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DEVELOPMENT OF AN AUTOMATED PHOTOVOLTAIC SYSTEM WITH WIRELESS MONITORING

Abstract. The work is devoted to the development of an efficient photovoltaic installation with automated wireless monitoring based on the LabView software. Long-distance communication technology - LoRa was used to wirelessly transmit data on the output characteristic states of the photovoltaic installation, storage battery and built-in sensors. This module operates at 433 MHz and transmits small data packets with low power consumption. This makes the stand-alone system energy efficient compared to similar wireless installations. The graphical software LabView was chosen to monitor the state of the developed system. The paper shows a block diagram of an automated wireless system, an operational algorithm of the external transmitting part of the installation, as well as electrical circuits of the transmitting and receiving control units. As a result of the work, a photovoltaic system with an automated wireless monitoring system and graphical data display was developed. The developed automated complex is more efficient and easy to use in comparison with other systems.

Key words: Wireless monitoring, solar panel, battery, current and voltage sensor.

Introduction. With the rapid development of wireless communication technologies through the use of microcontrollers and other communication devices, many industrial processes are controlled by automated systems, which in turn reduce human effort. Automated systems are managed and monitored via wired and wireless communication networks.Wireless automated systems - a complex of software and hardware that enables computer systems and communication devices to function without human intervention. The operations of an automated system are part of the automatic control of a system in which the processes are fully automated with support for control loops and special logic [1-3].

The use of wireless automated systems saves labor, time and money, increasing the accuracy of the work performed. This increases the availability, performance, and reliability of the services provided. Today, the use of such installations in photovoltaic systems is one of the most promising areas. Wireless monitoring is considered an important aspect to monitor the stability and performance of a photovoltaic system. The photovoltaic monitoring system can be used in solar-powered cars, solar-powered buses, solar-powered trains, etc. [4].

In the articles [5,6], the authors designed the design of a simple, cost-effective and low-power wireless monitoring system for photovoltaic installations. XBee RF modules were chosen as wireless receiving and transmitting devices. Also, based on the ZigBee and LoRa wireless modules, research works were carried out for online monitoring of the photovoltaic system [7-11].

The software of the automated system is an important part of this research work. In scientific articles [12-17], monitoring systems based on LabView software were developed. The authors claim that the LabView program can accurately monitor the state of sensors in real time.

Analyzing these materials, we can say that all the developed systems are aimed at improving energy efficiency, reducing the proportion of human intervention in the workflow.

This article presents an automated system of photovoltaic installations with wireless monitoring based on LabView software. The LoRa wireless module was chosen to build the communication network. As a result of the research work, an automated photovoltaic system with wireless monitoring was built, and an algorithm for the operation of the General system was developed. Experimental data on the effectiveness of the developed system were obtained.

Design of an automated photovoltaic system with wireless monitoring.

Block diagram of an automated system with wireless monitoring. The block diagram of an automated system with wireless monitoring is shown in figure 1. The photovoltaic installation (1) is controlled through the control unit (2). Control electronic unit contains a programmable logic controller, where the algorithm of operation of the general installation is loaded. The generated electrical energy is stored in the battery pack (3). The batteries are charged using the battery charge controller. At the output of the solar panel, as well as at the output of the battery charge controller, an ammeter and voltmeter (4) are installed, which measure the output electrical characteristics of the devices, transmits data to the microcontroller (5).The microcontroller, in turn, after processing all the received data, sends the data todispatcher via the wireless module LoRa E32 (6). At the receiving part of the dispatcher device also has a wireless module E32 LoRa (8). The communication channel between the receiver and the transmitter (7) is publicly available on the territory of the Republic of Kazakhstan. The wireless receiving module is directly connected via a USB 2.0 cable to a personal computer (9), where you can monitor the overall operation of the installation using LabView software.

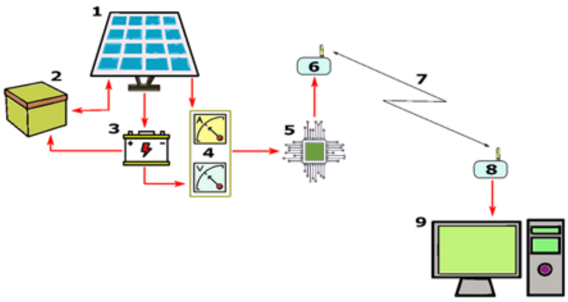
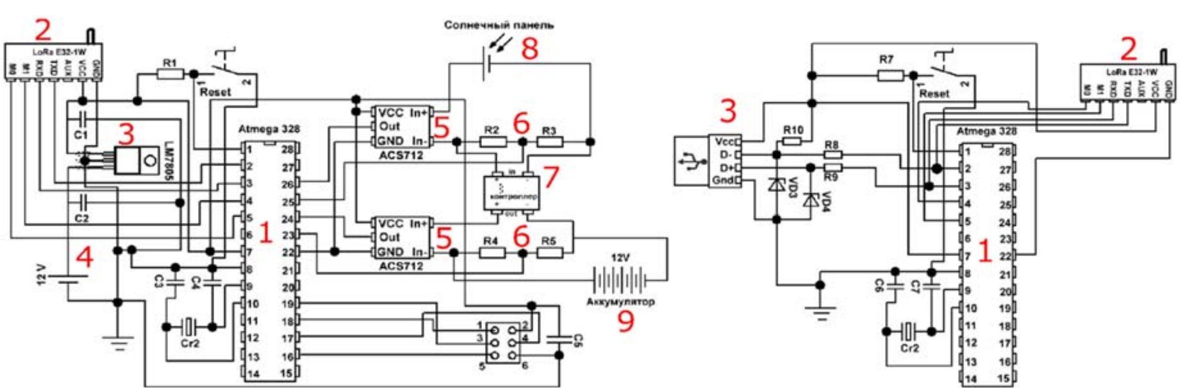


Figure 1 – Structure of the automated wireless monitoring system

Control electronic unit of the system. Figure 2 shows the electronic components of the transmitting and receiving parts of the automated wireless monitoring system. Figure 2 a shows an 8-bit Atmega328PU (1) microcontroller, which uses the developed algorithm to control all electronic components in the device. The unit is powered by a 12 V battery (4), via a voltage stabilizer LM7805 (3). The output electrical values of the solar panel (8) and the battery charge controller (7) are measured through an ACS712 ammeter (5) and a voltmeter made on the basis of a voltage divider (6). The data received from the sensors is processed in the microcontroller and sent to the dispatcher via the LoRa E32 (2) wireless module.

Figure 2 b shows the electrical diagram of the receiving part (dispatcher) of the system. Here, the LoRa E32 wireless module (2) and the Atmega328 PU microcontroller (1) are connected to the personal computer via USB 2.0 (3) cables.



a) b)

Figure 2 – Electronic components of an automated wireless monitoring system: a) transmitting part; b) receiving part

Algorithm of the general system operation. Figure 3 shows the algorithm of the automated wireless monitoring system.

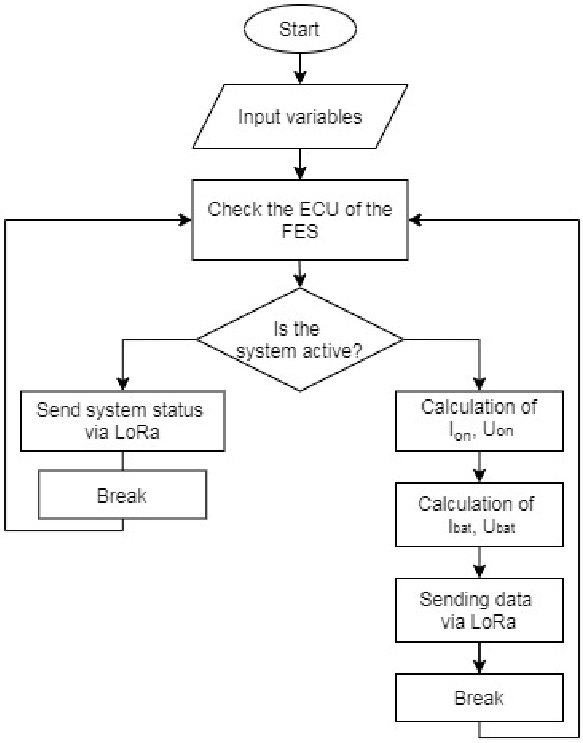


Figure 3 – Algorithm of operation of the automated wireless monitoring system

The built-in microcontroller works according to the specified software algorithm. At the first stage of the system operation, the microcontroller enters the operating mode. Next, enter the desired i/o ports of the microcontroller and variables. After that, the controller checks the activity of the electronic control unit (ECU) of the photovoltaic system (FES). If the system has not yet been activated, the controller sends a packet about the disabled state of the system and goes into sleep mode for a certain time. And if the system has switched to operating mode, the microcontroller takes measurements using the installed sensors and sends them to the dispatcher via the LoRa E32 wireless module. Then the microcontroller goes into sleep mode for a certain time.

Results and discussion. The monitoring interface of the automated wireless photovoltaic system was built on the basis of the LabView graphical software. As a result of the experiment, the electrical characteristics of the solar panel and battery were obtained and displayed on the dispatcher's monitor. Figure 4 shows the interface (front panel) of a wireless automated system.

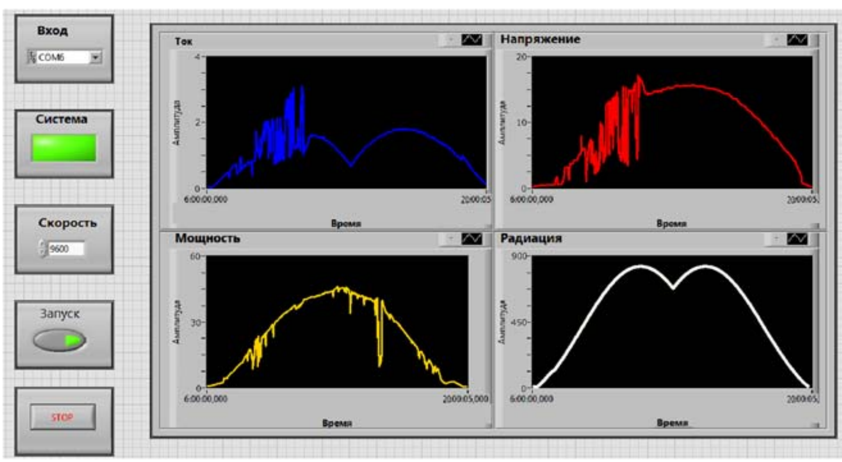


Figure 4 – Wireless monitoring system interface

The main window contains the input port, where you can select the port number of the computer connected to the external device. If the system is activated, the monitor indicator will turn green. Next, the speed of information exchange between the device and the computer is set. Below are the locking buttons for starting and interrupting the system. On the right side of the monitor are graphical indicators that show the electrical characteristics of the system: the current and voltage of the solar panel, the power of the solar panel, and the level of solar radiation W/m^2.All data obtained as a result of the experiment will be automatically saved in text format on the local PC.

Figure 5 shows the graphical (virtual) elements of the LabView program connected between (block diagram).

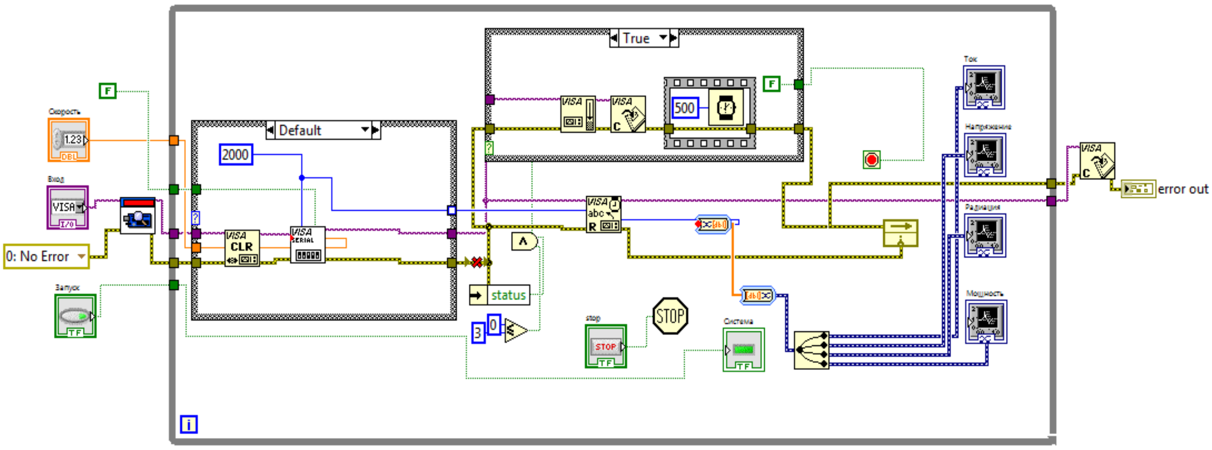


Figure 5 – Block diagram of LabView program

Separate graphs from the LabView program are shown below. Figure 6 shows a graph of the current and voltage generated at the output of a photovoltaic panel during one day. Here, the red line indicates the voltage, and the blue line indicates the current of the photovoltaic panel.

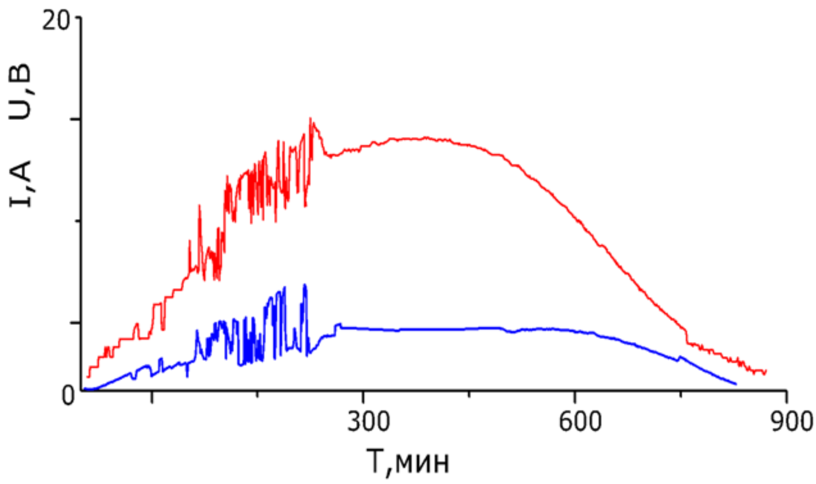


Figure 6 – Graph of the current and voltage of the photovoltaic panel

Figure 7 shows a graph of solar radiation over a single day. Since our radiation sensor is mounted on a single-axis tracker, you can see from the graph that in the middle of the day, the energy decreases due to the height of the sun coordinate location.

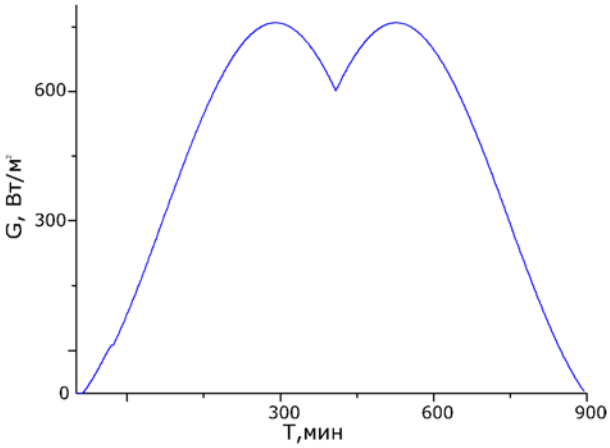


Figure 7 – Graph of solar radiation

Conclusion. During the research work, an automated wireless monitoring system for the photovoltaic system was developed and manufactured using an interface based on the LabView software. Data on the generation of solar energy and solar radiation during the day were obtained in the form of graphs in the LabView environment. The developed automated system reduces human involvement in the monitoring process and is easy to use. Installed electronic components consume a small amount of energy.

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СЫМСЫЗ МОНИТОРИНГ НЕГІЗІНДЕГІ АВТОМАТТАНДЫРЫЛҒАН ФОТОЭЛЕКТРЛІК ЖҮЙЕ ЖАСАУ

Аннотация. Ғылыми жұмыс LabView бағдарламалық жасақтама негізінде құрылған автоматтандырылған сымсыз бақылауы бар тиімді фотоэлектрлік қондырғыны әзірлеуге арналған. Фотоэлектрлік қондырғының шығыс сипаттамасын, аккумуляторлы батареяның және орнатылған сенсорлы құрылғылар күйін сымсыз байланыс жүйесі арқылы жіберу үшін LoRa ұзақ қашықтықтағы байланыс технологиясы қолданылды. Бұл модуль 433 МГц жиілікте жұмыс істейді және электр қуатын азырақ тұтыну арқылы шағын деректер пакетін жібере алады. Бұл ұқсас сымсыз қондырғылармен салыстырғанда автономды жүйені энергияны үнемдейді.

Әзірленген жүйенің күйін бақылау үшін LabVIEW графикалық бағдарламалық жасақтама таңдалды. Жұмыста автоматтандырылған сымсыз жүйенің блок-схемасы, қондырғының сыртқы ақпарат тарату бөлігінің жұмыс алгоритмі, сондай-ақ басқару блоктары, қабылдау-тарату бөлігі, электр схемалары көрсетілген.. Жұмыс нәтижесінде автоматтандырылған сымсыз бақылау жүйесі және деректерді графикалық түрде көрсететін фотоэлектрлік жүйе жасалды. Сондай-ақ, бір күн ішінде фотоэлектрлік панельдің шығысында пайда болатын күн радиациясы, ток және кернеу графиктері алынды. Әзірленген автоматтандырылған кешен басқа жүйелермен салыстырғанда тиімдірек және қолдануға оңай. Автоматтандырылған кешен адамның мониторинг үдерісіне қатысуын азайтады. Орнатылған электрондық компоненттер аз мөлшерде энергия тұтынады.

Түйін сөздер: сымсыз мониторинг, күн панелі, аккумулятор, ток пен кернеу құрылғылары.

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РАЗРАБОТКА АВТОМАТИЗИРОВАННОЙ ФОТОЭЛЕКТРИЧЕСКОЙ СИСТЕМЫ С БЕСПРОВОДНЫМ МОНИТОРИНГОМ

Аннотация. Работа посвящена разработке эффективной фотоэлектрической установки с автоматизированным беспроводным мониторингом на основе програмного обеспечене LabView. Для осуществление беспроводной передачи данных состояний выходной характеристики фотоэлектрической установки,

аккумуляторной батареи и встроенных датчиков использовалась технология связи на большие расстояния – LoRa. Данный модуль работает на частоте 433 МГц и передает небольшие пакеты данных с невысоким энергопотреблением. Это делает автономную систему энергоэффективной по сравнению с аналогичными беспроводными установками.

Для мониторинга состояние разработанной системы было выбрано графическое програмное обеспечение LabView. В работе показана блок-схема автоматизированной беспроводной системы, алгоритм работы внешней передающей части установки, а также электрические схемы приемо-передающей части блоков управления. В результате работы была разработана фотоэлектрическая система с автоматизиро-ванной беспроводной системой мониторинга и графическим отображением данных. Также были взяты отдельные графики солнечной радиации, тока и напряжение, генерируемое на выходе фотоэлектрической панели в течение одного дня. Разработанный автоматизированный комплекс по сравнению с остальными системами является более эффективным и простым в использовании. Автоматизированный комплекс снижает вовлеченность человека в процесс мониторинга. Установленные электронные компоненты потребляют незначительное количество энергии.

Ключевые слова: беспроводной мониторинг, солнечная панель, аккумулятор, датчики тока и напряжение.

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