GPRS Radio Communication For AI-Based Measurement And Control Complex

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Abstract— **This paper presents the results of development of the GPRS radio communication modem for an autonomous measurement and control complex based on Artificial Intelligence. The complex is designed for simultaneous measurement of the concentration level of radioactive radon gas in the near-surface layer, the level of the Earth's magnetic field intensity with simultaneous analysis of seismic processes in the territory of Azerbaijan and neighboring regions. while measuring the magnetic field strength, solar activity is simultaneously analyzed. GPRS radio communication modem was developed to ensure communication with the Internet, to apply the machine learning method and communicate with the center. The purpose of the development and research is to study the correlations of measured values with seismic activity. A software algorithm has been developed to control the complex and carry out measurements.**

Keywords— radio communication; control complex; Artificial Intelligence; functional architecture; diagnostic commands

I. INTRODUCTION

The study of seismic activity and the identification of its relationships with parameters measured on the Earth's surface is an important task in seismology. Over the past decades, scientists have attempted to develop methods for predicting earthquakes. Particular attention is paid to the search for precursors, among which radon anomalies and magnetic field variations stand out as potentially significant. In addition, growing computing power and the development of artificial intelligence methods open up new possibilities for analyzing complex multifactorial data [1].

Current research highlights the need for complex systems capable of collecting, processing and interpreting information in real time. This is especially relevant for regions with high seismic activity, such as the Caucasus region. The development of autonomous systems capable of operating in remote and hard-to-reach areas is becoming a key area of modern seismology. Such systems allow real-time monitoring without human intervention, minimizing risks and increasing response speed.

The concentration of radioactive radon gas and the intensity of the Earth's magnetic field are taken as the measured physical quantities. Therefore, at the first stage, only two types of detectors were developed: for radon gas and the Earth's magnetic field.

The developed complex consists of detector units, an interface, a control unit, an Internet channel unit, a unit for receiving data from a seismic center, a unit for receiving data on the current state of solar activity, an analysis unit based on Artificial Intelligence and decision making, and an autonomous power supply unit on solar panels. The detector units include a radon radioactive gas detector and magnetometer devices to measure the magnetic field strength in a given area.

It is known that solar activity has a strong impact on the Earth's magnetic field. Therefore, when studying the state of the magnetic field, its correlation with solar activity should be taken into account [3].

II. AI-BASED COMPLEX FOR MEASUREMENT AND CONTROL

The concentration of radioactive radon gas and the intensity of the Earth's magnetic field are taken as the measured physical quantities. Therefore, at the first stage, only two types of detectors were developed: for radon gas and the Earth's magnetic field [4].

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In simplified form, the algorithm of the software for control and analysis of the complex consists of the following main blocks interacting with each other. This algorithm is shown in Figure 1.

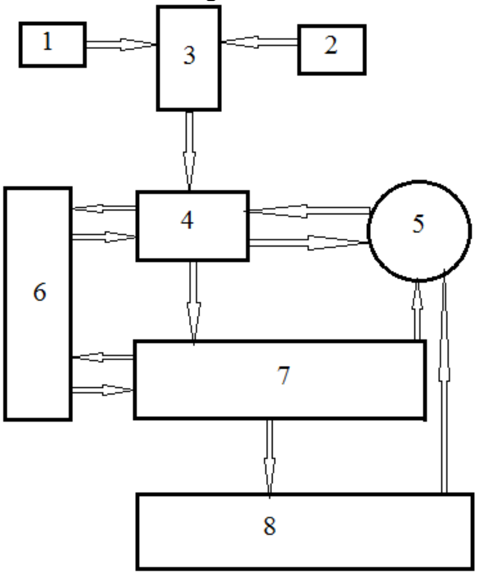

Figure 1. Simplified diagram of the algorithm of the software for control and analysis of the complex.

There are next units (blocks) in Figure 1:
- unit 1 for receiving, filtering and processing data on radon concentration on the earth's surface and at a depth of 1-3 meters;
- unit 2 for receiving data from a magnetometer;
- unit 3 for analyzing and filtering data from units 1 and 2;
- unit 4 for joint analysis of data from unit 3 and data coming from seismic center 5 and solar activity;
- unit 6 for GPRS radio communication modem;
- unit 7 for processing and in-depth analysis of data from unit 4 based on the Machine Learning method using the Internet channel and the Seismic Center database;
- unit 8 for analysis and decision-making based on the output data of unit 7.

III. GPRS Radio Communication Modem

GPRS radio communication modem provides wireless data transmission, voice communication over the GSM network, text messaging (SMS) and packet data transmission based on GPRS technology.

The presented circuit diagram reflects the functional architecture of a communication module based on the GSM/GPRS SIM900 chip.

1) *<u>The main SIM900 chip (U4).</u>*

The central element of the circuit is the SIM900A integrated circuit - a communication chip that supports quad-band GSM networks and provides interaction with an external microcontroller via a UART interface:

- The UART module is connected to the microcontroller via (Tx, Rx) signals;
- PWKEY, STATUS, NETLIGHT control lines are used to control and visually monitor the operating mode of the modem.

2) *<u>SIM card interface (U9).</u>*

The SIM card connection is placed in a separate interface block. This interface includes the following signals:

- SIM_VDD – power line,
- SIM_RST – reset signal,
- SIM_CLK – clock signal,
- SIM_DATA – duplex data line,
- SIM_PRE – presence signal.

3) These lines are connected to the SIM card tray through protective resistors and TVS diodes in series, protecting them from both electromagnetic influence and static charge.

4) *<u>Power cycle.</u>*

The module is powered by an LDO stabilizer type MIC29302WU. The use of this stabilizer allows you to reduce the voltage of 5 V to 4 V required for SIM900.

- Filtering of high-frequency pulses is ensured by the use of electrolytic and ceramic capacitors (100 µF and 100 nF) at the input and output;
- The power circuitry protects the module from current peaks and can provide the ~2A instantaneous current required during GPRS data transfer.

To monitor the operating modes of the module, two main LEDs are used:
- STATUS LED – displays the general operating status of the module,
- NETLIGHT LED – indicates the registration status in the GSM network.

Both LEDs are controlled by NPN transistors (BC547B), which isolate the signal lines from the voltage level in the module, increasing reliability.

The PWKEY signal is controlled by a transistor switch to turn the module on and off using software. This approach is effective both in automated systems and in devices that require energy conservation.

The RF output of SIM900 is connected to the GSM network via the external SMA antenna connector (RF1). The antenna unit ensures stable reception and transmission of the module signal.

The developed circuit diagram is distinguished by a stable power supply, SIM card interface protection mechanisms, operating mode control via LED indicators and GPRS functionality. This solution is suitable for widespread use in data acquisition and remote monitoring systems, IoT devices and wireless control applications.

SIM900 is a GSM/GPRS module developed by SIMCom. Through this module, microcontrollers can connect to the cellular network and perform the following functions:

- Making and receiving calls;
- Send and receive SMS;
- Connect to the Internet via GPRS (2G);
- Data transmission via TCP/IP protocol.

B. Main technical characteristics:

- Network support: GSM 850/900/1800/1900 MHz (quad-band)
- Supply voltage**:** 3.2 – 4.8 V (optimal 4.0 V)
- Current consumption of electric current:
  - Standby mode: ~10 mA;
  - During a conversation: ~250 mA;
  - Peak current: up to 2 A.
- Controlled by AT commands (via UART).
- UART interface: data transfer rate is in range of 9600 ÷ 115200 baud.

Dimensions: approximately 24x24 mm (the chips themselves), and the modules (boards) are approximately 40x40 mm.

IV. AT Commands And Their Use For SIM900 Module

AT commands (Attention commands) are standardized text commands used to communicate with GSM/GPRS modules via UART interface. With these commands, SIM900 allows you to manage calls, SMS, GPRS Internet, TCP/IP and other services**.**

AT commands usually start with the AT prefix and are returned by the module as an OK (command accepted) or ERROR (command not executed) response. The main diagnostic commands are presented in Table 1.

TABLE 1. The Main Diagnostic Commands.

Commands	Explanation	Example/Answer
AT	Checks the working status of the module	Answer: OK
AT+CPIN?	Checks the status of the SIM card	Answer: +CPIN: READY
AT+CSQ	Measures the signal level (values from 0 to 31)	Answer: +CSQ: 20,0
AT+CREG?	Network registration status	Answer: +CREG: 0,1 (Upon registration)

GPRS/Internet connection

Main sequence:

1. Setting up GPRS parameters

AT+SAPBR=3,1,"CONTYPE","GPRS"
AT+SAPBR=3,1,"APN","internet"

2. Open connection

AT+SAPBR=1,1

3. Checking the connection

AT+SAPBR=2,1
+SAPBR: 1,1,"10.120.45.87"

4. Starting the HTTP service

AT+HTTPINIT
AT+HTTPPARA="CID",1

5. HTTP GET request

AT+HTTPPARA="URL","http://example.com/data"
AT+HTTPACTION=0
AT+HTTPREAD

6. HTTP POST request

AT+HTTPPARA="URL","http://example.com/post"
AT+HTTPDATA=20,5000
temperature=25&humidity=60
AT+HTTPACTION=1
AT+HTTPREAD

7. Closing the session

AT+HTTPTERM
AT+SAPBR=0,1

TCP/IP connection.

SIM900 also supports direct opening of TCP/IP sockets. The list of commands is given in table 2.

TABLE 2. The list of commands.

Commands	Explanation	Example/Answer
AT+CIPSHUT	Closes the previous session.	OK
AT+CIPSTATUS	Shows TCP/IP status	Answer: STATE: IP INITIAL
AT+CSTT="internet"	Sets APN settings	Internet for Azercell
AT+CIICR	Establishes a GPRS connection	OK
AT+CIFSR	Gets an IP address	Answer: 10.12.45.23
AT+CIPSTART="TCP", "server.com","80"	Opens a TCP connection	OK / CONNECT OK
AT+CIPSEND	Sends information	GET /data HTTP/1.1
AT+CIPCLOSE	Closes the connection	OK

Figure 2 shows the developed circuit diagram of the GPRS modem.

Thus, given paper presents the results of the development and research of an autonomous (robotic) measurement control complex based on Artificial Intelligence. The complex is designed for simultaneous measurement of the concentration level of radioactive radon gas and the level of intensity of the Earth's magnetic field with simultaneous analysis of seismic processes in the territory of Azerbaijan and neighboring regions, as well as the current state of solar activity. GPRS radio communication modem was developed to ensure communication with the Internet, to apply the machine learning method and communicate with the center. A software algorithm has been developed to control the complex, carry out measurements, and analyze the obtained data using the Machine Learning method. The purpose of the development and research is to study the correlations of measured physical quantities with seismic activity.

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References

[1] A.A. Bayramov, F.N. Abdullayev, S.S. Suleymanov, R.D. Karimova, H.N. Safarov, E.A. Rzayev Multifactor model for seismological research. Seismoprognosis observations in the territory of Azerbaijan. 2024. Vol.26, № 2, pp.28-33.

[2] S.M. Moustavi, G.C. Beroza, Deep-learning seismology. Science, 2022, Vol. 377, No. 6607.

[3] W. Lowrie 'The Effects of Solar Activity on the Geomagnetic Field', *The Earth's Magnetic Field* (Oxford, online edn, Oxford Academic, 22 June2023). https://doi.org/10.1093/oso/9780192862679.003.0007, accessed 15 July 2025.

[4] A.A. Bayramov, F.N. Abdullayev, S.S. Suleymanov, A.A. Keramova. Development of an automated radioecological station for the purpose of studying the problems of industrial waste in seismically active areas. Materials of the Republican scientific-theoretical conference on the topic "ANAS-80". Ganja. 2025. pp. 24-27.

[5] S.S. Suleymanov, A.A. Bayramov, F.N. Abdullayev Study of seismic processes using AI technology. Current directions of development of information and communication technologies and control tools. Proceedings of 15-th International Scientific and Technical Conference. Xarkov, 2025. April 24–25, Vol.1: P.47.

[6] J. Hartmann, J.K. Levy Hydrogeological and Gasgeochemical Earthquake Precursors – A Review for Application. Natural Hazards. 2005. 34, 279–304.

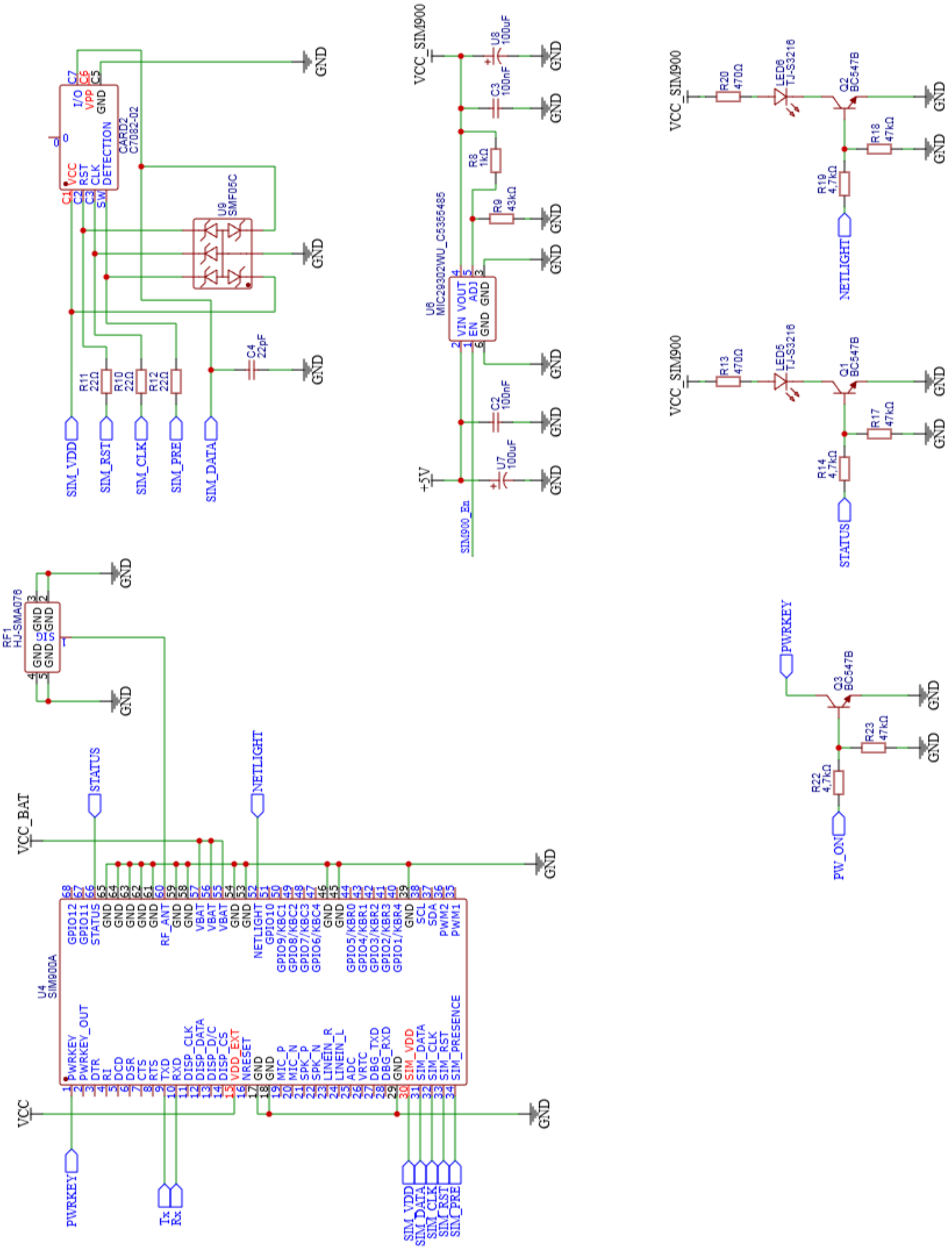

Figure 2. Schematic diagram of the GPRS modem.