R.R. VARDANYAN, D.G. ARSTAMYAN, S.E. AVETYAN

A METHOD FOR MEASURING THE PARAMETERS OF BIFACIAL SOLAR CELLS

At present, the development and application of bifacial solar cells are in full swing. The efficiency of these types of cells is relatively high and is mainly determined by the recombination parameters of the minor charge carriers of the cells, the measurements of which are very important in both development and production processes. The work describes a new effective method for measuring the recombination parameters.

Keywords: solar cell, bifacial, parameters, charge carriers, measurements.

UDC 621.384.3

R.R. VARDANYAN, T.M. DAVTYAN, D.G. ARSTAMYAN, S.E. AVETYAN

A LOW - COST METHOD FOR MEASURING THE SOLAR RADIATION

The measurement of solar radiation is an essential task. It is important to develop the solar energy systemu, as well as to assess the operation of those systems. At present, comparatively expensive devices are used for the solar radiation measurements. In this work, a simple and cost-effective method for the measurement of solar radiation is proposed.

Keywords: solar radiation, solar cell, measurement, current.

Introduction

In solar energy system design and assessment of their operation it is essential to know the amount of sunlight available at a particular location at a given time. The two common methods which characterize solar radiation are the solar radiance (or radiation) and solar insolation.

The solar radiance is an instantaneous power density in units of W/m^2. The solar radiance varies throughout the day from 0 W/m^2 at night to a maximum of about 1 kW/m^2. The solar radiance is strongly dependent on location and local weather. Solar radiance measurements consist of global and/or direct radiation measurements taken periodically throughout the day. The measurements are taken using a pyranometer (measuring global radiation), a pyrheliometer (measuring direct radiation) and/or other measuring equipment as the Survey 200R of Seaward. In well-established locations, this data has been collected for more than twenty years.

While solar irradiance is most commonly measured, a more common form of radiation data used in the system design is the solar insolation. The solar insolation is the total amount of solar energy received at a particular location during a specified time period, often in units of kWh/(m2 day). While the units of solar insolation and solar irradiance are both a power density (for solar insolation the "hours" in the numerator are a time measurement as is the "day" in the denominator), solar insolation is quite different than the solar irradiance as the solar insolation is the instantaneous solar irradiance averaged over a given time period. Solar insolation data is commonly used for simple PV system design while solar radiance is used in more complicated PV system performance which calculates the system performance at each point in the day [1].

Measurements of solar radiation with the use of the above-mentioned pyranometers or Survey 200R are comparatively expensive. A low-cost measurement method of solar radiation is proposed in [2].

The proposed method is based on the application of a lux meter. Thus to realize the measurements by this method a lux meter is needed. In [3] a cost-effective technique for estimating the solar irradiance based on the application of smartphone is proposed. This approach is useful but the accuracy of measurements is net high. In this paper, a low-cost method for the measurement of solar radiation based on the application of a sample of solar cell and a general multi-meter is proposed.

Description of the method

The generation of current in a solar cell, known as the "light-generated current", involves two key processes. The first process is the absorption of incident photons to create electron-hole pairs. Electron-hole pairs will be generated in the solar cell provided that the incident photon has an energy greater than that of the bandgap. However, the minority charge carriers – the electrons (in the p-type material), and holes (in the n-type material) are meta-stable and will only exist, on average, for a length of time equal to the minority carrier lifetime before they recombine. If the carrier recombines, then the light-generated electron-hole pair is lost and no current or power can be generated. The concentration of light-generated minority carriers depends on the number of incident photons of solar radiance.

The second process, the collection of these carriers by the p-n junction, prevents this recombination by using a p-n junction to spatially separate the electron and the hole. The carriers are separated by the action of the electric field existing at the p-n junction. If the light-generated minority carrier reaches the p-n junction, it is swept across the junction by the electric field at the junction, where it is now a majority carrier. If the emitter and base of the solar cell are connected together (i.e., if the solar cell is short-circuited), the light-generated carriers flow through the external circuit. The ideal flow at the short circuit is shown in the animation below.

It is known that the current of the solar cell is:

$$I = I_0 \left[exp\left(\frac{qV}{nkT}\right) - 1\right] - I_L,$$

where I_0 is the thermal generation current of the p-n junction, q - the electron charge, V - the voltage on the contacts of the solar cell, n - the coefficient depending on the type of the junction, k - the Boltzmann's constant, T - the absolute temperature, I_L - the light generated current (photocurrent). In the case of short circuit $V = 0$, the current is:

$$I = I_L, \text{ and } I_L = I_{SC} = G\, x\, \eta,$$

where G is the solar radiance, and η the coefficient of collection of minority charge carriers by the p-n junction. Thus the short-circuit current from a solar cell depends linearly on light intensity.

Taking into consideration the above-mentioned linearity of the short-circuit current on light intensity in the proposed method, the sample of a small solar cell is used as the light-sensing element. The solar cell is encapsulated to prevent it from external influences and keep the sensor parameters stable.

The short circuit current is measured by the general multi-meter. Calibration is conducted under the outdoor conditions under the illumination of solar rays. To calibrate the light sensor the Survey 200R of Seaward is used. The Survey 200R and the light sensor are placed perpendicularly to the rays of the sun (Fig.).

Fig. Seaward Survey 200R

The obtained results of the measured solar radiation and short circuit current of the solar cell (light sensor) are presented below, in Table. Note that the measurements are conducted in the yard of National Polytechnic University of Armenia on June, 12, 2019.

Table

№	Time of measurement	Solar radiation ***G*** measured by Survey 200R, W/m²	Short circuit current ***I*** $_{SC}$ of solar cell light sensor, mA
1	12:15	918	6,1
2	12:20	930	6,12
3	12:30	941	6,18
4	12:40	963	6,24
5	13:00	1010	6,32

Then the coefficients for each measurement

$$K = G / I_{SC} \text{ (W/m2 / mA)}$$

are calculated and the average value of the coefficient K = 153.77 (W/m^2) / mA is obtained.

By using this coefficient the solar radiation can be measured with the use of the solar light sensor. For this purpose, the short circuit current of the sensor must be measured by the multimeter and the obtained current in mA must be multiplied by the K:

$$G \text{ (W/m}^2\text{)} = I_{SC} \text{ (mA) x 153.77 ((W/m}^2\text{) / mA).}$$

Thus a simple and cost-effective method for measuring the solar radiation is developed. The parameters of the solar light sensor are stable and almost not changing over time, which ensures the high accuracy of the method. The accuracy of measurements mainly depends on the accuracy of the multimeter.

Conclusion

A simple and cost-effective method for the measurement of solar radiation is proposed. As the light sensor, the small piece of the solar cell is used and the short circuit current of the solar cell is measured with the use of a general multimeter.

This work was supported by State Committee Science MES RA, in the frames of the research project № 18AA-012.

REFERANCES

1. https://www.pveducation.org
2. **Arveson P.** A low-cost method for measuring solar irradiance using a lux meter//Solar Household Energy Inc. Technical Report TR-17. - March 29, 2017. - P.6.
3. **Al-Taani H., Arabasi S.** Solar irradiance measurements using smart devices: A cost-effective technique for estimation of solar irradiance for sustainable energy systems // Sustainability, MDPI. - 2018. - P. 11.

Ռ.Ռ. ՎԱՐԴԱՆՅԱՆ, Տ.Մ. ԴԱՎԹՅԱՆ, Դ.Գ. ԱՌՍՏԱՄՅԱՆ, Ս.Ե. ԱՎԵՏՅԱՆ

ԱՐԵԳԱԿՆԱՅԻՆ ՃԱՌԱԳԱՅԹՆԵՐԻ ԻՆՏԵՆՍԻՎՈՒԹՅԱՆ ՉԱՓՄԱՆ ՊԱՐԶ ՄԵԹՈԴ

Արեգակնային ճառագայթման ինտեսիվության չափումը կարևոր խնդիր է: Անհրաժեշտ է մշակել արեգակնային էներգիայի համակարգեր, ինչպես նաև նաև գնահատել այդ համակարգերի աշխատանքը: Ներկայումս արևի ճառագայթման չափման համար օգտագործվում են համեմատաբար թանկ սարքեր: Այս աշխատանքում առաջարկվում է արեգակնային ճառագայթահարման չափման պարզ և ծախսարդյունավետ մեթոդ:

Առանցքային բառեր. արևային ճառագայթում, արևային մարտկոց, չափում, հոսանք:

Р.Р. ВАРДАНЯН, Т.М. ДАВТЯН, Д.Г. АРСТАМЯН, С.Е. АВЕТЯН

УПРОЩЕННЫЙ МЕТОД ИЗМЕРЕНИЯ ИНТЕНСИВНОСТИ СОЛНЕЧНОГО ИЗЛУЧЕНИЯ

Измерение солнечной радиации является важной задачей. Следует разработать солнечную энергетическую систему, а также оценить работу этих систем. В настоящее время для измерения солнечного излучения используются сравнительно дорогие приборы. В этой работе предлагается простой и экономически эффективный метод измерения солнечного излучения.

Ключевые слова: солнечная радиация, солнечный элемент, измерение, ток.

ՀՏԴ 004.38:62-97:681.5.08

Պ.Հ. ՇԻՐԻՆՅԱՆ, Գ.Հ. ԿԻՐԱԿՈՍՅԱՆ, Ջ.Ս. ՍԵՎՈՅԱՆ, Վ.Վ. ՄՈՒՐԱԴՅԱՆ

ՋԵՐՄԱՍՏԻՃԱՆԻ ՉԱՓԻՉ ՀԱՄԱԿԱՐԳԻ ՄՇԱԿՈՒՄԸ ARDUINO-Ի ՄԻՋՈՑՈՎ MATLAB-Ի ՄԻՋԱՎԱՅՐՈՒՄ

Դիտարկվում են թվային ջերմաստիճանի տվիչների հիմնական կիրառման ոլորտները և միացման սխեմաները: Ներկայացվում է ARDUINO պլատֆորմի հիման վրա MATLAB–ի միջավայրում թվային ջերմաստիճանի տվիչի ծրագրային կառավարման մեթոդիկան: Իրականացված է թվային ջերմաստիճանի տվիչի կառավարման համակարգի գործող մակետը փոփոխական ջերմաստիճանի պայմաններում:

Առանցքային բառեր. թվային ջերմաստիճանային տվիչ, մայրուղի, տանող, տարվող, տակտային ազդանշանի ելուստ, տվյալների ելուստ, ARDUINO, MATLAB:

Ներածություն: Թվային ջերմաստիճանի տվիչը (ԹՋՏ) ներկայացնում է երկլար, հաջորդական ինտերֆեյսով չափիչ սարք: ԹՋՏ–ն ունի SMBus մայրուղու և երկլար հաջորդական ինտերֆեյսի համատեղելիություն, ինչը թույլ է տալիս մեկ