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Abstract— Monitoring systems are the most important part of modern solar power stations. Article contains the description of the existing monitoring systems, and their shortcomings are given. It is shown that as an alternative way of transfer of measuring information to the server there can be use of a radio network of the IEEE 802.15.4/ZigBee standard. Advantages of the wireless solar power plant monitoring system constructed on mesh topology based on wireless transceivers of this standard are described. The structure of such system and possible functionality is presented.

Index terms—Solar panel; mesh-network; monitoring system; IEEE 802.15.4.

I. INTRODUCTION

In recent years, the concept of "renewable energy sources" has become extremely popular. The estimates of their wide application range from enthusiastic to moderately pessimistic. Renewable energy sources usually include solar, wind and geothermal energy, the energy of sea tides and waves, biomass energy (plants, time-personal organic waste), and the energy of rivers.

Solar energy-the most grandiose, cheap, but also, probably, the least used by the person a source of energy. Interest in the problem of solar energy use has been growing recently. The potential of energy based on direct solar radiation is extremely large.

Solar energy belongs to the most material-intensive types of energy production. Large-scale use of solar energy entails a huge increase in the need for materials, and, therefore, in the workforce for the extraction of raw materials, its production, production of materials, the manufacture of heliostat, collectors, Other equipment, their transportation. In this regard, the payback period of solar power plants is very stretched-in time. In spite of this, scientists and energy continue to work on the search for cheaper possibilities of using solar energy. New ideas, new projects are emerging. As one of the ways to increase efficiency and reduce the time of solar power plants, there is a development of improved monitoring and control systems.

II. PROBLEM STATEMENT

Solar power Plant In addition to being the most ecologically clean, does not require particularly large investments. The amount of necessary equipment is determined by the required power. Solar energy plants can be:

- Small power, for example, to charge the battery during the daytime and power the street lamp in the dark;
- Medium power-to provide electricity to the private house;
- Large and over-high power for industrial power generation and its sale.

Many private entrepreneurs build their own solar power plants of medium and sometimes large capacity for the full energy independence of their homes, as well as the sale of surplus electricity to the network [1].

For solar power plants a monitoring system is required that allows to collect the metric of the installation work for the purpose of fault control, analysis and prediction of the efficiency of the installation. The most important parts of the monitoring systems are the possibility of remote access to it through cloud services, collection and timely transfer of information on the operation of the whole system and its parts (solar panels), alarm in case of breakage of any parts of the system, issuing warnings about the reduction of efficiency of work, as well as the ability to predict the output power and calculation of profits at the "green tariff".

As a rule, the standard modern monitoring system allows to determine the voltage, current and power of the solar power plant as a whole or groups of panels. There are also systems that allow you to control the operation of each solar panel separately. In our time on the market of systems of solar power installations the systems that are counted both on small power, and on big are offered. By the nature of electric current transmission, all existing systems can be divided into:

- Systems that transmit the electric current from array of panels to the battery or inverter, without preliminary conversion from DC to AC.

– Systems, which are convert a DC into AC using installed on each solar panel microinverters, AC at the output of the system through a special filter can connect directly to the external electrical network.

To transmit the measurement information to the main server, all existing monitoring systems use different interfaces and communication technologies.

Wired digital interfaces such as Ethernet, RS-485, CAN, etc. allow you to connect multiple devices to a single bus and provide a high-speed full-duplex mode of communication between the server and measuring sensors, but it requires a lot of cable, additional switches and sockets. Also all this requires a reliable and powerful power supply.

If you use wireless digital interfaces that use the star topology such as GPRS, Bluetooth, Wi-Fi, etc., you need to install additional repeaters and signal amplifiers to increase the coverage area. This also implies an increase in energy consumption. The use of a common cellular network GPRS is extremely risky, as the system becomes dependent on failures in the operation of the external mobile operator.

The communication technology, called PLC (Power line Communication), is to transmit data by power lines of direct or alternating current. The voltage in the network, which was generated by solar panels, is used as a carrier frequency for the modulation of the useful signal. At the output of the system, this useful signal is filtered by a special monitoring device, and the carrier is additionally skipped through the filter, after which comes to the consumer or the common electrical network. Despite the fact that this technology allows you to get rid of additional wires, it requires quite complex modulation and demodulation schemes, as well as additional filters. This greatly increases the cost and power consumption of the system. There is also a limit on the number of connected devices.

Based on the above, the shortcomings of the existing monitoring systems are:

– Complexity of the system when it is necessary to control the parameters of each solar panel separately. The number of wires, powerful transceivers, micro-conductors or additional devices increases, which increases the cost of the system and increases power consumption.

– If the total power line feeds the measuring devices, it is impossible to counter the system performance in the dark hours. If there is an accident or breakage of the line of communication, the dispatcher can learn about it only in the daytime, during intensive solar radiation, when the micro-inverter or other monitoring device will be able

to enter and transfer information to the server. Using a separate power supply for all devices requires additional wiring and increases power consumption.

– Complexity when scaling the system.

The reduction of energy consumption of the solar power plant monitoring system bears a low economic effect, as each saved watt of energy has its cost and can be sold at the "Green tariff". The lower the power consumption, the shorter the payback period.

III. USING THE IEEE 802.15.4/ZIGBEE WIRELESS NETWORK

The solar power plant monitoring system can be built on the basis of IEEE 802.15.4/zigbee wireless technology. This standard describes the exchange of data on the radio channel and is oriented to use in wireless sensory networks (WSN, wireless Sensor Networks), as well as low power consumption [2]. Wireless sensory networks are characterized by the transfer of small amounts of data with high transmission reliability. Each device on such a network can be in sleep mode most of the time and wake up periodically to transmit data to the server. This significantly reduces the power consumption of the device, which allows it to be powered by a battery that will charge in the daytime and gradually nourish the device at night or in the case of weak sunlight.

Today, many electronics manufacturers offer their solutions to work with WSN. There is a large selection of radio modules designed to work in the IEEE 802.15.4/ZigBee standard, low power consumption, as well as use in harsh weather conditions, which is appropriate for solar power plants. Such radio modules, as a rule, combine the transceiver chip, built-in PCB or chip-antenna or connector for external antenna, all necessary auxiliary protective and filtering electronic components. There is also a module, with a built-in microcontroller with necessary my peripherals, which is available to write to its own developer program. Examples of such radio modules include the Zigbit series from Microchip or the Xbee modules from the Digi company.

The reliability of data transmission in such a network is ensured by using a network topology called mesh or mesh, which is supported by the IEEE 802.15.4/ZigBee standard (Fig. 1). A Mesh network assumes that each node of the network can share information with neighboring nodes within reach. If you want to send a message to a host outside of the visibility zone (for example, the server), the messages are passed through a chain from one node to another. Different routing protocols are used. This ensures that messages from the sender's host to the

site are delivered to the recipient. If the package is lost, the standard provides for a re-transfer.

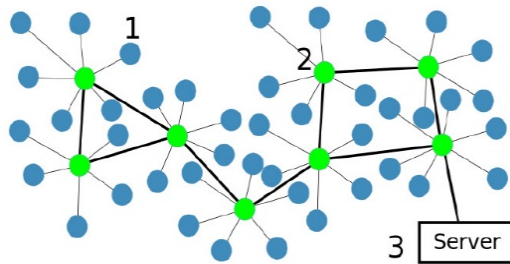


Fig. 1. Mesh Network: 1 is the Target device; 2 is the router; 3 is the Coordinator

Each node in this case acts as a router and a target device. In this case, each device can work in the "Sleep router" mode, thus saving battery power.

IV. STRUCTURE OF A WIRELESS MONITORING SYSTEM

Figure 2 shows the structural scheme of the solar power supply monitoring system. On each solar panel, a monitoring device with the necessary set of sensors is installed in the gap of DC output circuit. Because solar panels are usually located next to each other, they form a mesh network where the transceiver of each node needs to be in a common area of visibility with one or more adjacent nodes. This allows the use of low-power transceivers using a simple PCB-antenna.

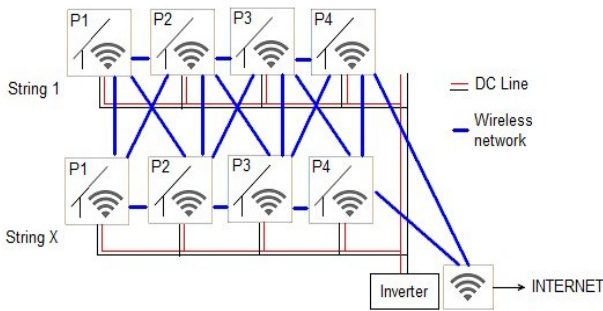


Fig. 2. Block diagram of monitoring system

The system provides a central device with a higher power transceiver. This device acts as a coordinator or server for the entire mesh network. On the other hand, the server has an Internet connection where, using cloud services, you can access the monitoring system from anywhere on the planet and from any device.

The monitoring device (Fig. 3) consists of: a) unit of voltage, current and temperature sensors; b) power management and battery charging schemes; c) a small battery; d) Transceiver and Controller micro-controller (RF module) with the necessary ACA of analog inputs for sensor connection.

If you design a monitoring device to connect panels with multiple channels to a single set of sensors with a microcontroller, you can further save on energy consumption and the cost of the device.

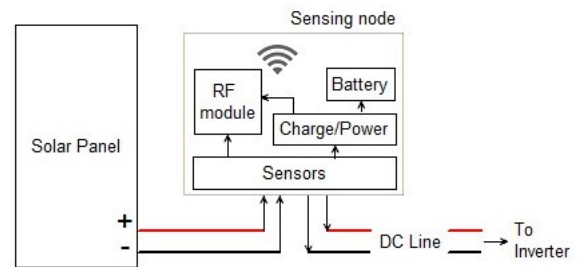


Fig. 3. Structure of the device of monitoring

If you design a monitoring device to connect panels with multiple channels to a single set of sensors with a microcontroller, you can further save on energy consumption and the cost of the device.

V. CONCLUSION

The proposed principle of the built-in monitoring system of solar power supply based on wireless transceivers of standard IEEE 802.15.4/ZigBee and mesh topology has a number of advantages in comparison with systems where transmission Telemetric information is transmitted by wire or radio channel with the "Star" topology.

The solar station is easy to scale by adding or removing new devices into a mesh network. It does not require additional actions related to the reconfiguration of the system. Everything can be executed automatically at the program level.

One of the main advantages of the offered system is low power consumption of devices that allows to use small and cheap accumulators. This allows you to monitor system health 24/7. In case the battery is close to the full discharge (for example, if there was not enough sunlight for a long time), the system can charge them by going to the charging mode of these accumulators by feeding the current to the DC line in reverse Direction.

Due to the possibility of two-way communication between the server and the network node or between several nodes it is possible to develop new unique functions of the system.

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В. М. Синєглазов, Є. В. Даскал. Бездротова система моніторингу сонячної енергетичної установки
Системи моніторингу сонячних енергетичних установок є найважливішою частиною со-тимчасових сонячних електростанцій. У статті міститься опис існуючих систем моніторингу, та наведені їх недоліки. Показано, що в якості альтернативного способу передачі вимірювальної інформації на сервер може бути використання радіомережі стандарту IEEE 802.15.4 / ZigBee. Описано переваги системи моніторингу сонячної електростанційці, побудованої по топології Mesh на основі бездротових радіомодулів цього стандарту. Представлена структура такої системи, а також можливий функціонал.
Ключові слова: сонячна електростанція; mesh-мережа; система моніторингу; IEEE 802.15.4.

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В. М. Синєглазов, Є. В. Даскал. Беспроводная система мониторинга солнечной энергетической установки
Системы мониторинга солнечных энергетических установок являются важнейшей частью современных солнечных электростанций. В статье содержится описание существующих систем мониторинга, и приведены их недостатки. Показано, что в качестве альтернативного способа передачи измерительной информации на сервер может быть использование радиосети стандарта IEEE 802.15.4/ZigBee. Описаны преимущества системы мониторинга солнечной электростанции, построенной по топологии Mesh на основе беспроводных радиомодулей этого стандарта. Представлена структура такой системы, а также возможный функционал.
Ключевые слова: солнечная электростанция; mesh-сеть; система мониторинга; IEEE 802.15.4.

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