INFLUENCE OF TEMPERATURE AND SOLAR RADIATION ON THE POWER OF PHOTOVOLTAIC PANELS

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Abstract. *Solar energy is converted into electrical energy directly using semiconductor materials used in photovoltaic (PV) panels. Despite great advances in semiconductor materials technology, panel efficiency has remained quite low in recent years. Panel performance is affected by many factors such as tilt angle, shading, dust, solar radiation, temperature and conductor loss. This paper examines the equivalent circuit of the panel and carries out simulations in MATLAB using standard photovoltaic panel data, and also studies the influence of temperature and solar radiation on the power and current-voltage characteristics of the photovoltaic panel.*

Key words*: photovoltaic panel, simulations in MATLAB, solar cell, efficiency, energy sources, photovoltaic module*

Introduction

In recent years, there has been a high demand for electricity due to population growth and the pace of industrialization. Most of the electricity is generated from fossil fuels such as oil, natural gas, etc. However, there are many environmental problems associated with the use of fossil fuels. Moreover, the fact that these energy sources will run out in the near future and renewable energy sources will have to be used in the future. Solar energy, one of the renewable energy sources, indirectly influences the formation of other renewable energy sources. In addition, solar energy has become more attractive because it is clean, renewable and easy to use [1, 2]. The solar cell is the smallest part of a photovoltaic system that directly converts solar radiation into DC voltage. Solar cells form a photovoltaic module by connecting in series or parallel. A photovoltaic panel with the required values of current, voltage and power is obtained by connecting modules in series-parallel [3, 4]. Solar energy in a photovoltaic panel is converted into electrical energy with an efficiency of 6-20% depending on the semiconductor material used in the photovoltaic panel. There are many factors that lead to low panel efficiency, such as panel angle, shading, dust, solar radiation level, temperature and other losses [5, 6]. Among these factors, solar radiation levels and temperature are more prominent. The level of solar radiation varies throughout the year. The average annual variation in the level of extraterrestrial solar radiation is 1367 W/m2 and is shown by dotted lines. On the other hand, the level of solar radiation falling on the Earth is less than the level of extraterrestrial solar radiation and varies depending on the geographical location of countries [7]. Changes in atmospheric conditions such as solar radiation levels and temperature during the day have a major impact on the panel's efficiency. Therefore, it is very important to know the level of solar radiation and the effect of temperature on the photovoltaic panel. However, in the catalogs, which are carried out in laboratory conditions and are called standard, panel manufacturers provide only the electrical characteristics of the photovoltaic panel at a solar radiation level of 1000 W/m^2, a cell temperature of 25 ° C and an air mass flow rate of AM1.5. As a result, the electrical parameters of a PV panel other than STC are unknown. It is necessary to know the electrical parameters of photovoltaic panels under atmospheric conditions. Taking these conditions into account, especially when designing autonomous and networked systems, will give more accurate results [3]. Many researchers have developed a model of photovoltaic panels in Matlab/Simulink program depending on the basic equivalent circuit of the photovoltaic cell, taking into account environmental factors such as solar radiation and temperatur. In these studies, the equivalent circuit of the photovoltaic panel is modeled in MATLAB with

Using standard panel values and the effects of changes at temperatures of 0, 25, 50 ° C and 200, 400, 600, 800, 1000 W/m2, solar radiation levels are investigated by panel current, voltage and power. The results section evaluates the most appropriate temperature and solar radiation levels for PV panels depending on the simulation analysis.

Mathematical model of a photovoltaic cell.

Obtaining the equivalent circuit of a photovoltaic cell plays a crucial role in studying the electrical energy obtained from photovoltaic panels. Solar cells are modeled as diodes because they are made from semiconductor materials. The current-voltage characteristic of a solar cell acts as a diode when it is not receiving solar radiation. Electricity generation in a solar cell is represented by the current source, and losses in photovoltaic cells are represented by series and parallel resistances. The electrical equivalent circuit of a photovoltaic cell is shown in Figure 1 [8].

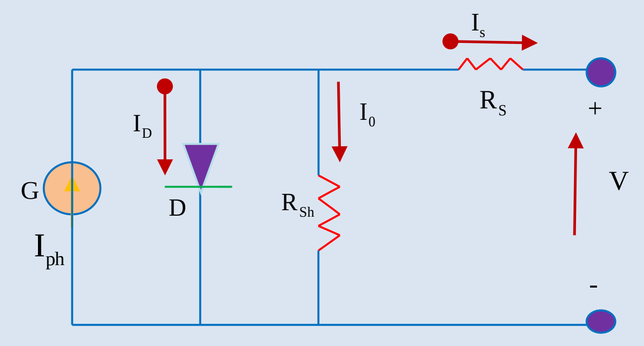

Рис.1. Идеальное электрическая схема одно-диодной модели

Figure 1. Equivalent circuit of a photovoltaic cell.

A practical model of a single solar cell is shown in Figure 1. In this circuit, Rs represents the series resistance of the PN junction cell and represents the shunt resistance, which is inversely proportional to the ground leakage current. The series resistor has a great influence on the I-V characteristic of the solar cell. and are the diode current and the shunt leakage current, where the output terminal current I is estimated by applying KCL in the solar cell equivalent circuit [3 - 5]:

$$I = I_{ph} - (I_d - I_{sh}). \qquad (1)$$

This equation is simplified by taking the sum of the saturation current and the shunt leakage current as, and hence the simplified equation is [3]:

$$I = I_{ph} - I_o. \qquad (2)$$

Photon current is generated when solar radiation is absorbed by a solar cell, so the value of photocurrent is directly related to changes in solar radiation and temperature, namely [3]:

$$I_{ph} = (I_{scr} + k_i DT)\frac{G}{G_r}. \qquad (3)$$

2.1. Photovoltaic Panel Simulation

Perlight Polycrystalline Photovoltaic Panel The 100 W PLM -100 P/2 was simulated in Matlab using the panel equivalent circuit. Catalog data of the photovoltaic panel are given in Table 1.

Table 1.

Photovoltaic panel catalog data

Electrical characteristics of solar modules PS - P 36 150 W	
Maximum power (Pmaxs)	150.04 W
Voltage at Pmax (Vmps)	18.41 V
Current at Pmax (Imps)	8.15 A
Short Circuit Current (Iscs)	8.63 A
Open Circuit Voltage (Vocs)	22.06 V
Temperature coefficient Isc	0.058 A/°C
Temperature coefficient Voc	-0.33 V/°C
Number of cells in series (Ns	36
Maximum power (Pmaxs)	150.04 W
Voltage at Pmax (Vmps)	18.41 V
Current at Pmax (Imps)	8.15 A
Short Circuit Current (Iscs)	8.63 A

II . RESULTS AND DISCUSSIONS

2.1. Current-voltage characteristics

Volt-ampere (I-V curve) and volt-watt (P-V curve) characteristics, respectively, under different illumination (solar radiation with values of 1000, 800, 600, 400, 200 and 550 W/m^2) at constant temperature are shown in Fig. 2.

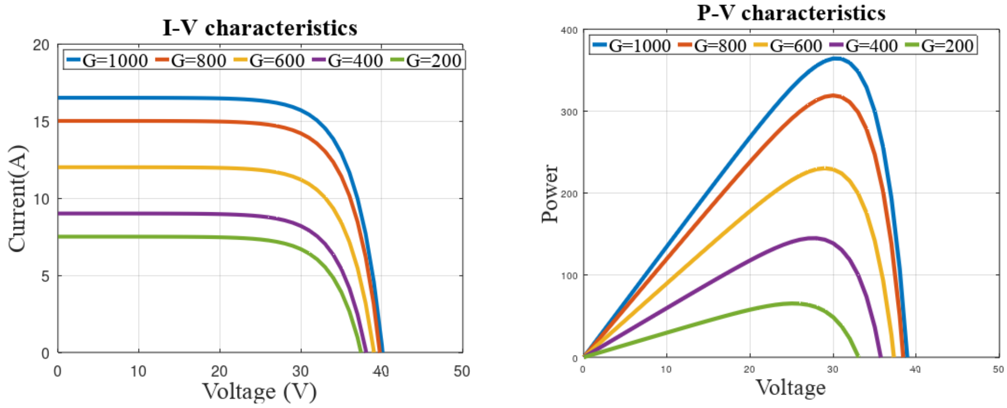

Fig.2. Current-voltage (I - V curve) and Volt-power (P - V curve)

characteristics under different illumination (solar radiation with values of 1000, 800, 600, 400 and 200 W/m2) at a constant temperature, respectively.

In real work, solar radiation with values of 1000, 800, 600, 400 and 200 W/m2 , which is the average value at a natural temperature of 25 ° C. The graph shows that the current of the photoelectric chamber depends on the temperature of the housing. However, upon irradiation, the current and voltage of the photocell increase. This results in the power output in this operating state. As solar radiation increases, it is clear that the short circuit current and open circuit voltage increase as shown in the figure. This is because when more sunlight falls on the solar cell, the electrons receive higher excitation energy, thereby increasing the mobility of the electrons and thus producing more energy, as shown in Fig. 2.

2.2. Effect of temperature on the performance of a photovoltaic system

An increase in temperature around the solar cell negatively affects the ability to generate electricity. An increase in temperature is accompanied by a decrease in the open circuit voltage, as shown in Fig . 3 . Increasing the temperature causes the material's band gap to increase, and therefore more energy is required to overcome this barrier. Thus, the power output will be reduced and hence the efficiency of the solar cell will be reduced. In Fig. 3 shows the V - P and I - P curves characteristics when the temperature of the solar cell changes.

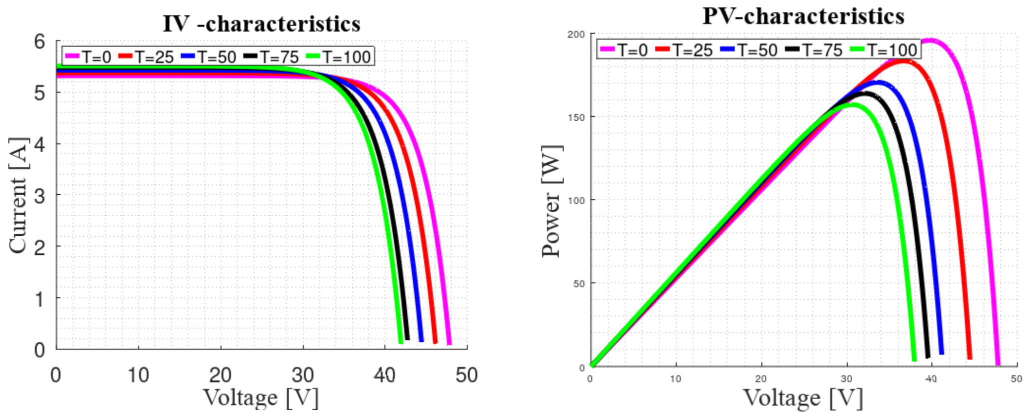

Fig. 3.

Current-voltage (I - V curve) and Volt-power (P - V curve) characteristics at different temperatures (temperatures with values of 0, 25, 50, 75 and 100 °C) under constant sunlight, respectively.

2.3. Values of short circuit current, open circuit voltage, maximum current, maximum voltage and maximum power of the photovoltaic panel

The values of short circuit current, open circuit voltage, maximum current, maximum voltage and maximum power of the PV panel were obtained at temperatures of 0, 25 and 50 °C and powers of 200, 400 , 600, 800 and 1000 W/m^2 using Matlab software . and the results are shown in tables.

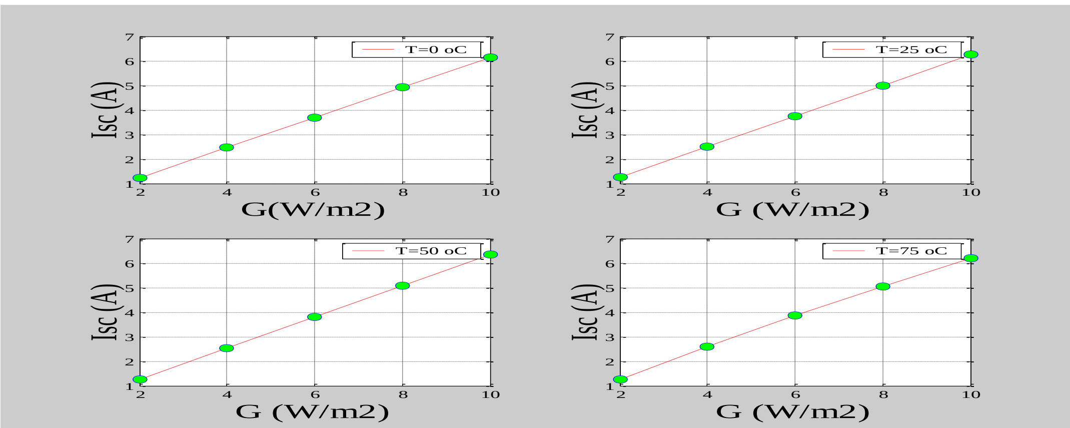

Fig. 4 . Changes in short circuit current of photovoltaic panel

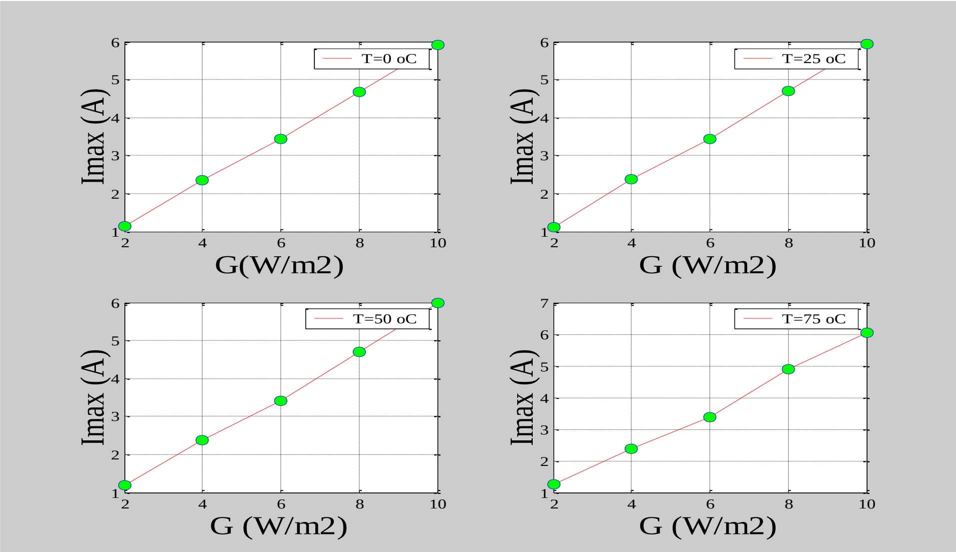

Fig.5. Maximum changes in PV panel current

The simulation results show that when the panel temperature is 0° C , the short-circuit current and maximum panel current increase in proportion to the solar radiation level. On the other hand, there is a slight increase in open circuit voltage and maximum panel voltage. Thus, when the level of solar radiation increases from 200 W/m^2 to 1000 W/m^2, the panel power increases by 5.5 times. Similarly, when the solar radiation level gradually increases at panel temperatures of 25 and 50 ° C , the short circuit and maximum panel current increase proportionally. However, there is a slight increase in open circuit voltage and maximum voltage. When comparing panel temperatures below 0° C and 25° C , it can be seen that as the panel temperature increases there is a slight increase in short circuit current and the maximum current values are almost the same.

Conclusion

The simulation results show that although the panel current increases proportionally to the solar radiation level, the panel voltage increases slightly. Similarly, the power of the panel increases in proportion to the level of solar radiation. On the other hand, panel temperature causes a slight increase in panel current and a proportional decrease in panel voltage. The panel's power decreases because the rate of voltage drop is greater than the rate of current increase. The results show that low temperature and high solar radiation conditions are more suitable for the obtained power values.

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