ACOUSTIC CONTROL OF THE TECHNOLOGICAL PROCESSES

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In this paper is considered hardware-software realization of a system for control of technological processes, based on acoustic control of technological mediums. The controller is realized on the base of PIC18Fxxx processor and the data for the specific object are received by noncontact ultrasound sensors. The controller allows additional tracking on up to four another analogous quantities in the range 0-5V. The control of the object is made by means of electrically divided digital outputs. The realized program, working under Microsoft Windows environment, has ability to monitor and visualize the state of the technological process in real time and storing of measured data. Realized in this way hardware-software system allow full control over separate objects of technological processes from chemical, food processing industry and etc.

Keywords: ultrasonic sensors, real time control, intelligent systems

1. INTRODUCTION

The main task of a trading or manufacturing organization is to increase the maintainability and incomes from the manufacture. One of the main ways of increasing the incomes is to enhance the quantity of the production. This can be achieved when new technologies are used and/or trough control and governing of the processes we pass to automatic production lines. The control with the usual measuring devices is ineffective; moreover a big staff is needed to work with it, if it has to correspond to the technological apparatus. The enlarged number of the control staff leads to the decreasing of the main productivity and increasing of the price of the production. This is contrary to the contemporary tendency of automate of the production processes and creation of fully automatic technologies. As it is shown from the world experience, the only alternative is to automate the control and governing processes [2, 3, 4].

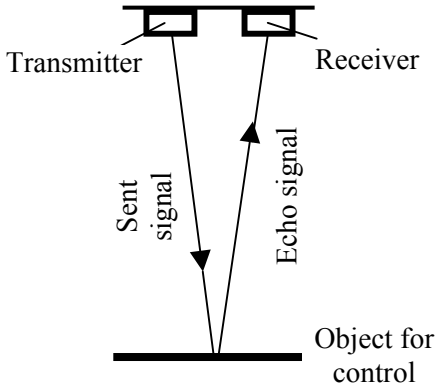

Fig. 1. Schematic location of transmit-receive elements according the controllable medium

In the great part of the technologies in the chemical, food and other industries are used processes whose parameters could be controlled trough ultrasound methods. For example: in biotechnologies such processes are registration of the change in the structure and viscosity of many rare materials, watching and control of the level of different liquid and solid mediums with different characteristics, measurement of the humidity of curd and cheese, dosage of rennet in the production of the white and yellow cheese; the condition of the melt in the metallurgy; determination of the reflective index by measuring the amplitude of the ultrasound waves after their reflection from the surface between tow homogenous mediums; determination of some physical mediums on the base of their distinguished characteristics.

In some of the existing systems for government of such processes often one uses self control of different technological working patterns. This led to the necessity of building an apparatus-programmed medium for monitoring, analysis and governs of physical values in a real time.

2. PRINCIPLE OF THE ULTRASOUND MEASUREMENT

From the known methods the ultrasound noncontact method had been chosen for the developed system for control and government of the technological processes. In this method the sound echolocation principle is used. It is based on the propagation of the acoustic waves with the frequency in the ultrasound range and the effect of their reflection. The measuring transducer is not in a direct contact with the object of measurement and control. These tow parts of the set are divided from the working medium (fluid), which in many cases in the industrial applications is air.

The application of the ultrasound noncontact method is based on the dependency of the velocity and absorption of the ultrasound waves in the mater, which is determined from its compound, structure and the character of the movement of the layers of the controlled medium.

In the developed system for primary converters are used noncontact ultrasound sensors, type UST40T and UST40R. They are piezoelectric converters, prepared from modern piezoceramic materials. In working mode they actively send acoustic waves and receive them back after their reflection from the controlled object. Their operation is based on the known straight and reverse piezoeffect. As a result of the reverse piezoeffect under the influence of electrical voltage, the piezoelectric material, from which is made the transmitter piezoelement, change its shape in dependence from the signal dynamics. The piezoelectric element is an electroacoustic system. This system on the own side creates acoustic wave, which begins to spread toward the object for control. After the reflection from the barrier (the border surface of two homogenous mediums), the same wave is returning back and begins acoustically to stimulate over the sensor, who works in receiving mode (Figure 1). By the use of straight piezoeffect the mechanical oscillations appeared on the piezoelements surface are converted to electrical signal. From technical point of view the interest is over the returned back after the reflection ultrasound acoustic wave. To the way from the transmitter (UST40T) to the receiver (UST40R), the acoustic wave modifies its characteristic parameters from the mediums distinctive which are researched. In this way the ultrasound signal carry information for the characteristics of the medium, which will be controlled [5].

For the data receiving there is need of sensor, working medium and border (reflector), which is in this case the object for control, whose dynamics is observed (Figure 1). For excitation of the sensor and for processing of returned after the reflection echo-signal is used a controller, realized on the base of device from the family PIC18Fxxx from Microchip company. The complexity of the controller is in dependence of the performed functions.

3. STRUCTURE OF THE CONTROL SYSTEM

The developed hardware-software system for technological control consists from two basic components: Intelligent controller and monitoring program. The chosen architecture of the monitoring system allows the building of technological network with intelligent controllers. The built-in algorithms in the monitoring system allow to it to track the

processes in many objects with the help of controllers, who supports the realized protocol for exchange.

3.1. Structure of the module for processes monitoring and control

The controller is with a modulus structure. The base element is the processor module (Fig. 2) based on one-chip microcontroller PIC18F458 who works with clock frequency 40MHz.

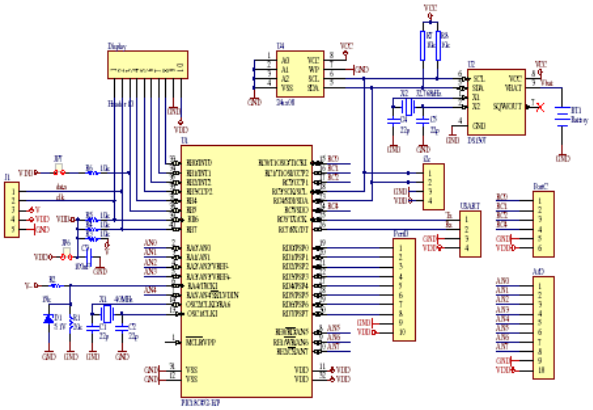

Fig. 2. The processor module

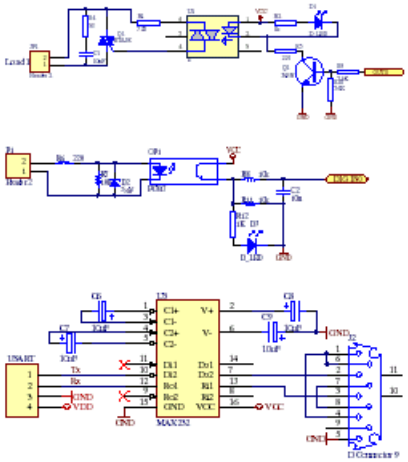

Fig. 3. The peripheral modules

The module allows in addition extension with EEPROM memory. In the base version there is 8KB with the help of module 25LC1024. For increasing of the accuracy in working mode there is added a real-time clock DS1307. It is with additional 56 bytes of non-volatile VRAM. The communication with the user is realized by means of two-button keyboard and a LCD display HD44780U, controlled with four-bit code. The module is powered by stabilized power source with 5V and 9V. All of the processor pins are bring-out to a connector. The second is input-output module, who realizes the communication with personal computer or other modules, if the controller is connected in network. There are developed communication modules for connection by RS232C, RS485 and USB. The choice of an interface depends from the concrete application. The current realization is based on RS485, realized by means of MAX3100 and MAX3088, who allows the building of network from controllers which are controlling different objects.

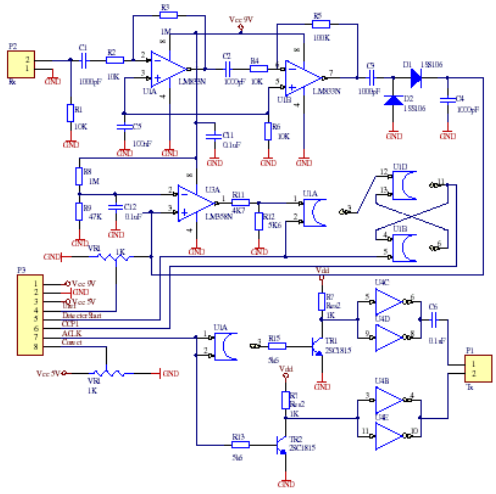

Fig.4. Ultrasonic sensor Transmitter and Receiver circuits

The communication with the object for control is realized by input-output module (modules), realizing galvanic separation of the digital inputs and outputs, as well as supporting the ability for connection of up to 8 analogue inputs. In the standard accomplishment toward the analogue inputs can be applied signals in the range 0-5V, which are converted by the built-in 10-bit ADC, with the minimal measured voltage of 0.005V. For rising of the working range, filtering of input signal or connecting of different type of sensors, as well as realizing of two-polar voltage measurement, there are realized extension circuit boards. The controller

allows the control of executive devices with high power consumption. For the purpose is used peripheral module, realized according to the scheme from Figure 3. The use of triac BTA08 as switching element allows the control of consumers consuming up to 15A currents. Often in the control systems it is necessary the controlling of given quantity to be realized by analogue signal. For this purpose it is realized module with two analogue outputs. The scheme solution is based on integrated circuit DAC MAX5616, consists of two DAC in one package. MAX5616 is controlled by I^2C bus and do not load additionally the controller, as taking more leads. Advantage of the controller is the availability of peripheral module for acoustic control, based on ultrasound method for measurement (subject of this Paper). The Measurement module is composed of two parts, transmitter and receiver.

This range meter uses the ultrasonic of about 40kHz. The way of measuring measures the time which the ultrasonic returns from the measurement object. The about 10-m distance can be measured by adjusting the resistance value of the inner circuit.

The transmitter consist of two inverters are connected in parallel with a purposed increase the transmission electric power off an ultrasonic sensor. The phase with the voltage to apply to the positive terminal and the negative terminal of the sensor has been 180 degrees shifted. Because it is cutting the direct current with the capacitor, about twice of voltage of the inverter output are applied to the sensor.

The ultrasonic signal which was received with the reception sensor is amplified by 1000 times (60dB) of voltage with the operational amplifier with two stages. It is 100 times at the first stage (40dB) and 10 times (20dB) at the next stage.

The detection is done to detect the received ultrasonic signal. This is the half-wave rectification circuit (Figure 4 elements D1, D2, C3 and C4) with Shottky barrier diodes. The DC voltage according to the level of the detection signal is output to the capacitor behind the diode.

The Signal detector is consisted of comparator U3 and resistors R12, R13 and R14. He detects the ultrasonic which returned from the measurement object. So, when the rectified ultrasonic signal becomes more than 0.4V, the output of the signal detector becomes the H level (Approximately 9V). This output is lowered with the resistor to make fit with the input of signal holding circuit (TTL: 0V to 5V).

The algorithm is based on the next sequence of actions:

1. Stop the reflected wave detector. Immediately after letting out a transmission pulse, the influence occurs to the receiver circuit and there is possibility to do wrong detection. To prevent from this, the operation of the reflected wave detector is stopped.

2. Start timer

3. Send-out the 40 kHz pulse (Figure 5). The 40 kHz pulse is the pulse which has 12.5 μs as ON time and 12.5 μs as OFF time in 1 cycle. Length this pulse its 0.5 ms.

4. Start the reflected wave detector. This signal activates 1ms after the end transmission pulse. After the wrong detection prevention time elapse, it is made a enable condition in the reflected wave detection.

5. Detected start moment of the reflected packet and started A/D conversion of the signals.

6. Detected end moment of the reflected packet and disabled A/D conversion of the signals.

7. Calculate measurement distance, make spectral analysis of the measurement data and classify the materials. The gauged interval of time by with microcontroller corresponds

(meets) to time of distribution of a ultrasonic signal from the device up to object and depends on the measured distance.

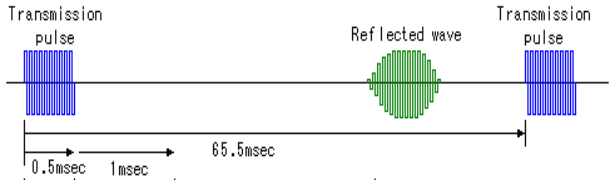

Fig. 5. Time diagrams

Since speed of a sound depends on temperature, measurement of distance will have the big error at the temperatures distinguished from room temperature. For increase of accuracy of measurement in all a range of temperatures the device can be added with a simple measuring instrument of temperature on thermistor and correction corresponding data. The measured distance and temperature also, at will, can be saved in the internal FLASH-memory.

For lowering the influence of parasitic noises and rising of measurement accuracy there are realized frequency filters, which are placed in the front of ADC, compensating the interferences. The time for scanning is according working frequency of the controller; the time needed for conversion of analogue quantity; the count of monitored quantities; the time for processing of regulating influence; time for generating of controlling influence and etc.

3.2. Monitoring and control of the processes

The second part of the developed control system is based on the software system of a hire level, based on a personal computer (Fig.6).

The system allows:

- A parameterization of the controller/controllers;
- Monitoring of the processes running in the controlled technological object in a real-time;
- Visualization of the current condition of the processes;
- Processing and analysis of the received data;
- Control of the processes in real-time (additional ability)
- Analysis of the process state and giving of conclusion for the state and etc.
- The program is realized on the bases of the C++ language and work under
- Windows95/98/2000/NT/XP.

The application software includes the following modules:

- Configuration module – it is used for configuration of the work regimes of the system. The available controllers are registered, as well as the work regimes of the separate channels for monitoring and control. This function is started only ones when starting the system or in the change in the work regimes;
- Communication module from the first level – it realizes communication on the separate interfaces (RS232, RS485 and USB);
- System module – it includes resources for filtration, compressing and initial processing of the measured data;
- Module for handling the local base of data, which preserves the measured values for a given period of time;
- Graph module – it realizes the output of a table and graph information on a video display. The output of the desired information is done by the request from the operator, trough a falling menu;
- Module for printing – it is used for printing of a text and graph information;
- Means for protection of the information – a scripting of the configured fails;

- Communication module from a second level – it realizes communication on TSP/IP, WAP etc.; And others.

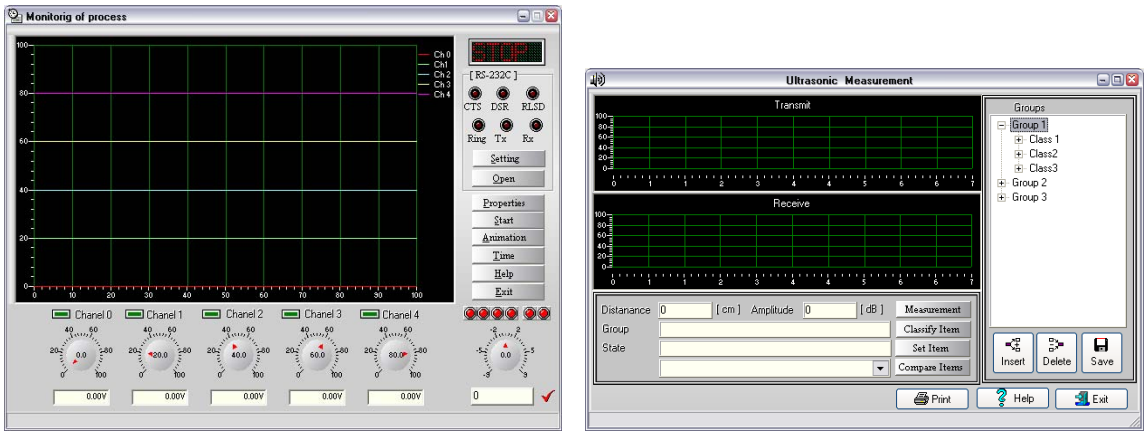

Fig 6. Monitoring system

4. CONCLUSION

The proposed flexible structure of the developed system for monitoring and control can be used for building of processor modules with application in many industries, like chemical industry, food industry and etc., which parameters (indices) of technological processes would be controlled by means of ultrasound methods. On the base on discussed system can be developed other applications, in relation with control and monitoring of: thermal objects; processing of pulse inputs; control of relay and analogue outputs; distributed systems for access control. The system allows maintenance of big number, distant in location, different type of objects with minimal expenses. The use of ultrasound sensor allows to be made measurements in toxic, corrosive and aggressive mediums. Another advantage is the small time for processing and storing of the information.

2. REFERENCES

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