Instruction for exercise 6

Title: Study of the absorption of ultrasonic waves

The purpose of the exercise: Learning the basic concepts related to the propagation of ultrasonic waves in different medium: reflection, refraction, attenuation, interference, scattering. Checking the law of absorption of ultrasonic waves in the air. Familiarizing students with the method of manufacturing and applying ultrasound waves.

Theoretical introduction:

Ultrasound is mechanical wave phenomena occurring in the solids, liquids and gases with a frequency greater than 20 kHz. The conditions for the propagation of ultrasonic waves are dependent on the properties of the medium in which they occur. As a result of internal friction, thermal conductivity, etc., part of the wave energy is constantly lost. As a result, the amplitude of the wave pressure decreases as a function of the distance. We say that the wave is attenuated. Attenuation factor is defined as the relative change in the wave pressure per unit length. Then the amplitude of the ultrasound wave pressure P as a function of the distance x can be described using expression below:

$$P(x) = P_o \exp(-\alpha x) \qquad (1)$$

where: P_o is amplitude of the wavelength at distance x=0. Attenuation factor α in air is the value dependent on: frequency, temperature and humidity. Verification of the absorption law of the ultrasound wave and measurement the absorption coefficient is made by measuring the amplitude of the wave pressure. We use an ultrasonic receiver to measure signal emitted by the transducer (transmitter) from different distances. For this purpose, we use the measuring set shown in Figure 1. By describing the function P (x) = U (x) in relation (1), in a semi-logarithmic coordinate system we obtain a straight line with the following equation: Y = aX + b, where Y = lnU, X = x, and factor a = α

Figure 1 Measurement kit for checking the law of absorption of ultrasound in the air

Measurements and reporting:

1. Set the measurement system according to the diagram in Figure 1
2. Set the voltmeter range - 20 V DC
3. Place the ultrasonic wave transmitter at the same height as the receiver.
4. Connect the transmitter to the socket - TR1 of the ultrasonic generator operating in the mode continuous "Con".
5. Connect the receiver to the left socket of the amplifier.
6. Select the input gain of the Pre.Ampl receiver and amplitude of the Ampl transmitter. Make sure that the "OVL" LED is not the ON mode.
7. Change the position of the receiver relative to the transmitter in steps of 2 cm and read the voltmeter (U) measurements (carry out measurements for different gain, keeping condition (6) in the series of measurements) for 8-10 steps of distance change – X.
8. Put results in the table.
9. Calculate lnU (x) for each X, Present the data in a graphical form in the coordinate system: (X = x, Y = lnU). By linear regression, determine the parameters a and b of the following equation: $Y = a\,x + b$ and their standard deviations: σ_a and σ_b.
10. The value of the slope (a) of the straight line $Y = ax + b$ is the value of the coefficient absorption α of ultrasonic wave in the air of given humidity and temperature.

Topics for the colloquium:

1. The propagation of sound waves in solid, liquid and gaseous media. Wave equation.
2. Coefficients: reflection, transmission and absorption of waves. Acoustic impedance.
3. Effects of ultrasonic waves on the tissue.
4. Ultrasonic wave generation (piezoelectric effect - simple and inverse).
5. Doppler phenomenon and its application in medicine