ІНФОКУМУНІКАЦІЙНІ ТЕХНОЛОГІЇ, АВТОМАТИЗАЦІЯ ТА ОБЧИСЛЮВАЛЬНА ТЕХНІКА В ТЕХНОЛОГІЧНИХ ПРОЦЕСАХ

UDC 621Ю391: [57+615.84]

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LOW–INTENSIVE MICROWAVE SIGNALS IN BIOLOGY AND MEDICINE

Abstract: Millimeter range signals have been widely used in biology and medicine over the 20-30 years of the last century. At this time in Ukraine have been developed and implemented treatment technologies, the main ones are millimeter therapy (MMT), microwave resonance therapy (MRT), information-wave therapy (IWT). The features of this technologies are the use of signals in the frequency band 40-78 GHz with extremely low signal levels - 10-9-10-11 W / cm2, the parameters are immanent to own communication signals of the human body. The author of the article attempts to conduct a combined analysis of hardware and software of these treatment technologies with mm-band signals. Thus the specialized equipment used for the treatment, technologies and the statistical results of its use for various diseases are considered. The problems of metrological support and measuring the weak signals of the mm range are proposed to solve by creating highly sensitive radiometric systems. The results of measurements of microwave signals of natural objects that can be used for physiotherapy and physical bodies that are in contact with or in human environment are submitted. Promising areas of the using the highly sensitive radiometric measurement equipment for research in biology and medicine are presented.
Keywords: low-intensive microwave signal, mm-band therapy, metrological support, radiometricequipment.

INTRODUCTION. Millimeter wave signals are widely used in biology and medicine at the last 20-30 years with the advent of electronic devices generating this range. The first experiments on the effects of mm-signals in living organisms are carried out using standard test generator in the frequency range from 37.5 to 78.33 GHz. Detection of positive changes in the body of experimental animals under the influence of mm-radiation caused expanding of the research in the human body. The largest contribution to this research, and the development and implementation of medical equipment and treatment technologies with mm-signals made teams led by Academician Devyatkov M.D. and Prof. S.P. Sitko. Directions of researches conducted by these groups have focused on determining the parameters of mm-signals for therapeutic intervention on the patients and the list of diseases and their treatment technology.

As a result, the first specialized medical devices for millimeter therapy "Явь" ("Yav") and "Поріг-1"("Porig (Threshold - 1") and appropriate technologies for their use in medical practice were created. However, the parameters of these devices (signal type, operating frequency, output level) significantly differed among themselves, and therefore have differences, and even in the names of treatment technologies. So the technologies developed by Kyiv specialists combined with name - Quantum medicine because they use extremely low power as noise so harmonic signals [1, 2].

At this time in Ukraine have been developed and implemented treatment technologies, the main ones are millimeter therapy (MMT), microwave resonance therapy (MRT), information-wave therapy (IWT). The features of this technologies are the use of signals in the frequency band 40-78 GHz with extremely low signal levels - 10^{-9}-10^{-11} W/cm^2, the parameters are immanent to own communication signals of the human body.

In contrast to the treatment with a low-frequency signals (HF, UHF), which are associated with heating and thermal effects, the MMT is based on non-ionizing energy-effects on the human body. Areas of influence in MMT are biologically active zones and points (BAP) of the human body. Millimeter signals are absorbed by BAT at the resonant frequencies, simulating the natural tones of the human body. In some cases for body as a self-regulating system the insignificant proportion of the MM-wave energy is quite enough to reduce pathological phenomena and restore normal physiological state. There are several hypotheses to explain the mechanisms of electromagnetic radiation action on biological objects [2, 3]. Almost all of them say that the primary target of MM signals are water molecules that strongly absorb such signals first of all in dermal nerve receptors and immune-competent cells.

Under the influence of MM-radiation the synthesis of ATP in cells and biologically active substances that affect the immune status increases. Observed changes in cellular metabolism are the prerequisite for further recovery of the functions at the level of the whole organism. This improved immune system parameters, blood parameters, condition of the nervous system, as evidenced by laboratory diagnostic methods during treatment of MM therapy. The effectiveness of therapy increases with using the mm-signal in the resonant frequency [1, 2], since this increases the amount of absorbed energy. All kinds of MMT are shown to be used in many serious diseases like kids cerebral palsy, aseptic necrosis of the femoral head, stomach and duodenal ulcers, diabetes and its complications, and others as additional complementary treatment. MMT can be used in different oncologic diseases as before surgical intervention so after it in standard treatment methods.

MAINBODY.

1. Devices and special radiation sources of millimeter-range frequencies

Currently, therapy with mm-range signals use about 25-30 types of specialized medical equipment [2].

Creation of the mm-wave band generators with low output associated with the solution of a number of complex technical problems. The main ways of obtaining low-intensity signals from devices for practical medicine are [4]:

- create generators for tens mWatt with subsequent reduction of power via attenuators;
- use second harmonic generator with resetting output by applying on its output high pass filter;
- use the frequency multipliers for the formation and allocation *n*-th harmonic signal;
- use of heat and spark generators.

There are several developed apparatus generating mm-range waves for medical purposes [1]:

- sets of harmonic signals with fixed operating frequencies, "Явь-1" ("Yav-1"), "Электроника-КВЧ" ("Electronics-UHF"), "РАМЕД-ЭКСПЕРТ" ("RAMED-Expert");
- "broadband generators" of the harmonic signals, "АМРТ-01" ("AMRT-01"), "АМРТ-02" ("AMRT-02"), later types of devices "Електроніка"("Electronics"), "АМТ-Коверт-04" ("AMT-Covert-04"), "ARIA-SC";
- "broadband devices" of noise signals "Поріг-1" ("Porig - 1"), "Поріг-3" ("Porig -3"), "Поріг-3М" ("Porig -3M"), "Арцах" ("Artsakh"), "Шлем" ("Shlem (Helmet)");
- combined devices generating as noise so harmonic signals, "АМРТ-01" ("AMRT-01"), "Арцах" ("Artsakh");
- devices with additional modes of quasi noise signals formatting due to "spill" the spectrum of harmonic signals, frequency sweeping within the operating frequency range "АМТ-Коверт-04"("AMT-04 Covert "), "ARIA-SC". This mode is easily implemented in new devices with embedded microprocessor (microcomputer).

The main types of such devices and their parameters are given in Table 1.

By operating frequency range of equipment located mainly in the 37 to 78 GHz, some devices (mainly noise signals generators) cover bands up to 90 GHz and 118 GHz even (Table 1]).

Table1

Apparatus for millimeter the rapy

Name of the device	Country of origin	Type of signal	Operating range, GHz	Output power, Wt
"AMRT-01"	Ukraine, Kharkiv	harmonic, noise	58-62 53-78	$3\cdot10^{-3}$
"Electronics-UHF"-101" (2 modification)	Ukraine, Kyiv	– // –	59-63 57-65	$5\cdot10^{-3}$ $5\cdot10^{-5}$
"Artsakh" (4 modification)	Armenia, YRFE NAS	– // –	59-61, 42-95	5 м Wt /см^2 10^{-19} Wt /Hz
"AMRT-02"	Ukraine, Kharkiv	harmonic, quasinoise	52...62	$1\cdot10^{-4}$
"ARIA-SC"	Ukraine, Kharkiv	– // –	53...64	$5\cdot10^{-5}$
LDK "Sharm", "Yav-1"),	Russia,	– // –	42,2; 53,5	$1\cdot10^{-2}$
"Stela-2"	Russia, Tomsk	– // –	59...63	$1\cdot10^{-4}$
("Porog-3" (4 modification)	Ukraine, Kyiv	noise	53...78	10^{-17} - 10^{-19} Wt /Hz
"Covert-01"	Russia, Moscow	– // –	53...78	10^{-20} Wt /Hz
MU-2001	Switzerland	– // –	42...78	$1\cdot10^{-21}$ Wt /Hz
"Electronics-UHF -011, 013" (2 modification)	Ukraine, Kyiv	quasinoise	57...65	$5\cdot10^{-5}$

There are attempts to create devices designed at more high frequency, which work even in the range of terahertz waves. The level of power generated also varies widely and covers the area from 10 mW to 1 nW for monochromatic and $1\cdot10^{-8}$ to $1\cdot10^{-20}$ W/Hz for noise signals.

Fig. 1 shows the distribution of power and frequency range of devices for millimeter therapy (Figure 1).

The information about the feasibility of the submillimeter range signals usage in practice of medicine have appeared recently.

Fig. 2 shows two types of noise generators with low-intensive output signals, positive flow "Porog-VT" and negative flow "Porog-NT, (Figure 2).

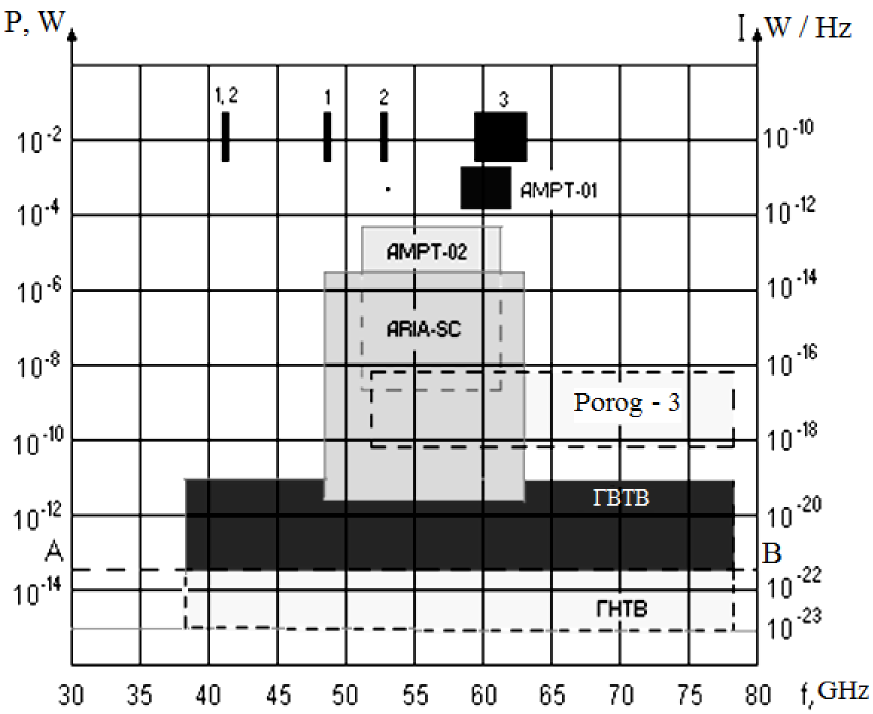
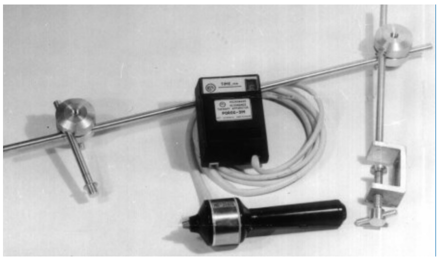


Fig. 1. Distribution of power and frequency range of devices microwave resonance therapy:
1 – "Yav-1", 2 – "Alenushka", (Ukraine), 3 –"Electronics-UHF", (Ukraine); ГНТВ – “Porog-NT” (Ukraine), ГВТВ – “Porog-VT” (Ukraine); the line AB – power level natural human radiation



“Porog-VT” Patent of Ukraine №265
(Bulletin №2 from 25.07.1994)

“Porog-NT” Patent of Ukraine №53743
(Bulletin №2 from 7.02.2003)

Fig. 2. Noise generators with low-intensive output signals, positive flow “PorogVT” and negative flow “PorogNT”

2. Metrologic apparatus software and technologies of low-intensive microwave therapy

One of the problems to be solved in quantum medicine technologies are providing metrology and inspection of the equipment attribution during its operation.

It should be noted that the lack of standard tools for measuring such small capacities does not allow to provide metrological support the equipment for quantum medicine and for biomedical research in the millimeter wavelength range [1].

Radiation of the ultra-low levels is monochromatic so noise signals are used in the new microwave technologies. The minimum values of integral power of monochromatic signals can be 10^{-10}-10^{-12}Wt (eg, ,ARIA-SC, AMPT-02), and the power spectral density of the noise signal is 10^{-16}-10^{-21}Wt/Gz (“Поріг-3”, “ПорогВТ”, “ПорогНТ”, “ Коверт-01” (“Porig (Threshold) 3”, “Porog-VT” , “Porog-NT” “Covert-01”). To measure such power levels it is necessary to radiometric sensitivity setting was at least an order of magnitude higher, and the measurement accuracy is not worse than the standard equipment of the same long-range power, ie 10-15% [5,8].

To solve this problem have been developed and certified by Standards Committee of Ukraine two highly sensitive radiometric systems (RMS) with a modulation transportation of the signal and sensitivity 0,5 • 10^{-22} W / Hz in frequency bands 37-53 GHz and 53-78 GHz, which provided Metrology maintenance and measurement of specialized medical mm range equipment in Ukraine [1.9].

3. Technologies of therapy with low-intensive microwave signals. Peculiarities and appliance fields of millimeter therapy

The use of mm-range signals in the practical medicine stimulated the emergence of several types of medical technologies that practically used [1]. Classification of the main technological directions of mm-range signals treatment is shown in Fig. 3.

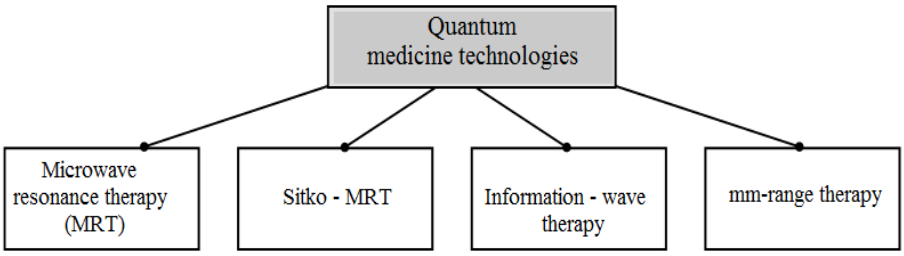


Fig. 3. Classification of main technologies of quantum – medicine

Despite the different names, these technologies have in common is that their use of millimeter wave signals using low intensity level reaches 10^{-20}-10^{-21} W / Hz cm^2 [5].

The most common among these technology areas is microwave resonance therapy (MRT), which by order of the Ministry of Health of Ukraine № 136 from 06.22.1989, is officially recommended for implementation in the hospitals of the country in separate MRT-cabinets [2]. The use of MRT is characterized by a general positive impact on the functional systems of the human body, and therefore used in various areas of practical medicine fig. 4 [6].

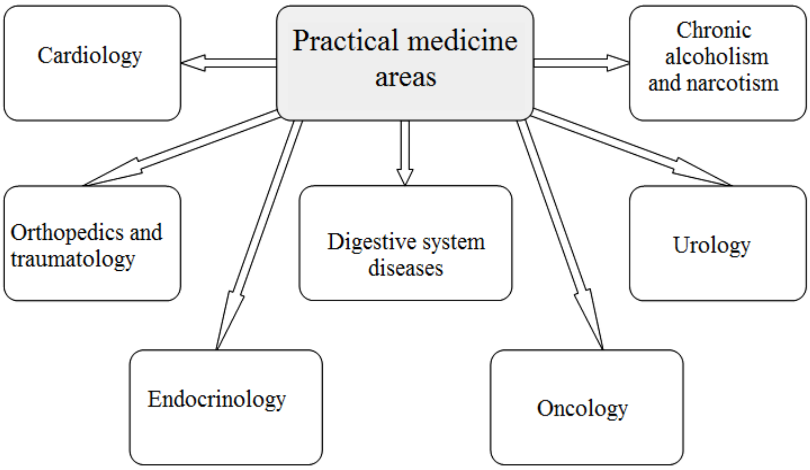


Fig. 4. Applications areas of Quantum Medicine

The most practical checking of the effectiveness of MRT was conducted in such areas of the medical practice: orthopedics and traumatology, gastroenterology, hematology, oncology. Promising is the use of MRI in cardiology in acute coronary disease - heart attacks, strokes and other diseases of the cardiovascular system. The experience of the Ambulance and infarction branch Department of the National Medical Academy for Advanced Training on over 100 patients in which MRT was used, along with the use of pharmacological agents significantly improves patient's state: decreases blood pressure, decreases tachycardia, stroke and minute cardiac output, as peripheral vascular resistance normalizes [6]. The use of MRT dramatically increases the effectiveness of pharmaceuticals.

The use of MRT in endocrinology at stages I-II of diabetes mellitus and insulin-independent diabetes with manifestations of diabetic macro-and micro angiopathies, polyneuropathy normalizes hemodynamic parameters in the lower extremities, increased pulse blood current, improves the conduction of nerve impulses in peripheral nerves.

MRT is effective in treatment of pain and paraesthetic syndromes in Dentistry. We have experience of good effect of MRT using in treatment of glossodynia (burning mouth syndrome) and in neuropathy of inferior alveolar nerve.

In addition, MRT gives a therapeutic effect without the deductive use of drugs, which reduces the load side and a negative impact on the patient of pharmatheutical therapy. The method can be widely used in the hospital and in the outpatient treatment of diabetes. The course of treatment is 10-15 sessions duration of 30-50 minutes of MRT.

MRT provides high efficiency in the treatment of stomach ulcers, enshrined on clinical examination in more than 6000 patients [6]. The results of MRT show favorably high therapeutic effect - complete healing of gastric ulcers by gastroduodenoscopy observed in 80-85% of patients.

The process of treatment (10-15 sessions) accompanied by relief of pain syndromes, the normalization of the secretory and motor functions of the stomach, decreasing the concentration of hydrochloric acid and the volume of gastric juice. Concentration of the adrenaline and cortisol in the blood decreases, and levels of prolactin and aldosterone increases, which ensures normalization of fluid and electrolyte metabolism.

Promising is the use of MRI technology and Sitko-MRT in the treatment of cancer patients in stage III-IV, who received standard treatment [2, 6]. If the cancer disease is characterized by significant pain, which is facilitated by the use or docked pharmaceuticals containing narcotic substances with following violations. The use of MRT allows decrease the dose of narcotic medicines.

Quantum medicine technologies can be a good alternative to pharmacological methods of pain relief, with a significant improvement in the "quality" of life. The example of more than 40 cancer patients in stage III-IV who received standard treatment and were treated at the Center of quantum medicine "Відгук" ("Feedback") [2, 6] shows that Sitko-MRT provides quick anesthetic effect, even for a few minutes, common state of patients improves; after treatment with MRT course of 10–20 sessions 85% of cancer patients report decrease of pain during 10 and more days [2]. After using of MRT immune-modulating effect was received: the amount and subpopulation correlation of immunocompetent cells normalized, their functional activity increased. In fact, MRT technologies effectiveness does not yield to traditional medicinal preparations (Figure 5)

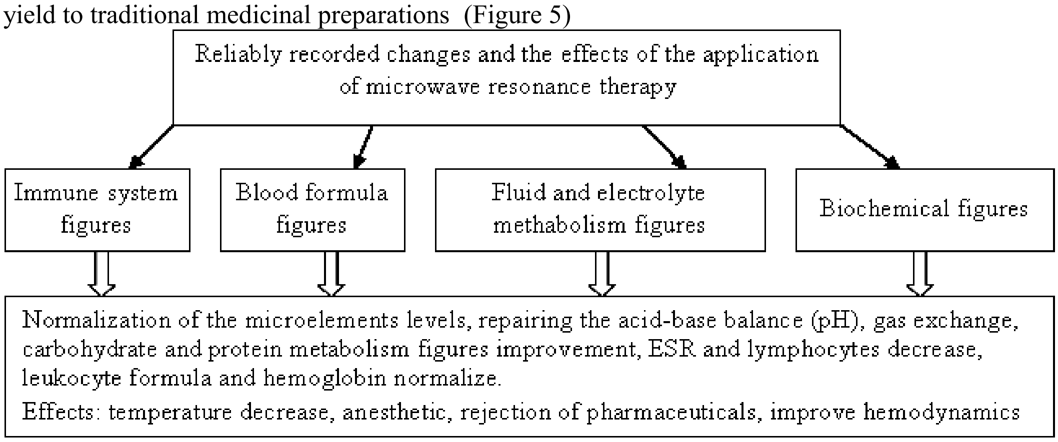


Fig. 5. Effects of Quantum Medicine

At the last time diseases of bronchopulmonary system become widespread. MRT can be a good assistant in the treatment of nonspecific lung diseases with bronchial obstructive syndrome because bronchodilator medicines usage in great quantity can lead complications. MRT technologies allow receive positive effect without complications in acute and chronic bronchitis, pneumonia, asthma, in breath insufficiency I-II stages. In these cases use of MRT improve health in more than 80% patients simultaneously to abolition of pharmaceutical medicines.

The results of the use of MRI in some diseases listed in the table. 2 [7].

Table 2

The results of treatment by microwave resonance therapy

Diseases	Improvement (%)	Recovery (%)
Alcoholism	90	40
Aseptic necrosis of the femoral head	98	60
Bronchial asthma	85	60
Bronchial obstructive syndromes	90	82
Vegetative and vascular dystonia	85	70
Gastritis, gastroduodenitis	95	89
Kids cerebral palsy	100	60
Osteochondrosis	94	70
Polyarthritis	80	67
Diabetes	80	63
Sores	92	68
Ulcer of stomach and duodenum	98	90
Other pathologies	60-95	35-90

It proved that the use of the MRT is quite promising in the treatment of a wide range of diseases and helpful in most of them.

Microwave therapy is widely used in various fields of practical medicine as a separate type of treatment, or in combination with other methods of influence on the patient.

Medical apparatus for microwave therapy is characterized by low output power (10^{-6}-10^{-13} Wt) and use mostly 37,5-78,3 GHz frequency range and is sufficiently safe for both the patient and for staff.

Further development of the considered therapeutic areas is possible through the creation of a new generation of equipment that would provide feedback to the patient and self-adjusting output parameters, as well as mastery of higher frequency millimeter range waves.

4. Scientific directions of low-intensity electromagnetic fields and radiation of millimeter range researches

Thus, the development and deepening of biomedical researches and technologies require the creation of highly sensitive radiometric equipment using new achievements of microwave technologies and element base and exploring possible directions for its use.

Promising is the use of radiometric instrumentation for early diagnosis of diseases associated with the presence thermal irregularities in humans, as well as for the study of electromagnetic fields and radiation (EMR) of the biological objects and of the human body characterizing the exchange of information both within the living organism and with the external environment.

Early diagnosis and measurement of thermal irregularities within the human body (at the (50-80) mm of depth) is possible with the radiometer operating at low frequencies, (0.9-1.5) GHz, and the sensitivity of such equipment should be at the level of (10^{-15} - 10^{-16}) Wt.

The research of natural electromagnetic fields and radiation and their interaction with the environment also requires the development of radiometric equipment with the sensitivity of the order of (10^{-14} -10^{-16}) Wt, depending on the range of operating frequencies.

Given the above, a classification of medical and biological problems that can be solved with the use of microwave radiometry equipment was developed Fig. 6.

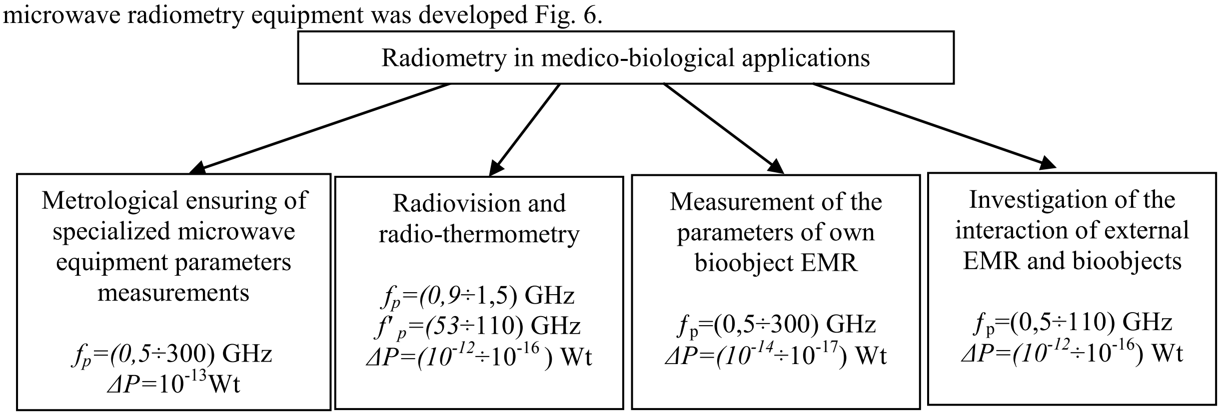


Fig. 6. Classification of radiometric problems in the medical and biological applications

Analysis of the Figure 1 data shows that, depending on the task of the biomedical applications, operating frequency range of radiometric equipment can vary from a few to hundreds of gigahertz, and the sensitivity – from 10^{-13} to 10^{-17}Watts.

Implementation of structural schemes of radiometric equipment such sensitivity is usually performed using the compensation, correlation or modulation method of transformation of input signals [5, 8].

Promising direction to use the microwave radiometric equipment is studying the parameters of own electromagnetic radiation (EMR) of living organisms.

Figure 7 shows the classification of the possible parameters of bio object own EMR, measurement of which can be performed using radiometric equipment (Figure 7).

For reliable signal recording the sensitivity of such circuits, operating on the difference signals, should be at the level (10^{-15} -10^{-16}) Wt.

Another area to use radiometric equipment when examining biological objects own EMR is to measure the correlation characteristics of the radiation

Radiothermal radiation, which is formed in equilibrium processes has a noise character, and its intensity is proportional to the temperature of the object *T*. Bioinformatic (non-thermal) radiation at the cellular level, which is determined by the non-equilibrium processes and provides synchronization of the body is deterministic. Due to the small size of the cell the energy density EMR already at a short distance from the biological object is reduced in many times, besides this reduction is accompanied by stochastization of the radiation. The total radiation of a living organism can be represented as a superposition of a deterministic and noise signal

$$U_\Sigma (t) = U_\omega (t) + U_T (t) \tag{1}$$

Registration of the deterministic weak signal $U_\omega (t)$ against a background of strong noise signal $U_T (t)$ is a difficult technical problem, the solution of which is possible only with the use of specialized highly sensitive radiometric system that measures the autocorrelation function.

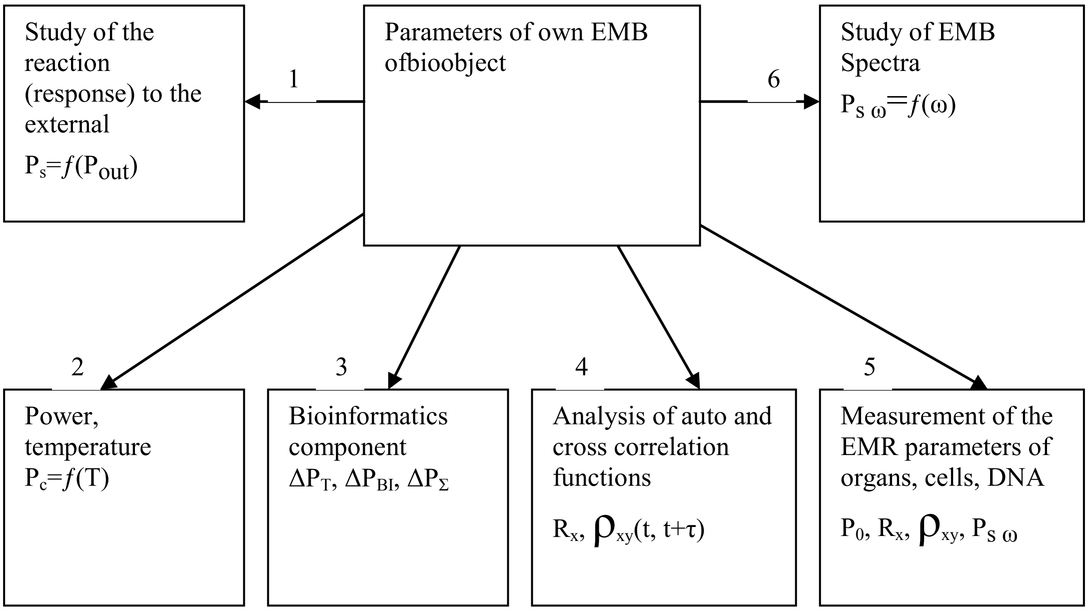


Fig. 7. Classification of measuring tasks in the study of the bioobject own EMR

Register autocorrelation function opens the possibility of identifying deterministic processes that can be masked by noise and thus to identify the source of bioinformatic radiation of the living organism.

An important parameter may be the cross-correlation characteristics of the two signals, providing registration of distribution (location) of the deterministic signal on those or other bio object areas.

Measurement of inter-correlation function allows exploring the gradients of temperature fields in the presence of selected sources in the bio object body (local thermal irregularities). Sensitivity of such RMS must be on the level of (10^{-16} - 10^{-17}) Watts.

Temperature anomalies in alive organism arising from tumors, trauma, inflammation, etc. strongly influenced the frequency features of EMR. Localization of the thermal irregularities sources may be at different depths from the body surface. Emission wavelength varies depending on the depth of its occurrence. Therefore, recording the frequency dependences of the intensity of EMR can detect and localize thermal irregularities sources in the human body.

Shape of the curve in the coordinates of frequency-voltage $U = f(\omega)$ provides information on the nature of the thermal irregularities and temperature gradient inside the object. Intensity on the frequency coordinate allows determining the depth of the source of thermal radiation.

One example of the use high-sensitive radiometric system is conducted by the authors [10, 11] studies the electromagnetic characteristics of dental materials, in order to determine the parameter which would provide a more accurate identification (compatibility, matching) with the natural tooth material.

These dental materials were studied: Sample № 1 – based on resorcin-formalin mix material «Foredent» (SPOFA, Slovenia), sample № 2 – glass-ionomer cement Endion (VOCO, Germany), sample № 3 – Zinc-oxide-eugenol material «Endomethazone» (Septodont, France), sample № 4 – polymer cement AH Plus (Dentsply, USA), sample № 5 – light-cured composite «Spectrum» (Dentsply, USA) (shade A3,5), sample № 6 – self-cured composite «Compolux» (Septodont, France), sample № 7 – стеклоиономерный цемент «Cavitan – plus» (SPOFA, Slovenia); sample № 8 – natural tooth material (enamel), № 9 – natural tooth material (dentine), № 10 – porous osseous tissue (cross section).

Samples № 1–4 represent materials used for root canals sealing, thus received in study data were compared to the similar data for dentine (sample № 9), which they contact with. Samples of materials № 5–7 use for tooth surfaces restorations so their properties were compared with dental enamel (sample № 8), too.

During the experiment, the intensity of each material radiation was tested at a temperature of 37^0C, the level of which was recorded by approved measuring setting НУ-2 with sensitivity of $1{\cdot}10^{-14}$ W at a frequency of 52 GHz.

According to the conducted measurements, the radiation power of the considered number of dental materials was concentrated in the range of (1,8-3,1)•10^{-13} W/cm^2. Identification was carried out by comparing the greyness coefficient of materials, which is calculated according to the formula

$$\beta = I_T / I_{АЧТ} \qquad (2)$$

where I_T – measured power of the studied material,

$I_{АЧТ}$ – the intensity of blackbody radiation at the same temperature, calculated by the formula Rayleigh-Jeans

$$I_{АЧТ} = \beta\left(f/c\right)^2 kT \tag{3}$$

where k – Boltzmann constant, T –temperature, β –physical body greyness ratio, f – radiation frequency, c – speed of light.

The results of the measurement and the calculation of the greyness coefficient of the material are presented in the on Fig. 8.

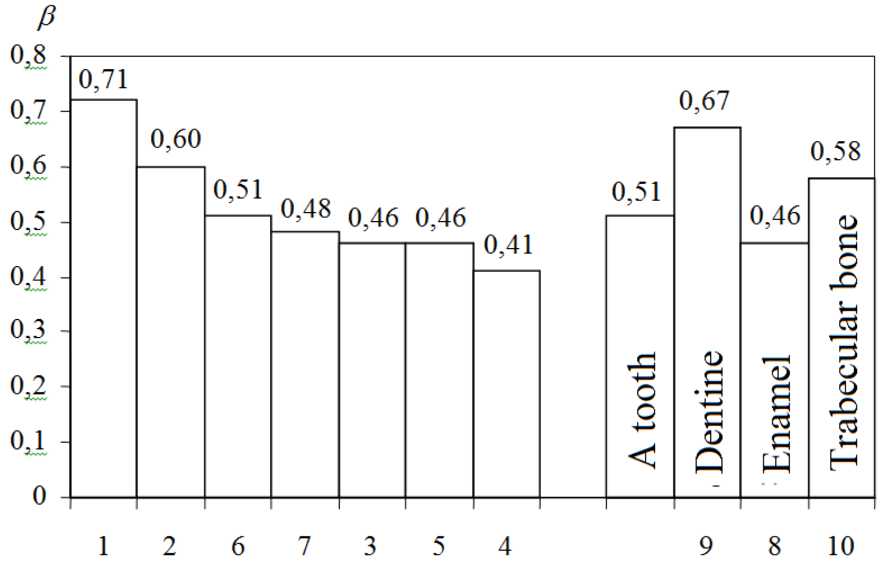


Fig. 8. The factor β of dental materials samples № 1–10

Identification of the grayness coefficient values gives deviation 38.0% of the materials paired № 4 and 9, and 7.6% in the pair № 1 and 9 used in root canals sealing, and from 0% in the materials paired № 5 and 8 to 10.8% in a pair № 6 and 8 – in the materials are used to filling the tooth surface.

Therefore, the preference should be given to matching materials. In addition, such verification is promising in the development of new dental materials.

Conducted studies allow to make some conclusions:

1. Alive organisms are characterized by large set of parameters of their own microwave EMR; its measurement and study contributes not only to deepen the knowledge of living objects, but also the development of new diagnostic and treatment methods.

2. Radiometric methods and tools have great potential for solving of practical and research problems in biology and medicine - metrological provision of specialized equipment, diagnosis of the state of alive organism, the study of the own microwave EMR parameters and their relationship with the environment.

3. Radiometry use in biomedical applications due to the need for fluctuation sensitivity to the level (10^{-15}-10^{-17}) Wt, which is a complicated technical task requiring its decision to create new options for highly sensitive radiometric equipment.

4. The proposed technical solutions, while providing the required sensitivity, extend the functionality of radiometric equipment, in relation to the objects of wildlife and humans.

5. Natural sources of the mm-range irradiation and using peculiarities in physiotherapy

Using low- intensive signals of the mm-range is effective enough in many areas of practical medicine - orthopedics, neurology, endocrinology pulmonology and other branches and technologies of physiotherapy. At the same time, along with specialized medical equipment, the materials and objects of natural origin are widely used in different technologies of the physiotherapy. First of all, these materials include primarily mineral wax, mud, paraffin, salt and a wide range of minerals used in lithotherapy [12].

The study of electromagnetic microwave fields and irradiations (EMR) of the minerals conducted by authors [5, 13, 14] confirmed the presence in the spectrum signal components of the millimeter range, which can be used as a therapeutic component when minerals are heated to therapeutically acceptable temperatures (40-50) ^{0}C. In the course of the studies were selected minerals with high emissivity which include jade, agate, onyx. When the

human body temperature is 36 ^{0}C the radiation level of these minerals is greater than the level of human body emission that promotes positive flow of EMR. Also were found minerals that at this temperature have less radiation level, thus in this case negative flow of EMR forms.

For the first time negative flows of the mm-range waves were recorded and studied by group of authors [15].

Considering these features authors [16] proposed a heat generator with reversible temperature control and appropriate formation of various streams EMR. Effective enough action of the negative flows confirm laboratory and clinical researches conducted at the R.E. Kavetsky Institute of Oncology (NAS of Ukraine) and Research Center of Quantum Medicine (Ministry of Health of Ukraine), as reflected in treatment technology, approved with patent [16]. In vitro studies show the inhibition (for 27.4%) of model "Sarcomas C-37" in laboratory animals when they were irradiated with negative flows. The positive flow accelerates (for 13,5%) tumor growth.

The effectiveness of natural materials using for Physiotherapy is explained mainly by heat and warming the respective areas of the patient's body. They don't take into account that during heating these materials emit a wide range of radio-frequency signals [5, 13, 14]. The therapeutic total effect will consist of thermal and microwave components, and therefore more in-depth study of the structure of natural materials signals for Physiotherapy is an urgent task.

1.5.1 Research EMR natural treatment formula for physio procedures

To study EMR properties of the natural mixed materials were chosen commonly used for the Physiotherapy materials - ozokerite (Borislav deposit, Lviv region.), mud (Mykulyntsi, Ternopil region.) crystalline salt (Artemivsk) and paraffin as a component of therapeutic compounds [14].

Emissivity of the slice of wood (ash) and a fragment of bone were also examined for comparison records. Ozokerite has a high heat capacity and low thermal conductivity with the possible temperature to use in thermal applications 40-50^0 C. It includes paraffin, ceresin, as well as in the composition of the curative mud - biologically active substances. As a result of measuring in the frequency $f = 45 ГГц$ the following values of the irradiation samples were obtained. They are presented in Table 3.

Table 3

EMR properties of the natural mixed materials

Studied sample	The value of power (W / s^2)	*β*
Ozokerite(pure)	$1,8 \cdot 10^{-13}$	0,1
Themud (pure)	$1,6 \cdot 10^{-13}$	0,08
Paraffin (pure)	$1,05 \cdot 10^{-14}$	0,05
Paraffin+ mud (used)	$0,5 \cdot 10^{-13}$	0,02
Wood	$6 \cdot 10^{-13}$	0,3
Salt	$2,2 \cdot 10^{-13}$	0,11
Manhand ($t_т$=31^{0}C)	$4 \cdot 10^{-13}$	0,21
Bone	$6,8 \cdot 10^{-13}$	0,35

The process of measuring the values of irradiation power was conducted using certified radiometric system with sensitivity [redacted], which makes it possible to confidently talk about the accuracy and reliability of the results.

Table 3 shows that the radiation level of the areas of the palm of the person, even at a temperature (31^{0}C), significantly lower than the temperature of the heated material (40^{0}C), is greater in 2 times compared to pure wax and in 4 times in relation to the treatment mix mud and paraffin.

Analysis of the results shows that along with warming ozokerite and mud applications (creation of positive flows) a microwave component is formed which creates "negative flow" in relation to the patient's body that can reduce pain syndromes with excess temperature. Paraffin, which added to the ozokerite and mud in the preparation of therapeutic mixture to stabilize it, reduces the emissivity of the mixture in the microwave range, the value of which depends on the percentage of components. This ratio can adjust the "negative" flow, adding to the mixture a higher percentage of paraffin, and therefore the effectiveness of pain syndromes treatment increases. The same ability has salt and solutions based on it (salt applications, baths, etc.), in opposite to wood and bone that have a higher level of radiation than the human body and form towards it EMR positive flows.

The dynamics of change of the material proper EMR when it cooled from the maximum heating temperature used during the procedure (50^0 C) to body temperature (controlled palm point) was also investigated. The graph showing the integrated power change is presented in Fig.9.

The level of the human body emission for the temperature control points 31^{0}C, 40^{0}C and 50^{0}C was calculated using the Nyquist formula

$$P = kT\Delta f\ , \qquad (4)$$

where Δf = 10^8 Hz – analysis band of highly sensitive radiometric system.

For point 31^{0}C the calculated value is 4.18 10^{-13} W/cm^2 which is different from the measured less than for 5 percent, which is suitable for microwave measurements and verifies measurements certainty well. The human body radiation levels were calculated for temperature 40^{0}C and 50^{0}C similarly.

From the studies of the EMR of medical materials using for physio procedures the following conclusions may be done:

1. Effective use of natural materials in the thermal physiotherapy should be associated not only with the presence of infrared components, but as studies have shown with the presence of microwave component, which has a significant impact on treatment outcome.

2. Microwave EMR of the studied therapeutic materials has negative flow in relation to the human body, which creates the effect of "selection" of energy at local inflammatory processes.

3. Using a material with low radiating ability (paraffin) mixed with the main component (ozokerite or mud) can not only stabilize the therapeutic mix, but also adjust the power of the negative flow.

4. It should be noted also that human bones have higher levels of microwave radiation component, compared with soft tissue and are a kind of microwave generators that stimulate the cells of our body.

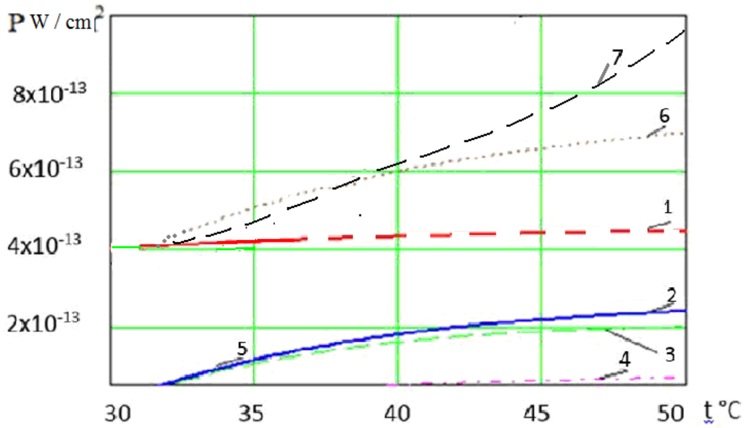


Fig. 9. The graph of the integrated power changes:
1 – human body; 2 – ozocerite mix; 3 – mud with added paraffine;
4 – paraffine; 5 – mud (pure); 6 – wood; 7 – bone

1.5.2 Research EMR minerals and precious stones

In folk medicine for the treatment of certain diseases different gems and minerals are using, too.

The research results presented in [5] confirm the difference of the electromagnetic activity of gems and minerals from other bodies creating in this way the possibility of their use for medical purposes. Measuring the level of EMR of the gems and minerals was performed at the frequency of 60 GHz and the temperature of 37°C, which corresponds to the upper boundary of the normal human body temperature.

Fig. 10 shows the intensity distribution of various minerals (Figure 10).

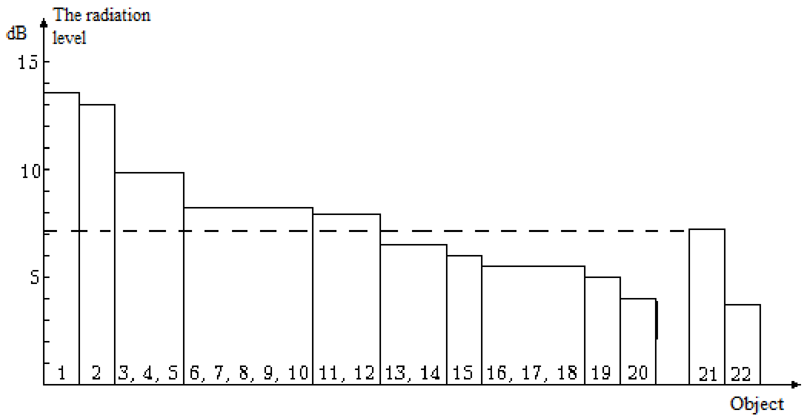


Fig. 10. Emittance distribution of minerals and other materials

The radiation level of minerals is given in columns diagram. Minerals were assigned to the following digital indexing: jade – 1, onyx – 2, agate – 3, coquina (shell rock) – 4, big femoral bone – 5, amethyst – 6, amber – 7, jasper – 8, pyrite – 9, small bones – 10, quartz (single crystal) – 11, chalk – 12, sulfur – 13, fluorite – 14, flint – 15, amazonite – 16, rhinestone – 17, calcite (feldspar) – 18, topaz – 19, morion (quartz) – 20. Under number 21 denotes the level of human palm radiation and column under number 22 characterizes the position of the electromagnetic properties of the water at a temperature of 37°C.

The listed minerals can be divided into two groups according to their microwave EMR levels – greater or less than proper human body EMR at the normal temperature (36-37°C). It reflected on the Fig.10 with a dotted line. Minerals with a larger radiation are jade, onyx, agate, amethyst, amber, jasper. In the thermal contact with a human body these minerals generate a microwave signal, which is redundant to human skin, and it is completely absorbed. Thus, these minerals provide “recharging” the energy in the case of continuous wear them on the human body.

The second group of objects contains minerals such as sulfur, fluorite, silicon, amazonite, rock crystal, calcite, topaz, morion. When these minerals are heated to the body temperature the radiation level is below the person's own radiation and they provide the absorption of the human microwave energy in thermal contact with the human body. In some minerals, such as chalk and a single crystal of quartz, almost the same with the person’s level of radiation was recorded, so they are balanced (neutral) in electromagnetic respect.

It should be noted also that the electromagnetic activity of “big” and “small” human bones is significantly higher than radiation intensity of the skin, as well as water as a main component of a living organism. A similar situation is with coquina (shell rock), which is mineral residue of biological objects - its EMR intensity is also higher than the body, especially the human palm. At the same time the structure of coquina and of the bone is different. If seashells are formed by deposition of calcium flat layers, some human bones have pipe shape. This provides the effect of some kind of resonance. The presence of calcium in the bones and coquina, despite structural difference, provides a high level of EMR. The positive effect of calcium on the radio- and thermal activity is also confirmed by the analysis of the chemical composition of minerals - jade and onyx, in which fixed the maximum intensity of the radiation and which contain a significant percentage of calcium.

Thus, living beings bones provide significantly greater level of radiation compared with surrounding soft tissues, obviously performing the function of thermal generators of the mm-range microwaves and play an important role in the external electromagnetic fields (EMF) influence on living organism.

Based on the results of experimental radiometric studies of physical bodies in mm-wave band it can be stated that in the simulated temperature gradients that actually occur in the natural environment, electromagnetic fields and radiation of mm-radiation are generated. The sources of these emissions are the various physical bodies and the environment (water, soil, stones). Similar EMFs are formed around human and living beings.

As can be seen from Fig.10, nephritis has significantly higher levels of radiation (13.5 dB) than human skin (7 dB), and quartz (morion) EMR level is slightly below the water data. A possible cause of increased level of radiation in the past three objects is the presence calcium salts in the human bones, shell rock and nephritis (for example, in bones - calcium phosphate $Ca_3(PO4)_2$). It is known that Ca atoms are responsive actively to thermal impacts. The mean square displacement of Ca atoms during thermal oscillations is equal to 0.114 $\mathring{A}$ [17]. By the reaction on thermal influence Ca takes place among such active elements as Li, Na, K, Rb and Cs, some of which (K, Na, Ca) are commonly used in biological objects during their life support. Obviously the raising of the radiation levels of the considered elements (bones, jade and shell rock) is associated with an increased rate of theirs greyness coefficient ■. Human bones are the kind of generator and a waveguide of the microwave oscillations and provide irradiation and transmitting the electromagnetic waves inside a biological object, in contrast to the human skin, which absorbs low-intensity mm range signals.

Considered the listed above, the reaction of the human body on the external low intensity microwave radiation was studied.

Figure 11 is a diagram showing the distribution of relative absorbance ability of the biological object K_{Π} according to the irradiating signal I_C level and the level of the object own radiation I_0' at a resonant frequency

$$K_{\Pi} = 10\,lg\frac{I_C}{I_0}\text{, dB} \qquad (5)$$

where $I_0 = I_0' + I_0''$, and I_0' – the level of the object own radiation and I_0'' – the level of the reflected signal.

Considering meaning I_o equation (4) can be written as

$$K_{\Pi} = 10\,lg\frac{I_C}{I_0' + I_0''}\text{, dB.} \qquad (6)$$

Increasing capacity of the irradiating generators within $1\cdot10^{-21} < I_C < 1\cdot10^{-19}$ W/Hz at selected frequencies leads to full absorption of the acting signal (AB portion of Fig. 11).

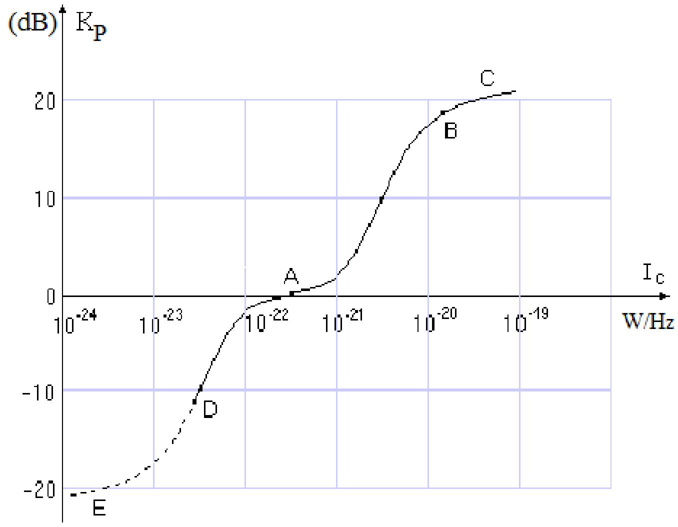


Fig. 11. Distribution of the human palm absorbance ability in contact with the positive and negative EMR flows

At further increase in capacity $I_C > 1\cdot10^{-20}$ W/Hz the reflected signal appears, which characterizes the saturation effect of the treated area (BC in Fig. 11) of the skin. In this case, the reflection component I_0'' increases, and the resulting bioobject radiation I_0 is relatively increased with the coefficient K_Π decreasing (Fig. 11).

Physical reduction of absorption, in our opinion, is connected to the saturation of the upper energy levels of biomolecules and the lack of free carriers that can absorb EMR photons. A further increase in the irradiation power (up to the appearance of thermal effects) favors a slight increase in absorption. Thus, living beings show the dosage ability to absorb mm-band EMR [5].

Note that the slope of increase of the reflected power exceeds the rising slope of the irradiation power. As a result the saturation occurs with the characteristics curvature on the section BC (Fig. 11). Based on the experimental data [5] and the distribution illustrated in Figure 11, it can be concluded that the dynamic range of the bio object absorptive capacity in levels that exceed its own level of radiation, is 15-20 dB. By the way, about the same level of microwave radiation has a wormwood cigarette, which is used in Chinese moxibustion. Levels of capacity placed on the intensities axis at the right of the point A, create a positive flow of EMR comparing to own biological object radiation, and placed on the left - negative flow [5, 15].

In studies [6, 7] the results of experiments on the effects of positive flows of EMR, which are used for the construction of the ABC distribution area (Fig. 11) are listed. Experimental verification of the negative EMR flows impact was carried with power levels about 10-15 dB lower than the power level of self-radiation (AD site). A further power reduction of the negative flows source (generator), and experimental verification of distribution represent a significant technical challenge that requires further additional research.

At the same time, as shown by laboratory and clinical studies [16] medical devices on the negative flows are very effective method for use in a variety diseases with the manifestation of "syndrome of excess", especially with pain syndromes - dystrophic lesions of the joints and spine: arthrosis, arthritis, osteochondrosis. Positive changes in patients with bronchial asthma and chronic obstructive bronchitis, in some number of cancer patients were noted also. From the above we can conclude:

1. Using a RMS to assess the objects absorbance abilities allow significantly reduce the levels of irradiating signals that reliably analyzed and are $1\cdot10^{-12}$-$1\cdot10^{-14}$ W/Hz for monochromatic and $1\cdot10^{-20}$- $1\cdot10^{-22}$ W/Hz for noise signals.

2. The absorbance and reflection abilities of living organisms has a pronounced non-linearity with respect to the level of exposure.

3. Analysis of experimental data of the biological objects absorbance ability shows that the human body responds to the signal level, which differs in 2-5 times from its own radiation.

4. Substantial (in 10-100 times) increase in intensity leads to reflection of the illuminating signal power which indicates the protective properties of living organisms.

1.5.3 The study of electromagnetic parameters of textile and leather for clothes and shoes manufacturing.

Measurement of weak EMF via RMS opens up the possibility of studying the interaction of human own field with textile and leather materials which are used for clothing and footwear manufacturing[5].

Methodology of the experiment: the studied materials were heated in an oven at a temperature of 36.0 ± 0.5°C, which corresponds to the average human body temperature at the comfortable climatic conditions, and then their radiation was measured. Evaluation of the emissivity was carried out using the RMS at a frequency of 52 GHz. The results of experimental research textile materials are shown in Fig. 12).

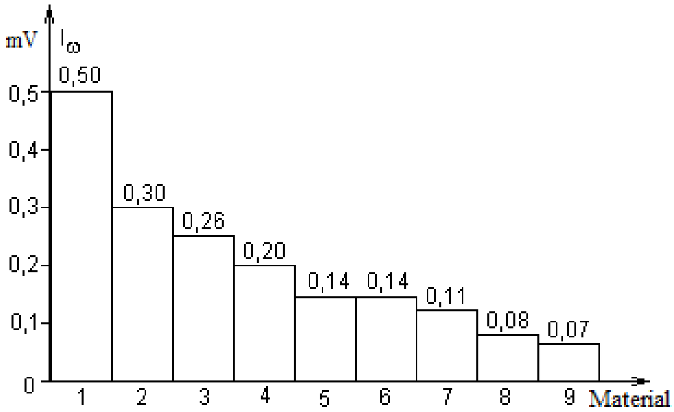


Fig. 12. Distribution emissivity of textile materials for clothes:
2 – nutriafur, 3 – foxfur, 4 – linen, 5 – sheepskin, 6 – cotton, 7 - glsin (35% polyester, 65% cotton), 8 – glzel (65% polyester, 35% cotton), 9 – 100% polyester; the column 1 – show the mean data of the human body irradiation.

Because of the intensity distribution (Iω), it is clear that natural materials (fur, cotton, linen) are closest to the emissivity of the human body. Synthetic or mixed materials have significantly lower emissivity and, in fact, are the source of electromagnetic negative flow, leading to increased energy extraction from the human body surface. At the same time, natural fibers help maintain the body temperature, and are more compatible with the human microwave field; they weakened it less.

Separate studies were carried out to assess irradiative abilities of the leather. During experimental studies of leather samples checked: the proper microwave irradiation at 36^0C and radio transparency by two figures - delay and bypass of the probing signal, which are difficult to define in the technological cycle of leather.

Heating the leather sample to the temperature of the human body, as seen from the formula (3), lead to the formation of extremely low signal with intensity within 10^{-13} Watts. To register this signal RMS with a sensitivity of 10^{-14} Watts was used. The measurement results are shown in Figure 13.

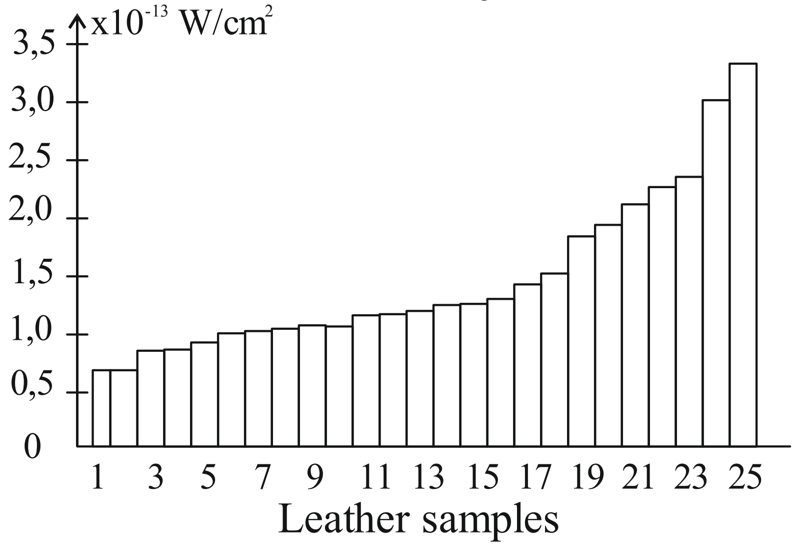


Fig. 13. Distribution of own radiation of skin samples

Name of the leather samples: 1 – goby; 2 – as; 3 – shark; 4 – crocodile; 5 – goats glazed kid leather (black); 6 – sheep (brown); 7 – pig leather; 8 – pork leather; 9 – goats; 10 – sheep chevron; 11 – white sheepskin; 12 – half-sheepskin; 13 – black sheepskin; 14 – blue shark; 15– goats glazed kid leather (brown); 16 – sheepskin (gray); 17–

bull; 18– "fish" dressed pork leather; 19 – bull; 20 – OPOEK elastic; 21– bullok; 22– horse leather; 23– vymitka; 24 – Elastic grown-up; 25 – Elastic lot.

There are follow groups of leather samples for theirs proper irradiation: with low intensity at the level $0.5 \cdot 10^{-13}$ W/cm^2 (samples 1–4); with intensity about $1 \cdot 10^{-13}$ W/cm^2 (samples 5–16); samples with emissivity banding 1.5-2.5 W/cm^2 (17–23); and samples of leather with elastic dressing which have radiation intensity more than $3 \cdot 10^{-13}$ W/cm^2 (samples 24, 25).

Considering the compatibility of the leather samples with the human body skin, which has the radiation level about $3.5 \cdot 10^{-13}$ W/cm^2, materials with higher level of irradiation have the benefits.

Measuring procedure of the radio transparency (Fig.14) was performed as follows. At the beginning signal from the approved reference oscillator of low intensity noise G (10^{-12} - 10^{-13} W/cm^2) by transmitting X_1 and X_2 receiving antenna was directly measured by RMS) (Figure 14).

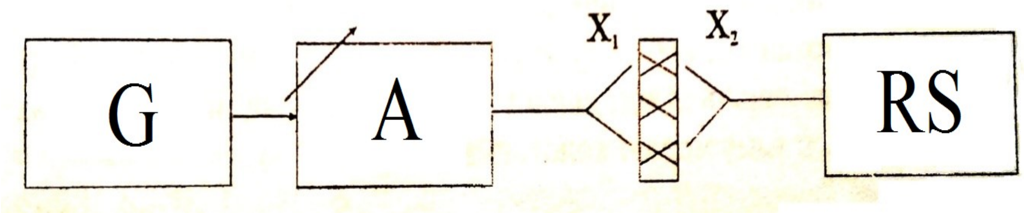


Fig. 14. Scheme to study radio transparency of leather samples

Then the leather sample was placed between antennas and power that passes through it was measured – P_{in}.

Power that delay or reflect by the leather sample determined with ratio

[redacted], (7)

where P_{out} – power on the output of the transmitting antenna X1, $P_{in.}$ –power on the inlet of the receiving antenna X2.

For skin thickness in the range of 0.1 to 3 mm the absorption and radio transparency is almost at the same level, despite the low level of the probe signal ($1 \cdot 10^{-13}$ W / cm^2). Dispersion of the figures of absorption and radio transparency does not exceed 15%.

Thus, the study of microwave properties of leather samples for light industry showed the possibility to evaluate some of its parameters with radiometric control method. It's enough to assess its suitability for quality manufacturing a particular type of footwear and clothing for the population.

In addition, the devices of high sensitivity are necessary to measure the thickness and density of the leather, its moisture and the presence of hidden defects.

6. Future areas of research intensive low signals in biology and medicine

Creating radiometric systems with sensitivity of 10^{-13} to 10^{-17} Watts enhances the research of weak fields and radiation from alive and inanimate objects. The main directions of promising scientific research using highly sensitive radiometric systems are:

- study the dynamics of natural radiation the human body during his life;
- evaluation of correlations between the various parameters of the human body;
- study the electromagnetic properties of water and aqueous solutions as key components of the human body;
- measuring proper electromagnetic radiation of bio objects, materials and substances that come into contact or are close to human and can affect it.

Application problems that can be solved by using highly sensitive RMS include:

- measuring the level of radiation of bone and tooth tissue and it substitutes for the identification and assessment of electromagnetic compatibility with the human body;
- assessing the compatibility of textiles with the human body and their comfort considering electromagnetic properties;
- measuring the emissivity of precious minerals and stones so as products with them;
- assessing the possibility of the registration of impurities in dielectric materials for their emissivity;
- carry out the flaw of dielectric materials and establishing correlation between radiation and the presence of defects (cracks, irregularities included).

During radiometric studies a number of features associated with the body and properties of some materials were revealed:

- the proper radiation of the human body is within $1 \cdot 10^{-21}$ - $1 \cdot 10^{-22}$ W/Hz см^2 ;
- the level of radiation an individual organism is constant, which is determined by the intensity of its cell metabolism and skin temperature. In fact, this level describes "electromagnetic homeostasis" of the living organism that is disturbed in diseases, stress conditions, which can be used as diagnostic sign;

- the correlation coefficient between the level of radiation and temperature of the body part is situated in the limits 0,85-0,87;

- registered experimentally sensitivity of the human body to external EMR ~ $1 \cdot 10^{-20}$ W/Hz. About this level of radiation has wormwood cigarette (moxa) used in Chinese medicine;

- the level radiation of the osseous tissue (bones, teeth) more than the radiation level of the soft tissues at the same temperature, and in fact, the bones are natural generators of microwaves, tanning surrounding cells of living tissues;

- testing the interaction of various bone and dental implants, garments items, jewellery and other materials and comparing it with the human body showed that the most consistent are the physical bodies with radiation close to the human body emission.

ACKNOWLEDGEMENTS.

The author wis hesto thank:

prof., PhD Sitko S.P. – founder of the mm-therapy direction in Ukraine for support of hardware implementations of mm-range medical devices;

assoc. prof., PhD Peregudov S.M. – for the development of noise generators, participation in experimental and the oretical studies;

PhD Fedotova I.V. – for providing the statistical data on treatment outcomes of some diseases and participating the discussion;

assoc. prof., PhD Golovchanska O. D. – for providing dental materials, participation in experimental and the oretical studies and assistance inpreparing this material.

The authornotes (posthumously) great contribution prof. Skrypnyk Y.O. and itsactive participation in the development of highly sensiti veradiometric mm-ranges ystems to measure lowintensive microwave signal sand devices for medical use.

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