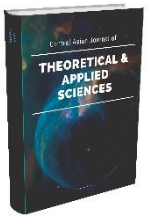

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Study of the Volt-Ampere and Volt-Watt Characteristics of the Photoelectric Battery

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Annotation: *This article provides information about the volt-ampere and volt-watt characteristics of a photoelectric battery.*

Keywords: *Photoelectricity, battery, volt, ampere, watt, energy, diversification, solar.*

INTRODUCTION.

Law of the Republic of Uzbekistan dated 21.05.2019. №ORQ-539 on the use of renewable energy sources was adopted by the Legislative Chamber on April 16, 2019 and approved by the Senate on May 3, 2019.

In accordance with the law, the main directions of the state policy in the field of using renewable energy sources are as follows:

- setting priorities and implementing measures in the field of using renewable energy sources;
- development and implementation of state programs and other programs in the field of use of renewable energy sources;
- strengthening the energy security of the country, diversifying the part of the fuel and energy balance related to the production of electricity, thermal energy and biogas using renewable energy sources;
- promoting the introduction of innovative technologies, scientific and technical developments in the field of using renewable energy sources, increasing the energy efficiency of renewable energy sources devices, expanding their production and localization;
- improvement of the organizational and legal mechanisms of attracting business entities to create energy production capacities based on the tested technologies of using renewable energy sources;
- state support and encouragement of producers of energy from renewable energy sources, as well as producers of devices of renewable energy sources;
- development of international cooperation in the field of use of renewable energy sources.

Cabinet of Ministers of the Republic of Uzbekistan:

- ensures the implementation of a unified state policy in the field of use of renewable energy sources;
- approves state programs in the field of using renewable energy sources;
- creates conditions for the development of fundamental, practical, innovative research in the field of using renewable energy sources, as well as for the promotion of scientific and technical achievements;
- coordinates international cooperation in the field of using renewable energy sources.

The Cabinet of Ministers within the framework of its powers in the field of use of renewable energy sources:

Regulation of connection of business entities producing electricity to the unified electricity system;

- procedure for state support to producers of energy from renewable energy sources, as well as producers of devices of renewable energy sources;
- the price and tariff policy that encourages the formation of favorable competitiveness and business environment in the energy market produced from renewable energy sources;
- adopts regulatory legal documents defining the procedure for keeping state accounts of renewable energy resources [1-3].

The Ministry of Energy of the Republic of Uzbekistan is a specially authorized state body in the field of the use of renewable energy sources.

Ministry of Energy:

- implements a unified state policy in the field of renewable energy sources;
- develops and implements state programs and other programs in the field of using renewable energy sources;
- coordinates the activities of state and economic management bodies in the field of using renewable energy sources;
- develops and approves technical regulations, norms and rules in the field of use of renewable energy sources within the scope of its powers;
- monitors the implementation of state programs and other programs in the field of using renewable energy sources; [4-6]

(National database of legal documents (www.lex.uz), May 22, 2019)

THE MAIN PART.

The planar construction of solar cells (the case where the optical radiation falls perpendicular to the surface of the structure) is the main construction in QE technology and their practical use. Such QE was developed on the basis of various materials. On the basis of the above analysis, highly efficient optimized structures were developed. But it was determined that the above basic requirements for any material should be preserved. To increase it and I_{kz}, it is desirable to increase the diffusion length on both sides of the r-n transition. To do this, it is necessary to choose the right material and try not to reduce the diffusion length during the technological preparation of the p-n junction. If its decrease is obvious, it should be taken into account. If it is not possible to increase L_d on the frontal surface, then the thickness of the frontal surface should be taken according to $L_p >> \ell$. Based on this, it is necessary to choose the base parameters.

In the early stages of the creation of solar cells, compared to the maximum of the spectrum of solar radiation, the optimal material was selected as an optimal material with a band gap of 2 eV. Later, it was found that the forbidden field width E_g should be less than 2 eV to increase the number of photoactive quanta and increase the short-circuit current [7-10]. But for this case, it is clear that the value of the generated photo-EUUK is relatively reduced, because the value of the potential barrier in the p-n junction is reduced.

Later, when it became possible to use varizone (materials with the possibility of changing the value of the prohibited field) in the preparation of QE materials, 2 types of their application were proposed:

1) Use of direct heterotransferences;

2) Use of the layer with a forbidden area value greater than the value of the forbidden area of the base material as a wide area.

There are two opposing views on the effect of the base material on the QE properties. QE F.I.K. In order to substantiate the serious dependence of the base material on the width of the forbidden zone, it is necessary to analyze the element VAX and study the effect of the optical radiation spectrum falling on it.

1956 J. Lofersky completed the above-required theoretical calculation for the spectrum of solar radiation under Earth conditions - the book. The values of optical and photoelectric losses were evaluated for QEs made of different optimized materials. The results of such samples are shown in Figure 1.9 below8.

The main characteristic of solar cells is calculated, volt-ampere characteristic (VAX) and spectral sensitivity YAO depends on optical and electrophysical properties of materials.

QE VAX differs from VAX of p-n junction diode VAX by the appearance of a new term I_f. I_f is the current generated in the solar cell under the influence of optical radiation. I_f Id is the current flowing through the diode and I is the current flowing through the external load, then the characteristic of the diode in the dark, I_o is the saturation current in the reverse direction of the p-n transition, q is the electron charge, T is absolute temperature, k – Bolsman's constant, U – voltage.

$I_f = I_d + I$ (1.7)

$I_d = I_o(\exp(qU/kT) - 1)$ (1.8)

For the case of open circuit with infinite resistance, i.e. at I=0, from the above equation

$U_{xx} = l_n(I_f/I_o + 1)\, kT/q$ (1.9)

originates.

Figure 1 a. Representations of QE VAX at different values of R_p and R_{sh} (a) and values of R_p at $R_{sh} = \infty$ (b); R_p=5 Om, R_{sh} = 100 Om; 2 - R_p=5 Om, $R_{sh} = \infty$; 3- R_p= 0, R_{sh} = 100 Om; 4- R_p= 0, $R_{sh} = \infty$; 5- 11 - R_p= 0; 1; 2; 3,5; 5; 10; and 20 Om

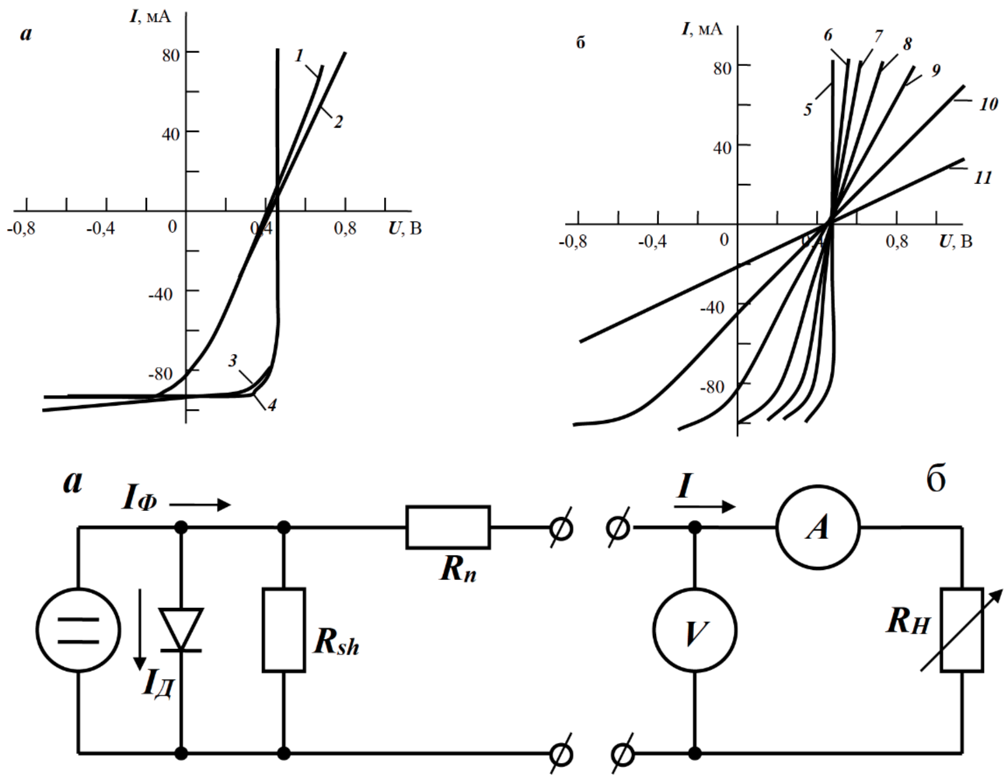


Figure 1. Equivalent (a) and measurement (b) circuits of a solar cell

In practice, the components of the series resistance in solar cells are the resistance of the layers forming the contacts, the resistance of individual p- and n-areas, the resistance of the transition areas between the metal-semiconductor, and the Rsh shunt.

resistance and so on [11-15]. Taking into account these resistances, as well as recombination losses in the p-n junction, VAX can be expressed in a more complicated form, i.e.

$$L_n (I + I_f)/I_o – (U – IR/I_o R_{sh} + 1) = q/AkT(U – I_m) \qquad (1.10)$$

The input coefficient A indicates the degree of closeness of the actual instrument to the ideal instrument. This equation can be practically written as follows.

$$I = I_f + I_o (\exp q(U + IR) /AkT – 1 - U + IR/R_{sh} \qquad (1.11)$$

Based on this equation, an equivalent and measurement circuit of the solar cell can be created, and such a circuit is shown in Figure 1 below.

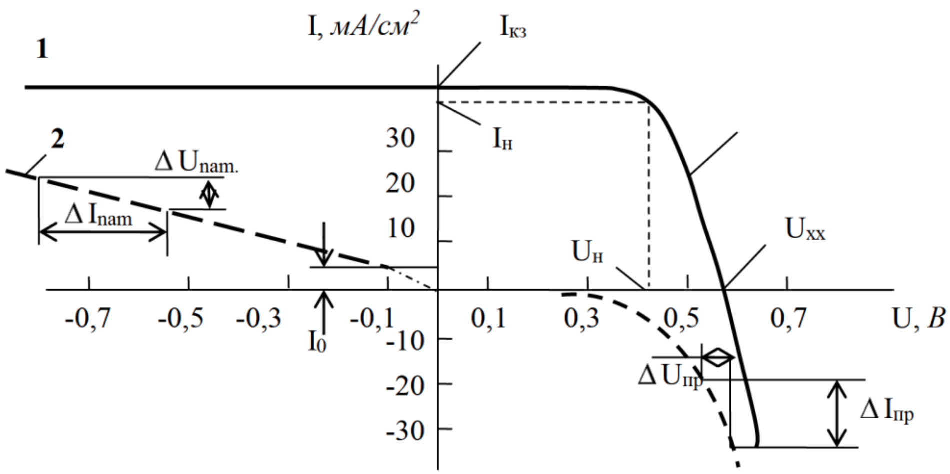
The power R per unit area of the solar cell can be estimated from the following equation.

$$P = (I_n U_n) = \xi I_{kz} U_{xx} \qquad (1.12)$$

Here, ξ - is the filling factor of the volt-ampere characteristic, that is, how close the VAX shape is to a rectangle. The fill factor is 0.8 and greater in modern QEs (elements based on silicon and gallium arsenide). Consider the effect of series and shunt resistance on VAX from Figure 1a. It can be seen from the figure that reducing the shunt resistance Rsh from infinity to 100 Ohm has almost no effect on the shape of VAX, including the output power R_v of QE. However, the change of the series resistance Rp from 1 Ohm to 5 Ohm causes the shape of VAX to deteriorate sharply, and the output power is reduced relative to R_v.

QE VAX characteristics in light and dark can be analyzed more precisely. Usually, depending on the voltage level, the transition mechanism of the reverse saturation current passing through the r-n junction changes. This current is usually the sum of two currents, viz

$I = I_{o1} [(qU/kT) - 1] + I_{o2} [(expqU/kT) - 1] – I_f$ (1.13)



Picture 2. Typical volt-ampere characteristic of a present-day silicon-based QE measured for non-atmospheric solar radiation. 1 - under the influence of light; 2 - situations in the dark

Here, I_{o1} is the current flowing through the thin p-n junction through the diffusion mechanism, and I_{o2}- is the reverse saturation current for the recombination event in the p-n junction region for A = 2. it is possible to determine some of its parameters, including Io, Rp, Rsh, A. Figure 2 below shows typical VAX for AM1.5 conditions and element VAX taken in the dark. Part of the VAX obtained under lighting conditions in the first quadrant, and its continuation in the fourth quadrant is a straight line. The slope of this straight line to the axis of currents determines the series resistance of the QE.

$R_p = \Delta U_{pr}/\Delta I_{pr}$ (1.14)

here, the change of ΔUpr/ Δipr value in the area near Uxx is obtained. The part of the given characteristic in the first quadrant and its continuation in the second quadrant is a straight line. Its deviation from the axis of voltages determines the value of the shunt resistance R_{sh} in QE, i.e.

$R_{sh} = \Delta U_{'pr}/ \Delta I'_{pr}$ (1.15)

here, the change of the values of ΔU_{pr} and ΔI_{pr} in the area close to the short-circuit current I_{kz} is obtained.

Since it is difficult to change the slope of the straight line around the short-circuit current I_{kz} of VAX taken in the light, the shunt resistance R_{sh} is determined from the slope of VAX taken in the dark (second quadrant dashed line), i.e.

$R_{sh} = \Delta U_{obr}/ \Delta I_{obr}$ (1.16)

Using the characteristic obtained in the dark, the reverse saturation current Io can be determined. solar cells are connected in the correct direction in the p-n junction mode of operation, that is, the formation of unbalanced charge carriers on both sides of the p-n junction due to the effect of optical radiation, which is r-n o 'indicates that the tooth is connected in the correct direction [16-18]. Therefore, it is desirable to find the reverse saturation current Io and idealization factor A from VAX measured in the dark or in the light in the correct direction. The diode equation for VAX obtained in the dark can be written in a different form as follows.

$L_n (I_d + I_o) = l_n I_o + qU/AkT$ (1.17)

this equation can be used for calculation in the case where the value of the current is large $I_d >> I_o$ and for the case where the reverse saturation current passes through the r-n transition based on the recombination mechanism. Based on VAX measured in the right direction of QE (for large currents and voltages), the function ln I_o = g'(U) can be plotted. The tangent of the slope of this equation is equal to q/AkT. Its cross section on the ordinate axis gives the value of l_n,I_o.

There is another way to determine the value of Io and A under conditions close to the real operation of QE. For this, the VAX of the QE is measured using a simulator at at least two different values of the light flux density. For the series resistance Rn, we present the above equation for the process of voltage drop and recombination in the p-n junction region, i.e.

$I = I_o[\exp\{q(U-IR_p)/AkT\} - 1] – If$ (1.18)

In walking mode I = 0, U = U_{xx} because, $R_p = 0$ and in that case $I_f = I_{kz}$ can be taken as In that case

$L_p (I_{kz} + I_o) = l_n I_o + qU_{xx}/AkT$ (1.19)

CONCLUSION.

In summary, to apply this equation, the linear values of the equation I_{kz} = (Eg) corresponding to each new optical radiation flux density are found using the reference QE, and from this I_{kz} and U_{xx} are determined. The value of q/AkT is found from the tangent angle, and the value of ln Io is determined from its intersection with the ordinate axis.

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