Bioradar in Study of Low-power Radio Frequency Radiation Influence on Sleep of Laboratory Animals

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Abstract— At present study we investigate the possibility of low-power radio frequency electromagnetic fields influence on physiological parameters of biological objects. A specially designed complex which allows generating low-power radio frequency signals with different types of modulation and remote measuring of biological object vital signs is described. The experimental data analysis reveals that respiration frequency increases in RF exposure conditions compared with non-exposure conditions ($p < 0.05$, Wilcoxon-test).

1. INTRODUCTION

At present an influence of low-power radio frequency (RF) electromagnetic fields on physiological parameters of biological objects is of high interest because the number of RF sources, which surrounds us in everyday life, is increasing. It is known that electromagnetic radiation exceeding some levels may have negative effect on biological objects. In publication the information about the parameters of radiating signal (power level, modulation type, frequency range, etc.) and the effects it causes is controversial [1, 2].

In past safety standards differed greatly from one country to another. For the USSR the standard was $10\,\mu\mathrm{Wcm}^{-2}$ for 2 h exposure per a day, for the U.S. it was 3 orders higher ($10\,\mathrm{mWcm}^{-2}$). The origin of such huge differences was caused by a fact that the USSR standards took into account non-thermal effects of electromagnetic radiation and the U.S. ones considered only thermal effects [3]. At present the difference in standard is not so big, however they are still present.

Usually in studies of low-power RF radiation influence on biological objects mobile phones with different standards (GSM, GPRS, EDGE) are used as a sources of radiation [4]. That fact limits the variety of tested frequency ranges and modulation types.

Another limitation of studies carried out till present is post experimental estimation of vital signs of the biological object, that neglects all effects which may occur in time of applying radiation and disappear immediately after it. Moreover, even in case of monitoring vital signs during the exposure only contact sensors were used, which may have an influence on the results of the experiments.

In present work the technique that allows investigating the influence of RF signals with different frequency range and modulation type on biological objects is described. For remote contactless monitoring of biological object vital signs a method of bioradiolocation [5] is used, which minimizes the influence on the object under examination.

2. EXPERIMENTAL INSTALLATION

In experimental studies a specially designed complex, which allows generating low-power RF signals with different types of modulation and remote measuring of biological object vital signs, was used. It consists of two main blocks. Block #1 generates RF in frequency range from 1 to 20 GHz with different types of modulation and RF output lower than 3 mW. Parameters of RF modulation can be changed by an operator, who through DAC and its software gives out desired pattern to the modulator. Block #2 measures remotely the vital signs of a biological object. Scheme of the experimental procedure is presented in Figure 1.

Block #1 of the complex consists of RF synthesizer (we used FSW-0020, Phaze Matrix), modulator and radiating horn antenna. Modulator was designed by using microwave amplifier HMC326MS8G (Hittite Microwave Corporation).

For remote monitoring of biological vital signs we used a multi-frequency radar BioRASCAN-14 [6] with quadrature receiver designed at the Remote Sensing Laboratory (Bauman Moscow State Technical University). The radar has following technical characteristics:

Number of frequencies 8
Sampling frequency 52.5 Hz
Operating frequency band 13.8–14.2 GHz
Distance space resolution 0.5 m
Recording signals band 0.03–10 Hz

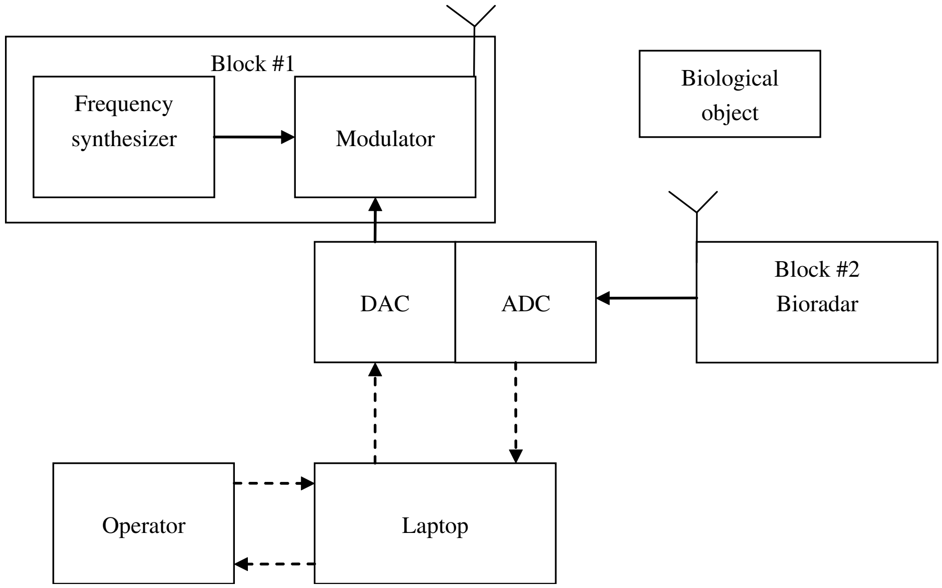

Figure 1: Scheme of the experimental procedure.

Dynamic range of the recorded signals 60 dB

This radar may be applied for distant monitoring of movement activity, respiration and heartbeat patterns of different biological objects.

Two rats (female, 4 month old each) were used as biological objects in the experiments. The complex for RF exposure and the bioradar were located at the distance of 0.5–1.0 m from a plastic box with a sleeping rat inside. For each rat, 30 records of received bioradar signals were collected for each of simulated experimental conditions (with and without additional modulated RF exposure). As a modulating signal we used harmonic wave with the frequency of 1 Hz, which is about the respiration frequency of a sleeping rat, the amplitude of the signal was 1 V. The duration of each record was not shorter than 3 hours. All experiments were conducted for the same light conditions to prevent the influence of a circadian rhythm on the experimental results.

3. RESULTS OF THE EXPERIMENTS

In this section the results of the experiments are presented. In Figure 2 record of radar signals reflected from the animal is shown. The fragment duration is 10 minutes. It is clearly seen that periods of movements with high amplitude of the pattern alternate with the calm state which corresponds to the lower amplitude of the recorded signal. For calm state, which occur if the animal was sleeping or resting, in bioradar signal the respiration pattern of the animal can be clearly seen (see insert in Figure 2).

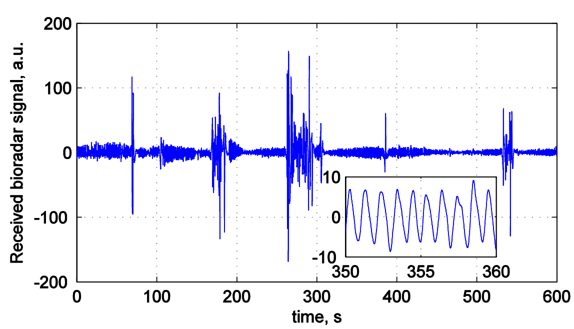

Figure 2: Radar signal reflected from an animal. The inset shows the signal over the interval [350, 360] s.

Experimental data were analyzed by using the algorithm introduced in [7]. Although the algorithm was designed for analyzing bioradar data for a sleeping human it can be also used for processing bioradar data in present case. For each bioradar record mean value of respiration frequency and total duration of movements artifacts were used for comparison of the data in different experimental conditions (with and without RF exposure).

For rat #1 the respiration frequency is 62 ± 2 (mean $\pm$ SD) and 71 ± 3 acts per minute for experiments without and with RF exposure conditions, respectively. For rat #2 the respiration frequency for same conditions were 81 ± 3 and 95 ± 3 acts per minute. Due to the fact that experimental data for both rats do not come from a normal distribution for their comparison in case of presence and absence of an additional RF exposure conditions Wilcoxon criteria was used, which indicated that respiration frequency increased in RF exposure conditions compared with non-exposure conditions ($p < 0.05$, Wilcoxon-test).

4. CONCLUSIONS

At present study we investigate the possibility of low-power RF electromagnetic field influence on physiological parameters of biological objects. A specially designed complex, which allows generating low- power RF signals with different types of modulation and remote measuring of biological object vital signs, was designed. The experimental data analysis reveals that respiration frequency increases in RF exposure conditions compared with non-exposure conditions ($p < 0.05$, Wilcoxon-test). Some limitations of our study should be noted. The study is limited by data peculiarities. The dataset is quite small and male/female ratio is imbalanced. Thus, the results should be accepted with caution.

The future activity will be directed towards expanding the data set and investigating the influence of parameters of RF-modulation on the vital signs of animals (in addition to the respiration frequency it is supposed to analyze changes in movement activity pattern). The research will be focused on the usage of a biologically informative modulation, which should impose on vital signs of the examinee according to several literature sources [8, 9].

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