VPLYV ELEKTROMAGNETICKÉHO POĽA VYŽAROVANÉHO MOBILNÝMI TELEFÓNMI NA ĽUDSKÝ ORGANIZMUS

INFLUENCE OF ELECTROMAGNETIC FIELD RADIATED BY MOBILE PHONES ON HUMAN ORGANISM

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Abstrakt V súčasnosti sa stala často diskutovanou otázkou interakcia elektromagnetického poľa s biologickými objektami,najmä s ľudským telom. Na vyšetrovanie elektromagnetických polí sa používajú teoretické aj experimentálne metódy. Mobilné telefóny patria k najrozšírenejším zdrojom elektromagnetických polí, čo je dôvodom pre vyšetrovanie ich účinku na ľudský organizmus.

Summary Interaction of electromagnetic field with biological objects, especially with human body is a frequently asked question of these days. To investigate the electromagnetic fields both theoretical and experimental methods have been used. Mobile phones and their base stations belong to the most widely spread sources of EM field. That is the reason for investigation of their impact on human organism.

1. INTRODUCTION

The deep knowledge of EM field interaction with human body is very important since electromagnetic environment exists all around. The electromagnetic radiation includes a broad range of types of radiation with diverse characteristics and effects. All radiation is a form of energy. In the case of heat radiation (i.e. infrared radiation) it can be immediately felt but we are unable to sense most other forms of radiation. The electromagnetic spectrum comprises extremely low-frequency electromagnetic fields, radio waves (radio, TV, mobile phone, microwave oven, radar systems), infrared light, visible light, ultraviolet light, X-rays, gamma rays. The amount of radiated and absorbed energy increases with frequency. Radiated power can be wholly or partly absorbed by the medium it passes through e.g. the human body. In the paper the possible health effects of radio waves especially of mobile phones and some methods of their investigation are presented. The radio waves are subdivided into three frequency ranges, i.e. the low RF range (300 Hz - 1 MHz), the medium RF range (100 kHz - 10 GHz) and the high RF range (10 GHz - 300 GHz). In our daily life we are simultaneously exposed to several forms of electromagnetic radiation. There were observed various kinds of health effects according to form and frequency of EM field energy to which people were exposed.

In our daily life we are exposed simultaneously to several forms of electromagnetic radiation. Very strong EM fields can give rise to acute effects (such as involuntary movements of muscles and limbs or disturbed heart rates). They were observed in employees long - term exposed to strong EM field with great power. The effects of chronic exposure to EM fields with a small field force, such as microwave ovens, mobile phones and various electric and electronic appliances used in daily life, are less clear. As the number of people using the mobile phone increases for every year (at a guess 5% people all over the world use mobile phones), it is urgent to determine the possible health effects and to define standards for field exposure limits. In order to prevent damage to health, certain levels of current density, SAR and power density may not be exceeded. The current density is measured in mA/m^2. Physiological effects are evident at the 10 - 100 mA/m^2 but not health effects. For the professionals is recommended not to exceed 10 mA/m^2 for the 300 Hz - 1 kHz range and for general population it is 2 mA/m^2 [6]. The *specific absorption rate (SAR)* is the absorbed quantity of energy per kilogram of body weight and the unit is W.kg-1. The energy absorption depends on size and temperature regulation of the body and on environmental variables such as air humidity. The SAR value of $4W.kg^{-1}$ is regarded as a safe upper limit. Applying a safety factor 10 it produces 0,4 W/kg for professionals. For the general population a further safety factor of 5 gives a limit of 0,08 W/kg, to cover vulnerable groups such as elderly and the sick [6]. The power density is expressed in W/m^2. The recommended limit for professionals is 100 W/m^2. For the general population the recommended limit depends on the frequency. A commonly used standard is 50 W/m^2 [6]. Since in practice the current density, the SAR and the power density cannot be measured in a human being, it was necessary to develop the method for simulating the EM field radiation and its absorption in the human body. The values of abovementioned quantities can be then calculated by the computational techniques. One of the best - known and most convenient method is the Finite - Difference Time - Domain (FDTD) method [1]. This method has many advantages. It is mathematically simple, based on a straightforward approximation of Maxwell´s equations. The equations are numerically solved for entire simulated circuit, finding the electric and magnetic fields as well as the charge distribution, the Smith Chart, the antenna characteristics, the SAR in

the head, conduction currents and others to an arbitrary level of precision in each moment in a time series.It is very useful tool to determine interaction of high-frequency EM fields and biological systems especially human body.

2. INTERACTION OF HIGH - FREQUENCY EM FIELDS AND BIOLOGICAL OBJECTS

The deep knowledge of the biophysical mechanisms between electromagnetic fields and biological systems is important for the definition of the EM field levels that can be considered hazardous for people and workers. Biological response appears deeply related to the amplitude and frequency of EM field exposure conditions.

Since mobile telephones are becoming normal part of everyday life it is necessary to determine their possible health effects. Transmitter frequency of GSM system (Global System for Mobile Communication) is 900 MHz or 1800 MHz. Then wavelength of incident wave s equal to 0,333m for GSM 900 and the same one is equal to 0, 167m for GSM 1800. If the electromagnetic wave penetrates into biological medium, its wavelength changes due to decreasing of propagation velocity. The changed velocity can be calculated from the expression

$$v = \frac{c}{\sqrt{\mu_r \varepsilon_r}} \qquad (1)$$

Here the values of relative permittivity ε_r are from 6 to 50,5 for various types of biological tissues and relative permeability μ_r is considered to be 1 [4].

The physiological effects in case of lower frequencies are due to the induction of small currents and in the case of higher frequencies due to the heat. But their effects are not strictly defined and single mechanisms can be in close interaction. GSM consists of both lower frequencies (i.e. by pulse modulated frequencies) and higher frequencies (i.e. carrier wave) so that both interact with human body. Recent research has indicated that the GSM pulse modulated radiation can cause various physiological effects such as changes in EEG pattern, alteration of the calcium balance in the nerve tissue (it was experimentally investigated on rats), inhibition of cell growth in the human amniotic epithelium, changes in brain activity, inhibition of synthesis of melatonin in the epiphysis, (melatonin is a hormone that regulates our biological clock) and many others. Reaction of single human beings to the exposure of EM fields depends on many factors such as immune system, organism´s adaptation, time period and frequency of absorbed EM field energy etc. As the three biological parameters available to measure the effects of GSM radiation on the human body i.e. the current density, the SAR, and the power density are difficult to measure directly in human body, there is the possibility to measure them in the immediate vicinity of the body or use simulation methods such as the FDTD method.

3. CONCLUSION

The article deals with some problems of EM field investigation in connection with their effects on biological systems. As an appropriate method to solve of the Maxwell´s equations of EM field numerically, the Yee´s FDTD method [1] was used. This method has many advantages. It is mathematically simple, based on a straightforward approximation of Maxwell´s equations. The equations are numerically solved for entire simulated circuit, finding the electric and magnetic fields as well as the charge distribution, the Smith Chart, the antenna characteristics, the SAR in the head, conduction currents and others to an arbitrary level of precision in each moment in a time series.
It is very useful tool to determine interaction of high-frequency EM fields and biological systems especially human body. Further research work will continue.

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