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the daily high fluctuation of student population.

In this paper, the measurement results obtained at campus location near the corner of Dr S. Milosevica and Dr V. Savica Streets will be presented. This location was chosen, since in the vicinity there are: The Higher School of Professional Business Studies, the Faculty of Economy and the Student's sport center. Additionally, an elementary school and a kindergarten are located, as shown in Fig. 2.

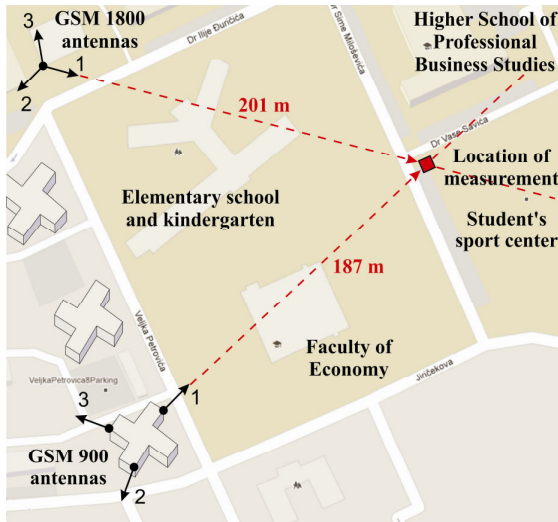


Fig. 2 Measurement location and surrounding base stations

Besides, two GSM base stations are active in the vicinity of this location, which main beams of sector 1 antennas intersect over the measurement location, as can be seen from Fig. 2 [9].

The open area measurement was performed, observing the so-called unperturbed field, without the presence of persons or any other objects that can influence EMF distribution. At this location, the measurement grid was formed, consisting of 25 squared arranged points with a matrix form. The measurement points were positioned equidistantly, with a distance of 1 m, according to standard SRPS EN 50400:2008 [10], which suggests that the minimum distance has to be 0.5 m, in case of the high-frequency measurements.

The measurement procedure was presented in a previous published paper [9], and here it will be shortly reintroduced:

- first, a preliminary field scan was conducted over the measurement grid, determining the spatial distribution of EMF strength and point of local maximum, the so-called hot-spot,
- next, detailed measurements were carried out within the hot-spot, using the continuous broadband monitoring approach, and
- finally, the exposure assessment of the general population was performed, according to Serbian legislation [3].

#### IV. MEASUREMENT RESULTS

The measurements were performed using handheld NBM-550 broadband field meter [8], [11], with continuous measurement mode [11], equipped with the electric field probe

EF 0691 [12], which frequency range is from 300 kHz to 6 GHz.

##### A. Preliminary Field Scan

Preliminary field scan was performed over the measurement grid at height of 1.1 m above the ground surface. The technical personnel held the instrument for a few seconds at the measurement point, recorded level of the electric field strength and moved forward to the next point. While measurements were being conducted, the field probe was positioned at least 50 cm from the operator's body, according to standard SRPS EN 50492:2010 [13], because dominant sources (GSM 900, GSM 1800) are in the range above 300 MHz.

Table I shows the results of the field scan procedure for high-frequency electric field over 25 measurement grid points.

TABLE I  
ELECTRIC FIELD STRENGTH [V/m]

P1	P2	P3	P4	P5
0.65	0.64	0.67	0.72	0.73
P6	P7	P8	P9	P10
0.67	0.73	0.74	0.79	0.85
P11	P12	P13	P14	P15
0.74	0.82	0.79	0.80	0.63
P16	P17	P18	P19	P20
0.86	0.89	0.85	0.74	0.79
P21	P22	P23	P24	P25
0.68	0.89	0.84	0.93	0.93

It can be observed that values of the electric field strength are in the range from 0.63 V/m to 0.93 V/m and the maximum value of electric field strength was found at points P24 and P25. Unfortunately, the presence of some metal objects in the vicinity of those points was noticed, which could cause interference and diminish the reliability and accuracy of results of monitoring. Thus, the point P22 was declared as a hot-spot, without any impairment on measurement validity.

##### B. Statistic Analysis of the Preliminary Field Scan

According to the preliminary field scan, it can be seen that spatial values of the electric field strength, at this location, are far below the Serbian prescribed reference levels [3], [14].

The highest value of the electric field strength is 0.93 V/m, which does not represent serious threat for the general population. Additionally, average and minimum values are also within the allowed limits, as shown in Table II.

TABLE II  
STATISTICAL ANALYSIS OF THE SPATIAL DISTRIBUTION

$E_{max}$ [V/m]	$E_{min}$ [V/m]	$E_{avg}$ [V/m]	St.Dev [V/m]
0.93	0.63	0.775	0.090651

It can be seen that standard deviation of field strength is very small with value of 0.090651. This number is a measure of how all values are dispersed from the average value. It is calculated using following equation:

$$\sqrt{\frac{\sum_{i=1}^n (E_i - E_{avg})^2}{n-1}} \quad (1)$$

where  $n=25$  is number of measurement points,  $E_i$  is measured value of electric field strength at point  $i$  and  $E_{avg}$  is electric field average value of 0.775 V/m.

This statistical analysis confirms that chosen location is location with almost uniform spatial distribution and very small deviation of the electric field strength.

### C. Continuous Monitoring in the Hot-Spot

After finishing first stage of measurement and declaring the so-called hot-spot point, continuous monitoring of the electric field was conducted in this point. It was done with 6 min averaging, as suggested in the guidelines [15], [16]. However, in this initial monitoring campaign measurement period was only four hours and during that time period continuous monitoring was performed by observing the maximum, minimum and the averaged field values. The NBM-550 instrument was set up on the wooden tripod and the probe was positioned at the height of 1.7 m, as shown in Fig. 3.

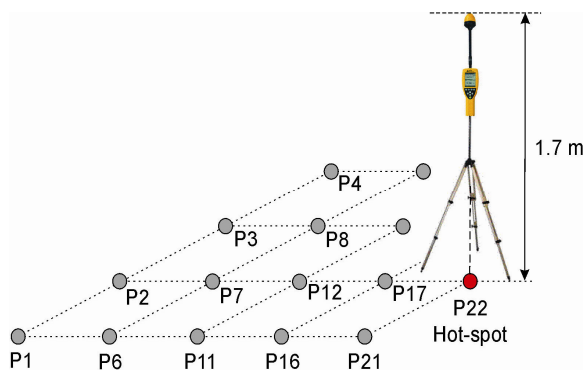


Fig. 3 Continuous monitoring of electric field strength at the hot-spot

Height of 1.7 m was chosen as the average human height, and the primary aim was to perform monitoring on highly sensitive position of the human head. During monitoring process, the instrument was set up to "Timer Logging mode" [11], recording values of the electric field without interruption during the time period of four hours.

Results of the continuous monitoring are shown in Fig. 4, where three curves are plotted on the graph describing fluctuation of the maximum, minimum and average level of the electric field during the monitoring period.

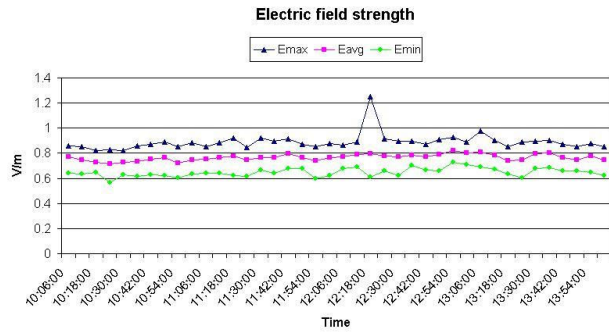


Fig. 4 Daily curves as a result of the continuous monitoring

The recorded values of the electric field strength are far below the Serbian prescribed reference levels [3], [14]. Averaged values are around 0.8 V/m, during entire period of monitoring, suggesting that chosen location is not dangerous for the general population. The peak in graph for the maximum value of the electric field, that can be noticed, is probably result of random increase of phone traffic, caused by the passerby at the site.

### D. Statistic Analysis of the Continuous Monitoring

Observing acquired measurement results of the continuous monitoring and the graph for the average value of the electric field, it can be concluded that field strength remains constant during the time period of four hours. In Table III some statistical data are given, confirming such conclusion.

TABLE III  
STATISTICAL ANALYSIS OF THE MEASUREMENT RESULTS

	Max	Min	Avg	St.Dev
$E_{max}$ [V/m]	1.248	0.819	0.888	0.066418
$E_{avg}$ [V/m]	0.820	0.718	0.766	0.025271
$E_{min}$ [V/m]	0.727	0.564	0.648	0.033754

It can be noticed that maximum value of the electric field strength, during monitoring period, is within the range from 0.819 V/m to 1.248 V/m. That is quite below the Serbian prescribed reference levels [3], [14]. Additionally, analysis shows that average and minimum values of the electric field strength are also within prescribed reference levels.

The standard deviations of the maximum, average and minimum values are 0.066418 V/m, 0.025271 V/m and 0.033754, respectively. Such small deviation results that almost constant field strength is present, even though it is expected that EMF radiation can achieve its peak in monitoring period, since several telecommunication and broadcasting services are fully operable.

### V. EXPOSURE ASSESSMENT

Based on permanent recording of the measurements during 24/7 period, the SEMONT system is able to detect fluctuations of EMF and daily exposure can be assessed for any instant of time.

### A. Exposure Assessment at the Test Location

Unfortunately, if the broadband measurement approach is applied it is not possible to determine the frequencies at which EMF sources emit. Therefore, the exposure assessment needs to take into account the entire frequency range covered by the field probe.

In the SEMONT system, the lower and upper level of global exposure ratio ( $GER$ ) was calculated according to the standard SRPS EN 50492:2010 [13]. The following expressions were used for  $GER$  level assessment [17]:

$$GER_{upper} = \left( \frac{E_{mes}}{E_{ref\ min}} \right)^2, \quad GER_{lower} = \left( \frac{E_{mes}}{E_{ref\ max}} \right)^2 \quad (2)$$

where  $E_{mes}$  is measured value of electric field strength, while  $E_{ref\ min}=11$  V/m and  $E_{ref\ max}=34.8$  V/m are the minimum and maximum reference levels of the electric field strength, prescribed by the Serbian legislation for the general population [3], [14], over the field probe frequency range.

While performing exposure assessment, the SEMONT system uses the average values of the measurements as  $E_{mes}$ . Results of performed  $GER$  assessment are shown in Fig. 5.

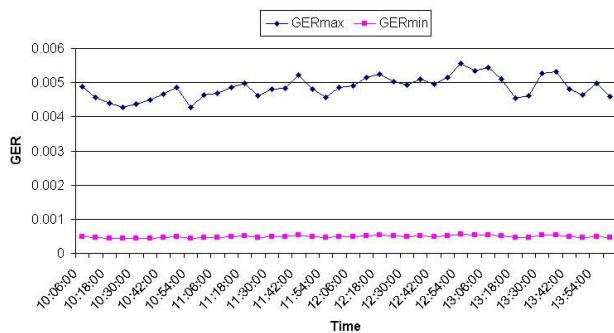


Fig. 5 The SEMONT  $GER$  assessment

The real exposure ratio lies between the lower and the upper limits, and monitoring shows that its level at the hot-spot ranges between 0.00042625 and 0.0055573, which is far below the allowed limit of  $GER_{max} = 1$ , prescribed by the legislation for the general population [3], [14].

### B. Statistical Analysis of the Exposure Assessment

Observing obtained  $GER$  results during the time period of four hours, the statistical analysis was performed and results are given in the Table IV.

TABLE IV  
STATISTICAL ANALYSIS OF THE EXPOSURE ASSESSMENT

	Max	Min	Avg	St.Dev
$GER_{upper}$	0.0055573	0.0042661	0.0048579	0.00031986
$GER_{lower}$	0.00055526	0.00042625	0.00048538	0.000031959

The maximum value of  $GER_{upper}$  is 0.0055573 and that result confirms that exposure is far below maximal allowed level, suggesting that EMF strength, present on the test

location, is not dangerous, neither for humans nor the equipment.

Beside, statistical analysis shows that standard deviations of  $GER_{upper}$  and  $GER_{lower}$  are 0.00031986 and 0.000031959, respectively; confirming that at the monitoring location there is no any unexpected increase of EMF radiation in environment.

## VI. CONCLUSION

Considering increased number of EMF sources, the development of modern systems for EMF monitoring became necessary, as a support for authorities in their efforts to timely inform public on current level of EMF strength in environment and their surroundings.

The SEMONT system is unique system at the national level in the Republic of Serbia, introducing an advanced and modern approach of the wireless sensor network implementation for daily supervision of the overall and cumulative level of the EMF, over an area of interest.

In order to test SEMONT functionality and to perform investigation of EMF over the area of the campus of the University of Novi Sad, initial monitoring was conducted.

In the vicinity of monitored location, the presence of two GSM base stations, as dominant sources, was noticed, indicating that significant electric field level could be expected in this area. However, results of preliminary spatial scan and continuous monitoring show that level of electric field strength is in acceptable range and far below allowed limit prescribed by the Serbian legislation for the general population.

The performed monitoring will be valuable for the verification of the SEMONT system functionality and for monitoring campaigns that will follow.

## ACKNOWLEDGMENT

This work is supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia, under the grant for project TR 32055.

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