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Study of photovoltaic module for electrical characteristics

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Abstract

The objective of this work was to study the electrical characteristics of different operation for photovoltaic (PV) module. Two operational factors for polycrystalline silicon of PV module were investigated, included of (1) new and used of PV module, and (2) tilt angle of PV module. Current-voltage characteristics and input solar energy were determined and followed by the International Electrotechnical Commission standard (IEC). These characteristics were calculated for the fill factor (FF) and efficiency, which were used to compare properties of different conditions. The results indicated that the tilt angle of PV module affects the fill factor and efficiency slightly. However, outdoor usage of PV module had an important influence on the fill factor and efficiency of the photovoltaic module due to its deterioration and decreased short - circuit current.

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Keywords: photovoltaic, current-voltage characteristics, the fill factor, polycrystalline silicon

1. Introduction

Nowadays renewable energy resources are playing an important role especially in part of power generation. Many countries have become concerned about the future energy and have begun searching for ways of renewable energy technologies. Renewable energy has many advantages; besides, decreasing the demand of using fossil energy, renewable energy reduces the emission of greenhouse gases. Photovoltaic (PV) energy or solar energy is one of the important renewable energy resources. Moreover, solar energy is looked on established technology and rapid growth for long time.

The photovoltaic technology has been developing for a long time. It is useful for power generation because its features are commercial energetic and photovoltaic cells that can directly convert solar radiation energy into electrical energy [1]. However, the amount of solar radiation energy depends on the various sun positions. That means the amount of solar radiation energy will be different in each geographic latitude, season, and time of a day. Therefore, many studies have been conducted to determine the optimum location for solar radiation collection [2, 3] and to develop some devices as solar tracking system for aligning a PV module or concentrating

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a solar reflector or lens towards the sun, for an example the study of 'Topology study of photovoltaic interface for maximum power point tracking' [4]. However, this system is still developing and its cost is expensive, even it increases efficiency and accuracy of following the sun.

Therefore, the objectives of this study were to investigate influence of the tilt angles of PV module for solar radiation collection, and influence of new and used PV module on electric characteristics (current-voltage characteristics and power-voltage characteristics) for deciding on using solar tracking system.

Nomenclature

A	Area of PV module (m^2)
FF	Fill factor
I_m	Maximum current (A)
I_{SC}	Short circuit (A)
P_{in}	Solar irradiance (W/m^2)
V_m	Maximum voltage (V)
V_{OC}	Open circuit voltage (V)
η	Efficiency of PV module (%)

2. Methodology

This study was set for measurement in natural sunlight. The measurement and setting instruments followed International standard of International Electrotechnical Commission [5]. In this study, global solar irradiance was not fluctuating by more than $\pm 1\%$ and the irradiance was at least 800 W/m^2 during a measurement. The active surface of the specimen was coplanar within $\pm 2°$ with the active surface of the reference device (Pyranometer) or θ angle, follow as Fig. 1.

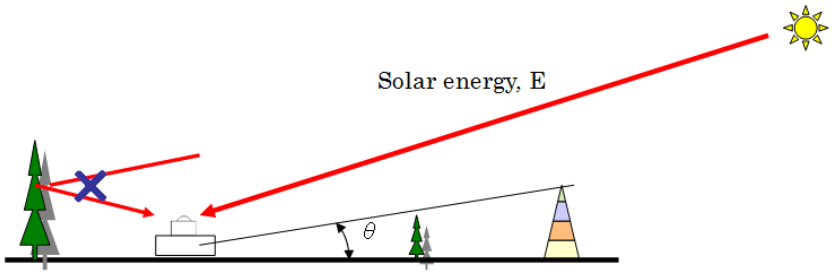

Fig. 1. The measurement and setting instruments

PV module in this study was polycrystalline Sharp solar module (ND-120T1D) 0.9975 m^2 of area, with maximum power 120.0 W. The tilt angles of PV module were compared between 0° and 30° from horizontal (Fig. 2). Besides, new PV module and 5-year-used PV module were investigated on current-voltage characteristics and power-voltage characteristics.

Fig. 2. Setting PV module for tilt angle experiments

The fill factor of current-voltage characteristics and efficiency of PV modules calculated from Eq. (1) and (2), respectively:

$$FF=\frac{I_m V_m}{I_{SC} V_{OC}} \quad (1)$$

$$\eta = \frac{I_m V_m}{P_{in} \times A} \times 100\% \quad (2)$$

3. Discussion

3.1 Tilt angle experiments

The PV modules, which were used in this experiments, were the new PV modules. For the tilt angle experiments, ambient temperature and humidity were around 34.4°C and 52%, respectively. Solar irradiance from pyranometer was around 802 W/m^2 and its fluctuation was not over $\pm$1%. The results from these experiments were shown in the current–voltage characteristic and the power-voltage characteristic (Fig. 3).

For PV module lied on 0 degree (0 deg) from horizontal, the highest voltage from open circuit was 18.67 V and similar with 30 degree from horizontal PV module (30 deg). But 30 degree had highest current (from short circuit) higher than 0 deg (7.05 A and 6.50 A, respectively). These would cause the maximum power of 30 deg (82.4 W) higher than 0 deg (77.4 W).

The results from the current–voltage characteristics allowed calculating to the fill factor (FF) and the conversion efficiency (η) and found, the efficiencies accorded with the results of the current–voltage characteristics which 30 deg higher than 0 deg (10.28% and 9.69%, respectively). Although, the fill factor of 30 deg (0.62) was lower than 0 deg (0.64) but it was slightly different.

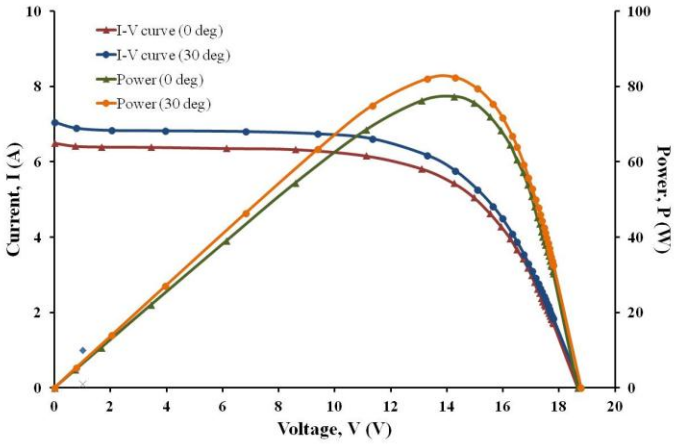

Fig. 3. The comparison of I-V characteristics and P-V characteristics for tilt angle experiments

3.2 New and used of PV module experiments

From the previous experiments, this used the 30 degree of PV tilt angle. The ambient temperature and humidity for the new and used PV module experiments were around 35.3°C and 32%, respectively. Solar irradiance from pyranometer was not fluctuating over $\pm$1%, with the average of 846 W/m^2. The results from these experiments were shown in the current–voltage characteristic and the power-voltage characteristic (Fig. 4).

For the new PV module, the highest voltage from open circuit was 18.6 V and 19.06 V for the used PV module. The highest current (from short circuit) for the new one was higher than the used one (7.37 A and 6.64 A, respectively). Moreover, the highest current in this experiment was higher than the previous experiments as well, because this experiment had the amount of solar irradiance more than the previous. For the maximum power, the new one (80.9 W) was higher than the 5-year-used PV module (71.8 W) as well.

After using the results from the current–voltage characteristics to calculate the fill factor (FF) and the conversion efficiency (η), it was found that the efficiencies and the fill factor according to the results of the current–voltage characteristics was that the new PV module was higher than the 5-year-used PV module. The conversion efficiencies were 9.56% and 8.53% for the new and used PV module, respectively. The fill factors were 0.59 and 0.57 for the new and used PV module, respectively.

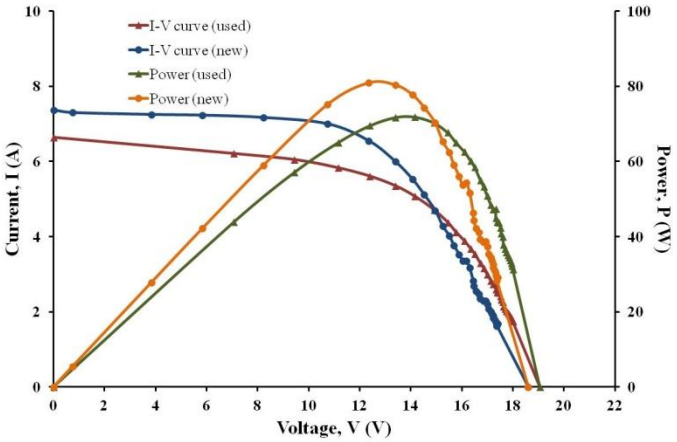

Fig. 4 The comparison of I-V characteristics and P-V characteristics for new and used of PV module experiments

4. Conclusion

To compare properties of different conditions of polycrystalline photovoltaic module, the tilt angle and new or used photovoltaic module, it could convert solar irradiance into electrical energy in the efficiency range 8.53% to 10.28%. The increase in the tilt angle caused the increase in the power and efficiency but it was slightly different. The increase in long term of photovoltaic module caused the decrease in the power and efficiency. The highest efficiency of energy conversion is observed for 30 deg of the new photovoltaic module. This might be because the sun always moves and it has inclination with ground; thus, tilt angle of photovoltaic module would be more suitable than no tilt angle. Besides, outdoor usage of photovoltaic module had an important influence on the conversion efficiency of the photovoltaic module. It might be due to its deterioration and decreased short-circuit current.

However, the future study will consider more for optimum tilt angle of photovoltaic module which can be used to harvest solar energy all day.

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