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## Device for determining parameters of a solar cell model

Student Humeniuk D.V., gr. DK-52

Director: Senior Lecturer Bondarenko N.O

National Technical University of Ukraine

«Igor Sikorsky Kyiv Polytechnic Institute»

**Aim and tasks of the study.** The intensive use of traditional fuels and the global energy crisis lead to the search for alternative, environmentally friendly, renewable energy sources. One of the most promising areas of energy development is the direct conversion of solar energy into electricity by means of solar panels. For their efficient functioning it is necessary to maintain a mode of operation that provides the maximum output power delivered to the load [1].

The aim of the work is development of an automated system for determination of the parameters of solar cells for calculating solar cell maximum power point (MPP) and optimal load resistance, which is different from similar engineering solutions in the simplicity of implementation, the availability of hardware and software processing principles and data visualization technologies, compatibility of the design with existing MPP tracking systems.

**Object and subject of the study.** The object of the study is a model of solar cells that allows calculating its output power depending on the illumination and ambient temperature.

The subject of the study is a method for calculating the parameters of a solar cell model, which provides the most accurate reproduction of the characteristics of the real solar cell.

**Practical results of the study.** In the study, an automated system is developed, which allows measuring the light and dark current-voltage characteristics (CVC) of a solar cell (SC). From these characteristics, the solar cell model's parameters are defined, which can be used to determine the MPP of the solar cell. With information on the MPP, it is possible to calculate the optimal resistance value for the studied SC and to provide the corresponding control signal to the voltage converter from SC [2].

The device consists of a STM32 based control unit, a digital-to-analog converter, a voltage-current transformation circuit, a current and voltage sensor and a laptop with a LabVIEW graphical programming environment. The digital voltage value from STM32 is transmitted to the AD5624R DAC via the SPI interface. AD5624R is a 12 bit DAC with built-in reference voltage 2.5 V [3]. In this configuration, the accuracy of the voltage control is 1.2 mV and the current setting is 40  $\mu$ A. The INA226 sensor was used to measure the voltage on the sample and the current flowing through it [4]. The current is measured as the voltage drop across the shunt resistor, which is connected to the corresponding sensor inputs using the built-in 16-bit ADC. A shunt resistor with a 0.1 Ohm resistance is used, which allows measuring current up to 800 mA with a resolution of 25  $\mu$ A. The readings of the sensor were calibrated using a precision voltmeter B7-46. Measurement and data processing is carried out with a virtual device created in the LabVIEW environment.

As a microcontroller, the SM32F401RE Nucleo development board was used. This unit provides control of the DAC, the current sensor INA226, connection of the circuit for measuring light or dark CVC, as well as recording and storing the data received from sensors in the computer. By measuring the light and dark current-voltage characteristics, it is possible to obtain an approximate solar cell model, whose parameters depend on the illumination and temperature. Solar cell light CVC is used to determine photocurrent. By its value at a certain temperature and luminosity, it is possible to define photocurrent at different temperatures and luminosity levels. The measured light CVC and calculated light CVC are shown in fig. 1. Saturation current and the parameter  $\alpha$  of the solar cell are calculated using the dark CVC. The measured dark CVC is shown in fig. 2. With the obtained data, a model of a solar cell is defined, which can be further used to determine the

maximum power point at different levels of illumination and temperature. . The difference of the modeled MPP value with the experimentally defined value was 6.6%.

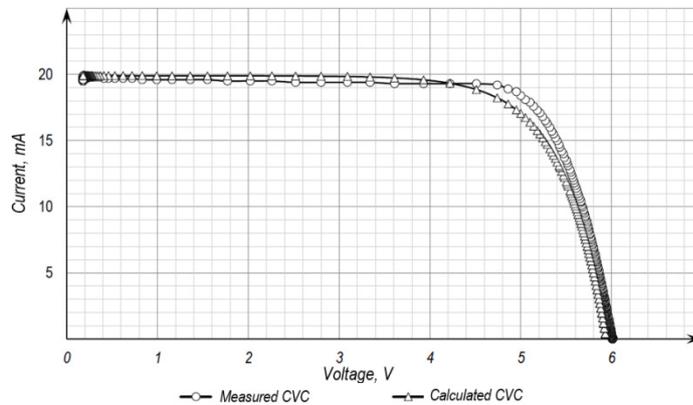


Fig. 1 Measured (CVC measured) and simulated (CVC simulated) light CVC of a solar cell

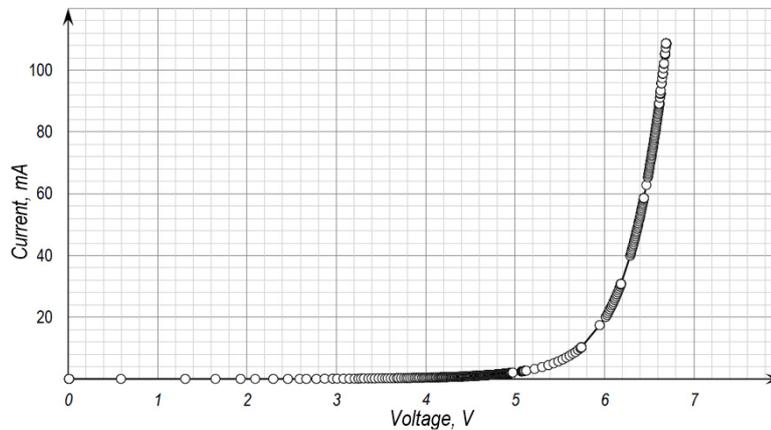


Fig. 2 Dark CVC of a solar cell

**Conclusions.** In the paper, an approach is proposed for the determination of the SC MPP using the solar cell model equation. The device for automated measurement of solar cell CVC, as well as the program for processing and storing the data in the LabVIEW programming environment is developed. According to the measured CVC, parameters of the SC model are calculated, which allows the calculation of the MPP for different values of temperature and illumination. The simulated MPP value, calculated by the proposed methodology, is slightly (6.6%) different from the experimental one. In the future, the study of methods for calculating the parameters of the SC, which would provide a more accurate SC model, will be continued.

**Keywords:** *alternative energy, solar cells, automated determination of parameters*

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