

# MONITORING AND CONTROL SYSTEM USING GPRS

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**Abstract:** A structure of a multifunctional hardware - software system for sensing and control of remote objects in the household and in the industry are considered. A version of data transferring between control center and controlled object using GPRS service is proposed. The monitoring and control are realized by a set of remote stations which control the objects and receive parameters from them. Every station has a microcontroller and GSM - GPRS modem with SIM card. The stations are linked to the switching server. Data received from remote stations are kept in the server. The server distributes information and sends control commands. Personal computers of the control center are connected in a local network. They receive data from WEB sites and send commands to the switching server. The design and the characteristics of two realized systems for remote monitoring and control are described.

**Keywords:** REMOTE CONTROL, REMOTE SENSING, GPRS COMMUNICATION, SWITCHING SERVER, CONTROL CENTER, REMOTE STATION

## 1. Introduction

Management of remote objects in households and industry requires the use of channels for transmitting data to obtain the parameters of the object and to send commands to it. Depending on the information size transmitted per unit of time, the distance to the controlled object, the required speed of response to changing parameters and other characteristics can be realized a variety of control circuits and methods for data transmission, and the medium for transmitting the information may be different [1].

If the analyzed parameters are few and change slowly, the response time is not critical, the distance from the control center to the objects is big, or they are moving, then the management and monitoring can be carried out on the radio. Imposed restrictions related to the spreading of radio waves depend on the location of the managed object, spectrum and ensuring sufficient output power of the transmitter significantly complicate the task, reduce reliability and increase the cost of implementation. Lately in connection with the development of the mobile network there are options for data transmission between the control center and the managed object using GSM network. The first services in GSM networks were asynchronous and related to schemes for switching circuits - Circuit Switched Data (CSD). They have been used analog telephone networks for a long remote data transmission. For dialing and transmission of data, only specific international standard protocols are used. Since all ordinary receivers provide support for these international standards of devices used in cellular telephone networks in the year 2000 additional services to exchange data with high speed were introduced. These are HSCSD (High Speed Circuit Switched Data) with speeds up to 38.4 kbit / s and packet switching in a data transmission GPRS (General Packed Radio Service) with speeds up to 53.6 kbit / s. Since the beginning of 2004 some cellular network operators have launched commercial UMTS (Universal Mobile Telecommunication Services) services, reaching speeds of 384 kbit / s. Ordinary CSD services are also available in UMTS networks [2].

## 2. Prerequisites and means for solving the problem

In CSD service one or more channels are occupied all the time. In GPRS data is broken into small packets and transmitted in one or more available radio channel between the mobile device and packet switched network (eg. Internet). These radio channels are occupied only temporarily and released immediately so that multiple devices have simultaneous virtual access to available wireless channel. Therefore, CSD (HSCSD) has an advantage for sending large amounts of data while mobile devices are on-line for a short time - for example, for transferring large files over the intranet within a company. GPRS service makes mobile communication faster, more convenient and cheaper. It provides high-speed operation of WAP and mobile Internet. The user can continuously remain on-line during transmission, because the price depends only on the amount

of transferred data. GPRS is advantageous for small volume of transmitted data, for example text or commands and continuous state on-line. Moreover, GPRS provides a direct connection to the Internet without Internet Service Provider [3]. This makes GPRS preferred for data transmission via GSM networks in the systems for monitoring and control.

## 3. Solution of the examined problem

The block diagram of the described system is shown in Fig. 1.

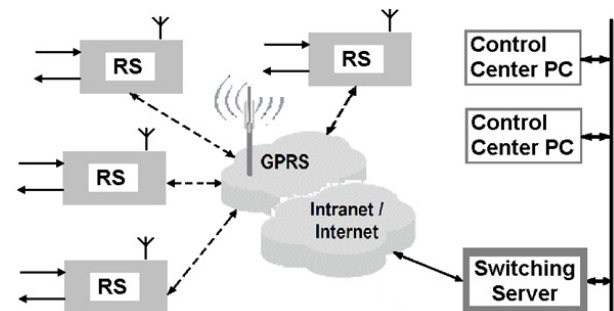


Fig. 1. Block diagram of a system for monitoring and control

System for monitoring and control is built by lot of remote stations (RS), which manage the objects and take the necessary parameters. Each station consists of managing microcontroller and GSM-GPRS modem with a SIM card. The stations are connected by the cellular network of a mobile service provider to a Switching Server, which stores the received data from remote stations, controlling the objects. It distributes and directs control commands. By controlling PC-s, connected in a local network the personnel in the control center receives data from objects and sends commands to the switching server.

Remote stations are powered by a 220V mains via an adapter 12V with the possibility of including a battery. A MPS430 microcontroller of company "Texas Instruments" with 400 KB RAM and 1.7 MB Flash memory is used. Two serial interfaces (RS-232 and USB), SIM card control and 4-band GSM modem, as well as five digital optical isolated inputs, 5 analog inputs, 4 relay outputs for control of the object are realized. In order to connect M2M between RS and the switching server in the microcontroller Java Virtual Machine and IMP-NG software are installed. The access to TCP / IP stack is done by a small number of AT commands. For example, the command to read data from ADC contains the following fields: one byte number of bytes sent, 4-byte number of radio, a byte read command and a byte number of input. The command to enable / disable input contains one byte number of bytes sent, 4-byte number of radio, one byte command activation (01) / disable (00) and a byte number of input. After sending a command to a radio, the server returns the byte 00 if there is no connection and byte 01 if the command is sent successfully.

ALOP (Advanced Light OSCAR Protocol) client, running on TCP / IP in real time is started to support GPRS communication on the control PC. The support of Advanced Encryption Standard (AES) ensures the security of information transferred through the system.

### 3. Results and discussion

To check the operation of the system a tester with 5 digital inputs, 5 analog inputs and 4 digital outputs was connected to a remote station / Fig. 2 /. The voltage on the analog inputs A1-A5 was changing by variable resistors and the levels of digital outputs were switched between 0/1 by the buttons S1-S5. The levels of the digital inputs and the relay outputs C1-C4 were indicated by the LEDs.

Correctness of input data and operation of the 4 relay outputs were checked by a little test app written in C ++ and running on the PC in the control center running under Windows OS.

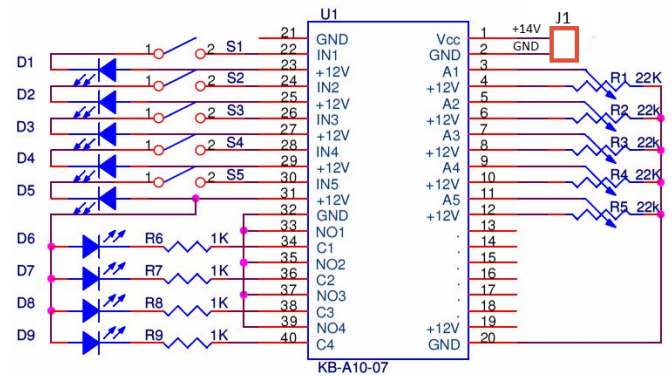


Fig. 2. Connecting the tester of remote station

Fig. 3 shows a screen-shot of the remote station system in test mode.

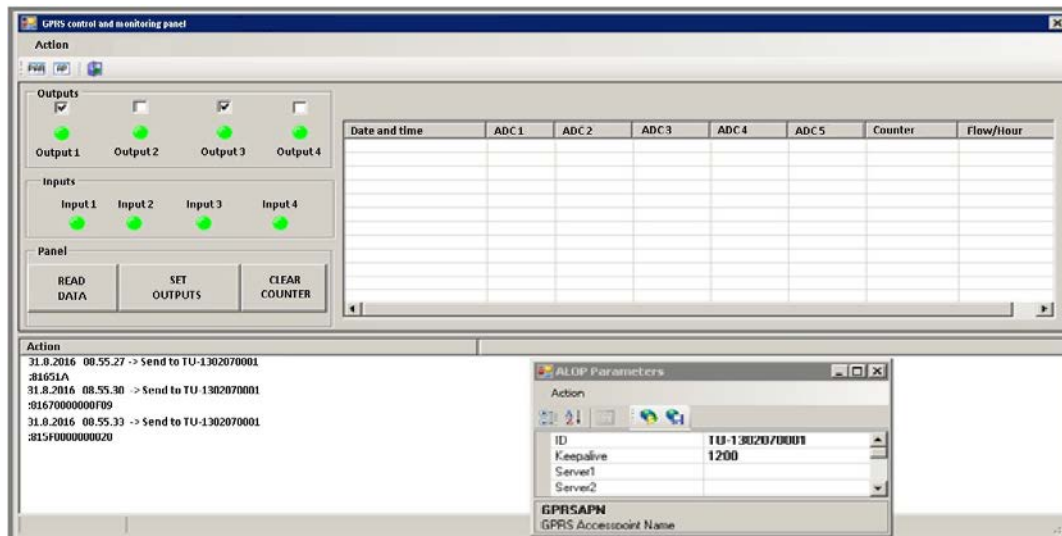


Fig. 3. Working screen of the system in test mode

Mobile automatic weather station is another example of application of the system for monitoring and control of remote objects. In classical ground stations the information is read from the devices and sent manually. The automatic weather station saves man labour and staff and can take measurements in hard to reach places [4]. Weather data transmitted over wires or radio for processing and for storage.

Automatic mobile weather station measures the temperature and humidity of air, atmospheric pressure, direction and speed of wind, and the brightness of the light at the location where it is. It has a block for data collection that makes these measurements automatically. It is cost-effective to use the national cellular networks to connect the device that collect data going to the server.

The collecting data device periodically reads data from various sensors through which information about the parameters of weather is received. Then it transforms their format into a format suitable for processing. Then it records the collected meteorological data in non-volatile memory to send it then to the WEB server via GPRS connection for storage and processing. The device interacts with sensors through its specialized interfaces and supports the necessary protocols to transmit information to sensors [5]. A block diagram of the device for the collection of meteorological data is shown in Fig. 4. The block of visualization and management of meteorological data is a device, by which the user can monitor the processed meteorological parameters and manage the block for collection of meteorological data.

This unit can be a mobile device or desktop computer with Internet access. It has a screen, suitable for displaying the results, the necessary memory for storing the software and the results. It has a module that communicates with other nodes of the system.

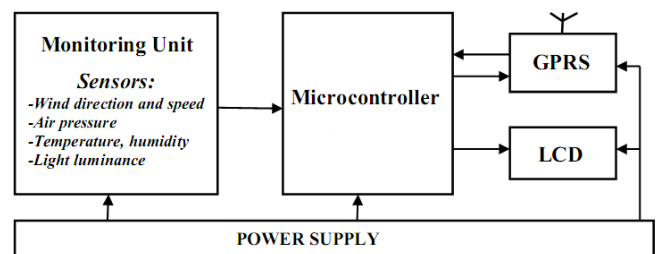


Fig. 4. Block diagram of the device for collection of meteorological data

Managing microcontroller CC430F5137 is a member of the family of microcontrollers of the company "Texas Instruments". Microcontrollers of this kind were widely used in digital devices, converters, heat measurement systems, wireless connection networks and systems for remote access [6]. The microcontroller includes integrated 1 GHz transceiver that can be used to connect the microcontroller with other remote peripherals. This controller has five modes of reduced consumption, and it is suitable for battery powering. It includes a powerful 16-bit MSP430 microprocessor, volatile memory 32KB, 4KB RAM, two 16-bit timers, a fast 12-bit ADC, a comparator, universal serial interface, real time clock and 44 lines for input / output. The control program is stored in the flash memory of the microcontroller. Programming can be made via standard JTAG interface.

A digital sensor for temperature and humidity on the type DHT22 is used. The sensor is controlled by the microcontroller using 1 signal line and a special protocol.

The digital sensor for measuring air pressure is of type BMP085. The sensor is connected to a microcontroller via I2C

serial interface. Data about the air pressure received by the sensor are recalculated using constants, stored in volatile memory.

The sensor for the wind direction is of the type NRG 1904. It is compact and resistant to the fluctuations of temperature, moisture and corrosion. This is an analog sensor and converts the angle from 0 to 3600 into voltage.

The wind speed sensor is of type 40C and is a standard analog sensor. It is widely used in industry. It generates a sinusoidal voltage with frequency 0-125 Hz, in proportion to the measured speed. To measure the frequency of the signal received by the sensor it passes through comparator and the frequency of rectangular pulses on the output of the comparator is measured. Light sensor is analog and it works using photo resistor.

For connection between WEB server and other nodes of the system for collection of meteorological data a GPRS module of type SIM800L (SIMCom) is selected. It is small, has low power

consumption and is controlled simply by the microcontroller. It can exchange data through the network and auxiliary functions of GSM / GPRS. It can also call and send SMS. This module supports communication protocols HTTP, FTP, TCP / IP. Management of the GPRS module is realized by sending AT commands via asynchronous serial interface of the microcontroller UART.

LED display is used for local visualization of the measurement values, and also shows state of the microcontroller. It is a symbol display with 2 rows and 16 columns. It uses a parallel interface with 7 signal lines.

The sensors and the microcontroller are powered with different voltage. They are obtained from a 12V stabilizer. Several other stabilizers are attached to its output.

A block diagram of the system software for collection and transmission of meteorological data is shown in Fig. 5.

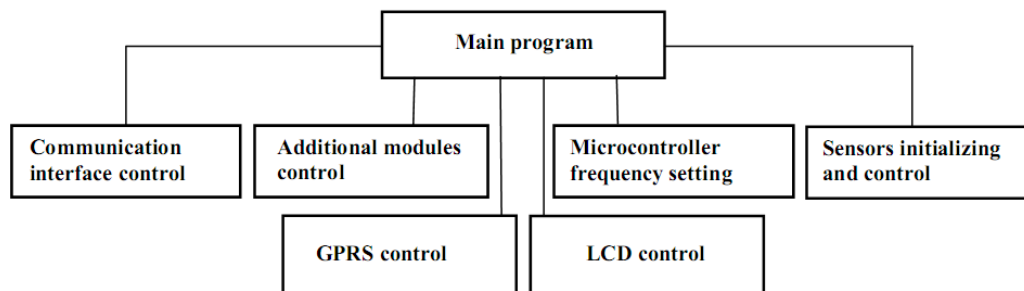


Fig. 5. Flowchart of the software

The communication between functional blocks is implemented differently. The connection between the block for collection and transmission of weather data and processing block is realized by a wireless network using GPRS - the device [7], which supports a stack protocol TCP / IP. The connection between the block for processing of weather data and display unit uses HTTP - protocol, such as GET and POST calls.

The realization of WEB system is done using two servers that work in parallel. The first server accepts HTTP - requests from the control unit of the weather station and display device, as well as some requests of the device for data collection. The server HTTP uses a free server Apache HTTP. The second server is TCP server. It implements connection with the data collection device and transmits the commands coming from the control unit.

The server TCP is realized using a library of programming language nodeJS - NET. The processing of HTTP - requests and receiving data is realized using programming language PHP. For storage of processed data and the data of different types associated with the system a database system MySQL is used.

To create templates, which are displayed on the device for visualization and control of metrological data, programming language AngularJS was used.

The proposed weather station was realized as a model using ready modules. It was used for research and to preparing students by studying its subsystems and their improvement.

#### 4. Conclusion

The practical application of the proposed system for monitoring and control of remote objects includes a collection of measurement data for electricity, water or gas from vending machines or level sensors. Other applications can be remote service test equipment, transmission of messages in a signaling system, high-speed data transfer of electronic payments, monitoring the performance of machines, vending machines and weather in autonomous meteorological stations [8]. This system is suitable for M2M connection with programmable logic controllers.

#### 5. References

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