Optoelectronic and Photovoltaic Devices course

Fifth lab – Analysis of solar cells

The aim of this set of experiments is to study the properties of solar cells as a function of the main operating parameters, including external illumination, temperature, and voltage. This goal will be achieved through the execution of a set of current-voltage measurements in different conditions. The silicon solar cell (IXOLARTM SolarBITs) is mounted on a Peltier-based temperature controller, and is placed under a LED-based light source (acting as a solar simulator), whose current can be modulated by a suitable circuit. A controlling board has been developed by the ACME team, and is directly mounted onto an Arduino Due board. The Arduino Due has two digital-to-analog converters (DACs), that are used to control the current on the LEDs, and to apply a variable voltage to the solar cell during the current-voltage measurements. Through circuits based on op-amps, the Arduino Due board can measure the voltages and current with a good resolution, in the ranges of interest. Labview is used to acquire the experimental data, i.e. the current-voltage measurements collected in different conditions.

**Room-temperature operation**

* Set the TEC temperature at 25 °C.
* Acquire the current-voltage characteristics of the solar cells in dark (i.e. in absence of external illumination)
* Plot the curve in linear and logarithmic scale

A graph of a function

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* **Extract the ideality factor and the saturation current of the solar cell, by proper fitting procedure and Comment the experimental results, based on the theoretical considerations made during the lectures**

As discussed during the lectures, the ideality factor tells us the quality of the diode. Ideal diodes have n approximately equal to 1 while values between 1 and 2 are typical for real devices. However from the experiment carried out, we got a rather unusual value. The formula applied was

where;

= slope of the linear fit of

With this the values and appling the code

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The values obtained where A math equations with black text

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As mentioned before, the ideality factor obtained experimentally greatly diverts away from what was discussed during the lectures and this can come from a few reasons, including the series resistance effect. Nonetheless, the value being close to 1 suggest good linear fitting selection.

Furthermore, the saturation current is relatively low as compared to the value of the datasheet which was present in the datasheet. This is desirable for high efficiency because the cell in this way exhibits minimal leakage current under reversed bias.

**Extracting the main cell parameters**

* Set the illumination level to 1 Sun (maximum illumination level) and measure the current-voltage characteristics under light at 5, 10, 15, 20mA
* Extract the open circuit voltage and the short circuit current
* Plot the output power as a function of the operating voltage
* Extract the maximum output power and the fill factor of the solar cell and compare with state-of-the-art devices (find 3 datasheets on the internet and add to the report)

**Cell parameters as a function of illumination level and temperature**

* Measure the I-V curves of the solar cells at different illumination levels (0.25, 0.50, 0.75, 1.00 Sun) (DOES THIS MEAN DIFFERENT CURRENT VALUES?), and different temperature levels (25, 40, 55, 70 °C)
* Plot the variation of short circuit current as a function of illumination level, fit with the expected theoretical behavior, and comment on the observed trend through the use of formulas seen during lectures
* Plot the variation of open circuit voltage as a function of illumination level, fit with the expected theoretical behavior, and comment on the observed trend through the use of formulas seen during lectures
* How does the fill factor change with increasing temperature? Describe and explain briefly the observed effects

**Solar cell modeling via Spice**

* Extract the main parameters of the solar cell (consider the 1-diode equivalent model)
* Use the previously extracted parameters to reproduce the electrical characteristics of the solar cell by Spice (you can use LTSpice, for example)
* Compare the experimental data with the simulated ones and comment in the lab report