Physics Experiment: Solar photovoltaic cells

Introduction

One method of converting energy from the sun (solar energy) is to use a solar cell also known as a photovoltaic cell. A solar cell uses the photovoltaic effect to convert solar radiation directly to DC electrical energy. The rate of energy generation or power from the solar cell depends on the amount of solar radiation falling on the active area of the cell. This power output () can be calculated from the product of the solar cell current (I) and voltage (V) expressed mathematically as.

The current and voltage of a solar cell vary depending on the load (resistance) connected across the cell as well as the amount of solar radiation that is incident on the cell. This variation is normally shown as a graph of current versus voltage and is referred to as the current-voltage (IV) characteristic curve. A typical curve is shown in figure 1 (all variables and parmeters are defined below).

Figure 1: Typical *IV* characteristic curves for a solar cell.

The current from the solar cell when the load resistance is zero (an open circuit) is called the short circuit current (I_{sc}). The voltage measured across the cell in this open circuit is called the open circuit voltage (V_{oc}).

The incident solar radiation is normally specified in terms of radiation flux density (referred to as irradiance, G). Irradiance is measured in W m^{-2}. It is evident from Figure 1 that I_{sc} for a solar cell increases with the increase in the amount of solar radiation incident on the active area of the cell.

In this experiment you will investigate the variation of I_{sc} with G for 2 small solar panels connected in series. Each solar panel consists of 12 individual solar cells connected in series. The short circuit current I_{sc} as a function of G can be expressed as

(1)

where I_{sco} is a known reference short circuit current measured at a known quantity of solar irradiance G_o and α is a constant that accounts for the non-linear variation of I_{sc} with G. The incident irradiance G is proportional to the angle of incidence (θ) between the radiation beam and the normal to the solar panels. Equation 1 can then be written as

(2)

where G_{s0} is the irradiance from the radiation source at normal incidence ($\theta = 0°$) to the solar cells.

Objective

The objective of the experiment is to determine the constant α using equation (2).

Apparatus

The experimental set up is shown in figure 2. It consists of a halogen lamp directed to shine its light onto a small PV module. The PV module is connected in series to a digital ammeter. The inclination of the PV module can be varied from 0° to 90° and a mounted protractor is used to measure the angle of inclination.

Procedure

1. Familiarise yourself with the experimental set-up but do not disconnect any cabling and remove any fixed components of the apparatus.

    a. Make sure that the digital ammeter dial is set to an appropriate position to measure a maximum current of 100 mA.

    b. Switch the halogen lamp on and check whether you get a reading from the ammeter.

    c. Adjust the inclination of the PV module by raising the white board that the PV module is attached to and check whether the ammeter reading decreases.

    d. Switch off the lamp and lay the PV module to its original horizontal position.

2. With the lamp switched on, record the following data in the data table on the answer sheet:

    a. the current (I_1) generated by the PV cells when *increasing* the inclination (θ) of the cells from 0° to 80° in equal intervals of 10°.

    b. the current (I_2) generated by the PV cells when *decreasing* the inclination (θ) of the cells from 80° to 0° in equal intervals of 10°.

3. Switch off the lamp and ammeter.

4. Determine the average of I_1 and I_2 and record it as I_{sc} in the table.

5. Use your results to calculate log (cos θ) and log (I_{sc}) and record them in the appropriate columns in the data table.

Questions

1.1 Record in the measured values θ, I_1, I_2 and the calculated I_{sc}. **(2 marks)**

1.2 Fill in the calculated log (cos θ) and log (I_{sc}). **(1.5 marks)**

2. Plot the graph of log (I_{sc}) versus log (cos θ). **(2 marks)**

3. Determine α from your graph. **(2 marks)**

4. Given that I_{sco} = and $G_0 = 1000$ W m^{-2} use your graph determine the value of G_{s0}. **(2 marks)**

5. In which direction would you face a photovoltaic panel being installed on a home in Durban? Place a cross on your choice on the answer sheet. **(0.5 marks)**