DEVELOPMENT OF THE CONTROL SYSTEM OF THE LEVEL WITH CONTROLLER

Abstract. The Arduino microcontroller is an excellent level measurement device due to its features such as low power consumption, high performance and ADC. The microcontroller can be used with a for accurate level measurement in a variety of applications. Information about the importance of connecting the level transmitter to controllers for remote control, visualization of its data, more accurate operation, and compatibility with systems where processes are automated is given. Solu Sl067 level transmitter was used for this purpose. Non-contact level measurement schemes are shown using ultrasonic sensor HC-SR04 connected to Arduino Uno controller. In addition, information on controlling the water level in the tank with an electrode level transmitter with an IC1 555 controller is provided, and the functional scheme is noted.
Keywords: microcontroller, measurement device, level sensor, level transmitter, ultrasonic sensor.

INTRODUCTION

Automation of technical processes refers to a set of tools and methods for the implementation of various systems without the participation of individuals. The level of existing technologies and the speed of progress have reached such a point that it is no longer possible to do successful work without a significant modernization of the technological base and the introduction of computer technology. Today, the technical basis of the development of industry and various areas of production is the automation of production processes.

The automation of production processes undoubtedly leads to an improvement in the overall labor productivity of the company, an increase in the quality of the product and an increase in the safety of the workplace. The last decade has seen a shift from analog control systems to digital control systems, which provide higher accuracy and more data processing, storage and transmission options [1, 2]. Continuous technological processes in most companies require continuous automated control of the amount of product, raw material or liquid in the tank. Level measurement systems are designed to control the level of various environments in product storage tanks during production processes in industrial companies, as well as to maintain a constant level of liquids in tanks, to prevent leakage and overfilling.

In every industry, the product level in the production tanks must be precisely controlled to meet the requirements of the entire technical process.

The use of level measuring devices allows you to control not only the level, but also the properties of the measured product (level, density and pressure). The biggest way to improve production efficiency is to use automated control systems [3-5].

RESEARCH OF MICROCONTROLLERS AND SELECTION OF SUITABLE MICROCONTROLLER

Microcontrollers have become an essential part of electronic devices, from household appliances to complex industrial machines. With technological advances, microcontrollers have become more powerful, sophisticated, and versatile, making them ideal for a wide range of applications. When researching microcontrollers, several factors come into play. One of

the most critical factors is the processing power of the microcontroller [6]. This determines the speed at which the microcontroller can perform tasks and the complexity of those tasks. Other factors to consider include the amount of memory available, the number of input/output pins, and the ease of programming. It is also essential to consider the specific needs of the project. Different microcontrollers have different features and capabilities, and selecting the right one can make a significant difference in the success of the project.

A microcontroller is a sort of microcircuit that is used to operate electrical devices. A typical microcontroller contains randomly accessible memory and read-only memory, as well as containing both CPU and peripheral device functions. In general, a microcontroller is a single-chip computer and can perform fairly simple tasks. Computers, consumer electronics, and industrial applications all use microcontrollers [7-10]. Variety of designs are used to build microcontrollers. Harvard, Princeton and companies such as CISC (Complete Instruction Set Computers), RISC (Reduced Instruction Set Computers) are examples [11].

RISC and CISC processors differ from each other because CISCs have smaller packet instructions and therefore more advanced addressing capabilities. In this case, the developer has to mix the instructions to perform more complex tasks.

Academician S.A. Lebedev and John von Neumann contributed to Princeton's architecture. It stores programs and data in shared memory, as shown in (figure 1). Simplified CPU circuitry and flexibility to allocate resources across memory locations are key advantages. The use of different address spaces to store instructions and data is a feature of the Harvard design (figure 2). This architecture was hardly used until the late 1970s when MC developers realized that this design gave them certain advantages [11-14]

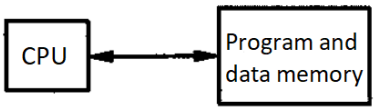

Figure. 1. Princeton architecture

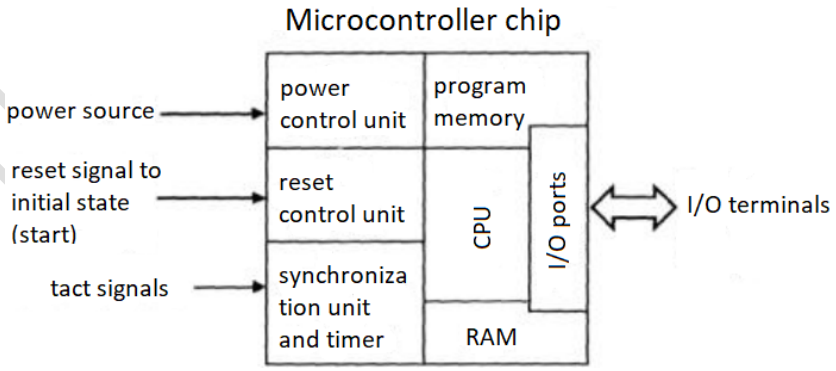

Figure. 2. The structure of microcontroller

Microcontrollers include many different devices. All these devices fall into the following main categories: Embedded systems are systems that are designed to perform a specific task. These systems are composed of hardware and software that work together to perform the task. Embedded 8-bit microcontrollers are a type of embedded system that is widely used in many applications. They are small, inexpensive, and low-powered devices that are capable of performing simple tasks. Embedded 8-bit microcontrollers have many features that make them appealing for use in many applications. These features include low power consumption, small size, low cost, and a wide range of peripherals. They typically have a small amount of memory and are programmed in assembly or C. They are also designed to be very reliable and can operate in harsh environments. Embedded 8-bit microcontrollers are used in a wide range of applications, including consumer electronics, automotive, industrial control, and medical devices. In consumer electronics, they are used in products such as digital cameras, MP3 players, and remote controls. In the automotive industry, they are used in engine control units, airbag systems, and anti-lock brake systems. In industrial control, they are used in systems such as level controllers, motor control systems, and robotics. In medical devices, they are used in devices such as blood glucose monitors, pacemakers, and insulin pumps. Embedded 8-bit microcontrollers offer many benefits for designers and developers. They are inexpensive, easy to use, and reliable [15]. They are also flexible, allowing developers to customize them to meet the specific requirements of their application. They are also widely available, with many manufacturers producing them.

16-bit microcontrollers are integrated circuits that have a data bus of 16 bits. They have a processing power of up to 16 MHz and a memory capacity of up to 64KB. They are widely used in various applications such as automotive electronics, industrial automation, and medical devices. Due to their low power consumption, they are ideal for battery-powered applications. One of the main advantages of 16-bit microcontrollers is their cost-effectiveness. They are cheaper compared to 32-bit microcontrollers and are widely available in the market. They are also easy to program and have a simple architecture, making them ideal for small-scale applications.

However, there are also limitations to 16-bit microcontrollers. They have limited memory capacity, which restricts the size of the program that can be executed. They also have limited processing power, which limits their performance in complex applications. 32-bit microcontrollers are integrated circuits that have a data bus of 32 bits. They have a processing power of up to 200 MHz and a memory capacity of up to 2MB. They are widely used in various applications such as audio systems, digital cameras, and gaming consoles. Due to their high processing power, they are ideal for complex applications that require high-speed data processing. One of the main advantages of 32-bit microcontrollers is their processing power. They can handle complex instructions and large amounts of data, which makes them ideal for applications that require high-speed data processing. They also have a large memory capacity, which allows for larger programs to be executed. However, 32-bit microcontrollers are more expensive compared to 16-bit microcontrollers [16]. They also consume more power, making them unsuitable for battery-powered applications. They are also more complex to program and have a complex architecture, making them unsuitable for small-scale applications. Digital Signal Processors (DSPs) are specialized microprocessors designed to execute digital signal processing algorithms efficiently. DSPs are widely used in various applications such as mobile phones, audio and video processing, and control systems. DSPs have many advantages over general-purpose microprocessors, including high-performance processing, low power consumption, and flexibility in implementing complex algorithms. DSPs have a unique architecture that enables them to process multiple data

streams in real-time. The architecture consists of a data memory, program memory, arithmetic logic unit, and a set of specialized instructions for signal processing. The data memory is used to store input and output data, whereas the program memory contains the instructions for signal processing. The arithmetic logic unit performs mathematical operations such as addition, multiplication, and division. DSPs have many applications, including audio and video processing, speech recognition, radar systems, and control systems. In the audio and video processing industry, DSPs are used for noise reduction, equalization, and compression. In speech recognition, DSPs are used to convert analog signals to digital signals and then process them to extract relevant features. In radar systems, DSPs are used to filter and process the received signals to obtain information about the target. In control systems, DSPs are used to implement control algorithms for various applications such as robotics, automotive, and aerospace. DSPs have many advantages over general-purpose microprocessors. They are designed to handle multiple data streams in real-time, making them suitable for real-time signal processing applications. DSPs are also highly efficient in executing signal processing algorithms, which enables them to process large amounts of data quickly. Additionally, DSPs consume less power than general-purpose microprocessors, making them ideal for battery-powered applications such as mobile phones [17].

A typical microcontroller consists of a central processing unit (CPU), memory, input/output (I/O) ports, and various peripheral devices. The CPU is responsible for executing instructions and controlling the overall operation of the microcontroller. The memory is used to store data and program instructions. The I/O ports allow the microcontroller to communicate with other devices, such as sensors and actuators. Microcontrollers are typically programmed using a specialized language, such as C or assembly language. The code is written on a personal computer and then transferred to the microcontroller using a programmer. Once the code is loaded onto the microcontroller, it will execute the instructions and perform the desired function. Microcontrollers are used in a variety of applications, including robotics, automotive systems, and industrial automation. They are often used to control motors, sensors, and other devices. For example, a microcontroller might be used to control the speed of a motor in a robot or to monitor the level of a machine in an industrial setting.

Some microcontrollers, especially 16- and 32-bit microcontrollers, rely on external memory containing both program memory (ROM) and some data memory (RAM) required for a particular application (figure 3).

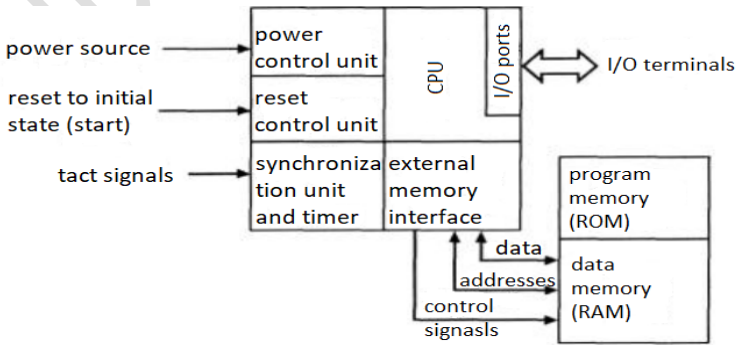

Figure. 3. Block diagram of a microcontroller with external memory

Microcontrollers can also have external memory, which can be used to store additional data or program instructions. This allows for more complex programs to be executed on the microcontroller. However, using external memory can add cost and complexity to the design. In addition to the benefits of internal memory, external memory can also provide more flexibility and storage capacity. This is particularly useful for applications that require large amounts of data to be stored or processed. For example, in a data acquisition system, external memory can be used to store large amounts of sensor data. There are several types of external memory that can be used with microcontrollers, including static random access memory (SRAM), dynamic random access memory (DRAM), and flash memory. The choice of memory type will depend on the specific requirements of the application. SRAM is a type of memory that is fast and efficient, but it requires constant power to maintain the stored data. DRAM is similar to SRAM, but it is slower and less efficient, and it requires periodic refreshing to maintain the stored data. Flash memory is a type of non-volatile memory that is commonly used for storing program code and data [18]. When using external memory with a microcontroller, it is important to consider factors such as access time, power consumption, and compatibility with the microcontroller. Some microcontrollers have specific requirements for the type and configuration of external memory that can be used. In summary, external memory can be a useful addition to a microcontroller-based system, providing increased flexibility and storage capacity (figure 4). However, it is important to carefully consider the specific requirements of the application when choosing a type of external memory to use [7].

The number of GPRs in a microcontroller can vary depending on the specific architecture. Some microcontrollers have only a few GPRs, while others can have several dozen. The number of GPRs can affect the performance of the microcontroller, as more GPRs can allow for faster data manipulation.

In addition to GPRs, microcontrollers can also have special-purpose registers (SPRs) that are used for specific functions, such as controlling the operation of peripherals or managing interrupts. SPRs are typically located outside of the CPU and are accessed using special instructions.

When programming a microcontroller, it is important to carefully manage the use of GPRs and SPRs. Efficient use of registers can help to optimize the performance of the microcontroller and reduce the amount of memory required for program code and data.

In summary, GPRs are an essential component of microcontroller architecture, providing fast and efficient data manipulation. The number of GPRs can affect the performance of the microcontroller, and the use of SPRs should also be carefully managed when programming the microcontroller [9]. According to the order of the names, flash, RAM, and EEPROM are memory types that store programmers, temporary working data, and long-term data that are independent of the microcontroller's power source [12]. The program determines the tasks and modes of operation, but the activities are carried out in hardware, that is, together with the main program.

1. 8-bit AVR.
2. AVR is 32 bit.
3. AVR xMega chip

The 8-bit microcontroller family has been the most popular for the past decade. First, there are two popular families known as AVR 8-bit microcontrollers:

• ATTINY—Often there are eight pins or more. Memory functions and sizes are usually smaller than the following;

• ATMEGA are more advanced microcontrollers with larger memory, pins and various functional units;

The most powerful subfamily of microcontrollers, xMega is sold in packages with multiple pins from 44 to 100. This is necessary for projects with a large number of sensors and actuators. In addition, it delivers outstanding performance thanks to improved memory space and processing speed. AVR microcontrollers are easy to use, use little energy and provide a high level of integration. These microcontrollers can be used in a wide variety of devices such as public systems, public address systems, LCD displays, and boards with limited space. They are also used in a variety of applications such as authentication, automobile electronics, measuring battery levels, and preventing short circuits and overheating. Selecting the most suitable microcontroller for a project requires careful research and consideration of various factors, including processing power, memory capacity, input/output pins, and ease of programming. By selecting the right microcontroller, a project can be completed more efficiently and effectively, leading to greater success. In conclusion, during the research phase, it is essential to identify the specific needs of the project, including the required processing power, memory capacity, and input/output pins. Once these needs are established, it is important to research the various microcontrollers available on the market and compare their features, capabilities, and ease of programming. It is important to take the time to conduct thorough research and select the right microcontroller for the job. With the right microcontroller, a project can be completed more efficiently and effectively, leading to greater success. In summary, microcontrollers are critical components of electronic devices, and selecting the right microcontroller for a project requires careful research and consideration of several factors. A thorough understanding of these factors can help engineers and developers choose the most suitable microcontroller for their project, leading to greater success and efficiency.

OPERATİON PRİNCİPLE OF MİCROCONTROLLER BASED CONTROL SYSTEM

We got acquainted with different ways of determining the level. An ultrasound transmitter connected to the controller is one of the devices that can be used for this purpose. The positive aspect of this device is that when measuring the level with its help, we no longer need the parts of the sensor that touch the water, this sensor is a remote measuring sensor. For this we will use the HC-SR04 transmitter adapted to the Arduino controller. Here we will use one Arduino Uno, HC-SR04 sensor, Relay circuit and ULN2003. The HC-SR04 ultrasonic module is a module that can provide non-contact measurement with an accuracy of up to 3 mm in the range of 2 cm to 400 cm. It works on the principle of echolocation. Here, the Arduino sends a 10 microsecond 10 KHz sound wave to the trigger pin of the sensor, this wave hits the water surface and echoes, and the signal level is received on the echo pin. In this case, the time between the 2 signals plays a key role in measuring the distance. Taking into account that the speed of sound is 340 m/s, the distance is calculated like this.

Distance=(time/2)*Speed of sound

To determine the water level in the tank, we need to know the total length of the tank. It is this value that will allow us to calibrate the tank. 1 Buzzer is used to signal the circuit when the tank is empty. One of the disadvantages of this method is that if you install this system for a narrow pipe or tank with a small diameter, high-frequency peaks may echo from the walls of the container, causing noise. In this case, our measurement will be wrong. Therefore, the diameter of the container should not be less than 7.5 cm for a half-meter tank.

The structural diagram of the connection of the ultrasound transmitter is given in figure 4.

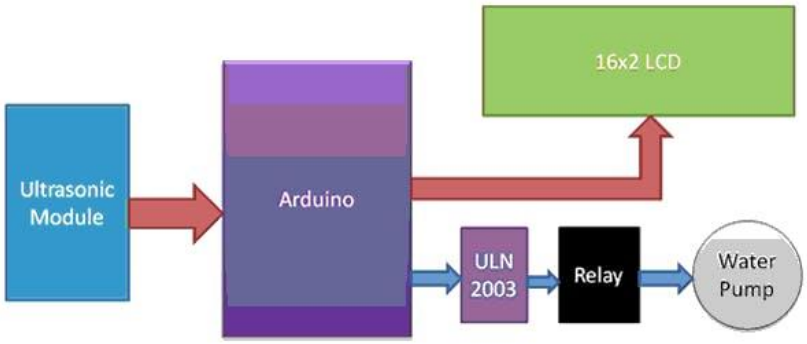

Figure 4. Structural diagram of the connection of the ultrasound transmitter

We can learn the distance with the help of the sensor, and then we convert the distance plot to the level measurement by programming the Arduino:

```
/* Water Level Meter
Measuring water level with ultrasonic sensor HR S04.
*/
int trig = 12;
int echo = 11;
void setup()
{
 Serial.begin(9600);
 pinMode(trig, OUTPUT);
 pinMode(echo, INPUT);
}
void loop()
{
 long t = 0, h = 0, hp = 0;
 digitalWrite(trig, LOW);
 delayMicroseconds(2);
 digitalWrite(trig, HIGH);
 delayMicroseconds(10);
 digitalWrite(trig, LOW);
   t = pulseIn(echo, HIGH);
    h = t / 58;
 h = h - 6;  // offset correction
 h = 50 - h;  // water height, 0 - 50 cm
 hp = 2 * h;  // distance in %, 0-100 %
 Serial.print(hp);
 Serial.print("\n");
 delay(1000);
}
```

When we want to test if our transmitter is working properly, we fill the tank all the way, then open a valve and let the water flow. Inside the Arduino, we will see the function of stepwise discharge of water.

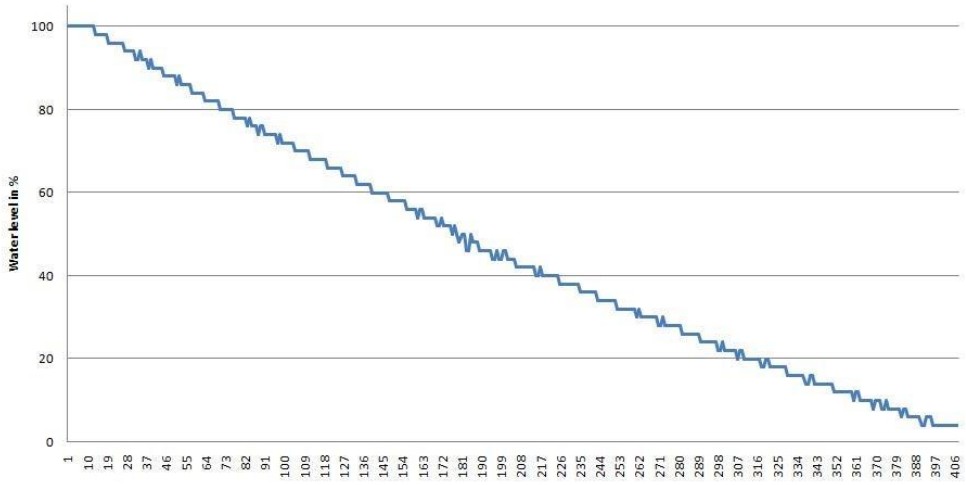

Figure 5. Step discharge function of the ultrasound transmitter

We will get acquainted with the level sensor circuit, which monitors the water level in the tank, turns off and on the pump motor according to the maximum and minimum water levels. The circuit has 2 switches to control the pump motor. Here, 2 fin sensors play the role of a switch. Two aluminum rods are used so that the water in the tank can float inside. Pipes are connected vertically to the wall of the tank. The 1st sensor is placed at the minimum water level. The 2nd sensor is placed at the maximum water level. As the water level rises, the state of the moving contact transmitters changes from normally closed to normally open. When the water level drops, it returns to its previous state.

The normally closed contact of switch S1 is connected to ground, and the normally closed contact of switch S2 is connected to the 12 V power supply.

When the water in the tank drops below the minimum level, the contacts of both fin transmitters will be normally closed. In this case, IC1's trigger input (2) and reset input will be connected to ground and 12 V respectively. That is, IC1 will be connected to ground and 12 V respectively. When IC1 555 turns on, it energizes relay RL1 through transistor SL100, so the relay turns on and starts the motor when switch S3 is open.

When the water reaches the maximum position, it pushes the moving contact of the 2nd sensor to its normally open position and connects to ground. In this case, IC1 resets and turns off the pump. As water is used, the contact of sensor 2 becomes normally closed and connected to 12V. But since the contact of sensor 1 is still normally open connected to 12V, IC1 does not turn on.

When the water level drops below sensor S1 again, IC1 is connected to the ground and 12V inputs again, turning on the transistor and the relay is supplied with 12V and the pump starts again (figure 6).

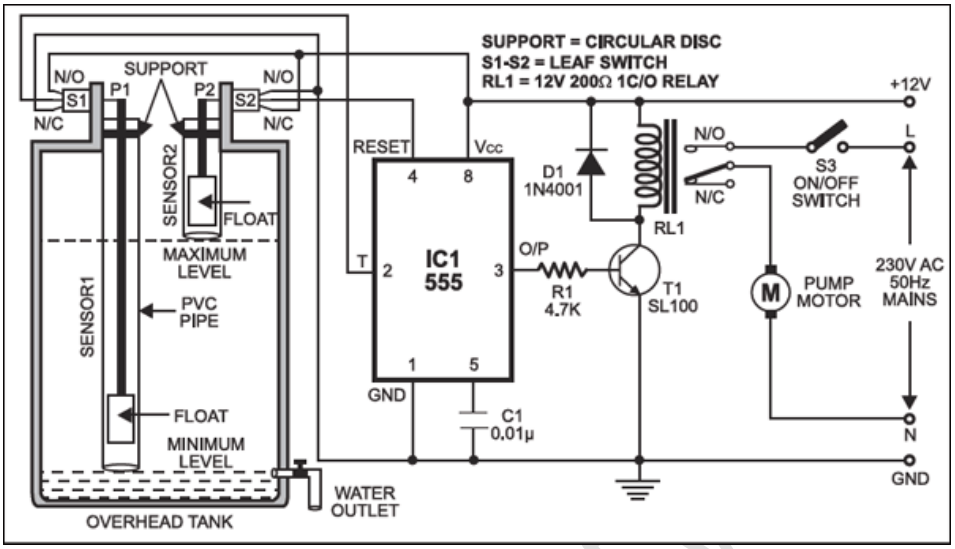

Figure 6. Schematic of level measuring device with IC1555

IC 555 is an integrated timer chip that generates pulses inside. It includes a flip-flop and 2 operational amplifiers. It is capable of producing both rectangular and sawtooth pulses. These frequencies can be connected at different frequencies from 0.1 Hz to 100 kHz. This chip has different modes. In its unstable mode, it is used to generate multiple pulses and is used in LED Christmas lights. It also has a mode that emits only a single pulse, in which case it is used to detect a missing pulse. It is necessary to use the chip as a normal key. It can also be used as a Schmitt trigger, which converts a noisy input signal into a clean digital output signal (figure 7).

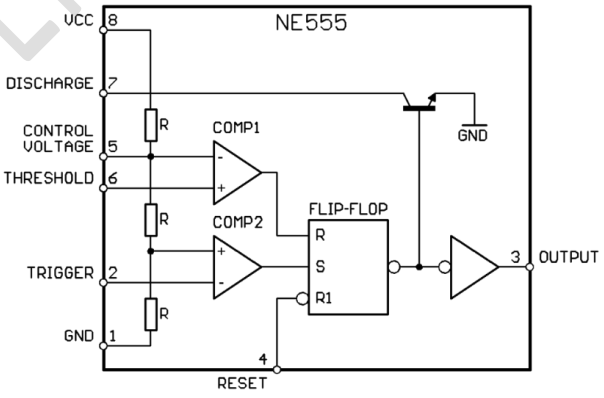

Figure 7. Internal circuit of IC1555 chip

CONCLUSION

In conclusion, the Arduino microcontroller is an excellent level measurement device due to its features such as low power consumption, high performance and ADC. The microcontroller can be used with a level sensor for accurate level measurement in a variety of applications. Information about the importance of connecting the level transmitter to controllers for remote control, visualization of its data, more accurate operation, and compatibility with systems where processes are automated is given. Solu Sl067 level transmitter was used for this purpose. Non-contact level measurement schemes are shown using ultrasonic sensor HC-SR04 connected to Arduino Uno controller. In addition, information on controlling the water level in the tank with an electrode level transmitter with an IC1 555 controller is provided, and the functional scheme is noted.

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