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Transmitted Power of Mobile Phones in 4G Network of Seoul

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Abstract

The transmitted (Tx) power of mobile phones during a voice call has been investigated in operating 4G (LTE) networks in Seoul. The power value of a phone was recorded for more than 280 hours per a mobile operator using a commercial software on a notebook computer. The objective of this study is to find an average Tx power of a mobile phone according to an operating frequency band of three major Korean operators in real environments for Seoul, one of the largest populated cities in the world. The results will be used for cumulative exposure assessment of individuals in real environments.

1. Introduction

Technologies of wireless communication systems are rapidly changed and Code division multiple access (CDMA), Wideband CDMA (WCDMA) and Long Term Evolution (LTE) networks by three operators currently coexist in South Korea. Now service of the fifth generation of wireless technology is just around the corner.

Until now, numerous studies on electromagnetic absorption in the human body exposed to RF EMF radiation from mobile phones have been published and most of them are based on a constant transmitted (Tx) power of a phone, not real Tx power. This paper presents Tx power data measured according to a frequency band and a provider of a mobile phone operating in 4G networks of Seoul.

2. Measurement Method

The Tx power of mobile phones was measured in Seoul Metropolitan City with the population density of about 16,500 persons/km^2. The total administrative districts of Seoul City are 25. Each district is further divided into a neighborhood unit and has about 10 to 25 neighborhoods. Tx power (dBm) of commercial phones, time, and GPS data have been collected in a moving vehicle at about 400 neighborhoods, which cover more than 95% of the total neighborhoods.

The measurements were carried out in voice call mode while driving along side streets. Three mobile phones were controlled by software (OPTis-S, Innowireless Co., Ltd.) on a notebook computer at the same time. The devices under test (DUTs) were connected to networks of different operators and they sit next to each other using an apparatus in transparent acrylic in a vehicle.

3. Results

In Korea, any given phone could only work with a single technology and one frequency band until the LTE system was introduced in late 2011. However, an operating frequency band of a mobile phone can be changed according to the corresponding operator's bands.

A data file consists of time, GPS, Tx power, and LTE band and it has been stored every one second, which means the averaging time of one second. The software (OPTis Analyzer, Innowireless Co., Ltd.) used for the analysis allows the selection of averaging time from 10 milliseconds to 10 seconds for the raw data file. The average and standard deviation of Tx power data measured in Sinsa 1-dong according to several averaging time has been investigated as shown in Figure 1. The standard deviation seems reduced for a larger averaging time but a difference less than 0.3 dB was observed in the average Tx power.

The operation ratio results of LTE bands, detected by the three mobile phones are in Table 1. At the time of measurement, two different LTE frequency bands were allocated to each network operator. The information on band operation ratio during the voice call (VoLTE) mode is very important because the head absorption of electromagnetic field is dependent on the operating frequency. Operator O_c was found to service LTE only in one band (Band 5) in Seoul from the measured results.

Table 1. Operation ratio of LTE bands.

Band (UL[a]) \ Operator	O_A	O_B	O_C
Band3 (1.7 GHz)	21.6	42.9	-
Band5 (800 MHz)	78.4	-	99.3
Band7 (2.5 GHz)	-	-	0.7
Band8 (900 MHz)	-	57.1	-
Sum	100.0	100.0	100.0

[a] uplink frequency

As shown in Table 1, the band operation ratio is different among the three operators. Fig. 2 shows cumulative distribution of the collected power data transmitted from a mobile phone for each operator and each band. The maximum difference of five times in the mean Tx power was observed between bands or operators; the Tx power of Band3 of O_A is much lower than that of Band5 of O_C as shown in Fig. 2. The measured results suggest that exposure level to radiation from a mobile phone depends on the operators and bands.

The specific absorption rate (SAR) of commercial mobile phone models are tested for the equipment certification with the safety limits. The SAR measurement is performed in a specific anthropomorphic mannequin (SAM) phantom [1], [2] and the maximum SAR or the peak spatial SAR in the phantom does not dependent on the operating frequency band of the phone on investigation of SAR test reports of commercial phone models [3]. However, when Tx power levels are similar, a lower frequency causes higher deposition of electromagnetic energy in the human brain [4].

Average SAR distribution can be estimated in the brain of subscribers of each operator based on the operation ratio of the frequency bands of Table 1 and the Tx power values of Table 2. However, for accurate estimation of cumulative exposure, transition of wireless technologies as well as the operating frequency bands and Tx power levels need to be monitored continuously, because the data of the above tables were obtained within a specific time window.

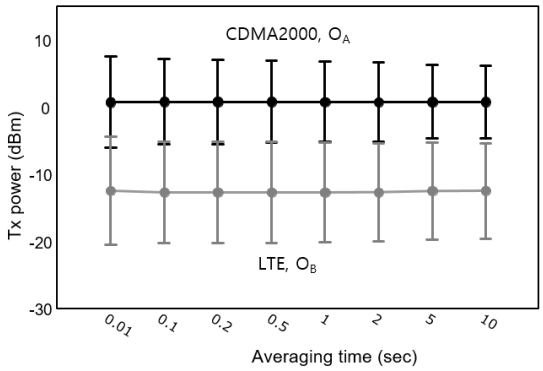

Figure 1. Average value of measured Tx power data for about 45 minutes according to the averaging time.

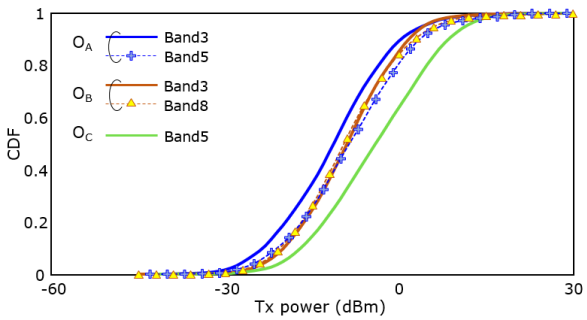

Figure 2. Cumulative distribution functions of the power transmitted from 4G mobile phones operating in Seoul (VoLTE).

4. Conclusions

In this paper, the measured Tx power results of mobile phones have been reported during voice calls in operating 4G (LTE) networks in Seoul. Even the 90th percentile values of Tx powers were much lower than the maximum available Tx power (< 300 mW) of a mobile phone.

However, it needs to consider the differences between the operators and frequency bands for exposure assessment of individuals in real environments. Furthermore, the operation ratios among 2G, 3G, and 4G subscribers are changed every year; in Korea, 2G subscribers accounted for about 30% in late 2010 but they are only 3% of total subscribers in August 2018. On the other hand, 4G subscribers match up to about 82%. The mobile phones of 4G subscribers can be connected to 4G or 3G network for voice calls. Therefore, it is very important to monitor and record the phone Tx power levels in the networks for health effect assessment for long-term exposure of electromagnetic field.

5. Acknowledgements

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6. References

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