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The Issue of Developing Power Supplies for Remote Monitoring Systems of Overhead Power Lines

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***Abstract.** The purpose of this work is, on the basis of the research carried out, to give recommendations on the choice of solar panels when servicing monitoring systems for overhead power lines. The technical characteristics of serially produced solar cells (SC) are considered. A complete overview of the existing types of solar cells is given. Their technical indicators are given, such as efficiency, generated power per square area, service life. The existing types of solar cells are analyzed. A suitable type of solar panels is proposed to power the remote monitoring system of overhead power lines for the regions of Kazakhstan – crystalline silicon solar panels.*

***Keywords:** remote monitoring system, overhead power line, solar panels, coefficient of efficiency, photovoltaic cell, power, service life.*

Introduction

Providing a stable power supply to the remote monitoring system located on the supports of overhead power lines (OHPL), adapted to the conditions of Kazakhstan, is an urgent issue. To date, the measuring elements (sensors) of the OHPL monitoring system are mainly powered by rechargeable batteries, which are charged directly from solar panels (batteries).

A serious problem that hinders the creation of systems for monitoring leakage currents, as well as systems for early detection of icy manifestations, is the complexity of organizing the power supply of information collection, processing and transmission devices placed on the supports of overhead power lines (OHPL). To date, energy-efficient algorithms for the operation of power sources of monitoring systems have not been developed, and there are no corresponding technical solutions for the power supply of system elements.

As you know, one of the most popular power sources for the remote monitoring system of overhead transmission lines today is solar panels [1].

The most important factor when choosing solar panels (SP) for remote monitoring systems of overhead transmission lines is its technical characteristics, that is, their efficiency and maximum coefficient of efficiency (CE), as well as its service life.

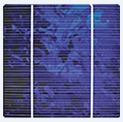
Overview and analysis of existing solar panels

Solar panels consist of solar photovoltaic cells connected to a common electrical circuit. Depending on the value of the coefficient of efficiency and geometric dimensions of the photovoltaic cell, three types of silicon SP are most popular: single-crystal (CE up to 21.5%), polycrystalline (CE 14-17%) and amorphous (CE 5-8%) [2]. According to the internal design, single-crystal silicon wafers are more efficient by 2-3% (Table 1).

As a result of the modernization of solar panels (SP), since 2019, it has been possible to increase the efficiency of silicon crystal panels by 15-20% and, accordingly, to increase the power output to the load. In clear sunny weather, silicon cells on 1 cm^2 of the area generates about 25 mA of electric current at a voltage of 0.5 V, which corresponds to 12-13 mW/cm^2. If compare silicon panels by type, the most widely used photovoltaic technology based on polycrystalline silicon (more than 60%) is currently used in the production of joint ventures on the world market [3]. Although monocrystalline silicon panels have excellent technical performance, due to the more expensive production process and the manufacture of high-quality (high-purity) silicon, this product is more expensive than other types. And also, not many companies can afford to produce a source product in this quality.

To increase the efficiency of photovoltaic cells

Table 1 – Electrical parameters and standard dimensions of silicon solar cells [2]

Type of solar cells	Size, mm	CE, %	Maximum power (RTMM), W	No-load voltage (UXX), V	Short-circuit current (IKZ), A
Polycrystalline SP 	156*156	16,4	3,99	0,618	8,27
		16,2	3,94	0,616	8,21
		15,0	3,65	0,607	7,77
Monocrystalline SP 	156*156	17,6	4,21	0,624	8,63
		17,4	4,16	0,623	8,57
		16,0	3,82	0,613	8,08
Monocrystalline SP 	125*125	17,4	2,59	0,621	5,35
		17,2	2,56	0,619	5,31
		16,0	2,38	0,607	5,08

in the joint venture, gallium arsenide (GaAs) is used [2, 4]. This element has a high efficiency (up to 28%). During operation, it was found that at high temperatures, the photovoltaic losses are lower than those of silicon solar panels. The project of the Swiss company «INSOLIGHT» has developed inexpensive roof solar panels with an efficiency of up to 29%. The high efficiency of the SP is achieved by using a combination of materials in the space industries and solar-concentrating lenses. Solar panels have a multi-junction structure, where several layers of gallium arsenide are combined with layers of indium-gallium phosphide and germanium. This structure allows you to increase the output power to the load per unit area. And also, to increase the optical concentration of the light flux on the photovoltaic cells, the surface of the SP will be covered with cells made of lenses, which will increase the efficiency at the same geometric dimensions [5].

The use of thin-film photovoltaic cells based on cadmium telluride (CdTe), copper-indium-diselinide ($CuInSe^2$) and hybrid methods increases the efficiency of solar panels [2].

Technical characteristics of mass-produced solar panels

Как известно, СП состоят из последователь-но и SP consist of series and parallel connected photovoltaic cells, as you well know. Commercially mass-produced SP have a power from 50 to 200 W (at maximum sunlight) [2, 4]. The efficiency of the SP stated in the passport is lower by 1-3%, this can be affected by glass reflection, shading, high temperature, etc., which have a significant impact on their technical characteristics.

The output power of the SP to the load is very much dependent on the magnitude of the luminous flux and the load. Due to the daily and seasonal fluctuations in the luminous flux, there is an uneven power supply when powered by the joint venture. In order to organize an uninterrupted power supply, the SP loads are completed with a battery and a charge controller.

Currently, solar panels have been investigated in real field conditions for different installations. As a result of the research, an analysis of the energy characteristics and resource of solar power plants operating in the United States and in Europe for 20 years was performed. The test results showed that the efficiency of the SP decreased by 10% every year [2].

As a result of industrial tests, it was found that the service life of the types of solar panels: monocrystalline solar panels serve from 30 years or more; polycrystalline panels usually work from 20 to more years; and amorphous from 7 to 20 years. Statistics show that thin-film panels in the first two years lose from 10% to 40% of power. And therefore, crystal silicon panels are mostly popular on the market (85-90%). Other components such as, storage battery from 2 to 15 years and power electronics from 5 to 20 years [2].

The power of the SP is almost proportional to the value of the illumination of the panels. For example, the power index of crystal panels is 150-200 W/m^2, amorphous about 100 W/m^2.

The efficiency values for various modifications of solar panels are shown in Table 2.

Conclusion

The conducted studies of solar panels according to various criteria (i.e., coefficient of efficiency, power, service life, price and availability) allowed us to conclude:

- for the power supply of remote monitoring systems of overhead power lines, in the conditions of

Kazakhstan, *crystal silicon solar panels* are most fully suitable;

- crystal silicon solar panels have higher efficiency and technical performance indicators: coefficient of efficiency reaches up to 24.7%, power on average from 150 to 200 W/m^2, service life of 20 years or more, as well as easily available in the sales market and relatively inexpensive.

Table 2 – Types of SP with the CE

Type of SP	Solar cell	CE
Silicon – Si	Crystal	24,7
	Polycrystal	20,3
	Thin-tape	16,6
	Thin-tape submodel	10,4
Gallium arsenide – GaAs	Crystal	25,1
	Thin-tape	24,5
	Polycrystal	18,2
Thin tape of chalcogenides – CIGS	Solar cell	19,9
	Submodel	16,6
Amorphous and nanocrystalline silicon – Si	Amorphous	9,5
	Nanocrystal	10,1
Photochemical	Based on organic dyes	10,4
	Based on organic dyes (submodel)	7,9
Organic	Organic polymer	5,15
Multi-layer	GaIn+GaAs+Ge	32
	GaIn+GaAs	30,3
	GaAs+CIS (thin-tape)	25,8
	a-Si+mc-Si (thin submodel)	11,7

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Электр берудің әуе желілерін қашықтықтан мониторингтеу жүйелері үшін электрмен қоректендіру көздерін құру мәселесі

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Аңдатпа. *Осы жұмыстың мақсаты – жүргізілген зерттеулер негізінде электр желілерінің қуат беру әуе жолы мониторингі жүйелеріне қызмет көрсету кезінде күн батареяларын таңдау бойынша ұсыныстар беру. Сериялық өндірілген күн батареяларының техникалық сипаттамалары қарастырылған. Қолданыстағы күн батареяларының түрлеріне толық шолу келтірілген. Олардың техникалық көрсеткіштері берілген, мысалы, тиімділік, бір шаршы алаңда өндірілетін қуат, қызмет ету мерзімі. Қолданыстағы күн панельдеріне талдау жүргізілді. Қазақстан аймақтары үшін әуе электр желілерін қашықтықтан бақылау жүйесін қуаттандыру үшін күн панельдерінің қолайлы түрі ұсынылады.*

Кілт сөздер: *қашықтан бақылау жүйесі, әуе электр желісі, күн панельдері, тиімділік коэффициенті, фотоэлектрлік элемент, қуат, қызмет мерзімі.*

Вопрос создания источников электропитания для систем удаленного мониторинга воздушных линий электропередач

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Аннотация. *Цель данной работы – на основе проведенных исследований дать рекомендации по выбору солнечных батарей при обслуживании систем мониторинга воздушных линий электропередач. Рассматриваются технические характеристики серийно выпускаемых солнечных батарей (СБ). Приведен полный обзор существующих видов солнечных батарей. Даны их технические показатели, такие как коэффициент полезного действия, вырабатываемая мощность на квадратную площадь, срок службы. Проанализированы существующие виды солнечных батарей. Предлагается подходящий тип солнечных батарей для питания системы удаленного мониторинга воздушных линий электропередач для регионов Казахстана – кристаллические кремниевые солнечные панели.*

Ключевые слова: *система удаленного мониторинга, воздушная линия электропередачи, солнечные панели, коэффициент полезного действия, фотоэлектрический элемент, мощность, срок службы.*

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