International Journal of Internet, Broadcasting and Communication Vol.7 No.2 130-136 (2015)
http://dx.doi.org/10.7236/IJIBC.2015.7.2.130

IJIBC 15-2-20

A Study on Compatibility between LTE and WLAN System for Mobile Satellite Wireless Package System

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Abstract

In this paper, we analyzed the adjacent channel interference of the LTE band 40 defined by 3GPP on the WLAN system based on the Monte-Carlo method, and found the guard band required for compatibility between the two systems. This study have a difference compared to the previous studies about cell radius was determined using Extended Hata Model considering practical environment, interference protection distance related to guard band, and the spectrum emission mask improvement effect for minimizing the interference. Simulation results, for no channel interference compatibility of LTE and WLAN for mobile satellite wireless package system, we can find the need 15MHz guard band at specified spectrum emission mask and 10MHz guard band at assumed spectrum emission mask.

Keywords: *LTE, WLAN, Monte-Carlo Method, Radio Channel Interference Analysis, Disaster Communication*

1. Introduction

Recent disaster communication system is required to spread the conditions in any environment when the emergency situation such as a natural disaster occurs. A novel wireless disaster communication system introduced a wireless package system based on the amateur radio HR(HAM Radio) and satellite communication [1]. In this paper, when a mobile terminal of satellite communication package system connected to WLAN repeater, we analyzed the adjacent channel interference of the LTE band 40 on the WLAN system based on the Monte-Carlo method, and found the guard band required for compatibility between the two systems. This study have a difference compared to the previous studies about cell radius was determined using Extended Hata Model considering practical environment, interference protection distance related to guard band, and the spectrum emission mask improvement effect for minimizing the interference. In the configuration of the paper, Chapter 2 explain interference scenarios and methods, obtain

Manuscript Received: Jun. 25, 2015 / Revised: Jul. 21, 2015 / Accepted: Jul. 30, 2015
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Cell Radius based on Extended Hata Model, and Chapter 3 analyzes interference protection distance related to guard band, and the spectrum emission mask improvement effect using SEAMCAT simulator. Chapter 4 presents a guard band required for compatibility between the two systems, and concluded finish.

2. Radio channel interference scenarios and methods

Interference scenario configuration device is Victim Receiver (Vr) receiving interference, Wanted Transmitter (Wt) transmitting to Vr a desired signal without the effects of interference, Interfering Transmitter (It) that causes the interference signal to Vr, and Wanted Receiver (Wr) receiving the desired signal without interference from It [2][3][4]. In this paper, we define Vr: WLAN AP, It: adjacent interferer LTE BS or UE, Wt: WLAN MS transmitting a signal to Vr, and Wr: LTE UE or the BS receives a signal from the It. The above description were shown in Figure 1, Interference values of WALN AP (Vr) is received from the LTE BS or UE can be determined by changing the distance (D) between Vr and It of Figure 1. Figure 4 shows the guard band and allocation channel of LTE and WALN system.

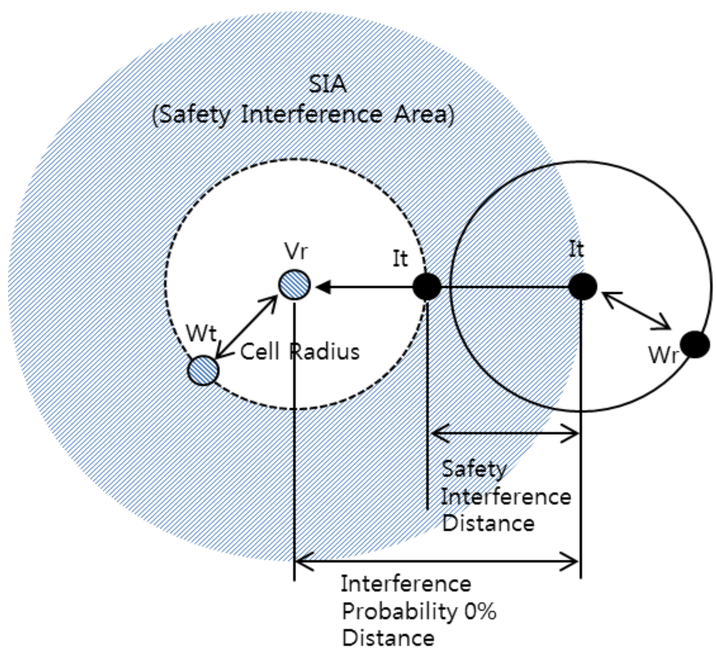


Figure 1. Scenario model for distance

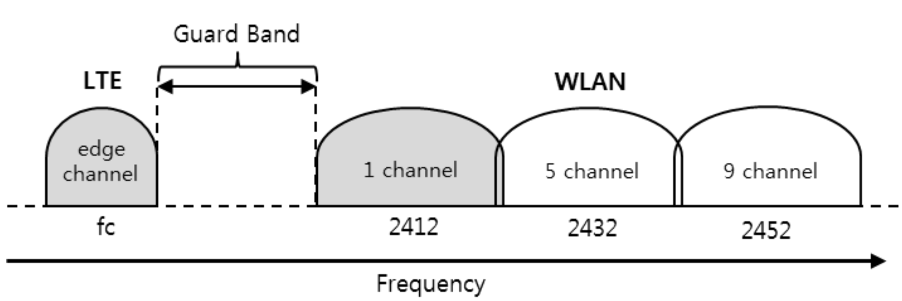


Figure 2. Allocation channel of LTE band 40 and WLAN system

Prior to scenarios application, Vr and Wr is placed on the maximum service radius having the lowest received signal strength from Wt and It respectively, this case is the worst case. The WLAN system service coverage can be calculated by the Link Budget. A link budget is accounting of all of the gains and losses from the transmitter, through the medium (free space, cable, waveguide, fiber, etc.) to the receiver in a telecommunication system, this method used to determine the size of the cell. The size of the cell using the Link Budget is calculated using that have a total value of signal to noise (SNR) and noise power due to the bandwidth and noise figure of the receiver less than the path loss value. As shown in Table 1 [5], in the case of a WLAN (IEEE 802.11g) is used in the 2.4GHz ISM band, channel 1 having the carrier frequency 2,412MHz transmits 15 dBm output power. If the signal to noise ratio (SNR) at the receiver is used the minimum 33dB, the noise power intensity is -106dBm, the received power is $P_r > (-106dBm + 33dB) = -73dBm$ from a given signal to noise ratio. Using the calculated Pr and main parameter of Table 1, the maximum allowable path loss value MAPL (Maximum Available Path Loss) may be calculated as follows, and displays in Table 2.

$$\text{MAPL} = EIRP - Sensitivity + \sum(Loss + Gain) = 98dB \tag{1}$$

In this paper, unlike previous studies we consider the actual propagation environment that Cell Radius was determined using the Extended Hata Propagation Model. In applying to MAPL Extended Hata Model the determined value in the formula (1),

$$PL = L(0.04) + \frac{[\log(d) - \log(0.04)]}{\log(0.1) - \log(0.04)]} \times [L(0.1) - L(0.04)] \tag{2}$$

$$\text{L}(0.04) = 32.4 + 20\log(\text{f}) + 10\log\left[d^2 + \frac{(H_b - H_m)^2}{10^6}\right] \tag{3}$$

$$\begin{aligned} \text{L}(0.1) = {} & 46.3 + 33.9\log(\text{f}) + 10\log\left(\frac{\text{f}}{2000}\right) \\ & - 13.82\log(\max\{30, H_b\}) \\ & + [44.9 - 6.55\log(\max\{30, H_b\})](\log(d))^{\alpha} - a(H_m) - b(H_b) \end{aligned} \tag{4}$$

$$\text{a}(H_m) = (1.1\log(f) - 0.7)\min\{10; H_m\} - (1.56\log(f) - 0.8) + \max\{0; 20\log\left(\frac{H_m}{10}\right)\} \tag{5}$$

$$\text{b}(H_b) = \min\left\{0; 20\log(\frac{H_b}{30})\right\}$$

$$H_m = \min(h1, h2)$$

$$H_b = \max(h1, h2)$$

$$\alpha = 1, d \leq 20\text{km}$$

$$h1 = \text{Tx antenna height}, \text{h2} = \text{Rx antenna height}$$

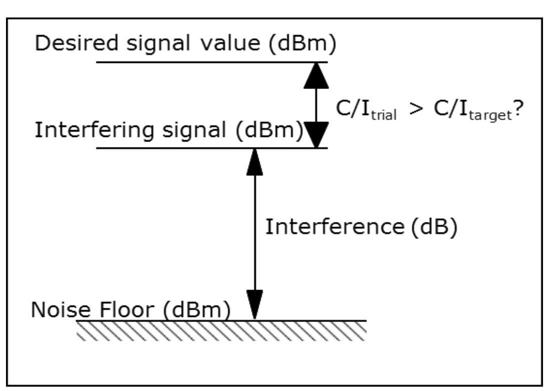
Cell radius can be seen from the above formula that is approximately 70m. Service coverage of the 2.4GHz ISM band WLAN in urban outdoor environmental conditions is about 70m. Vr and Wr is placed on the maximum service radius having the lowest received signal strength from Wt and It respectively, and by changing the distance D between Vr and It, find the distance satisfying the interference probability tolerance of Vr from the point of the interference probability zero. Defines a distance referred to as interference useful portion [2][3][4]. Interference impact analysis on distance scenarios been done through SEAMCAT of Monte-Carlo Simulation Method, which based on the statistical model allowed for radio interference scenario. Figure 3 shows the calculation processing of the interference probability in SEAMCAT simulation. If the strength of the desired signal and interference signal strength ratio is less than the pre-defined interference protection ratio (Carrier to Interference ratio, C/I) value, the interference occurs. The interference probability is calculated by subtracting the ratio of the total number of received signal the number of simulated events that meet the interference protection ratio from 1 [4]. In general, the probability of interference in the interference analysis deemed suitable within 2-5% [6]. In this study, the interference probability was determined to within 5%.

Table 1. WLAN System parameter

Parameter	*Value*	*units*
Frequency	2412	MHz
Channel Bandwidth	22	MHz
Sensitivity	-73	dBm
Interference Criteria(C/I)	10	dB
Noise Floor	-106	dBm
Antenna Height	2.5	m
Antenna Azimuth	0~360	Degree
Antenna Peak Gain	6	dBi
Output Power	15	dBm

Table 2. WLAN DL link-budget

Parameter		*Value*	*units*
Tx	Max. Tx Power	15	dBm
	Tx Antenna Gain	6	dBi
	Cable Loss	0	dB
	EIRP	21	dBm
Rx	Sensitivity	-73	dBm
	Tx Antenna Gain	6	dBi
	Fading Margin	2	dB
	Cable Loss	0	dBm
	Total	-77	dB
Maximum Available Path Loss		98	dB



- If $C/I_{trial}^{i} > C/I_{target}$: "good" event
- If $C/I_{trial}^{i} < C/I_{target}$: "interfered"

Figure 3. Illustrative summary of the interference probability calculation

3. Simulation and Analysis

The main parameters of the WLAN Physical Layer used in the simulation are assumed in Table 1 [5], the main parameters of the LTE Physical Layer are shown in Table 3 [7][8]. Figure 4 and Figure 5 represent the spectrum emission mask characteristic defined by the 3GPP standard [7][8], and the spectral emission mask assumed in this paper in order to minimize the interference from adjacent channels. In this study, we assumed the outdoor environment of urban using Extended Hata propagation model, channel interference impact of each guard band change on LTE BS and MS having the specified emission mask and the assumed emission mask on WLAN system were analyzed by simulation.

Table 3. LTE System parameter

Parameter	*Value*	*units*
Frequency	Variable	MHz
Channel Bandwidth	10	MHz
RB number	50	EA
Sensitivity	-98	dBm
Interference Criteria(C/I)	21	dB
Noise Floor	-104	dBm
Antenna Height	30(BS)/1.5(UE)	m
Antenna Peak Gain	15(BS)/5(UE)	dBi
Output Power	43(BS)/22(UE)	dBm

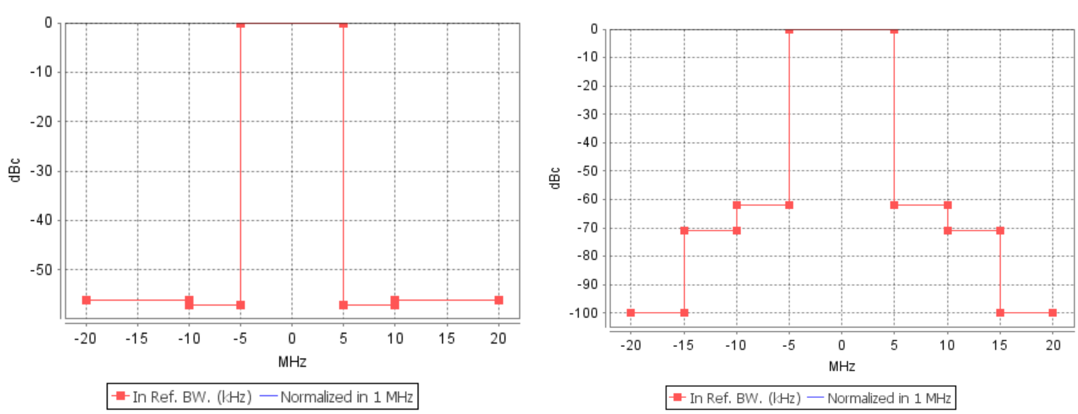


Figure 4. Spectrum emission mask of LTE BS (Specified mask Vs. Assumed mask)

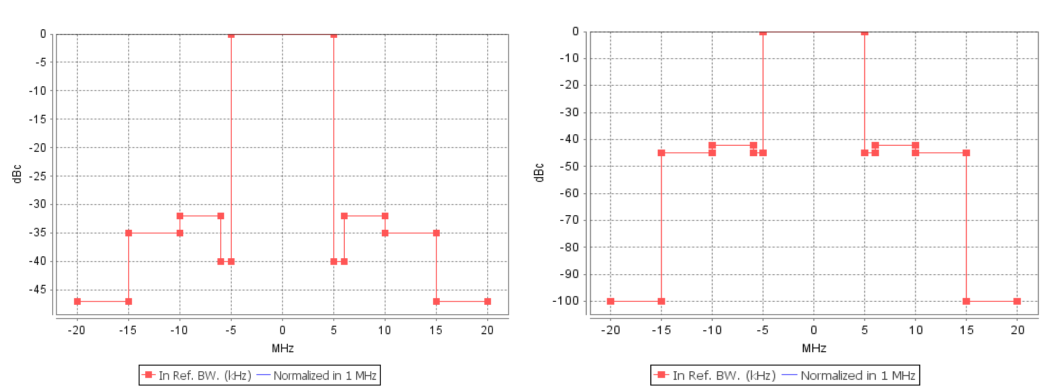


Figure 5. Spectrum emission mask of LTE UE (Specified mask Vs. Assumed mask)

3.1 LTE BS Channel Interference on WLAN System

Figure 6(left) is worst case having the lowest RSSI which Vr (WLAN) is located in the outer service coverage from Wt. Assuming that the interference tolerance of 5% on LTE and WLAN system, the protection distance is required approximately 0.48km at 5MHz guard band in specified emission mask and 15MHz guard band is needed in order to avoid the interference. When using assumed emission mask, the protection distance is required approximately 0.19km at 5MHz guard band and guard band in order to avoid the interference is significantly improved to 10 MHz.

3.2 LTE MS Channel Interference on WLAN System

Figure 6(right) also is worst case having the lowest RSSI which Vr (WLAN) is located in the outer service coverage from Wt. Assuming that the interference tolerance of 5% on LTE and WLAN system, the protection distance is required approximately 0.077km at 5MHz guard band in specified emission mask and 15MHz guard band is needed in order to a

void the interference. When using assumed emission mask, the protection distance is required approximately 0.061km at 5MHz guard band and guard band in order to avoid the interference is improved to 10 MHz.

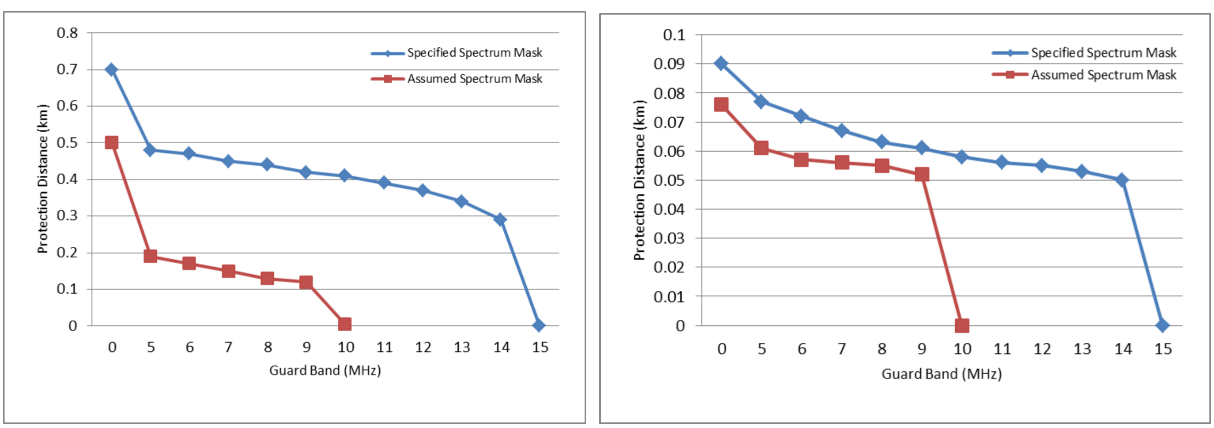


Figure 6. The relationship between the guard band and the protection distance (BS vs. UE)

4. Conclusion

In this paper, we analyzed the channel interference protection distance between LTE and 2.4GHz WLAN system for mobile satellite wireless package system. Simulation results, for no channel interference compatibility of LTE and WLAN system, we can find the need 15MHz guard band at specified spectrum emission mask and 10MHz guard band at assumed spectrum emission mask. The analysis results are expected to be used as a reference for determining the minimum guard band in the frequency processing techniques for compatibility of LTE and WLAN system.

5. Acknowledgement

This work was partially supported by the Technological Innovation R&D Program (S2176630) funded by the Small and Medium Business Administration(SMBA, Korea)

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