Software for estimating of a premises acoustic security

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Abstract. Protection of acoustic information is one of the most important tasks in the overall complex of measures to ensure information security of the technical protection object. Important stages of the acoustic channel protection are the assessment and periodic monitoring of the insulation properties of enclosing structures. The article presents the developed program, which provides the possibility of preliminary estimation of the premises with the use of additional equipment. The main algorithms of software operation are considered. The analyses of results and estimated accuracy of developed software are presented.

Keywords: acoustic channel, voice information leakage, premises security control, premises acoustic isolation, protocol formation, automated evaluation system.

1. Introduction

In the modern information society, information is one of the important resources of any state. The most common and the most unprotected form of data transfer is acoustic.

In conditions of competitive practices and tendency to achieve scientific and technical superiority, the various types of technical monitoring are plays an important role. On the other hand, the intelligence means and systems of reconnaissance of speech information are constantly being improved and undergo a modification. Therefore, the data leakage protection through technical channels has been formed as an integral part of the countercheck to monitoring, especially to a technical components.

The basic requirements for countercheck of monitoring are inherent to a data protection measures. Activities to protect acoustic information are divided into passive and active methods[1].

One of the main acoustic information passive protection methods is ensuring of the required insulation properties of the enclosing structures of the controlled zone. Therefore, the insulation properties of enclosing structures estimation is an urgent problem and it is the basis for measures to protect voice information.

2. Acoustic information leakage channel

Speech (vibro-acoustic) information can be eavesdropped with the microphones of air conduction, it can be fixed with the help of microphones of a solid medium (vibrometers, velosimeters, accelerometers), or directly listened to by a person. The structure of the acoustic channel for information leakage is shown in Figure 1.
The spectrum of the speech signal varies during the process of uttering various sounds. In this process, some harmonic components are amplified, others are suppressed. The spectrum regions in which the basic power of the acoustic signal is concentrated is called the formants. Formats of speech sounds are located in the frequency range from 150-200 to 8600 Hz. The main energy of the formant majority part is concentrated in the frequency range 300-3000 Hz, which allowed us to limit the spectrum of the speech signal transmitted over the standard telephone channel by this band [2-5]. The medium of distribution of the information carrier from the source to the receiver can be homogeneous and heterogeneous, it can be formed by successive sections of various physical media: air, wood doors, glass windows, concrete or brick walls, various rocks on the earth's surface, etc. But even in a homogeneous medium, its parameters are not constant, they can differ significantly at distinguished points[6-9].

The main information indicator of speech information leakage on the acoustic (vibroacoustic) channel is verbal intelligibility of speech. This information indicator is normalized and used to make a decision about the presence of a voice information leakage[10, 11].

Verbal intelligibility of speech W is calculated by the formula:

\[ W = \begin{cases} 1.54R^{0.25}[1 - \exp(-11R)], & \text{if } R < 0.15, \\ 1 - \exp\left[\frac{-11R}{1 + 0.7R}\right], & \text{if } R \geq 0.15, \end{cases} \]  

(1)

where R is the integral index of speech articulation.

The integral index of articulation is determined by the formula:

\[ R = \sum_{i=1}^{5} r_i, \]  

(2)

where \( r_i \) is the octaval index of speech articulation.

The octaval index of articulation is determined by the formula:

\[ r_i = k_i \left\{ z - \frac{0.78 + 5.46\exp[-4.3 \cdot 10^{-3}(27.3 - |E_i - A_i|)]}{1 + 10^{0.1|E_i - A_i|}} \right\} \]  

(3)

where \( z = \begin{cases} 0, & \text{if } E_i \leq A, \\ 1, & \text{if } E_i > A, \end{cases} \)

\( A_i \) – format parameter of the spectrum of a speech signal in an octave band, dBA;
\( K_i \) – octave band weighting factor;
\( E_i \) – octave parameter of the relations: acoustic (vibroacoustic) signal / noise, in the possible placement of sound receivers (microphones) and vibration receivers (vibration sensors) of acoustic
speech intelligence equipment (in the place of possible listening to speech without the use of technical means).

It follows from the formula (3) that to reduce the intelligibility of speech, it is necessary to reduce the ratio "speech level / noise level" (signal / noise) in the places of sensors possible allocation of acoustic reconnaissance equipment.

The reduction of the signal-to-noise ratio is possible either by the speech signal level reducing (passive methods of protection) or increasing the noise level by the creating acoustic and vibration interference (active protection methods). The acoustic (speech) signals strength loss is accomplished by soundproofing the rooms, which is aimed at localizing the sources of acoustic signals inside them[12].

Sound insulation is estimated by the value of the acoustic signal strength loss and is provided by architectural and engineering solutions, as well as using special building and finishing materials[10]. In the case of the premises soundproofing does not provide the required efficiency of information protection, special sound-absorbing materials are used.

3. Estimation of leakage protection by an acoustic channel. Software ASL

To evaluate the protection against leakage through an acoustic channel, the ASL software is developed. This software is developed using the object-oriented C# programming language on the FrameWork software version 4.5.2.

The created ASL software provides the following functions:
1. To conduct an automated measurements and calculations of insulation properties of enclosing structures, which greatly simplifies the procedure for analyzing the data obtained and reduces the cost of conducting measurements;
2. to generate and maintain a database of up-to-date object information and the results of the measurements;
3. to calculate of indices of allocated premises security from an acoustic channel leakage at given standardized indicators of information security;
4. to generate the necessary protocols and conclusions.

The functioning of the program is organized in 4 main stages, which are sequentially connected with each other (Figure 2).

![Figure 2. Control-flow chart of the ASL program.](image-url)
result of the first and second stage, full report of the premises audit is formed. Also, the program provide to save the obtained data in the database for further reuse.

A distinctive feature of the ASL software is the possibility of forming an automated complex for audit of the premises acoustic protection with the use of additional equipment.

The developed software is based on the method of measuring the sound-insulating ability of enclosing structures of protected premises, in which the transmitting measuring system must contain: a noise generator; amplifier; acoustic system. A block diagram of the equipment for creating an audio signal is shown in Figure 3. The receiving measuring system must contain: a sound level meter with a microphone.

![Figure 3. Control-flow chart of the equipment generating the test signal.](image)

(1 - noise generator, 2 - power amplifier, 3 - speaker system)

The developed software is allowed a noise generation power amplifying by PC. It is recommended to use a laptop with Bluetooth support as a PC for added convenience. this is explained by the fact that as an acoustic system you can use a wireless speaker of the required power. To automated recording of measurement results, it is recommended to use CEM sound level meters with the DET model range with the optional COM port configuration.

When going to step 3 of the "measurement of insulation properties" it is necessary to take into account that each CT scan is performed in two stages. The first stage of measurement is carried out in the room, the second - measurements in checkpoint. Therefore before starting the scan, the user must select the reference point and the location of the sound level meter, and also specify the connection port of the sound level meter.

ASL software allows measurements in fast or accurate modes. The difference between these modes is the number of measurements in the set for each octaval band. For rapid scanning, the number of measurements is equal to 10, and for the precision mode it is equal to 100. Figure 4 shows the ASL program window during the scanning process.

As a test signal, the program generates a sawtooth signal. The octaval levels of the emitted test signal in the room are calibrated in manual mode, by adjusting the volume level of the acoustic source. The frequency of the output acoustic signal changes in the automatic mode.

When saving check point data, the program runs statistical data analysis for the presence of anomalous values. The principle of this method is to determine the average value and dispersion in each octaval band. The measurement value, which exceeds the deviation in the size of the two variances, is marked in the measurement table. The preservation of data is limited by the number of dissatisfying points to selection criteria. If the such points amount exceeds the threshold of 20% in at least one octave band, the user is notified that the results can not be saved. To successfully save the data, the user must eliminate the factors that affected the incorrect result and repeat the measurements.
Figure 4. ASL software window during scanning.

4. Evaluation and testing of the created software
The quality of the software can be assessed as compliance with clearly established functional and operational requirements. The main requirements for the developed ASL software are usability and a results adequacy. The obtained software results should be evaluated before certification and release, since this is the main factor affecting the quality of the product. The fulfillment of the remaining requirements is evaluated by users in the operating the developed software.

The evaluation of the ASL software results was carried out by a comparison with the data taken directly from the sound level meter. The developed software product scans the indoor test signal, the noise figure and the total signal-to-noise value at the reference point. For the assessment, it was decided to use the signal/noise values in the checkpoints. The volume of control measurements is equal to 50. ASL software takes readings from time intervals of 0.5 seconds, but the physiological feature of a person does not allow recording at this frequency. Therefore, the number of control measurements was reduced to 25. The results of the measurement in the octave band of 250 Hz are shown in Fig. 5. A comparative analysis of the data obtained by two methods revealed a unsignificant deviation of the signal/noise values by ASL software and the sound level meter. This deviation is due to rounding of the sound level meter readings to decimal. Therefore, the readings of the ASL software can be considered as equal to the sound level meter values. For example, in Figure 5 there is a scatter in the readings relative to the actual value. This is due to the presence of such an external factor as the variable background noise in the checkpoints. When performing measurements without auxiliary software, the user must perform data analysis manually. ASL software makes it possible to simplify this procedure.
Having completed the evaluation of the ACS software, it is proved that the developed software product, measuring the signal / noise level, has reliable data at the output, and simplifies the procedure for analyzing the received data.

5. Conclusions
At the moment, the market presents a large number of different hardware and software solutions to estimate the effectiveness of the security of the premises, which have a number of advantages and disadvantages. The main disadvantage of valuation complexes is their cost. The developed software makes it possible to estimate the insulation properties for your own purposes before attestation or periodic testing.

To improve the program in the future, it is proposed to use the method of measuring verbal intelligibility, the results of which will be a quantitative indicator. Also, work is under way to expand the list of sound level meters, compatible with the developed software.

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