International Journal of Electronic Engineering and Computer Science
Vol. 2, No. 3, 2017, pp. 16-22
http://www.aiscience.org/journal/ijeecs

Digital Fluid Level Transmitter with Thermistor

Farid Agayev*, Sevinj Guliyeva

Control and System Engineering Department, Azerbaijan State Oil and Industry University, Baku, Azerbaijan

Abstract

The research focuses on the type of devices used to measure various types of fluids in household and industry, thermistor digital transmitters, and their operation principles. Other transmitters used in the measurement of the level and their working principles were studied, and each of the environments used was evaluated. The process of transmitting signals from the transmitter to the control unit and the process of generating a control signal are also reflected in the case. In addition to the transmitters with the transmitter, a link was established between them and the software was written to control the level with the help of the signal. With the help of PID controls and thermistor transmitters, the issue of controlling the level in the water pool was considered.

Keywords

Sensitive Element, Transmitters, Level Sensors, Thermistor Digital Transmitters, Measurement of the Level, Level Transmitters, Control Object

Received: August 12, 2017 / Accepted: November 12, 2017 / Published online: December 9, 2017

1. Introduction

It is known that in the present-day technology, technology is increasingly developing, and this development shows itself in science, the economy, and in the whole industry. With regard to this development, processes are becoming increasingly automated, and manual work is replaced by automated processes. Of course, automated processes help us with different types of devices, which perform long-term measurements and calculations in a few seconds. Some kind of devices are also transmitters, which allow them to receive information within a few seconds from the remote control object. Various types of transmitters are based on different work principles. For example, temperature transmitters, heat transmitters, level transmitters, pressure transmitters and so on. Today, industry is one of the key issues in determining the level of production. For example, oil wells measure oil depths, oil stored in vats, water level in pool, etc. It is very important to determine. Many different types of level transmitters are used for this purpose. These transmitters are manufactured in different designs based on different work principles. One of these types of transmitters is the thermistor digital fluid level transmitters. Temperature-sensitive thermistors are used as sensitive elements in thermistor transmitters. As you know, the output of these transmitters is analog signals, so you need to convert the signals to the digital form through ARC before transmitting these signals to the controller. For this purpose, the transmitter and the ARC are manufactured together with the hybrid construction, or before the transmitter's output is sent to the ARC later to the controlling object.

The main purpose of the research is to study the widely used thermistor digital transmitters in the industry, to get closer acquaintance with the principles and structure of the work, as well as to compare the different and distinctive aspects of the wide-spread transmitters and to make the ARC- And it is a good idea to explore and change the transmitter's transmitting signals into any software application on a control device (eg a computer).

* Corresponding author
E-mail address: agayev_f-h@yahoo.com (F. Agayev)

2. Statement of the Problem

Liquid level transmitters are used to measure the level of fluids as it appears in the name. In the natural water basins (we can measure the level with underwater hydrostatic pressure transmitters), the level of water in the high altitude, the level of water in deep wells and underground water basins, the level of sewage, rivers, etc. Different transmitters can be measured in different ways. Many companies produce transmitters to measure the level of fluid and natural water basins. Level transmitters are diverse to measure the level of any type of liquid, based on a very different working principle. Sensors in industry, everyday life and so on. The role of places is very large. The level transmitters in the industry include transport tanks, storage tanks, oil, diesel and so on. We can give examples of the transmitters used to measure the level of storage of such substances. Examples of transmitters used in household appliances, such as washing machines, dishwashers, heating systems, juicers, refrigerators, etc. Level sensors can transmit the measured signal in two ways:

A) in analog form (interconnected);

B) discrete form (with breaks).

These sensors continue to work normally at different temperatures depending on their structure. Liquid level sensors determine the level of liquids, including liquids and suspensions, fine substances and powders. Sensors can be measured either from containers or from natural streams (eg, in rivers) by continuous or intermittent levels. Undefined level transmitters measure uninterrupted levels as seen in the name, and determine the exact amount of flow in any area and transmit an uninterrupted signal. Discrete level transmitters transmit only if the liquid level is less than or equal to a certain value. Level sensors are very important sensors and play a very important role in industry. The level sensors used in the industry also differ from one another, depending on the external device and the processing logic. Operation principle is based on sensors (liquid and suspensions), temperature, pressure or vacuum, sound or electrical waves, vibration-sensing sensors, etc. There are some types. Level sensors change the level based on changing the various parameters. If the sensor determines the level of the change, it is important to select a suitable sensor. Let's get acquainted with some widespread types of transmitters.

Measurement of the level with the pressure transducer is one of the widely used methods in the industry. As the level of fluid changes, its pressure changes so that its height is determined. This transmitter is usually used to determine the height of the fluid flowing through the pipe. Many companies produce products - donors to measure the level of fluid tanks and natural water basins [1-4]. GEMS is one of the companies producing fluid level transmitters. Let's look at some of these products. GEMS filter-type fluid-level transmitters ensure that the levels are measured reliably and continuously from the remote jets to the required distance.

Pneumatic level sensors are used in areas where hazardous situations can be present, in areas where electricity is not present or limited, and their inner ear can be programmed to measure the level of heavy lubricant and suspension solutions. The operating principle of the pneumatic sensors is based on the effect of the air flow as it appears. The air flow squeezes the diaphragm, which is used to activate the sensor's key. The moving part of the sensor is only the diaphragm that the diaphragm is in no way inaccessible to fluid. These sensors are suitable for use in high-viscosity liquids such as oils, as well as in water-based and abrasive liquids. An additional advantage of these transmitters is that the relatively low price can measure the fluid level (ie, the cost of this transmitter is relatively cheap). The principle of operation is that the detector measures the level of liquor and transmits it to the camera by creating a corresponding pressure level. The diaphragm located on the camera manages the microscope to match the pressure it receives.

The conductive material level sensors are the ideal sensors for measuring a wide range of electrically conductive liquids, especially soda, chloride acid, nitrogen acid, iron chloride, and similar liquids. Since these fluids are corrosive, the electrodes of the sensors must be made of titanium, hastelloy B or C or 316 stainless steel and must be isolated from polyethylene, teflon based materials. Many electrodes of different length can be used in one sensor, depending on the design. With the increase in temperature and pressure, the abrasive liquid is more aggressive (eg sulphate acid, which means fattening). These hard conditions should be taken into account when selecting the sensor to use. Transmitting sensors are extremely safe because they require less voltage and current.

Ultrasound level sensors are used to measure the high viscosity fluid level without direct contact between the fluid and the sensor. These sensors produce high frequency (20kHz-200kHz) acoustic waves (in the form of vibration), reflecting the back of the waves to the surface of the liquid, and determining the fluid levels according to the pre-set program inside the sensor. Ultrasound level sensors also provide acoustic waves that are environmentally friendly by changing the sound velocity due to humidity, temperature, and pressure. Ultrasound transmitters can be used as transmitters and receivers of sound power, which is a mechanical vibration known as "call". These types of transmitters allow measuring the level both indefinitely and

at intervals. Ultrasound sensors also have some disadvantages. Some of the material is made of vapors or some of the environments that prevent the reflecting of the waves transmitted by the ultrasound transmitters. There are also environments or materials that are wasted instead of reflecting the waves. In such cases, other sensor types should be used.

Optical transmitters include sediment, solid suspension fluids, solid solutions, high viscosity, non-transparent and others. Used to measure the level of fluids such as both continuous and intermittent. These transmitters use visible, infrared or laser beams to measure the level. The rays emitted by these transmitters have almost the ability to cross, reflect, and break all the items. There are also types that are directly in contact with both liquid and non-direct contact. Direct contactless sensors are placed at a certain distance from the fluid and leave infrared rays that reflect the level by returning back to the surface of the liquid. One feature of these sensors is that they can be integrated into other devices (eg ARC) that are used in the process (measurement) and measure the measurement immediately with high accuracy. These simple and compact sensors have two parts:

1 - Light transistor infrared LED pair;

2 - Transparent prism tip in front of LED.

These sensors detect the infrared radiation or infrared radiation from the LEDs. Infrared rays are sent from the LEDs and reflected on the back of the fluid, and the prism feels the returning rays. If the fluid level is low, the density of the infrared radiation received by the transmitter differs slightly from the density of the beam transmitted to the liquid. If the level rises, the density of the rays emitted by the sensor differs sharply from the density of the returned beams, and the decrease is observed. At this point, some of the rays emitted by the LEDs disappear within the fluid. Based on the returning rays, the transmitter determines the fluid level. Depending on the design of this transmitter, it can also be used for accurate determination of water level in organic and abrasive liquids, as well as lily ponds. If the transmitters are replaced with a laser instead of a LED, it is used to measure the level of the sensors from the sensor (measured at discretely when level LEDs). Sensors based on laser beam have been further improved. Thus, laser beams can penetrate more dusty or smoky environments. Laser beams can be reflected on the most rigid surfaces. Optical sensors should be cleaned frequently to keep their workloads high. The main advantages of these sensors are the small size and the low cost. The downside is that with these sensors it is possible to measure the level at intervals, not too often to measure the level indefinitely. Therefore, laser sensors are used to measure the level indefinitely.

Hydrostatic pressure transmitters include abrasive liquids in deep vapors, in natural water basins, on boats and so on. Used to measure depth of water [5-9]. Completely or partly into the water. The principle of operation is based on the water pressure-P dependent on the height of the water. Liquid generates its gravity, gravity force, weight and hydrostatic pressure, and the value of these quantities increases the height of the liquid column. P-density is defined as the height (1) in the constant gravitational constant at the constant gravitational constant as the level of liquid reaches its elevation:

$$h = \frac{P}{\rho g} \tag{1}$$

That is, water in ships such as "liquid height", oil in vats and so on. We measure the hydrostatic pressure to measure the level and find the water level indirectly. The height of the fluid column increases excess hydrostatic pressure. Pressure on the surface of the water tank is 100 mbar above normal pressure, and the pressure of each meter in the water column is compared to the pressure on the water surface, and the water level is determined. Hydrostatic pressure transmitters, also called "submarines", were created for this purpose. Underwater transmitters or hydrostatic level transmitters are such pressure gauges that are placed underneath the liquid to measure the current at the depth of the chinks. If it is not possible to install these sensors at the bottom of the chimney or pipe, there is a special hydrostatic level sensor that places this sensor at a certain distance from the surface of the water, extending a cable from the sensor to the bottom of the liquid and measuring its level through the sensor itself. These sensors are a small converter in the head, turning large pressure in the vapor into normal atmospheric pressure. Otherwise, the normal change in atmospheric pressure will be reflected in the sensor's output with great errors. In addition, many sensors also need to be compensated for the temperature change in the fluid. There are two types of contact that are directly in contact with the fluid and are not directly in contact.

The nucleus transmitter or gamma ray detector determines the gamma rays weakened when measuring the level. Nuclear-level measuring devices can be used to measure levels at intervals or intervals. The principle of nuclear power transmitters is based on the penetration of nuclear radiation rays from the walls of industrial tanks. On one side of the casing, the radiation beam source is located on the other side (against the wall) and the sensitive detector is calculated so that the difference between the rays released from the source and the beam collected in the detector is calculated and the level of fluid in the chin is measured approximately.

3. Solution of the Problem

The thermistor is a type of resistor and resistance to change in temperature. The difference between the thermistors and the resistors is that thermistors use only ceramic and polymer materials, and only the pure metal is used in the resin. Also their temperature reaction is different. Resistors are used in very high temperature diopazons, and thermistors are used in limited temperature diopazons, typically in temperature ranges between 90°C and 130°C.

The line of integrity between resistance and temperature:

$$\Delta R=k\Delta T \tag{2}$$

Here, ΔR - the change of resistance,

ΔT - temperature change,

K is the temperature coefficient of resistance.

There are two types of thermistors depending on the k-temperature coefficient. If it is positive, resistance to increased temperature increases. These thermistors are called a positive thermistor thermistor (PTC) or positor and are sequentially connected to the circuit. If it is negative, temperatures are reduced to a greater degree of resistance, and these thermistors are called negative temperature thermistors (NTCs) and are connected to the circuit parallel. Sometimes the temperature coefficient k is instead of the resistivity coefficient α_T. It is designated as follows:

$$\propto_T=\frac{1}{R(T)}\frac{dR}{dT} \tag{3}$$

The principle of operation of the thermistors is based on the expression given above.

$$R_t=R_0(1 \pm \propto t) \tag{4}$$

R_0 resistance of thermistor at 0ºC. As can be seen, the resistance varies when the temperature changes.

As it moves through the thermistor, it begins to warm up and its temperature is increasing and higher than the ambient temperature. This event is called "self-warming effect". Self-warming effect is the main principle of thermistor digital fluid level transmitters. Temperature-changing systems use thermistors, resistors and other sensitive sensors to accurately measure the level of fluids. Typically, such levels may be determined by self-heating or cooling depending on the sensor's level change. It is known that when the thermistor is activated, the current flows through it and this current generates heat. When the thermistor is immersed in the liquid, the heat generated inside the thermistor begins to decline as the thermistor transmits its heat to the liquid. In this case, the temperature of the thermistor remains relatively constant and the resistance does not change because the energy given from the source is transmitted to the liquid in the heat form. When the thermistor is activated, the power given to it (5) is calculated.

$$P_E=I\ V \tag{5}$$

The heat transferred to the fluid according to the cooling law of the Newton is determined by the following expression.

$$P_T = K(T(R) - T_0) \tag{6}$$

Here T (R) - indicates the temperature of the thermistor, the temperature of the T-cell. K is the ratio expressed in milliwatts, typically at each ºC temperature. Recognizing that the energy given to the thermistor is corrupted to the energy transmitted to the liquid, let's equate both sides of (5) and (6):

$$P_E = P_T \tag{7}$$

$$I\ V = K(T(R) - T_0) \tag{8}$$

In view of the fact that, under the law of Om, there are $I = \frac{V}{R}$ (8) statements:

$$R=\frac{V^2}{K(T(R)-T_0)} \tag{9}$$

Based on the above statement, the level is determined by determining whether the transmitter's surface is covered by fluid based on the resistance of the thermistor inside the transmitter. If the surface of the transmitter is covered with fluid, the temperature of the thermistor is approximately equal to the liquid's temperature and the transmitter's tension evaluates the tension obtained from the source and the logic is "0". If the fluid level is gradually decreasing, in other words the liquid and the thermistor are not in contact with each other (the level below), the thermistor's heat is not reduced by the fluid, and the self-heating effect re-appears in the thermistor [10-12]. When the resistance increases, the voltage of the transmitter is greater than the voltage given by the source, the logic "1" is received, the circuit breaker, the contact and so on. Is activated. As a result of the self-heating effect, the temperature of the thermistor increases. This leads to an increase in its resistance. These are in the positive temperature coefficient thermistors-PTC.

Occasionally, there may be a problem with measuring levels at high temperatures. If the temperature of the thermistor in the predetermined temperature is very low, the temperature of the thermistor will increase when contacted with the high temperature fluid. This also causes errors, resulting in misleading information to the control system. This effect can be particularly significant in high-viscosity liquids, such as oils, buttermilk oils, etc. These liquids have the capability of low cooling (thermistor heat sinking). Based on the thermistors, the transmitters operate efficiently from the

range of 40 to 250 F. These 12 V units can work in max 11-15 V. Let us measure the level of a 10 m high watercourse with a thermistor digital transmitter based on this working principle (Figure 1). Select the ADM4850 series semi-duplex differential line transmitter to measure the level of this crane.

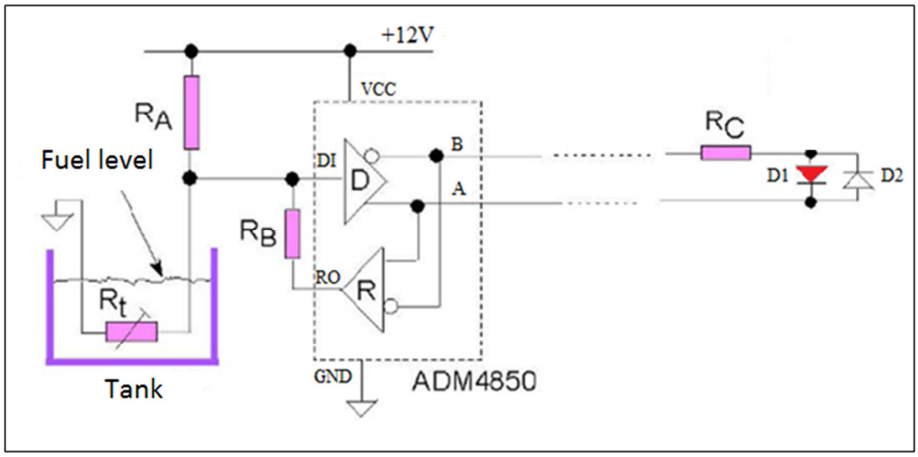

Figure 1. Example of scale measurement with the introduction of the ADM4850 series transmitter.

As you can see, the transmitter of the transmitter is transmitted to the controller, for example, to the computer and to make the appropriate decision. Obviously, the output signal of these verbosers is analog signals. All control devices operate with digital signals, so the output of the transmitters should be assigned to the ARC before transmission to the controller. Let's get a brief look at ARCs and their working principles to see how translators transpose analog signals to digital signals. Let's look at the determination of the level of oil in the cylinder by applying the devices we have studied the above working principle (ARC and the thermistor digital transmitter). Transmitters let us remotely control the level. Separate the process into two parts, including a work area and a work area. The area in the work area is measured by vats. The transmitters are placed in these vans. The chain level is transmitted to the control unit in the workplace on a computer, and when the level reaches the required level, the controller transmits the signal to the field and closes the valve. Select the ADM4850 series to set the level of the watercourse, select the thermistor digital range transmitter in range 0-10 V and place it in the sack. The output signal of this transmitter is coupled with the voltage transducer (GCP) located in the work room through the cables. In order to avoid distortion of transmitted transmitters, we can also combine the power amplifiers to strengthen the output signal of the transmitter's output before the GCP. The GCs give the binary codes received to the 7-segment indication element to convert it to a decimal, and thus we can visually monitor the incremental level. At the same time, the GCP output signal is also provided to the control device-computer (in the form of binary codes), which generates control signals.

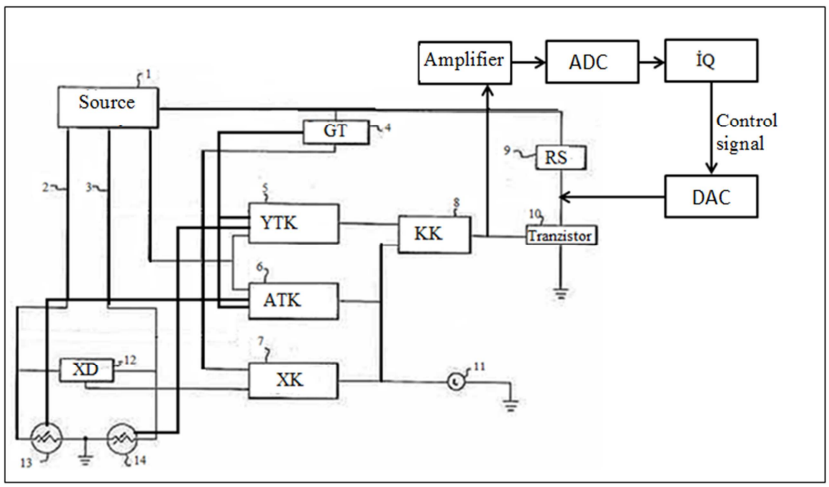

Figure 2. Placement scheme of the thermistor transmitter inside the chamber.

GT - Tension Regulator; YTK - Upper party compiler; ATK - Down Side Compass; XD - Error detector; XK - Bug Compatible; KK - switching compartment; RS - Rele system; ADC - Analog dicital converter; IQ - Managing Device; DAC - Digit analog converter

As shown in Figure 3, we choose a computer as a controller and can see the level change by incorporating discrete pricing from the output of the GPU into the Matlab software package.

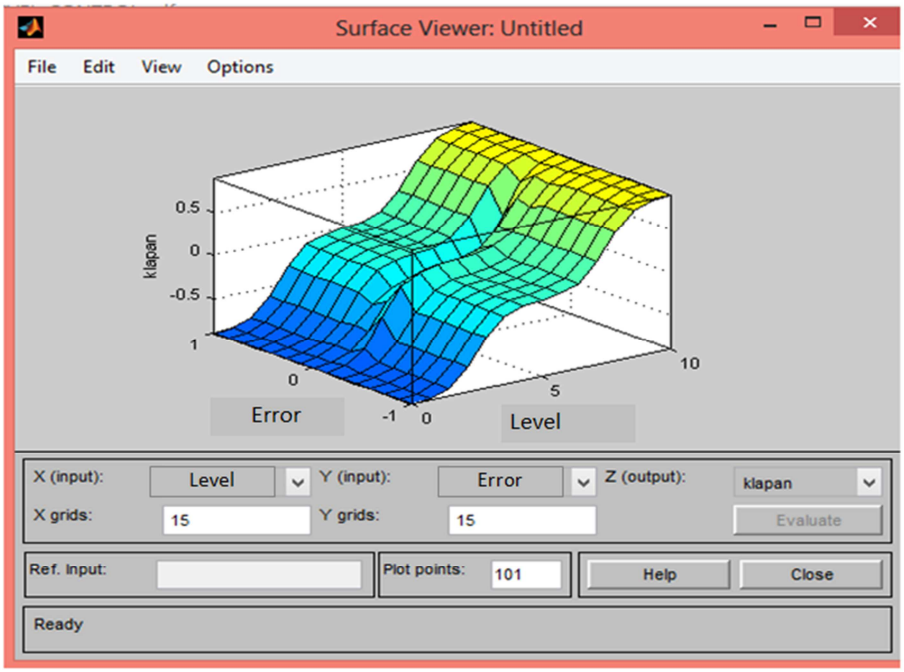

Figure 3. Description of level change in "Matlab" software.

We used a computer as a managed object in the process of managing the oil tank. The PMK (programmable logic controller) is now widely used as a control object along with the computer. PMK is a small "brain" that decides on the transmitter transmitted on the basis of a software written earlier here. The PMC uses the LD - Ladder Diagram or FBD to write software.

Let's see the level control in the small water pool via PMK (Figure 4). Place two transmitters in the water pool: one at the bottom of the pool and the other in the upper part of the pool. Also, use two input valves - the lower and upper valves to fill this pool with water and install an outlet valve for drainage. To manage the process in the pool, PMK's "brain" needs to be transmitted from a computer program to bluetooth or cable. This program is written by the FBD programming language in ZelioSoft software.

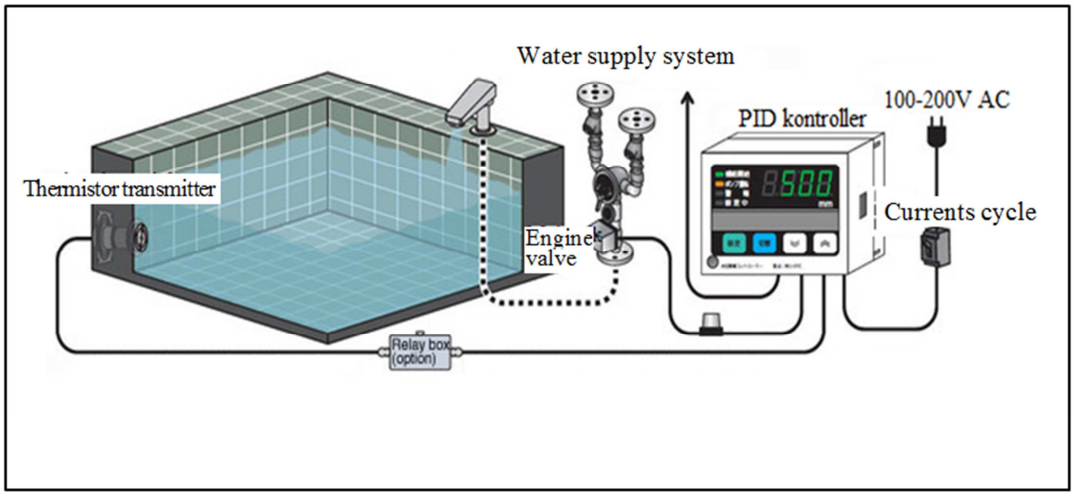

Figure 4. Water level control in the pool with PMK and thermistor transmitter.

In this pool, level control can be accomplished with LabView software as well as PID controls, and this program is one of the best ways to transmit transmitters from the transmitter. At this time, the POD controller receives the signal from the transmitter and connects the Labview software with special cables. In the above mentioned pool, the processes that occur between the PID controller and the transmitter in the level control will be more clearly reflected in the Labview software. The program has a special file that receives alerts from the transmitter.

4. Conclusions

Studies conducted in the research have led to the following results: the types of transmitters widely used in the level measurement have been investigated, their working principles, the environment in which they are used, and comparable to each other; the principle of operation of the thermistor, which is a sensitive element of the thermistor fluid level transmitters, has been studied; analog number converters, their working principle, transmitter and controlling object are in the process of transmitting the analogue output signal to the digital signal transmitter; using a thermistor digital transmitter, the remote control of the process was investigated by studying the water level in the oil and water pool and the managerial elements - the controller via the PC and PID controls; signals received from the transmitter are included in the LabVIEW and ZelioSoft software, and simple software for level control has been compiled and the transmitter transmitted in the LabVIEW software has been analyzed.

References

[1] Alfred K. Susskind, Notes on Analog-Digital Conversion Techniques, John Wiley.

[2] Yang C., S. Chen, and G. Yang, “Fiber optical liquid level sensor under cryogenic environment”, Sensor and Actuators A: Physical, vol. 94, No. 1-2, 2013, pp. 69-75.

[3] Su D., K. Ren, J. Luo, C. He, L. Wang, X. Zhang, "Programmed and simulation of the fuzzy control list in fuzzy control", “IEEE/WCICA”, pp. 1935-1940, July 2014.

[4] Dapeng Z., Todd S., Travis N., Yachun H. Analog to Digital Converters.

[5] Toni M. & Kinner, Russell H. P. E., Enhancing PLC Performance with Vision Systems. 18th Annual ESD/HMI International Programmable Controllers Conference Proceedings, 2011, p. 387-399.

[6] Peng Y., J. Luo, J. Zhuang, C. Wu, "Model reference fuzzy adaptive PID control and its applications in typical industrial processes", “IEEE/ICAL”, pp. 896-901, Sep. 2008.

[7] http://automationwiki.com/index.php?title=Bubbler_Level_Measurement

[8] http://www.analog.com/en/analog-dialogue/articles/thermistor-senses-liquid-levels.html

[9] http://www.best-microcontroller-projects.com/liquid-level-control-using-thermistors.html.

[10] https://www.researchgate.net/figure/272790461_fig7_Fig-45-Response-of-Fuzzy-Logic-Controller-Fig-45-Tank-Demo-Using-Ruleviewer.

[11] http://www.elektrikport.com.

[12] http://www.bourabai.kz/toe/adc.html