Experimental Interference Studies Between WCDMA and UWB System

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Abstract - Ultra wideband (UWB) technologies have been developed to exploit a new spectrum resource in substances and to realize ultra-high-speed communication, high precision geolocation, and other applications. The energy of UWB signal is extremely spread from near DC to a few GHz. This means that the interference between conventional narrowband systems and UWB systems is inevitable. However, the interference effects had not previously been studied from UWB wireless systems to conventional mobile wireless systems sharing the frequency bands such as WCDMA system. This paper experimentally evaluates the interference from two kinds of UWB sources, namely a direct-sequence spread-spectrum UWB source and an impulse radio UWB source, to a WCDMA digital transmission system. The average frame error rate degradations are presented. From these experimental results, we show that in all practical cases UWB system can coexist with WCDMA terminal without causing any dangerous interference.

Keywords: UWB, WCDMA, Interference.

1 Introduction

Recently, Ultra Wideband (UWB) technology has attracted a lot of interest in the research community and in industry. UWB offers the potential for high data rates, low-power transmissions, low cost, robustness to multipath fading, and excellent range resolution capabilities. UWB can be used in the design of wireless local and personal area networks providing advanced integrated multimedia services to nomadic users within hot-spot areas[1].

UWB signals are generated using sub-nanosecond pulses thus spreading energy over very large frequency band. An UWB radio signal occupies a bandwidth is greater than 25% of a center frequency or more than 1.5GHz. Clearly, this bandwidth is much greater than the bandwidth used by any current technology for communication. Due to the very large bandwidth, no spectrum can be allocated to UWB exclusively thus UWB band overlaps with many other narrowband systems. Therefore to guarantee existing systems from UWB emissions the FCC restricted the UWB operating bands in the 3.1-10.6 GHz frequency range and regulated UWB power emission by defining frequency-power masks for each specific UWB application/device. The assessment of interference caused by UWB devices is of fundamental importance to guarantee not conflicting coexistence and to gain acceptance of UWB technology worldwide. Some results on the coexistence between UWB and existing fixed wireless systems operating in the 3-5GHz band have been already presented in the literature and in regulatory forums[2]. Recent FCC rulings proposed a radiated power limit from UWB devices of -41 dBm/MHz from 3.1 to 10.6 GHz[3]. In comparison with the GPS and other indoor communications techniques the effects of wireless UWB systems on cellular mobile telephone services has not been well covered in the literature.

This paper experimentally evaluates the interference from two kinds of UWB sources, namely a direct-sequence spread-spectrum CDMA(DS-CDMA) UWB source and an impulse radio UWB source, to a WCDMA digital transmission system. From these experimental results, the interference effects of DS-CDMA UWB source is not severe compared to the Impulse UWB.

2 Experiment System Descriptions

2.1 Victim System

The victim system used in this interference experiment was a WCDMA mobile handset of KTF digital wireless communication systems employing CDMA which is the most commonly used mobiles in mobile and wireless communication systems. The receiver carrier frequency are 2130 MHz, respectively, the transmission bandwidth is 3.84 MHz for WCDMA. The mobile was connected with an RF cable for measuring the conduction BER testing and test cable for obtaining the diagnostic information using commercial DM software.

2.2 UWB characteristics

The UWB transmitter employed in this experiment uses parameter values of Table. 1 and wideband spectral characteristics as shown in Fig. 1, which are manufactured by Time Domain Corp and Freescale Corp. In our measurement, the UWB frequency band is centered on approximately 4.1GHz with -41dBm/MHz. Hence, this UWB transmitter is almost satisfied with FCC Part 15 emission regulation for practical usage [3].

Table 1. UWB Characteristics

UWB source	Impulse UWB PulseOn200	DS-CDMA XSUWBWDK
Specification	**Pulse Repetition Frequency(PRF)** 9.6MHz **Center Frequency (Radiated)** 4.7GHz **Bandwidth (10dB radiated)** 3.2GHz **EIRP** -41.5dBm	**Center Frequency** 4.0GHz **Frequency Range** 3.1~5.5GHz **Resolution Bandwidth** 1MHz **EIRP** -47dBm
Corporation	Time Domain	Freescale

2.3 BER Measurement System

Consequently, now, we specifically consider WCDMA mobile and UWB device. These two different wireless systems are connected in the conduction environment and likely to interfere with each other and experience a decrease in sensitivity level. This paper presents experimental results of the coexistence tests with these two different systems. The main goal of this work is to determine how the performance of WCDMA mobile is degraded in the existence of UWB device in the neighborhood.

The measurement configuration employed in this experiment is described in Fig. 1. The base station signal was generated by a Anritsu MT8820A Radio Communication Analyzer Base Station Emulator (BSE), which is a mobile test instrument capable of generating signals emulating two sectors of a WCDMA base station compliant with the ETSI TS 134 121[8] Air Interface Standard. The UWB signal passed through the directional coupler(or splitter) and an attenuator was combined with the radio signal with the first hybrid. The second hybrid was inserted to measure the radio frequency power with a spectrum analyzer. This setup enabled us to eliminate the effects of signal fading, which is not the subject of this study. Transmission via space or power lines was completely negligible. Bit error rate (BER) was averaged over the 1000 sampling points.

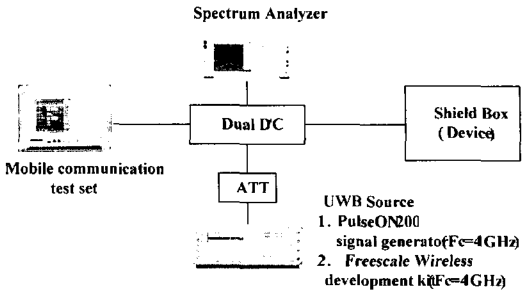


Figure 1. BER Measurement Setup

3 Experimental Results and Discussion

In each environment, the BER is measured with varying the power level of UWB interferer. WCDMA system is also considered in each fixed measurement between two devices. For more accurate experiments, each measurement is repeated.

3.1 Pathloss Calculation

The assumption being made is that the aggregate UWB power at the receiver can be modeled as the superposition of UWB powers at various locations and that the effect of the medium on a UWB transmitter's power is attenuation according to the semi-empirical model implemented as the ITM(Irregular Terrain Model). To account for the very short distances that are common to UWB interference scenarios, the free-space propagation component of the attenuation is reformulated in a way that can be expressed by [3]

$$L(dB) = 20\log_{10}(\frac{4\pi d}{\lambda} + 1.64) \qquad (1)$$

which closely approximates near-field measured results as the distance becomes small. The methodology in this calculation does not take the bandwidth of the transmitter's signal as a parameter, so that UWB signals are treated no differently than narrowband signals with the same center frequency.

From Eq.(1), the same condition without no interfere source, path loss 39dB is obtained at 1m distance between victims and interferer for WCDMA frequency band.

3.2 Link Budget Analysis

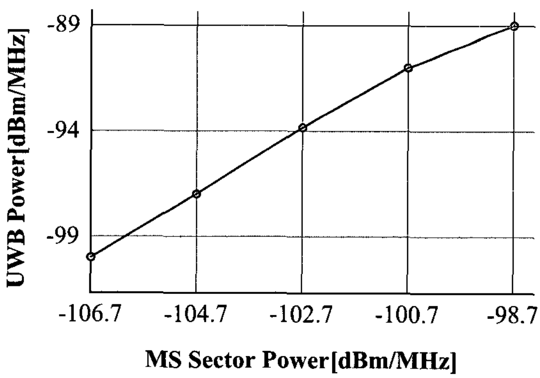
Following Table 2 has been used for coupling path loss and theoretical minimum allowed UWB emission level. According to the Table 2, the theoretical minimum allowed UWB emission level at 1m distance from WCDMA mobile is -72.8dBm/MHz. In interference analysis between UWB and victim systems, the major issue to be considered is the configuration methods to set the value of interference criteria. According to the ITU-R M.1225 standards, the value is used below -20dB in the some fixed service usage, and in general it is used below -6dB for mobile communications. While doing so, the model of path-loss between two devices is based on the above path loss equation with irregular terrain model which is the worst case scenario.

Table 2. Link budget analysis

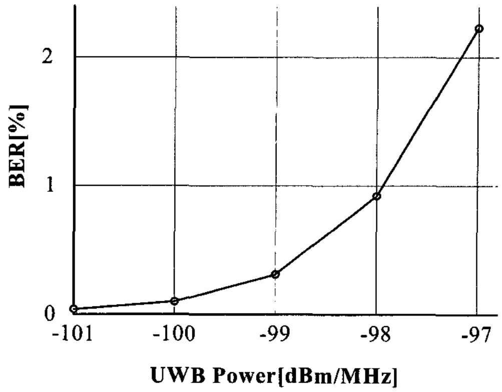
Parameter	Value
Frequency	2100 MHz
Thermal noise density	-174 dBm/Hz
Reference bandwidth	1 MHz
Victim bandwidth	3.84 MHz
Victim noise figure	8 dB
Noise floor	-100 dBm
Allowed interference level in victim bandwidth	-106 dBm
Allowed interference level in reference bandwidth	-111.8 dBm/MHz
Free space path loss(ITM)@1m	39 dB
Victim receiver antenna gain	0 dBi
Victim receiver line loss	2 dB
UWB power level@1m	-72.8 dBm/MHz

3.3 Discussion

The experimental results of interference between each UWB signals, impulse and DS-CDMA sources and WCDMA terminal are shown in Figure 2 and Figure 3, respectively.

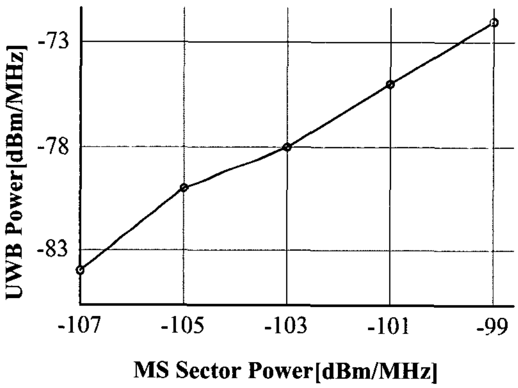


(a) UWP power for WCDMA BER criterion

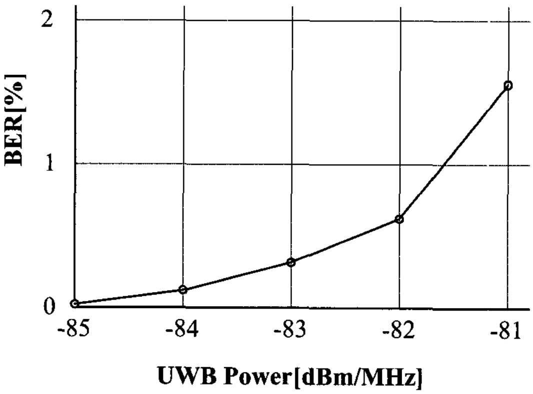


(b) BER degradation as UWB Power increase

Figure 2. Interference results between WCDMA mobile and Impulse UWB source



(a) UWP power for WCDMA BER criterion



(b) BER degradation as UWB Power increase

Figure 3. Interference results between WCDMA mobile and DS-CDMA UWB source

The downlink frequency of WCDMA mobile is 2130 MHz (10650CH). In case of impulse UWB signal, maximum allowable UWB power level is -101dBm/MHz in order to satisfy the receiver sensitivity of BER 0.001 at 106.7dBm/3.84MHz for WCDMA base station power level. Since UWB power level is given -62dBm/MHz considering 39dB path loss for 1m, there is 10.8dB margin comparing 72.8dBm/MHz from link budget analysis.

Figure 3 shows the interference level of WCDMA terminal with DS-CDMA UWB signal. In order to satisfy the receiver sensitivity criterion of WCDMA, the -85dBm/MHz of UWB power level is enough and it may be considered as -46dBm/MHz with 39 dB path loss at 1m, which is above the UWB emission limit of FCC at 2GHz. These results means that if we use the band pass filter with high steep performance for UWB signal generation, the possibility of interference will be reduced.

4 Conclusions

Due to the very large UWB signal bandwidth, the assessment of the possible interference caused by UWB devices on already existing narrowband systems in fundamental to ensure not conflicting coexistence and, therefore, to guarantee acceptance of UWB technology worldwide. The characteristic of UWB communication is that spreading the energy from DC to several GHz is transmitted not to affect to other narrow band communication systems. However, the ultra wideband signal over 500 MHz causes the interference to other communication systems outside of 3.1-10.6GHz band. This paper measured and analyzed the interference between WCDMA and UWB system around 2 GHz. For WCDMA mobile, impulse UWB signal have lower interference effect if the UWB signal satisfies FCC and ETSI emission limit with -63dBm/MHz at 1m. In case of DS-CDMA, since output power level of UWB signal is very low at the band of 3.1-10.6GHz, the results show that the interference effect, of which the maximum allowable output power level is -47dBm/MHz, is much lower than that of impulse UWB signal. We show that in all practical cases UWB system can coexist with WCDMA mobile terminal without causing any harmful interference.

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