Radio Propagation Characteristics in the Large City and LTE protection from STL interference

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***Abstract*— This paper describes composite propagation effects of both the median pathloss and shadow fading in the large city. In general, the propagation characteristic for the power profile of received signal has the relative power reduction and fluctuation according to distance to the receiver's location far away from the transmitter. The result of these channel propagation losses is due to the reduction of electric field in the air according to the separated distance between a transmitter and receiver, and due to the multipath effect such as the plane reflection and edge diffraction of the propagated radio signals at the plane of buildings and roads or vehicles etc. Propagated multipath radio signals via different paths may be simultaneously received to a target receiver with different field strength and phases. Actually, it is not easy to how to predict the optimum radio propagation characteristics in the large city from a transmitter to target receiver at the specific mobile or fixed communication link, because the outdoor environment have the different height of transceivers and various structure factors such as buildings, roads, and vehicles in the large city including the urban, suburban and rural area. Therefore, the measurement is currently candidate solution for predicting the radio propagation characteristics in the novel environments. In this paper, two different stations between a fixed and mobile station are considered. Measurement results are compared with the general radio propagation model of 3GHz frequency and lower. As another issue, we discuss and propose on the closed form of the interfering received signal strength intensity when two different stations like a fixed system as the repeater and a mobile system as Long Term Evolution coexist in the same area. In the coexisting environment, two different stations overlap the cell coverage and are assigned in the adjacent channel frequency. Therefore, the potential interference may cause to their reception each other. Here, it is important to analyze the interference impact to the victim station as a receiver from the interfering station as a transmitter to get out of the interference. In this paper, it is assumed that an interfering station as a transmitter is fixed repeater and a victim station as a receiver is a mobile Long Term Evolution system. For estimating interfering received signal strength intensity, it is issued to figure out a radio propagation characteristic. However, it is unknown for the available median pathloss model to apply for analyzing the performance of Long Term Evolution system from interfering fixed repeater in the large city with none line of sight in the coexisting environment. Finally, we propose the median pathloss characteristic from measuring the electric field strength of a fixed repeater as an interfering transmitter and calculated interfering received signal strength intensity to a victim station. Using both the measurement and the theoretic calculation results, the separated distance between an interfering transmitter and victim receiver is discussed for the protection of a victim station.**

***Keyword*— interference, wave, pathloss, fading**

I. INTRODUCTION

LONG Term Evolution (LTE) has been developing to transport increasing traffics of mobile communication data [1]. Studio transmitter link (STL) station does transport a radio station's audio data from the broadcast studio to a repeater in another location. The transmitter studio link (TSL) is the return link, which transports telemetry data from remotely located a repeater back to the broadcast studio. STL and TSL station are a kind of the fixed microwave link station. Figure 1 shows the frequency allocation and arrangement between STL and LTE uplink bands. Two stations operate each other in adjacent frequency bands. Let us consider the potential LTE interference impact from STL station's emission at 1.7GHz frequency bands in the coexisting case both LTE base station and STL system in the same service area.

In this situation, the analysis and its results on the potential LTE performance impact due to the interference of STL station in the large city were not known to us, yet. Therefore, we tried to derive a theoretic LTE interference impact from the harmful power of STL station in the adjacent frequency bands.

Fig. 1. Frequency assignment of both STL and LTE uplink.

To calculate interfering STL and desired LTE station's received signal strength intensity to the LTE reception, let us consider theoretic median pathloss and shadowing model, because interfering or wanted transmitter power is reduced by the separated distance between a transmitter and a victim

Manuscript received November 1, 2014. This work was supported by the ICT R&D program of MSIP/KCA. [2013-005-036-001, Wireless Channel and Frequency Characterization based on Field Measurements for Broadband Mobile Hot-Spot Applications]

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receiver. In addition, radio propagation characteristic varies to the outdoor environment factors such as building, ground, and etc.

In this paper, general radio propagation models in the various environments like urban, suburban, and open area are considered. Extended Hata model is general and feasible median pathloss model within lower than 3GHz frequency bands in the mobile communication service. Extended Hata model is used to calculate pathloss according to the separated distance in none line of sight (NLOS) as well as line of sight (LOS) environment [2]. In the free space environment case, reference ITU-R P.525 model is available to calculate the median pathloss between a wanted transmitter and desired receiver in open area [2]. In referred [1]-[2], using median pathloss and long term fading characteristics with log-normal distribution, we can calculate available cell area corresponding to the minimum sensitivity level of desired receiver. If referred general model of [1]-[2] are always good in agreement with measurement results, we could use theoretic median pathloss model and shadowing value without waste time for long measurement process and database analysis. However, composite median pathloss and shadowing characteristics according to separated distance in the large city including dense urban and suburban environment was not known to us. Therefore, we measured radio propagation characteristics in the large city and found various median path loss characteristics, when STL station transmits the audio data from the broadcast studio to a repeater in another location. Currently, the median path loss value getting from the referred theoretic model [1]-[2] is not a good match with our measurement results in the specific environment like the large city including the dense urban and suburban, because theoretic median path loss model is very general model in the specific site environment and is not good agreement with all environments. Also, a choice of the median pathloss model for the link budge calculation on the transceiver station is not difficult. For example, mobile operators choose Extended Hata model within lower than 3GHz frequency bands for calculating the site coverage in macro or micro or hotspot environment. In the other hands, TV broadcasters use the reference ITU-R P. 1546 model in the point to multi point environment with time varying and spatial rates of the radio signal profile [3]. However, this simple choice may happen a large error in the specific environment like the large city including the dense urban and suburban. This error may happen to inaccurate the median pathloss calculation and we could have faults calculating an interference impact to the LTE reception in the adjacent frequency bands from an interfering STL signal power.

Actually, for the link budge calculation, the mobile LTE operators use Extended Hata model in the LOS and NLOS environment in the urban or suburban. The other fixed STL microwave broadcasters use the free space loss model in the open area and the reference ITU-R P. 1546 model in the LOS and NLOS environment over the coverage of 1km and higher. This is the reason that each mobile or fixed station's environment has different conditions, which they include the transmitter antenna height, the receiver antenna height, the transmission distance, and the receiver sensitivity, etc.

In this paper, we talks to derive the composite median path loss and shadowing value for the LTE protection from the interference impact of interfering STL transmitter. As an approach, we measured the transmission power of STL station during moving with a vehicular from the STL broadcast studio to a repeater in another location. The measurement frequency is at 1.7GHz bands and it is within in-bands of LTE bands at the adjacent STL frequency bands. As the fixed STL microwave broadcasters, we considered two stations with different link paths in the large city. One STL station is Far East Broadcasting Company (FEBC) and, while the other is Seoul Broadcasting Station (SBS).

Finally, we found to shall be used composite median pathloss with shadow fading to correspond to various urban, suburban, and rural environments in the large area. Measurement results are in good match with the results of composite different median pathloss models of various urban and suburban.

II. Station Parameters

To calculate interfering transmitter and desired LTE received signal strength intensity to a LTE reception, let us consider fixed STL with wireless services as interfering transmitter.

Fixed wireless service utilizes a transmission tower similar with a cell phone tower on the top of the building. The equipment installed upon transmission tower communicates with one of a repeater for the wireless transmission of the information data. STL station as a transmitter station means a kind of the transmission tower providing the fixed service and does transport a radio station's audio and video data from the broadcast studio to a repeater in another location. A repeater as a receiver installs the transceiver equipment on the top of mountain to communicate with a fixed wireless broadcast studio on the top of buildings in the city. A repeater and the broadcast studio include a grid meshed or dish shaped antenna connected to the radio transceiver. The antenna beam of the broadcast studio should be faced to the pointing direction of a repeater for LOS access to reduce pathloss between a transmitter and receiver. This is the reason that the obstructions of a hill and several high buildings can adversely affect to the performance impact of the quality of service (QoS). As the fixed STL microwave broadcasters operating at 1.7GHz frequency bands [4]-[7], we considered two stations with different link paths in the large city. One STL station is FEBC and, while the other is SBS. The STL transmitter sends the radio station's audio analogue or digital data from the broadcast studio transmitter to the radio transmitter operating as a receiver in another location. STL radio links can be analogue or digital type and considered broadcast auxiliary services (BAS). Table 1 shows system parameters of STL stations and these values are assumed.

SBS is digital type and FEBC's station is the older analogue system. Two STL stations operate in the frequency of 1.7GHz bands with the channel bandwidth of 230 kHz. Antenna type is the same grid parabola with 26dBi including the feeder loss of 2dB. The antenna height (sea level) of the FEBC and SBS transmit station is 35m or 70m, relatively. The antenna height (sea level) of receiving station is the same height of 625m. Receiver is located in the tower of on the top of Mt. Gwanaksan. The antenna 3dB beamwidth of STL stations is 6.5degree in the elevation axis as shown in Figure 2.

Table 2 shows system parameters of LTE station and these values are assumed.

TABLE I
STL STATION PARAMETERS [4] –[7]

Parameters	FEBC (TFT8300)	SBS (SL9003)
Analogue/Digital	Analogue	Digital
Channel bandwidth (㎑)	230	230
Transmit power (W)	5.0	1.0
Operating frequency (㎓)	1.7GHz bands	1.7GHz bands
Antenna gain (dBi)	26 (grid parabola)	26 (grid parabola)
Antenna HPBW (degree)	6.5 (elevation)	6.5 (elevation)
Antenna height (m)	Transmitter 35 Receiver 625	Transmitter 70 Receiver 625

TABLE II
LTE STATION PARAMETERS [8]

Parameters	Values	Units
Downlink peak rates	100	Mbps
Uplink peak rates	50	Mbps
Transfer latency	< 5	msec
Scalable carrier channel bandwidth	1.4~20	㎒
Duplexing	FDD	
Antenna gain	15	dBi
Antenna HPBW	7.0 (elevation)	degree
Antenna downtilt	-3	degree

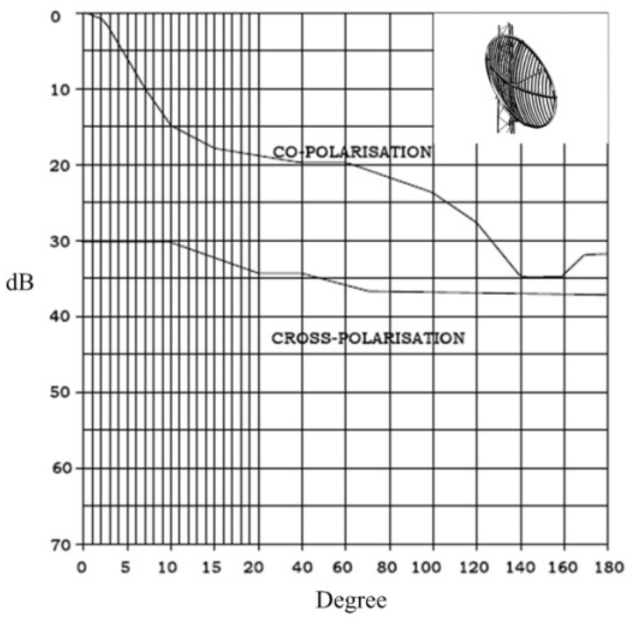


Fig. 2. STL station's antenna elevation pattern (e.g. grid parabola) [4].

LTE base station supports moving mobiles, and multi-cast as well as broadcasting data. We assumed the channel bandwidth of 5MHz x 2 supporting the frequency division multiplexing (FDD). LTE stations operate in the frequency of 1.7GHz bands. Antenna type is the linear antenna with x-polarization and with 15dBi gain including the feeder loss of 3dB. Antenna height (sea level) of LTE base station is 15m. LTE base station is a receiver in the uplink. The antenna 3dB beam-width of LTE station is 7.0degree in the elevation axis as shown in Figure 3.

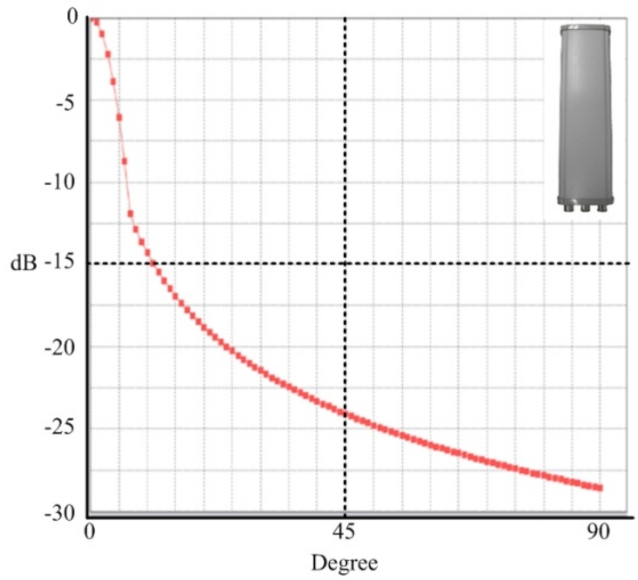


Fig. 3. LTE base station's antenna elevation pattern (e.g. Linear) [4].

III. MEASUREMENTS

A. Measurement Path

We assumed coexisting scenarios between STL and LTE station in the large city. The antenna height (sea level) of FEBC and SBS transmit station is 35m or 70m as shown in the Table 1, relatively. The antenna height (sea level) of LTE base station is 15m in the Table 2. STL transmit stations are assumed as the interfering transmitters and LTE base station is assumed as a victim receiver to protect from the interfering STL transmit stations. To derive the interfering received signal strength intensity to LTE base station receiver, we tried to find the available median pathloss model in the case of both the transmitter antenna height of 35m and higher, and the receiver antenna height of 15m and higher. However, we didn't look for the available radio propagation characteristics. Finally, we measured the median pathloss characteristics and calculated interfering received signal strength intensity to a victim LTE base station. Using both measured and theoretic calculation results, the separated distance between the victim station and interfering station is discussed for the protection of a victim station. Figure 4 shows the STL link (Link 1) of FEBC transceiver between the broadcasting transmit station on ground and receiving station on the top of Mt. Gwanaksan. The measurement of FEBC transmit power was performed within the measurement region 1 during moving the car in the large city. Figure 5 shows the STL link (Link 2) of SBS transceiver between the broadcasting transmit station on ground and receiving station on the top of Mt. Gwanaksan. The measurement of the transmit power of SBS was performed within the measurement region 2 during moving the car in the large city. The distance of Link 1 and Link 2 in a straight line between the transmit antenna pointing of the broadcasting transmit station and receiver antenna pointing of the receiver is about 10km and 12.4km, respectively.

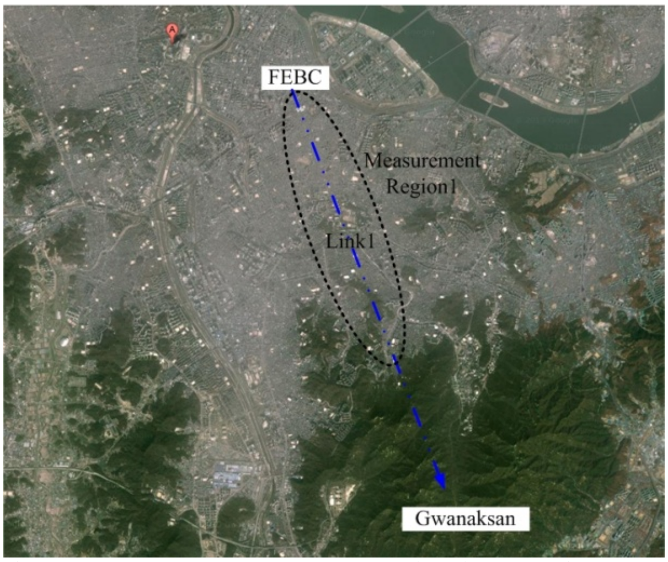


Fig. 4. Measurement route I (e.g. FEBC tansmit station to a receiver on Mt. Gwanaksan) [4].

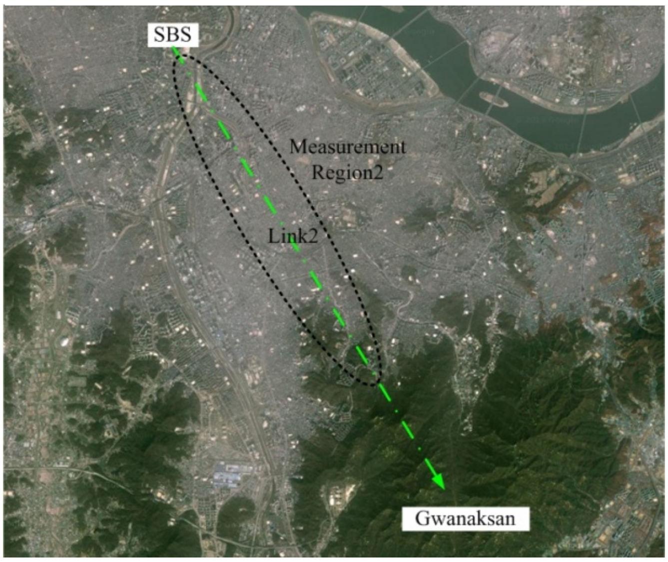


Fig. 5. Measurement route II (e.g. SBS transmit station to a receiver on Mt. Gwanaksan) [4].

B. *Measurement Environment*

Figure 6 shows the measurement scenario using a vehicular in order to measure the median pathloss and long term fading characteristics at 1.7GHz bands in the large city.

Measurement was performed on road in the large city including huge or small buildings and hills with moving car from the STL transmit station. A car with the measurement system has been moved from the STL transmit station (Transmitter) to near by the front of the STL receiving station (Receiver) on the top of Mt. Gwanaksan. The measurement system includes the vector network analyzer, the low noise amplifier, the band-pass filter, and the omni antenna. The antenna height (h_v) on the top of a car is 2.5m. We defined the antenna height of STL station as follows; STL transmit antenna height is H_1 and STL receiving antenna height on the top of Mt. Gwanaksan is H_2.

IV. Results & Analysis

A. *General Median Path loss Models*

For comparing measurement with theoretic analysis results, we looked for the general candidate median pathloss model. [2], [4]

In this model, for line of sight in the open area, the free space model is used.

$$PL_{FSL}(dB) = 10\log\left\{\left(\frac{4\pi}{c}\, d_1 f\right)^2\right\} = 32.44 + 10\log\left\{\left(\frac{H_1 - h_v}{1000}\right)^2 + d^2\right\} + 20\log(f) \quad (1)$$

The free space pathloss is proportional to the square of the separated distance in km between the radio transmitter and radio receiver. In addition, it is proportional to the square of the operating frequency in the unit of MHz of receiver in (1). Free space pathloss is the minimum radio propagation loss in the signal strength of electromagnetic wave that would result from the unobstructed direct line of sight path through the air in the open area. Free space pathloss is examples applied to the fixed microwave link or broadcasting link or telecommunication link over the short distance in the open area, etc.

For the telecommunication link operating at 3GHz and lower bands, Extended Hata model is typically used. Extend Hata pathloss is the radio propagation loss in the signal strength of electromagnetic wave that would result from the obstructed none line of sight as well as the unobstructed line of sight path through the air in the urban, suburban, and rural area. Extended Hata model was developed by European study committee (COST 231). This model is an extension of Okumura-Hata model, being applicable for the frequency to 3GHz and lower bands, with receiving antenna heights from 1m to 10m and the transmitting antenna heights of 30~200m. It is used for the prediction of pathloss for mobile wireless system in urban, suburban, and rural environments.

In case of urban environment,

$$PL_{Urban}(dB) = 46.3 + 33.9\log(f) - 13.82\log(\max\{30, H_1\}) + [44.9 - 6.55\log(\max\{30, H_1\})]\log(d) - a(h_v) - b(H_1) \quad (2)$$

In case of suburban environment,

$$PL_{Suburban}(dB) = PL_{Urban} - 2\{\log[(\min\{\max\{150, f\}, 2000\})/28]\}^2 - 5.4 \quad (3)$$

In case of rural environment,

$$PL_{Rural}(dB) = PL_{Urban} - 4.78\{\log[\min\{\max\{150, f\}, 2000\}]\}^2 + 18.33\log[\min\{\max\{150, f\}, 2000\}] - 40.94 \quad (4)$$

where,

$$a(h_v) = (1.1\log(f) - 0.7)\min\{10, h_v\} - (1.56\log(f) - 0.8) + \max\left\{0, 20\log\left(\frac{h_v}{10}\right)\right\} \quad (5)$$

$$b(H_1) = \min\left\{0, 20\log\left(\frac{H_1}{30}\right)\right\} \quad (6)$$

where, f is frequency in MHz, d is distance between a transmitting antenna and receiving antenna in km, H_1 is the transmitting antenna height above the ground level in meter, h_v is the receiving antenna height above the ground level in meter. $a(h_v)$ is the correction factor of the receiving antenna height. $b(H_1)$ is the correction factor of the transmitting antenna height.

The long term fading has different variation values due to separated distance between a transmitter and receiver in urban, suburban, and rural environment. Shadow fading calls for the long term fading or the slow fading, because channel characteristics vary slowly and location between a transmitter

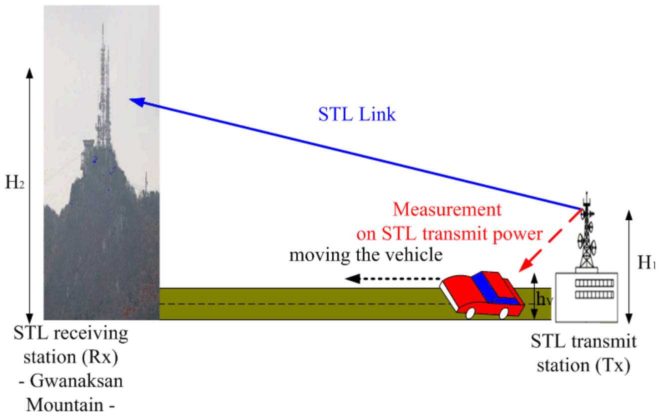
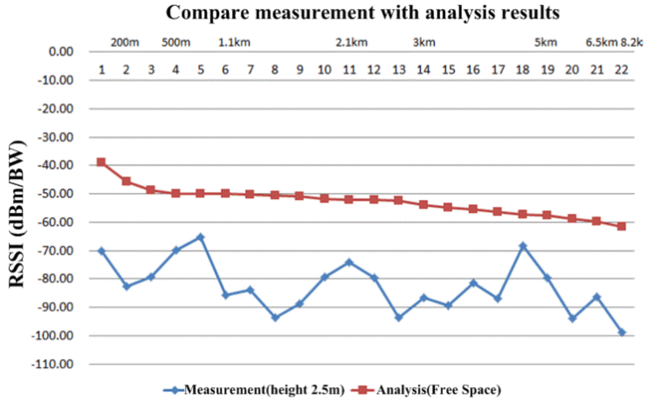


Fig. 6. Measurement method [4].

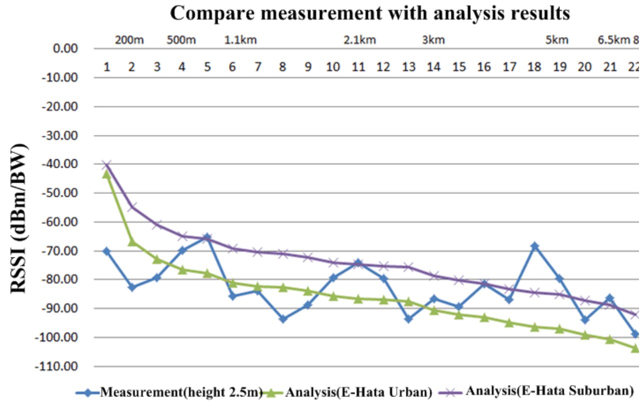
and receiver. The standard deviation of the long term fading to the separation between a transmitting antenna and receiving antenna with the distance range from 0.1 to 0.2km is 17 dB in the roof below. For the distance range of 0.2km to 0.6km, the standard deviation is s.t.d = 17-20(d-0.2)dB. For the separation distance range larger than 0.6km, there is 9dB [2], [4].

B. *Results Comparison*

Measurement was performed on the road in the large city including huge or small buildings and hills with moving car from STL transmit station as shown in Figure 6. The received signal strength intensity (RSSI) of SBS or FEBC STL measured to the measurement system within the car show in Figure 7 and Figure 8, relatively. Figure 7 shows on the RSSI results of SBS and Figure 8 shows on the RSSI results of FEBC on both measurement and theoretical Extended Hata pathloss. We used the received antenna of omni directional type. The height of the received omni antenna on the top of roof is 2.5m on the ground level. In Figure 7 and Figure 8, x-axis means the separated distance in a straight line between the STL transmitting antenna and received antenna. The maximum separated distacne of FEBC and SBS is 10 and 12.4km, respectively. But, the height of STL antenna on ground level is enough high to install on the tower on Mt. Gwanaksan. RSSI level is measured by enough distance to be able to approach near to the tower on Mt. Gwanaksan. For Figure 7 and Figure 8, the maximum measurement distance of FEBC is about 7 km out of 10km, and SBS is about 8.2km out of 12.4 km. As shown in Figure 4 and Figure 5, the measurement region 1 in Link 1 path and measurement region 2 in Link 2 path are the area moving the car from the STL transmitter to the front of Mt. Gwanaksan in order to measure the RSSI level, respectively. The RSSI level according to

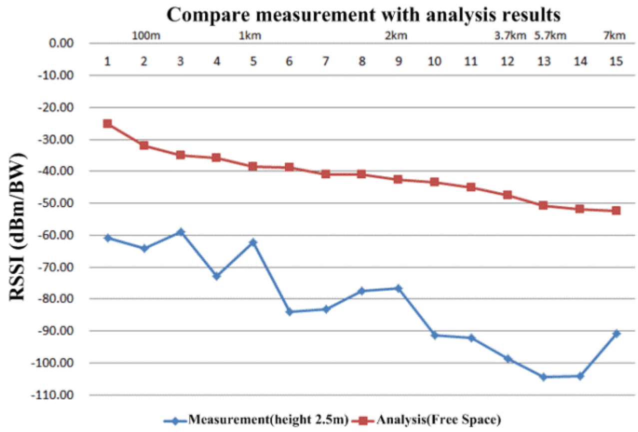


(a) measurement vs. free space model

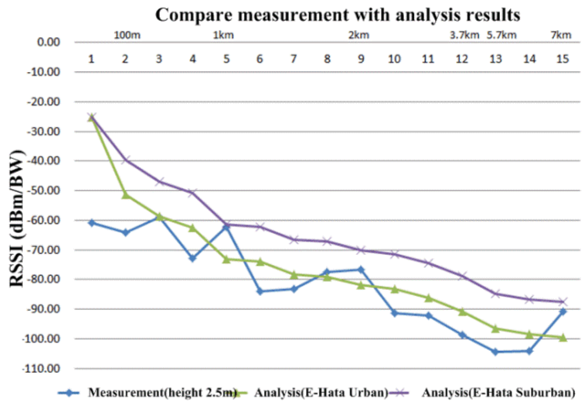


(b) measurement vs. Extended Hata model

Fig. 7. Comparison on measurement and analysis results(SBS's RSSI in the large city).



(a) measurement vs. free space model



(b) measurement vs. Extended Hata model

Fig. 8. Comparison on measurement and analysis results (FEBC's RSSI in the large city).

separated distance from a transmitter and receiver varied due to the around environment including multiple buildings, many cars, and the park etc.

Figure 7 and Figure 8 show different RSSI characteristics according to distance considering the car moving path. The reduction of RSSI level according to the distance means pathloss value including the long term fading. Figure 7(a) shows that results of both measurement and the free space pathloss are compared each other.

The RSSI values to receiving antenna with the antenna height of 2.5m from the SBS transmit station with the antenna height of 70m in the urban area are -70 ~ -100dBm in the measurement results and -40 ~ -60dBm in the free space pathlss results. Figure 8(a) shows that measurement and Extended Hata (urban, suburban) pathloss results are compared each other. The RSSI values to receiving antenna with the antenna height of 2.5m from the FEBC transmit station with the antenna height of 35m in the urban area are -60 ~ -100dBm in the measurement results and -25 ~ -52dBm in the free space pathlss results. Figure 7 and Figure 8 show the long term fading characteristics.

Approximately, the fluctuation value is 10 ~ 13dB in SBS and is 6 ~ 10dB in FEBC from the STL transmit station to the Mt. Gwanaksan path. The standard deviation of shadowing in COST231 model [2] provides 3 ~ 4dB ranges. In COST231, the value has smaller variation than measurement results in the large city including the urban and suburban environment. This difference is due to the radio propagated environment including the reflection and diffraction at the buildings, obstructs, and forest etc. As shown in Figure 7 and Figure 8, the measurement results of pathloss according to the separated distance are good mapping with Extended Hata urban and Extended Hata suburban pathloss except for the measurement point of the near location from pointing station as a transmitter, although relative shadowing variation is larger than reference COST231 value of 3 ~4dB. Finally, the median pathloss is able to apply for estimating the reduction characteristics of the signal power in addition to high variation of the shadow fading with log-normal distribution in the case of the large city at 1.7GHz bands.

C. *Interference Calculation*

As shown in Figure 1, the interfering STL transmit signal cause the potential interference impact to the LTE base station reception at the frequency of 1.7GHz bands. LTE is assumed as the reverse FDD system. To calculate the interfering STL signal strength intensity and desired LTE received signal strength intensity to the LTE reception, let us consider the theoretic median pathloss and shadowing characteristics as shown in Figure 7 and Figure 8, because the interfering and wanted transmitter power are reduced according to the separated distance between the transmitter and receiver. We found facts that the median pathloss and long term fading characteristic is applied to estimate different attenuation characteristics according to the separated distance between the interfering transmitter of the fixed pointing station and the reception of the mobile communication station such as LTE system in the large city as shown in Figure 7 and Figure 8.

Figure 9 shows the interference analysis scenario to the LTE reception due to the interfering STL transmit station

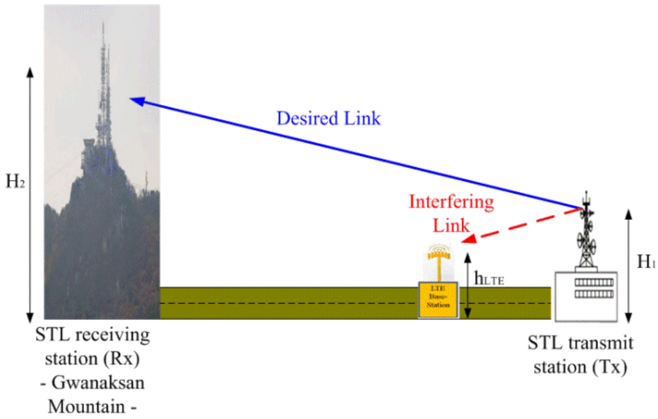


Fig. 9. Desired and interfered link [4].

when the LTE base station is located in straight line between STL links (Link 1 and Link 2) as shown in Figure 4 and Figure 5, respectively. For the calculation of the interference impacts between different systems such as the LTE receiver and STL transmitter in this paper, we used the measurement results at 1.7GHz bands in the large city shown in Figure 7 and Figure 8. Measurement was performed on the road using the receiver with the antenna height of 2.5m of the omni directional antenna type. The measurement results are calibrated on the receiving antenna height because the antenna height of receiver in the measurement is 2.5m, while the antenna height of the LTE base station is 15m. Therefore, the correction value due to difference of the receiver antenna height between 2.5m in the car and 15m in the LTE base station is required. We used the correction value of about 11dB based on the measurement according to the receiver antenna height difference.

We derived the interfering received signal strength intensity to the LTE base station reception from the emission power of the STL transmit station in the adjacent channel usage. The emission power of the STL transmits station means the totally interfering signal power received to the LTE base station receiver to the out of band spectrum of STL transmit station.

Figure 10 shows the emission characteristic of the FEBC station and Figure 11 shows the emission characteristic of the SBS station based on the realistic conducted power measurement. Equation (7) is derived to calculate the interfering received signal strength intensity to the LTE base station reception [4].

$$iRSSI\,(\text{dBm}) = I_{\text{ooB},\Delta\text{F}} + G_{\text{Rx}}(H_1, h_{\text{LTE}}, \delta) + \text{a}(h_{\text{LTE}}) \quad (7)$$

where, *iRSSI* depicts the totally received interfering signal strength intensity including the antenna gain and correction value $\text{a}(h_{\text{LTE}})$ in dB as the difference of the received signal strength intensity due to the difference of between 2.5m and 15m of the received antenna height, $I_{\text{ooB},\Delta\text{F}}$ means the received interfering signal strength intensity to the reception of the LTE base station based on the measurement results as shown in Figure 7 and Figure 8. As shown in Figure 10 and Figure 11, the out of band (ooB) emission power of the fixed STL transmit station is potentially influenced to the system performance to the reception of the LTE station. The totally

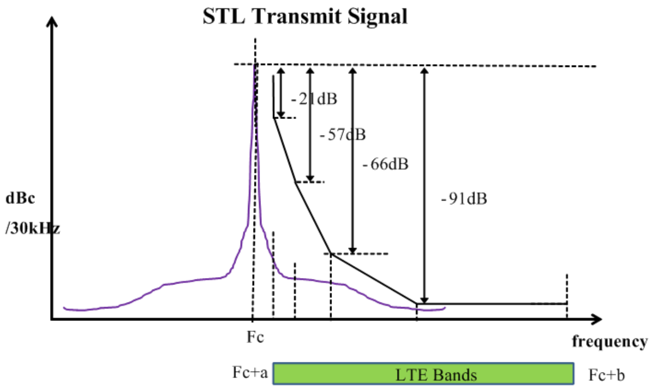


Fig. 10. FEBC Station's Emission Characteristics [4].

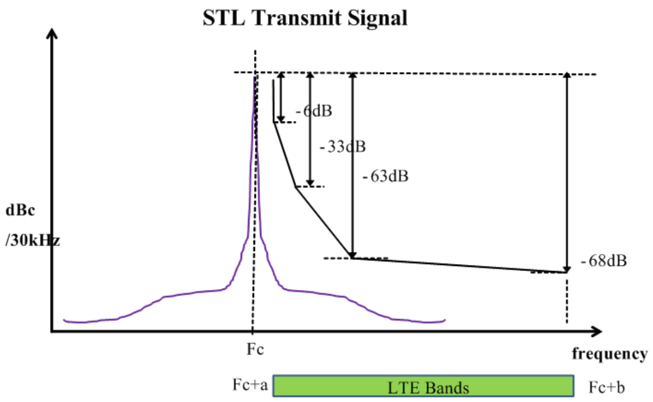


Fig. 11. SBS Station's Emission Characteristics [4].

emission power is calculated as the total transmit power received within the separation frequency (ΔF) bands from the offset (Fc+a) frequency to the end frequency (Fc+b) of the channel bandwidth of 5MHz of the LTE base station.

$G_{Rx}(H_1, h_{LTE}, \delta)$ depicts the total antenna gain of the LTE base station including both the antenna height of the STL transmitter and LTE base station with the antenna up or down tilting. For example, we assumed that the LTE base station has the down tilt of 3dB, the antenna end of the STL transmit station is pointed to the end of the STL receiving station. Also, the antenna gain considers the direction of the elevation angle to derive the total antenna gain. For predicting on the interference impact to the LTE base station reception, we must define the permissible totally received interfering signal strength intensity to the victim station. In this paper, a permissible interference limit is -108dBm/5MHz to the victim system as the LTE base station. This value is derived from the protection ratio of LTE base station. LTE protection ratio is I/N, which the ratio the totally received interfering signal strength intensity to noise power of the victim station such as the LTE base station [8]-[9]. The protection ratio of I/N is defined as - 6dB. This means that the permissible totally received interfering signal strength intensity to the reception must be less than the total noise power. Total noise power is derived as the equation (8).

$$N\,(\text{dBm}) = 10\log(kT \cdot B \cdot NF) \qquad (8)$$

where, kT depicts boltzmann constant of k and ambient temperature of T. This kT value is about -170dBm/Hz in the general communication system. B is the bandwidth of 5MHz

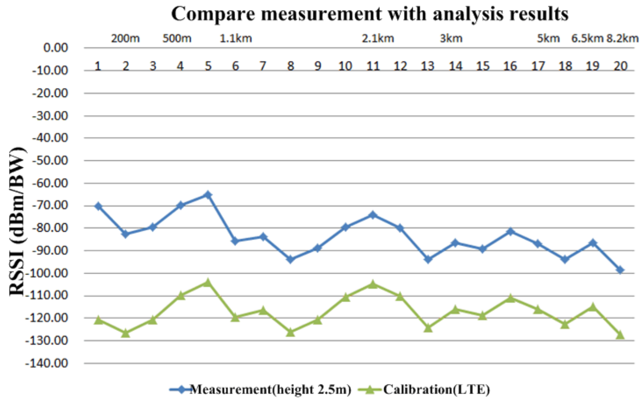


Fig. 12. SBS Station's iRSSI.

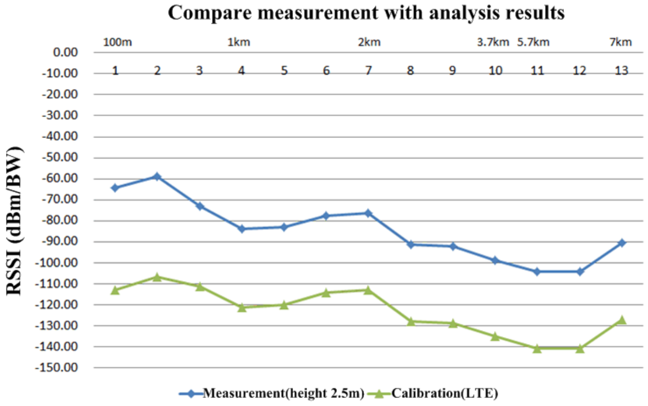


Fig. 13. FEBC Station's iRSSI.

of LTE base station and NF depicts the noise figure of 5dB of LTE base station receiver.

Therefore, the permissible totally received interfering signal strength intensity to the victim station is -114dBm/5MHz. Figure 12 and Figure 13 show the totally received interfering STL (SBS in Figure 12 and FEBC in Figure 13, respectively) signal strength intensity to the LTE base station when the receiving antenna height of the roof top to the measurement vehicular is 2.5m and the receiving antenna height of the LTE base station 15m, respectively. To limit the received interfering signal strength intensity, the separation distance is required between the STL transmit station as the interfering transmitter and the LTE base station as the victim station. If the permissible totally received interfering signal strength intensity to the reception is -114dBm/5MHz, the satisfied distance between the SBS station and LTE base station is 2.2km over in Figure 12 and the satisficed distance between the FEBC station and LTE base station is 2km over in Figure 13.

V. CONCLUSION

This paper described to derive composite median path loss and shadowing value for the protection of the LTE base station from the interference impact due to STL transmitter. As an approach, we measured the STL's transmission power during moving with a vehicular from the STL's broadcast studio to the STL receiver in another location. As the fixed STL microwave broadcasters, we considered two STL stations with different link paths in the large city. One STL station is FEBC and, while the other is SBS. Finally, we found to should be used the composite median pathloss with long term fading corresponding to the various urban and suburban environments in the large area. Measurement results are in good match with the results of composite different median path loss. In addition, to calculate the interfering STL signal strength intensity and desired LTE received signal strength intensity to the LTE reception, we considered the theoretic median pathloss and shadowing characteristics. For predicting the interference impact to the LTE base station reception, we defined the permissible totally received interfering signal strength intensity to the victim station. If the permissible totally received interfering signal strength intensity to the reception is -114dBm/5MHz, the satisficed distance between the SBS transmit station and the LTE base station is 2.2km over and the satisficed distance between FEBC transmit station and the LTE base station is 2km over.

For the coexistence between the STL station and LTE base station, it is expected to use the required minimum separation distance. And, the antenna correction factor is very important value to predict the radio propagation phenomenon such as the pathloss and shadowing for high accuracy and is available to calculate the interference impact in the adjacent channel bands.

ACKNOWLEDGMENT

This work was supported by the ICT R&D program of MSIP/KCA. [2013-005-036-001, Wireless Channel and Frequency Characterization based on Field Measurements for Broadband Mobile Hot-Spot Applications]

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