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UDC 621.391.6:519.72

EVALUATION OF OPTOELECTRONIC CHANNEL LEAK SPEECH WITH THE USE OF MATHEMATICAL MODELS

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In this article we analyzed optoelectronic channel leakage of voice information. It's a method for processing the measurement signal, including an assessment of the cumulative effect of amplitude and phase modulation. Acoustic vibrations of the solid medium, subject to amplitude and phase modulation, presents a model of a rectangular vibrating membrane. The method of estimating the signal/noise ratio by using the mathematical model developed security assessment. During the research density distribution phase at various energy indicators was built showing the degree of dependence of the phase of the resulting fluctuations of the original signal.

Protecting an acoustic (voice) information is one of the most important tasks in the whole complex of measures to ensure the information security of the object information and carried out passive and active methods.

The speech signal is a complex acoustic signal, which includes noise and harmonic components, so it is important to justify the choice of the measuring signal. Under the influence of the acoustic oscillations of the speech source in enclosing structures and engineering communication facilities there are vibrations.

Depending on the propagation medium of speech signals and methods of interception technical (parametric) leakage channels of information are divided into acoustic, vibro-acoustic, electro-acoustic, optical and electronic.

The criteria for evaluating the security of voice data are [1]:

– Information rate (normalized value speech);
– The energy ratio (the ratio of signal power to noise power).

Estimation of security of optoelectronic channel leakage of voice information is relevant, since there is the possibility of interception of the speech signal remotely (at a considerable distance from the disinformation of the object).

The analysis of existing methods and techniques of information leakage. Protection of information due to the rapid development of technology is more complicated.

We selected electro-optical channel leakage of voice information as the object of research. The subject is the technique of estimation of the signal / noise ratio.

The purpose of research is to develop a mathematical model to assess the security and it is based on the structure of the distribution density of phase with different energy performance.

Optoelectronic (laser) channel leakage of acoustic speech information generated by irradiating a laser beam vibrating under the effect of the acoustic speech signal reflects off-premises surfaces (windows, mirrors, etc.). The reflected laser radiation is modulated in amplitude and phase and is received by the receiver of the optical (laser) radiation, demodulation which distinguishes voice information.

For such channel organization it is preferred to use the specular reflection of the laser beam. At small distances to reflective surfaces (a few tens of meters) a diffuse reflection of the laser radiation may be used.

Sophisticated laser systems are operating in the near infrared wavelength range, while changing to intercept voice data over an optical channel.

To ensure informational signal it's necessary to provide:

– Assessment in terms of background (natural) and artificial noise;
– Implementing a spatial processing;
– Assessment of the mixture signal + noise to determine the signal level;
– Evaluation of the reverberation noise resonance phenomena;
– Consideration of the uneven frequency response (frequency response);
– Evaluation of speech intelligibility in the optical channel of information leakage.

It is proposed to analyze the correlation theory of speech [1, p. 75]. Correlation method takes into account factors affecting methodological (theoretical) uncertainty (accuracy) assess speech intelligibility in a channel of information leakage:

- Sensitivity curves of the ear;
- Normalized values of attenuation elements of design;
- Spectral density of speech;
- Ripple transmission medium;
- Resonance design, the enclosed space;
- Reverb (sustain);
- Man-made interference.

Justification of the choice of the measuring signal. Harmonic signal is received as a measuring signal of the correlation theory of speech. It is used for processing a quadrature coherent receiver, which is not sensitive to the initial phase of the measuring signal. The high selectivity of coherent quadrature receiver solves the problem of reliable detection of the measurement signal in all channels of leakage of voice information. Harmonic signals are not inherent factors reducing systematic error of measurement. The noise of the high-level time allocation of meter weak signal increases. There is its accumulation (increase in the ratio of power signal to the noise power) and a decrease in deformation of the spectral density of the finite harmonic-ray signal. The result of measurement by the value of a harmonic signal is speech, obtained basing on the correlation theory intelligibility. The amount of time of discerning speech is a single criterion for assessing the channel leakage of voice information.

From the analysis [3] reflected from the windows of the laser beam at the absent-three kinds of modulation of optical radiation:

1) frequency caused by the Doppler effect due to the oscillatory motion of the window glass under the influence of acoustic signals;

2) the phase caused by the presence in the reflected signal as a specular reflected radiation and diffraction components;

3) the amplitude modulation due to variations in the illumination beam with respect to the direction of specular (maximum) reflection.

The peculiarity of optical-electronic channel is that the pencil beam incident on the vibrating under the influence of surface acoustic waves, exposing the amplitude-phase modulation of the optical beam is reflected or refracted. Acoustic vibrations of the medium turn into swings hard surface that is considered as a model of a vibrating rectangular membrane.

It is called membrane freely bent, stretched on some flat circuit film. We consider small oscillations of the membrane, and it is believed that the area is unchangeable and co-oscillations of each point are made in a direction perpendicular to the plane of xOy. After u = u (x, y, t) denotes the magnitude of deviation of the point (x, y) from the rest position of the membrane [5, c. 351].

For forced vibration equation is

$$\frac{\partial^2 u}{\partial t^2} = c^2 \cdot \left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}\right) + \frac{F(x, y, t)}{\rho} \quad (1)$$

Where $c^2 = T/\rho$, T - membrane tension, ρ - density of its surface, F (x, y, t) - power otne hay-unit area.

In the case of free vibration membrane is a rectangle R ($0 \le x \le a$, $0 \le y \le b$). ka = mπ, lb = nπ, where m, n - integers [4]. From

$$k = \frac{m\pi}{a}; \quad l = \frac{n\pi}{b}; \quad (m = 1, 2, \ldots; n = 1, 2, \ldots). \quad (2)$$

Natural frequency is of the form

$$\omega_{mn} = c\lambda_{mn} = \pi c\sqrt{\frac{m^2}{a^2} + \frac{n^2}{b^2}}; \quad (m = 1, 2, \ldots; n = 1, 2, \ldots); \quad (3)$$

and the relevant periods

$$\tau_{mn} = \frac{2\pi}{\omega_{mn}} = \frac{2}{c\sqrt{\frac{m^2}{a^2} + \frac{n^2}{b^2}}}; \quad (m = 1, 2, \ldots; n = 1, 2, \ldots). \quad (4)$$

Risk assessment information of the vibration signal is to determine the coefficient of vibration isolation of protecting designs, as well as the various elements of engineering and technical systems, including communication, measuring the level of vibration noise and protecting structures, in the calculation of information rate security assessment - speech W followed A comparison of the value of the indicator with norm-tive value Wn. Moreover, if the rules on the protection of the speech information of limited access are not fulfilled, and the level of vibration informative signal exceeds the level of vibration noise is determined by the distance of the interception of voice information laser means time-prospecting and range interception of data taken with stethoscopes exploration and transmitted IR .

If the range interception optoelectronic reconnaissance is less than the radius of the controlled area, a decision on the absence of information leakage of opto-electronic channel [4].

Mathematical model of electrooptical channel. The first thing to belt-thread why using phase modulation, rather than the frequency. By Gonorovsky [6, p. 145], the frequency is none other than the rate of change of phase fluctuations. The total phase fluctuation at the time that can be defined as

$$\varphi(t) = \int \omega(t)dt = \int_0^t \omega(t)dt + \theta_0 . \quad (5)$$

The frequency may vary over time, it is possible to present an integral and differential relations:

$$\varphi(t_2) - \varphi(t_1) = \int_{t_1}^{t_2} \omega(t)dt \quad (6)$$

$$\omega(t) = \frac{d\varphi(t)}{dt} \quad (7)$$

In these expressions $\omega(t) = 2\pi f(t)$- the instantaneous frequency of oscillation.

From (5) and (7) that the change in phase fluctuations with time, φ (t) results in a change of the instantaneous frequency according to the law of the derivative of φ (t), and the change in the instantaneous-term frequency by law ω (t) leads a phase change according to the law of the integral of ω (t).

Represent a harmonic oscillation quadrature signal s (t), represented by

$$s(t) = a \cdot \cos(\omega t) + b \cdot \sin(\omega t) \quad (8)$$

In the Hilbert transform obtain conjugate signal s1 (t)

$$s_1(t) = a \cdot \sin(\omega t) - b \cdot \cos(\omega t) \quad (9)$$

This type of oscillation occurs when radiation sine and cosine signals represented by a vector diagram in Figure 1.

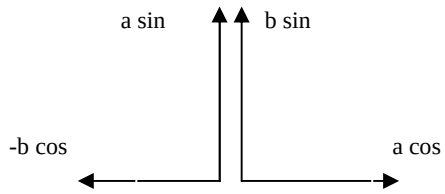

Fig. 1. Stock chart

Vibrations create an amplitude-phase modulation. A distinctive feature of the work-Stew from work A.V.Glushchenko, L.A.Glushchenko, V. Tupota [3] is an obtaining individual values of amplitude and phase components.

$$A(t) = \sqrt{(a \cdot \cos\theta(t) + b \cdot \sin\theta(t))^2 + (a \cdot \sin\theta(t) + b \cdot \cos\theta(t))^2} = \sqrt{a^2 + b^2} = a\sqrt{1 + k} \quad (10)$$

Where $k = \frac{b}{a}$,

$$\psi(t) = arctg\left(\frac{\cos\theta(t) + k \cdot \sin\theta(t)}{\sin\theta(t) - k \cdot \cos\theta(t)}\right) \quad (11)$$

Thus, the use of harmonic quadrature signal allows you to find am-amplitude-phase modulation as the total effect on the measuring signal.

In [7, p. 166] V.L.Lebedev suggested that in addition to the fluctuation of noise on the system affects unmodulated oscillations with amplitude U0, the frequency of which is equal to the resonant frequency of the system. The problem of the envelope is non-linear, so unmodulated oscillations (signal) and voltage fluctuation should be considered together.

The final formula for the probability density phase, which will reflect the energy of the Cree-criterion (the ratio of signal power to noise power) is given.

$$\omega(\theta) = \frac{e^{-\eta^2}}{2\sqrt{\pi}}\left\{\frac{1}{\sqrt{\pi}} + \eta \cdot \cos\theta\, e^{\eta^2 \cos^2\theta}[1 + \Phi(\eta \cdot \cos\theta)]\right\} \quad (12)$$

Here $\eta = \frac{U_0}{\sqrt{2}\sigma}$ - the ratio of the effective voltage signal and the noise at the output of the system.

In the absence of a signal (η = 0), the expression (1.31) becomes.

Increasing the amplitude of the signal causes the concentration of the most probable phase values near θ=0. This means that the phase of the resulting oscillation is increasingly determined by the phase of the signal (Fig. 2).

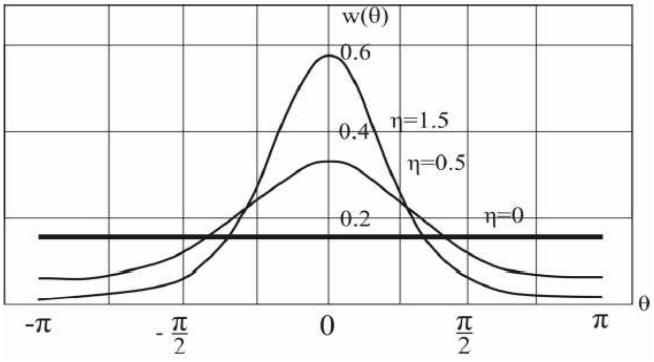

Fig. 2. Graph of the probability density at different phases of signal/noise ratio

To conclude it is necessary to say that using quadrature harmonic measurement signal solved the problem of separating amplitude and phase modulation of the measurement signals in the channel leakage speech information on optoelectronic channel.

Correlation method for determining the normalized value of speech is applied in the channel of information leakage. The energy index defined as the carrying-on signal / noise ratio is depending on the phase of the resulting fluctuations.

A mathematical model of signal processing, modulated in amplitude, phase and frequency estimates optoelectronic channel for leaks of information on the total effect. The amplitude-phase modulation is acting on the directional beam.

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UDC 537.296

USING TESTS TO CHECK STUDENTS' KNOWLEDGE IN THE AREA OF DISCRETE MATHEMATICS

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Tests can be classified according to various criteria. The main classification is based on the purpose of the test. It can evaluate a person's abilities, their personal qualities, intelligence, certain mental functions (attention, memory, imagination, knowledge). Since we are considering the specific use of tests in the area of discrete mathematics, we will talk about the test of knowledge.