Dark and Light IV Characteristic Curve of the Solar Module

Materials required:
- Solar module
- Load module
- Demonstration Ammeter/Voltmeter
- 5 hook-up cables

Additional components:
- Black cardboard (part 1)
- DC power supply (part 1)
- Lamp 100-150 watts (part 2)

Instructions:

Please follow the operating instructions!

Part 1: Dark IV Curve Fig. s1a

1. Place the solar module on a solid base and cover it completely with a piece of black cardboard.
2. Set up the apparatus as shown in Fig. s1a and connect the solar module to the DC power supply in "forward direction", i.e. the positive terminal of the DC power supply to the positive terminal of the solar module and the negative terminal of the DC power supply to the negative terminal of the solar module.
3. Adjust the DC power supply to different voltages (in 0.5 volt steps between 0 and 1.5 volts, and in 0.2 volt steps between 1.5 and 2.5 volts) and measure the dark current and voltage.

The voltage across the DC power supply must not exceed 3.0 volts!
Table of measurements:

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<th>Voltage / V</th>
<th>Current / mA</th>
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Evaluation:
1. Draw the IV diagram (dark IV characteristic curve of the solar module).
2. Interpret this characteristic curve.
The dark IV curve of a solar module corresponds to the IV curve of a semiconductor diode:

If the solar module is connected in forward direction, electrons are driven into the barrier layer. This makes it conductive again, so that a current can flow through the diode.

If the polarity is reversed, this is termed the reverse direction.

You can verify this with a small experiment. Swap over the polarity at the DC power supply according to Fig. s1a and gradually increase the voltage. What happens to the current? (This measurement should only be made within a range of 0 to 3 volts, otherwise the solar module will be destroyed.)
1. Set up the apparatus as shown in Fig. s1b.
2. Illuminate the solar module well with a lamp (the distance between the lamp and the solar module should be about 30 cm, the short-circuit current should be approx. 700 mA).
3. Wait for approx. 5 minutes until the module has warmed up and the characteristic curve can be recorded at a relatively constant temperature.
4. Start by measuring the short-circuit current (by shorting out the resistances). Then measure the voltage and current at different resistances (0.3, 0.5, 1, 2, 3, 5, 10, 20, 50, 100 Ω). The final measurement is taken in the "OPEN" position.
## Table of measurements:

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<th>Resistance / Ω</th>
<th>Voltage / V</th>
<th>Current / mA</th>
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## Evaluation:

1. Draw the IV diagram (light IV curve of the solar module).
2. Interpret the characteristic curve.
3. Determine the maximum power point (MPP) by drawing a graph plotting the power \( P = V \times I \) against the voltage.
The following data are of importance when looking at a characteristic curve:

- the open-circuit voltage (rotary switch "OPEN"),
- the short-circuit current and
- the maximum power point.

When there is no current drain, the solar module has an open-circuit voltage of approx. 2.15 volts \((R = \infty)\). An individual silicon solar cell typically has an open-circuit voltage of 0.5 - 0.6 volts.

If we short-circuit the solar module \((R = 0 \, \Omega)\), the maximum current (short-circuit current) flows. In our example of a characteristic curve, the short-circuit current amounts to about 680 mA.
The maximum power point "MPP" refers to the point at which the solar module can output its maximum power at a specific level of irradiation. This point is at the "knee" of the IV characteristic curve and can be determined by two different methods:

1. By drawing the rectangle with the largest possible area within the IV characteristic curve ($P = V \times I$).
2. By drawing a PV diagram and reading the value of maximum power.

In our example measurement, the MPP is at about 1100 mW.

Adapting a solar module to the power of the respective load plays a crucial role in practical applications. Wherever possible, the power of the load should always be close to the MPP.
Experiment variations:

You can determine the influence of light intensity on the power of the solar module. To do this, record two further characteristic curves, changing the distance between the lamp and the solar module (e.g. to 20 cm and 40 cm).

**At a distance of 20 cm the solar module must only be illuminated for the duration of the experiment.**

Draw graphs plotting P against V and compare them with the diagram at a lamp distance of 30 cm.