USE OF GTEM-CELL IN BIOMEDICAL EXPERIMENTS

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Abstract - *Use and application of the GTEM-cell, which is a transmission structure based on a TEM-cell approach, are described. The cell can be used for calibrating small antennas, for immunity and emission testing, and for biomedical experiments. It provides homogenous electromagnetic fields with TEM (transversal electromagnetic mode) distribution, similar to the free space. It has a shield to prevent radiation from the outside, which would interfere with our measurement. Plant Lemna minor has been exposed to the electric field similar to those of the cellular phones and the effect on the growth has been studied. The experiments included exposure to the frequencies of 400 MHz and 900 MHz with strength of electric field being 22 V/m. The time of exposure was 2 and 4 hours. The influence of AM (80%) 1 kHz sine modulation was also tested. Our investigations confirmed that electromagnetic field of frequencies produced by mobile phones or base stations can affect plant growth.*

Keywords: GTEM-cell, biomedical experiments, Lemna minor

1. INTRODUCTION

Biomedical experiments are matter of extensive research for the last twenty or so years. They have been intensive lately due to the increased use of mobile phones, which have spread rapidly. Although until now, there was no direct link between mobile phones and the risk of health hazard, the possibility for it can not be ruled out [1,2].

Mobile phones are using frequencies in the range from 400 to 1900 MHz and beyond. At high power, the organic material can be heated, but the average power emitted by a mobile phone is in the range from less than 1 W to 2 W. This could raise the temperature of the nearby brain cells from 0.1 to 1 °C. Cell phone radiation is also non-ionizing; in other words it is not energetic enough to break the chemical bonds of organic molecules. However some authors suggest that EM field generated by mobile phones could change the cell membrane's permeability and interfere with organic molecule.

The experiments have been going in two directions: using small animals and cell cultures. The standards (level of acceptable field strength) in the world have been different based on those two approach. The GTEM-cell, can be used for such tests. It has shielded environment and the possibility to generate TEM field, which appears in open space.

Similar research in the world is quite rare, due to the fact that the cooperation between different fields of research is absolutely necessary.

2. INSTRUMENTATION

GTEM-cell is a transmission structure based on a TEM-cell approach [3]. Slightly spherical wave propagates from the source into a 50 Ω rectangular coaxial transmission line and its distributed hybrid termination without geometrical distortion of the TEM wave. Since the opening angle of the waveguide is small, the undistorted spherical wave can be considered as a plane wave. The TEM mode excited by either a CW source or a pulse generator simulates an incident plane wave for immunity and emission tests.

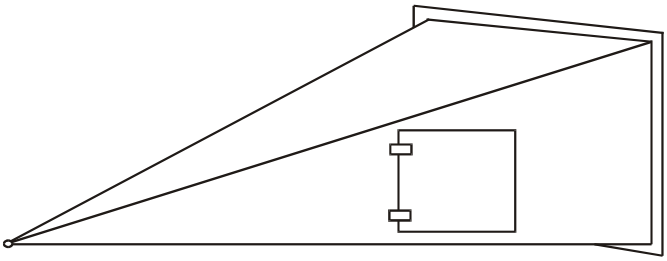

Fig 1. GTEM-cell

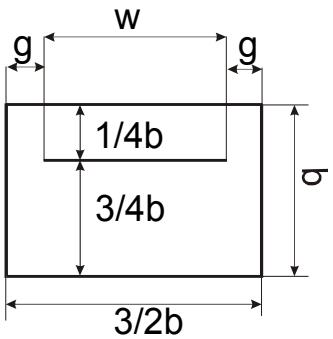

Fig 2. GTEM-cell cross section

The characteristics of GTEM-cell (Fig 1. and 2.) are: 50 Ω impedance, inner conductor at 3/4 height, inner height to width ratio equals 2 to 3 and angle septum/bottom plate

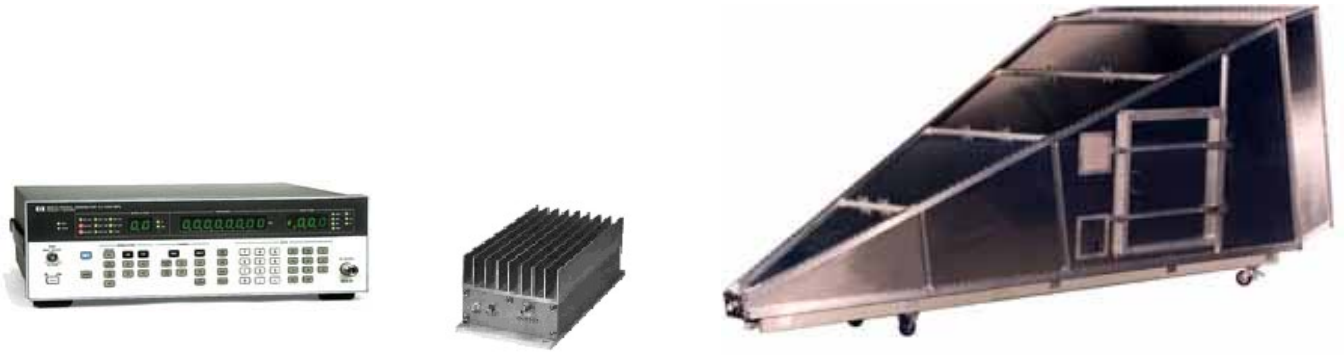

Fig 3. Instruments used for the measurements

equals 15°, with angle septum/top plate of 5°. Septum as well as coating is made of copper.

The N type connector is at the end of the tapered section. Septum is supported with dielectric material. At the other end of 1,15m long GTEM cell, there are pyramidal absorbers 25 cm long for electromagnetic wave termination and the distributed resistive load for current termination. An object of max 20 cm x 20 cm can be inserted for testing.

The experiment was carried out in a controlled environment of an electromagnetic laboratory. The slight problem was moving the plants from their growth chamber into the EM laboratory and then back. This was an additional stress to them that we tried to compensate by moving the control plants also. While the plants were exposed to the electromagnetic field in the GTEM-cell, the control plants have been in a dark closet.

In the second experiment where we studied the effect of longer exposure we have divided 4 hours of exposure to two hours by two to allow the amplifier to cool down.

Measurements (Fig 3.) were performed with HP 8657A signal generator, with RFGA0101-05 linear amplifier and GTEM-cell [4].

3. LEMNA MINOR

Plants have important role in the living word not only as a source of food but also as producers of oxygen. Recently besides many investigations on animals, more experiments used plant as a test organism to study the toxic effects.

Duckweed *Lemna minor* is a small widely spread aquatic plant, which has been used as an effective bioassay (test) organism due to its easy handling and sensitivity [5]. Moreover, results obtained with Lemna test can be used to predict the possible effect on other plants, even other organisms because of the similarity on the cellular base.

Healthy *Lemna minor* plants, growing in sterile laboratory conditions, were used in experiments. First, plants were exposed to the field frequencies of 400 MHz and 900 MHz (E= 22 V/m) for 2 hours. Further we used only 900 MHz because it had more negative effect on duckweed. In the second experiment we exposed plants 4 hours instead of 2 hours to see if the longer period of exposure would have greater influence on growth, while in the third experiment we used EM field with AM modulation (80% 1 kHz sine) Control plants were not exposed to any field.

After exposure plant growth was monitored during two weeks by counting the number of leaves on days 0, 3, 5, 7, 10, 12, 14 and relative leaf (plant) number was calculated [6]. Results are represented as a mean values ± standard error from eight replicates. Bars indicate standard errors.

4. RESULTS

The effect of 2 hour exposure to the electric field (E = 22 V/m) with frequencies 400 and 900 MHz on *Lemna minor* growth is shown on Fig. 4. The electric field (f = 900 MHz) caused obvious decrease of leaf number during second week of experiment in comparison to the control plants. The relative leaf number of plants exposed to the electric field (f = 400 MHz) was similar to the relative leaf number of control plants that were not exposed to any field.

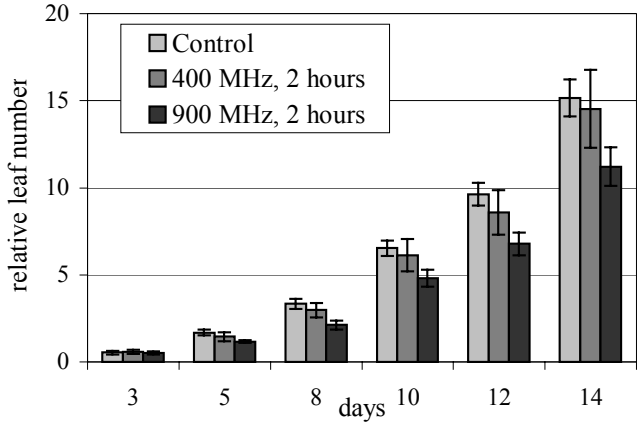

Fig. 4. Growth of *Lemna minor* after exposure for 2 hours to the electric field (**E** = 22 V/m, f = 400 and 900 MHz). Each value is the mean of eight replicates ± standard error.

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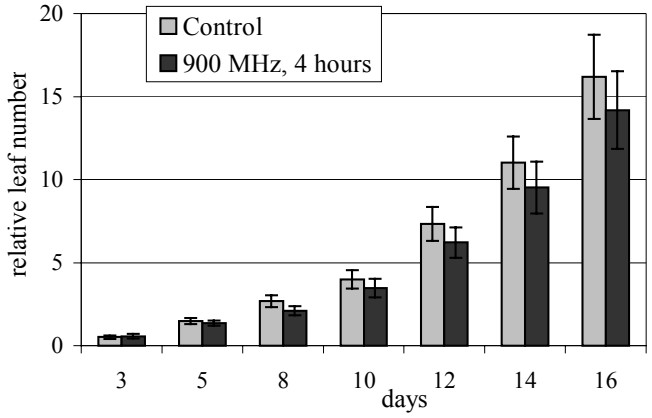

Fig. 5. Growth of *Lemna minor* after exposure for 4 hours to the electric field (**E** = 22 V/m, f = 900 MHz). Each value is the mean of eight replicates ± standard error.

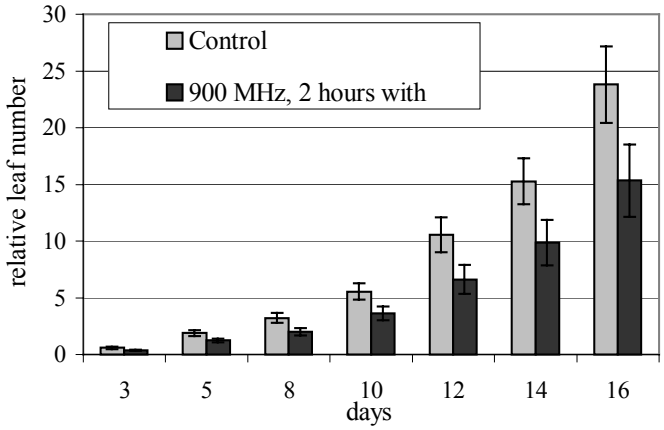

Fig. 6. Growth of *Lemna minor* after exposure for 2 hours to the electric field (**E** = 22 V/m, f = 900 MHz) with AM (80%) modulation sine 1kHz. Each value is the mean of eight replicates ± standard error.

Longer exposure period (4 hours) to electric field (E = 22 V/m, f = 900 MHz) did not cause stronger decrease of growth in comparison with 2 hours (Fig. 5.). However, plants were not exposed all the time for 4 hours, because after 2 hours was a break because of amplifier heating. It is possible that plants developed some defence mechanism during that break so other 2 hours of exposure did not have more negative effect.

On the other hand, electric field (E = 22 V/m, f = 900 MHz) with modulation caused more inhibitory effect than field without it (Fig. 6.). It was not unexpected because the modulation signal adds power to the basic frequency signal of 900 MHz. According to the Parseval law the total power of both carrier and modulated signal with 80% AM is 32% higher. That is why the effect was stronger with the modulated signal.

5. CONCLUSION

GTEM-cell designed at FER, Zagreb can be used for biological exposures. *Lemna minor* was exposed to the electric field of 22 V/m and the results show that the growth was negatively affected. In our further investigations we intend to study the effect of mobile phones on proteins in the plant cell that are known to be affected by many stress factors.

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