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METHOD OF BIOLOGICAL OBJECTS ELECTROMAGNETIC IDENTIFICATION

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Abstract: The paper deals with one of the approaches to the problem of biological objects information which we face dramatically when providing an informational support of physical security systems for vital areas. The problem is enhanced by the unsteady nature of the environment effect and nonstandard working conditions. The proposed identification method is based on the phenomenon of a dependence (relation) between biological objects inherent radiations and the intensity of an external electromagnetic field of radio wave band with low intensity and given time-modulation parameters. The use of this method will enable to synthesize intrusion detection equipment with complete set of functional properties and minimal complexity of equipment implementation.

Key words: biological object, informational support, identification, electromagnetic field

Identification, in a broad sense of the word, is a determination of a degree of correspondence of a model to a real object or phenomenon. In a narrow sense, the problem of identification is reduced to the rebuilding of a structure and parameters of a model on the basis of field observation results and measurements. Such statement of a problem of identification is not new. To solve it we need technical means and algorithms, which are to perform a sequence of identification and selection procedures for a required class of objects on the basis of features inherent only to them or the most descriptive features.

In the information support for physical security systems intruders identification process means that intrusion detection equipment register parameters of different phenomena in environment caused by various effects - mechanical, acoustic, electrical, magnetic, etc. – arising as a result of intruders actions and presence.

The construction and parameters of the equipment for intrusion detection is determined by environment conditions and the nature of effects caused by intruders. Unfortunately, intrusion identification equipment available at present is capable only of identifying the desired signal against the background of different interfering signals. And even in this situation the potential of the available technique to solve the problem of intrusion identification is not realized completely because of the unique character of the occasional disturbances and interferences distorting the desired signals during the process of the environment parameters measurement, the limited time space of observation, specific performance conditions and the defects of the signal processing models.

In security standards used today as guidelines the probability of intruder detection P_{int} is determined as

$$P_{\text{int}} = 1 - P_m = \frac{N}{N + N_{i.m.}} = 1 - \frac{N_{i.m.}}{N_{d.i.} + N_{f.a.} + N_{i.m.}}, \quad (1)$$

where P_m – the probability of missing an intrusion;

N – total number of events registered by intrusion detection equipment (IDE);

$N_{d.i.}$ – number of detected intrusions;
$N_{f.a.}$ – number of false alarms;
$N_{i.m.}$ – number of the missed intrusions.

In this case all factors of the environment are classified: Ω_1 is an interference and Ω_2 is an intruder, and to describe objects their features are denoted as x, so for the known class descriptions – densities of probability distributions – we have $f_1(x)$ for an interference and $f_2(x)$ for a desired signal. Since the natures of these classes are very different, the total group of events involves the probability of correct detection and the probability of missing an intrusion, so the final decision about the presence of a false alarm is made by a human operator. It means that the validity of information received from the equipment solely is not high enough. And future consumers and decision-makers can not get true data about IDE performance from equipment specifications which do not take into account performance conditions when a human operator or guard is not allowed or can not be present at the protected site.

The selection problem is considered to be solvable by an application of a sequence of object identification algorithms for observed signal sets. This is true if the observed objects features are measured without errors and the values ranges corresponding to different classes of objects do not overlap. However, in the statistical statement of the problem such solutions are not optimal by the criterion of average risk minimum [7]. Moreover, regardless of the principle of setting selection borders between feature values ranges, situations are possible when no feature realization or more than one feature realization is within the space range for objects of the selected class. In such cases it is impossible to make a definite decision, which means that fundamental rules usually applicable for identification in selection problems are not such, indeed.

To eliminate this contradiction we had to solve a number of problems.

1. To make a retrospective analysis of the protected sites and features of intruders strategies and potential of methods of designing technical means (TM) of the informational support system for conditions when the a priori information about the processes (phenomena) observed in the area protected by TM ranges from scarce to complete.
2. To develop general methodology of analysis of structural properties of processes, which are measured in the informational support systems (ISS). For this purpose features of the ISS structure and the purpose of its functioning have been stated; a brief quality analysis of all possible relations among the system components has been made to find the relations having major effect on the result achievement in the system of higher hierarchy grade. The causes, features and consequences of situations when the structure and parameters of the existing informational support systems do not fully correspond to the stated requirements have been analyzed.
3. To develop the protection system concept and state the main directions of efficiency increase of the TM of the ISS. The concept is based on correspondence of its structural properties and the stated ideas. We have illustrated that even stationary, fully observable process may appear hard to be identified completely because of the used model inadequacy and the non-steady nature of a disturbed environment.
4. To develop methodology of features descriptiveness evaluation for intruders classification. By means of it we have determined that the most descriptive phenomena are the electromagnetic fields.

The preliminary stage of investigations has resulted in the conclusion that our purpose is to search for techniques of introducing the selection procedure for a class of intruders we are concerned about into the TM functioning algorithm. And among all diverse intruders we need to identify biological objects and subsequently select man in particular. A scheme of

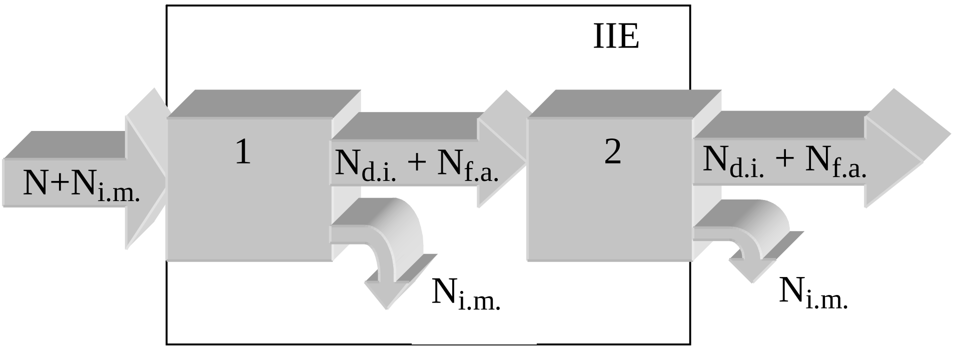

Fig. 1. Principle of operation of intrusion identification equipment.

functioning principle of intrusion identification equipment, further referred to as IIE, is presented in Fig. 1. The IIE performs identification (1) and selection (2).

Apparently in the course of selection correct and all erroneous decisions of different kinds will make a total group of inconsistent events, and it does not matter greatly which signal has been taken as a true one. Hence, the total a posteriori risk will be minimal under any relation between the costs of the correct and the erroneous decisions, if the decisions in favour of this or that hypothesis have been taken by the criterion of a posteriori probability maximum. Then under ideal identification the intruder identification probability $P_{i.i.}$ is determined as

$$P_{i.i.} = 1 - \frac{N_{i.m.}}{N_{d.i.} + N_{i.m.} + N_{f.a.}} - \frac{N_{f.a.}}{N_{d.i.} + N_{i.m.} + N_{f.a.}} = 1 - P_{i.m} - P_{f.a.}. \qquad (2)$$

Conventional intrusion detection devices available today and based on measuring well-known physical phenomena (capacitance, inductance, magnetometry, seismic disturbances, radio location and different electronic techniques) do not include the selection procedure. Their utilization does not allow to proceed to the higher level of the quality of the physical security systems informational support. So, the task is to develop the corresponding identification technique. The main point is to design the intruder model, the application of which will enable a detection device to have a maximum set of operating functions and minimum construction complexity, both being determined by the vector dimension of the process we are to measure. The identification criterion must be consistent with vector dimension for selected class parameters, which may be obtained on the basis of the a priori statistical characteristics.

The intruder model, originally designed to get a response only in the presence of a living organism, meets the above listed requirements. The remaining disturbing factors of an environment are not taken into account and are treated as a "background". The intensity of electromagnetic radiation which is characteristic of a living is taken as an identification criterion. According to numerous evaluations, living organisms have extremely individual intensities of radiations, which carry information about their source structure and parameters and differ from the corresponding parameters of the environment.

The inherent electromagnetic fields (EMF) characteristics of metabolism processes in biological objects (BO) are caused mainly by the charged particles motion within biological objects volume [1,7]. Their dynamics in space and time is very informative, and the data can be used for identification purposes [5, 10]. EMF of BO are the most intensive in infrared band where man is characterized by radiation power of more than 10 mW /cm^2, which makes the total value of above 100 W. This radiation with wavelength of 10^{-5}–10^{-6} m is modulated by BO physiological processes which preset the dynamics and distribution of BO body surface temperature.

The radiation in radio-heat band (wavelength 10^{-3}–10^{-4} m) gives information about the temperature and time rhythms of body organs. In this wave band signals from the depth up to 0.1 m are sensed and have sufficient space resolution.

Low-frequency EMFs (frequency about 1000 Hz) are related to electro-chemical transmembrane potentials, which reflect the functioning of different organs (heart, stomach, an so on) and systems (skeletal muscles an so on) of BO.

Magnetic fields which are related to currents in conductive tissues and accompany physiological processes are observed in some bands. Apart from the listed above parameters, it is very important to measure the changes in environment parameters which are relevant because during a metabolism process BO causes disturbances in the environment changing its gas, aerosol and ion concentration. This is accompanied with the environment conductivity, dielectric permeability and refraction factors changes [1,2].

At 10^{-6}–10^{-3} m wavelength the BO EMF remote sensing is difficult despite of the considerable intensity because the environment natural electromagnetic background is essentially non-steady. The analysis of special experiments series at low frequencies gives evidence of weak inherent EMFs of BO which means that their remote sensing by the equipment available today is also problematic when it concerns the purpose of identification [3-5]. At the same time, in this band it is possible to transmit information to rather long distances, which accounts for the search of means and techniques to increase the intensity of BO inherent radiation up to the level when it is readily sensed and registered [7].

To develop this method we had to create a concept of BO electromagnetic identification. The concept states that there is a physical phenomena of dependence between BO inherent EMF and BO mass and geometrical dimensions in case BO are effected by external EMF of given intensity and time-modulation parameters. The concept is based on numerous theoretical and experimental data about the features and laws that govern the biological effect of the low intensity EMF of radio band on BOs and the most possible mechanisms of these fields sensing and generation.

The formal model to check the concept sufficiency and consistency has been synthesized on the basis of methodological tool of non-linear physics. The model proves the existence of the effect stated by the concept and confirms its consistency with the modern science concepts.

The mathematical model includes some simplifying and restrictive assumptions and is based on the method of moments [9,10]. The volume occupied by a BO is considered to be spherical, and this geometrical figure allows the application of approximated solution of Maxwell equations. The material environment is assumed to be homogeneous and isotropic [1,2,6,7].

According to Kirchhoff law [6], any system of charges and currents is the source of EMF all over the band of wavelengths, by which it is affected. This is explained by the generation of multipole moments varying with the field.

If we eliminate from consideration electromagnetic processes characterizing the activity of biological generators concentrated in plasmatic membranes of biological cells and treat object as neutral, then for this case there are known solutions for the components of the scattered electromagnetic radiation in a wave zone [1,7,8]. However, as radiators BOs have imperfect forms, and the secondary radiation of the highest intensity should be expected not in the wave, but in the proximity region. So, let's analyze a field in the immediate proximity of an object at distances less than the wave length $\lambda=cT=2\pi c/\omega$ which is characteristic of a static case [8]. We shall also take into account the contribution into the EMF of the scattered radiation caused by indirect charges and currents when the functioning of bioelectrical generators is synchronized by the external field. For this purpose let's image the BO as a conductive sphere with radius a and a surrounding dielectric shell of thickness b and permeability ε. In this case potential φ is determined by the expressions [7]:

$$\begin{aligned}&\varphi(r<b)=3p_{\omega}E_{ext}\, r\, Cos\;\;\Theta(a^3/r^3-1)\Theta(r-a),\\&\varphi(r>b)=-E_{ext}\, r\, Cos\Theta\left\{1-(p_{\omega}/r^3)[b^3(\varepsilon-1)+a^3(2\varepsilon+1)]\right\},\end{aligned}\tag{3}$$

where $p_{\omega}\equiv[\tilde{\varepsilon}+2+2(\tilde{\varepsilon}-1)a^3/b^3]^{-1}$ – is an electrical dipole moment [7].

The value of conductivity σ in the expression $\tilde{\varepsilon}=\varepsilon-j\overline{\sigma}/\omega$ for complex equivalent permeability depends on values of intensity of a local electromagnetic field $E_{ext}\,|G(d,\omega)|$ in BO. The modulus of a complex transfer function $|G(d,\omega)|$ determines the changes of BO medium electrodynamic parameters under given time-modulation and intensity parameters of an external field E_{ext} [1,2].

In the first case, the BO medium is passive at external disturbances and its response is of specifically linear nature which is determined by its standard pattern, so that at $E_{BH}|G(d,\omega)|$ $<E_L$

$$\overline{\sigma}=\mu_r\sigma+j\omega\varepsilon_0(\mu_r\varepsilon_r-1).\tag{4}$$

In the second case when the local field achieves some threshold level $E_{ext}\,|G(d,\omega)|\geq E_L$, the medium starts to become active, and its response to external influence becomes non-linear. This new non-linear nature of the response is the result of resonance-field activity of external EMFs, when the cell oscillators are synchronized in their functioning. This synchronization is possible when the oscillators are linked or interact and the a mount of synchronization energy is sufficiently large, besides the relations between the frequencies of the synchronized and synchronizing systems must be equal, divisible or rational.

Therefore, in the expression $E_{ext}\,|G(d,\omega)|\geq E_L$ we should take into account the effect of the local EMFs, which are produced by bioelectrical generators, on subsequent tissue layers towards the direction of the external field propagation, and the external field structure grades. The superposition of these fields with the external field creates conditions for functioning synchronization of cells of deeper tissue layers. If the mean level of the intercellular correlation were not dependent on intercellular space, then the correlation factor γ of two points A and B in the tissue layer $0<k<d$ would be unit. The intercellular space r can be taken as the experimentally observed relation [5-7]:

$$r\approx\frac{d(G_{1i}^n+G_{2i}^n)}{4G_{1i}^n}\sqrt{r_2/3(r_1-r_2)}.\tag{5}$$

Here r_1, r_2 are the correlation factors between the membrane potential changes of remote (r_2) and neighbouring (r_1) cells, and G_i^n is the cell membrane conductivity, which characterizes the cell state. Then $\gamma(r)$ is obtained as

$$\begin{aligned}\gamma(r)\approx\frac{4t(t+k)G_{1i}^n}{k(G_{1i}^n+G_{2i}^n)}\sum_{m=0}^{m_1}(m+1)\left(\frac{G_{2i}^n-G_{1i}^n}{G_{2i}^n+G_{1i}^n}\right)^m\times\\\times\left[\frac{1}{(r^2+4(m+1)^2t^2)^{1/2}}-\frac{1}{(r^2+4(m+1)^2(t+k)^2)^{1/2}}\right],\end{aligned}\tag{6}$$

where t is the radius of «the average» cell oscillator, and m_1 is the quantity of oscillators or the scale of the analysis.

As the EMF primary effect is realized on the cell level and is related to the cell membrane elements, molecules of protein - enzymes and other structures, which are elementary self-excited generators, then when synchronized the external field changes the spectral characteristics of self-excited generators first of all, which effects the cell membrane permeability and the value of transmembrane currents. The centre of synchronization band is determined by the value of self-excited generators partial frequencies.

Numerous experimental researches [3-5] give evidence of frequency and energy windows which arise when BOs are influenced by low intensity modulated EMF, this phenomenon is caused first of all by the EMF effect on membranes, namely on their permeability to cations. In conditions of a steady balance the ion gradient on a membrane is constant in time, as the active transport compensates the corresponding ion leaks by electrochemical gradient. Under external EMF influence the cell membrane permeability increases, and it is manifested in decreasing of potassium and natrium ions concentration on cell membranes. The analysis of a series of special experiments [5] has shown that the electromagnetic fields influence on cell membrane permeability is 40 - 50 % related to their governing effect on the active transport and is 50 % due to the diffusive flow change. Hence, the external EMF in combination with the local field influences directly the «gate» mechanism of the ion conductivity channels for cell membranes, even if the amplitude of a synchronizing signal is negligibly small [3-5].

The energy threshold value in the presence of a synchronized information signal depends on specific molecular mechanisms of interaction of an external fields modulation-time parameters, the noise level in a biological system and frequency difference between synchronizing and synchronized oscillations. The most favourable combination of these factors provides the energy threshold values, corresponding to the external field intensity 10^{-7} V/m, i.e. to the level of a natural background [4].

In this case

$$\overline{\sigma} = G_e + \frac{\omega^2 \tau^2 G_i}{1+\omega^2\tau^2} + j\omega\left[C_e + \frac{C_m}{1+\omega^2\tau^2} \right]. \qquad (7)$$

The expression (7) is an admittance at contacts of an electrical scheme which is an equivalent representation of an «average» biological cell according to the Hodgkin – Huxley model [1]. We can get the order of the relaxation magnitude τ, if we take the typical cell parameters. As a first approximation capacitance C_m is related to the cell membrane and is proportional to $r^2\varepsilon_m / t$ where r is membrane thickness, t is the radius of the cell and ε_m is the dielectric permeability of a membrane. Conductivity is similarly related to the current in a cell and must depend on the inside-the-cell conductivity G_i and outside-the-cell conductivity G_e. As both these mediums have approximately identical conductivity σ_i, then we can assume that they are proportional to $r^2 \sigma_i /r$. Then the relaxation time is obtained as the value of the order $r\varepsilon_m/t\sigma_i$. For typical parameters of an «average» cell $r = 10^{-5}$, $\varepsilon_m = 3$, $t = 10^{-8}$ m, $\sigma_i = 1$ cm/m and the relaxation time is $\tau = 2.7\cdot 10^{-8}$ s, which corresponds to the central frequency of a dispersion of 6 MHz [1,2].

If we treat a biological object as a system consisting of such equivalent circuits connected in different series and parallel combinations, we can represent a BO as volumetric conductor with the following electrical parameters:

$$Y = F(\sigma + j\omega\varepsilon_0\varepsilon_r(\omega))A/d = Y_c \frac{[AN^{2/3}]}{[dN^{1/3}]} = FY_c N^{1/3} A/d, \qquad (8)$$

where $\sigma + j\omega\varepsilon_0\varepsilon_r(\omega) = Y_c N^{1/3}$;

N – number of cells in a volume occupied by a BO;

A – area of a maximum cross section of an object;

d – maximal linear dimension of an object in the direction of an external field;

F – factor of synchronization;

[ ] - the integer part of the number.

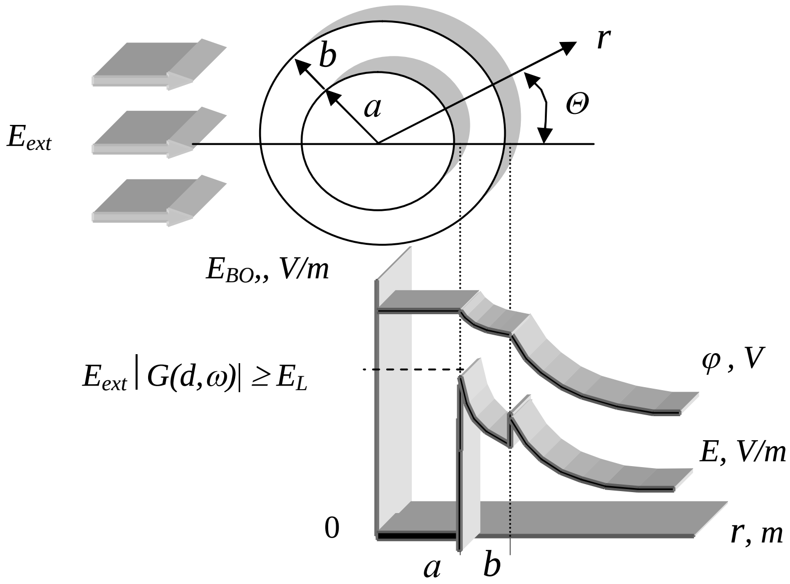

Fig.2. The dynamics of the field intensity components change of BO inherent EMR in the neighbouring region.

The increase of the BO electromagnetic radiation is caused basically by partially synchronized activity of cells which is result of an external EMF effect of informational type on membrane structures. Even if the cells functioning is mutually independent, the presence of the field governing effect has a synchronizing effect on a large group of adjacent cells dipoles at the wave front of the field. We suppose that within one basic unit the inner links quantitatively dominate over the governing signals which come from other cells. The values of the relation between membrane conductivity and external EMF parameters on condition that they are consistent to the electromagnetic characteristics of BO tissues have been estimated in different works; taking these values into account we can assume that in synchronized mode this relation has the average increase of F=1.25 [7]. The resulting from it structure conformations are fast and completely convertible.

Then the dynamics of the field intensity components change of BO inherent electromagnetic radiation (EMR) in the neighbouring region (Fig. 2) can be described by an expressions [7]:

$$E_r = -\frac{\partial\varphi}{\partial r} = \frac{E_{ext}}{4\pi\varepsilon_0}\frac{2p_\omega Cos\Theta}{r^3}, \quad E_\Theta = -\frac{\partial\varphi}{r\partial\Theta} = \frac{E_{ext}}{4\pi\varepsilon_0}\frac{p_\omega Sin\Theta}{r^3}. \qquad (9)$$

Hence, the vector modulus E is

$$E = \sqrt{E_r^2 + E_\Theta^2} = \frac{E_{ext}}{4\pi\varepsilon_0}\frac{p_\omega}{r^3}\sqrt{1+3Cos\,2\Theta}. \qquad (10)$$

To check the adequacy of the obtained model the influence of the low intensity structurized fields on BO electromagnetic radiation has been measured experimentally. The results of the analytical studies and the computational experiment with the model allowed to have a basis for the methodology and technology of the experiment. The skeleton diagram of the experimental unit is presented in Fig. 3, the unit includes

- R-140 – a radio transmitter to produce an external field;
- G3-101A – a generator to set the modulation frequency of an external field;
- AR3000A – a receiver to sense the radiation of a BO and of external field (Tabl. 1);
- SDU5000 – a display device to represent the spectrum and analyse spectral characteristics of BO inherent electromagnetic radiation and external fields (Tabl. 2);
- PC – personal computer to process the results of the experimental studies.

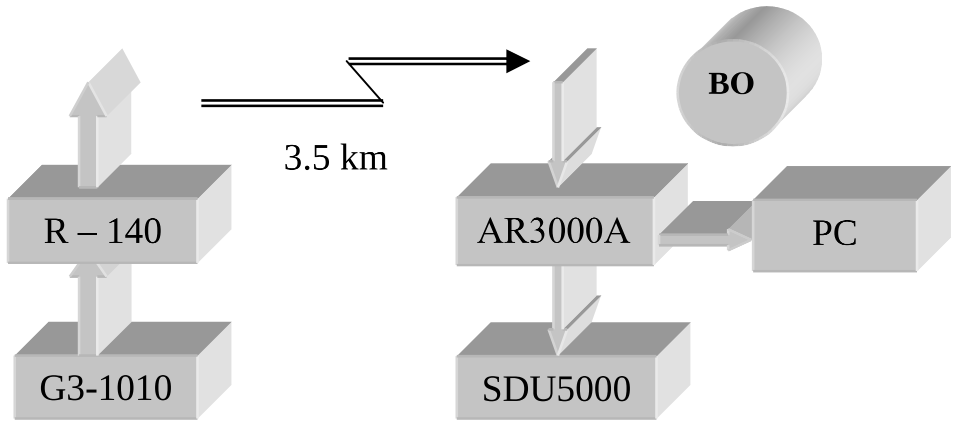

Fig.3. The skeleton diagram of the experimental unit.

Table 1.The receiver AR3000A specifications

Received range	100 kHz – 2036 MHz			
Type of modulation	NFM, WFM, AM, USB, LSB, CW			
Type of the receiver	Superheterodyne with 3–times transform for USB/LSB\CW/AM/NFM and 4-times form for WFM			
Speed of scanning	50 channels/s			
Speed of search	50 channels/s			
Number of channels	400 (4 banks with 100 channels each)			
Receiver sensitivity, ?W	10 dB S/N		12 dB SINAD	
	SSB/CW	AM	NFM	WFM
100 kHz – 2.5 MHz	1.0	3.2	–	–
2.5 MHz – 1.8 GHz	0.25	1.0	0.35	1.0
1.8 GHz - 2.0 GHz	0.75	3.0	1.25	3.0
Receiver selectivity	2,4 kHz / -6 dB, 4,5 kHz / -60 dB (USB/LSB/CW) 12 kHz / -6 dB, 25 kHz / -70 dB (AM/NFM) 180 kHz / -6 dB, 800 kHz / -50 dB (WFM)			
Power of sound	1.2 W at 10% distortion (4 Ω) 0.7 W at 10% distortion (8 Ω)			

For the purpose of producing the wave zone in the area where the experiment is conducted the transmitter is located at the distance of 5 km from the area of the experiment. The radio transmitter is housed in a metal case, which is grounded. The receiving antenna is located on the building roof and mounted on a dielectric base to provide its isolation from the ground. The feeder connecting a receiving antenna and a radio receiver is shielded, and the shield is grounded.

In the first series of experimental investigations the spectral monitoring of the BO electromagnetic radiation in the absence of deliberately produced external electromagnetic field of the band 1-200 MHz has been performed. A biological object was presented by a man height 1.85 m, mass 82 kg.

The given series of experiments has not manifested a great increase in the values of the parameters sensed by a receiver. The registered minor excess of the average background level can be accounted for capacitance and inductance effects, the increase in the antenna effective length and the unexpressed reflection effects [7].

In the second series of the experiments in the area where the experiment was conducted an electromagnetic field with the vertical polarization of the wave has been produced; the parameters of the field were; the carrier frequency 23 MHz, amplitude modulation with the frequency 1 kHz at modulation factor 80 %. The field intensity varies in the range 0 – 8000 mkV/m. The receiving antenna was a copper pin 0.38 m long and 0.004 m in diameter arranged horizontally. The biological objects in the experiment were a man (height 1.85 m and mass 82 kg) and a dog (maximum height at the withers 0.56 m and mass 43 kg). The results of this second series of experiments have been processed by "fast" Fourier transform (FFT) on a PC and are shown in Tab. 3 and in Fig. 4.

The mutual location of an object and the receiving antenna relative to the wave front of an external field has a negligible effect on the signal magnitude at the receiver output. At the same time if an object is present in the sensitivity zone of a receiving antenna, the spectrum of the received signal becomes wider, which is manifested in the change of the characteristic, read from the spectrum display device.

Table 2. The SDU5000 display device specifications

Input frequency	10.7 MHz
Survey band	0 – 10 MHz (with spacing 1 kHz)
Accuracy of frequency	± 600 Hz
Frequency scale resolution	5 or 30 kHz
Reference level	10, 40 dB
Maximum input level	10 dB
Dynamic range	Minimum 50 dB
Linear accuracy of the level	In the range of ± 2 dB
Pulse of the range	+3 dB –10 dB @ 10.7 MHz ± 5 MHz
Marker mode	Direct reading of signal frequency and signal level, peak values detection, averages value (adjusted from 2 to 32 signals)
Plotter mode	Contour, draw
Display mode	Top, bottom
Input impedance	20 kΩ
Combined output video signal	18 NTSC, PAL 75 Ω
Type of display	75 mm, liquid crystal, 16 colours
Resolution	192 / 210 points
Time of image refreshing	500 ms

Table 3. The results of the experimental investigations.

<table>
<tr><th rowspan="2">Number</th><th rowspan="2">Type of biological object</th><th rowspan="2">Parameter, mkV/m</th><th colspan="7">The distance from the object to the receiving antenna R, m</th></tr>
<tr><th>0.00</th><th>0.25</th><th>0.50</th><th>1.00</th><th>2.00</th><th>3.00</th><th>4.00</th></tr>
<tr><td rowspan="2">1</td><td rowspan="22">A HUMAN BEING</td><td rowspan="22">E_{ext}/E_{BO}</td><td colspan="7">0.0</td></tr>
<tr><td>7.3</td><td>4.1</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td></tr>
<tr><td rowspan="2">2</td><td colspan="7">80.0</td></tr>
<tr><td>28.2</td><td>10.1</td><td>5.6</td><td>3.0</td><td>1.0</td><td>0.0</td><td>0.0</td></tr>
<tr><td rowspan="2">3</td><td colspan="7">116.0</td></tr>
<tr><td>31.4</td><td>14.7</td><td>12.4</td><td>4.8</td><td>1.3</td><td>0.0</td><td>0.0</td></tr>
<tr><td rowspan="2">4</td><td colspan="7">159.0</td></tr>
<tr><td>64.1</td><td>24.1</td><td>13.3</td><td>7.7</td><td>2.0</td><td>0.0</td><td>0.0</td></tr>
<tr><td rowspan="2">5</td><td colspan="7">310.0</td></tr>
<tr><td>101.7</td><td>49.6</td><td>21.2</td><td>11.0</td><td>3.1</td><td>0.0</td><td>0.0</td></tr>
<tr><td rowspan="2">6</td><td colspan="7">462.0</td></tr>
<tr><td>276.0</td><td>82.0</td><td>61.0</td><td>40.0</td><td>20.0</td><td>0.0</td><td>0.0</td></tr>
<tr><td rowspan="2">7</td><td colspan="7">647.0</td></tr>
<tr><td>1050.4</td><td>231.0</td><td>151.0</td><td>77.0</td><td>34.0</td><td>13.0</td><td>0.0</td></tr>
<tr><td rowspan="2">8</td><td colspan="7">810.0</td></tr>
<tr><td>1658.0</td><td>476.0</td><td>249.0</td><td>169.0</td><td>66.0</td><td>51.0</td><td>0.0</td></tr>
<tr><td rowspan="2">9</td><td colspan="7">907.0</td></tr>
<tr><td>1773.0</td><td>501.0</td><td>306.0</td><td>179.0</td><td>56.0</td><td>53.0</td><td>0.0</td></tr>
<tr><td rowspan="2">10</td><td colspan="7">1110.0</td></tr>
<tr><td>1823.0</td><td>541.0</td><td>367.0</td><td>203.0</td><td>100.0</td><td>60.0</td><td>0.0</td></tr>
<tr><td rowspan="2">11</td><td colspan="7">8000.0</td></tr>
<tr><td>1858.0</td><td>670.0</td><td>460.0</td><td>3310.0</td><td>150.0</td><td>60.0</td><td>0.0</td></tr>
<tr><td rowspan="2">12</td><td rowspan="2" colspan="2">A dog</td><td colspan="7">462</td></tr>
<tr><td>50.0</td><td>17.0</td><td>9.0</td><td>3.0</td><td>0.0</td><td>0.0</td><td>0.0</td></tr>
</table>

Conclusions

1. Analytical studies of a relation between the character and the magnitude of BO inherent radiation and the intensity of an external structured low intensity EMF of radio wave band have been made and allowed to create a methodology and technology for conducting field-test experiments.
2. The adequacy of the designed model and the existence of the interrelation between BO electro-magnetic radiation and the intensity and the modulation-time parameters of an external field have been completely confirmed by experimental investigations.
3. The characteristic form of the experimentally discovered dependence of BO inherent EMR on the external field intensity (Fig.4) proves that the BO response to this external influence has an essentially non-linear character and thus confirms the validity of analytical conclusions.
4. Three sections of the plot have been singled out. The first (the external field intensity is 0 – 159 mkV/m) and the third (the external field intensity is 810 – 8000 mkV/m) sections correspond to the model of the passive environment, when the BO response to the external effect is linear. It is caused mainly by multipole radiation, capacitance and inductance

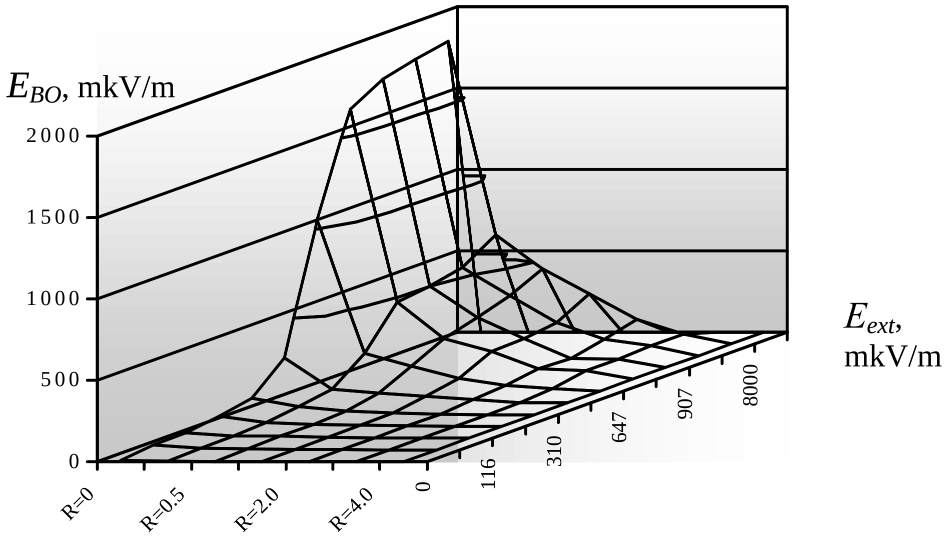

Fig. 4. The results of the experimental investigations.

effects and the increase of the receiving antenna effective length. The second plot section shows the case (the external field intensity is 159 -810 mkV/m). when the BO own medium, which becomes active, contributes to the BO inherent radiation. In this case the response almost by two times exceeds the outer effect, which can be accounted only by the resonance phenomena.

5. Considerable excess of the total signal «intruder + an external field» over the level of the natural electro-magnetic background (signal/noise ratio exceeds 100) provides the required sensitivity and selectability to identify BO.
6. The peculiar mode of «saturation» present on the plot (section 3) proves that BO identification is possible under given value of the external field intensity.
7. The theoretical statement of the relation between BO inherent EMR and BO mass/dimensional parameters under given values of an external field has been confirmed. Under the same external field intensity of 462 mkV/m the inherent EMR of a man and a dog differ by 5.5 times.

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МЕТОД ЭЛЕКТРОМАГНИТНОЙ ИДЕНТИФИКАЦИИ БИОЛОГИЧЕСКИХ ОБЪЕКТОВ

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Рассматривается один из подходов к решению проблемы идентификации биологических объектов, которая особенно остро встает при решении задач информационного обеспечения физической защиты объектов. Это обусловлено нестационарным характером воздействий окружающей среды и сложными условиями эксплуатации. Предлагается использовать метод идентификации, в основе которого лежит эффект зависимости собственных электромагнитных излучений биологических объектов от напряженности внешнего низкоинтенсивного электромагнитного поля радиоволнового диапазона с заданными модуляционно-временными параметрами. Его реализация при создании технических средств обеспечивает их высокую избирательность, изначально предполагающую реакцию только на живые организмы. Остальные возмущающие факторы окружающей среды во внимание не принимаются и рассматриваются в качестве «фона». Применение данного метода позволяет впервые ввести в алгоритмы функционирования технических средств идентификации процедуру селекции заданного класса нарушителей, основывающуюся на классификации биологических объектов по их наиболее информативным признакам, что повышает степень полноты и достоверности информации о состоянии контролируемого пространства. При этом технические средства обладают достаточно полным функциональным набором при минимальной по сложности приборной реализации. Библ. 8.

Ключевые слова: биологический объект, информационное обеспечение, идентификация, электромагнитное поле

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