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METHODOLOGY FOR THE ASSESSMENT OF ELECTROMAGNETIC FIELDS GENERATED BY MOBILE BASE STATIONS

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Abstract: One of the most common sources of electromagnetic fields (EMF) in the environment, which is most visible to the public, is the base stations of mobile operators. This contribution shall be devoted to the development of a methodology for the assessment of EMFs generated by mobile base stations. In order to address this issue, an experiment was carried out to assess the electromagnetic fields in the selected industrial site. In the experiment, measurements were made of the intensity of electromagnetic fields at the selected measuring points in the various operating modes of the V5 base station — on and off. Subsequently, measurements were made of the intensity of the electromagnetic fields during the operation of the mobile MBTS base station, which was temporarily operated on the site under consideration. In the various operations of the base station, the measured intensities of the electromagnetic field were manifested differently depending on the location of the measurement. The results of the experiment suggest that consideration should be given to the appropriateness of the EMF evaluation methodology, which favors the evaluation of a particular resource rather than the entire site.

Keywords: Methodology, electromagnetic field, the base station of mobile operation, experimental measurement

INTRODUCTION

In recent decades, there have been rapid developments in telecommunications and information technology, which bring with them increasing levels of electromagnetic fields in the environment. Despite the fact that, since the 1980s, increased worldwide attention has been paid to electromagnetic fields, their measurement, monitoring, and assessment, it has been necessary to make further progress in the methodological area, which mainly concerns the search for new, modern approaches to the objectification of EMF specific sources [1]. Exposure to electromagnetic fields from mobile base stations shall be controlled in accordance with the legislation currently in force. From the point of view of the safety of the population, mobile operators must carry out individual health measurements whenever technology changes at base stations.

In an article by Boo, SF et al. [2], authors conducted an experiment comparing the radiated power levels of base stations with the ICNIRP safety guidelines. The measured EMF levels were lower than the ICNIRP exposure limits. Similarly, in [3], measurements of exposure to electric, magnetic, or electromagnetic fields (EMF) in households were performed. In the article, they reported that all measurement results were well below the International Commission on Non–Ionizing Radiation Protection (ICNIRP) guidelines. Yuan et al. [4] monitored the environment around base stations. They found that the requirements of electromagnetic limits for environmental control were met at all monitoring sites in urban areas.

The contribution describes an experiment in which we carried out measurements of the intensity of electromagnetic fields at a selected location under different operation modes of the base stations. This is the case where one base station has been canceled and replaced by another base station situated elsewhere. Subsequently, an analysis of the strength of the electromagnetic field was carried out at various measuring points. The results of the frequency selective measurement are shown in the frequency spectrum tables and graphs. The result of the measurements is also the cumulative electromagnetic field intensity values, which can be compared to the action, and legislative values.

EXPERIMENT MEASUREMENT OF ELECTROMAGNETIC FIELDS

An experiment to assess changes in the intensity of electromagnetic fields generated by mobile base stations was carried out by measurements at a selected location. We chose this area because of the large number of base stations present in the area. This site is located on the Južná trieda in Košice, Slovak Republic. There are currently 10 mobile operator base stations on the site and a mobile base station is acting as a temporary replacement. Several operators operating in Slovakia have base stations located in the designated area. In Figure 1, there is the location of the base stations at the selected site as well as the azimuth of the antenna radiation.

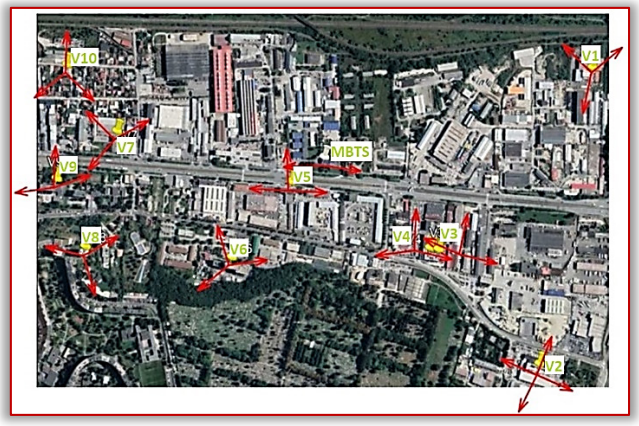

Figure 1. Site assessed with EMF radiation sources

The V5 base station was significant for our experiment, given that we changed the mode of its operation when we measured it. It's on the roof of the building. The antennas are located at 17m and 20m above ground in 3 sectors with the azimuth of 75°, 170°, and 350°. The base station shall use the following frequency bands 900 MHz, 1800 MHz, 2100 MHz, and 2600 MHz. The antenna types at this point are ARIA3415, APXVERR26–C for 900 MHz, 1800 MHz, 2100 MHz, and APXVLL13N–C–na20 for the 2600 MHz frequency band.

The MBTS mobile base station is located next to an existing building at 68 Južná trieda Street. The mobile base station is operated as a dual–sector with ADU4518R9v06 antennas at a height of 15 m and azimuths of 175° and 345°. MBTS uses all frequency bands, i.e. 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, and 2600 MHz.

SELECTION OF MEASUREMENT SITES

In order to assess the impact of the EMF on mobile base stations, we have identified at the selected site 10 measuring points labeled M1–M10. We have focused on the area in which the mobile base station of the mobile operator will be located as a replacement for the V5 base station that has been shut down. In Figure 2, there is the location of the measuring points and their identification by number as well as the V5 base station and its replacement temporary MBTS together with the direction of the antenna radiation.

Figure 2. Location of measurement sites

The measurements have been made at each measuring point for the different modes of operation of the EMF source. The first round of measurements was carried out during the continuous operation of base station V5. We then shut down this source of the electromagnetic field and repeated the measurements. After the mobile base station has been activated and the V5 base station has been completely shut down, we have performed the measurement a third time. Measurements were performed at each measurement site using a Narda SRM–3006 measuring instrument consisting of a spectrum analyzer and a probe for measuring the electric field component. The measuring instrument was placed on a tripod at a height of 1.5 m. The output of the measurements is the frequency spectrum, cumulative values of the electromagnetic spectrum intensity, and the maximum EMF values for the dominant frequencies at each measurement site during individual measurements. The measurement time was set to six minutes. The measurement was performed in the frequency band of the measurement chain from 420 MHz to 6 GHz. During the measurement, the dynamic measurement range was set on the instrument to 10V/m, RBW – 5MHz, the minimum display frequency F_{min} – 700 MHz, and maximum display frequency F_{max} – 3500 MHz.

EXPERIMENT EVALUATION

In evaluating the data obtained by the experiment, we carried out a spectrum analysis, an analysis of the output data, and an evaluation of the results. Data from individual measurements shall be arranged according to the significance of the EMF evaluation by the instrument. The output of the measurement shall also be frequency spectrum graphs and cumulative EMF intensity values for all measuring points.

In processing the results, we set the interfaces of the individual graphs to a significant segment, F_{min} 750 MHz and F_{max} 3400 MHz. On the graph, you can see significant peaks – peaks that occur at an activity at a specific frequency according to the EMF intensity. The resulting tables show the 10 most significant peak values with the highest EMF intensity for a specific base station.

The evaluation was carried out at each measuring point. In the contribution, we offer selected results from locations where the changes were significant.

— Analysis of measurement results at the measuring point M5

The measuring point of the M5 was placed against the source of the V5 electromagnetic field, where the operational changes took place. The distance of the M5 measuring point from the V5 source building shall be 50 m. In Figure 3, there is a representation of the position of the measuring point M5.

Figure 3. Location of the measuring point M5

With the power off, we assumed that the peak values displayed on the frequency spectrum would be minimal. In Table 1, there are the 10 most significant measured values for the various operating modes at the measurement point M5.

Table 1 Peak values of the measuring point M5

Č.	On V5		Off V5		MBTS	
	Freq. [MHz]	Intensity EMF [mV/m]	Freq. [MHz]	Intensity EMF [mV/m]	Freq. [MHz]	Intensity EMF [mV/m]
1	936	1367	1869	699,7	2657	591,8
2	2664	487,1	2653	604,4	805	543,4
3	1869	453,4	946	507,3	2665	396,4
4	2647	451,9	799	364,8	936	300,4
5	954	373,1	935	345,2	950	296,5
6	2629	331,9	789	294,4	1868	285,7
7	2116	292,2	1854	204	2116	230,3
8	1809	275,2	1809	149,9	2138	225,9
9	793	230,5	1879	123,8	2634	193,9
10	802	209	2149	71,96	798	177,7

The following changes have occurred in the different modes of operation (see Table 1):

- F_{2600} – With the V5 source on, the intensity is 451,9 mV / m; with the V5 source off, it is 604,4 mV / m; with the MBTS in operation, it is 591,8 mV / m,
- F_{1800} – With the V5 source on, the intensity is 453,4 mV / m; with the V5 source off, 699,7 mV / m, with the MBTS operating 285,7 mV / m
- F_{800} – With the V5 source on, the intensity is 209 mV / m; with the V5 source off, 364,8 mV / m; with the MBTS operating, 534,4 mV / m

In Figures 4–6, there are the frequency spectrums at the M5 measurement point for the individual base station operation modes.

Figure 4. Frequency spectrum in measurement point M5 – V5 source on

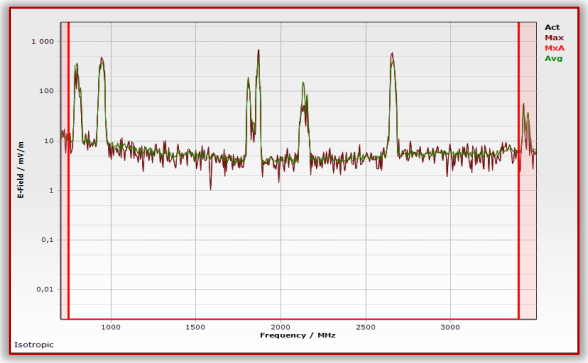

Figure 5. Frequency spectrum in measurement point M5 – V5 source off

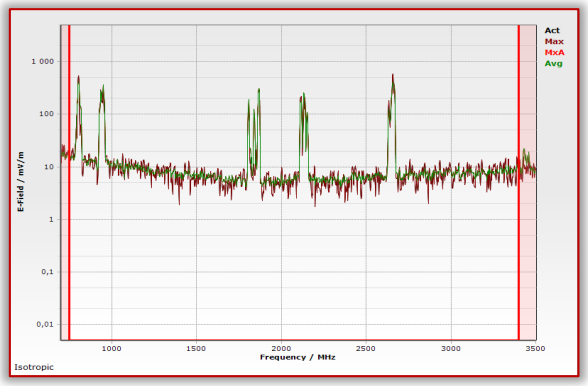

Figure 6. Frequency spectrum in measurement point M5 – MBTS source

The frequency spectrum shown also shows peak values at frequencies that are not generated by the V5 base station. It appears from the technical parameters of the V5 base station that the 800 MHz frequency is not used at the V5 base station, but a significant peak value is displayed in the frequency spectrum in both on and off V5 cases. This implies that the measurement values are also influenced by an unspecified source – probably another base station. Nor has it been confirmed that the V5 base station's measured frequencies will be minimal when switched off (see 1869MHz in tab. 1.).

— Analysis of measurement results at the measuring point M9

The measuring point of the M9 was 105 m from the building where the V5 source is located. In Figures 7 and 8, there is a representation of the frequency spectrums, showing a number of declines in the strength of the electromagnetic field for individual frequencies.

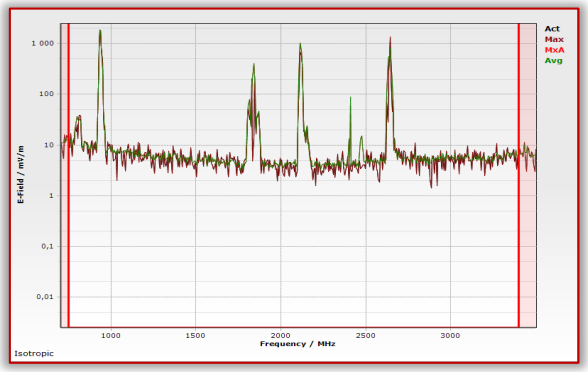

Figure 7. Frequency spectrum in measurement point M95 – V5 source on

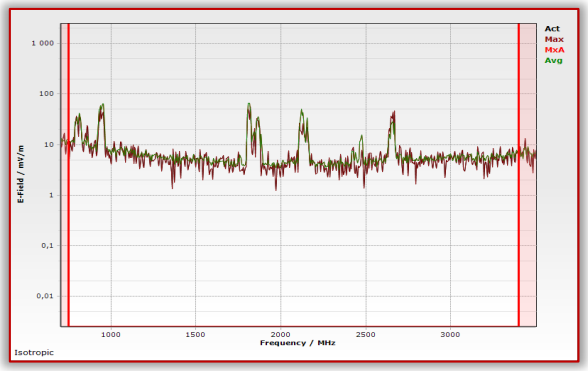

Figure 8. Frequency spectrum in measurement point M9 – V5 source off

In Table 2, the 10 most significant measured values for the various operating modes at the measurement point M9 are given. At 936 MHz with the V5 source on, the strength of the electromagnetic field shall be 2005 mV / m, and, with the V5 source off, the current value shall be 55,19 mV / m, representing a 36–fold decrease (see values marked in tab. 2).

The measurement was carried out in the afternoon, at 4 PM, and the time difference between the on and off measurement was 30 minutes.

Table 2. Peak values of the measuring point M9

Č.	On V5		Off V5		MBTS	
	Freq. [MHz]	Intensity EMF [mV/m]	Freq. [MHz]	Intensity EMF [mV/m]	Freq. [MHz]	Intensity EMF [mV/m]
1	936	2005	1819	55,6	935	305,1
2	2644	1361	939	55,19	803	303,2
3	2114	702,1	1807	52,51	2113	145,9
4	1844	230,2	952	47,85	1838	132,3
5	1829	203,3	2669	46,85	2638	58,52
6	2659	78,28	2658	45,16	1808	52,96
7	2624	67,93	930	44,68	2646	52,12
8	1808	51,78	815	41,32	1865	49,66
9	1818	41,94	2651	39,27	950	49,6
10	1864	41,91	795	37,41	2665	40,39

RESULTS OF THE EVALUATION

From the evaluation of the measurement results, changes in the strength of the electromagnetic field for the individual measuring points are evident for changes in the operation of V5 and its replacement by a mobile base station. This decrease can be seen at all measurement points even at cumulative values. In Table 3, cumulative values for individual measuring points in different operating modes are given.

Table 3. Cumulative values for M1–M10

Measuring point	M1	M2	M3	M4	M5
V5 source on [mV/m]	778,0	252,3	1043	632,0	1631
V5 source off [mV/m]	485,7	169,2	401,9	392,2	1296
MBTS [mV/m]	756,6	397,5	599,0	1043	1292
Measuring point	M6	M7	M8	M9	M10
V5 source on [mV/m]	1174	237,3	486,0	2373	416,0
V5 source off [mV/m]	529,0	148,6	164,1	168,3	369,7
MBTS [mV/m]	773,7	257,8	270,2	555,2	884,9

For example, at the M5 measurement point, the changes in the cumulative values of the electromagnetic field intensity are insignificant, namely 1631 mV / m with the source switched on, 1296 mV / m with the field switched off and the MBTS 1292 mV / m started. At the M9 measuring point, which is also close to the source, during continuous operation, the electromagnetic field intensity value is 2373 mV / m, when switched off, the intensity drops to 168,3 mV / m and, after starting its MBTS replacement, the intensity value rises to 555,2 mV / m.

Mobile operators at the site under assessment operate in the frequency range 800–2600 MHz, which according to the current legislation in force in the Slovak Republic corresponds to the exposure action values for electromagnetic fields of 39 000–61 000 mV / m.

CONCLUSION

Before the experiment, we assumed that the EMP intensity values with the V5 source switched off would be minimal. This assumption has not been confirmed at the measurement point M5. Although the measurement with the V5 base station switched off and on was carried out in a range of about 2 hours, they appeared in the peak spectrum at frequencies that were not considered in the evaluation. At some measuring points e.g. M9 has been shown to decrease the strength of the electromagnetic field several times at individual frequencies compared to the switched–on source. The results of the experiment suggest that consideration should be given to the appropriateness of an EMF evaluation methodology that prioritizes the evaluation of a particular resource rather than the entire site.

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