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Interference Mitigation Effect for UWB coexistence with BWA

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1. Introduction

Interference impacts by UWB system to the existing communication systems have also been considered in the worst case [1]-[2]. These results have been derived so pessimistic conclusions. Therefore, this paper proposes low duty cycle (LDC) in order to mitigate strong interference to a Broadband Wireless Access (BWA). Also, we analyze LDC's effect through UWB interference modeling to BWA using frequency band of 3.5GHz.

2. Broadband Wireless Access (BWA) Features

In this paper, BWA system is considered as a victim service from UWB interference. BWA is the system based on orthogonal frequency division multiplexing (OFDM) and time division multiplexing (TDD) schemes. FFT sizes are 256. Channel bandwidth is 3.5MHz or 7.0 MHz [3].

3. Interference Modeling Approach

A. Scenario for UWB coexistence with BWA

Firstly, the whole considered area around the victim BWA would be populated by multiple UWB devices. It was assumed that multiple UWB devices more than one were transmitting at a given time. Also, the given simulation area of $1km^2$ is considered. Therefore, area is limited by circle of 0.6 km radius around a victim BWA.

B. Modeling the duty cycle of UWB transmitter

The duty cycle become model by "on-off" keying of the transmit power, which is set through uniform distribution function applied to the result of a uniform sample between 0 and 1 for transmit power of the interfering transmitter. Therefore, the duty cycle of UWB devices, considered to be less than 5% (<0.05) in worst case, was modeled by setting the output power distribution of interfering transmitter.

C. Modeling of permissible interference to victim

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The permissible interfering signal power to a victim BWA in dBm/MHz, *iR* is described in equation (1)

$$iR = 10\log_{10}\sum_{n=1}^{N} 10^{\frac{p_n}{10}} \quad (1)$$

where, p_n is the received UWB interfering signal power to a victim BWA from i-th active UWB transmitter. It is defined by equation (2).

$$p_n = P_{Tx} - \Gamma_{n\to Vr} + G_n + G_{Vr} \quad (2)$$

Here, P_{Tx} depicts that the conducting power of an active UWB interfering transmitter in dBm/MHz. It is assumed that UWB device has the function of duty cycle. G_n in dBi and G_{Vr} in dBi depict the UWB antenna gain and BWA antenna gain, respectively. $\Gamma_{n\to Vr}$ in dB depicts the median path loss between UWB transmitter and BWA victim receiver. Path loss is considered for the worst case. Therefore, the path loss model defined in equation (3) in [4] is used for the analysis of UWB interference impacts on a BWA victim receiver.

$$\Gamma_{n\to Vr} = 20\log_{10}\left(\frac{4\pi r_0}{\lambda}\right) + 10\beta\log_{10}\left(\frac{r_{n\to Vr}}{r_0}\right) \quad (3)$$

where, r_0 means the reference distance in meter, λ is wavelength, β means the attenuation coefficient, for example, $\beta = 2$ in case of free space. $r_{n\to Vr}$ depicts the separation distance between UWB transmitter and BWA victim receiver.

4. Simulation Results

The major parameters for the evaluation of UWB interference impacts are summarized in Table 1. Using the monte carlo method, the interference probability is calculated by averaging the results of happened interference events through "snap-shot" in a given time.

A. Interference effect by UWB without duty cycle

In Figure 1, LDC is not implemented to UWB device.
Therefore, UWB device would be always set by 100% duty cycle for UWB transmission. Also, UWB maximum power is transmitted for communication among UWB devices.

For evaluation, two kinds of BWA antenna gain, G_{Vr}= 0 dBi or G_{Vr}=8 dBi were compared. And, a number of multiple UWB devices, *Nint* = 20 or *Nint* = 40 devices are considered.

Firstly, BWA antenna gain effect showed. As a result, G_{Vr} = 8 dBi gave higher interference impact than the case of G_{Vr} = 0 dBi.

Secondly, multiple UWB devices' effect showed for the same BWA antenna gain. Here, higher UWB density caused the stronger interference into BWA victim system than lower UWB density did.

For UWB device without LDC, UWB maximum power density, which is UWB PSD Tx., would be limited by – 80 dBm/MHz.

B. Interference effect by UWB with duty cycle

In Figure 2, LDC is considered for analysis of UWB interference mitigation effect. Here, two UWB maximum power are compared; one is FCC limits of – 41.3 dBm/MHz, the other is UWB PSD Tx of – 61.3 dBm/MHz. Also, two kinds of BWA antenna gain, G_{Vr}=0 dBi or G_{Vr}=8 dBi were considered such as shown in Figure 1.

For *Nint* = 40 in Figure 2(a), UWB interference probability with FCC limits of – 41.3 dBm/MHz is gradually decreased. However, 5% duty cycle influenced the UWB interference effect of about 10% to BWA with 0dBi antenna gain. Therefore, maximum UWB power should be lower than FCC limit of – 41.3 dBm/MHz. In Figure 2(b), UWB PSD Tx of – 61.3 dBm/MHz is considered. The same duty cycle of 5% in Figure 2(a) is lower than UWB interference probability than FCC limit.

Finally, FCC limits could conditionally be transmitted through implementing LDC function to UWB device.

5. Conclusion

This research has shown that the deployment of UWB with LDC could be so effective method for UWB coexistence with BWA using the frequency band of 3.5 GHz in order to mitigate strong UWB interference.

References

[1] ITU-R attachment 1 to annex 5 to document 1- 8/347-E: "Studies related to the impact of devices using ultra wideband technology on system operating within the mobile service," Jun. 2005.

[2] ITU-R attachment annex 1 to document 1-8/88-E: "Summary of studies related to the impact of devices using ultra-wideband technology on radiocommunication services," 21 Oct. 2005.

[3] Part 16: Air Interface for Fixed Broadband Wireless Access Systems, IEEE 802.16TM-2004, Oct 2004.

[4] ITU-R.P.525-2: "Calculation of free space attenuation," 1994.

Table 1: Parameters for evaluation of UWB interference impact

Parameters	Value
Frequency bands	3.5 GHz bands
Nint	20, 40 devices
G_{Vr}	0 dBi, 8 dBi
G_n	0 dBi

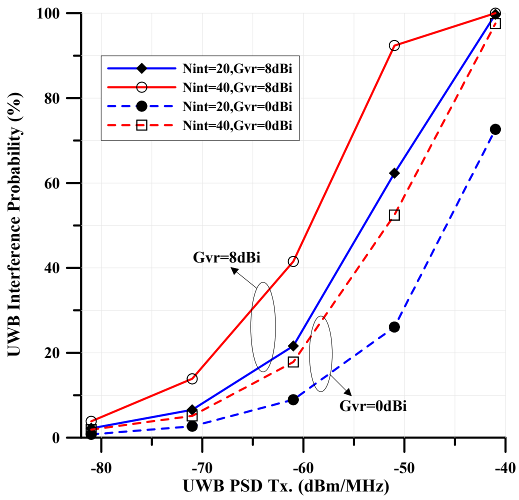
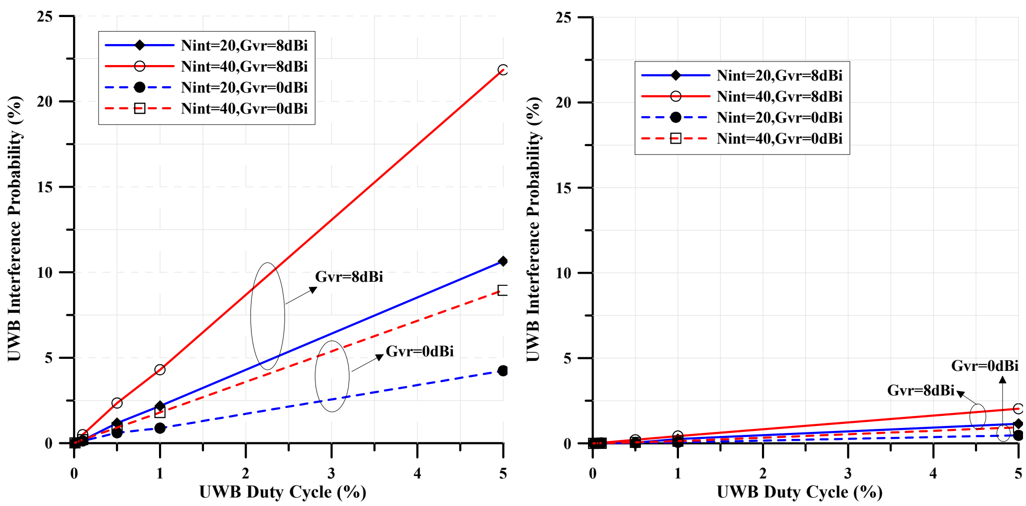


Figure1: UWB Interference probability to BWA (c.f. duty cycle of 100%)



(a) UWB PSD Tx. = – 41.3 dBm/MHz (b) UWB PSD Tx. = – 61.3 dBm/MHz

Figure2: UWB Interference probability to BWA vs. UWB duty cycle