# INCREASING THE ACCURACY OF NON-CONTACT MEASUREMENT USING THE A9G MODULE IN GROUNDWATER MONITORING

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***Abstract****. This article is about finding an effective solution to the problems of determining the distance and temperature of underground water using ultrasound and radio waves. In the method proposed in the article, we use the highly integrated A9G module, which allows for systematic compensation of the temperature coupling, or easy creation of curves for reconfiguration. The purpose of this scientific research is to increase the distance and accuracy of non-contact measurement of water level in wells.*

*This is achieved by simultaneously creating an ultrasound and a radio wave in the well, which is the starting point for the travel time of the sound wave from the wellhead to the water table, measuring and adjusting the travel time of the sound wave. basic features such as taking into account the ambient temperature are clearly defined.*

*Our proposed method has led to a higher accuracy of groundwater distance determination compared to currently used methods, as other methods measure directly at the water surface and do not take into account the gas temperature in the interval. our proposed method also takes into account the intermediate gas temperature, which increases the reliability.*

*With this dual measurement and gas temperature consideration, we eliminate random measurement and increase accuracy.*

***Keywords****: ultrasound, radio wave, method, sensor, A9G module, microcontroller, non-contact measurement, receiver, transmitter, distance, temperature.*

Mathematical modeling system of geofiltration processes of regional hydrogeological regions, rapid analysis of groundwater level changes, creation of effective water resource management systems in necessary cases is of great importance in the world. In this regard, in the years of water scarcity, the role of groundwater in the total water resources and their interdependence, the study of hydrogeological characteristics of groundwater, the justification of hydrotechnical structures and the meliorational water supply procedure, the prevention of groundwater pollution one of the important tasks is to improve the intellectual systems that support decision-making on the rational use of water resources and monitoring the state of hydrogeological objects, mathematical modeling, and eliminating the salinity of agricultural areas.

The main criteria for evaluating the systems and devices for measuring the distance and temperature of underground water are the environment of the studied object, the reliability of the systems and the reliability of the data obtained from the metrological characteristics of the measuring devices. Thus, changes in this field are based on new approaches to the formation of water system data accounting based on innovative technologies in the field of measurement technology and metrology. We achieve this reliable measurement using ultrasound and radio waves. Ultrasonic measurements are typically used to detect changes in the density or compressibility of a medium such as water. When ultrasound is used to measure the level and temperature of groundwater, gas temperature can affect the speed of sound in the medium. A calibration method can be implemented to mitigate the effect of temperature on ultrasound measurements. This approach involves establishing a relationship between temperature changes and their effect on the speed of sound in water. By taking these changes into account, more accurate measurements can be obtained.

We use the A9 model, one of the most effective models today, for continuous transmission of data from measurement sensors. This module is a type of cellular communication module produced by A9G AI-Thinker. The A9G module supports multiple positioning modes. The A9G module supports TCP/IP protocols via AT commands through the serial interface. This makes it easy to integrate into various applications, including personal tracking. It is also widely used in IoT devices that require location tracking and communication capabilities, such as smart meters, environmental monitoring devices. The operating temperature of the A9 model is -20 ℃ +20 ℃. It also supports GPRS data service, maximum download speed is 85.6 Kbps, upload data is 42.8 Kbps. These features enable reliable and faster data transfer to the server or cloud platform using the remote communication of the A9G module

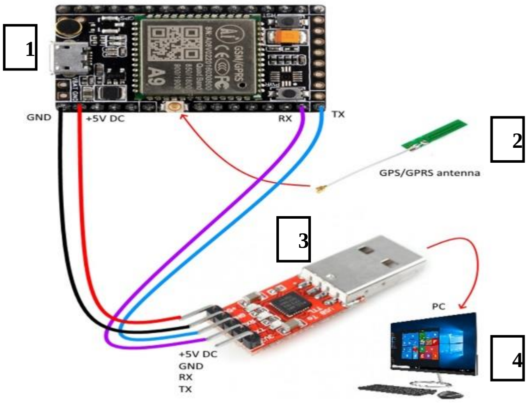


***Figure 1. Connection pins to Atmega 328 microcontroller with model A9.***

1- A9 model;
2- GPS/GPRS antenna of A9 model;
3- Atmega 328 microcontroller;
4-PC.(personal compter)

We give a code loader to the PWRKEY pin of the A9 model, connect the GND pin of the A9 model to the GND pin of the Atmega 328, connect the HST_RXD pin of the A9 model to the RX pin, and the last connection connect the VCC pin of the Atmega 328 to the VBAT pin of the A9 model, the maximum is 4.2 volts.

We mentioned above that the purpose of this scientific article is to increase the distance and accuracy of non-contact measurement of the water level in wells.

This is achieved by simultaneously creating a sound and radio wave in the well, which is the starting point for the travel time of the sound wave from the wellhead to the water surface, measuring and adjusting the travel time of the sound wave, the speed of sound in the gas environment, taking into account the ambient temperature, is taken into account.

$$D = Vs\,(℃) * T. \quad (1)$$

*(1)* determining the distance according to the formula, where D is the distance from the wellhead to the water surface, Vs.(°C) is the speed of sound in a gaseous medium taking into account the temperature of the propagation medium, T is the distance of the sound wave from the wellhead to the water surface diffusion time.

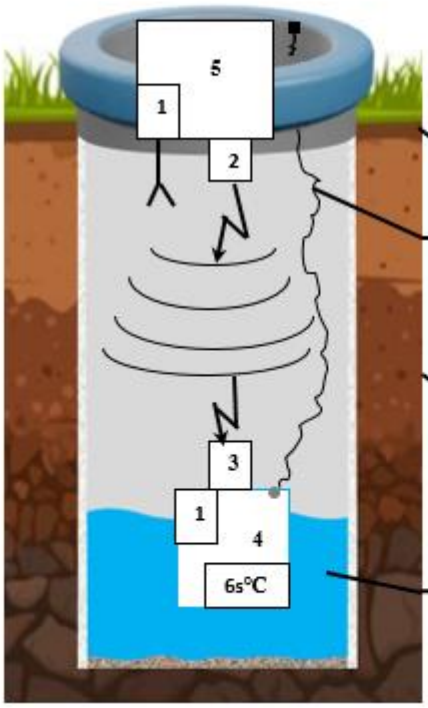


***Figure 2. Block diagram of the method of measuring the water level in the well.***

1-Transceiver (receiver of radio waves);
2-ultrasound transmitter (transmitter);
3-ultrasound receiver (receiver);
4-microcontroller control on the water surface (floating part);
5-wellhead control microcontroller - main;
6-I2C temperature sensor;
7-soil (ground level);
8-well wall;
9-water surface at the bottom of the well;
10-holding line.

Figure 2. Based on the mutual integration of ultrasound and radio wave sensors, a method of measuring the distance and temperature of underground water with high accuracy has been developed. The automated measuring device consists of parts such as ultrasonic and radio transmission and reception sensors, I2C temperature sensor, A9 model of data transmission and reception, and a microprocessor that processes commands, and its technological structure.

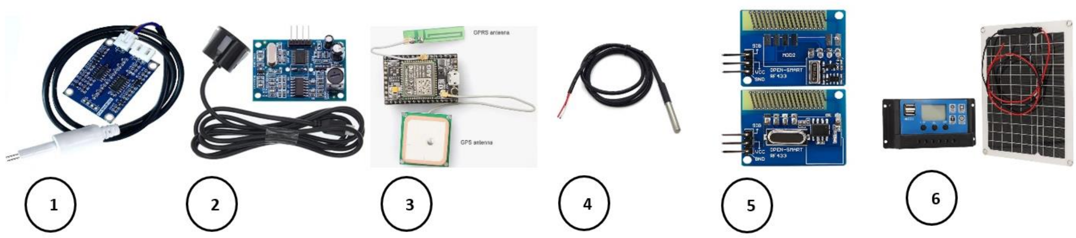

***Figure 3. 1- TDS module determines water quality and other parameters, 3.5V-5V, 2- Ultrasonic sensor JSN-SR04T, 3 - A9G module GSM+GPS, 4 - DS18B20 water temperature measuring sensor (temperature sensor) 5- Radio to transmitter and receiver Open-smart long range 433mhz Transmitter Receiver Modules, 6- 300V solar panel kit, high efficiency waterproof charging for weather, strong output power.***

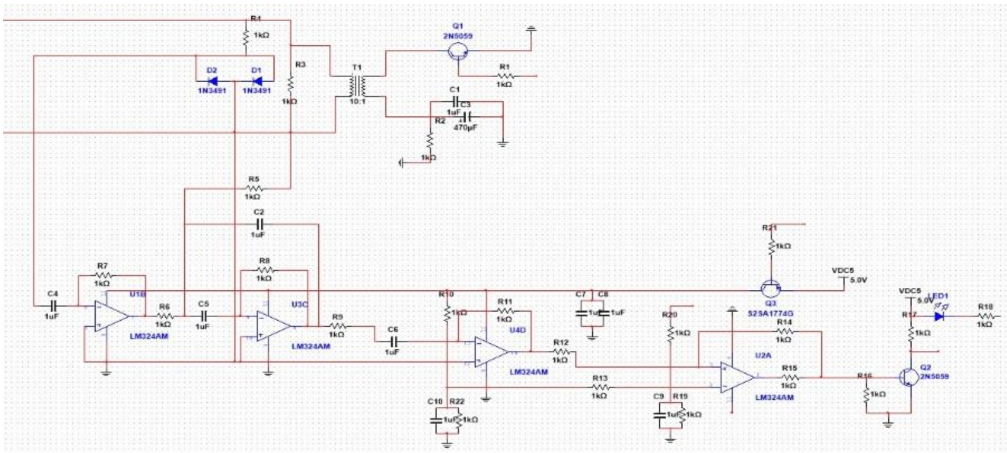

***Figure 3. Electronic schematic diagram of automated measuring devices drawn in P-CAD software.***

Radio-wave gaseous environment $3 * 10^8\, m/s$ propagates at a speed i.e. practically instantaneously it reaches the receiver $1'$s radio receiver, the microcontroller wakes up and the timer of the floating part of the microcontroller is also turned on and the sound wave $3 * 10^2\, m/s$ propagates at a speed, i.e. By turning on the timer T2, the floating part of the radio wave is 6 degrees smaller than the radio wave, which allows you to receive the beginning of sound vibrations with the time of arrival of the radio wave to the radio receiving system of the 1st receiver. The sound wave arrives at the ultrasound receiver 3 and turns off the timer by setting the time T2, and at the same time a response radio wave is sent to complete the countdown time T1 in the timer of the main stationary part. So it's on. both microcontrollers 4 and 5, the time T1 and T2 for the sound wave to travel from the mouth to the well fluid level. This two-way measurement eliminates accidental measurement and increases accuracy. Knowing the sound wave transit time and the speed of sound in the gas environment according to the timers, the distance from the liquid level to the mouth is determined by the formula, taking into account the temperature sensor readings. $D = Vs(°C) * T$ . In this mode, the method of operation is carried out in several years, that is, the service life of the batteries of the floating part is equal to the period of overhaul of the wells. There is a holding connector (10) for lifting and holding the floating part. Thus, the floating part is raised with it and the batteries are replaced. The proposed method, compared to the known ones, has a high detection accuracy, because it is located directly on the surface of the liquid and the gas in the interval is measured taking into account the temperature, which increases the reliability.

The proposed method is intended to be used for determining the water level of hydrostatic wells.

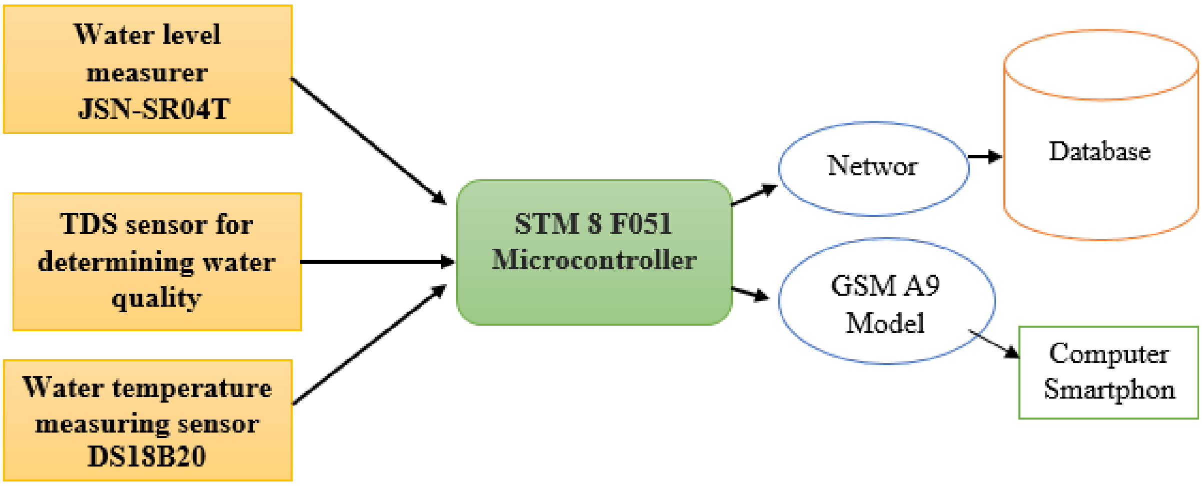


*Figure 4. Block diagram of automated measuring system.*

The device is floating inside the pod, the parts are wireless ISM transmission special communication, the parts are water level meter sensor, seven-in-one water quality detector, water temperature battery source, wireless ISM transmission special communication, wireless ISM transmission and reception , meter sensor, low power control microcontroller STM8F051, motion sensor, GSM A9 module, SIM card, 3.7 V battery.

Long-range detection must take into account the attenuation of ultrasonic energy through air. The rate of attenuation depends primarily on frequency. The relationship between the frequency of the structure and the maximum detectable distance is presented as follows:

↑ *Frequency::* ↑ *Resolution ::* ↑ *Narrower Directivity ::* ↑ *Attenuation ::* ↓ *Distance*

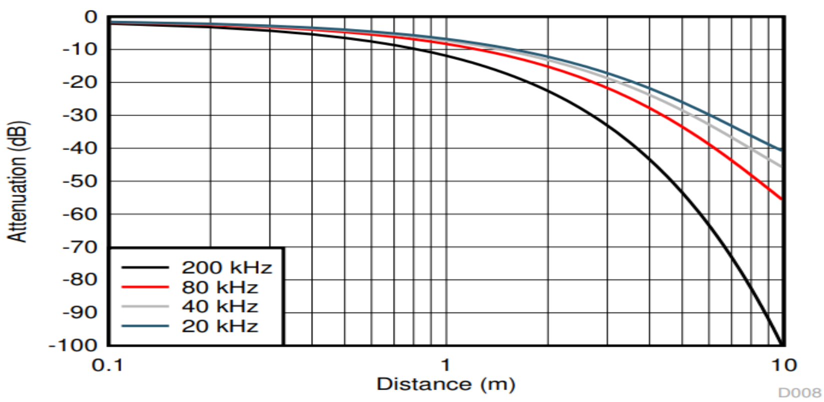


*Figure 5. Properties of sound pressure attenuation over distance.*

Ultrasonic energy does not propagate linearly over distance. Figure 5 shows the attenuation of sound pressure with distance and frequency. The advantages of high-frequency designs are increased accuracy and directivity (forward beam pattern), but the disadvantage is increased attenuation. The degree to which ultrasonic sensor energy undergoes scattering and absorption during propagation through air increases with frequency, and therefore the maximum detectable distance decreases. Targets and objects to be detected: The signal emitted by the ultrasonic sensor affects the echo force that returns to the target point where the sound is reflected. For example, a large, flat steel wall will reflect more echoes than a narrow tree. This difference (acoustic impedance), the ratio of the pressure on an imaginary surface in a sound wave to the speed of particle flow across the surface, is due to a combination of the orientation and the maximum cross section of the target.

Acoustic - in other words, acoustic impedance is a property of a material that describes how much it "pushes back" sound waves trying to pass through it. Materials with high acoustic impedance tend to reflect more sound energy than they transmit, while materials with low acoustic impedance tend to transmit more sound energy than they reflect. resistivity is based on the density and acoustic velocity of a given material, and it is important to determine the amount of reflection that occurs at the boundary of two materials with different acoustic resistivities.

The acoustic resistance of air is four times smaller than that of many liquids or solids; therefore, most of the ultrasound energy is reflected into the tissues based on the difference in reflection coefficients, but lighter materials with low density or significant amounts of air voids such as sponges, foams, and soft woven fabrics generally absorb more ultrasound energy. Table 1.1 shows a sample list of the characteristics of various material types as they relate to ultrasonic absorption by air.

***Table 1.1 Speed of sound at air temperature***

| (Temperature)°C | Speed of sound $(\boldsymbol{m/s})$ |
|---|---|
| -40 | 307 |
| -30 | 313 |
| -20 | 319 |
| -10 | 325 |
| 0 | 331 |
| 10 | 337 |
| 20 | 343 |
| 30 | 349 |
| 40 | 355 |
| 50 | 361 |
| 60 | 367 |
| 70 | 373 |
| 80 | 379 |
| 90 | 385 |
| 100 | 391 |
| 110 | 397 |
| 120 | 403 |

Table 1.1 speed of sound is shown over temperature. As can be seen from the table, as the temperature increases, the speed of sound increases. 0 °C speed of sound at temp 331 $\boldsymbol{m/s}$ will be 10 °C speed of sound at 337 $\boldsymbol{m/s}$ increases at.

Changes in temperature, humidity and air pressure, speed of sound, transmission resistance characteristics of the structure reflect the resistance characteristics of the equipment, such as a variable parallel load in the structure. Temperature has the greatest effect on the performance of ultrasonic sensors.

**REFERENCES**

1. Dzhumanov Zh.Kh., Razhabov F.F., Kim E.V., Yakhshiboev R. Development of a model and calculation of the biosignal flow balance based on microcontrollers, ISSN2181-7812 2020. P.187-188.

2. Yakhshiboev R.E,Turaev B,Jamolov Kh.M, Atadjanova.N.S, Kim E.V.,Sayfullaeva.N.A.
3. Dzhumanov Zh.Kh., Yusupov R.A., Egamberdiev Kh.S., Yakhshiboev R.E. The use of geographic information systems to substantiate promising areas for the organization of prospecting and exploration works (for example, for water supply of national economic facilities) IICS-2020.
4. Dzhumanov Zh. Kh. Yakhshiboev R. Development of a mathematical model and a software package for calculating items of the balance of information flow (for example, drinking water). IICS-2020
5. Abutaliev F.B., Usmanov R.N. Experience in numerical modeling of hydrogeochemical processes on the example of the Kuanyshdzharma groundwater deposit in the Southern Aral Sea region // DAN RUz. –T., 2001. – №3. S.23-26.
6. Abutaliev FB, Khabibullaev I. Solution of the problem of groundwater filtration in heterogeneous multilayer aquifers // Modern research methods and data processing in hydrogeology / Tr. State Enterprise "Institute GIDROINGEO" - T .: SAIGIMS, 1980. - Vol. 6. - S. 14-20.
7. Baer Ya. Physical and mathematical foundations of water filtration.- M .: Mir, 1971.-452p.
8. Veselov V.V., Panichkin V.Yu., Miroshnichenko O.L. Solutions of inverse problems of geofiltration on mathematical models of hydrogeological objects // Sb. proceedings of the XXXII session of the Geological Congress. –Florence, Italy 2004. MES RK, Almaty, 2004. S. 417-426.
9. Dzhumanov Zh.Kh., Geoinformation technologies in hydrogeology. –T.GP “Institute HYDROINGO” 2016. 258s