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UWB 센서에 의한 광대역 무선 시스템의 간섭 영향 분석

Analysis on the Impact of UWB Sensor on Broadband Wireless Communication System

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요 약 본 논문은 간섭원으로써 4.5 GHz를 사용하는 UWB 센서가 동대역을 사용하는 피간섭원 광대역 무선 시스템에 미치는 간섭을 분석하였다. 분석방법으로는 Minimum Coupling Loss(MCL)와 Spectrum Engineering Analysis Monte Carlo Advanced Tool(SEAMCAT)을 사용하였으며 그 결과는 다음과 같다. 양립성 확보를 위해서 UWB 센서와 광대역 무선 시스템의 이동국 사이에는 1.2 m 이상의 보호 이격거리가 요구되었고 다수의 UWB 센서가 존재하는 경우에는 간섭 확률 5 % 이하를 만족하기 위해 UWB 수신기 PSD는 -68.5 dBm/MHz 이하로 요구되었다.

Abstract This paper presents the impacts of Ultra Wide-Band(UWB) sensor using frequency of 4.5 GHz on Broadband Wireless communication system which uses frequency of 4.5 GHz. The Minimum Coupling Loss (MCL) method and Spectrum Engineering Advanced Monte Carlo Analysis Tool (SEAMCAT) is used to evaluate the interference effects of UWB sensor on Broadband Wireless communication system, respectively. The minimum protection distance between single UWB sensor and mobile station of Broadband Wireless communication system should be more than 1.2 m to guarantee the co-existence. In case of multiple UWB sensors, UWB transmitting PSD of around −68.5 dBm/MHz below should be required to guarantee interference probability of 5% below for mobile station of Broadband Wireless communication system.

Key Words : UWB sensor, Broadband Wireless communication system, Interference probability, Guard band

Ⅰ. Introduction

The importance of Ultra Wide-band(UWB) technology has been increased with the advent of communication services including low-cost, high speed and wireless network in these days. In addition, as the frequency resources become limit, the technology has been highly attracted in order to share the frequencies between UWB system and other existing services such as mobile communication, satellite communication and broadcasting system.

As the UWB spreads from DC to several GHz, it is appropriate for short-range communication networks requiring high rate and large capacity of data transmission. The UWB technology has been developed mainly for the distance measurement, communications devices for the military purpose and object measurement in basement[1]. The Federal

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Communications Commission (FCC) defined the UWB system as 20 % above Fractional Bandwidth of center frequency or the system with 500 MHz above RF bandwidth[2]. In the past, the impulse method has been suggested to get wide-band frequency characteristics as an implementation method. Although Multiband Orthogonal Frequency Division Multiplexing (MB-OFDM) and Direct Sequency-CDMA(DS- CDMA) have been discussed actively in IEEE. Because they have advantages of implementation feasibility and flexible frequency bandwidth[3], and FCC has provided spectrum mask illustrated in Figure 1 for UWB Surveillance systems, but the potential interference due to the very large bandwidth occupied by the UWB signal have been reevaluated for the successful operation of the existing systems. The impacts for interference of UWB systems to the existing communication systems have to be considered in the worst case.

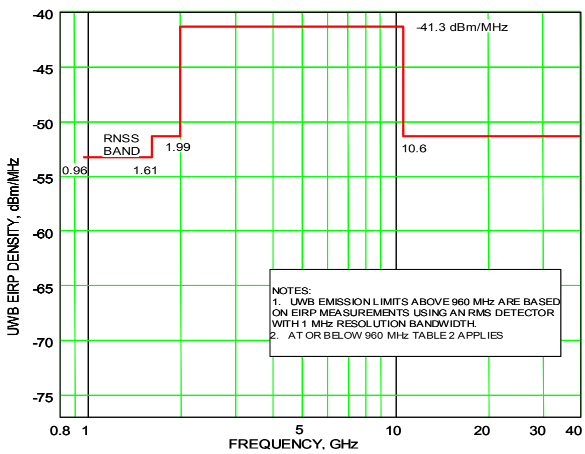

그림 1. UWB 감시 시스템의 방사 마스크
Fig. 1. UWB Surveillance systems emission mask

This paper analyzes particularly the impacts of UWB sensor system of Samsung Company using frequency of 4.5 GHz on Broadband Wireless communication system which uses frequency of 4.5 GHz in outdoor, The Minimum Coupling Loss (MCL) and SEAMCAT are used as interference analysis methods to evaluate the interference effects of UWB sensor system on Broadband Wireless communication system[4],[5].

The analysis results show the minimum protection distance between UWB system and Broadband Wireless communication system as well as the allowable transmitting power spectral density of UWB sensor system for the compatibility.

Ⅱ. Interference analysis of the impact of single UWB sensor on mobile of Broadband Wireless communication system in Outdoor environment

The impact of single UWB sensor on mobile station of Broadband Wireless communication system is analyzed in terms of MCL method. The system parameters for MCL method and analysis scenario for worst case are considered. The minimum protection distance between interferer and victim system is obtained.

The scenario for the interference analysis is established as follows. Service environment: Outdoor environment. Interferer: single UWB sensor. Victim system: mobile station of Broadband Wireless communication system. UWB sensor transmitting power spectral density(PSD): -63 dBm/MHz@4.5 GHz provided by Samsung Company in Outdoor. In Bands: 3.1 ~ 10.6 GHz, Antenna characteristics: omni directional. Reference Distance: 36 cm or 1m. Reference Bandwidth: 1 MHz.

The specifications of Broadband Wireless communication system are defined as follows. Operating frequency: 4500 MHz. Channel bandwidth: 10 MHz. Noise Figure: 8 dB. Noise Floor: -96 dBm. Antenna characteristic: Omni directional antenna. Path loss model: free space path loss.

When the protection criteria which is the ratio of Interference over Noise Floor (I/N) was defined as -6 dB by considering worst case scenario, the allowable maximum UWB PSD and the minimum protection distance is analyzed. The analysis results using MCL method are summarized in Table 1.

표 1. MCL과 시스템 파라미터를 이용한 간섭 분석 결과 요약
Table 1. The summary of interference analysis results using system parameters and MCL method

Parameter	Value	Units	Equation
Frequency	4500	MHz	F
Thermal noise density	-174	dBm/Hz	KTBHz
Reference bandwidth	1	MHz	Bref
Victim bandwidth	10	MHz	B
Victim noise figure	8	dB	NF
Noise floor	-96	dBm	N = KT + B + NF
Interference criteria	-6	dB	I/Nth
Allowed interference level in victim bandwidth	-102	dBm	I = N- [I/Nth]
UWB EIRP (Samsung Company) in 10 MHz	-53	dBm	P= -63+10log(10)
Victim receiver antenna gain	0	dBi	GR
Victim receiver line loss	2	dB	LR
Path loss required	47	dB	Lp= P +GR-LR-I
Minimum allowable distance	1.2	m	20 log(D) = Lp - 20 log(F) + 27.5

Based on Table 1, when 0.36 m is chosen as reference distance, the maximum allowable UWB PSD = -73.3 dBm/MHz.

Ⅲ. The analysis of the impact of multiple UWB sensors on mobile station of Broadband Wireless communication system in Outdoor environment

The SEAMCAT is used for the analysis of the impact of multiple UWB sensors on mobile station Broadband Wireless communication system in Outdoor environment. System parameters and scenario are defined for the SEAMCAT analysis. The maximum UWB transmitting PSD is considered so as to keep minimum interference probability so much as no occurring in mobile station Broadband Wireless communication system.

The analysis scenario is assumed in Figure 2. Service environment: Outdoor. Interfering system: UWB sensor system of Samsung Company. Interfering transmitter (It) is UWB sensor. UWB sensor transmitting PSD: - 63 dBm/MHz@4.5 GHz provided by Samsung Company in Outdoor. The sensing distance is within 40 m of UWB , the space of fence pillar is 4 m, the fixing height on fence pillar is 2.2 m. the beam width: horizontal is 150°, perpendicular is 35°, the density of transmitters/km^2 is 25.

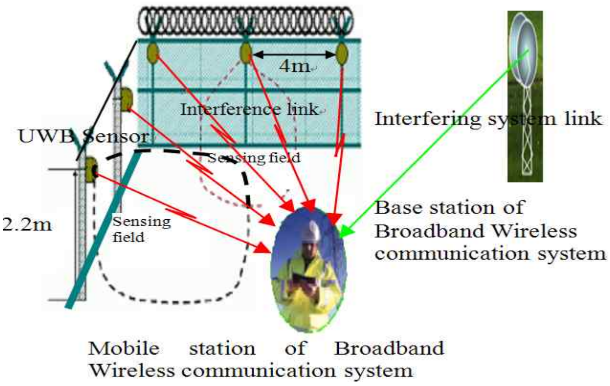

그림 2. 다수의 UWB 센서와 광대역 무선 통신 시스템
Fig. 2. Multiple UWB sensors and Broadband Wireless communication system

Interfering system: We can limit UWB PSD = -63 dBm/MHz on in band of 4.2 ~ 4.8 GHz depending on the transmitting power of UWB sensor of Samsung

Company, however the UWB PSD limit on out of band refers to emission mask for UWB surveillance system that is provided by FCC. Figure 3 displays proposal emission mask for UWB sensor system in Korea. Therefore, according to Figure 3, UWB emission mask is summarized in Table 3 and obtained as Figure 4 in SEAMCAT for interference analysis. Reference Bandwidth: 1 MHz. Main parameters of UWB sensor system of Samsung Company are summarized in table 2.

Victim system: Broadband Wireless communication system, Victim receiver (Vr) is the Mobile station (MS) of Broadband Wireless communication system, Wanted transmitter (Wt) is the Base station (BS) of Broadband Wireless communication system. Parameters for Broadband Wireless communication system are as follows: Operating frequency: 4500 MHz. channel Bandwidth: 10 MHz. Noise Figure: 8 dB. Noise Floor: -96 dBm. Antenna height: 15 m for base station and 1.5 m for mobile station. Propagation model: Free space (considering the worst scenario). Main parameters of Broadband Wireless communication system are summarized in table 4.

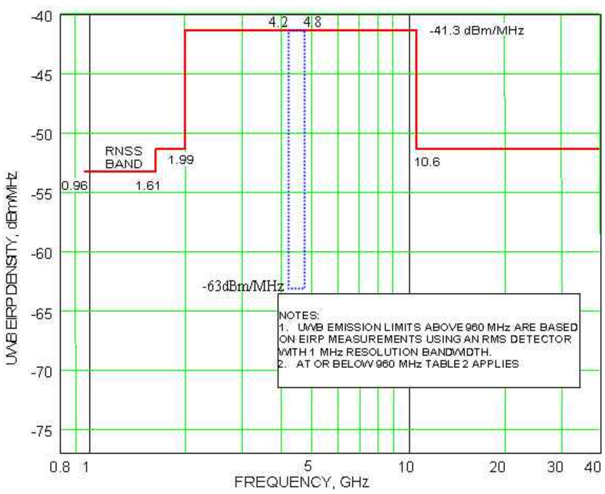

그림 3. 한국의 UWB 센서를 위한 방사 마스크
Fig. 3. Proposal emission mask for UWB sensor system in Korea

표 2. 삼성 UWB 센서의 주요 파라미터
Table 2. Main parameters of UWB sensor system of Samsung Company

Parameter	Value	Units
Frequency	4500	MHz
UWB EIRP (Samsung Company)	-63	dBm/MHz
Transceiver Antenna Height	2.2	m
Antenna Gain	11	dBi
Sensing distance	40	m
Density of transmitters /km2	25	
Probability of transmission	1	
It->Vr propagation model	Free space (considering the worst case)	

표 3. 심켓에서의 UWB 센서 불요방사 마스크
Table 3. Unwanted mask for UWB sensor system in SEAMCAT

Frequency offset(MHz)	-63 dBm UWB Power	Attenuation in dBc in SEAMCAT
216-960	-40	23
960-1610	-53.3	9.7
1610-1990	-51.3	11.7
1990-4200	-41.3	21.7
4200-4800	-63	0
4800-10600	-41.3	21.7
>10600	-51.3	11.7

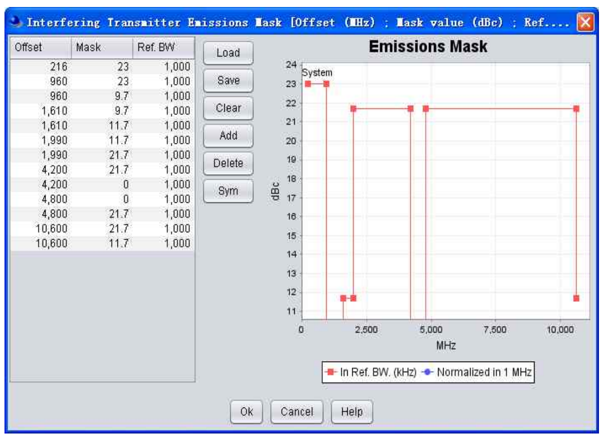

그림 4. UWB의 불요 방사 마스크
Fig. 4. Unwanted emissions mask for UWB

표 4. 광대역 무선 통신 시스템의 주요 파라미터
Table 4. Main parameters of Broadband Wireless communication system

Parameter	Value	Units	Equation
Frequency	4500	MHz	F
Thermal noise density	-174	dBm/Hz	KT
Reference bandwidth	1	MHz	Bref
Victim bandwidth	10	MHz	B
Victim noise figure	8	dB	NF
Interference criteria	-6	dB	I/Nth
Noise floor	-96	dBm	N=KT + B + NF
SNR (QPSK 1/2)	9.4	dB	SNR
Victim receiver (Vr)Sensitivity	-86.6	dBm	RS=KT+B +NF+SNR
Victim receiver antenna gain	0	dBi	GR
Victim receiver line loss	2	dB	LR
Wanted transmitter (Wt) power	30	dBm	PWt
Wanted transmitter gain	10	dBi	GT
Path loss required	124.6	dB	Lp=PWt+GR +GT-LR-RS
Wt->Vr Coverage radius	9	km	20lg(D)=LP -20lg(F)+27.5
Base station height	15	m	
Mobile station height	1.5	m	
Wt->Vr propagation model	Free space		

Based on parameters of systems, Scenario is set up in SEAMCAT, and interference probability can be obtained through simulating in the SEAMCAT. The analysis results of the impact of multiple UWB sensors on mobile station of Broadband Wireless communication system are as following:

Calculation mode: Compatibility. Signal Type: Unwanted. Interference criterion: I/N. Algorithm: Quick. Samples: 20000, Density of transmitters/km^2=25, see Figure 5.

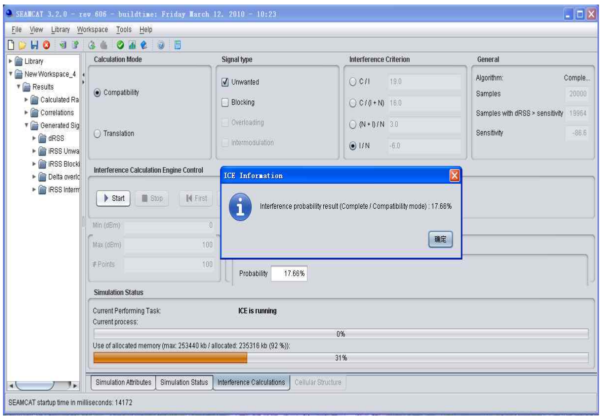

그림 5. UWB PSD = −63 dBm/MHz일때의 간섭 확률
Fig. 5. Interference probability when UWB PSD = −63 dBm/MHz

Calculation mode: Translation, Signal Type: Unwanted, Interference criterion: I/N. Algorithm: Quick, Samples: 20000, Interference probability vs transmitter power supplied, Density of transmitters/km^2=25. The result is illustrated in Figure 6.

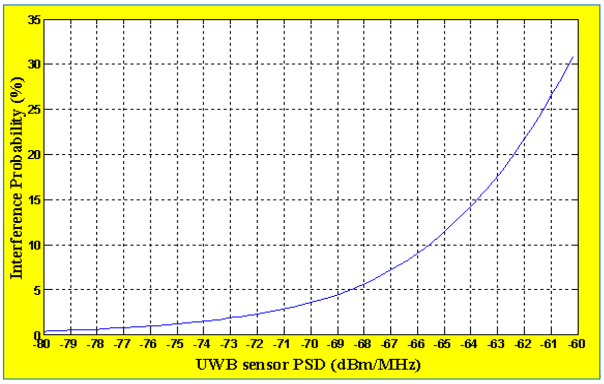

그림 6. 간섭 확률 대 UWB 송신 파워
Fig. 6. Interference probability vs UWB transmitter power supplied

Under condition of density of transmitters/km^2 =25, from Figure 5, interference probability is 17.66 %, when UWB PSD = -63 dBm/MHz; from Figure 6, if interference probability of 0.5 % below is acceptable, UWB PSD should be -68.5 dBm/MHz below.

Figure 5, 6 show that It has different scenario comparing with chapter Ⅱ. Because chapter Ⅱ is single case which has only one interferer. But, chapter Ⅲ is Multiple case which has 25 interferer. So, we analyze to use SEAMCAT in chapter Ⅲ. Finally, we get Interference probability according to interference transmitting power. Also, Figure 5 is in Compatibility mode and Figure 6 is in Translation mode.

Ⅳ. Conclusion

The impact of single and multiple UWB sensors on mobile station of Broadband Wireless communication system have been analyzed through MCL method and SEAMCAT. In the case of Outdoor environment, the minimum protection distance between UWB interferer and mobile station of Broadband Wireless communication system and the allowable maximum UWB transmitting PSD are defined to meet I/N of -6 dB. The interference effect of multiple UWB sensors on mobile station of Broadband Wireless communication system is analyzed through SEAMCAT simulation to reduce or avoid occurring of interference probability in mobile station of Broadband Wireless communication system.

As a result, when I/N of -6 dB is chosen as protection criteria for the case of single UWB sensor, the required minimum protection distance between UWB interferer and mobile station of Broadband Wireless communication system should be more than1.2 m. When 0.36 m is chosen as reference distance between UWB interferer and mobile station of Broadband Wireless communication system, the maximum allowable UWB PSD = -73.3 dBm/MHz. In case of impact of multiple UWB sensors on mobile station of Broadband Wireless communication system, UWB PSD of -68.5 dBm/MHz below is required to guarantee interference probability of 5% below.

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