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Monitoring And Measuring The Level Of Water Objects Bythe Ultrasonic Method

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***Abstract*:** This article discusses ultrasonic sensors for level monitoring and measurement, with unified 4 ... 20 mA output current signals, with two-wire digital industrial communication interfaces such as HART, PROFIBUSSPA and Foundation Fieldbus. [1.10] The most widely used ultrasonic sensors of the LUC4 and LUC-T series and methods for installing and connecting ultrasonic sensors of the LUC-T series are presented. The principle of the implementation of the ultrasonic method for determining the water level is also presented here. This measurement method guarantees reliable operation of ultrasonic sensors in various conditions. [2.5.11]
The advantages and disadvantages of the ultrasonic measurement method are shown. To implement the method, it does not impose high requirements on the wear resistance and strength of the equipment and is independent of the density of the controlled medium. [3.12] The sensor has a built-in compensation system from the influence of temperature fluctuations on the measurement result. [4.13] Sensors of the LUC4, LUC-T series are specially designed and operate on a non-contact measurement method and measure the level of water and various liquids. [5.20]
Keywords: *ultrasonic sensors, water level, ultrasonic measurement method, non-contact method.*

I. INTRODUCTION

The management of technological processes in the water sector is related to the measurement of water level. Modern automation systems require statistical and informational data to optimize process control,increase water efficiency. This constantly increasing demand for information leads to the need to use in the monitoring systems not simple signaling devices, but means providing continuous measurement. [6] For this, new measuring instruments based on ultrasonic, electromagnetic and other methods of monitoring and measuring the level of liquids were developed and experimentally tested.
In the presented article, the main goal is to control and measure the level in water systems using ultrasonic sensors and the level measurement method. [1.7]

II. METHODOLOGY

Devices for continuous monitoring of liquid levels are created using various physical principles and measurement methods. The considered level gauges work with unified 4 ... 20 mA current output signals, with two-wire digital industrial communication interfaces, such as HART, PROFIBUSSPA and Foundation Fieldbus, their modifications for installation in hazardous areas of class 0, as well as complete solutions based on measuring instruments, controllers, means for interfacing with a control device and additional equipment [1]

To determine the water level in water management systems, we consider the principle of operation of ultrasonic sensors and methods for measuring the level. In the simplest and most common case, when the ultrasonic sensor is located at the upper point of the tank, the medium level is calculated as the difference between the height of the tank and the distance between the sensor and the surface of the medium (in the general case, a correction should be made that takes into account the difference between the actual height of the sensor and the height of the tank) .[5.8] This distance is calculated by the measured time, which is necessary for the ultrasonic pulse to travel from the sensor to the surface of the controlled water and vice versa (Figure 1).

$$h = h_{tot} - 1/\ 2\ v_s t$$

Here “vs” is the propagation velocity of an ultrasonic signal in a given medium.

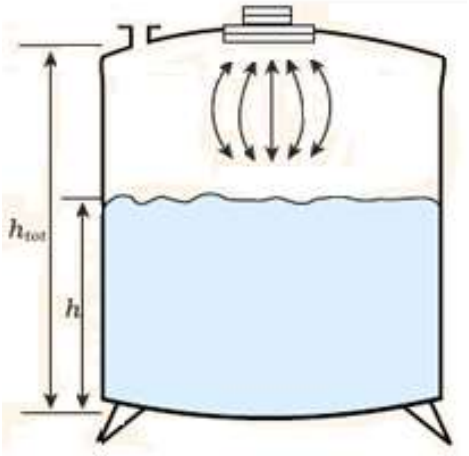

Fig. 1. The principle of implementation of the ultrasonic method for determining the level.

The chemical and physical properties of liquids do not affect the measurement result obtained by the ultrasonic testing method, so the level of both water and various liquids can be measured without problems. However, it must be remembered that the speed of propagation of ultrasound is influenced by air temperature in the medium of its propagation. [9] In addition, being strongly dependent on temperature, the speed of ultrasound depends on air pressure: it increases with increasing pressure. Relative changes in the speed of sound associated with changes in pressure in a normal atmosphere are approximately 5%. The speed of ultrasound also depends on the

composition of the air, for example, on the percentage of CO2 and humidity. [10]

The influence of relative humidity on the speed of ultrasound is less than the effect exerted by temperature and pressure: the additional difference in speed in dry and moisture-saturated air is about 2%. [11] The main advantages of the ultrasonic testing method:

+ non-contact;

+ applicable to contaminated liquids;

+ the implementation of the method does not place high demands on the wear resistance and strength of the equipment;

+ independence on the density of the controlled environment.

The disadvantages of the ultrasound method are:

- large divergence of the radiation cone;

- reflections from non-stationary obstacles (for example, agitators) can cause measurement errors;

- applicable only in tanks with normal atmospheric pressure;

- The signal is influenced by dust, steam, gas mixtures and foam.

Fig. 2. Appearance of ultrasonic sensors LUC4T, LUC-T.

The most widely used ultrasonic sensors are the LUC4 series of ultrasonic sensors of the LUC4 series are specially designed for measuring the level of liquids. The Teflon coating of the sensor housing allows the use of a sensor with corrosive liquids. Masking of stationary objects makes it possible to install the sensor in places where supports or other elements of the internal structure of the tank fall into the measurement zone. [5.12] Figure 3 shows the sensor installation diagram.

In the tank there is a bracket that forms a spurious echo signal (Fig. 3). Without suppression, the measurement results will be inaccurate. The following algorithm is recommended: 1)calibration of the sensor outside the tank with simulated empty tank,2)suppression of the echo signal from a stationary object in the working position, 3) calibration of the sensor in the working position when the tank is full.

Suppression of a spurious signal reduces the power of the useful signal, and in some cases it is necessary to evaluate this decrease so as not to lose the useful signal. The sensor is also

equipped with means to compensate for the effects of temperature changes. [13.14] In addition, it is possible to install external probes that monitor the temperature of the measured surface regardless of the conditions at the sensor installation site, which minimizes errors caused by temperature fluctuations.

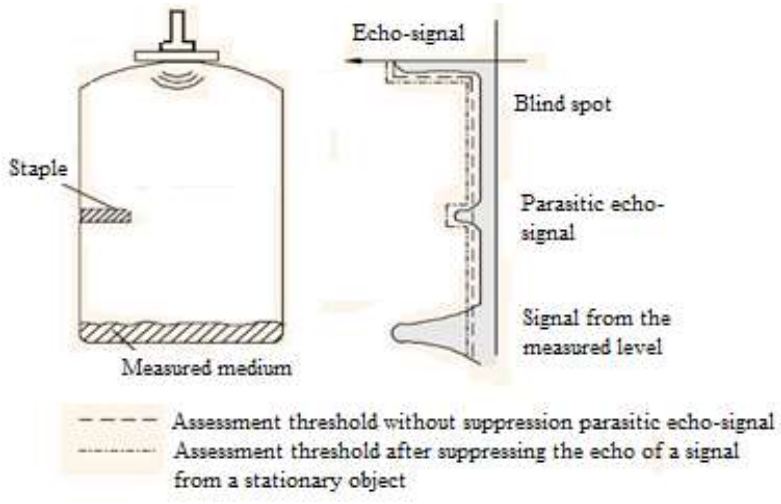

Fig. 3. Suppression of an echo - signal from a stationary object in the tank.

Ultrasonic sensors of the LUC-T series are also used. The compact ultrasonic sensors of the LUC-T series are also designed for non-contact level measurement of liquids. The LUC-T series includes three types of sensors with different types of electrical outputs (2 or 4 wire connection) and ranges for measuring the distance to the interface level starting from 0.25 m. LUC-T xxxx 5: in case of 4 wire connection with when measuring with dimensions of the structural components of the material from 4 mm, the guaranteed measurement range is up to 2 m, while measuring the level of liquids - up to 5 m (2 wire connection with power through the information channel - up to 4 m). [5.15] LUC-Txxxx6: in the case of a 4-wire connection when measuring the level of bulk materials with sizes of structural components of the material from 4 mm, the guaranteed measuring range is up to 3.5 m, when measuring the level of liquids - up to 8 m (2 wire connection with food through the information channel - up to 7 m). LUC-T30 (4-wire connection only): the guaranteed measurement range when determining the level of bulk materials with sizes of structural components of the material from 4 mm is up to 7 m, when measuring the level of liquids - up to 15 m. All sensors have a built-in system to compensate for the influence of temperature fluctuations on measurement results. [16.17]

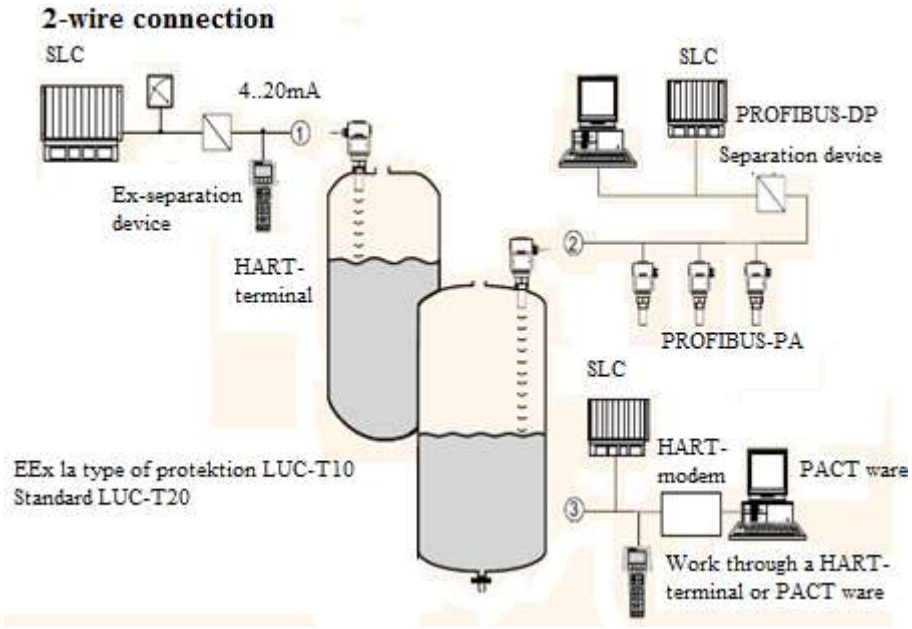

Fig. 4. Installation and connection methods for ultrasonic sensors of the LUC-T series.

III. RESULTS

An important advantage of these sensors is non-contact measurement of the level of liquids. It can also be used to measure the level of contaminated liquids. To implement the method, it does not impose high requirements on the wear resistance and strength of the equipment and is independent of the density of the controlled medium.
From the influence of temperature fluctuations on the measurement result, the sensor has a built-in compensation system.[3.18]

IV. DISCUSSIONS

The ultrasonic sensors of the LUC4 and LUC-T series presented in this article are used to monitor and measure the level of liquids in various environments. The method of ultrasonic level measurement is considered. Shows how to install and connect ultrasonic sensors. Compared to other measurement methods, there are advantages and disadvantages. This has been mentioned above. [5.19]

V. CONCLUSIONS

The method of measuring the water level considered by the ultrasonic testing company guarantees long-term operation of ultrasonic sensors in various climatic conditions. The main features of these LUC-T sensors are. An optimized set of fastening methods: threaded connection type G 1/2 "or 11/2" NPT. Q Possibility to read the status of the sensor via LED indicators. Various versions of the outputs of the glue (optional). The sensors are compatible with HART and PROFIBUSSPA network protocols and can be configured using Pepperl +

Fuchs PACT ware (Process Automation Configuration Tool) software. [1.5.20]

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