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The work is devoted to the issue of generating electric energy by a solar module at night. The article presents the conclusion of the formula for calculating the no-load voltage of the module. The obtained result makes it easier to find this parameter because the desired value is determined mainly by the technical parameters of the solar module.

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I. INTRODUCTION

As you know, the Sun is the source of life on the planet Earth. Today, one of the promising areas of energy supply to consumers is the development and introduction of renewable energy sources [1, 2].

There are also many works in the literature devoted to optimizing and increasing the efficiency of solar panels [3-7] since renewable energy sources are gaining more and more popularity all over the world every year. The most dynamically developing direction in this field is photovoltaics, the practical significance of which is the direct conversion of solar radiation energy into electricity.

A solar battery is a semiconductor device that converts sunlight into electrical energy. It is a p-n junction with ohmic contacts (fig. 1).

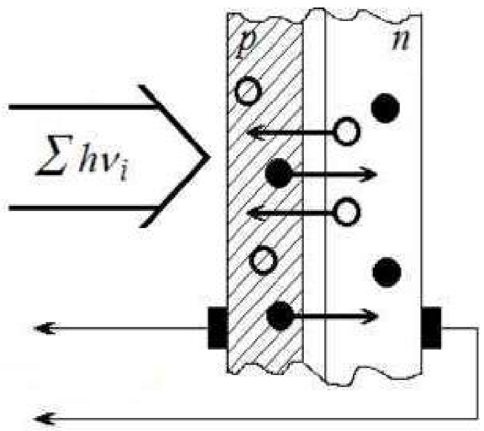

Figure 1: The structure of the solar battery

Solar radiation is converted into electrical energy of constant current by solar cells. Most solar cells are silicon semiconductor photodiodes. The energy characteristics of solar cells depend on the following parameters: the intensity of solar radiation, the magnitude of the load, the operating temperature.

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If the energy of the light quanta is greater than the bandgap of the p-n junction semiconductors, then electron-hole pairs are generated under the action of light. They are separated by a potential barrier field in the transition region and move to the n-and p-regions, the basic carriers. As a result, electrons in the n-region and holes in the p-region become in excess, and these regions acquire negative and positive charges, respectively. In the absence of a load, the accumulation of charges causes a decrease, and even the disappearance of a potential barrier. As a result, the separation of pairs stops. There comes a state of equilibrium-saturation. The voltage that occurs in such a state at the p-i-junction is called the opening or idling voltage U_{xx}. By connecting an external circuit to the device, you can take away electricity. At night, the panel receives light from the stars and the moon.

In this regard, the question arises about the generation of electricity by solar panels at night.

II. MATERIALS AND METHODS

The paper uses the method of approximate calculation.

III. RESULTS

In the idle mode, the voltage of the solar module is equal toIn the idle mode, the voltage of the solar module is equal to

$$U_{oc} = \frac{kT}{Aq} \ln\left(\frac{J_s}{J_{os}} + 1\right) \tag{1}$$

where: k is the Boltzmann constant ($k = 1.38 \cdot 10^{-23}$ J/K), e is the elemental charge ($q = 1.6 \cdot 10^{-19}$ C), A is the coefficient, J_{os} is the saturation current, J_s is the reverse photocurrent.

With $J_s >> J_{os}$, the expression (1) will take the form

$$U_{oc} = \frac{kT}{Aq} \ln\left(\frac{J_s}{J_{os}}\right) \tag{2}$$

Let's find the ratio of the no-load voltages during the day U_{ocd} and at night U_{ocn}

$$\frac{U_{ocd}}{U_{ocn}} = \frac{\ln\left(\frac{J_{sd}}{J_{os}}\right)}{\ln\left(\frac{J_{sn}}{J_{os}}\right)} = \log_{\left(\frac{J_{sn}}{J_{os}}\right)}\left(\frac{J_{sd}}{J_{os}}\right) \tag{3}$$

If we express one expression as a power of another

$$\frac{J_{sd}}{J_{os}} = \left(\frac{J_{sn}}{J_{os}}\right)^n \tag{4}$$

that

$$\frac{U_{ocd}}{U_{ocn}} = n \tag{5}$$

The primary photocurrent is proportional to the radiation flux (radiation power) F incident on the solar cell: $I_S = \alpha\ \Phi$, where α is the proportionality coefficient. Then the ratio of radiation fluxes during the day Φ_{cd} and at night Φ_{cn} is still the same

$$\frac{\Phi_{cd}}{\Phi_{cn}} = \frac{J_{cd}}{J_{cn}} = m \tag{6}$$

where from

$$J_{sd} = mJ_{sn} \tag{7}$$

where m = 40000-400000 (the illumination created by sunlight is greater than the illumination with a full Moon at night on the surface of our planet). Substitute (7) in (4)

$$\frac{J_{sd}}{J_{os}} = \left(\frac{J_{sd}}{mJ_{os}}\right)^n \tag{8}$$

where from

$$m^{\frac{n}{n-1}} = \frac{J_{sd}}{J_{os}} \tag{9}$$

From the formula (2), we express the ratio of currents

$$\frac{J_{sd}}{J_{os}} = e^{\frac{AqU_{ocd}}{kT}} \tag{10}$$

then

$$m^{\frac{n}{n-1}} = e^{\frac{AqU_{ocd}}{kT}} \tag{11}$$

from where n is equal to

$$n = \frac{AqU_{ocd}}{AqU_{ocd} - kT \ln m} \tag{12}$$

We find the coefficient A from the following formula

$$I_{mp} = -I_{sc}\left(1 - \frac{1}{AU_{mp}}\right) \tag{13}$$

where: U_{mp}-voltage at the point of maximum power, V; I_{mp}-current at the point of maximum power, A, V; I_{sc}-short circuit current, A.

Wherefrom

$$n = \frac{AqU_{ocd}}{AqU_{ocd} - kT \ln m} \tag{14}$$

substitute the expression (14) in (12) and get the formula for finding the number n

$$n = \frac{1}{1 - \frac{kT \ln m U_{mp} \left(1 + \frac{I_{mp}}{I_{sc}}\right)}{qU_{ocd}}} \tag{15}$$

substitute (15) in the expression (5)

$$U_{ocn} = \frac{U_{ocd}}{n} = U_{ocd} - \frac{kT \ln m U_{mp} \left(1 + \frac{I_{mp}}{I_{sc}}\right)}{q} \tag{16}$$

IV. DISCUSSION

As we can see, the obtained formula (16), the no-load voltage determines the no-load voltage at night during the day, the technical parameters of the solar cell, the temperature, and the relative illumination coefficient. We will perform the following analysis of the resulting expression. If the radiation fluxes are equal during the day and at night (m=1) the fractional part in the formula (16) turns to zero, and $U_{ocd} = U_{ocn}$, which is to be expected.

V. CONCLUSION

The work is devoted to the use of solar energy. The conclusion of the formula for calculating the no-load voltage of the solar module at night is given. The obtained result may be applicable for further engineering calculations of energy generation by solar modules.

REFERENCES

1. Ranjeva M., Kulkarni A.K. Design Optimization of Hybrid, Small, Decentralized Power Plant for Remote/Rural Areas // Energy Procedia. – 2012. – V. 20. – P. 258–270.
2. Kanareykin, A. I. On the efficiency of solar energy use in the middle zone of the Russian Federation // Problems and prospects in the international transfer of innovative technologies: Collection of articles following the results of the Interna-tional Scientific and Practical Conference. - Sterlitamak: AMI, 2021. - C.23-25.
3. Babaa S., Armstrong M., Pickert V. Overview of maximum power point tracking control methods for PV systems. Journal of Power and Energy Engineering, no. 2, pp. 59–72. DOI:10.4236/jpee.2014.28006.
4. Djeghloud H., Guellout O., Larakeb M., Bouteldja O., Boukebbous S., Bentounsi A. Practical study of a laboratory undersized grid-connected PV system. 2014 IEEE Innovative Smart Grid Technologies – Asia (ISGT ASIA), 2014, pp. 618–623. DOI: 10.1109/ISGT-Asia.2014.6873863.
5. Dolara A., Faranda R., Leva S. Energy comparison of seven MPPT techniques for PV systems. J. Electromagnetic Analysis & Applications, 2009, no. 3, pp. 152–162. DOI:10.4236/jemaa.2009.13024.
6. Dorofte C., Borup U., Blaabjerg F. A Combined two-method MPPT control scheme for grid-connected photovoltaic systems. European Conference on Power Electronics and Applications. Dresden, 2005, pp. 1–10. DOI: 10.1109/EPE.2005.219714.
7. Kanareykin A. I. On the correctness of calculating the Fill Factor of the solar module IOP Conf. Series: Earth and Environmental Science 808 (2021) 012018. DOI:10.1088/1755-1315/808/1/012018.