



THEORETICAL DEVELOPMENT OF A DEVICE FOR CLEANING SPMT FROM MECHANICAL PARTICLES

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<https://doi.org/10.5281/zenodo.7139064>

Abstract

In order to test the effectiveness of the proposed method of protection and purification, we will conduct an experiment. Since the complete assembly of the device under existing conditions is not available, the experiment will be carried out with two key components of the system: SPMT and film. During the experiment, artificial sand and dust pollution will also be created, since in laboratory conditions it is impossible to simulate real pollution using dust collected in the air.

Key words: *autonomous, solar panels, power generation,*

Introduction

The main purpose of this device is to prevent small particles from getting on the surface of the SPMT in order to avoid its shading, and, consequently, a decrease in power generation. Also, the device should not have a high initial cost and high operating costs. The device should be autonomous, that is, it should work without human intervention or minimize the process of its participation in the cleaning of the SPEM. We propose an installation consisting of a receiving and supplying roller with a film wound on them and having a tension. The structure is attached to the SFEU. This device will have an advantage over conventional cleaning as it will prevent particles from reaching the SPMT glass. The need for cleaning is confirmed by US scientists: Google conducted a pioneering experiment at its 1.6 MW [1] solar farm in Mountain View, California. They found that cleaning solar panels was the main way to maintain the electrical power they produce. Cleaning solar panels that had been in operation for 15 [2] months resulted in a doubling of electricity generation. The same study also found that rain is not the best way to clean SPEMs.

Solar panels that were professionally cleaned increased their output by 12% [3] compared to those that were cleaned by rain. One of the objectives was to minimize the cost of the device. The most cost-effective option is not to purify the SPMT at all. But in this case, SPPM can lose 15-25% [4] of their efficiency if they are not cleaned properly. This means that they will generate 15-25%



less electricity that will have to be buy from the unified energy system at established tariffs. This increases the payback period of SFEU.

It is also necessary to know how many times a year it is necessary to clean the SPMT so that contaminants do not accumulate on them, and so that the device does not work too often. In most cases, the main pollution occurs in the winter, so spring is the best time to do the annual cleaning. Solar panels that are cleaned once or twice a year produce 3.5% and 5.1% [4] respectively more electricity than those that are left uncleaned. However, for the conditions of the Termez region, cleaning should be carried out more often due to the large amount of dust in the air.

Solar panels installed near pollution sources such as highways, factories and airports need to be cleaned more frequently. Otherwise, the cleaning time is optimal at the junction of the seasons (autumn and winter), when the removal of leaves and snow is important for optimal performance.

The physical basis of the solar battery

Solar panels, which convert solar radiation into electrical current, have been around for over a hundred years, although early solar panels were too inefficient to be practical. Now, we try to demonstrate the practical experience with silicon solar cells.

Experimental procedure

In order to test the effectiveness of the proposed method of protection and purification, we will conduct an experiment. Since the complete assembly of the device under existing conditions is not available, the experiment will be carried out with two key components of the system: SPMT and film. During the experiment, artificial sand and dust pollution will also be created, since in laboratory conditions it is impossible to simulate real pollution using dust collected in the air.

Experiment plan:

- 1. We measure the voltage and current on the cleaned module on a sunny day.*
- 2. We pollute the module. We measure the same parameters.*
- 3. We clean the module manually. I put the film on top. We measure current and voltage.*
- 4. Contaminate the film. We measure the same parameters.*
- 5. We stretch the film. We measure current and voltage.*
- 6. We build current-voltage characteristics.*





7. Based on the CVC data, we make a conclusion about the effectiveness of the assembled model.

The experiment requires a solar module, film, sand, dust, a multimeter. All the schemes outlined below are shown in Figures.

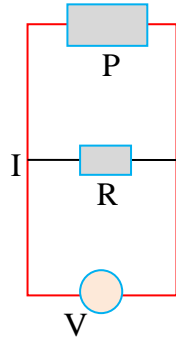


Fig.1. Measurement of Power, W

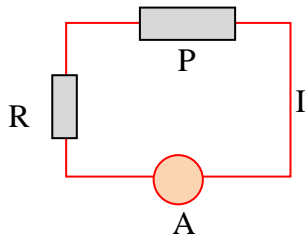


Fig.2. Measurement of Current, A

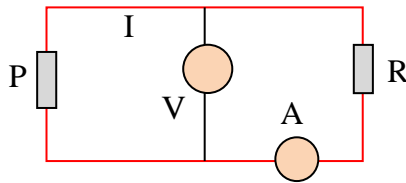


Fig.3. Measurement of Voltage, V

Experiment

For the experiment, we will choose a 100 W SPM, a thick cellophane film covering the working surface of the panel, a multimeter, and a wire rheostat. The experiment was carried out on a mid-solar day. AT depending on the resistance of the external circuit, the power of a low-power source varies. The following figure is presented in Appendix E in Figure E1.





Fig.4 - Clean solar panel without film

First, measurements were taken on a clean solar panel. Measurements were also taken for panel short circuit and idle. The measurement results are summarized in table 1:

Table 1 - Results of the experiment for a clean panel without a film

R	U	I	P
0	0	5.3	0
3.8	18.2	4.8	87.3
4.8	20	4.2	84
8.6	21.5	2.5	53.8
∞	22	0	0

In this and subsequent tables, R is the resistance of a short circuit, wire rheostats, idling; U is the voltage of the solar battery, I is the current generated by the solar battery; P is the power calculated by formula 1:

$$P_s = W \cdot I$$

Next, we will conduct a similar test, but with a clean film. The results of the experiment are summarized in table 2:

Table 2 - Results of the experiment for the panel in the film

R	U	I	P
0	0	5	0
3.7	17	4.6	78
4.6	19	4.1	79
6.6	20	3	60
∞	21	0	0

According to the results of two experiments, it can be seen that when the panel is covered with a film, the output power decreases. However, let's do a third experiment to see if this reduction is critical for the panel compared to the conditions when the film is contaminated. As a pollutant, we will choose a small amount of building cement mixture, since this is the closest prototype of the pollutant in the city of Termez. We simulate real conditions for the urban environment, since the device is poorly applicable outside megacities and areas with high concentrations of mechanical parts in the air. To do this, we will apply drops of water on the film (imitation of rain and dew) and a little construction mixture. The result obtained is shown in Figure 2:



Fig.5 - Solar panel with dirty film

Since this experiment is only a model of the conditions of the Termez region and in particular the city of Termez, such a quantity of pollution in real conditions is possible over a period of 3 months to six months. In such time intervals, setting up an experiment is difficult, so the simulated pollution effect takes into account the worst case, that is, the maximum precipitation of mechanical particles from the air onto the panel. Depending on the work of industrial enterprises, contamination of the panel with mechanical particles is

a priority, but not the only one. For other types of pollution, the experiment was not carried out due to their absence. A picture of a contaminated panel is presented in Appendix E in Figure E1.

For greater clarity, we construct graphs of current-voltage characteristics (CVC) and the dependence of power on voltage, presented in Appendix G in Figure G1.

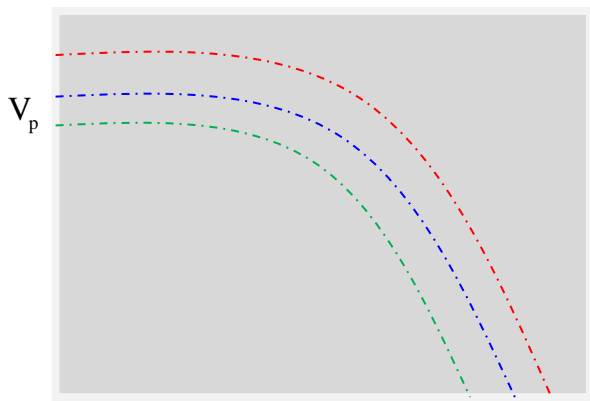


Fig 5. I-V characteristics of panels for three experiments

As can be seen from the graph, in the absence of the use of a film, the current and voltage values on the I-V characteristic drop sharply, which is not good for the payback of the entire solar power supply system.

A logical conclusion can be made based on the dependences of power on voltage, presented in Appendix 3 in Figure 31. In the absence of a film and cleaning, the power drops sharply. The difference between the blue and gray graphs is large, which makes it necessary to clean the solar panel from contamination. In the absence of time for mechanical manual

Volt-ampere characteristics

When the p-n junction is illuminated, in addition to the dark current, a current will flow through it, due to the generation of charge carriers by optical radiation I_{kz} . Thus, it is possible to write the CVC of the SB as the sum of the currents (for the ideal case):

$$I = I_0 \left(e^{\frac{qV}{kT}} - 1 \right) - I_{kz} - I_s \quad (1)$$

Graphically, the dependence of current on voltage for the SB has the form: (Figure 10).





Data was received from the Matlab software, processing was carried out on the Origin package and the CVC was plotted, then the parameters of the solar cell are obtained. Found the operating current and operating voltage: $U_p=1.63V$, $I_p=0.71A$. Area measured with a ruler. Battery area:

$$S = L \cdot h = 0.025m^2$$

Where: width $L=0.125m$, height $h=0.2m$. Solar radiation: $W=500W/m^2$

$$\eta = \frac{U_p I_p}{S W} = \frac{1.63 \cdot 0.71}{0.025 \cdot 500} \cdot 100\% = 9.26\%$$

$$F = \frac{V_p I_p}{V_x I_s} = \frac{1.63 \cdot 0.71}{1.814 \cdot 0.798} = 0.799.$$

Efficiency

The most important characteristic of SE is the efficiency factor. It is defined as the ratio of the maximum power delivered to the solar cell load to the power of solar radiation incident perpendicular to the working surface.

$$\eta = \frac{V_p I_p}{P_s} \cdot 100\%$$

where: V_p and I_p - voltage and current at the operating point, at which the maximum power delivered to the load is reached (Figure 10.), P_s - power of the radiation incident on the solar cell.

$$P_s = W S$$

where: S is the area of the battery, W is the solar radiation. Battery area:

$$S = L \cdot h$$

Where: L -width, h -height.



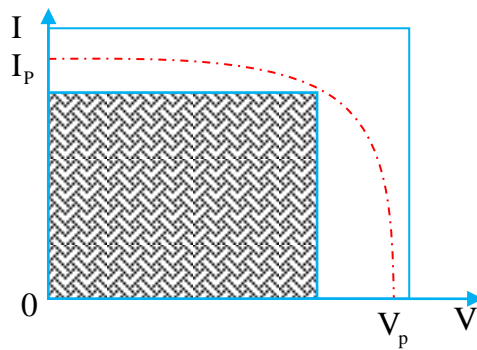


Figure 10. Volt-ampere characteristic of the ESS and the dependence of the released power on the load on the voltage.

Conclusion

As can be seen from the graph, in the absence of the use of a film, the current and voltage values on the I-V characteristic drop sharply, which is not good for the payback of the entire solar power supply system.

A logical conclusion can be made based on the dependences of power on voltage, presented in Appendix 3 in Figure 31. In the absence of a film and cleaning, the power drops sharply.

Create current-voltage characteristic data, find the operating point, get the operating voltage, with this know the operating current, then you can calculate the efficiency.

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