

## The intensity of electromagnetic fields in the range of GSM 900, GSM 1800 DECT, UMTS, WLAN in built-up areas

**Abstract.** Devices and installations used in radiocommunication or radio diffusion are currently the most numerous sources of electromagnetic field - especially in the high frequency range. The work presents the values of the intensity of the electromagnetic field which were measured using the ESM140 in several cities and towns.

**Streszczenie.** Urządzenia i instalacje wykorzystywane w radiokomunikacji czy radiodifuzji są aktualnie najliczniejszymi źródłami pola elektromagnetycznego – szczególnie w zakresie wysokich częstotliwości. W pracy przedstawiono wyniki badań natężenia składowej elektrycznej pola elektromagnetycznego uzyskanych przy użyciu urządzenia ESM140 w kilku miastach i miejscowościach. **Natężenie pola elektromagnetycznego w zakresach: GSM 900, GSM 1800 DECT, UMTS i WLAN w oszarach zabudowanych**

**Keywords:** intensity of electromagnetic fields, GSM, exposure.

**Słowa kluczowe:** pole elektromagnetyczne, GSM, ekspozycja.

### Introduction

The effect of civilisation development associated with radio communication and radio diffusion technologies is the widespread exposure to electromagnetic fields in the field of high frequencies in the environment. Radio and television broadcasting stations, GSM base stations, or broadcasting devices from the WiFi band are indispensable in the present world. It is important, however, that they work and are located in such a way that on the one hand they optimally fulfil their telecommunications functions, and on the other – minimally affect the environment, mainly in terms of the level of electromagnetic radiation in urban areas. From the point of view of environmental and human protection, as well as electromagnetic compatibility, it becomes important to monitor and measure the electromagnetic field (in particular the electrical component) produced by devices operating on communication frequencies.

Socio-scientific needs of the study of the impact of radio communication installations and devices are governed by governmental institutions as well as research centers [1-11]. Conclusions from many studies are not unequivocal, although most often there is no statistically significant relationship between exposure and chronic or acute symptoms of health. A special case is the study of the influence of the electromagnetic field on the human reproductive system, reproductive processes – including the developing embryo and then the fetus. Knowledge on this subject is still developing and all conditions of human reproduction are still unknown. Many scientific publications, among others in terms of the impact of the electromagnetic field on semen are contradictory. Some have a beneficial effect on the sperm's movement parameters, while others have an inverse effect [1,2,3,7].

The actual levels of electromagnetic radiation values to which people are subjected depend on existing installations and radio communication devices in the immediate vicinity and the coverage of the area by the impact of telecommunications infrastructure. Therefore, researchers from several centres in the Lublin region decided to use three ESM140 dosimeters to determine the actual levels of electromagnetic emissions and indicate values for selective frequencies GSM 900, GSM 1800, as well as DECT, UMTS and WLAN 2.4 GHz.

### High frequency electromagnetic fields

Issues of impact on humans and the environment of non-ionising electromagnetic field, produced by devices of cellular telephone systems, devices working in the DECT band and wireless wifi have been invariably arousing interest for many years. This is one of the reasons for the ongoing research to determine whether the increase in electromagnetic background as a consequence of a large number of sources generating electromagnetic fields and acting simultaneously, poses a threat to living organisms.

Depending on the purpose of the source of electromagnetic fields, the range of frequency produced and processed, the power of the transmitter, different parts of the population are subject to varying degrees of exposure to these fields. The size of this exposure depends on the degree of industrialization and urbanization of a given region and is statistically higher for the residents of large cities compared to rural areas [4,5,11, 13, 14]. Each time, spectral analysis indicates that, in addition to broadcasting television and radio stations, increased field strengths occur in the operating band of mobile radio and mobile telephony. This is also confirmed by the spectral characteristics presented in Figure 1. The identified intensity of the electromagnetic field of urban origin is proportional to the number of inhabitants, specific energy and industrial installations, transport and the city itself, and in the spectrum most often manifests itself in the form of broadband.

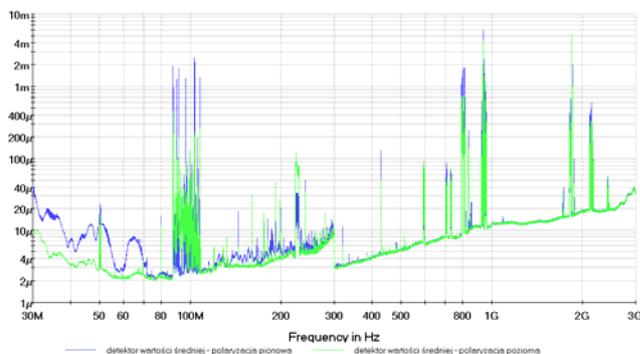


Fig. 1. Electromagnetic spectrum in the range 30MHz-3GHz on a scale from  $\mu\text{V}/\text{m}$  to  $\text{mV}/\text{m}$  in the town of Bełzec, measurement 10.05.2018

Transmission devices of radio communication systems are mainly transmitters and antennas of medium or high power radio and television stations and base stations of mobile radio systems (public mobile telephony and non-public systems) of lower power. The FM radio broadcasts predominate in radio broadcasting, the number of which in 2016 amounted to around 1000 and several dozen in the DAB + digital system and television stations, the number of which in the DVBT digital system is 313 [8-11]. On the other hand, base stations of mobile telephony are practically everywhere. Currently in Poland, the estimated number of GSM900, GSM1800 (GSM – Global System for Mobile Communications) and UMTS900 and UMTS2100 (UMTS – Universal Mobile Telecommunications System) mobile base stations is approximately 110,000. They are located both in large cities and in rural areas, at ports, airports, roads, railway tracks and non-urban spaces. The masts of base stations arouse strong emotions and anxiety of people living near them. People's concerns related to masts concern the radiation emitted by the equipment installed on them and violations of landscape values, which together translates into a decline in the value of properties located in their close vicinity. The number of sources of the electromagnetic field from devices and installations using wireless technologies in the WiFi, Wimax and Bluetooth band is also dynamically growing. Here the number of devices is no longer countable.

Therefore, extensive activities are undertaken to reduce the level of human exposure to electromagnetic fields. And the impact of the electromagnetic field on people and material objects results in the induction of an electric field in them, which may cause adverse health effects of exposed or indirect hazards, such as interference with equipment operation or experiencing contact currents when touching objects affected by the electromagnetic field [ ]. Due to the interaction of the high-frequency and microwave EM fields, the absorption of electromagnetic energy may result in an increase in body temperature or local overheating. Therefore, the analysis of the distribution of electromagnetic field intensity is performed:

- for environmental protection purposes – in accordance with the Regulation of the Minister of the Environment of October 30, 2003 [12]
- at work – in accordance with the Regulations of the Minister of Family, Labour and Social Policy of June 27, 2016 (Journal of Laws of 2016, item 952) and of June 29, 2016 (Journal of Laws of 2016, item 950)
- for the purposes of electromagnetic compatibility – in accordance with the requirements of Directive 2014/30/EU.

For purposes of environmental protection, areas of limited use are designated, while at workplaces, protective zones are marked out and working time limits determined. With regard to electromagnetic compatibility, manufacturers' declarations certifying the conformity of the device or installation with harmonized standards are issued. As shown by our own research and literature [ ], radio communication devices and systems are a source of EM-field, and during the emission in the vicinity of antennas and some other elements of the system there is an EM-zone of protection zones. Typical radio communication systems are maintenance-free, but they require periodic inspections, adjustments and maintenance, and thus a work space can be distinguished in their environment. However, this article does not refer to such a situation, and the recorded intensities were collected in the generally accessible public space of the urbanized environment.

The most popular telecommunications systems in our country were tested: GSM900, GSM1800, UMTS, DECT and WLAN. The systems mentioned have the character of

digital data transmission, which amounts to transmission devices generating electromagnetic waves of a rectangular shape, modulated and at different frequencies (Table 1).

Table 1. Frequency ranges of signals of selected telecommunications transmissions in Poland

system	GSM900	GSM1800	UMTS	DECT	WLAN
uplink MHz	880-915	1710 - 1785	1920 - 1980	1880 - 1900	2400 - 2485
downlink MHz	925-960	1805 - 1880	2110- 2170	1880 - 1900	2400 - 2485

### Measurement method

The method widely used in protective measurements (both for health and safety purposes and environmental protection) are broadband measurements with measures adapted to measurements in the immediate vicinity of sources as well as in the far field. The advantage of such measurements is to obtain a single result corresponding to the resultant field strength of all sources within the measuring range of the probe. The disadvantage of broadband measurement is the lack of selectivity of threats from a specific frequency. This is counteracted by narrowband measurements, carried out, for example, with spectral analysers or selective detectors. The sample spectrum from Figure 1 confirms that it indicates specific information about existing electromagnetic signals in the environment.

For the research (presented in the further part of the article), Maschek ESM 140 dosimeters were used, at the disposal of the three universities from which the co-authors of the publication come. The ESM140 is a device that measures the electromagnetic field in real time at certain high frequency bands. This meter measures the value of electric field strength levels and selectively indicates values for the GSM 900, GSM 1800 frequencies as well as for the frequency of DECT, UMTS, and WLAN 2.4 GHz. The measuring range of the meter is between 0.01-70 V/m, the sensitivity is 10 mV/m and accuracy  $\pm 2$  dB (in the fixed position) and  $\pm 4$  dB (during the dosimeter measurement on the arm). The sampling time has been set to 0.5 s.

The measurements were taken both in buildings and in the open, urbanized area. The device fastened on the arm of the person measuring (Fig. 2) was worn for a set time (the measurement cycle lasted about 10 hours). Thanks to the low weight of the device, placing it on the hand of the person subjected to the test is convenient and almost imperceptible in many hours of use. Therefore, the entire work space, wherever the person is located, is subjected to the examination and there is a possibility of occurrence of electromagnetic fields. Such a method ensures full reproduction of the exposure to which the person is being subjected.



Fig. 2. An image of one of the ESM 140 dosimeters used in the tests together with the method of its installation

Although staying in buildings mainly related to staying in homes or workplaces, and expositions from open areas

resulted from the time of staying outside, on the way to work/home, it should be emphasised that due to the continuity of measurement, other aspects of life were also registered; e.g. shopping, transport or outdoor recreation.

Five people carried out the research. With the use of three ESM-140 meters, research was carried out in several locations – in the cities of Lublin, Chełm, Kielce, Kraków, Warsaw and the cities of Bełżec, Orłów Murowany and Stryków in the period of January-May 2018. Field studies in respect of environmental conditions were each time carried out in accordance with the guidelines of the Regulation [12].

## Findings

The results obtained were summarised in Graph ESM-140 dedicated to the meter. The names appearing in the following charts mean:

- GSM900/1800Up – the measured effective value of transmission from a mobile phone to a base station;
- GSM900/1800down – the measured effective value of transmission from base stations to a mobile phone (or other device – the so-called mobile station);
- UMTSup/UMTSdown – the measured effective value of the transmission signal of telecommunications services from and to a mobile phone (or other terminal device), respectively;

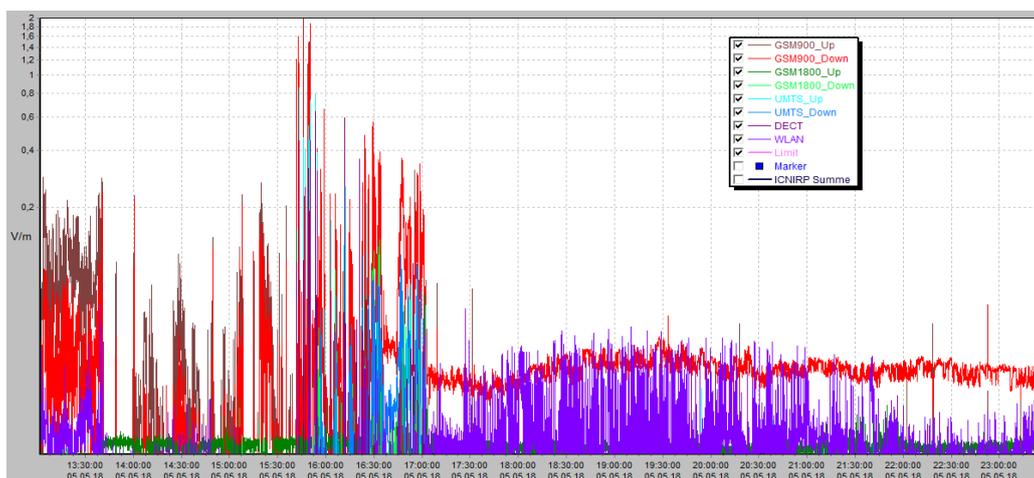


Fig. 3. E intensity values of the electromagnetic field measured in two locations. Measurements from 1.00 to 4.00 p.m. in the area of Stryków, one hour trip by car, from 5.00 p.m. staying on an estate in Orłów Murowany.

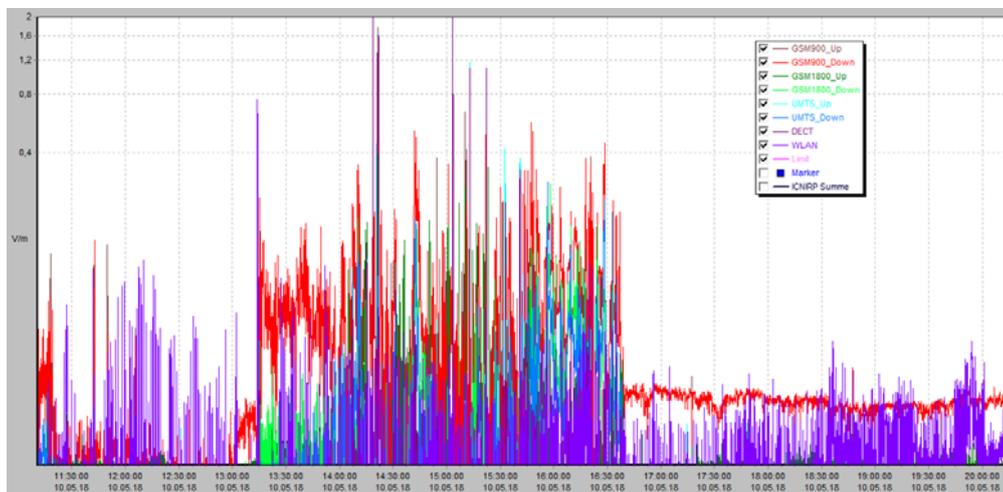


Fig. 4. The values of the intensity E of the electromagnetic field measured on the Lublin-Bełżec route (until 1.00 p.m.), on the premises of a single-family house by 4.30 and on the way back.

- DECT – the measured effective value of the signal used in the digital wireless communication system over short distances, without the possibility of detecting the direction of propagation from/to the base station (e.g. a cordless telephone operating in fixed telephony);
- WLAN – the measured effective value of the signal used in the wireless local area network (WiFi), without the possibility of detecting the direction and propagation source between the devices.

The measured values contained in Figures 3 and 4 present selected data recorded by dosimeters. A total of 20 measurement cycles of several to under twenty hours were carried out. The descriptions under the charts briefly characterise the place and special conditions to which the researcher was subjected. The recorded data from ten cycles were subjected to basic statistical analysis. The summary is contained in Table 2.

Table 2. Statistic summary of measurement values from 463129 measurement records, values in units of V/m.

system	Mediana	mean	maximum
GSM900up	0,000205	0,023045	25,28103
GSM900down	0,024176	0,03864	11,90002
GSM1800up	0,007337	0,012721	3,191358
GSM1800down	0,00499	0,008678	1,913311
UMTSup	0,002119	0,007856	13,33553
UMTSdown	0,005081	0,009797	0,860986
DECT	0,001436	0,006188	9,989812
WLAN	0,004238	0,009126	0,964483

Fields not exceeding the level of 7 V/m specified in the Regulation are not considered to adversely affect any of the environmental elements (plants, animals) and do not adversely affect human health. During the measurements, only one person registered staying in the area beyond the permissible limit. On the one hand, this registered emission did not last long and statistically it is only a single deviation that can be omitted. On the other hand it is proof that it is necessary to constantly monitor the environment to determine the impact of radio communication equipment and installations on the environment.

### Conclusions

Field levels in the vicinity of antenna masts, caused by radio communication system transmitters, depend among others on ERP radiated power, directional gain or the installation level of transmitting elements. These levels are under constant control and cyclical monitoring of state services – Regional Inspectorates of Environmental Protection. Unfortunately, the procedures only apply to generally accessible public areas.

Unfortunately, people's life, work or leisure cycle does not cover just such spaces. Therefore, measurements are important that will continuously monitor the values of the intensity of the electromagnetic field to which people are exposed.

The measurements carried out in the winter-spring period showed that in one cycle a person with a dosimeter would be present in an area with an exceeded field intensity level, but over half of the records indicate that the obtained values are a few orders lower than the permissible one.

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