Journal of Engineering
Research and Education
Vol. 8 (2016) 29-38

Daily performance of kaneka g-sa060 amorphous silicon photovoltaic module based on solar irradiation and temperature in kangar malaysia as dc voltage source on spwm transformerless photovoltaic inverter

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ABSTRACT

This paper presents the daily performance of Kaneka G-SA060 amorphous silicon photovoltaic (PV) module. It is very important to study the data of solar irradiation and temperature related to the performance of PV module. In this paper, the daily data of irradiation and temperature are recorded throughout a year by Centre of Excellence for Renewable Energy (CERE) Weather Station, Universiti Malaysia Perlis (UniMAP). A mathematical modelling of PV performance is applied for the daily data of irradiation and temperature. The result shows that if the solar irradiation increases and the temperature is constant, thus the PV performance will increase. Inversely, if the temperature increases and the solar irradiation is constant, thus the PV performance will decrease. The performance of three unit of 91.8 V, 60 W PV modules connected in series are simulated in order to obtain an information of the total of open circuit voltage, short circuit current and maximum power through the year of 2015. This information is very important to decide that sinusoidal pulse width modulation (SPWM) transformer less photovoltaic inverter (TPVI) is suitable or not to be applied in Kangar, Malaysia.

INTRODUCTION

PV performance depends on the solar irradiation and temperature. If the solar irradiation increases and the temperature is constant, thus the PV performance will increase. Inversely, if the temperature increases and the solar irradiation is constant

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thus the PV performance will decrease [1-4]. The PV performance affects the capability of the charging system in the PV inverter application. A high PV performance will produce a high current [5].

This paper presents the daily solar irradiation and temperature in Kangar that applied in to mathematical modelling of PV performance.

RESEARCH METHODOLOGY

Installation of PV Array and Weather Station

The PV array and weather station are installed in front of CERE, UniMAP, in Northern Malaysia. Three unit of 91.8 V, 60 W PV modules are connected in series to be a PV array as shown in Figure 1. The solar energy (solar irradiation) is converted by PV array to be DC electricity. The solar irradiation and temperature are recorded by CERE weather station every minute as shown in Figure 1. The solar irradiation and temperature affects the PV array performance.

Figure 1: PV array and CERE weather station

Mathematical Modelling of PV Module Performance

The proposed PV module performance based on mathematical modelling of the PV panel as explained below.

1. Data of solar irradiation and temperature.

   Daily data of solar irradiation and temperature through the year of 2015 are needed to calculate the PV module maximum power. This data are recorded by CERE weather station, UniMAP, in Kangar, Perlis, Northern Malaysia.

2. Type selection of PV module.

   Data sheet of 60 W, 91.8 V, Kaneka G-SA060 amorphous silicon (a-Si) PV module is used in this study. The data sheet of PV module is important as information to calculate its open circuit voltage, short circuit current and maximum power. Normally, they are related to the solar irradiation and temperature. The connection of PV array that connected to the SPWM TPVI system is shown in Figure 2.

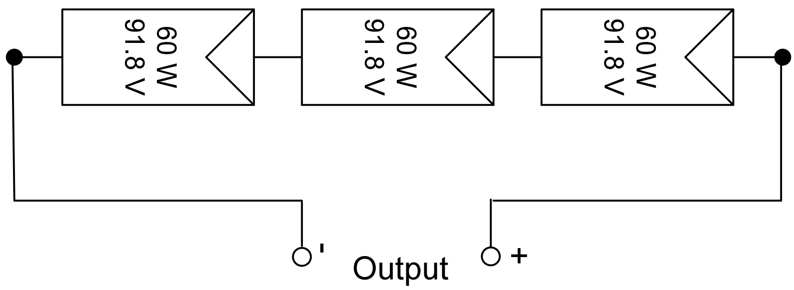

Figure 2: The connection of PV array

3. Mathematical modelling of PV module

   The solar irradiation and temperature are arriving on the PV module affect the PV module maximum power. For calculating the daily the PV module maximum power, firstly the Eq. (1) is applied to calculate the PV module current and voltage. Secondly, current verses voltage curve of the PV module is plotted and observed its maximum power.

   The PV module opens circuit voltage and circuit current is modelled in mathematical. They are following as suggested by [6]. The data of maximum open voltage, $V_{\max}$ and minimum open voltage, $V_{\min}$ are required in the model application. They are in two operation points (solar irradiation and temperature) for the same nominal temperature, T_N of 25 ^{0}C at the high solar irradiation level, $\alpha_{\max}$ of 1000 W/m^2 and low solar irradiation level, $\alpha_{\min}$ of 200 W/m^2.

There are five electrical parameters of PV module beside those four parameters as mentioned above are needed to simulate the PV module performance. They are the open circuit voltage, V_{MPP} and current, I_{MPP}, at the maximum peak point, and the short circuit current I_{sc}, all parameters are at the standard test condition (STC) as well as the coefficient of temperature for open circuit voltage, TC_v and the coefficient of temperature for the short circuit current, TC_i. The parameter of "b" in Eq. (1) is the parameter of PV model fixed. It affects the plotting of current verses voltage curve in order to achieve the maximum power point. The open circuit voltage $V_{oc}(\alpha, T)$ as function of solar irradiation and temperature and the circuit current $I(\alpha, T, V)$ as function of solar irradiation. Temperature and voltage are given by [11] are shown in Eq. (1) to (4).

$$I(\alpha,T,V) = \frac{\alpha}{1000}.I_{sc}.\tau_i(T).\left[\frac{1-e^{\left[\frac{V}{b\left(V_{\max}+\tau_v(T)\right)\left(1+\frac{\alpha-\alpha_{\max}}{\alpha_{\max}-\alpha_{\min}}.\frac{V_{\max}-V_{\min}}{V_{\max}}\right)}-\frac{1}{b}\right]}}{1-e^{-\frac{1}{b}}}\right] \tag{1}$$

When $I(\alpha,T,V) = 0$ A, the open circuit voltage is given by

$$V_{oc}(\alpha,T) = \left[V_{\max}+\tau_v(T)\right]\left[1+\frac{\alpha-\alpha_{\max}}{\alpha_{\max}-\alpha_{\min}}.\frac{V_{\max}-V_{\min}}{V_{\max}}\right] \tag{2}$$

$$\tau_i(T) = 1+(T-T_N).\frac{TC_i}{100\%} \tag{3}$$

$$\tau_v(T) = (T-T_N).TC_v \tag{4}$$

RESULTS AND DISCUSSION

Daily Solar Irradiation and Temperature through the Year of 2015

The daily solar irradiation and temperature through the year of 2015 as shown in Figure 3 and 4 was observed and analyzed to obtain the power of PV module as shown in Figure 6. The maximum and minimum solar irradiation that related to the temperature for the same day are shown in Table1. It means to show that effect of solar irradiation and temperature on the power of 3 x 60 W, 91.8 V, Kaneka G-SA060 a-Si PV module (the higher solar irradiation produces higher PV module power).

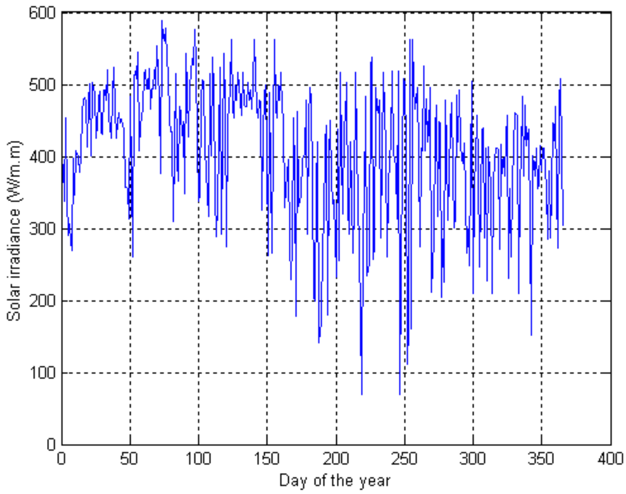

Figure 3: Daily solar irradiation through the year of 2015

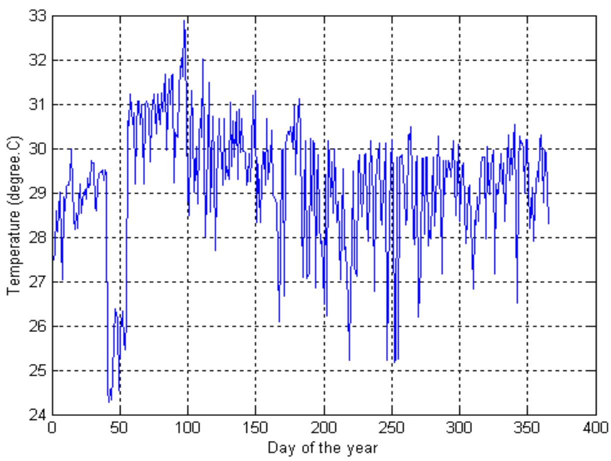

Figure 4: Daily temperature through the year of 2015

Table 1: Minimum and maximum of the solar irradiation and PV module power

	Solar irradiation (W/m^2)	PV module power (W)
Minimum	68.73 (25.23 ^{0}C) on 7 August 2015	8.42
Maximum	589.3 (30.76 ^{0}C) on 15 March 2015	83.99
Average	406.77 (29.18 ^{0}C)	57.07

The daily solar irradiation and temperature is applied into Eq. (1) to (4) to obtain the current verses voltage and power verses voltage of 60 W, 91.8 V and 3 x 60 W, 91.8 V, Kaneka G-SA060 a-Si PV module as shown in Figure 5 to Figure 9.

The figures show the generated performance of 60 W, 91.8 V and 3 x 60 W, 91.8 V, Kaneka G-SA060 a-Si PV module in term of current, voltage and power. Three units of PV module generate the open circuit voltage of 275.4 V, it is suitable for DC voltage source of SPWM TPVI and based on the Figure 9 that the average total power through the year 2015 is 57.52 W.

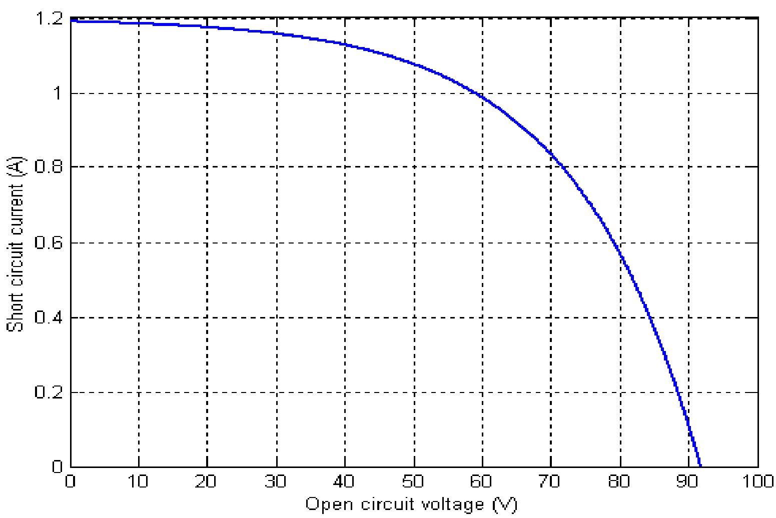

Figure 5: current verses voltage curve of 60 W, 91.8 V, Kaneka G-SA060 a-Si PV module for STC (1000 W/m^2 and 25 ^{0}C)

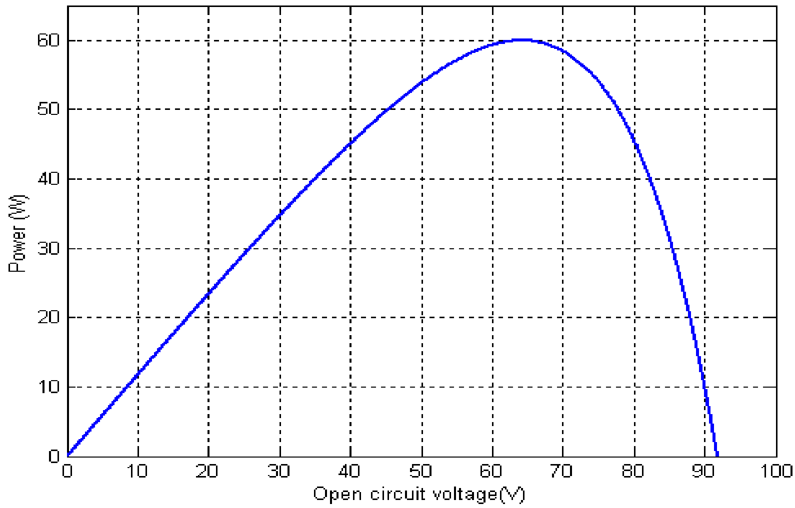

Figure 6: Power verses voltage curve of 60 W, 91.8 V, Kaneka G-SA060 a-Si PV module for STC (1000 W/m^2 and 25 ^{0}C)

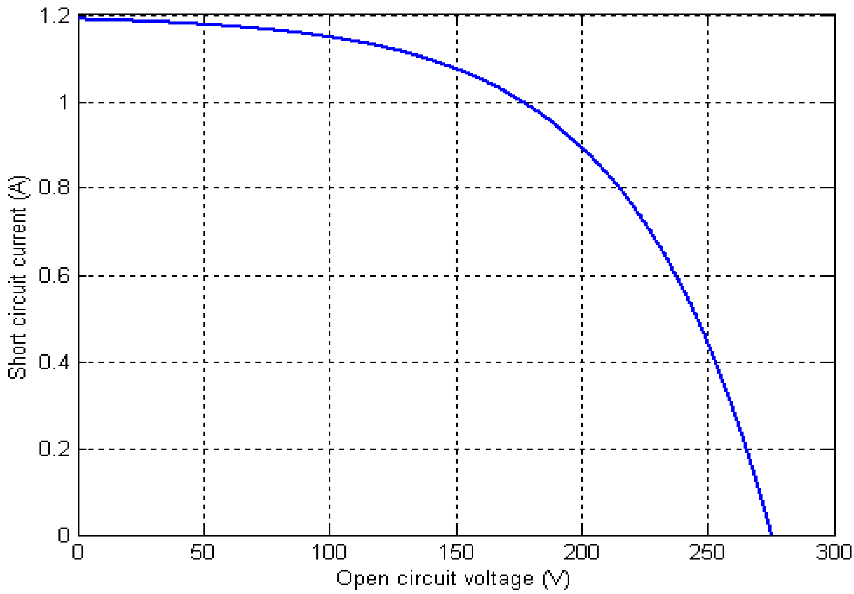

Figure 7: current verses voltage curve of 3 x 60 W, 91.8 V, Kaneka G-SA060 a-Si PV module in series connection for STC (1000 W/m^2 and 25 ^{0}C)

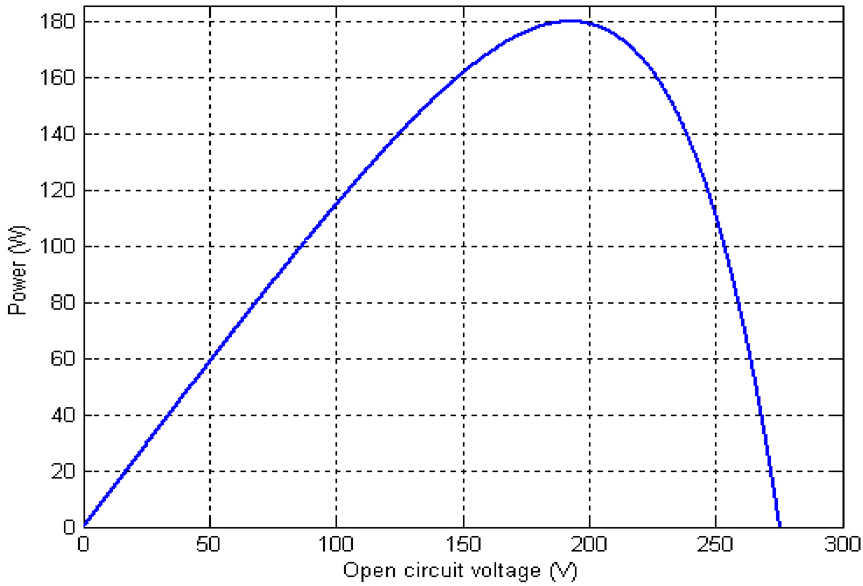

Figure 8: Power verses voltage curve of 3 x 60 W, 91.8 V, Kaneka G-SA060 a-Si PV module in series connection for STC (1000 W/m^2 and 25 ^{0}C)

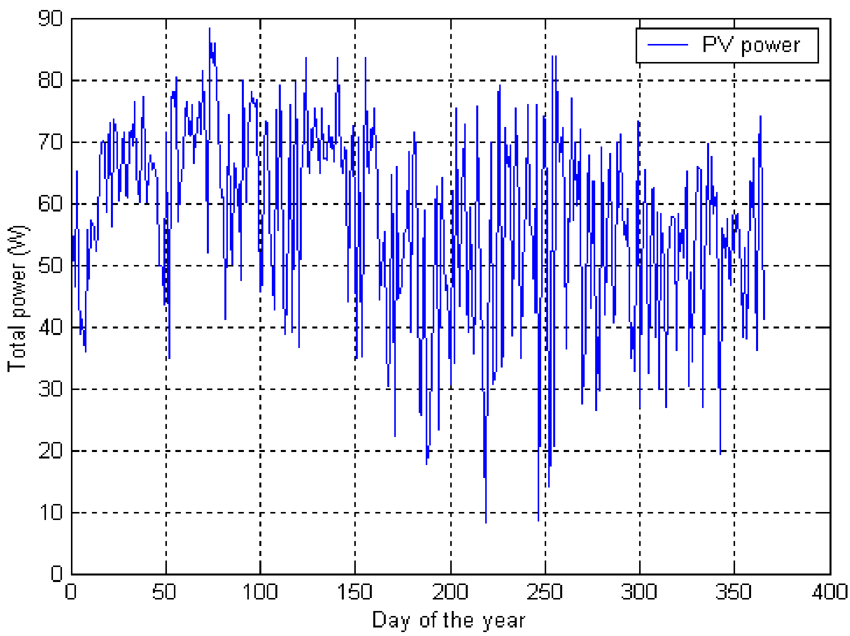

Figure 9 Daily power of 3 x 60 W, 91.8 V, Kaneka G-SA060 a-Si PV module

CONCLUSIONS

From the study of Kaneka G-SA060 amorphous silicon (a-Si) PV module performance can be deduced that minimum, maximum and average solar irradiation throughout the year of 2015 are 68.73 W/m^2 at 25.23 ^{0}C , 589.30 W/m^2 at 30.76 ^{0}C and 406.77 W/m^2 at at 29.18^{0}C , respectively. The PV performance generated are 8.42 W, 83.99 W and 57.07 W, respectively. Three units of PV module generate the open circuit voltage of 275.4 V, it is suitable for DC voltage source of SPWM TPVI and based on the Figure 9 that the average total power through the year 2015 is 57.52 W.

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