Estimation of EMF for base stations using signal decoding technique

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Abstract

In this paper, EMF radiated from base stations was evaluated using signal decoding technique for LTE FDD communication system. We also applied the decoding technique to the fifth generation (5 G) new radio (NR) structure to estimate EMF radiation. The signal decoding technique is a logical method, which the radiated field is estimated based on constant signals transmitted by a base station such as reference signal (4G) and synchronization signal block burst (5G). However, the measured results showed that the received field strength is significantly influenced by fading in the real environment.

1. Introduction

Recently, some countries are preparing to launch the 5 G NR service, and the public is concerned about the health effects of human exposure regarding the new technology. It is difficult to evaluate the channel power measurement method for electromagnetic field (EMF) evaluation, because the 5 G NR uses massive multiple input multiple output (MIMO) and beam forming technology. IEC 62232 introduces a signal decoding method for evaluating EMF of long term evolution (LTE) frequency division duplex (FDD) and time division duplex (TDD) communication [1]. In this paper, EMF evaluation is performed through measurement using signal decoder for base stations of LTE FDD communication. Also, the EMF was estimated using the signal decoding method for the Korean 5 G NR structure in 3.5 GHz band.

2. LTE FDD

The LTE is currently the most widely used technology in the world, and FDD service is being provided in Korea. The frame of LTE is composed of resource elements (RE) and one RE consists of one subcarrier in the frequency domain and one orthogonal frequency division multiplexing (OFDM) symbol in the time domain. IEC 62232 presents signal decoding technique for the EMF evaluation for LTE base station; a constant power signal, i.e., reference signal (RS) is measured and the exposure level at the maximum traffic condition is estimated by extrapolation. The RS is suitable for measurement because the LTE RS is continuously and constantly transmitted from the base station over the occupied radio bandwidth.

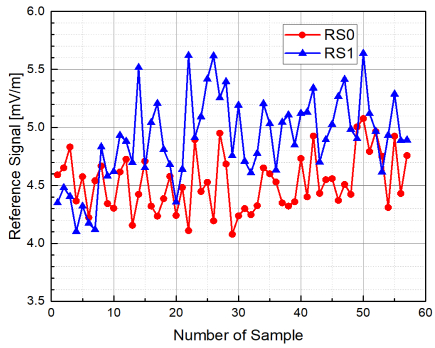
In this method, the RS of an LTE cell is measured at a test point. If multiple antennas are used for transmission by the cell, the RS should be determined for each antenna. The maximum electric strength (V/m), E_{max} is:

$$E_{max} = \sqrt{N_{RS}} \cdot E_{RS} \tag{1}$$

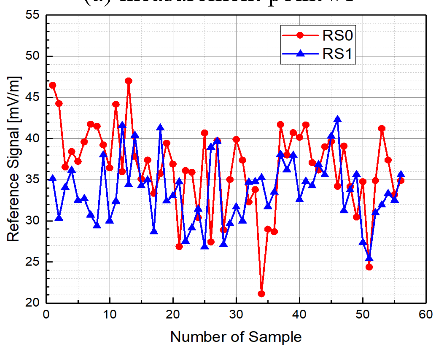
where, E_{RS} is the electric field strength (V/m) of the RS, N_{RS} is the extrapolation factor, which is the ratio of the maximum transmission power to transmission power corresponding to the RS[1]. In the case of a MIMO antenna system, Eq. 1 is modified as:

$$E_{max,RS} = \sqrt{N_{RS}} \cdot \sqrt{E^2_{max,RS0} + E^2_{max,RS1}} \tag{2}$$

where, $E_{max,RS0}$ denotes the maximum electric field strength (V/m) from branch $RS0$ of the MIMO antenna and the sum is taken over all branches.



(a) measurement point #1



(b) measurement point #2

Figure 1. The *RS0* and *RS1* measurements for in-situ environment of the LTE base station.

Figure 1 shows the $RS0$ and $RS1$ measurements using the signal decoder (SRM-3006, Narda-STS) at two different LTE FDD base station (MP #1 and MP #2) operating with a frequency of 1820 MHz and a channel bandwidth of 20 MHz. The RS power from the base station is constant, but the measured value (RSRP: reference signal received power) in real environment varies with time in Figure 1. The maximum, minimum and average measured values of the RS is provided in Table. 1

Table 1. The maximum, minimum and average measured values of the RS at measurement point (MP)

	Reference signal at MP #1 [V/m]			Reference signal at MP #2 [V/m]		
	Max.	Min.	Avg.	Max.	Min.	Avg.
$RS0$	0.0051	0.0041	0.0045	0.0470	0.0211	0.0364
$RS1$	0.0056	0.0041	0.0049	0.0423	0.0254	0.0337

Table 2. The results of EMF evaluation

		Reference signal [V/m]			
		MP #1		MP #2	
		$RS0$	$RS1$	$RS0$	$RS1$
Max.		0.0051	0.0056	0.0470	0.0423
Min.		0.0041	0.0041	0.0211	0.0254
Avg.		0.0045	0.0049	0.0364	0.0337
N_{RS}		1200	1200	1200	1200
$E_{max,RS}$	Max.	0.263		2.191	
	Min.	0.200		1.145	
	Avg.	0.231		1.719	

Table 2 shows the results of EMF evaluation using RS values in Table 1. According to $E_{max,RS}$ in Table 2, the maximum and minimum values at MP #1 are about +13 %, - 13 % different from the average values, and are about +27 % and -33 % at MP #2, respectively.

3. 5 G New Radio

In 5 G NR systems, The SS Block consists of primary synchronization (PSS), secondary synchronization (SSS), physical broadcast channel demodulation reference signal (PBCH DMRS) and physical broadcast channel (PBCH) [2][3]. The PBCH DMRS corresponds to RS of LTE system. In NR system, the field strength of PBCH DMRS, which is constant, can be obtained using a decoding technique. The electric field strength of PBCH DMRS would be employed instead of E_{RS} in LTE for estimation of EMF radiated from 5 G base station. The extrapolation factor ($N_{PBCH\ DMRS}$) at 5 G NR is the ratio of the maximum transmission power to transmission power corresponding to the PBCH DMRS. However, in order to obtain the maximum transmission power for one frame at one user of a specific measurement point, time factor (T_f) should be considered. It is the ratio of the total number of REs to the maximum number of REs occupied at the measurement point. The expected frame structure of Korean operators in shown in Fig. 2. It can be obtained by the calculation as shown in Equation 3.

$$T_f = \frac{N^{RE}_{occupied}}{N^{RE}_{total}}$$
$$N^{RE}_{occupied} = N^{RE}_{total} - N^{RE}_{S,F\&U} - N^{RE}_{U,U} - N^{RE}_{D,BS} \quad (3)$$

where, N^{RE}_{total}, $N^{RE}_{occupied}$ are the total number of REs and the maximum number of REs occupied in one frame, $N^{RE}_{S,F\&U}$ is the flexible and uplink number of REs in S slot, $N^{RE}_{U,U}$ is the uplink number of REs in uplink slot, $N^{RE}_{D,BS}$ is the beam sweeping number of REs in downlink slot. If we calculate the frame structure of Korea in Figure 2, $N^{RE}_{total} = 917280$, $N^{RE}_{S,F\&U} = 52416$, $N^{RE}_{U,U} = 183456$, $N^{RE}_{D,BS} = 91728$, $N^{RE}_{occupied} = 589680$, and $T_f = 0.643$.
Therefore, by using parameters, the EMF exposure estimate at $E_{PBCH\ DMRS} = 0.1\ V/m$, which is assumed value, can be estimated as the maximum exposure $E_{max,RS} = 3.68\ V/m$. We will perform EMF evaluation by measuring the electric field strength of PBCH DMRS for 5 G NR base station in the future, and we will observe the variation of PBCH DMRS in real environment.

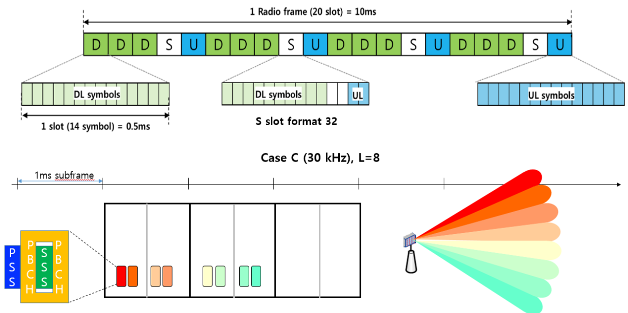


Figure 2. The frame structure agreed by the operator in Korea.

4. Acknowledgements

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5. References

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