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A novel single sensor PV MPPT controller

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Abstract - *This paper proposes a novel single sensor maximum power point tracking method for PV system composed of Solarex MSX-60W PV panel operating at variable atmospheric conditions and DC-DC boost converter controlled using the proposed MPPT that uses only one sensor in order to reduce the cost and the complexity of the MPPT controller. The performance of the proposed single sensor MPPT controller is evaluated using the implemented Matlab/Simulink PV power system model. Simulation results show that the proposed single sensor MPPT controller can provide similar results using only one sensor compared to the conventional two sensors MPPT.*

Résumé - *Cet article propose une nouvelle méthode de suivi du point de puissance maximale pour un système PV composé d'un panneau PV Solarex MSX-60W fonctionnant dans des conditions atmosphériques variables et d'un convertisseur DC-DC boost contrôlé par le MPPT proposé qui utilise un seul capteur afin de réduire le coût et la complexité du contrôleur MPPT. La performance du contrôleur MPPT à capteur unique proposé est évaluée en utilisant de du modèle de système d'alimentation PV Matlab/Simulink mis en œuvre. Les résultats de la simulation montrent que le contrôleur MPPT à capteur unique proposé peut fournir des résultats similaires avec un seul capteur par rapport aux deux capteurs MPPT classiques.*

Keywords: PV system - MPPT - DC-DC - Step size - Single sensor.

1. INTRODUCTION

Oil and other non-renewable fossil fuels are being quickly consumed, which is creating major impacts on air and water pollution as well as concern on global climate change. A shift to zero-carbon emission solar hydrogen systems could fundamentally resolve these energy supply and environmental problems. As consequence, alternate energy becomes more popular but major questions remain to be answered on which fuel or fuels will emerge and to what extent alternative sources will replace gasoline as the main product of crude oil [1, 2].

Photovoltaic energy is, involving several fields such as mechanics, optics, power electronics, control theory, and other fields. The discovery of the photovoltaic effect allows to transform solar light directly into electrical energy Based photovoltaic cell to create a photovoltaic effect we need a photovoltaic system.

Photovoltaic systems has a problem is influenced by changing climatic conditions, such as irradiation and temperature, which makes it possible to produce electrical energy varies as a non-linear voltage-current characteristic with a maximum power point (MPP), which depends on environmental factors [3].

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There are various methods for controlling optimum electrical power: method on the physicochemical properties of cells, method on mechanical followers of automatic orientation of solar panels, and method on the interface of power electronics that connects the generator PV with its load. This last method is commonly known as the electrical control of PV systems. One of the systems in the development of topologies of static converters and controlled by MPPT (Maximum Power Point Tracking) control for the best capture of maximum power.

Therefore, a MPPT search technique of the maximum power point (MPP) to control the duty cycle of the DC/DC converter is necessary to ensure optimal operation of the PV chain under different operating conditions. Electricity is the most important for lighting, heating, cooking, distraction, communication and information, and so on. And for this the direct conversion of solar radiation into electricity is known as photovoltaic effect and to create a photovoltaic effect we need a photovoltaic system [4, 10].

This paper proposes a novel single sensor maximum power point tracking method for PV system composed of Solarex MSX-60W PV panel operating at variable atmospheric conditions and DC-DC boost converter controlled using the proposed MPPT that uses only one sensor in order to reduce the cost and the complexity of the MPPT controller.

The performance of the proposed single sensor MPPT controller is evaluated using the implemented Matlab/Simulink PV power system model. Simulation results show that the proposed single sensor MPPT controller can provide similar results using only one sensor compared to the conventional two sensors MPPT.

The remainder of the paper is organized as follows. In Section 2, the photovoltaic cell modelling is presented. Section 3 describes the proposed single sensor variable step size MPPT controller. Section 4 presents the simulations results and discussions. In Section 5, the conclusions are stated.

2. PV CELL MODELLING

The well-known and widely used model based on the well-known Shockley diode equation is presented below figure 1.

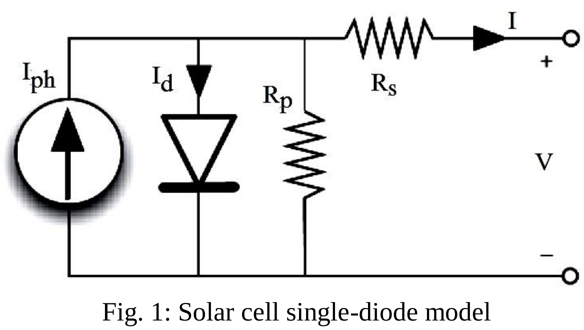

Fig. 1: Solar cell single-diode model

The output current I can be expressed by:

$$I = N_p I_{ph} - N_p I_{rs} \left(e^{\left(\frac{q(V + R_s I)}{A.k.T.N_s} \right)} - 1 \right) - N_p \left(\frac{q(V + R_s I)}{R_p \cdot N_p} \right) \quad (1)$$

where, V is the cell output voltage; q is the electron charge; k is the Boltzmann's constant (1.3806503×10^{-23}J/K); T is the temperature in K; I_{rs} is the cell reverse saturation current; A is the diode ideality factor; N_p is the number of PV cells connected parallel; N_s is the number of PV cells connected in series; R_s is the serial resistance; N_p is the parallel resistance.

The generated photocurrent I_{ph} is related to the solar irradiation by the following equation:

$$I_{ph} = \left(I_{sc} + k_i\,(T - T_r)\right)\frac{S}{1000} \tag{2}$$

where k_i is the short-circuit current temperature coefficient, S is the solar irradiation in W/m^2, I_{sc} is the cell short circuit current at reference temperature and T_r is the cell reference temperature.

The cell's saturation current is varies with temperature according to the following equation:

$$I_{rs} = I_{rr}\left(\frac{T}{T_r}\right)^3 \exp\left(\frac{q\,.\,E_G}{k\,.\,A}\left(\frac{1}{T_r} - \frac{1}{T}\right)\right) \tag{3}$$

where, E_G is the band-gap energy of the semi-conductor, I_{rr} is the reverse saturation at T_r .

3. PROPOSED SINGLE SENSOR MPPT

The proposed single sensor MPPT algorithm uses only one sensor based on:

$$p_0 = \frac{V_0^2}{R_L} \tag{4}$$

where P_0 is the output power; V_0 is the output voltage; R_L is the load resistance.

Tracking the maximum of P_0 reduced to track:

$$\frac{\partial P_0}{\partial V} = 0 \equiv \frac{\partial P_0}{\partial D} = 0 \tag{5}$$

According to the equation of the boost converter, we have:

$$V_0 = \frac{V_{PV}}{1 - D} \tag{6}$$

where V_{PV} is the PV module voltage.

According to (10) and (11), we have:

$$\frac{\partial P_0}{\partial D} = \frac{1}{R_L} \times \frac{\partial\,(V_{PV}^2)}{\partial D} = \frac{1}{R_L} \times \frac{\partial\left(\left(\frac{V_{PV}}{1 - D}\right)^2\right)}{\partial D} \tag{7}$$

$$\frac{\partial P_0}{\partial D} = \frac{1}{R_L} \frac{\left((1-D)^2 \times \frac{\partial (V_{PV}^2)}{\partial D} - V_{PV}^2 \times \frac{\partial (1-D)^2}{\partial D} \right)}{(1-D)^4} = 0 \quad (8)$$

$$\frac{\partial P_0}{\partial D} = \frac{1}{R_L} \frac{\left((1-D)^2 \times \frac{\partial (V_{PV})}{\partial D} + V_{PV} \right)}{(1-D)^3} = 0 \quad (9)$$

$$\frac{\partial P_0}{\partial D} = \frac{\partial V_{PV}}{\partial D} + \frac{V_{PV}}{1-D} = 0 \quad (10)$$

Equation (15) means that the maximum power point is achieved when:

$$\frac{\partial V_{PV}}{\partial D} = -\frac{V_{PV}}{1-D} \quad (11)$$

4. RESULTS AND DISCUSSION

To evaluate the proposed single sensor MPPT controller, we have implemented the model of the PV system composed of Solarex MSX-60 W PV panel operating at variable atmospheric conditions and DC-DC boost converter controlled using the proposed MPPT that uses only one sensor under Matlab/Simulink environment.

The parameters of the Solarex MSX-60W PV panel are given in **Table 1**.

Table 1: Electrical Characteristics of Solarex MSX -60 (1 kW/m², 25 °C).

Description	MSX-60
Maximum Power (P_{MPP})	60W
Voltage Pmax (V_{MPP})	17.1V
Current at Pmax (I_{MPP})	3.5A
Short Circuit current (Isc)	3.8A
Open Circuit voltage (Voc)	21.1V
Temperature coeff of Voc	-(80±10)mV/°C
Temperature coeff of Isc	(0.065±0.01)%°C
Temperature coeff of power	(-0.5±0.05)%°C
NOCT	47±2°C

Figure 2 show the pattern test used to evaluate the proposed single sensor MPPT.

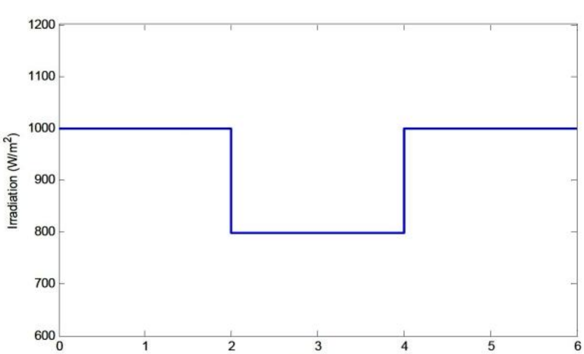

Fig. 2: Pattern test

Figure 3 shows the output power using the proposed MPPT.

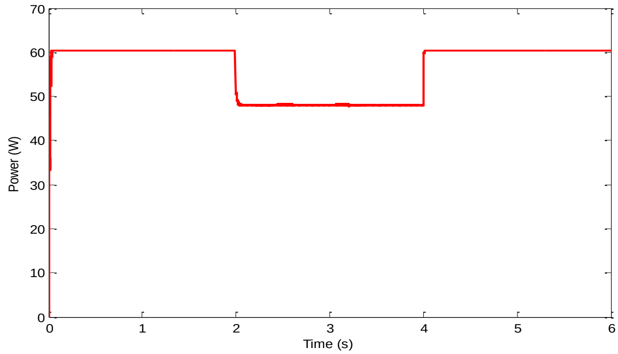

Fig. 3: Output power

Figure 4 shows the corresponding PWM ratio using the proposed single sensor MPPT.

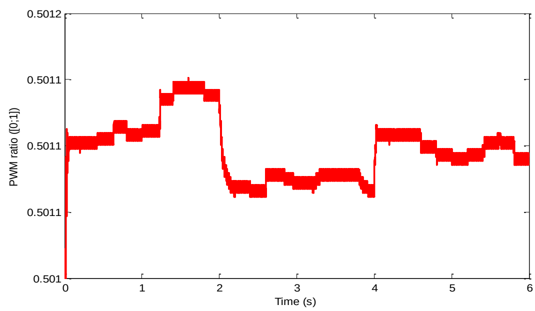

Fig. 4 PWM ratio.

While figures 5 and 6 show the IV and PV characteristics, respectively.

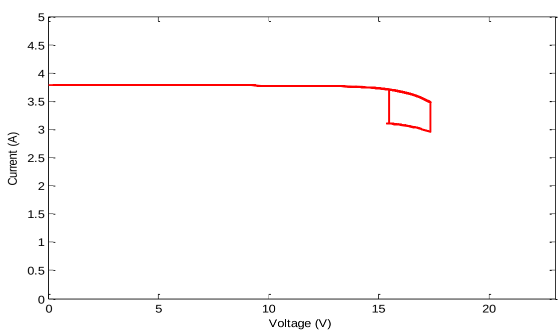

Fig. 5: IV characteristic

From figures 2 and 6, we see clearly that the proposed single sensor MPPT controller proves similar characteristics to those provides by classical MPPT controllers using two sensors.

In addition, the proposed single sensor MPPT controller reacts correctly and provides PV characteristics accordingly to irradiation changes corresponding to the theoretical values

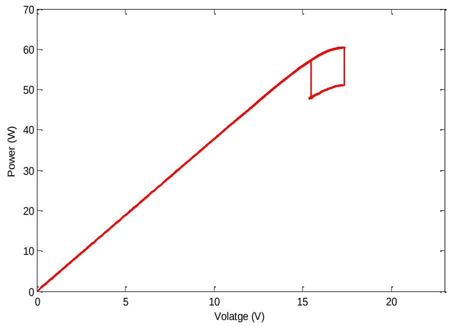

Fig. 6: PV characteristic

5. CONCLUSION

This paper deals with the development of a single sensor MPPT controller used to track the maximum power of PV generator system composed of Solarex MSX-60W PV panel operating at variable atmospheric conditions and DC-DC boost converter controlled using the proposed MPPT that uses only one sensor in order to reduce the cost and the complexity of the MPPT controller.

The proposed single sensor MPPT has been implemented and evaluated using Matlab/Simulink environment. Simulation results show that the proposed single sensor MPPT controller can effectively track the maximum power using only one sensor compared to the classical MPPTs using two sensors.

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