Simulation and Comparison of Modeling of Photovoltaic Modules During Different Values of Solar Irradiations Whilst Temperature of twenty five degree Celsius

Ameer A. Kareim
Department of Electrical Engineering, Faculty of Engineering, University of Kufa, Al-Najaf Al-Ashraf Governorate, Iraq
ameera.abbas@uokufa.edu.iq

Abstract
In this paper, a simulation by MATLAB code lines has been done for modeling of three types of mono-crystalline silicon photovoltaic modules by using single diode diode models. The three types of photovoltaic modules are DelSolar D6M195B2A, EPOLLY ep125M/72-195W and LDK 195 MC. The MATLAB simulation has been done by using the data provided by the commercial datasheets. In this paper, three types of photovoltaic modules have been modeled by MATLAB simulation at diverse values of solar irradiations (G) whilst temperature (T) equal to 25°C. A current-voltage (I-V) characteristics curves with regard to photovoltaic modules have been plotted by using MATLAB simulation at different values of G are 100, 400, 700 and 1000 W/m², whilst T of twenty five degree Celsius. It has been noted from simulation results that during the changing of values of G for three photovoltaic modules leads to change the values of short circuit current (Ish) for each photovoltaic module. The simulation results of modeling of EPOLLY ep125M/72-195W photovoltaic module have been presented that the changing of values of G leads to small changing of values of Ish. Whereas, the simulation results of modeling of DelSolar D6M195B2A and LDK 195 MC photovoltaic module have been presented that the changing of values of G leads to changing of values of Ish, and that changing is bigger than case of EPOLLY ep125M/72-195W photovoltaic module. It has been concluded that EPOLLY ep125M/72-195W photovoltaic module is more suitable to be used during the regions that have frequently changing of values of G than using DelSolar D6M195B2A and LDK 195 MC photovoltaic module.

Keywords: Photovoltaic (PV), Short Circuit Current (Ish), Open Circuit Voltage (Voc), Solar Irradiations (G), Temperature (T)
1. Introduction

As the name of "Photovoltaic" (PV) proposes, the retention of light-photons – in a semiconductor can, under specific conditions, make an electric flow. The change standards depends on the way that in a semiconductor fixed electrons can be changed over into unreservedly moving conduction electrons. This all the while makes an emphatically charged 'opening' and in this manner a second accuse transporter of a contradicting charge [1].

In the event that a potential contrast exists in the semiconductor material, regardless of whether because of a p-n intersection or a fitting surface charge, at that point this charge transporter can be compelled to go in an outer circuit, for example an electric flow can be created. As a rule, the charge bearers that have been made can just arrive at this potential hindrance as a result of warm vibrations. No other power drives them toward this path. This implies the charged particles should exist until they arrive at the likely hindrance. This lifetime or dissemination length (the normal separation voyaged) is one of the key components for the productivity of photovoltaic vitality age. Obviously, a large number of other physical attributes, for example, cell configuration, help to decide usefulness and proficiency [2].

Because of the accessibility of solar energy at an exceptionally high rate, the investigation and examination of the sunlight based vitality frameworks are broadly performed to accomplish the best abuse of this sort of sustainable power sources [3]. As the solar energy is a clean source, so it contributes successfully in diminishing the contamination rates around the earth, besides that it assists with decreasing the burdens on the conventional nonrenewable vitality frameworks utilized for generating the electricity, for example, steam power stations and hydroelectric power stations [4, 5]. In light of this, a lot of examination considers have been done for solving of the problems showed up because of the expanded advancement in the field of solar energy [4]. Most of the gave investigations have concerned with analyzing the performance of the photovoltaic (PV) modules which are comprising of groups of solar cells (SC) [6]. By the end of the last decade, the interest for the PV
modules saw an amazing rising, and simultaneously, their costs diminished recognizably [7].

Despite the fact that the PV has carried incredible advantages to the grid/micro grid [8-10] and the electricity markets, it suffered from a remarkable challenge related to the operating efficiency which changes according to the weather conditions under which the SC works [11, 12]. This is in addition to its high maintenance cost as announced in Ref. [13, 14].

In this paper, a simulation by MATLAB code lines has been done for modeling of three types of mono-crystalline silicon photovoltaic modules by utilizing single diode diode models. The three types of photovoltaic modules are DelSolar D6M195B2A, EPOLLY ep125M/72-195W and LDK 195 MC. The MATLAB simulation has been done by using the data provided by the commercial datasheets [15], [16], and [17]. In this paper, three types of photovoltaic modules have been modeled by MATLAB at various values of G, whilst T of twenty five degree Celsius. I-V characteristics bends of photovoltaic modules have been plotted by using MATLAB at different values concerning G, whilst T of twenty five degree Celsius. The four values of G are 100, 400, 700 and 1000 W/m², whilst T of twenty five degree Celsius have been used in MATLAB simulation. It has been noted from simulation results that during the changing of values of G for three photovoltaic modules leads to change the values of Ish for each photovoltaic module. The simulation results of modeling of EPOLLY ep125M/72-195W photovoltaic module have been presented that the changing of values of G leads to small changing of values of Ish. Whereas, the simulation results of modeling of DelSolar D6M195B2A and LDK 195 MC photovoltaic module have been presented that the changing of values of G leads to changing of values of Ish, and that changing is bigger than case of EPOLLY ep125M/72-195W photovoltaic module. It has been concluded that EPOLLY ep125M/72-195W photovoltaic module is more suitable to be used during the regions that have frequently changing of values of G than using DelSolar D6M195B2A and LDK 195 MC photovoltaic module.

This paper is sorted out as follows; part 1 audits the presentation. Part 2 surveys methodology, part 2.1, it is include modeling PV modules using
single diode model. Finally, section 3, represents the results and discussion.

2. Modeling PV Modules Using Single Diode Model

Solar cells are represented utilizing diode models; single diode model [18], [19], [20], two diode model [21], [22]-[23] and three diode model [26]. In general, single diode model is the most utilized model as it offers a good compromise between simplicity and accuracy compared to the other models [18]. Single diode model of solar cell is utilized in this paper for modeling of DelSolar D6M195B2A, EPOLLY ep125M/72-195W and LDK 195 MC photovoltaic module.

The strategy of modeling a PV module is no different from modeling a PV cell. It is uses the same PV cell model. The parameters are the all same, but only a voltage parameter (such as the open-circuit voltage (Voc)) is different and must be divided by the number of cells [24], [25]. The modeling of PV module using single diode model can be written as in [24], [25].

The investigation done by Walker [24], utilizes the electric model with moderate complexity, appeared in Figure 2.1, and gives genuinely exact outcomes. The model comprise of a current source (Isc), a diode (D), and a series resistance (Rs). To improve a model, it also comprises temperature impacts on the Ish and the reverse saturation current of diode (Io). It utilizes a single diode with the diode ideality factor (n) set to achieve the best I-V curve match.

![Equivalent circuit utilized in the MATLAB simulations](image)

Figure 2.1 Equivalent circuit utilized in the MATLAB simulations [24]
The equations [24] which describe the I-V characteristics of the PV cell are

\[ I = I_{sc} - I_o \left[ e^{q \left( \frac{V+I R_s}{n k T} \right)} - 1 \right] \quad (2.1) \]

\[ I_{sc} |_{T} = I_{sc} |_{T_{ref}} \cdot [1 + a (T - T_{ref})] \quad (2.2) \]

\[ I_{sc} |_{G} = \left( \frac{G}{G_o} \right) I_{sc} |_{G_o} \quad (2.3) \]

\[ I_o = \frac{I_{sc}}{(e^{q V_{oc}/k T} - 1)} \quad (2.4) \]

\[ I_o = \frac{I_{sc}}{(e^{q V_{oc}/n k T} - 1)} \quad (2.5) \]

\[ I_o |_{T} = I_o |_{T_{ref}} \left( \frac{T}{T_{ref}} \right)^{\frac{3}{n}} \cdot e^{-q E_g / nk T} \cdot \frac{1}{1 - 1/T_{ref}} \quad (2.6) \]

\[ I = I_{sc} - I_o \left[ e^{q \left( \frac{V+I R_s}{n k T} \right)} - 1 \right] \quad (2.7) \]

\[ dI = 0 - I_o \cdot q \left( \frac{dV + R_s \cdot dI}{n k T} \right) \cdot e^{q \left( \frac{V+I R_s}{n k T} \right)} \quad (2.8) \]

\[ R_s = - \frac{dI}{dV} - \frac{n k T/q}{I_o \cdot e^{q \left( \frac{V+I R_s}{n k T} \right)}} \quad (2.9) \]

\[ R_s = - \frac{dV}{dI} \left| V_{oc} - \frac{n k T/q}{I_o \cdot e^{q V_{oc}/nk T}} \right. \quad (2.10) \]

\[ X_{n+1} = X_n - f(X_n) / f'(X_n) \quad (2.11) \]

\[ f(I) = I_{sc} - I - I_o \left[ e^{q \left( \frac{V+I R_s}{n k T} \right)} - 1 \right] = 0 \quad (2.12) \]
\[ I_{n+1} = I_n - \frac{I_{sc} - I_n - I_0 \left[ e^{\frac{(V+I_nR_s)}{nkT}} - 1 \right]}{-1 - I_0 \left( \frac{qR_s}{nkT} \right) e^{\left( \frac{V+I_nR_s}{nkT} \right)}} \] (2.13)

3. Results and Discussion

The simulation results are implemented by using MATLAB code lines. The simulation results are used a single diode model parameters of a mono-crystalline silicon for modeling of PV modules. The modeling of DelSolar D6M195B2A, EPOLLY ep125M/72-195W and LDK 195 MC photovoltaic module is done by using the commercial datasheets during diverse values of G, whilst temperature equal to 25°C.

Firstly, modeling of DelSolar D6M195B2A photovoltaic module is simulated by MATLAB at four values of G are 100, 400, 700, and 1000 W/m², whilst T is 25°C. As appeared in Figure 3.1 below:

Figure 3.1: MATLAB simulation with regard to I-V bends of DelSolar D6M195B2A PV module during various values of G whilst T is 25°C

Figure 3.1 showed changing in values of G leads to changing in values of Ish. The changing of values of Ish due to changing of values of G is registered in Table 3.1 below:

| G (W/m²) | Ish (A) |
|----------|---------|
| 1000     |         |
| 700      |         |
| 400      |         |
| 100      |         |

Table 3.1: Ish values due to changing of values of G whilst T=25°C during modeling of DelSolar D6M195B2A photovoltaic module
| $G$ (W/m²) | $I_{sh}$ (A) |
|-----------|-------------|
| 100       | 0.859       |
| 400       | 3.436       |
| 700       | 6.013       |
| 1000      | 8.59        |

From Table 3.1, the difference between values of $I_{sh}$ at specific values of $G$ can be written as below:

$I_{sh}$ (at specific value of $G$) – $I_{sh}$ (at specific value of $G$)

Then,

$I_{sh}$ (at $G = 400$) - $I_{sh}$ (at $G = 100$) = 2.577 A

$I_{sh}$ (at $G = 700$) - $I_{sh}$ (at $G = 400$) = 2.577 A

$I_{sh}$ (at $G = 1000$) - $I_{sh}$ (at $G = 700$) = 2.577 A

Secondly, modeling of EPOLLY ep125M/72-195W photovoltaic module is simulated by MATLAB at four values of $G$ 100, 400, 700, and 1000 W/m², whilst $T$ of 25°C. As appeared in Figure 3.2 below:

![Figure 3.2: MATLAB simulation of I-V curves concerning EPOLLY ep125M/72-195W PV module at different values of G whilst T equivalent to 25°C](image_url)
Figure 3.2 presented that changing in values of $G$ leads to changing in values of $I_{sh}$. The changing of values of $I_{sh}$ due to changing of values of $G$ is recorded in Table 3.2 below:

| $G$ (W/m²) | $I_{sh}$ (A) |
|------------|--------------|
| 100        | 0.5814       |
| 400        | 2.326        |
| 700        | 4.07         |
| 1000       | 5.814        |

From Table 3.2, the difference between values of $I_{sh}$ at specific values of $G$ can be written as below:

$I_{sh}$ (at specific value of $G$) – $I_{sh}$ (at specific value of $G$)

Then,

$I_{sh}$ (at $G = 400$) - $I_{sh}$ (at $G = 100$) = 1.7446 A
$I_{sh}$ (at $G = 700$) - $I_{sh}$ (at $G = 400$) = 1.744 A
$I_{sh}$ (at $G = 1000$) - $I_{sh}$ (at $G = 700$) = 1.744 A

Thirdly, modeling of LDK 195 MC photovoltaic module is simulated by MATLAB at four values of $G$ 100, 400, 700, and 1000 W/m², whilst temperature of twenty five degree Celsius. As appeared in Figure 3.3 below:
Figure 3.3 displayed that variety in values of G leads to changing in values of Ish. The changing of values of Ish due to changing of values of G is recorded in Table 3.3 below:

Table 3.3: Ish values due to changing of values of G whilst T=25°C during modeling of LDK 195 MC photovoltaic module

| G(W/m²) | Ish(A) |
|---------|--------|
| 100     | 0.878  |
| 400     | 3.512  |
| 700     | 6.146  |
| 1000    | 8.78   |

From Table 3.3, the different between values of Ish at specific values of G can written as below:

Ish (at specific value of G) – Ish (at specific value of G)

Then,

Ish (at G = 400) - Ish (at G = 100) = 2.634 A
Ish (at G = 700) - Ish (at G = 400) = 2.634 A
Ish (at G = 1000) - Ish (at G = 700) = 2.634 A

4. Conclusion
In this paper, DelSolar D6M195B2A, EPOLLY ep125M/72-195W and LDK 195 MC are photovoltaic modules that have been modeled by MATLAB simulation. I-V bends of PV modules have been plotted by using MATLAB at various values of G, whilst T of 25°C. It has been noted from simulation results that during the changing of values of G for three photovoltaic modules leads to change the values of Ish for each photovoltaic module. The simulation results of modeling of EPOLLY ep125M/72-195W photovoltaic module have been presented that the changing of values of G leads to small changing of values of Ish. Whereas, the simulation results of modeling of DelSolar D6M195B2A and LDK 195 MC photovoltaic module have been presented that the changing of values of G leads to changing of values of Ish, and that changing is bigger than case of EPOLLY ep125M/72-195W photovoltaic module. It has been concluded that EPOLLY ep125M/72-195W photovoltaic module is more suitable to be used during the regions that have frequently changing of values of G than using DelSolar D6M195B2A and LDK 195 MC photovoltaic module.

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