Laboratory Guide: Determination of the IV curve of a photovoltaic module

V2 - 25.10.2017

The aim of this laboratory task is to study different electrical connections between PV modules by tracing the current-voltage (IV) curve of:

- One PV module
- Two PV modules connected in series
- Two PV modules connected in parallel

For all module configurations, estimate the following parameters.

- Short circuit current
- Open circuit voltage
- Maximum power
- Fill factor
- Maximum power conversion
- Characteristic resistance
- Series resistance
- Shunt resistance

For a single module, take both open circuit voltage and short circuit measurements for a range of temperatures between 25ºC and 50ºC; plot each parameter as a function of temperature and estimate:

- Voltage thermal coefficient
- Current thermal coefficient

Compare with reference values from the PVEducation website* and comment.

In addition, you should observe the effect of shadowing has on the short circuit current and the open circuit voltage when (for a single module, and for two modules connected in series and in parallel):

- A module is shadowed
- A cell is shadowed
- Half of a cell is shadowed

PV modules with 300 mA of short circuit current and 1.5V of open circuit voltage are available in the laboratory, as well as a variable resistor box, multimeters, thermocouples, and a light source to simulate solar sunlight. The modules will be connected to the resistor box to simulate a load. The load resistance is varied from short-circuit (0 Ohm) to open-circuit (>10 K Ohm). The multimeters will be connected in series to measure the current and in parallel to measure the voltage. The thermocouple is used to measure the temperature of the solar module.

Given that that the solar modules will heat up when exposed to the intense light of the lamp, you are instructed to only turn it on for brief moments to take readings. I.e. you will vary the load/resistance and then turn the light on to read the respective current and voltage. **Never let the PV module(s) get hotter than 60 ºC for more than 5 seconds!**

For the determination of the voltage and current thermal coefficients you will leave the lamp turned on to heat up the PV module and take the reading accordingly. You will also take readings as the module cools down by again only turning the lamp on to take readings. Probably the easiest way to take these readings is to first measure the short-circuit current then quickly switch the resistance box to a very high resistance (>10 K Ohm) and then read the respective open-circuit voltage.

*http://www.pveducation.org

Laboratory Guide: Determination of the working conditions and main characteristics of a charge controller

V2 - 25.10.2017

The aim of this laboratory task is to study the performance of the charge controller under normal operation condition as well as the thresholds for over discharge and overcharge of the batteries.

In order to test the normal operation conditions of a charge controller (*Steca PR3030*, 12/24V 30A)

1. DC power supply (0-3A, 0-30V) will be used to simulate the PV module,
2. A 12 V 7Ah lead-acid battery will be the storage medium and
3. the load will be a variable resistor rheostat (0 to 42 Ohm, 5A max – resistance range limited to 5 – 42 Ohm for safety reasons explained below).

After all the cabling has been correctly connected with multimeter in series to measure the current going through the batteries and another multimeter to measure the current through the load, you can turn on the power source and carefully adjust the voltage to 13.8V.

To prevent damage to the rheostat, the minimum resistance it can be set to has been limited to 5 Ohm. This is to prevent too much current being able to flow through it because it is rated at a max of 5A. (e.g. at 2.4 Ohms, 12 V, the current flowing through the rheostat will be 5A any lower resistance and the current will increase further).

You should try the following settings:

a) PV ON, Load ON
b) PV ON, Load OFF
c) PV OFF, LOAD ON
d) PV OFF, LOAD OFF

For all of the above you should observe how the current flowing to and from the charge controller varies as you vary the resistance of the load. Present your conclusions and discuss what each situation represents in a real scenario.

To protect the batteries from over-charging and over-discharging, charge regulators are programmed to cut the current flow to and from the batteries when the voltage gets too high or too low. To determine the cut-off voltages you can determine this by disconnecting the battery from the charge controller and using the DC power supply to simulate a battery. Here you can again set the DC voltage to the batteries nominal standby voltage of 13.8V and then slowly increase and decrease the voltage to observe what the charge regulator does.

Laboratory Guide: Real World Measurements on a PV module system

V2 - 25.10.2017

The aim of this laboratory task is to get a handle on taking measurements and assessing the performance of actual PV systems. The system is in the Campus Solar outdoor testing site and it is composed of:

3 Sanyo HIP-210 NHE 1 modules and
Sunny Boy SB 1100 LV Inverter

You will be using a *Unaohm UT905* test set which has been designed to test PV installations and certify their functioning.

Before coming to the lab session you must carefully read the supporting information for the modules, inverter and PV test kit. These can be found in the zip file you downloaded to obtain this document on the Moodle page.

In particular, you should think about:

- How is the PV test set actually connected up to the installation?
- What are the safety procedures necessary to ensure that no one is at risk of electric shocks? Remember that solar modules, when exposed to solar irradiation, are always capable of high voltages.

It is also suggested that you visit the PV-GIS website (http://re.jrc.ec.europa.eu/pvgis/) and determine the expected power that the modules should be producing on a clear sky day at this time of the year. You should bring this with you beforehand.

Below are some examples of details you should take into consideration.

- What is the orientation and inclination of the modules?
- Remember that the inverter does Maximum Power Point Tracking (MPPT).
- Pay close attention to the specification of the modules.
- Why does the Inverter allow the connection of two strings in parallel?
- Try to compare your data with other groups and days.
- What is the weather like?
- How is the temperature effect taken into consideration by the "test kit" and how does it compare to your calculation?
- How does the "test kit" calculate the theoretical power output of the modules? What is the temperature coefficient?
- Think about the placement of the Inverter.
- Take note of how exactly measurements were undertaken and what problems were encountered. What are the uncertainties?
- How does the measured efficiency of the modules and inverter compare to what is specified?
- Do not forget to consider how the efficiency of the inverter varies with power.
- How could the measurements be improved?