MODELING OF MONITORING SYSTEMS OF SOLAR POWER STATIONS FOR TELECOMMUNICATION FACILITIES BASED ON WIRELESS NETS

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MODELING OF MONITORING SYSTEMS OF SOLAR POWER STATIONS FOR TELECOMMUNICATION FACILITIES BASED ON WIRELESS NETS

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Abstract: In this paper described of modelling processes of the real-time remote monitoring system of solar power sources, modelled and investigated by wireless sensor nets of telecommunications devices. As a modelling environment was obtained Proteus software. In processes of modelling of the system, structure and a block diagram of the system were developed, each of elements is deleted to parts of the system and separately described. Specially created software for the research system. The structure of the system developed and software tested by modelling processes. The results of modelling of monitoring system presented in a virtual terminal, an oscillography, and a local web browser.

Keywords: Arduino board, Communication, real-time monitoring, solar power stations, monitoring, wireless remote control, WSN, ZigBee.

1. Introduction

Presently Smart Grid - smart energy systems are using to provide a stable and high-quality power supply of telecommunication facilities. This leads to solving many problems, including remote monitoring, two-way information systems, energy consumption controls, demand to increasing energy, to provide reliability and security [1,11].

Real-time remote monitoring of solar power sources of telecommunication devices through wireless sensor nets are basis of Smart Grid power supply system’s [2,14].
For real-time remote monitoring of solar power sources of telecommunication devices through wireless sensor nets is required remote monitoring of solar panel voltage, current, light illumination, dusting, environment and battery temperature, battery current, battery voltage, and other types of measurements of telecommunication devices. In remote monitoring of solar power sources through wireless sensor nets, controller devices unit (CDU) receives relevant data from each sensor (how it is used in real-time, in hours, in days, in weeks, etc.) [5].

The resulting data usually transferred to database (DB) and provide to personnel by mobile communication via the Arduino Ethernet module or Arduino GSM module, view as SMS, as web pages and other forms [6].

The collected data about operating mode during monitoring will be sent to monitoring center, where responsible person can promptly admit a decision to correct of situation. Operational and maintenance personnel will be able to quickly identify and fix cause of the malfunction, based on detailed information from a set of technical tools installed in the monitoring system. In this case, by reducing cost of recovery and downtime during preventive maintenance use of monitoring systems will increase a reliability of telecommunications systems, which can be evaluated a coefficient of technical maintenance [1-5].

A positive economic effect is achieved with use of monitoring systems, many actions aimed at checking technical condition, at maintaining system's performance and at identifying causes of malfunctions are performed remotely automated or automatically [6,8-12].

2. Statement of a Problem

For now, remote monitoring systems of existing solar energy sources is not an optimal solution for real-time monitoring of energy sources of telecommunications facilities. Existing systems have a number of technical limitations. The main reasons for this are [3]:

1. Use of optical fiber technologies in remote monitoring systems is not always desirable, as telecommunications facilities are often located far away from monitoring center, in deserts, mountains, forests and plains.

2. Monitoring system of energy sources of telecommunications facilities must promptly transmit data in real-time, implementation of a preventive system aimed at troubleshooting and diagnostics. This requires a secure and reliable connection to avoid serious failures and interruptions.

3. Keep monitored parameters on the local monitoring center's server (database). This data collection allows us to research and predict failures and their timelines.

This research activity is focused on developing an optimal system for real-time remote monitoring of solar power sources of telecommunications facilities through wireless sensor nets. Aims at designing and simulating on system of Proteus environment, with a focused to technical constraints, which arising from caused given above.

3. Main Part

When developing a Solar Power Plant Remote Monitoring System, important to take information about all the parameters that apply to it. The main parameters for a solar power plant are follows: solar panels power; amount of solar radiation; environment temperature; environment humidity; voltage and current at controller output; controller temperature; voltage and current on the battery; battery temperature; accumulator charge; voltage and current at load; required power of power load. They define a basic characteristics of research system. The development of a monitoring system on all parameters of solar power plant was initially designed as a block diagram [2, 4, 7].

3.1. Block diagram of the monitoring system of solar station

The remote monitoring system of solar power sources through wireless sensor nets of telecommunication facilities were conditionally divided into two parts: the data collection unit from solar power station and monitoring center (Fig. 1 and Fig. 2).

The data collection unit from solar power plant consists following blocks (fig. 1):
- solar panel;
- accumulator battery;
- voltage sensor;
- current sensor;
- humidity sensor;
- temperature sensor;
- light sensor;
- dust sensor;
- controller devices unit (Arduino UNO);
- wireless network module (ZigBee/Xbee);
- display;
- telecommunication objects (load).

Fig. 1. Block diagram of measuring and transmitting unit of monitoring system of solar power station.

Fig. 2. Block diagram of receiving unit of monitoring system of solar power station.

The monitoring center consists following blocks (fig. 2):
- controller device unit (Arduino MEGA);
- wireless network module (ZigBee/Xbee);
- display;
- local server.

The monitoring center is also connected to Internet, where operator has access to rights monitoring system assigned to it through any Internet-connected device [13, 15].
3.2. Hardware of monitoring system of solar power station

This chapter provides basic information about devices and modules used for designing and modeling on the Proteus software environment as described above.

3.2.1. Solar panel

Solar panels are a semiconductor device, that converts solar energy directly into unchanged electricity and is now widely used as an alternative source of energy for telecommunications facilities. Depending on number of photovoltaic converters in solar panels, they can produce unchanged currents of varying voltage and power, and may vary in size.

3.2.2. Controller device units (Arduino UNO/MEGA)

The Arduino Uno and Arduino MEGA board are taken as CDU. The Arduino Uno was used to measure parameters of solar power supply from control unit and transfer it to central control unit. Arduino Uno is a board, that is based on an open source microcontroller ATmega328P (fig. 4.a) [1,4].

3.2.3. Wireless network module (ZigBee/Xbee)

ZigBee is a standard for high-level wireless communication protocols that support small, low-power digital transmitters based on IEEE 802.15.4 standard.

3.2.4. Display

Display - The LCD display is used to reflect parameters being monitored. In this researches used a 128x64 OLED graphical display as experimental model. Its real and Proteus software environmental view is illustrated in Fig. 6 a, b. This display connects to microcontroller unit through the I2C interface. This enables efficient use of microcontroller ports [7, 8, 9].

3.2.5. Accumulator battery

A battery is a source of chemical power source, a reusable electrical driving force. Its main peculiar feature is repetition of internal chemical processes, which allows it to accumulate energy and apply multiple cycles (via charge-recharge) for autonomous energy supply of various electrical appliances and equipment [10].

3.2.6. Temperature and Humidity Sensor

The DHT22 series sensor was used to measure temperature and humidity of area, where solar panel installed (Fig. 8). The DHT22 sensor is a well-established electronic temperature and humidity sensor that connects of microcontroller and DHT22 sensor, through a single data-exchange tire [2, 4].

3.2.7. Current sensor

The AC power sensor as a device used to measure and control alternating current, direct current and pulse current. Current sensors are widely used in electrical engineering to create contrariwise communication systems. There are various types of current sensors such as resistive current sensors, current transformers, and Hall effect sensors. Hall effect sensors can measure and control DC current, AC current, and pulse current. In addition, they have reliable electrical insulation, stand out with a wide range of frequencies, and do not emit heat [5, 7, 10, 16].

3.2.8. Voltage sensor

The voltage sensor is a module, that measures voltage in electrical nets. There are several types: voltage sensors of transformers, resistors, capacitors and other types. The most common type of voltage sensor is made with two resistors. It has a very simple structure. The two resistors are connected consecutively and their loose ends are connected to power supply nets. At the same time, a high voltage is distributed over these resistors. As a result, a voltage of less than 5V , generated on point, in which two resistors connected [5, 7, 10, 16].

3.2.9. Light sensor

The light sensor is a device for measuring of level of ambient light. In the model, light sensors are used to monitor of degree of illumination of telecommunications facilities in area, where solar energy sources are located, to determine whether, the sun is sunny or cloudy and whether area's illumination is sufficient for energy production. The range of light sensors is formed at different intervals (luxe). They can be adjusted depending on location and conditions of installation [2, 4, 6].

3.2.10. Dusting sensor
The dust sensor can measure the dust value by transmitting a signal of 4… 20 mA, or report, that dust level exceeds aset values. Many dust sensors operate on principle of quantum particle measurement and detect high-resolution particles larger, than one micron. These particles include cigarette smoke, household dust, spores, mold and more. Typically, sensors such as SM-PWM-01C, GP2Y1010AU0F are used to determine level of dust. These sensors determine a concentration of air in air by using an optical sensitivity method [8].

### 3.3. Software Algorithm of the monitoring system of solar power station

Solar power station monitoring system has been modeled in two parts: solar power station management and its measurement system, and monitoring center. They can be viewed as a distributed system. In other words, these two systems are at a certain distance from each other and have related and unrelated control processes. Therefore, a separate software was written for each system model in Arduino IDE environment. Created algorithm illustrated in Fig. 3, as a block diagram [3].

![Software Algorithm Diagram](image)

**Fig. 3. Software algorithm for monitoring system:**

*a* software algorithm for transmission part,  
*b* software algorithm for receiving part

Fig. 3.a illustrates solar power station management and its algorithm for measuring software system. As shown from this algorithm, the signals, coming from sensors located in object are converted to digital and their values are determined. All defined parameters are displayed in the Serial Monitor. At the same time, values of parameter are passed through serial ports to XBee wireless nets module [3].

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Fig. 3.b illustrates the algorithm of management system of the solar power station’s monitoring center. In this case, after the system is fully loaded, the serial port determines the data flow or byte sequence (value type - String) from the XBee wireless network module. Then each character in this information is scanned and the value corresponding to the character is divided by the measured parameters. Defined parameters are displayed on the Serial Monitor and LCD. At the same time, these values are transmitted to Web Server using Internet network interfaces.

4. Designed Structures of Monitoring System

The structure of power monitoring system of any facility consists of three parts. These are measuring part, server part and web page. Specific sensors (such as current, voltage, etc.) are installed in measurement unit for energy sources and consumer loads. These sensors will be connected to control unit, which is a small computing system.

The sensors detect changes in object and transmit signal to control unit as voltage or current. The control unit converts to voltage or current signal into digital form and transmits it via wireless nets to central control unit (or Monitoring Center). There may be more than one such as system. The information transferred from them is consolidated in central control unit (Monitoring Center) and transmitted via Internet to server. At the same time, it is possible to monitor real-time values from sensors using a web browser [2, 4, 17].

The process of designing remote monitoring of solar power sources of telecommunications facilities in Proteus software environment was carried out in three stages:
- Equipping the solar power station with sensors and IoT technology;
- Equipping the monitoring center with IoT technology
- Creating a website for monitoring.

Typically, this system is designed to remotely monitor solar power stations located in different areas. As an example in this experiment implemented a monitoring system for only one solar power plant in a virtual environment. But proposed idea can be used during monitoring of all power plants in designated area. There may be used more than 100 such as solar power stations.

![Fig. 4. Solar power plant equipped on the basis of IoT technology.](image)

Fig. 4. Solar power plant equipped on the basis of IoT technology.

Fig. 4 shown first step of power system, designed in proposed virtual environment. Several sensors are used for area, where solar panels are located and telecommunications facilities: light sensors, dust sensors, temperature and humidity sensors, voltage sensors, and current sensors. The characteristics of these sensors are mentioned above. They usually serve to determine condition of solar panel’s, installed location (such as the temperature of the solar panel, dusting the surface, air humidity), the amount of energy the solar panel produces, amount of battery charge and energy consumed by telecommunications facilities. Defined parameters are transmitted to monitoring center using ZigBee/Xbee wireless nets modules [5, 7, 10, 14].
In next section, Monitoring Center is designed to monitor and analyze parameters measured at solar power plants (Fig. 5). The monitoring center is equipped with Arduino MEGA, virtual terminal, ZigBee/Xbee wireless network module, LCD display, as well as Internet network module (may include YUN WiFi & Ethernet module, as well as GSM, Ethernet, WiFi). The monitoring center receives the parameters measured and transmitted at solar power plant using ZigBee / Xbee wireless nets module.

The received data is displayed using a virtual terminal and LCD display. Simultaneously, these parameters are passed to webserver. The measured parameters are stored in webserver memory.

It is well known, that the monitoring system requires a system of remote control, management and evaluation of distributed system parameters to stay at a discretionary distance. A simple web page was created to fulfill the tasks set out in third stage of monitoring system modeling (Fig. 6).

The webpage can be referenced by typing a web address in any web browser. As a result, a web browser display page shown in Fig. 6. On this page, values of solar power plants' measured parameters (solar panel dusting, voltage, current, battery charge, ambient light, temperature, humidity) are presented in various graphical images and figures. Watching every change in the real-time organize in shown webpage. This allows us to monitor system performance, to quickly identify problems, and to use optimal solutions to address it, to evaluate and improve system's performance.

5. Results

As a results of system modeling of simulation process, were usually analyzed use Virtual Terminal and Digital Oscilloscope. The Virtual Terminal and Digital Oscilloscope are connected to signal channels transmitted by the solar power station to Xbee nets module and received through Xbee nets module, located in monitoring center, as well as Internet wireless interface (YUN WiFi & Ethernet). The initial cheeked performed for transmitted and received signals, and a result is illustrated
in fig. 7.a and fig. 7.b. Fig. 7.a, belongs to transmitting values and Fig. 7.b belongs to the receiving values. In shown figures, values of transmitted by solar power station and received by monitoring center are same. This means, that measured values are passed and received through Xbee nets of module, nav’t any errors.

![Fig. 7. The view window of values, transmitted and received by Xbee nets module, during simulation in Virtual Terminal.](image)

As shown from simulation results of solar power station of telecommunications facilities, monitoring system model in any web browser may be installed on PCs or smartphones.

![Fig. 8. Web page view of solar power station monitoring system.](image)

The result of simulated system was verified by using a Microsoft Edge web browser installed on the PC (fig. 6). For view of results, first need open a web browser. Then enter “localhost: 8181”. As a result, the web page shown in Fig. 8 will be open. On the basis of created web page, researched system status can be monitored in real time.

### 6. Conclusion

Today, the increasing demand for renewable energy sources led to development of research and to improve their efficiency of such systems and to use it in various facilities. In particular, use of solar power station for telecommunications facilities is a key factor in energy conservation processes. Therefore, design of this system was developed and modeled. Mainly factors of this research is that, software product for this system has been modern created. There was research on all parameters of solar power station. On the basis of nasalizing of results, can be watching, that, these settings
parameters and values may be changed by monitoring center and webpage settings. In this case, when optional parameters of the solar power station were changed, monitoring center and web site were updated at the same time. Value has been changed to replace the previous one. This moments of freeshare is a key determining factor for accurate and reliable operation of the power control and monitoring system.

References: