KAPITEL 9 / *CHAPTER 9* [9]
ASSESSMENT OF THE PARAMETERS OF THE SPARK DISCHARGE GENERATOR FOR COMPLIANCE WITH HEALTH STANDARDS

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Introduction

The impact of electromagnetic fields (EMF) high, medium and especially small doses and intensities attracts scientists and specialists working in the fields of physics, biology, medicine, agriculture, ecology, chemistry, etc. [1-4].

Natural EMF exists independently of human activity and is important factors in the evolutionary development of life on Earth. As a result anthropogenesis mostly man-made, in the surrounding area, an increase in intensity and spectral distribution of EMF change compared with the natural background. It is estimated [3-5] that in recent years the overall intensity EMF has more than 50 thousand. Times especially at industrial frequencies within of communications, including cellular, navigation, radar. Therefore, predicting the prospects of life on Earth and study the impact of electromagnetic fields on biological objects, including plants and microorganisms, as well as the living world and health, is relevant today [6-7].

Especially relevant is the work related to the study of effects on BW low intensity radiation (UHF) band, which discovered and investigated resonances bio macromolecules and their individual components [1-6]. However, at present there is no comprehensive explanation of the characteristics of their influence.

There are laboratory experiments, the use of low intensive EMF in medical practice [8-10]. These include information-wave (IVT) and microwave resonance (MRI) or therapy, magnetic and laser therapy based on stimulation or inhibition of functions and systems of the body by the action of EMF on reflex zones and localization of pathology [8- 16]

The results of several scientific studies, as reflected in works ND Devyatkova, MB Holanta, ON Betsky [1-3], VP Kaznacheyeva [4], SP Sytko [8] MV Vol'kenshtein [11] ND Kolbun [12], and others. It was found that the biological response to the effects

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of electromagnetic fields UHF band can occur at very low levels of operating factors. Moreover, the energy equivalent of such effects is comparable, and in some cases lower energy processes at cellular structures of living organism [3].

Research quantitative characteristics biological object own electromagnetic radiation (especially the human body) has led to the development of a number of wireless devices that use low-power millimeter wave generators with different baseline characteristics [13]. As a source of EHF electromagnetic radiation they use solid-state generators IMPATT diode or Gunn diodes [14].

The sources of short-wave radiation power flux density not exceeding 10 mW / cm2, and the frequency range of electromagnetic waves for most devices is 42 ... 65 GHz. We use continuous-wave mode, pulse-modulated and frequency modulation. The technique involves the use of medical experimental search of optimal frequencies, power and other characteristics of the emission.

The main disadvantages of these technical implementations are:

- fixed frequency or narrow linearity of the signal effect, which reduces the likelihood of bioresonance information processes [14];
- redundant power flux density radiation for most devices that exceed the maximum permissible level of 2.5 mW / cm^2 legally established in Ukraine [15];
- power spectral density does not comply with the law change 1 / f, that just because in their own radiation radio frequency, because of significant interest for the study and defined as

$$|g(w)|^2 \cong w^{-n}, \quad (1)$$

where n = 1-4 - fractional value that describes the non-stationary random process that can serve as a model behavior or developmental systems.

The energy spectrum of such signals

$$|g(w)|^2 = \frac{const}{w^n}, \quad (2)$$

where n = 1-4, most commonly used n = 1-2.

Currently, such processes known in astrophysics, meteorology, geology, economics, medicine, biology, so their impact on lives is important to learn.

The means to generate signals can be power-law noise bulbs, transistors, metal films, aqueous ions, etc., but you must have broadband amplifiers of signals is technically not rational.

Technical means for generating signals power-law may spark generator that generates a broadband frequency range ultralow emission intensity of the nonthermal (information) the effect [16-18].

Thus, the following definition of extremely low intensity [19-20]

1 - electromagnetic radiation, because they do not lead to increase its temperature or the temperature of local areas because, if the impact is carried out in selected areas, such as reflex areas or in places of localization of lesions that do not exceed a value over 0,1 °C . Accepted in international practice limit values of the spectral density of electromagnetic radiation (SDER) at the frequency such influences are the energy flux density in the area of exposure: 100mW / cm^2.

2 - irradiation of biological objects does not exceed the maximum permissible level which each country is set by law and can vary widely. For example, the United States and the European Union in microwave the maximum permissible level - 1mW / cm^2 for Ukraine - 2,5mkVt / cm^2 for - 10mkVt / cm^2, i.e. differences reach 400 again.

3 - from the physical point of view is low intense signals singing of measuring thermal energy emitted by biological object.

$$P = (100\text{-}1000)\, kT_0, \quad (3)$$

where k = 1,38 × 10-23J/ °K

T_0 - temperature biological object °K

At T_0=300 °K

$$P=(10\times10^3)\times1{,}38\times10^{-23}\times300\,^{o}K=(10\text{-}10^3)4\times10^{-21}Вт=4(10^{-23}\times10^{-12})W$$

There may be other low-definition signals. The paper used mainly second and third definition, since the second is a legal norm, and the third is used for physical and mathematical calculations.

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9.1. Principle of operation of the spark discharge generator

Generator - active electronic devices, generating and radiating in open low-intensity electromagnetic rays comparable in intensity with the radiation biological objects and the environment [16-18].

The source of these emissions is the spark discharge plasma at pressures and gas composition close to atmospheric pressure.

For the purposes of technological design, organize generation and transmission of electric radiation, spark discharge organized in symmetrical coaxial lines (Fig. 1).

The open end of the line (1-2) on the dielectric loaded antenna that excites flat dielectric applicator for contactless EMR on reflex zones or localization of lesions in the patient's body.

Figure 3 dashed line allocated block diagram of the studied electronic device that generates and emits intense low broadband to LF to UHF band electromagnetic radiation similar to the characteristics of natural radiation because in the same frequency range.

By the voltage converter (100 ... 150V) is connected thermistor oscillator loaded on pulse transformer, which is the power source spark arrester, and that in turn is a plasma generator wideband signal as a power noise 1 / f [17].

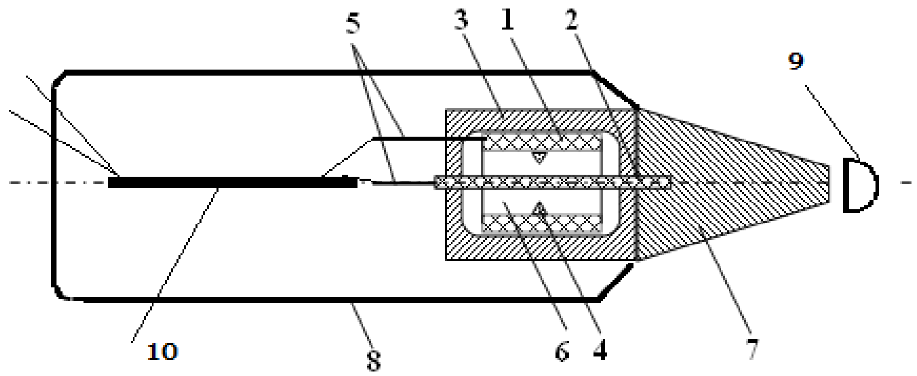

Figure 1 - Coaxial spark gap and dielectric antenna for excitation applicator

1 - a metal tube (German silver); 2 - central core (molybdenum); 3 - dielectric cylinder; 4 - metal projections (discharge initiation region); 5 - inputs electrodes; 6 - the spark discharge cavity; 7 - dielectric antenna; 8 - metallic screen (building) 9 - applicator, 10 - PCB.

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Control circuit is through the microprocessor, and the total power provided from the adapter - 110-240 / 5V-2,0A, protection from electric shock, according to the requirements set for medical devices.

Electronic device made of PCB (10) placed in a metal casing (8), which acts as a screen, except for the open end of the coaxial line loaded on SCA and further applicators (9) (Figure 1).

With the present design shows that only high-frequency waves that occur in the spark discharge may extend in the direction of the antenna-applicator and then - in the open space. Low-frequency electromagnetic radiation is a wavelength greater than the size of the hole in the narrowest part of the body 1, cannot be extended and will exponentially damped.

Characteristics of high-frequency radiation in the spectrum of the spark defined parts plasma discharge impedance device coordination emitter antenna and applicator and properties of materials making up the antenna and applicator.

9.2. Impact assessment parameters to EMF on biological objects

The impact of radiation on the human body part is made in the near field applicator - antennas for any of the known dependence of electrodynamics [20].

$$SDER = 1 / R, \quad (5)$$

where R-distance between the center of the applicator and its projection on the patient's body.

SDER the calculations used in the near field dependence. [20]

$$SDER = 4R / A \quad (6)$$

where P - the average radiating power

A - effective area applicator - m^2

For parabolic antennas formula (6) gives overestimated values SDER to within 3dB SDER what is permissible in the calculations.

When the proposed power load energy impact of ICT is significantly lower than

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that of cellular phones, televisions and other appliances.

Pulse mode handset based on the conditions of formation of a given radiation spectrum. Determining the impact energy is performed in a known manner [21]:

$$IS(J) = P\ (W) \times T\ (sec) \qquad (7)$$

and the power load on the selected area of SDER the body:

$$E = SDER\ [W / m^2] \times B\ [m^2]\ T\ (sec) \qquad (8)$$

where SDER calculated using the formula (6)

B - irradiated area, usually no more than a few square centimeters

$$B = (1\text{-}5)\ cm\ 2 = (10\text{-}4\text{-}5 \times 10\text{-}4)\ m^2$$

T = 1 hour. = 3600 seconds.

When you put the relationship between the magnitude of load power SDER and weight of the patient, can be known in the sanitation value SAR (specific absoption rate):

$$SAR = SDER / Q\ [W / kg] \qquad (9)$$

where Q - patient weight (kg).

Based on the practice of making noise generators based on gas discharge lamps, found that when negotiating path to anywhere in UHF, SHF and EHF bands (fundamental limitations and range HDTV does not exist) can reach agreement, in which the spectral density of the noise will be close to value:

$$S(f)=(20\text{-}50)\ кT_0, \qquad (10)$$

where T0 - ambient temperature T_0=300 ºK,

and the ratio (20-50) displays the spectral properties of the plasma intensity compared with no discharge

k - Boltzmann constant

Substituting (9) these values taking into account that the device emits a range AF = 290 × 10^9 Hz

$$P = \int_{10ГГц}^{300ГГц} S(t)df \approx 50 * 1.38 * 10^{-23} * 10^{11} \approx 10^{-7}Вт \approx 0.1mkW \qquad (11)$$

Note that the formation of a spark arrester in the low frequency range of signals will also occur due to range of the spark, but with increasing frequency, they quickly reduced and if the discharge pulse duration will be up to 1mks, the pulse width range

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is:

$$AF = 1 / AF = 1 / 10^{-6}Hz \text{ i.e. } 1MHz \quad (12)$$

and the number of harmonics in the rectangular pulses is equal duration deviation repetition period to pulse duration.

Fn = 40Hz, 1 / Fn = 25ms

i.e. porosity

$$n = 25ms / 1mks = 25\times10^{-3}/1\times10^{-6}=25\times10^{5} \quad (13)$$

Comparing the values which obtained by the expressions (11) and (13) shows that they differ by an order, but they are much less SDER provided that all radiating capacity will be located in a zone whose area 1sm2.

If the use ratio (6) and calculate that the agreement between the generator and load impedance is not perfect, it can be concluded that the value SDER be commensurate with the value obtained from the relation (11), provided that the power generator is P = 0,1MW affect the local area on the patient's body, covering an area 1sm^2. Thus both these two methods of calculation show that SDER impact in the local area signal does not exceed 0,1uW / cm^2.

We know that in this case the spectrum is discrete in nature, and its intensity decreases along the lines of - 1 / n2, where n- number line.

So close to the frequency of 1MHz and higher intensity of spectral lines in comparison with the intensity at a frequency repetition will be reduced by the amount of:

$$\frac{S(t)}{f} = 1\text{МГц} = \frac{\frac{S(t)}{f}=40\text{Гц}}{25*10^{3}*25*10^{-3}} = 10^{-9} \quad (14)$$

Given the rapid decrease in intensity discharge pulse spectrum and non-resonant (Rayleigh) scattering of electromagnetic radiation on the nature of the abbreviated (with a wavelength) vibrator system power in this part of the UHF band UHF negligible.

Thus of the above assessment, the signal applied to the applicator with surge pulse is 0,1MW.

Estimates of radiation can also be obtained by other means. To do this, use the

Stefan-Boltzmann law [21]

$$P = \delta \varepsilon A T^4 \quad (15)$$

where δ= 5,67 × 108Vt / (m2K4) - Stefan-Boltzmann constant

A - surface area-emitting m^2

ε - radiating ability of the body (0.5 mW)

T - the temperature of the emitting medium.

For the "cold" plasma can take T=300 °K

Substituting the constants in the equation (15) we obtain the value of the emitting power per pulse:

$$P_e = 5{,}67\times10^{-8}\times0{,}5\times10^{-4}\times300 = 25\text{mVt} \quad (16)$$

For average power value should be divided into porosity:

$$P_{av} = 25\times10^{-3}/25\times10^{3} = 10^{-6}\text{Вт} = 1\text{mkVt} \quad (17)$$

Comparing the values which obtained by the expressions (11) and (17) shows that they differ by an order, but they are much less SDER provided that all the radiated power is localized in the zone area is 1 cm2.

If we use a ratio (6) and consider that the impedance of the generator and the load is not perfect, it can be concluded that the value SDER be equivalent to the values obtained by the ratio (11), provided that the power generator P = 0,1 mW will affect a local area on the patient's body in 1 cm2.

Another physical mechanism than the excitation impulse current, electromagnetic radiation is actually a plasma spark. The analysis of factors such radiation showed that the dominant component in the millimeter range is thermal radiation.

Therefore, to assess the radiation power spark in the form of a thin plasma cylinder located between the electrodes used expression:

$$P_r \approx \frac{2\pi}{\lambda^2} \cdot kT_k S\Delta f \approx 10^{-39} T_k S\Delta f f_{average}$$

where S- the area of plasma cylinder $f_{average}$ - the average rate in the study strip, Δf - the frequency band in which power is measured, T_k - temperature cold plasma spark in the range of 30 to 300 K.

Given the biological importance of radiation in the 65 GHz frequency bands 60

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... 70 GHz, the length of the plasma cylinder (1 ... 2) mm and a diameter of channel samples (0.01 ... 1) mm output power Pr = 10-17 10-4 W .

Thus, both of the methods of calculation show that SDER swim in the local area signal does not exceed 0,1 mW / cm^2.

9.3. Experimental test results

An important factor that determines the type of biological response is noise level (random randomness) formed a spectrum of vibrations. Component radiation, physical processes in plasma, are, in fact, is noise level [23,24].

Noise level excited oscillation pulsed current fluctuations in part provided the spark discharge parameters (point and breakdown voltage) and is partly determined by hardware implementation block device. This suggests that the frequency axis position and amplitude are fluctuation character. Thus, we can talk about the existence of additional frequency, amplitude and phase modulation, which increases the density fluctuations generated spectrum and increases the likelihood of biological reactions. For quantitative and qualitative assessment emitting characteristics of the device has been designed experimental stand (Figure 3).

The device operates from a network stabilized DC voltage that sets the maximum value of the pulse amplitude. Bit frequency pulse generator sets the thermistor, the length of the active part (voltage) determines the capacitive discharge pulse generator, the amplitude of the voltage required for electrical breakdown in the discharge gap is achieved using increasing pulse transformer.

The signal is proportional to temporary dependence of current in the circuit discharge removed from the low-load resistor R non-inductive and registered in the visual, analog and digital forms spectrum generating low-frequency oscillations in biologically important frequencies (0.01 ... 60kHz) using spectrum analyzer SK4-56.

Qualitative assessment of spectral components at frequencies 0,1..1HHz performed using UHF RF analyzer to end high frequency spectral power density not exceeding 10-16W/cm×Hz, but it is a difficult technical challenge. Because registration was applied radiation radiometer which enables measurements at several fixed frequencies of 6.9, 18, 35, 54, 90HHz.

Methods of measurement of the main characteristics of periodic pulse sequences based processes oscillography results that can simultaneously measure the pulse parameters and observe their shape.

For the measurement and recording of multiple signals in an array of points describing the signal in digital form, used computer processing.

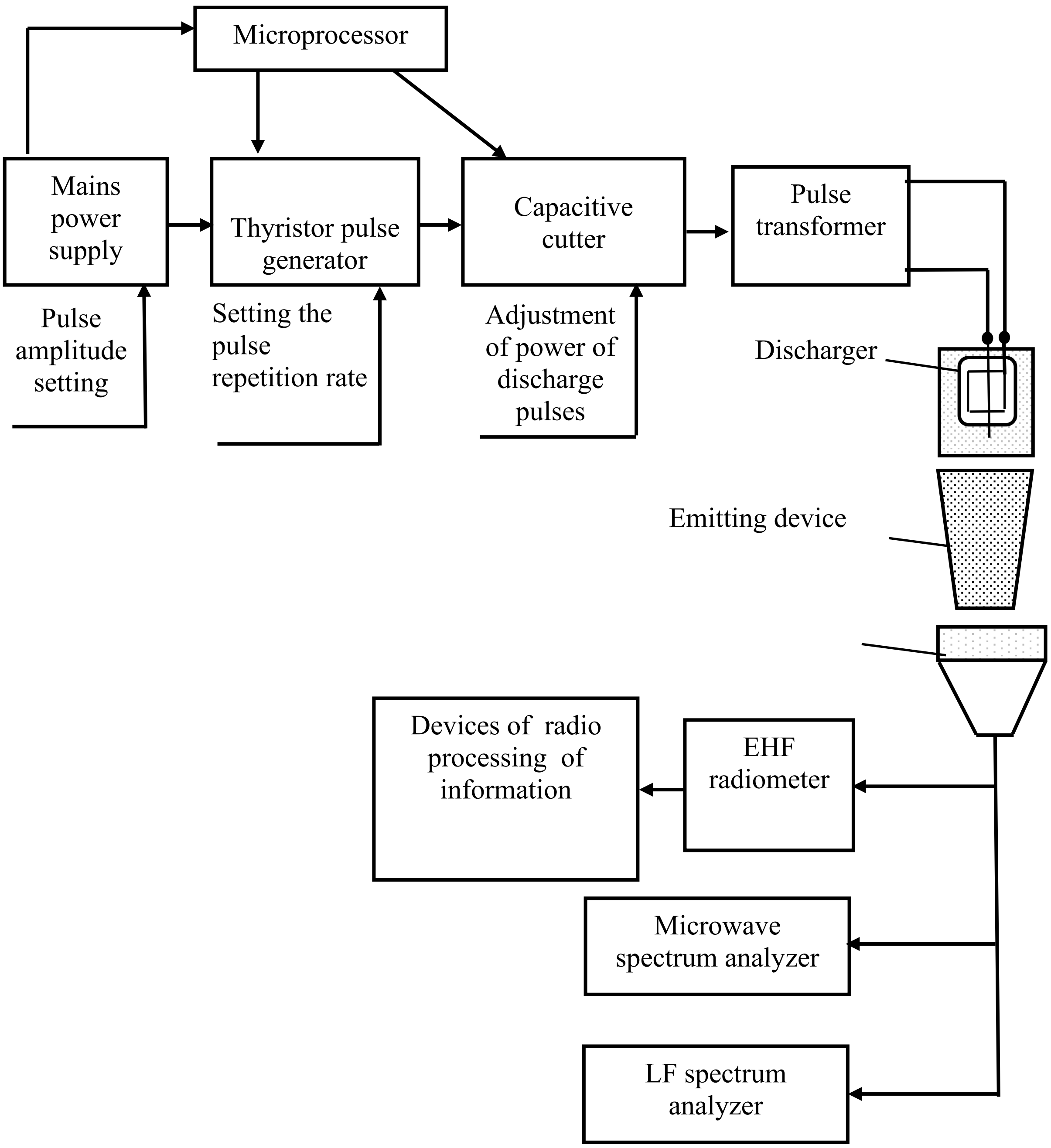

Figure 3 - Block diagram of experimental stand

In the study of radiation parameters of HF and UHF band (1 ... 300HHz) the sensitivity of existing instruments proved insufficient as to estimate the parameters applied method of substitution. As a source of noise during the replacement lamp used GS-20 with a range of 2,4-4 cm wavelength, spectral noise 65 kT^0integrity. As the measuring receiver used P5-34 receiver, λ = 8,24-12,05 kHz.

The first option pulse current study was conducted at a discharge cage waveguide for 3 values which accumulation system and different values of the distance between the electrodes. The second option investigations conducted on the basis of the final load, ie the open end of the coaxial dielectric waveguide loaded to the antenna.

From the analysis of curves (Fig. 4-5) power shows that there are three specific areas: 1 - one or multiple samples; 2 - the interval of damped periodic or aperiodic oscillation current, mainly without spark breakdown; 3 - transients in chains electrical circuit. Established that the electrical parameters of the circuit forming pulse voltage arrester design and determine the duration of specific areas.

Formed oscillation spectrum contains a continuous line and radio components. Line spectrum frequency pulse caused by spark discharge, the interval between the spectral lines is repetition frequency of each spectral line can uncouple a few components in multiple breakdowns due to temporary or streamers spread formation. Continuous spectrum due mainly thermal radiation plasma spark.

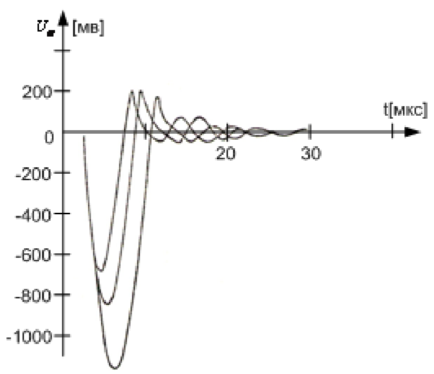

Figure 4 - Impulse voltage across the resistor spark for three value storage tanks (1 - 0.5 uF 2 - 0.75 uF 3 - 1.5 uF)

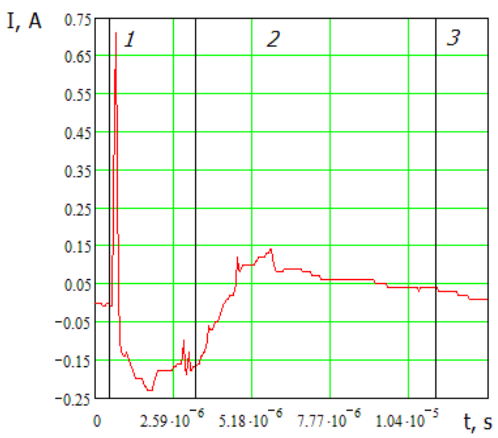

Figure 5 - Current form bit radiator circuit

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Increased energy level does not change the slope edge of the pulse. The energy level affects the amplitude of the current and period. That is, the process increasing the oscillation period is a consequence of the immutability of the front slope pulse. Investigation of the parameters of the spark discharge between the electrode distance shown that the form of periodic sequences impulse voltage difference is related to the instability of the pulse clock generator and key control discharge storage capacitor in the discharge circuit.

The results made it possible to conduct a quantitative calculation of the energy and spectral characteristics of exciting oscillations considering the structural properties of the device for radiation patterns of excitation current short-pulsed rectangular waveguide discharge.

The spectral power density (Figure 6) linear range of oscillation frequency is reduced proportionally k-harmonic (~ 1 / f_k) and at 60 ... 70 GHz has a value in the medium power category tens of mW. The spectral power density of thermal radiation cord plasma spark at a frequency of 60 GHz is evaluated by ~ 10-20 ... 10-19 W / cm^2Hz, but the true value of this parameter can be significantly lower as a result of non-stationary process and the complexity of the problem of spatial characteristics.

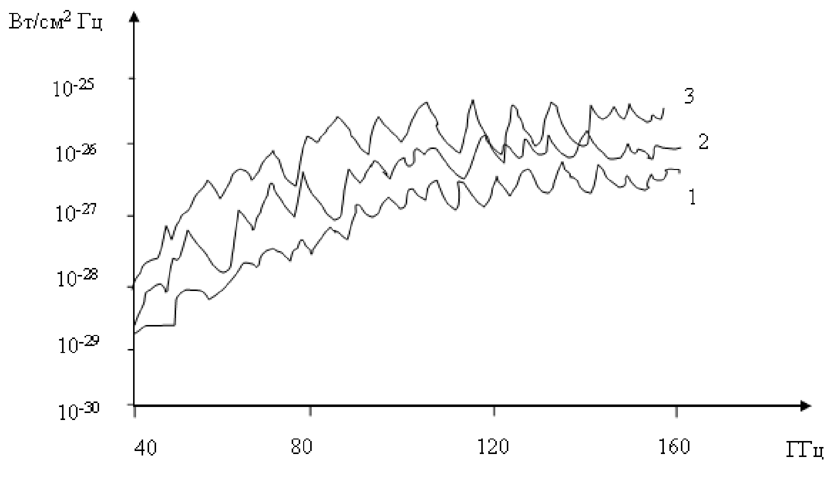

Figure 6 - Spectral power density radiation short-rectangular waveguides with dimensions1.8 mm on 3.6 mm

As a result of experiments and analysis of the results received value SCHPYE 2,7 × 10-19Vt / Hz at a frequency of 10 Hz, which corresponds to the calculations.

According to these calculations and the experiment was the basic specification of the generator, which is given in tabl.1.

Table 1 - Specifications of generator

	Parameter	**Unit**	**Numerous value**
1	Frequency range	Hz	3×10^{8}-3×10^{11}
2	Power spark discharge	W	5×10^{-2}
3	Average radiating power	W	10^{-7}
4	The spectral density of electromagnetic radiation at the frequency 60 - 70 GHz	W /(cm^2 Hz)	10^{-20}...10^{-19}
5	The duration of pulses of electromagnetic radiation	µs	1.0 ± 0.1
6	Repetition frequency of electromagnetic radiation	Hz	40 ± 5

Conclusions

The paper presents a new approach using an effective method of formation of electromagnetic radiation from nonthermal biological effects form excited by periodic pulsed gas discharge in coaxial electrode system that is loaded on the cylindrical dielectric antenna and realized radio technical devices.

Based on the technical characteristics of the generator obtained by the calculation and experimental data, it can be argued that not only the parameter SAR (specific absorption rate) on the body as a whole and in its individual parts in the range of 300 MHz- 10HHts and more hard destiny power criterion in the range 10-300 GHz oscillator meet Ukrainian and European standards. This margin of safety up to 1000 times. European standard SDER is 1mW / cm^2, and SDER generator is a thousand times smaller, that SDER = 1µ W / cm^2.

Also, experimentally confirmed that the generated electromagnetic processes with periodic pulsed spark discharge can be attributed to the noise-like type 1 / f (power-law) in the LF and HF spectral regions.

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