AUTOMATED MEASURING SYSTEMS IN MONITORING THE HYDROGEOLOGICAL CHARACTERISTICS OF AQUIFERS

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Abstract. *In this paper presented, the general structure of the proposed control system device, the capabilities and differences of the proposed device are expressed with graphical and tabular data. Has presents ways of creating remotely monitoring of elements of the hydro regime characteristics of aquifers in observation wells based on proposed device of hardware and software systems.*

Keywords: *aquifers, ground water label, groundwater level measuring, sensors, control system device, remote monitoring.*

АВТОМАТИЗИРОВАННЫЕ ИЗМЕРИТЕЛЬНЫЕ СИСТЕМЫ ПРИ МОНИТОРИНГЕ ГИДРОГЕОЛОГИЧЕСКИХ ХАРАКТЕРИСТИК ВОДОСНАБЖУНИЯ

Аннотация. *В представленной статье общая структура предлагаемого устройства системы управления, возможности и отличия предлагаемого устройства выражены графическими и табличными данными. Представлены способы создания дистанционного мониторинга элементов гидрорежимных характеристик водоносных горизонтов в наблюдательных скважинах на основе предлагаемого устройства программно-аппаратных комплексов.*

Ключевые слова: *водоносные горизонты, метка грунтовых вод, измерение уровня грунтовых вод, датчики, устройство системы контроля, дистанционный мониторинг.*

INTRODUCTION

The hydrogeological regime elements that are subject to measurement are the level, temperature, salinity, pressure of groundwaters, etc. The groundwater level changes according to the seasons of the year, and in a long-term cycle. Long-term level fluctuations are associated with rhythmic climate changes and are confined to various cycles, among which 4, 12 and 36-year cycles are most clearly recorded [1]. The amplitudes of fluctuations in groundwater levels in long-term fluctuations can exceed the amplitudes of seasonal fluctuations and reach significant sizes up to 10 m or more. The study of the hydro regime of aquifers is necessary to determine the calculated value of the thickness of the aquifer, forecast the position of the level for the entire period of long-term operation of groundwater intakes and other engineering calculations. An increase in the level of groundwater is facilitated by changes in water management conditions, crops, irrigation, interconnection with river basins, water intakes, etc. The results of mathematical modeling and field measurements show that under the influence of anthropogenic factors, groundwater levels can rise by 10-15 m or more.

MATERIALS AND METHODS

The regime and balance of groundwater are interrelated, and if the regime reflects the change in the quantity and quality of groundwater over time, then the balance is the result of this change. The balance can be drawn up for large areas or for individual plots (irrigation and filtration fields, group water intakes, etc.). In this case, automated systems for measuring the hydrological parameters of groundwater give a good result, and the study of aquifers is more accurate and informative [2].

Population growth, climate uncertainties, and unsustainable groundwater pumping challenge aquifer sustainability worldwide [3]. Efficient and data-driven groundwater supply management is a necessity to maintain essential water-dependent functions. Currently, managers lack the cost-effective, scalable, and reliable groundwater monitoring systems needed to collect vital groundwater data. Existing automated groundwater monitoring systems tend to be cost-prohibitive, and manual methods lack the spatial or temporal resolution to sufficiently meet critical water modeling, management, and policy objectives. In this study, we developed a fully automated, open source, low-cost wireless sensor network (LCSN) for real-time groundwater data acquisition, processing, and visualization in the South American Groundwater Observatory (GWO), located in California, USA. We demonstrate the steps taken to create the GWO, including field, hardware, software, and data pipeline components so that it may be easily reproduced in new areas [4].

Groundwater level measurement. Measuring groundwater level or depth-to-water is critically important for identifying long-term trends, including declining groundwater levels. To manage aquifer, there is need for timely and accurate data to assess groundwater conditions in order to manage and prevent adverse situations. The principal source of information about the hydrological stresses acting on aquifers and their impact on groundwater recharge, storage and discharge is groundwater level measurements [5].

One of the devices for automated measurement of parameters of the groundwater regime are devices of the diver family and the most popular are divers from Schlumbenger Water Servires (Eijkelkamp) for automated measurement and recording of the level, temperature and electrical conductivity (mineralization) of aquifer. The pressure, temperature and conductivity sensor and power supply are contained in a hermetically sealed housing. This makes the diver less sensitive to humidity and external electrical influences. The Diver water level logger range provides a robust line of data loggers for groundwater and environmental professionals. The Diver water level loggers accurately measure and record fluctuations in surface and groundwater levels, temperature and conductivity [6]. In recent years, with the rapid development of almost all sectors of our country's economy, the demand for information on underground resources, hydrogeological conditions, engineering and geological properties of soils, geodynamic processes and the development of geoecological conditions in industrial, oil and gas regions has increased. is going on [7].

Therefore, the application of information systems and their effective use in the field of hydrogeology is of great importance today. This makes it possible to use automated devices in effective monitoring of the hydro regime characteristics of underground waters in monitoring wells [8].

Advantages of using an automated device to monitor the quantitative and qualitative characteristics of groundwater:

- it is not necessary to periodically lower / raise water level sensors or electrodes;
- remote reception of groundwater parameters;
- autonomous work without human intervention;
- the possibility of organizing wireless data transmission;
- the ability to record data electronically at the required time interval.

RESULTS

Proposed device. Currently, research work is being carried out on the use of automated devices with the above advantages and their further improvement. Currently used devices work autonomously and do not require frequent visits of the observer to the well, which gives certain economic advantages and allows the device to be used in hard-to-reach and remote places. The transmission of the measurement results immediately after the measurement in the form of SMS-messages ensures the rapid collection of data, that is, using the communication channel according to the GSM standard, it can transmit the measured data to any distance and can be used to:

sending an SMS to mobile phones about the current state of groundwater (up to 2 numbers). Messages are sent in plain text explaining specific information about water level, temperature and conductivity;

transferring data to a computer program on the server that provides data collection, processing and visualization from remote control devices.

The program also allows for centralized management and coordination of various processes occurring at remote sites, using the operational transfer of information between these sites and control points [9].

The experimental operation of the device in laboratory and field conditions allows to draw a conclusion about the effectiveness of its use in measuring the quantitative and qualitative indicators of groundwater.

The automated measuring device consists of two interrelated parts:

1) immersion device placed in a stainless case with pressure, temperature, electrical conductivity sensors and a microcontroller circuit board;

2) pressurized compartment - here is the connected GSM-modem with an external antenna and the device's power source (rechargeable battery).

3) The pressure sensor located in the stainless case of the device allows to measure the level of underground water. It determines how deep the casing is from the surface of the water with the help of the values measured by the air pressure and water pressure sensors. The device can accurately measure the thickness of water up to the unit of length mm.

4) The temperature sensor in the device allows you to measure the water temperature in ℃.

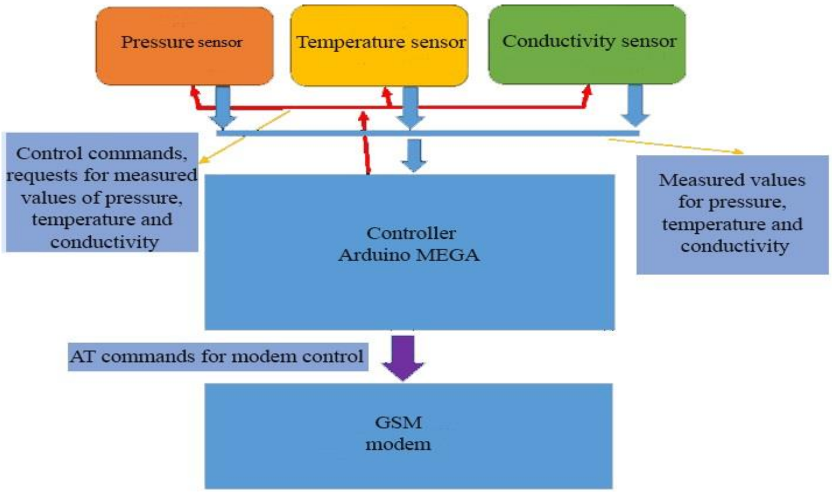
5) The electrical conductivity of underground water is measured by the electrical conductivity sensor. With its help, the general mineralization of underground water is determined. The sensor determines the results in units of μSm. The presence of a microcontroller in the device consists in controlling all sensors, waking them up at a specified time interval, and controlling the process of obtaining results.

6) The GSM modem, which is the second part of the device, allows sending the data received from the sensors to a remote receiving GSM modem or mobile communication devices [8].

The structural and functional diagram of the device is shown in Figure 1.

Figure 1.

Structural and functional diagram of the proposed device.



The device modem described above works only in SMS (GSM) mode. This makes it possible to retrieve data from the device's memory only at a specified time interval. Sometimes users need to be able to control the device remotely.

For this purpose, the operation of the modem of the device in Internet (GPRS) and SMS (GSM) mode provides a number of opportunities, that is, remote control of the device and SMS (GSM) mode is used in areas where the Internet is not available.

To make the device modem work in GSM/GPRS mode, it is necessary to develop an additional module and software. In this mode, the energy consumption of the system is significantly saved (Fig. 3).

This management system consists of the following modules and software protocols:

– Arduino Nano (Atmega 328)
– Modem SIM800L GSM device
– ModBus software protocol
– Energy saving algorithm in Arduino Sketch

Arduino - this module is an embedded device that works on the currently very popular SISC architecture with an Atmega328 microcontroller. RS485 to TTL - this module is a device that prevents the risk of data loss from long distances. This module is in direct contact with the ModBus protocol, and data exchange is carried out through this protocol. Modem SIM800L module is designed to provide remote data transmission. This module is one of the most important modules of the system. Because this module receives data and sends data (Figure 4). Modem SIM800L device works at 3.7V voltage. This leads to a decrease in energy consumption (Table 1).

Figure 3

General structure of the control system scheme.

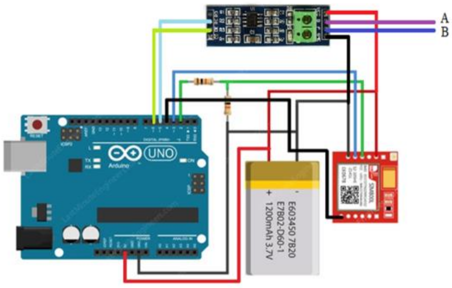


Figure 4.

Modem SIM800L GSM module overview.

DISCUSSION

Capabilities and differences of the proposed device. The features of the modem module of the device are listed in the following table:

Table 1.

The features of the modem module.

	Available device GGM-1	**The device under investigation AIU-2**
Voltage	12V	3.7V
Error	0.2 %	0.07 %
Energy consumption	60 J	8 J
C.O.P.	78 %	85 %

The measurement characteristics of the device are given in the following table:

Table 2.

The measurement characteristics of the device

Measurement features	**Available device GGM-1**	**The device under investigation AIU-2**	**Foreign device (DIVER)**	**Explanation**
level	available	Available	available	it is generated

				with the help of the values measured by air and water pressure sensors
temperature	available	Available	available	the water temperature is measured in℃ based on the temperature sensor
electrical conductivity	available	Available	available	The electrical conductivity of underground water is measured on the basis of the electrical conductivity sensor.
pressure	available	Available	available	The pressure of underground water is measured through a pressure sensor.
The possibility of determining the general mineralization from the above features.	not available	available	available	it is derived from the measured values based on temperature and electrical conductivity sensors

The measurement characteristics of the devices are given in the following table:

Table 3.

The measurement characteristics of the devices

Devices	Price, $	Accuracy of measurement characteristics			Device discovery	Software support
		level mm	T°C	electrical conductivity µS/cm		
Available device GGM-1	600	2.5	2	5	There is a chance to find it because it is made locally	Software is available, but online remote control is not available
The device under investigation AIU-2	800	2	0.5	3	There is a chance to find it because it is made locally	Software available, online remote control available
Foreign device (DIVER)	1200	2	.2	1	Since the device is manufactured abroad, the possibility of finding it is not available in some cases, besides, a number of paperwork is required when purchasing and putting it into use.	Software available, online remote control available

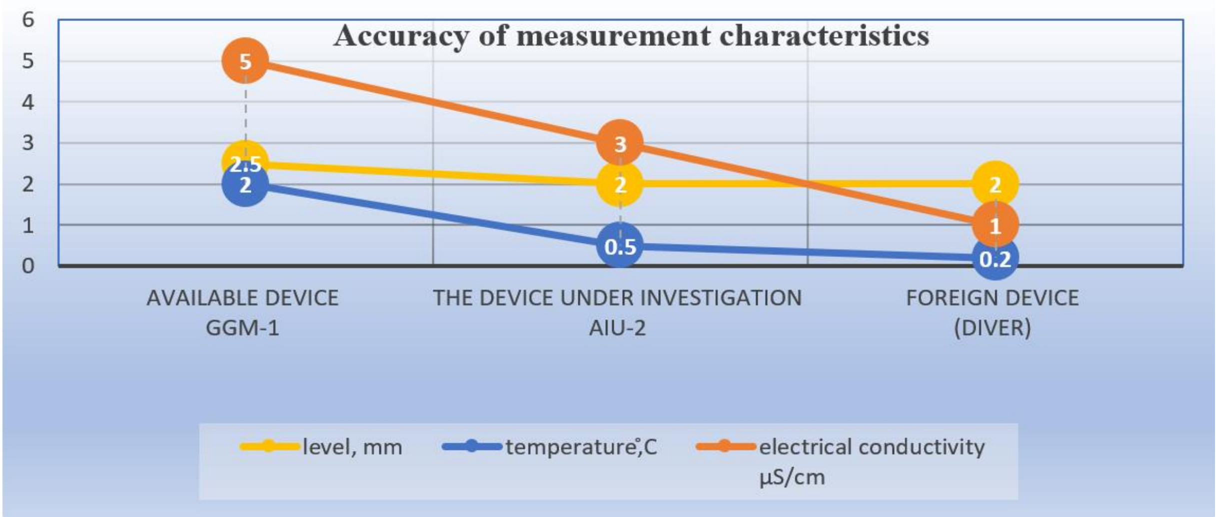
The measurement characteristics of the devices are expressed in the following graph:

Figure 5.

Graphical view of the price of devices.

Figure 6.

A graphical representation of the data showing the accuracy of the measurement characteristics of the devices.



CONCLUSIONS

As a conclusion, if the proposed device AIU-2, which is used to study the hydroregime characteristics of underground water in observation wells, the possibility of remote online monitoring of underground water will be created. As a result of this, it will be possible to remotely monitor the level and temperature of underground water, electrical conductivity, increase the reliability of information and the efficiency and productivity of the ongoing hydrogeological works, and save financial costs.

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