. Modelling of a solar panel

In the obscurity, a semiconductor presents a high resistance. When it is strongly illuminated, its resistance decreases. If the energy of the photons that constitutes the luminous ray is sufficient, these photons will be able to excite the electrons blocked in the valence layer to jump to the conduction layer. It is the phenomenon of photo conductivity [5]. A solar panel is an association in parallel and in series of several cells. The equivalent model of the solar panel is given in figure 2. This model contains two inputs, E_s (the sunshine) and T_j (the temperature), and two outputs, I_G and V_G .

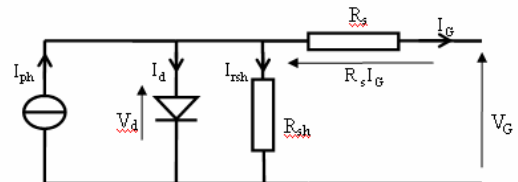


Fig. 2. Equivalent model of the solar panel

B. Output power characteristics

For any solar panel, the output power is function of the temperature and the sunshine values of the site where the panel is placed (Figure 3). In this figure, the output power is not constant. To maximize this power, it is necessary to define the Maximum Power Point Tracking (MPPT) methods, and apply these methods to controlled choppers.

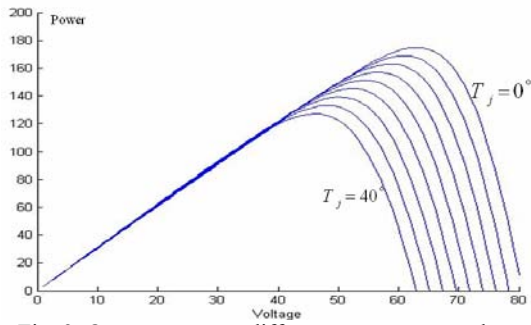


Fig. 3. Output power at different temperature values

4. Maximizing the output power

Several MPPT methods exist in order to maximize this output power and to fix its value, in steady-state, to its high level. In this paper, the incremental conductance method is treated. This method consists in using the slope of the derivative of the current with respect to the voltage in order to reach the maximum power point. To obtain this point, $\frac{dI}{dV}$ must be equal to $-I/V$ (Figure 4).

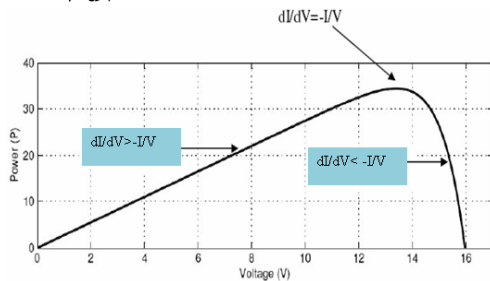


Fig. 4. Output power

5. Simulation Results

The temperature average value is taken equal to 25°C with variation of $\pm 15^\circ\text{C}$. The sunshine average value is fixed to 600 W/m^2 , with variation of $\pm 200 \text{ W/m}^2$.

With the ‘Incremental conductance’ method, the curve of the output power versus time is illustrated in figure 5. To reduce the time response of this curve, it is proposed to make change on the chopper duty cycle. The new one takes the value of: $\alpha = (\alpha_n + \alpha_{n-1})/2$

The obtained power (Figure 6) has ripples which can be dangerous for the batteries. To minimize these ripples, the delta-adaptative method was applied (Figure 7).

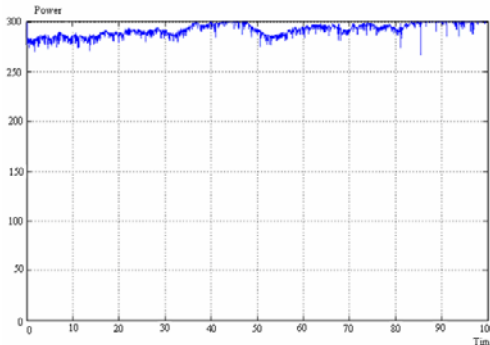


Fig. 5. Power waveform by using the incremental conductance MPPT method

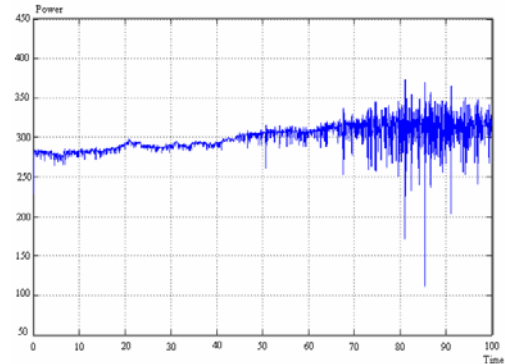


Fig. 6. Power after improving the conductance method

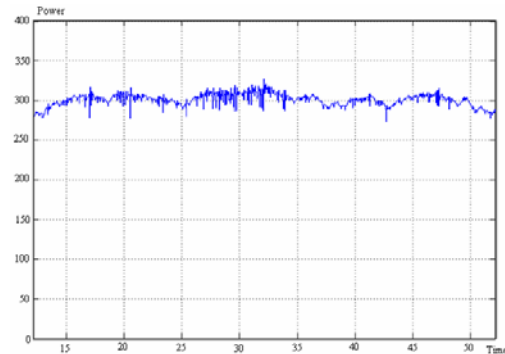


Fig. 7. Power after applying the delta-adaptative method

6. Conclusion

In this paper, after presentation of the studied system, the conversion from solar energy to electrical one is treated. The ‘incremental conductance’ method is used to maximize the output power. This method had been improved by using the averaging strategy of the chopper duty cycle. The time response is reduced, but, ripples of high amplitude appears. To eliminate these ripples, the delta adaptative method was applied. Simulation results prove that the delta adaptative method permits the reduction of the power ripples and gives the maximum value to the power amplitude with a reduced time response.

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