Application of programmable arrays allows increase in the processing speed keeping the cost of the product within an acceptable range.

Reference

1.Sampling Phased Array: A New Technique for Signal Processing and Ultrasonic Imaging / Bernus L. [and others] // In: Insight. –Volume 48. – Issue 9. – p. 545–549.

2.Ultrasonic Arrays for Quantitative Nondestructive Testing an Engineering Approach / Bolotina I.O. [and others] // Russian Journal of Nondestructive Testing. – 2013 - Vol. 49 – No. 3. – p. 145–158.

3.The Use of Geometrical Acoustics for the Solution of Visualization Problems / Kvasnikov K.G. [and others] // Russian Journal of Nondestructive Testing. – 2013 – Vol. 49 – No. 11. – p. 625–630.

NEW GENERATION ACOUSTIC BOREHOLE DEPTH GUIDE

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Blasting operations are the main step in the preparation process of mining coal, iron ore and other mineral resources. Expenses to carry out the blasting operations comprise a significant part of the mined rock cost. Hence the errors in the hole-depth measurement lead to increase in the mined rock cost, as well as it might result in the top horizon downfall where mining occurs.

A basic error in ultrasonic depth-gauge measurement is caused by inaccuracy in determination of the ultrasonic pulse arrival. Generally the moment of ultrasonic pulse arrival is determined with a comparator. However, due to the complex shape of reflected ultrasonic pulse the comparator operating time does not coincide with the pulse initiation.

Nowadays, the existing ultrasonic hole depth-gauges have measurement errors and a high value of uncontrolled area. However, the major issue concerning the hole formation depth measuring lies in low measurement accuracy related to the hole shape changes due to earth movement. Therefore, the research objective of the current study is the development of a universal

method of ultrasonic pulse analysis which allows receiving accurate information on the depth.

Fig. 1 shows oscillograms of two echo-pulses received at different distances. The amplitude of the echo-pulse differs by more than 3 times and the duration of the forward front of the envelope echo-pulses – by 1.5–2 times relative to each other. The way to find the pulse arrival moment existing today assumes the use of the comparator with a fixed or floating operation threshold. Change in the amplitude and shape of echo-pulses at different distances leads to error of up to 10–15 periods of the carrier frequency variation (Fig. 1). Use of the floating threshold allows reducing this error by 1.5–2 times, but the situation cannot be cardinally changed.
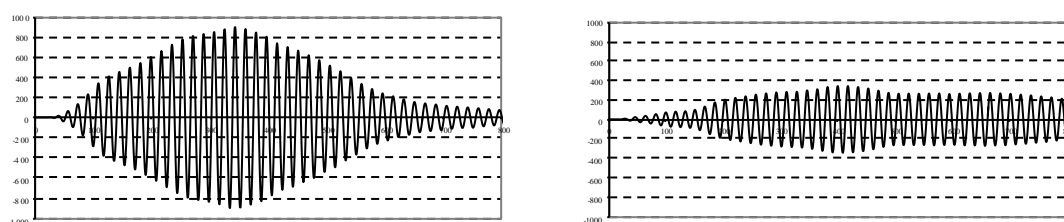
a b

Fig.1. Oscillograms of two echo-pulses received at different distances:
a) 20 cm, b) 120 cm

The authors demonstrate a new method to measure the distance between two signals of different frequencies that would eliminate a significant portion of the measurement error associated with the waveguide ultrasound propagation, and to increase the measurement accuracy.

According to the new method, two signals are emitted at different frequencies and the time intervals between the two radiation sensors triggered and the comparator are measured (see Fig. 2).

Triggering of the comparator occurs at different times for different frequencies signal with respect to the excitation signal - t_1 and t_2, calculation of distance is built relatively of these points.

After measuring the time intervals between the emitted and the received signals, the slots are compared and then corrected in accordance with the expression:

$$(\Delta t_1 - i \cdot T_1) - (\Delta t_2 - i \cdot T_2) < T_1/4 \text{ , (1)}$$

where T_1 is the period of oscillation of the first ultrasonic wave, T_2 is the second period of ultrasonic wave oscillation, i is iteration index, Δt_1 is the first measured time interval, Δt_2 is the second measured time interval.
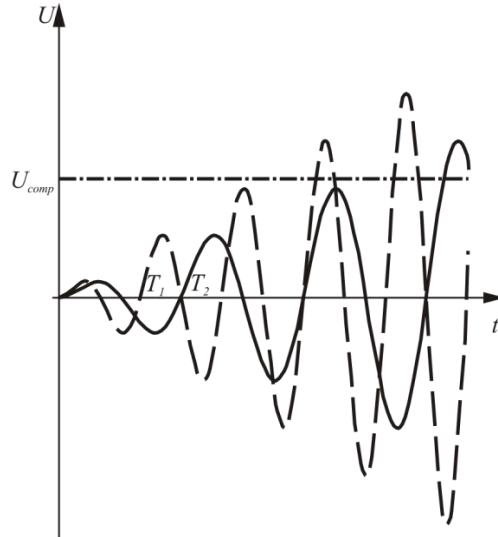
Fig. 2. Response time of the comparator for the arrival of signals of different frequencies

After emission and reception of ultrasound signals at two frequencies, detection and correction of two time slots and distance determination becomes possible, that can minimize the measurement error of the ultrasonic locator.

During the correction of all operations, compensation is selected, which yields the minimum time interval between $(\Delta t_1 - i \cdot T_1) \& (\Delta t_2 - i \cdot T_2)$. The shift of the time coordinate defined by the activation of the comparator on the time axis by successive subtraction of the time intervals of the multiple periods of the carrier frequency eliminates the error inherent in the method of single comparator.

The offered method has been realized in the ultrasonic locator. The block diagram of the locator is shown in Fig. 3.
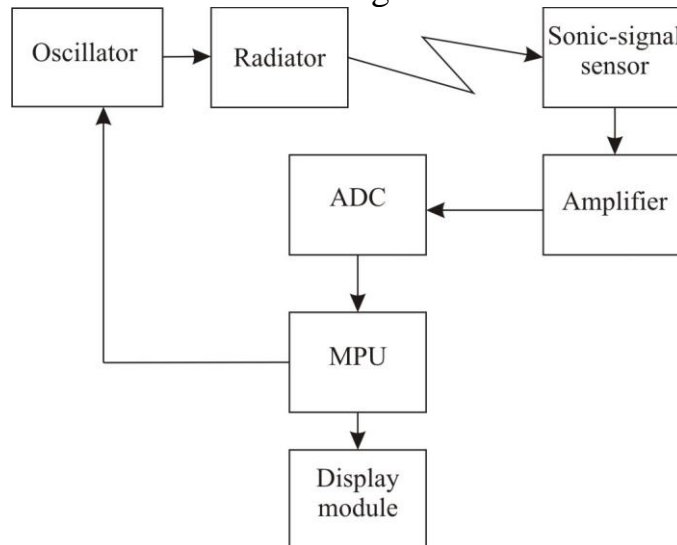

Fig. 3. The device structure.

The emission of an acoustic signal is controlled by a microcontroller, which enables the generator. The generator produces a pulse group. Pulses are applied to the emitter which emits an acoustic signal. The signal reflected from the bottom of the hole recorded by the receiver. When amplified, the echo signal applied to the ADC input. Digitized data is received and processed by the microcontroller. After that, another frequency signal is produced in the same algorithm. After processing of two different frequency signals, the calculation result is displayed.

Significant variations in the measurement errors when using the single comparator are conditioned by the waveguide propagation of ultrasonic vibrations, which leads to a significant change in the pulse shape at various distances. Based on these data, the following conclusion can be made: a substantial increase in measurement accuracy occurs only for larger measured distances. At distances greater than 12 m, the error frequency method does not exceed 1% (confidential interval was ± 0.2%), while the error of the single comparator method is greater than 7% (confidential interval of ± 1%).

Reference

1.Soldatov A.I., Chiglinseva J.V.(Shulgina) Ultrasonic borehole depth-gauge //International Siberian Conference on Control and Communications (SIBCON-2009). Proceeding - Tomsk, March 27–28, 2009. - Tomsk: The Tomsk IEEE Chapter & Student Branch, 2009. – Pp. 313–317

2.Mathematical analysis of the echo-impulse position detection by the dual-frequency sensing method [Electronic resources] / Yu. V. Shulgina [et al.] // Mechanical Engineering, Automation and Control Systems (MEACS) : proceedings of the International Conference, Tomsk, 16-18 October, 2014 / National Research Tomsk Polytechnic University (TPU) ; Institute of Electrical and Electronics Engineers (IEEE). — [S. l.]: IEEE, 2014. — [4 p.]

3.Determination of the time position of the echo-pulse by two-frequency sounding method / Ju.V. Shulgina [et al.]// Control. Diagnostics. — 2014. — No. 13. — [Pp. 152–154].