# Measurements of electromagnetic fields emitted in urban environments

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***Abstract:*** *The paper presents an analysis of the results of measurements of electromagnetic radiation from a base station installed on the roof of a site located in an area with a higher degree of urbanization, an extended center of the capital of Bulgaria, Sofia. Using mobile measuring equipment Narda AMB-8057-03, the dynamics of electromagnetic radiation in the frequency range from 100 kHz to 7 GHz was monitored over a period of eight days (weekdays and weekends). The obtained values for the levels of electromagnetic fields comply with the current national legislation and European standards. They are ≤ 10 μW/cm$^2$. However, there remains a need for monitoring, tracking and control of the emitting EMF sources, because the susceptibility of an individual person is individual and the possible health effects are different, which in some cases manifests itself as "hypersensitivity" to electromagnetic radiation.*
***Keywords****: ELECTROMAGNETIC RADIATION, ELECTROMAGNETIC POLLUTION, ENVIRONMENTAL LEGISLATION, EMF MONITORING*

## *1. Introduction*

Modern wireless communication systems (GSM) and networks (GSM base stations) are an integral part of telecommunications infrastructure. They provide continuous connectivity for billions of users worldwide and offer a vast range of capabilities. However, this has also led to the saturation of the environment, especially urban areas, with technical sources of electromagnetic emissions. Electromagnetic pollution is caused by the ever-increasing demands of mobile users for high-quality service, high data speeds, and ultra-reliable communication between devices. The new 5G mobile networks meet all these requirements, but also result in increased electromagnetic radiation. As is known, mobile phones (GSM) operate by communicating with a fixed infrastructure called a base station, generating radio frequencies between them. 5G telecommunications networks operate at high frequencies up to 8 GHz. To ensure reliable communication between devices, small cells with a large number of transmitters are used to cover smaller areas. In urban environments, more and more base stations (BS) are mounted on walls and rooftops of buildings where people work or live. Such a system with multiple antennas can generate very large electromagnetic radiation emissions, higher concentrations of electromagnetic energy, closer to the general public. As a result, the level of exposure to electromagnetic fields (EMF) can lead to an increase in radiation exposure for users.

Electromagnetic pollution is becoming increasingly serious with each passing day in the modern urban environment, raising growing concerns about the impact of electromagnetic radiation (EMF) on human health. As a result, maximum permissible exposure limits for non-ionizing radiation have been established, regulating the conditions for human exposure to electromagnetic fields. These standards have been adopted and published in various international and national laws and regulations [1-6].

Although everyone is aware of the benefits provided by electromagnetic systems and devices, only a few users understand the real dangers associated with them. EMFs are biologically active and can have adverse effects on the environment, plants, and animals, as well as on human health [7-11]. Many research teams are increasingly focused on studying the influence of EMFs on the biological effects triggered in human and animal physiology. EMFs negatively affect the nervous system and the brain due to the electrical nature of nerve impulses [11-13]. Using mobile phones before bed delays and reduces sleep, causes depression, leads to mood changes, and affects brain physiology, resulting in poor concentration [14]. It can also lead to changes in cellular structure and DNA, as well as impact the immune, hormonal, and reproductive systems [15-17]. Other studies report headaches, a warming sensation in the ear, and a burning feeling on the facial skin [18].

The present study was conducted at the request of citizens due to concerns about exposure to electromagnetic radiation from a base station installed near the facility where they reside permanently.

## *2. Characterization methods*

Measurements were conducted using a Narda AMB-8057-03 mobile measurement kit equipped with an isotropic antenna to assess the characteristics of electromagnetic fields propagating in the environment and reaching the antenna from all spatial directions (360°), including points that are difficult to observe.

This type of equipment is used for monitoring electromagnetic fields. The device measures and records data from continuous measurements of the E (electric) and H (magnetic) components of electromagnetic fields within the frequency range of 100 kHz to 7 GHz, transmitting the data once every 24 hours to a storage server.

Mobile equipment Narda AMB-8057-03 provides the ability to visualize and review measurement information for a selected time interval, date, week or day, for the entire frequency range (110 kHz – 7 GHz) or for a selected sub-range. The electric field measurement data is averaged for consecutive intervals every 6 minutes for both the average value (RMS) and peak values (Peak) for a given frequency.

## *3. Results and Discussion*

Measurements of electromagnetic fields were conducted in object located in the extended downtown area of Sofia, Bulgaria's capital. The measured object is an apartment on the eighth (top) floor of a residential building. A mobile operator's base station antennas are installed on the roof of an adjacent building positioned at a right angle to the studied object (Fig. 1). The distance between the object and the antennas is approximately 50 meters in a straight line with direct visibility to the antennas.

The measurements were conducted continuously over 24-hour periods for eight consecutive days (including both weekdays and weekend days), with the objective of studying the temporal distribution characteristics of EMF in two frequency bands: 1842 MHz and 2140 MHz. These frequency bands encompass the operational frequencies of all mobile network operators functioning within Bulgaria's territory.

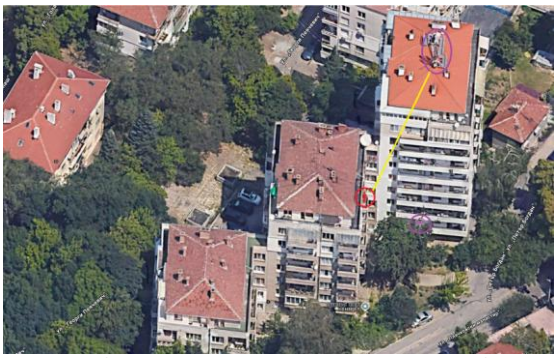

***Fig.1*** *Location of measuring equipment and arrangement of base stations around the research object [19]*

In Figure 2 and Figure 3, the daily results of the conducted measurements are graphically displayed, visualized, and recorded by the Narda AMB 8057-03 mobile equipment. The average value (RMS) and peak value (Peak) for the respective frequency ranges of 1842 MHz and 2140 MHz are presented in different colors. The

data was obtained and visualized in V/m, with the maximum permissible value of 6 V/m outlined on the graphs (Limit - white line). During the measurement, data on the ambient temperature in degrees is accumulated, visualized, and recorded.

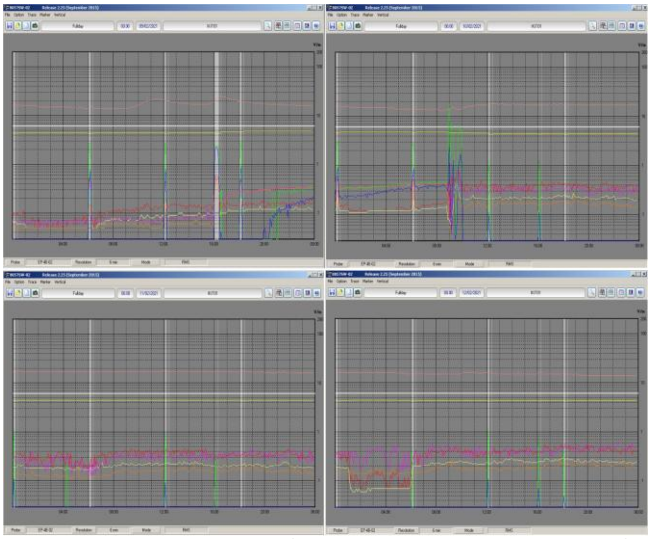

***Fig.2*** *Measured electromagnetic field values in the studied object over four consecutive days*

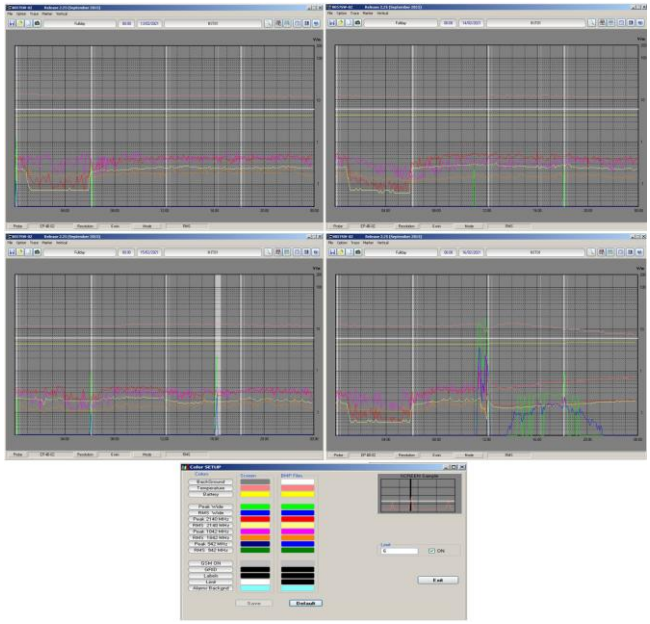

***Fig.3*** *Measured electromagnetic field levels in the study object over four consecutive days, including legend*

The accepted maximum permissible levels of electromagnetic radiation in Bulgaria, ensuring adequate protection of public health, are set at 10 μW/cm². The mobile measurement equipment NARDA AMB 8057-03 measures, records in digital files, and visualizes the results in V/m. For comparison with the permissible limits according to BDS (Bulgarian National Standards), national, and international standards, the measured values are converted from V/m to μW/cm² using a standardized formula.

Figure 4 and figure 5 display the maximum averaged values (RMS) from continuous 24-hour measurements of electromagnetic fields in two frequency ranges - 1842 MHz and 2140 MHz - for each day in the studied object.

The maximum averaged values (RMS) of the measured electromagnetic radiation power density for the 1842 MHz frequency range during the study period ranged from 0.01 to 0.06 μW/cm², while for the 2140 MHz frequency range, they ranged from 0.015 to 0.075 μW/cm².

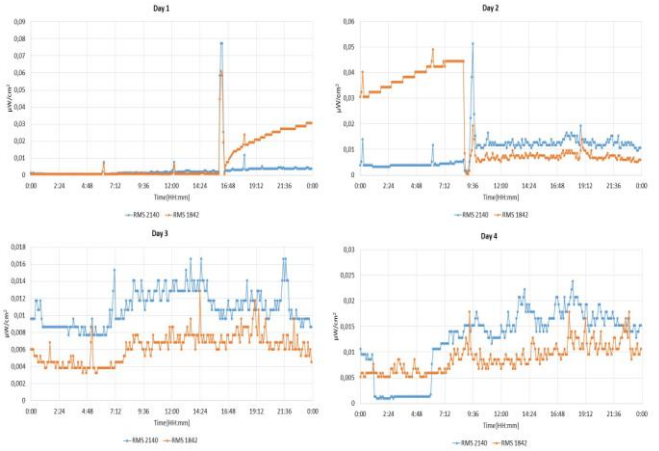


***Fig. 4*** *Maximum average values RMS at frequency range 1842 MHz and frequency range 2140 MHz from measurements of electromagnetic fields in a research object four consecutive days*

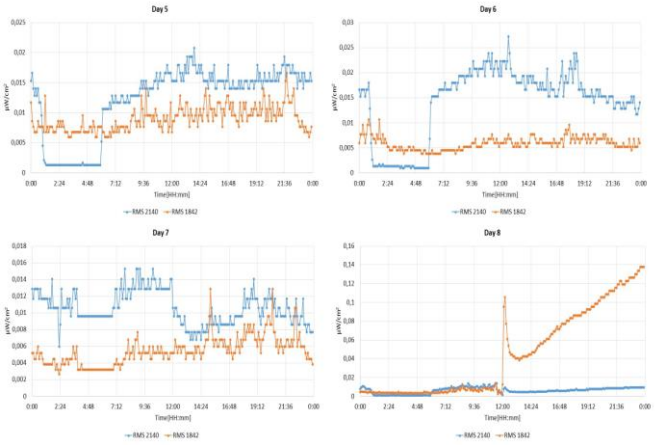


***Fig. 5*** *Maximum average values RMS at frequency range 1842 MHz and frequency range 2140 MHz from measurements of electromagnetic fields in a research object four consecutive days*

From the graphs shown in Figure 4 and Figure 5, the maximum averaged values for each time period remain well below the permissible limit of 10 μW/cm² as per the standard. Quantitatively, the EMF levels in the study area are quite stable, although slightly greater variations are observed in the recorded maximum peak values (figure 6 and figure 7) compared to the maximum averaged values.

The maximum peak values (Peak) of measured EMF range from 0.045 to 0.10 μW/cm² for the 1842 MHz frequency band, and from 0.05 to 0.17 μW/cm² for the 2140 MHz frequency band - significantly lower than the permissible exposure standart.

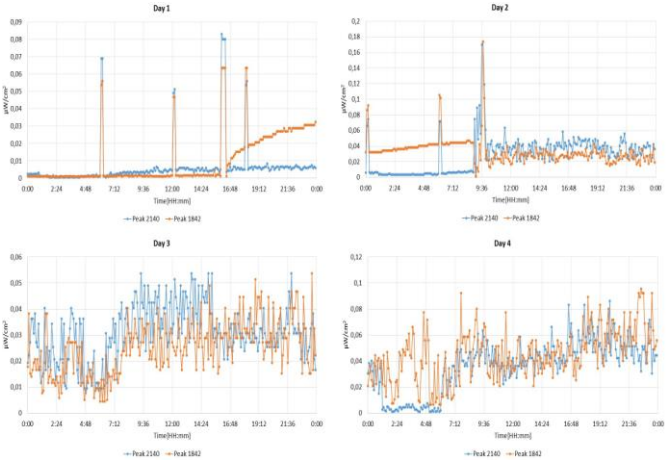


***Fig. 6*** *Maximum peak values RMS at frequency range 1842 MHz and frequency range 2140 MHz from measurements of electromagnetic fields in a research object four consecutive days*

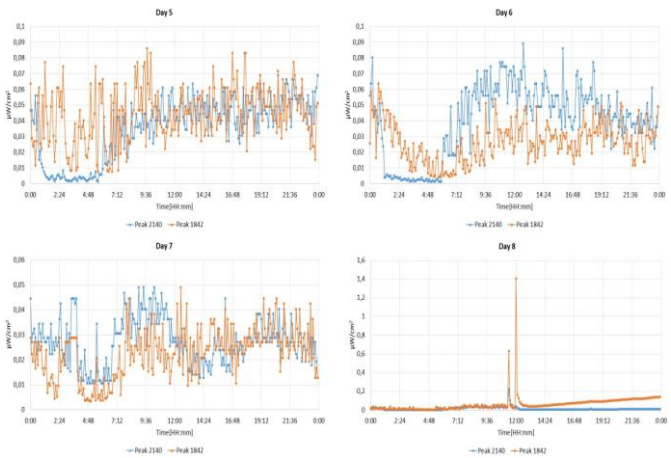


***Fig. 7** Maximum peak values RMS at frequency range 1842 MHz and frequency range 2140 MHz from measurements of electromagnetic fields in a research object four consecutive days*

## *4. Conclusions*

The purpose of this study was to monitor the dynamics of electromagnetic radiation in object (an apartment on the eighth/top floor of a building) located approximately 50 meters in direct line of sight from installed mobile operator base station antennas. Following analysis of data from continuous 24-hour measurements conducted over eight days (including weekdays and weekend), the following was established:

All measured values were significantly below the accepted maximum permissible limit of ≤10 μW/cm², which ensures adequate protection of public health in Bulgaria.

- The maximum average values (RMS) of the measured power density of electromagnetic radiation:

- For the frequency range of 1842 MHz, RMSmax - 0.06 μW/cm².
- For the frequency range of 2140 MHz, RMSmax - 0.075 μW/cm².

- The maximum peak values (Peak) of the measured power density of electromagnetic radiation:

- For the frequency range of 1842 MHz, Peakmax – 0.10 μW/cm².
- For the frequency range of 2140 MHz, Peakmax - 0.17 μW/cm².

The antennas from the nearby base station do not pose a health risk to the surrounding population. Although the measured EMF values are generally safe and well below the norm, the need for monitoring and control of the Base Station remains, because the susceptibility of an individual is individual and some people may experience negative health effects from prolonged exposure.

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