Monitoring of the change of the level of liquids and loose matreials in reservoirs

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Abstract: *An approach for receiving data and processing information about the level of filling tanks with liquids and loose materials is presented in the paper. This information may be used in different technological processes. The developed electronic scheme based on PIC16F84A micro controller is presented, too.*

Key words: *control. sensor, ultrasound, level, distance, reflection, controller, automation, transmitter, receiver*

INTRODUCTION

The receiving and processing of the information for the degree of filling the reservoirs with different materials is an important part of the controlling the technological processes. It is necessary to watch and control in all areas of the industry the level of different liquid and solid mediums, used in specific work conditions and kept in reservoirs with various constructions.

Different methods for measurement can be used for determination the level of the liquid and solid materials. The changes of the height of the filling the reservoir are transformed to the predetermined initial value. The big diversity of the measured or registered geometrical values (distance, length, width, path, contour, diameter, level, slope, angle) set the pattern for various methods for realization of the sensors [4].

The most used for that purpose methods, applied in sensors for measurement, control and management in level measurement, level signalization and level regulation devices are the following [5]: float sensors, optical sensors, ultrasound sensors, capacitance sensors, thermal sensors, radiation sensors, electro contact sensors, vibration sensors, radar sensors. Sensors based on pressure.

The development of the ultrasound methods for measurement, used in the industry automation, is very intensive. The measurement of velocity (velocity and capacity of a fluid), measurement of distance (level, depth, surface of a fluid) and measurement of a density refer to this kind of measurements. The echolocation sound principle is applied in these methods. It is based on the propagation of acoustic waves with frequency in the ultrasound range, which have many advantages in the concrete application [1]. The accuracy of this method is not influenced from some factors, such as cleanness of the medium, conductivity, aggressiveness, presence of steam, layer of foam and others. The authenticity of the initial results depends in various degrees on the temperature, pressure, and surface turbulence of the medium, high viscosity and presence of air in the fluid. This method permits contact and out of contact measurement of the height of the filling of the reservoir.

THE MAIN POINTS OF THE SUGGESTED DECISION

An approach for out of contact measurement of the level of filling of a reservoir with the help of ultrasound sensors is presented (Figure 1). For assuring a fool monitoring of the running filling, the level is determined by means of generating high frequency impulses with the direction to the bottom of the reservoir. We had measured the time needed for the signal, radiated from the sensor, to reach the surface of the vessel, to reflect on it and to come back to the sensor. Te measured period is functionally dependent on the level of the fluid in the vessel. It is visualized with a PC in a control room, or on a liquid crystal displays, put on convenient places in workshops or on the machines themselves. The

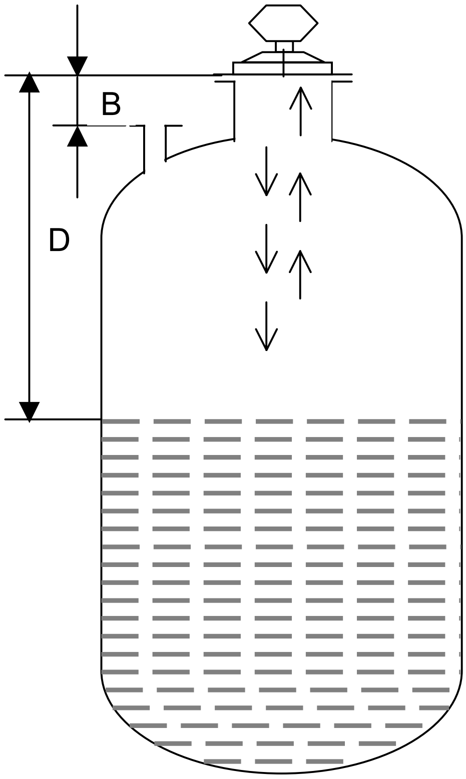

Figure 1. Reservoir with fluid, whose level of filling is measured

generated utrasound acoustic wave wit a fixed frequency propagates in the air with a velocity c_1 about 340 m/s. This velocity depends feebly on the physical condition of the air, which permits the measurement of the distance between the subject and the sensor to be done during the time of the travel of the sound wave. If the sensors are two, one of them is used as a transmitter and the other – as a receiver.

MEASUREMENT OF TIME

The velocity of the sound in the air at 0°C is 331m/s (Figure 2). The change of the temperature with c 1°C leads to the change of the velocity with 0,59 m/s. This means that with the increase of the temperature with 1°C the velocity of the sound will increase with 0,17 % [2, 3]. These data are shown on the Table 1, where correspondence between the distance and the time needed for its travel are presented. The length of the standard impulses from 0,302 μs or a standard generator with a frequency of 3 311 258 Hz have to be used for assuring the accuracy of $\pm$0,1mm in measurement of the distance. Then at 10 pulses we receive an accuracy of 1 mm. Since it is difficult to stabilize the generator at this frequency, a generator working at a frequency of 10 MHz (0,1μs) is chosen.

The number of the received signals for different distances are presented in Table 2.

It is seen from the Table 2, that the number of the impulses, received after counting, is not divisible on ten. But this fact is not important because the impulses are counted and transformed into two – ten format from a micro controller.

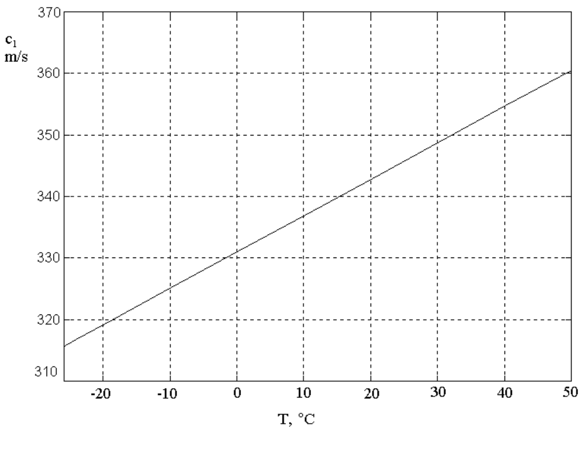

Figure 2. Dependence of the velocity of the sound on the temperature

The time diagram of the measurement is shown on the Figure 3. The feeding of the packets of impulses from the generator (Figure 3a), the time of receiving the signal from the receiver (Figure 3b) and the time, which is measured with the number of the standard impulses, as a function of the time (figure 3c) are seen.

The coefficient of efficiency and the possibility for the object to be registered from the sensor depends on the capabilities of the sensor and the characteristics of the object, as well as on its position in the given work area, but also to a certain extent on the range and type of the sensor. It is seen from the characteristics of the attenuation of the sensor, that a zone, in which impulses can't be accepted, is formed just in front of it. This is so called lock distance (or dead zone) B (Figure 1). The range, in the frames of which, the availability of the object will be registered can be chosen by relevant adjusting the sensor.

The time from the radiating to the receiving of the impulses (time for travel) is proportional to the distance sensor – level. The distance D (Figure 1) can be received from the velocity of the sound c_1 and the time for travel by the formulae:

$$D = c_1\, t / 2\,. \qquad (1)$$

Table 1. Propagation of the sound

Distance	Time for propagation
1m	3,021 ms
1cm	30, 21 μs
1mm	3, 02 μs
0,1 mm	0, 302 μs

The measurement depends on the properties of the material (specific weight, conductivity, viscosity, dielectric permeability), as well as on the temperature variations of the medium, in which the sound is propagating.

It follows from these considerations that the accuracy of the design is in the range of ±0,1mm. The temperature range, in which the sensor will work, is predetermined in advance during the stage of the design. This is made possible with the help of the system for compensation the temperature dependence of the velocity of the sound in air (Figure 2).

Table № 2. Number of the received impulses for different distances

Distance	Number of the received impulses at a length of etalon impulses 0,1 μs
1m	3 021
1cm	302
1mm	30

The ultrasound sensors who perform the measurement are made of piezoceramics most often in the form of a disk with a determined resonance frequency. After the shaking of the piezoceramic disk of the sensor, the oscilation with a ultrasound frequency arise.

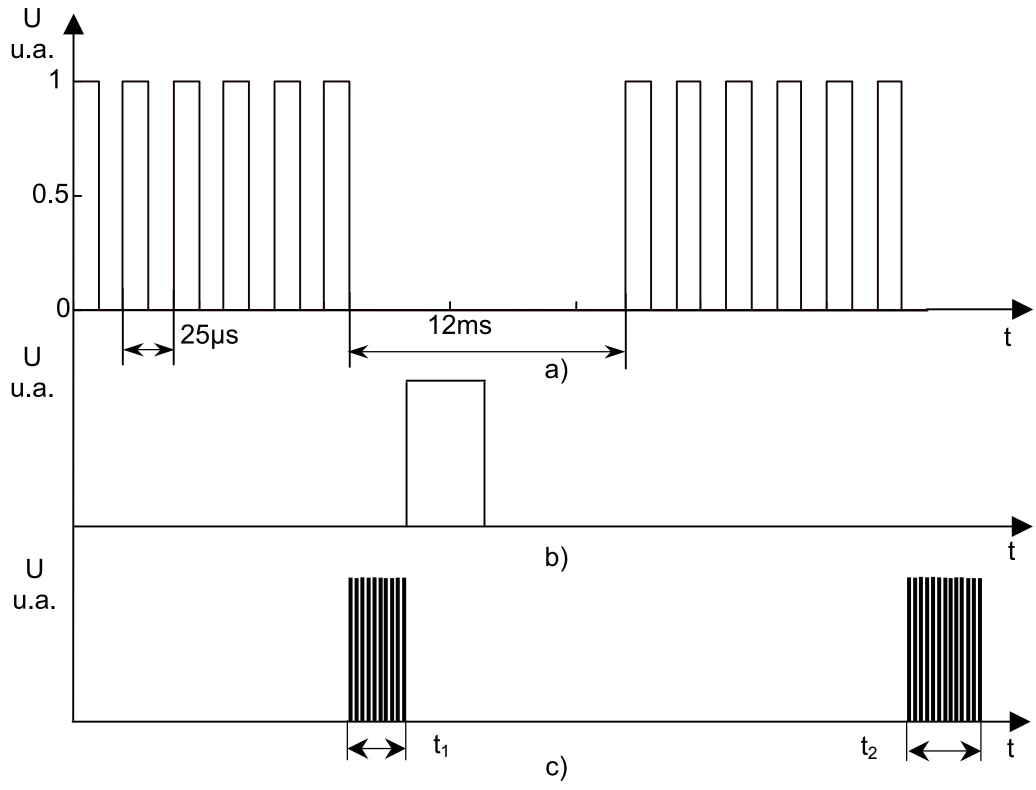

Figure 3. Time diagram of measurement: a) pulse packets; b) received signal from the receiver; c) measured time with number of pulses

Appropriate conditions have to be created and different methods used for the fast quenching of the oscillations of the piezoelement. This in the practice will determine the measurement in small distances. The smallest measured distance in the frames of the minimal range of the sensor determines its so called dead zone.

From the time diagram on the figure 3 is seen, that the dead zone of the sensor has duration 150 μs (the time for radiation the packet of 6 impulses). This zone corresponds with a distance of 5 cm. If the accepted impulse returns earlier e.g. before the period of time equal to 150 μs (the duration of the packet of 6 impulses) is finished, "0" will be indicated on the display.

The range in the frames, of which the availability of the object shell register can be chosen by appropriate adjusting of the sensor.

For transmitter and receiver of ultrasound vibrations a couple of miniature piezoceramic sensors of model UST-40R and UST-40T are used.

The transmitter and receiver are into line by parameters couple of ultrasound transducers with work frequency 40 kHz.

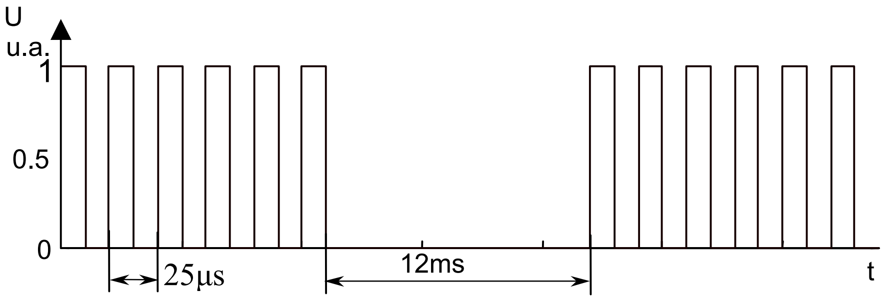

Figure 4. Packets of rectangular impulses for shaking of the transmitter

The piezoceramic elements have a form of a disc with a diameter of 12 mm. A packet of 6 rectangular impulses with a period T = 25 μs (40 kHz) is passed to the receiver UST-40R, with the aim of its fool shaking (Figure 4). For realizing of the time diagram on the figure 4, two timers 555 can be used; one of them work with a frequency 40 кHz and is run by the other, working with a frequency 66, 66Hz (12ms high level + 12

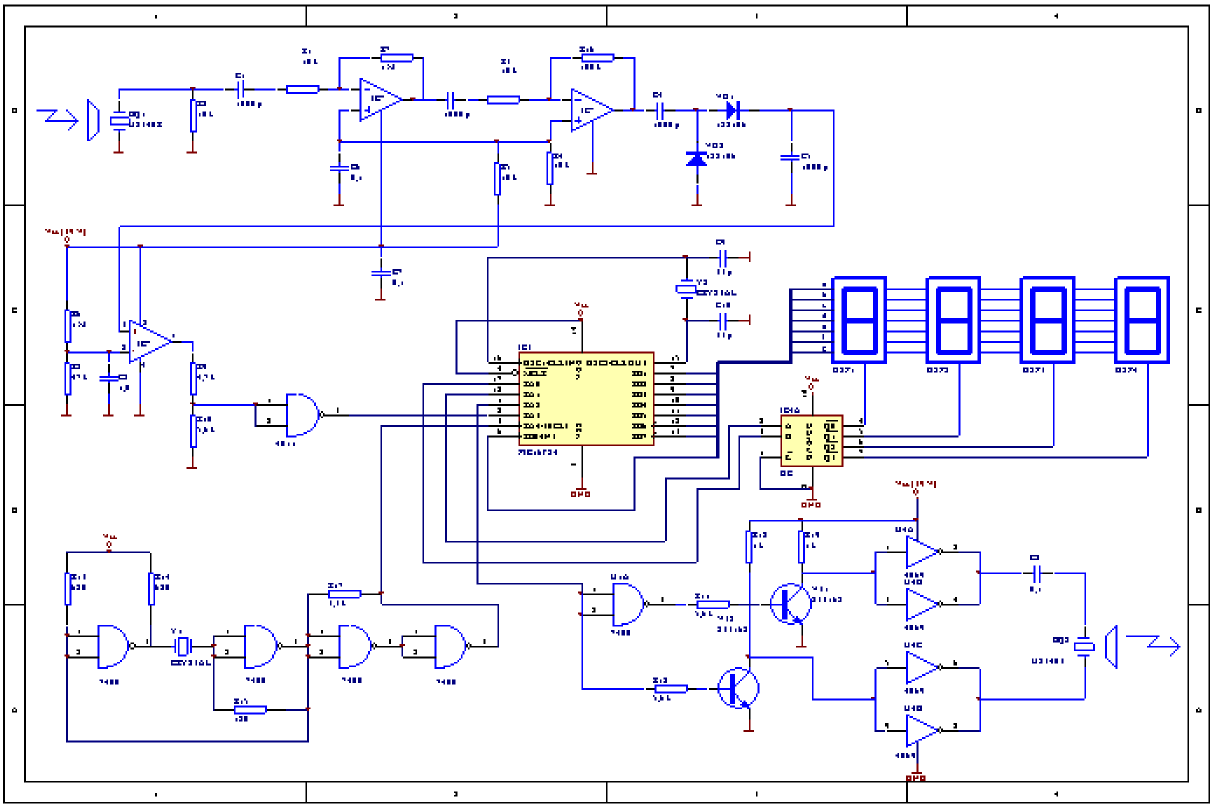

Figure 5. Principle electrical scheme of the suggested solution

ms low level).

Another way for working out rectangular impulses with the shown on the figure 4 parameters is by using a micro controller.

The method, described earlier, is realized with the presented on the figure 5 principle electrical scheme.

CONCLUTIONS

With the presented scheme solution the input and the output circuits are separated to prevent the influence one to other. A comparator is used for decreasing the influence of noise over the main signal.

The ultrasound transmitter is supplied with square form packets, modulated with pulses with frequency 40 kHz. This is from necessity to make better oscillations of the transmitter. There are many different scheme solutions for this purpose. For example, for realizing of time diagram from figure 4: 1) two timers of type NE555 can be used. The first one works with frequency 40 kHz and is controlled from the second timer with 66.66 Hz; 2) the output form the first timer is connected to the counter. On every 6 pulses from the timer, the counter makes start pulse for a monovibrator. The monovibrator makes a pulse with 12ms width, which is used to reset the counters value.

These two variants are good like scheme solutions, but there are the following shortcomings:

- the physical realization is related with high number of electrical parts of the scheme, which is not profitable from technical and economical point of view;
- difficult adjustment of electrical scheme because of manufacture tolerances of electrical parts;
- difficult recurrence of the results.

The noted shortcomings are avoided in the presented solution by using of microcontroller PIC16F84A. The creation of square form pulses, modulated with 40 kHz is a software task.

In this scheme solution with PIC16F84A there is an opportunity to handle the dynamic indication by the software. Without microcontroller the handle of dynamic indication requires more electrical parts and this is related with more difficult adjustments and higher prime cost of the device.

The microcontroller do not make a temperature correction. Additional integral schemes such as DS1629, DS18S20 or LM75, may be included for measuring the temperature. The correction, which should be made in the program, is described earlier (fig. 2). For this purpose must to be use microcontroller PIC16F873, which supports I^2C interface by hardware (in PIC16F84A there is not hardware support of I^2C interface). The communication between the microcontroller PIC16F873 and DS1629 for example, is made by the I^2C interface. The outside generator of the scheme may be put away and replaced with a inside time frequency, which is divided by the program way. On the free end, instead of the generator, the output from the scheme for measuring the temperature is put.

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