

Review Article

Increasing the Power and Efficiency of Solar Panels in Low Light

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Abstract: A method of increasing the power generated by the solar battery under reduced solar radiation using an additional source is considered. The method is based on the activation of a silicon semiconductor element by applying additional voltage to the p-n junction. As a result of the experiments, an increase in the power and efficiency of the solar battery by 25-30% was obtained.

Keywords: Solar battery, power, radiation p-n junction.

INTRODUCTION

The power of solar energy during the year in different regions on the surface of the Earth decreases from 1 to 0.1- 0.4 kW / m² with an efficiency of solar panels not higher than 20%. In this regard, we ask ourselves: is it possible in some ways to increase the efficiency of solar cells without changing their structure.

As such a method, we consider connecting to a solar silicon battery, which is a semiconductor pn junction, an additional power source, which is supposed to be able to reduce the required solar radiation power spent on the work of the electron exit from the substance according to the equation of the external photoelectric effect.

We begin the implementation of the task by describing the experiment with the TPS-107S (36) -15W solar battery with nominal values: power 15 W, current 0.88 A and voltage 22 V. The experimental design is shown in Fig. 1.

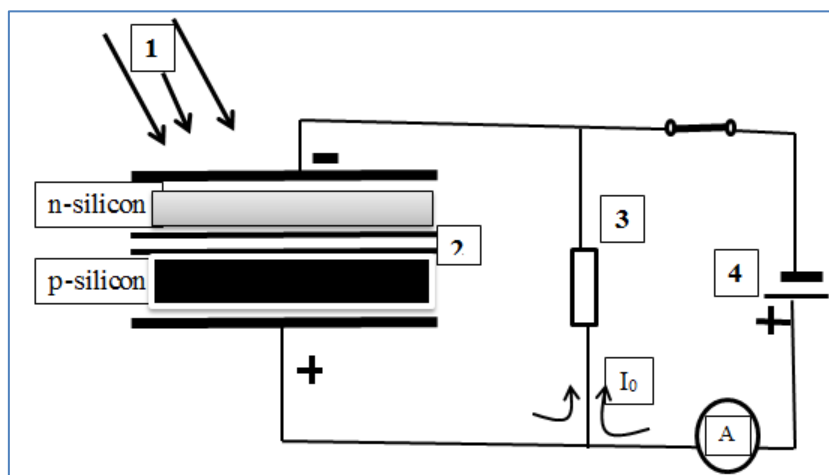


Fig-1: Experiment design1. Solarradiation. 2. Solar silicon battery. 3. Load - resistor R
4. Cumulative source of electrical energy

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Consider two modes of operation of the solar battery: in "pure" form without connecting an accumulative source to it (1st mode) and with connecting the latter (2nd mode). We introduce the following notation for the 1st mode of operation:

P_B is the power of the electric signal generated by the solar battery;
 U_B - voltage at the load - active resistance R ;

Designations for the 2nd mode of operation:

P_C - total electric power of the battery during solar radiation and due to the storage source connected to the load;

P_G - power of the electric signal generated by the solar battery;

P_0 is the power consumed by the DC storage source and completely transferred to the load (resistor R);

ΔP - additional power generated by the p-n junction under the action of two sources (solar and storage);

U_0 is the voltage at the load equal to the voltage at the output of the storage source;

I_0 - is the current of the storage power source.

We write the power balance equation taking into account the notation introduced:

(1)

where
$$P_C = P_G + P_0 = P_B + \Delta P + P_0,$$

(2)

$$P_G = P_B + \Delta P, \quad P_0 = I_0 U_0, \quad P_B = U_B^2 / R.$$

We also introduce the parameter X equal to the ratio of the current value of the energy density of solar radiation to the maximum value of this parameter when the Sun is at its zenith and not covered by clouds.

The measurements were carried out during the day with an interval of 30 minutes with a change in parameter X from 1 (the Sun at its zenith) to 0 (complete dimming) at a load of $R = 20 \Omega$.

Each time, at the same level of solar radiation (i.e., the parameter $X = \text{const}$), two measurements were performed. First, when the storage source was turned off, the voltage U_B was measured. Then, a storage source with a voltage of $U_0 = 18 \text{ V} = \text{const}$ was connected to the solar battery and the load, and the current I_0 was measured.

The results of numerous experiments in the form of four graphs calculated by formulas (1) and (2) and showing the dependence of the energy parameters of the solar battery on parameter X , i.e. the battery illumination level by the Sun are shown in Fig. 2.

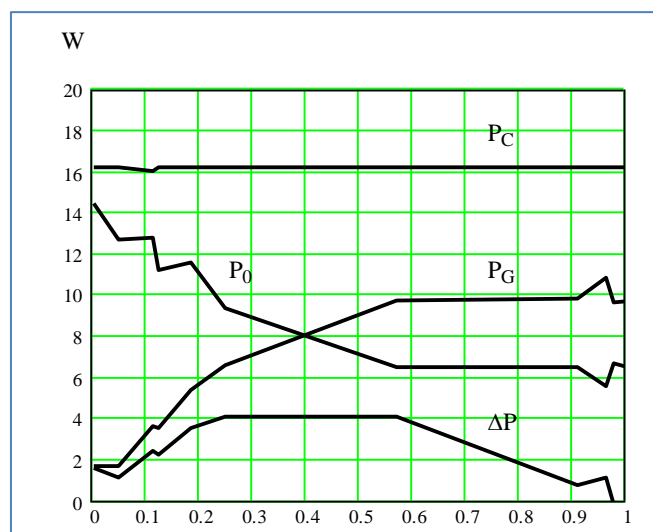


Fig-2: The dependences of the solar battery power on the relative energy density of solar radiation X

From the results obtained experimentally, it follows that with a decrease in the solar illumination of the battery due to an additional source, the power of electric energy consumed by the load increases 3-4 times. Wherein:

- 50 - 60% of the energy supplied to the load (or, respectively, 8 -10 W of power in the considered example according to Fig. 4) is the energy stored in the storage device and previously received there from the solar battery in bright light or another source;
- Another part of the energy supplied to the load, in the amount of 40-50% of the energy (i.e. another 6-8 watts of power in the example under consideration), comes into the load directly from the solar battery.

Since the solar battery produces only 4 W without an additional source, it can be argued that according to the proposed method, the power generated directly by the solar battery with weak solar radiation increases by 1.5 - 2 times. At the same time, the same power is taken and supplied to the load from the storage energy source. Therefore, in the total energy balance, an additional increase in power is 25%.

The basis of solar panels of different capacities is the same silicon semiconductor film. Therefore, the result can be attributed to all batteries of this type, regardless of their capacity.

The theoretical interpretation of the obtained experimental result is based on the equation of the external photoeffect - the Einstein equation, which describes the energy balance in a substance under the action of solar radiation [1-5]. Given the effect on the processes occurring in the semiconductor under the action of a constant voltage U applied to it, this parameter should be included in this equation and written:

$$hf = mv^2 / 2 + A_{out}(U), \quad (3)$$

where h is the Planck constant, f is the frequency of the radiation acting on the substance; $mv^2 / 2$ is the kinetic energy of the emitted electron, $A_{out}(U)$ is the work function is the energy needed to remove an electron from a substance, which, as shown by experiments, depends not only on the value of solar energy, but also on the voltage U applied to p - n transition.

As a result of the application of an additional voltage to the p-n junction, the power required to remove the electron from the substance decreases and, therefore, the kinetic energy of electron emission increases, i.e., the generated electric energy increases under the influence of solar radiation energy. When this, as experiments have shown, the redistribution of the values of the two energies on the right side of equation (3) can vary from a ratio of 1: 4 to a ratio of 2: 3 or even 1: 1 in favor of the generated electrical energy. Therefore, no contradiction with the law of conservation of energy occurs.

1. The conducted experimental studies showed the possibility of a significant increase in electric energy (up to 2 times) generated by a silicon solar battery with reduced solar radiation. At the same time, the same power is taken and supplied to the load from the storage energy source connected to the battery. Therefore, in the total energy balance, an additional increase in power is 25-30%.

2. Based on the proposed method for increasing the power of solar cells with reduced solar radiation, a significant (up to 25% or more) increase in the power of existing solar power plants (SES), which include energy storage devices, is possible. The modernization of such SES will consist only in the installation of a switching element that connects a storage device to the solar panels while reducing the radiation energy of the Sun on the Earth's surface by two or more times.

This process of increasing power is accompanied by the selection and sending to the load the same power from the storage source. With this factor in mind, a "net" increase in the capacity of a solar power plant can be 25-30%.

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