

Measurement and Comparison of Signal Levels of GSM900, GSM1800 and UMTS Bands

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Abstract: Signal levels of GSM900, GSM1800 and UMTS bands were measured as mobile on the main streets in the city center of Diyarbakır at the same time and route during a week. The measurements were performed by using high precision and portable spectrum analyzer with an isotropic electric field antenna and a laptop. The high precision spectrum analyzer is a device that measures the high frequency electromagnetic fields. The isotropic electric field antenna allows a three axis measurements. The laptop was used to record and analyze the measurement samples. Electric field strengths were measured as signal levels in this study. Some statistical parameters such as standard deviation and variance were calculated with 95% confidence interval for measurement samples. The highest signal levels were measured as 3.8580 V/m for GSM 900 band, 2.9440 V/m for GSM1800 band and 6.0900 V/m for UMTS band during a week. Similarly, mean electric field strength values as average signal levels were calculated as 0.4985 V/m for GSM 900 band, 0.2350 V/m for GSM1800 band and 0.6281 V/m for UMTS band. According to the mean electric field strength values, the average signal levels of three bands were ranked as UMTS, GSM900 and GSM1800 from the largest to the smallest, respectively. The highest variation in standard deviation and variance was observed on Wednesday for GSM900 and UMTS bands and Thursday for GSM1800 band.

Keywords: Signal level, Electric field strength, GSM, UMTS, Statistics.

1. Introduction

Advanced technological developments in mobile communication systems have influenced people's lives in many ways. Electromagnetic field (EMF) signal levels of mobile communication systems such as Global System for Mobile Communications (GSM) and Universal Mobile Telecommunications System (UMTS) are very important for epidemiological studies [1–3]. The effects of EMF signal levels on human health were examined by many scientific studies [4,5]. Basic restrictions for EMF signal levels were recommended by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) [6]. Turkey has adopted the ICNIRP's reference levels for EMF exposure.

Mobile communication systems such as GSM and UMTS use different technologies. For this reason, signal levels of them may be different in the environment. GSM uses time division multiple access technology (TDMA) and frequency division multiple access technology (FDMA). The maximum output power of a radio transmitter used in GSM is 10-40 watt and frequency of power control is about 2 Hz [7]. UMTS uses code division multiple access technology (CDMA). The maximum output power of a radio transmitter used in UMTS is 20-60 watt and frequency of power control is 1500 Hz [7]. Power control and discontinuous transmission are two smart techniques [8] which are used in GSM and UMTS networks to reduce the EMF signal levels in the environment. Thus, these smart techniques enable to save the power of mobile phone and base station.

The aim of this study was to measure signal levels of GSM900,

GSM1800 and UMTS bands as mobile in the city center of Diyarbakır in Turkey at the same time and route during a week.

Then, signal levels of them were compared with each other and statistically analyzed. Some statistical values such as standard deviation and variance were calculated with 95% confidence interval. The average signal levels of three bands were evaluated.

2. Material and Method

The measurements were performed between 10 November 2014 and 16 November 2014 as mobile on the main streets where people spend time and have fun. Communication way from base station to mobile phone is called downlink. Likewise, communication way from mobile phone to base station is called uplink. Output power of the base station is much higher than output power of the mobile phone. Therefore, downlink band was only taken into account during the measurements. Downlink frequency bands of GSM900, GSM1800 and UMTS as shown in Table 1 were measured during the whole week between 17:00 and 18:20 hours at the same route.

Table 1. EMF Bands and their frequency range

RF EMF Band	Frequency Range (MHz)
GSM900 DL	935 - 960
GSM1800 DL	1805 - 1880
UMTS DL	2110 - 2170

DL: Downlink

The measurement set consisted of selective radiation meter SRM-3006 (Narda Safety Test Solutions, USA) connected to isotropic antenna by a radiofrequency cable and a laptop for data collection. SRM-3006 is a high precision and portable spectrum analyzer which measures the high frequency electromagnetic fields. The isotropic antenna is the three axis electric field antenna frequency range from 27 MHz to 3 GHz, dynamic range 0.2 mV/m - 200 V/m and maximum extended measurement uncertainty +2.6/-3.8 dB for 85-2200 MHz. Cable contains ferrite

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to reduce the effects of the external fields and its length is 1.5 meter [9].

Channel bandwidth for GSM900 [10] and GSM1800 [10] is 200 kHz, and for UMTS [11] is 5 MHz. Resolution bandwidth of SRM-3006 for GSM900 and GSM1800 was set to 50 kHz and for UMTS was set to 1000 kHz for better measurement.

SRM-3006 equipped with three axis electric field antenna which was placed at 1.70 meter height above ground was mounted on the top of the car. Average speed of the car in the measurement route was about 40 km/h.

In this study, electric field strength values of three bands were measured as signal levels. The worst case was considered during the performance of measurement. In this way, the maximum instantaneous electric field strength values of GSM900, GSM1800 and UMTS bands were chosen as measurement samples at an interval of 10 second during the mobile measurements. Then, the number of measurement samples for

each EMF band was become equal to 472 samples per a day and 3304 samples per a week.

The program written by us got information (e.g., latitude, longitude, the maximum instantaneous electric field strength values) from the SRM-3006 and recorded measurement samples for statistical analysis. Descriptive statistics such as standard deviation and variance were calculated with 95% confidence interval. Measurement samples were analyzed using IBM SPSS Statistics software, version 21 [12].

3. Results and Discussion

Currently, there are three mobile network operators in Turkey. GSM frequency band of two mobile network operators is 900 MHz but the other is 1800 MHz. UMTS frequency band of three mobile network operators is 2100 MHz.

As seen in Table 2, Table 3 and Table 4; 10, 11, 12, 13, 14, 15, 16 denote measurement days (Monday, Tuesday, Wednesday, Thursday, Friday, Saturday and Sunday).

Table 2. Daily Statistics for GSM900 DL

EMF band	N	Range	Minimum	Maximum	Sum	Mean	Std. Deviation	Variance
GSM900_10	472	2.8594	0.0316	2.8910	225.7753	0.478338	0.4312111	0.186
GSM900_11	472	3.0889	0.0321	3.1210	230.1624	0.487632	0.4306846	0.185
GSM900_12	472	3.8250	0.0331	3.8580	235.3006	0.498518	0.4636433	0.215
GSM900_13	472	2.1772	0.0308	2.2080	221.1566	0.468552	0.4148358	0.172
GSM900_14	472	2.4504	0.0336	2.4840	229.4507	0.486124	0.4238145	0.180
GSM900_15	472	2.8609	0.0342	2.8950	221.1493	0.468537	0.4340354	0.188
GSM900_16	472	3.1351	0.0329	3.1680	222.0962	0.470543	0.4346786	0.189

N: number of samples Std: Standard

Table 3. Daily Statistics for GSM1800 DL

EMF band	N	Range	Minimum	Maximum	Sum	Mean	Std. Deviation	Variance
GSM1800_10	472	1.6957	0.0533	1.7490	101.6737	0.215410	0.2206387	0.049
GSM1800_11	472	2.7386	0.0535	2.7920	100.0886	0.212052	0.2668446	0.071
GSM1800_12	472	2.6898	0.0532	2.7430	104.4067	0.221201	0.2548263	0.065
GSM1800_13	472	2.8910	0.0530	2.9440	110.9306	0.235023	0.2713217	0.074
GSM1800_14	472	1.7811	0.0519	1.8330	101.6694	0.215401	0.2271515	0.052
GSM1800_15	472	2.0164	0.0536	2.0700	105.7467	0.224040	0.2543026	0.065
GSM1800_16	472	2.1617	0.0524	2.2140	104.4510	0.221294	0.2443795	0.060

N: number of samples Std: Standard

Table 4. Daily Statistics for UMTS DL

EMF band	N	Range	Minimum	Maximum	Sum	Mean	Std. Deviation	Variance
UMTS_10	472	3.1661	0.0729	3.2390	280.1896	0.593622	0.4958261	0.246
UMTS_11	472	4.6792	0.0748	4.7540	293.7641	0.622382	0.5356311	0.287
UMTS_12	472	6.0150	0.0750	6.0900	296.4812	0.628138	0.5753035	0.331
UMTS_13	472	3.9406	0.0724	4.0130	290.9976	0.616520	0.5179273	0.268
UMTS_14	472	3.9470	0.0741	4.0210	291.0592	0.616651	0.5403461	0.292
UMTS_15	472	4.7784	0.0786	4.8570	285.9496	0.605825	0.5459556	0.298
UMTS_16	472	4.3507	0.0753	4.4260	287.3403	0.608772	0.5040396	0.254

N: number of samples Std: Standard

Table 5. A Weekly Statistics for Measured EMF Bands

EMF band	N	Range	Minimum	Maximum	Sum	Mean	Std. Deviation	Variance
GSM900	3304	3.8272	0.0308	3.8580	1585.091	0.479749	0.4332338	0.188
GSM1800	3304	2.8921	0.0519	2.9440	728.9667	0.220632	0.2489943	0.062
UMTS	3304	6.0176	0.0724	6.0900	2025.782	0.613130	0.5309375	0.282

N: number of samples Std: Standard

Table 2 shows some statistical values [12] about measured GSM900 band. The maximum electric field value is 3.8580 V/m and the minimum electric field value is 0.0308 V/m. As seen in Table 3, for GSM1800 band, the maximum electric field value is 2.9440 V/m and the minimum electric field value is 0.0519 V/m. As shown in Table 4 about UMTS band, the maximum electric field value is 6.0900 V/m and the minimum electric field value is 0.0724 V/m.

It should be noted that the number of base stations which radiate in UMTS band in the city center are greater than the base stations of the other bands. Similarly, the number of base stations which radiate in GSM900 band are greater than the base stations of GSM1800 band.

According to the mean electric field values in Table 5, the largest mean electric field value is 0.613130 V/m in UMTS band and the smallest mean electric field value is 0.220632 V/m in GSM1800 band. The measured EMF signal levels among three bands can be ranked from the largest to the smallest as UMTS, GSM900 and GSM1800, respectively.

It should be noted that three mobile network operators use the UMTS band, two mobile network operators use GSM900 band and the other operator just uses GSM1800 band. In addition, the number of base stations and deployment of sites also affected the EMF signal levels. Due to these reasons, measurement results may vary from street to street and from city to city.

During a week, the highest variation in standard deviation and variance was observed on Wednesday for GSM900 band. The standard deviation is 0.4636433 and the variance is 0.215 as seen in Table 2.

Likewise, the highest variation in standard deviation and variance was determined on Wednesday for UMTS band. The standard deviation is 0.5753035 and the variance 0.331 as seen in Table 4. The highest variation in standard deviation and variance was observed on Thursday for GSM1800 band. The standard deviation is 0.2713217 and the variance is 0.074 as seen in Table 3.

4. Conclusions

Signal levels of GSM900, GSM1800 and UMTS bands were measured as mobile on the main streets in the city center of Diyarbakır during a week.

In terms of the mean electric field value, it was determined that the average signal level of the UMTS band during a week was greater than the GSM900 band and the average signal level of GSM900 band was greater than GSM1800 band. The average signal levels of three bands can be listed as UMTS, GSM900 and GSM1800 from the largest to the smallest, respectively.

The highest variation in standard deviation and variance during a week was observed on Wednesday for GSM900 and UMTS bands. Furthermore, the highest variation in standard deviation and variance was determined on Thursday for GSM1800 band.

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