Damascus university journal
V… ( ): ??-??

مجلة جامعة دمشق للعلوم ....
المجلد ... العدد... : الصفحات.

أنظمة إمداد الطاقة ذات الكفاءة العالية للتكنولوجيا الطبية

أ.د. ياكيموفيتش باريس اناتوليفيتش[1]، أ. د. كوفشينوف فلاديمير فلاديسلافافيتش[2]، م. بيريزنياك ف.أ [3]، م.م. الرفيعي فائز متعب موسى [4]

[1] بروفيسور، جامعة سيفاستوبول الحكومية – روسيا، أنظمة ومجمعات الطاقة، BAYakimovich@sevsu.ru

[2] بروفيسور، جامعة سيفاستوبول الحكومية – روسيا، أنظمة ومجمعات الطاقة، kuvshinov.vladimir@gmail.com

[3] بروفيسور، جامعة سيفاستوبول الحكومية – روسيا، أنظمة ومجمعات الطاقة، kuvshinov.vladimir@gmail.com

[4*] مدرس مساعد، جامعة واسط – العراق، الهندسة الميكانيكية، fa99ez@mail.ru

الملخص:

لضمان التشغيل المستمر للمعدات الطبية، من الضروري استخدام مصادر طاقة موثوقة وغير منقطعة. تقترح هذه الورقة نظام إمداد طاقة محمول يعتمد على بطاريات قابلة لإعادة الشحن ونظام كهروضوئي لضمان تشغيل جهاز EMS. تستخدم اللوحة الكهروضوئية للنظام المعروض محولات سيليكون أشباه الموصلات مع أسطح استقبال معدلة بالنانو.

تاريخ الايداع
تاريخ القبول

Damascus university journal
V… ( ): ??-??

مجلة جامعة دمشق للعلوم ....
المجلد ... العدد... : الصفحات.

Highly efficient power supply systems for medical technology

Yakimovich B.A.(Dr)[1], Kuvshinov V.V.(Dr)[2], Bereznyak V.A.(PhD)[3],Al-Rufaee F.M.(PhD)[4]

[1] Professor, Sevastopol state university - Russia, energy systems and complexes energy systems and complexes, BAYakimovich@sevsu.ru

[2]Assistant professor, Sevastopol state university - Russia, energy systems and complexes, kuvshinov.vladimir@gmail.com

[3]PhD student,_Sevastopol state university - Russia, energy systems and complexes,

[4*]Assistant lecturer, Wasit University - Iraq, Mechanical engineering, fa99ez@mail.ru.

Received:
Accepted:

Abstract:
To guarantee continuous operation of medical equipment, it is essential to use dependable and uninterrupted power sources. This paper proposes a portable power supply system that is based on rechargeable batteries and a PV system to ensure the operation of EMS-apparatus. The photovoltaic panel of the presented system uses semiconductor silicon converters with nano-modified receiving surfaces.

Keywords: Photovoltaic panel, Nanomodified solar cell surface, EMS-apparatus, Rechargeable batteries, Solar generation system.

1. Introduction:

EMS-technologies are used to treat patients with muscular atrophy, musculoskeletal diseases, and injuries to joints and limbs. This contributes to increased treatment efficiency and patient recovery. Ensuring the quality operation of medical equipment is a crucial task for medical institutions, rehabilitation centres, temporary hospitals, and field sanitary facilities. This can be achieved through the use of energy-saving technologies and independent energy sources, particularly for EMS devices. It is important to maintain uninterrupted operation of medical equipment. The work proposes various types of power supplies for non-patient care settings that are independent of central power lines. These devices use renewable energy sources, specifically solar batteries with highly efficient photoconverters and energy storage systems. Therefore, many studies focus on solar energy harvesting for PV self-powered applications (Fig. 1)[1, 2]. These power systems do not replace the main generating capacity of medical institutions and do not complicate their operation. Instead, they effectively assist the operation of medical equipment in non-stationary conditions. Additionally, these systems do not emit harmful substances and contribute to improving the environment. Therefore, the proposed systems can be confidently referred to as reliable sources of power supply for low-power medical equipment. The use of backup power supply and energy storage systems based on photovoltaic energy sources in health care facilities can significantly reduce the negative effects of conventional fossil fuels. These systems can be either thermal or electrical energy storage systems or additional generating units. These systems can be installed both in medical centres and mobile hospitals and work together with stationary power plants, which allows them to be effectively used as alternative energy sources [3]. Of all types and kinds of low-power backup power supply systems, photovoltaic systems with energy storage fulfill the necessary requirements [4]. EMS-technologies are used to treat patients with muscular atrophy, musculoskeletal diseases, and injuries to joints and limbs. This contributes to increased treatment efficiency and patient recovery. Ensuring the quality operation of medical equipment is a crucial task for medical institutions, rehabilitation centres, temporary hospitals, and field sanitary facilities. This can be achieved through the use of energy-saving technologies and independent energy sources, particularly for EMS devices. It is important to maintain uninterrupted operation of medical equipment. The work proposes various types of power supplies for non-patient care settings that are independent of central power lines. These devices use renewable energy sources, specifically solar batteries with highly efficient photoconverters and energy storage systems. Therefore, many studies focus on solar energy harvesting for PV self-powered applications (Fig. 1)[1, 2]. These power systems do not replace the main generating capacity of medical institutions and do not complicate their operation. Instead, they effectively assist the operation of medical equipment in non-stationary conditions. Additionally, these systems do not emit harmful substances and contribute to improving the environment. Therefore, the proposed systems can be confidently referred to as reliable sources of power supply for low-power medical equipment. The use of backup power supply and energy storage systems based on photovoltaic energy sources in health care facilities can significantly reduce the negative effects of conventional fossil fuels. These systems can be either thermal or electrical energy storage systems or additional generating units. These systems can be installed both in medical centres and mobile hospitals and work together with stationary power plants, which allows them to be effectively used as alternative energy sources [3]. Of all types and kinds of low-power backup power supply systems, photovoltaic systems with energy storage fulfill the necessary requirements [4].

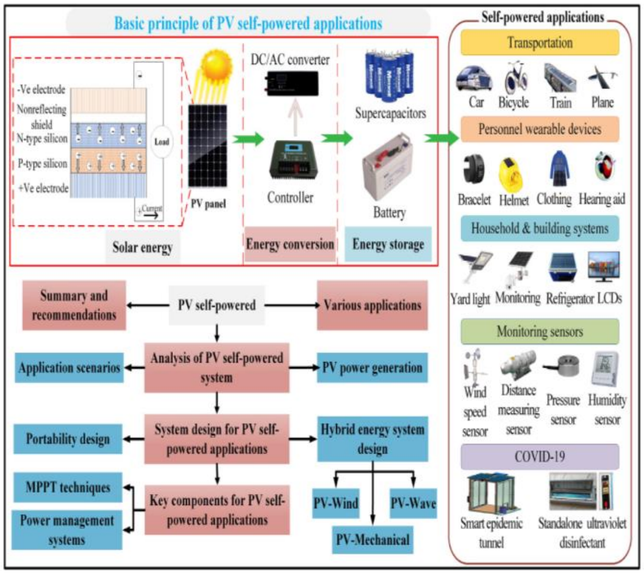

Figure 1 - Architecture of PV technologies [2].

2. Material and Methods:

When operating energy complexes to supply medical institutions, it is necessary to have some reserve power at all times in order to reduce the negative impact of power shortages, as well as in the event of frequent disconnections of centralized power supplies or the absence of a common power grid. The necessary energy is stored in batteries or other back-up storage devices. The required energy can be obtained either from the general grid or by using generating solar power installations [5]. A solar charging station based on photovoltaic converters and Batteries is an effective solution to provide electricity to hospitals and treatment infrastructure. The proposed standby power supply system's consist of a hybrid power system equipped with various power generators: low-power photovoltaic panels, compact solar cells, portable generators in containers, as well as a system of electricity storage and distribution [6]. The main advantages of such installations are their mobility and compactness. The aim of this work was to ensure the quality operation of medical equipment by utilizing high-efficiency solar cells and energy storage devices. This would enable uninterrupted operation of various low-power medical equipment and EMS-apparatuses. To achieve this goal, high-efficiency silicon photoconverters with nanomodified surfaces and battery for uninterrupted power supply. The systems proposed in this work are designed for continuous use in non-patient environments and can be relocated outside medical facilities. To achieve this, photoconverters with enhanced energy performance were selected [7]. The aim of this study was to develop an energy-efficient solar panel for charging, based on a photovoltaic converter with a nanomodified receiving surface [8]. This panel could be used to ensure uninterrupted operation of the EMS device shown in Fig. 2. The electrical performance of photoconverters, battery capacity, and the number of solar cells are the main technical parameters that determine the quantitative, qualitative, and cost characteristics of the products. In this study, a 300 W photovoltaic panel was used to charge the battery. The panel consisted of nanomodified photovoltaic cells, a charge-discharge controller, and other auxiliary equipment. The silicon nanomodified cells presented in this study were processed in the laboratory of spark plasma sintering at MSTU 'Stankin' in Moscow. They exhibit high performance characteristics, including increased efficiency, protection against overheating, and increased hardness.

Figure 2 - External view of EMS-apparatus (Electric Mio Stimulation)

Damascus university journal
V… ( ): ??-??

مجلة جامعة دمشق للعلوم ....
المجلد ... العدد... : الصفحات.

The devices used enable compliance with all design requirements, including technological, reliability, operational, maintenance, repair, storage, packaging, labelling, and transportation requirements for medical equipment. The laboratory of Spark Plasma Sintering at MSTU 'Stankin' has developed elements with improved performance characteristics. Specifically, these elements exhibit greater heat resistance, significantly higher impact resistance compared to conventional silicon elements, and a 20% increase in efficiency value compared to unmodified elements. Additionally, these elements are more resistant to transport and experience less degradation during operation.

3. Results and Discussion:

To provide stable power generation and reliability of the charging system, a combined photovoltaic system with energy storage was used. As previously stated in this work, field tests were conducted on the 300 W PV systems, consisting of photovoltaic panels (each with a capacity of 300 W), a 40 Ah battery, inverters, and other equipment (Fig. 3). This system can be connected to the grid and operate autonomously. The compact size of the system enables it to be easily transported and used in the field. Additionally, the high-quality photovoltaic converters greatly enhance work efficiency.

Figure 3 - Basic equipment for the backup power supply system of medical equipment and EMS-apparatus

During the research process, we conducted full-scale experimental studies on the operation of the system. To increase the efficiency of solar plant operation and reduce electricity losses, it is essential to optimize the use of both main and auxiliary equipment [5]. Therefore, we conducted experimental studies on the plant's operation. Figure 4 displays the power characteristics of a single module in a 300 W solar plant during summer months under varying illumination.

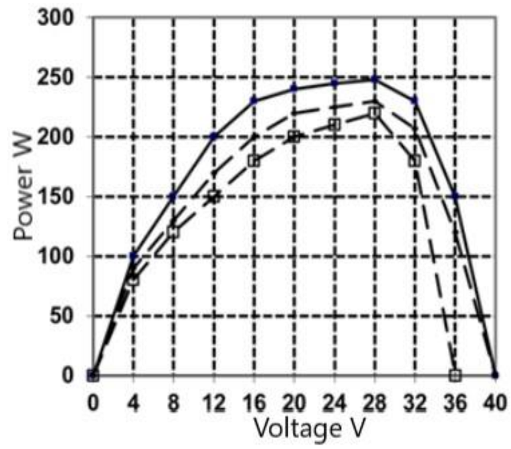

Figure 4 - Power characteristics of a 300 W photovoltaic panel.

For the operation of the backup system as an energy storage device the accumulator batteries were used. Through experimentation, we obtained data on the charging capacity of the battery in relation to charging time (refer to Fig. 5). The graph shows that the battery reaches 15% of its nominal capacity after 1 hour of charging. It takes 8-14 hours to charge the battery from 30% to 98% of its capacity. For qualitative analysis of energy storage, it is necessary to check the parameters of the charging current, which corresponds to the capacity divided by 10.6, time required to charge up to 98% is up to 10 hours.

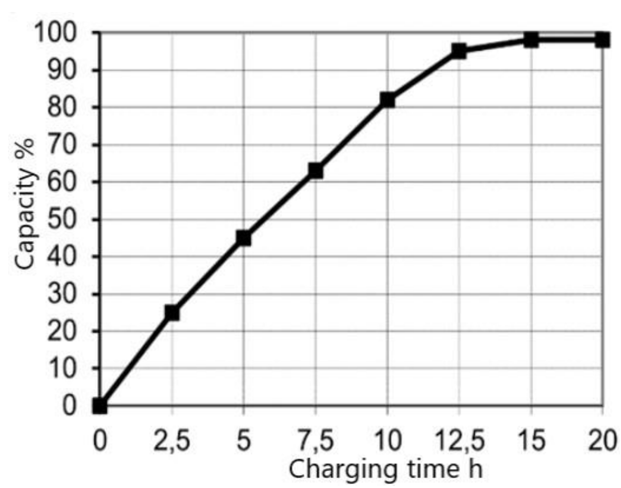

Figure 5 - The dependence of the relative charge capacity on time.

To determine the sufficient percentage of charge, it is necessary to carry out experimental testing of the dependence of the charging current on the solar radiation flux falling on the working surface of the panel. In this case, the angular coefficient was assumed to be about 0.8. I.e., the irradiance is about 800 W/m2, the charging current characteristic is shown in Fig. 6.

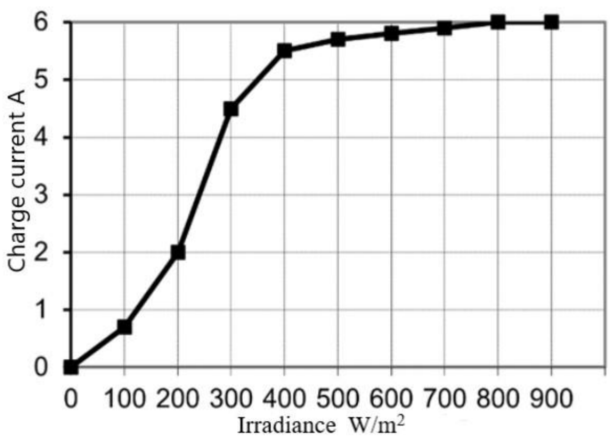

Figure 6 - The dependence of the charge current on the irradiance

These studies are very significant for further calculations of charging and operation of the battery station in combination with photovoltaic modules used as uninterrupted power supplies for medical equipment. The use of the proposed systems makes it possible to provide autonomous power supply both for own needs and for stationary objects. The use of photovoltaic units as generation systems provides reliable operation of medical equipment in the absence of central power supply. The proposed backup power supply systems do not replace the main generating capacities and do not complicate their operation, while they effectively assist their operation. Also, these systems do not produce harmful emissions and improve the environment.

Conclusions: The research results suggest that an system for powering medical equipment has been proposed, using photovoltaic systems with energy storage when working together with the centralised grid. The batteries can be charged either from solar energy or from the general grid. The use of independent power supply allows the medical equipment to be used in the field. This work proposes high-quality solar cells with increased efficiency and quality characteristics such as protection against degradation, utilization of the diffused solar radiation flux, and prevention of overheating of the working surface.

The article proposes a methodology for using different sources to accumulate and generate electric energy, specifically focusing on the use of backup and uninterruptible power sources for medical equipment. The use of renewable energy sources to power medical equipment is an important task in many regions, as it improves the environment and reduces dependence on traditional fossil fuels.

4. References:

1. Increasing the efficiency of solar and wind power plants through the use of energy storage devices // Kuvshinov V.V., Kakushina E.G., Vlasov N.A., Bereznyak V.A., Ghashim M. /Energeticheskiye ustanovki i tekhnologii, 2022, vol. 8(1). pp. 90-95. (Russian)

2. Daning Hao, et al. Solar energy harvesting technologies for PV self-powered applications: A comprehensive review, Renewable Energy, 2022, Vol. 188, pp. 678-697.

3. Use of photoelectric converters as power sources for medical equipment Kuvshinov V.V., Matveev Yu.V., Bereznyak V.A., Smirnov V.V., Timan D.I. Yestestvennyye i tekhnicheskiye nauki, 2023. vol. 1 (176). pp. 166-168. (Russian)

4. Rauschenbach G. Handbook for the design of solar panels. M.: Energoatomizdat, 1983. 397 p. (Russian)

5. Kuvshinov, V.V., Morozova, N.V. / Possibilities for increasing the power characteristics of solar installations for use in the energy sector of Crimea // M.: Sputnik+, 2017. 175 p.

6. Photovoltaic devices made of crystalline silicon. Method for correcting the results of measuring the current-voltage characteristic (IEC 891-87): GOST 28976-91. – [Input. 04/19/91]. – M.: IPK Publishing House of Standards, 2004. – 42 p.

7. Vasiliev A.M., Kukushkin D.Yu., Trofimov V.V. Deposition of metal nanoclusters from colloidal solutions onto the surface of porous roll materials using electrophoresis // Izvestiya RAN. seriya fizicheskaya, 2019 volume, vol. 12(83), pp. 1670–1674.

8. Possibilities of increasing the power of photoelectric converters by modifying their surfaces with silver nanoclusters / Kuvshinov V.V., Krit B.L., Morozova N.V., Kukushkin D.Yu., Savkin A.V. // Vektor nauki Tol'yattinskogo gosudarstvennogo universiteta, 2018, vol. 1 (43), pp. 36-42.