Marzena MALICKA[1]
Mateusz MALICKI[2]

MEASUREMENT OF THE INTENSITY OF THE ELECTRIC FIELD OF THE RADIO WAVE EMITTED BY SELECTED MOBILE PHONES

We are constantly watching the growth of mobile phone users around the world. This causes interest in the issue of the influence of electromagnetic radiation on the human body. The sources of electromagnetic fields are among others mobile telephony. Mobile telephony consists of two basic elements: telephones (terminals) and base stations. Specific Absorption Rate (SAR) means the unit of amount of radiofrequency energy absorbed by the human body when using a mobile phone. The aim of the study was to measure the intensity of the electric field of the radio wave emitted by selected mobile phones. The measurements were carried out in the Radiation Measurement Laboratory at the Provincial Sanitary-Epidemiological Station in Rzeszów. Measurements were made for devices operating in different data transmission systems operating in certain frequency bands. The electric field of the electromagnetic field was measured using an wide field electromagnetic field measuring device type NBM-550 No. B-0240 with EF-1891 type probe. Measurements were made for devices with switched on and off data transmission at the time of receipt and during signaling. In the following sections describe mobile telephony and the basic characteristics of the mobile phone technology. The last part presents the way of making measurements and presentation of results.

Keywords: electromagnetic field, mobile telephony, base stations, Specific Absorption Rate (SAR)

INTRODUCTION

Today we are constantly exposed to many negative factors between other electromagnetic radiation. Natural electromagnetic radiation is the result of cosmic and atmospheric phenomena. Artificial electromagnetic radiation comes from industrial and everyday equipment. The sources of electromagnetic fields are

[1] Corresponding author: Marzena Malicka, Rzeszow University of Technology, Powstancow Warszawy 8, 35-959 Rzeszow, Poland, phone: (17) 8651744, e-mail: m.malicka@prz.edu.pl
[2] Mateusz Malicki, Provincial Sanitary-Epidemiological Station in Rzeszów, e-mail: mateusz.malicki@wsse.rzeszow.pl

power lines, radio and television stations, Internet access stations and mobile telephony. The electromagnetic field is an electric, magnetic and electromagnetic field with frequencies from 0 to 300 GHz (according to Article 3 point 18 of the Environmental Protection Law). The electromagnetic field is described by: field power density (W/m^2), intensity of the electric field (V/m), and the intensity of the magnetic field (A/m) [1].

Currently, there are as many as 4.92 billion unique mobile users in the world – 66% of the population – and 8.05 billion active SIM cards - that means 1.64 of a single user. Poland is ranked 17th in terms of penetration of mobile users – as many as 74% of our people use mobile phones. Spain (88%), Singapore, Italy and Japan (85%), followed by Germany (82%). Data based on a detailed report on the state of the Internet, mobile and social media in the world in 2017.

1. MOBILE TELEPHONY

Mobile telephony is a telecommunications infrastructure that enables subscribers to wirelessly connect to a cellular area controlled by individual base station antennas. A characteristic feature of this type of telephony is to provide the user with mobility. It can set up calls in the radio coverage area associated with all base stations on the network. The world's largest mobile telephony system is GSM-second-generation mobile telephony (about 80% of the mobile telephony market). In 2001 the first commercial telephony network was launched. Among the world's most deployed 3G systems, most networks (73%) are built on the UMTS (Universal Mobile Telecommunications System) standard. The successor of the third generation is the wireless data transmission standard is Long Term Evolution (LTE). The main goals of the new standard are, among other things, increasing the capacity of mobile telephony by increasing the speed of data transmission, reducing delays.

Mobile telephony consists of two basic elements telephones (terminals) and base stations. According to data from the Office of Electronic Communications in Poland there are 45.5 thousand base stations. Currently the most common sources of artificial electromagnetic fields are cellular base stations. Cellular base stations consist of sector antennas and radio antennas. The sectoral antenna is responsible for communicating with the mobile phone, and the radio antenna for communication between the base stations [2]. Table 1 shows examples of electromagnetic field sources and their corresponding frequency ranges.

The main principles of protection of people at the workplace against non-ionizing electromagnetic radiation are defined among others in the Regulation of the Minister of Family, Labor and Social Policy of 29 June 2016 (Item 950).

Mobile base stations are designed so that the average field power density values that could exceed the allowable level are concentrated at high altitudes. Due to the increase in mobile phone users, base stations are designed for multi-system operation. In addition, according to the Law of Environmental Protection, it is mandatory to obtain a permit to emit electromagnetic fields into the environment without which the newly constructed investment or the object can not be put into use [3].

Table 1. Sources and frequency ranges of emitted electromagnetic fields (Military Institute of Hygiene and Epidemiology Volume 35, Supplement 2)

Description of the magnetic field	**Frequency range**	**Wavelength**	**Sources and circumstances of occurrences of fields**
Static magnetic and electromagnetic fields	0	-	electric motors, electrolysis and industry
(AC) grid network fields	50 or 60 Hz	6000 or 5000 km	electrical power, lighting, heating, engines, power supply and industry
Very low frequency fields	0,1-1,0 kHz	300-3000 km	industrial equipment
Low frequency fields	1-100 kHz	3-300 km	industrial equipment
Radio waves	0,1-300 MHz	1-3000 m	radiophony, radiotelephones, medical devices
Microwaves	0,3-300 GHz	1-1000 mm	radiolocation, radionavigation, mobile telephony, medical devices, home and industrial appliances

The electromagnetic field emitted by mobile phones depends on the type of phone, the distance from the base station, the phase of the call. Maximum field values are dialed and their value decreases during the call [4]. Due to the dynamic development of mobile telephony, various data transmission systems have been developed, including those operating at frequencies of 900 MHz, 1800 MHz, 2000 MHz and 2100 MHz.

2. PERFORMING MEASUREMENTS

The experiment consisted in checking the indication of electrical component of the electromagnetic field intensity emitted by selected smartphones and one mobile phone. Measurements were made for devices operating in different data transmission systems operating in certain frequency bands. The measurements were carried out in the Laboratory of Radiation Measurement in the Provincial Sanitary-Epidemiological Station in Rzeszów. The electric field of the electromagnetic field was measured using an wide field electromagnetic field measuring device type NBM-550 No. B-0240 with EF-1891 type probe. The meter and the probe are attached to a tripod. On the second stand, the device was placed just below the probe. The distance between the probe and the head of the test source was determined by means of a measuring tape. The distance between the measurements was constant and was 4 cm. Measurements were made from the front of the phone (Fig. 1, Fig. 2).

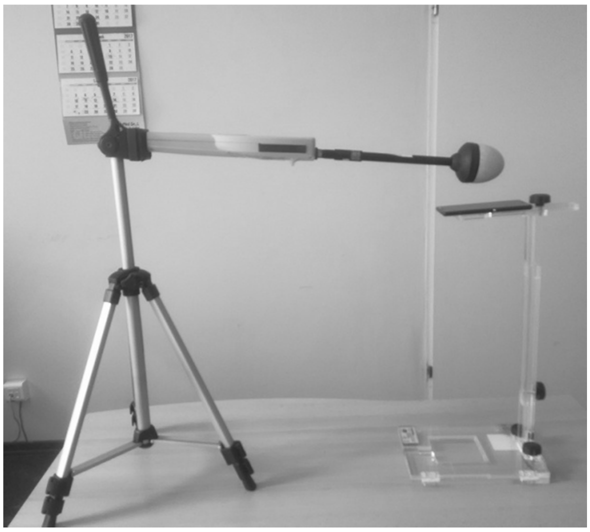

Fig. 1. Method of measurement (side view)

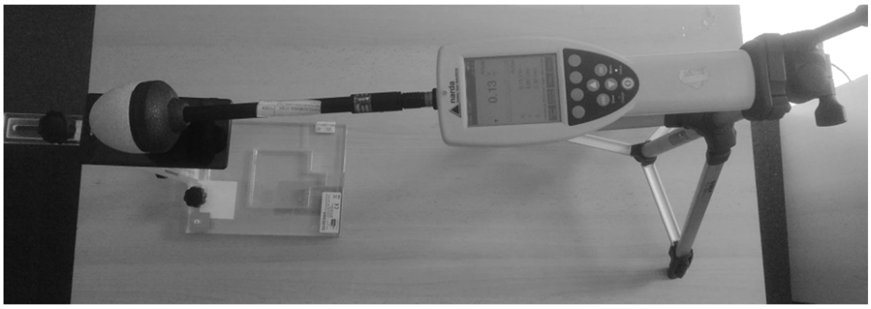

Fig. 2. Method of measurement (top view)

Measurements were made for 5 different smartphones and one mobile phone. During the experiment the phones range was maximal. The average results of electrical component of electromagnetic field measurements based on the ten readings are summarized in Table 2. Measurements were performed with data switched on and off while receiving and during signaling.

Table 2. Measurement of electrical component of electromagnetic field for selected devices

Device type	**Data transmission technology**	**Measurement with data enabled, V/m**		**Measurement without data transmission, V/m**	
		during signaling	**at the time of recept**	**during signaling**	**at the time of recept**
Smartphone 1	LTE	<0,5*	<0,5*	0,56	<0,5*
Smartphone 2	LTE	<0,5*	<0,5*	<0,5*	<0,5*
Smartphone 3	LTE	0,83	0,95	0,89	0,98
Smartphone 4	HSDPA	<0,5*	<0,5*	<0,5*	<0,5*
Smartphone 5	LTE	0,95	1,43	0,72	0,63
Mobile phone	–	–	–	15,9	5,7

* indication below the detection limit of the meter according to the calibration certificate of the device.

The results shown in Table 2 read directly from the meter were corrected according to the calibration certificate of the device according to the formula:

$$\mathrm{Ecor} = \mathrm{Em} \cdot \mathrm{Cd} \cdot \mathrm{Cf} \tag{1}$$

where: Ecor – corrected value; Em – measured value; Cd – dynamic characteristics; Cf –frequency characteristics.

According to the calibration certificate, results ranging from 0,5 to less than or equal to 0.75 V/m were corrected for correction factor ($\mathrm{Cd} \cdot \mathrm{Cf}$) 1.05. Values in the range of greater than 0.75-1.5 V/m were corrected for a correction factor of 1.09. Values in greater than 0.75-1.5 V/m were corrected for a correction factor of 1.09. The calculated values are shown in Table 3.

Table 3. Measurement results after correction with correction factors

Device type	**Data transmission technology**	**Measurement with data enabled, V/m**		**Measurement without data transmission, V/m**	
		during signaling	**at the time of recept**	**during signaling**	**at the time of recept**
Smartphone 1	LTE	<0,5*	<0,5*	0,59	<0,5*
Smartphone 2	LTE	<0,5*	<0,5*	<0,5*	<0,5*
Smartphone3	LTE	0,91	1,04	0,97	1,07
Smartphone 4	HSDPA	<0,5*	<0,5*	<0,5*	<0,5*
Smartphone 5	LTE	1,04	1,56	0,76	0,66
Mobile phone	-	-	-	18,3	6,3

After analyzing the results of the measurements in Table 3, it is concluded that most of the measured values for smartphones oscillate around 0.5 to 1.56 V/m.

Measurements for cellular phones gave values of 18.3 V/m during connection and at the time of recept of 6.3 V/m.

During the measurements for all devices, a momentary increase in the electromagnetic field (about one second) to 2.5 V/m was observed at such phases as the start of the connection and at the time of recept. This can be explained by the fact that when making a call, the phone transmits for a short while with a power close to the maximum. When the connection is established, the signal parameters are adjusted to the reception and transmission conditions and the signal strength is reduced. It is recommended that you wait a while before applying the telephone to your ear [5].

3. CONCLUSIONS

During a call the phone is usually kept close to the head, so measurements are taken at a distance of 4 cm. Due to the construction of the probe, it was not possible to carry out measurements at a closer distance.

In order to limit the impact of mobile phones, you can use certain recommendations such as:

- increasing the distance between the head and the mobile phone,
- use headset and handsfree with internal or external antenna in your car,
- shortening talk time,
- avoid making calls away from base stations, turning off phones where there is no coverage (in the absence of coverage, it will attempt to connect to the base station, acting with full power of the transmitter),
- you can move closer to the window when the call is in progress so that the transmitter and base stations can work with less power.

Electromagnetic radiation from cell phones and base stations is not indifferent to human health. Negative effects depend on the absorbed value of the electromagnetic energy and the resistance of the body [6].

It is certain that every cell phone emits radiation. Therefore, choose a model that has the lowest SAR value. Specific Absorption Rate (SAR) means the unit of amount of radiofrequency energy absorbed by the human body when using a mobile phone. EU law requires the SAR value for each mobile phone to be given in Europe – this value can not be higher than 2 W/kg.

The SAR is difficult to determine and may be estimated for example by measurements of the electric field strength of the radiation, the temperature increase or by numerical simulations [7, 8].

REFERENCES

[1] Różycki S., *Ochrona środowiska przed polami elektromagnetycznymi. Informator dla administracji samorządowej*, Generalna Dyrekcja Ochrony Środowiska, Warszawa 2011.

[2] http://www.wios.warszawa.pl/pl/monitoring-srodowiska/monitoring-pol-elektro/zrodla-promieniowania/78,Zrodla-promieniowania-elektromagnetycznego.print (available: 03.11.2017).

[3] Michałowska-Samonek J., *Aktualne zasady dotyczące badania pól elektromagnetycznych wysokiej częstotliwości*, Prace Instytutu Elektroniki, 2008, z. 238.

[4] Zmyślony M., Politański P., *Zagrożenia zdrowia i ochrona zdrowia pracujących w narażeniu na pola i promieniowanie elektromagnetyczne 0-300 GHz*, Instytut Medycyny Pracy im. prof. J. Nofera, Łodź 2009.

[5] http://wsse.krakow.pl/strona/index.php/obszary-dzialan/nadzor-sanitarny/108-promieniowanie/67-bezpieczne-korzystanie-z-telefonow-komorkowych (available: 03.11. 2017).

[6] Kuciński S., *Wpływ telefonii komórkowej na zdrowie człowieka*, II Krajowa Konferencja Naukowo-Techniczna „Ekologia w Elektronice", Warszawa 5-6.12.2002.

[7] Christian P. Karger, *Mobile phones and health: A literature overview*, Z. Med. Phys., 2005, 15, pp. 73-85.

[8] Fazlul Hoquel A.K.M., Sazzad Hossain Md., Sattar Mollah A., Akramuzzaman Md., *A study on specific absorption rate (SAR) due to non-ionizing radiation from wireless/ /telecommunicationin Bangladesh*, American Journal of Physics and Applications, 2013, 1(3), pp. 104-110.

POMIAR NATĘŻENIA SKŁADOWEJ ELEKTRYCZNEJ POLA ELEKTROMAGNETYCZNEGO SYGNAŁU FAL RADIOWYCH EMITOWANYCH PRZEZ WYBRANE TELEFONY KOMÓRKOWE

Obecnie stale obserwuje się wzrost liczby użytkowników telefonów komórkowych na całym świecie. Powoduje to zainteresowanie zagadnieniem wpływu promieniowania elektromagnetycznego na organizm ludzki. Źródłem pola elektromagnetycznego jest m.in. telefonia komórkowa, która składa się z dwóch podstawowych elementów: telefonów (terminali) i stacji bazowych. Współczynnik absorpcji swoistej (SAR) oznacza jednostkę energii o częstotliwości radiowej zaabsorbowanej przez ludzkie ciało podczas korzystania z telefonu komórkowego. Celem pracy było zmierzenie natężenia pola elektrycznego sygnału fal radiowych emitowanych przez wybrane telefony komórkowe. Pomiary przeprowadzono w Laboratorium Pomiarów Promieniowania w Wojewódzkiej Stacji Sanitarno-Epidemiologicznej w Rzeszowie. Pomiary przeprowadzono dla urządzeń pracujących w różnych systemach transmisji danych, działających w określonych pasmach częstotliwości. Pomiary wykonano za pomocą wywzorcowanego, uniwersalnego, szerokopasmowego miernika natężenia pola elektromagnetycznego typu NBM-550 nr B-0240 z sondą pomiarową typu EF-1891. Wskazania urządzeń sprawdzano dla włączonej i wyłączonej transmisji danych podczas odebrania i w trakcie łączenia sygnału. Opisano telefonię komórkową i podstawowe cechy tej technologii. W ostatniej części artykułu przedstawiono sposób wykonania pomiarów i wyniki.

Słowa kluczowe: pole elektromagnetyczne, telefonia komórkowa, stacje bazowe, SAR

Recived: 13.11.2017
Accepted: 25.11.2017