The Research of the UWB Interference Effects on the Mobile Communication System

Hong-jong Song* ***Regular Member***, Jae-sang Cha*, Goo-man Park* ***Lifelong Members***

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 Cellular CDMA and Korean PCS. 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 Cellular CDMA and K-PCS digital transmission system. The average frame error rate degradation of each system are presented. From these experimental results, we show that in all practical cases UWB system can coexist with Cellular CDMA and K-PCS terminal without causing any dangerous interference

Key Words : UWB, Interference, coexistence, mobile communication

Ⅰ. 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 (geolocation) 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 verylarge 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

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telephone services has not been well covered in the literature. This is probably not surprising. Most current mobile telephone system fall below 1GHz and thus are not in the frequency band in which it is anticipated that most UWB communication systems will use. The 1.5 GHz cellular band is heavily protected by current FCC regulations. It can be anticipated that 2 GHz services will be somewhat affected, however, this is at the edge of the main UWB bandwidth and is not as popular as other cellular services at the present time[4].

Some experiments have been performed. For example, in [5], the effect of a prototype UWB communication system meeting FCC requirements on a 1.9GHz PCS band mobile phone was examined. Although the tests were subjective voice quality only, no discernible difference was found by the people making the telephone calls. In these tests the mobile phone was located approximately 1.5m away from the UWB transmit antenna.

In this paper, interference effects have been studied to conventional mobile wireless system such as Cellular CDMA and K-PCS system for impulse radio UWB source using experimental results which are partially supported by SK Telecom Corp., LG Telecom Corp. and Korean UWB Forum.

Ⅱ. Experiment System Descriptions

2.1 Victim System

The victim used in this study was a Cellular CDMA of SK Telecom and K-PCS of LG Telecom digital wireless communication systems employing CDMA which is the most commonly used mobiles in mobile and wireless communication systems. The receiver carrier frequency are 893.37 MHzand 1.86375 GHz, respectively, the transmission bandwidth is 1.25 MHz for Cellular CDMA and K-PCS. The mobile were connected with an RF cable for measuring the conduction FER testing and test cable for obtaining the diagonastic informations 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 is manufactured by Time Domain Corp (PulseON200TM). In our measurement, the UWB frequency band is centered on approximately 4.1GHz with －40dBm/MHz. Hence, this UWB

Table 1. Impulse UWB Characteristics

Pulse Repetition Frequency(PRF)	9.6MHz
Center frequency(Radiated)	4.7GHz
Bandwidth(10dB radiated)	3.2GHz
EIRP	-41.5dBm

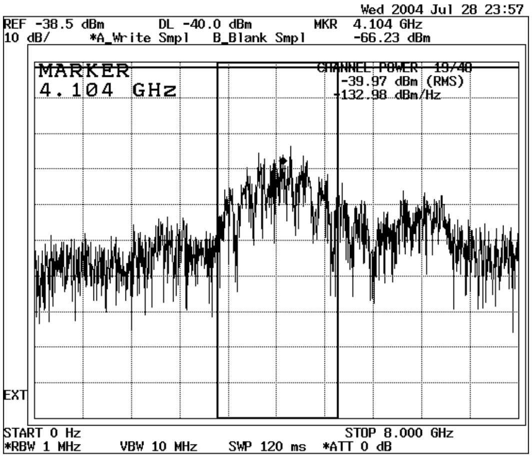

Fig. 1. UWB Signal Spectral Characteristics

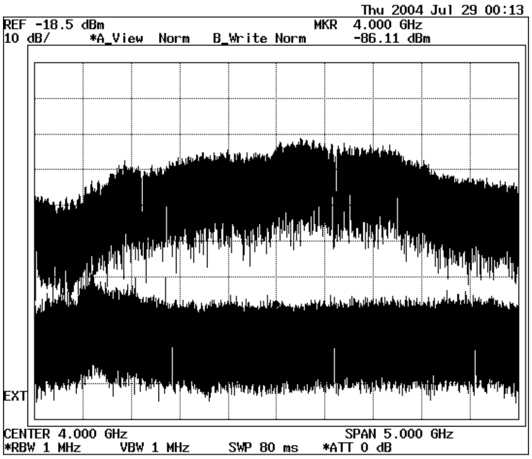

Fig. 2. Frequency Spectra of ambient noise (a) with impulse UWB radio (b) no UWB source

transmitter is almost satisfied with FCC Part 15 emission regulation for practical usage [3].

Frequency domain waveforms of the UWB source is presented in Fig. 2, observed with a spectrum analyzer. In Fig. 2, there are two kinds of plots, (a)one is the impulse UWB source (b) the other is the ambient noise without UWB source. The spectrum of the impulse radio spans from 1.5GHz to 6.5GHz and center frequency of the source is 4GHz, when the spectrum peak power level with no UWB source is -86.11dBm for 1MHz RBW.

2.3 Comparison of Emission Masks of UWB system

For some decades UWB applications such as Ground Probing Radar have operated on a quasi-legal basis. Their numbers were small and the benefits outweigh the risks. It was only about five years ago when interests within the US began a serious look at applications for high data rate communications that the debated hotted up. The main applications foreseen are said to be wireless connections for home audio/video equipment and WLAN, although cellular is not ruled out in the longer term. In February, 2003, the FCC reconfirmed the provisional mask (Figure 3), at –41dBm/MHz mean power density from 3.1-10.6GHz, for a further period of evaluation. At the same time arguments that a 1dB increase in noise would cause significant interference to mobile phones were dismissed[7]. This FCC report agrees that capacity would be impacted but state that operators should incorporate higher margins. It cites that interference from other mobiles could legally have spurious levels as high as –13dBm/MHz, forgetting that industry requirements are much tighter than this.

While the European Commission appear to be adopting a similarly proactive stance towards UWB, the radio regulatory body CEPT are adopting a more cautious approach. Studies have indicated that interference to 5GHz WLAN could cover 5m distance causing significant problems in meetings and offices. ETSI is in the process of producing a formal request for spectrum for UWB. ITU will

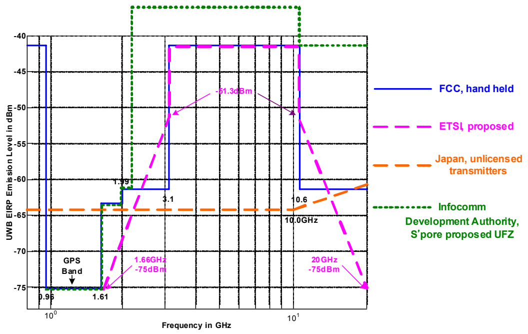

Fig. 3. Proposed Emission Masks

report on UWB studies next year. By this time however major market areas of the world will probably have decided which way to go.

2.4 FER Measurement System

Consequently, now, we specifically consider 800MHz CDMA Cellular System(or 1800MHz K-PCS)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 CDMA Cellular system(K-PCS) is degraded in the existence of UWB device in the neighborhood

The measurement configuration employed in this experiment is described in Fig. 4. The base station signalwas generated by a HP8924C(or Agilent8960) Base Station Emulator (BSE), which is a mobile test

Table 2. Total transmitted power for Cellular CDMA

Parameter	BSE
Sector Total Power (dBm)	-94 ~ -104
Pilot Channel (dB)	-7
Paging Channel (dB)	-16
Sync Channel (dB)	-12
Traffic (dB)	-15.6
OCNS (dB)	-1.7046
PN Offset	12
CDMA Channel	799

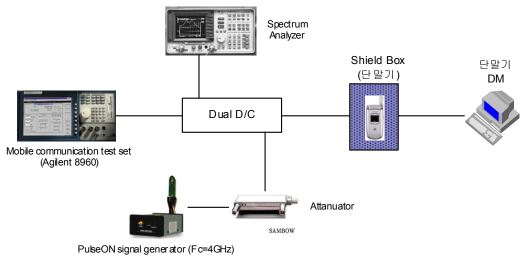

Fig. 4. FER Measurement System

instrument capable of generating signals emulating two sectors of a CDMA base station compliant with the ANSI-95 Air Interface Standard. The traffic analysis software, DRDM is installed in Notebook PC for measuring FER or Ec/Io etc. 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 eliminated the effects of signal fading, which is not the subject of this study. Transmission via space or power lines was completely negligible. Frame error rate (FER) and Ec/Io was averaged over the 1000 sampling points.

Ⅲ. Experimental Results And Discussion

In each environment, the FERis measured with varying the power level of UWB interferer. And different CDMA mobile systems(Cellular CDMA and K-PCS) is also considered in each fixed measurement between two devices. For more accurate experiments, each measurement is repeated.

Fig. 5 shows the code domain power characteristics of Cellular CDMA Link when call processing was established between CDMA handset and Agilent 8924C Base station emulator.

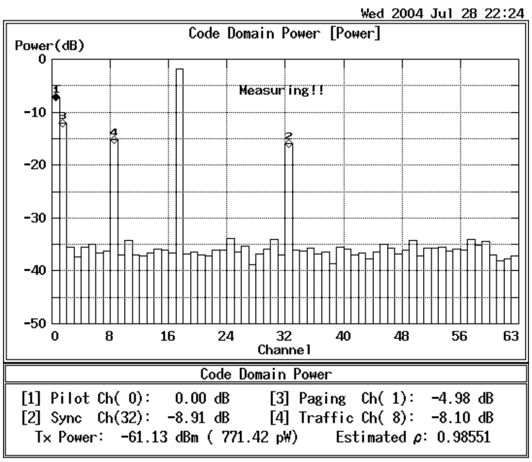

Fig. 5. Each Code Domain Power of Cellular CDMA

Fig. 6 depicts the degradation in frame error rate and Ec/Io as UWB power on. It is observed that 2.3dB degradation of Ec/Io and 1.5% FER drop is occurred when the UWB is on.

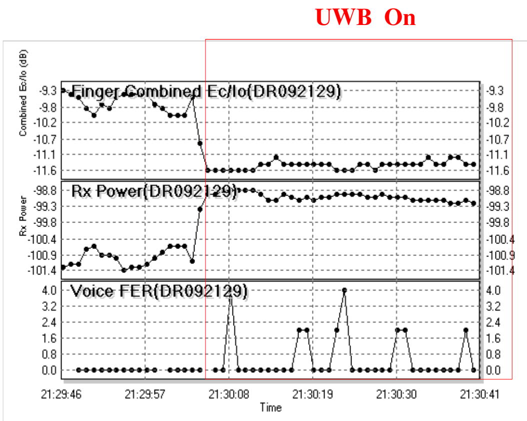

Fig. 6. FER and Ec/Io degradation as UWB Power injection

Ⅳ. Path loss 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]

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

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 36dB is obtained at 1.65m distance between victims and interferer for CDMA cellular, path loss 22dB is obtained at 0.15m distance between victims and interfere for K-PCS system.

In realistic condition, we must use the UWB antenna or BPF for other bands interference. If the BPF which has the -10dB rejection level at 800MHz band characteristics is used, the minimum allowable distance will be 50cm for CDMA cellular system.

Table 3. Measurement Results for Cellular CDMA

UWB Jamming Level [dBm, Peak.]	Cellular Rx Level [dBm]	Cellular Terminal Pilot Ec/Io			Path loss [dB]
		FER [%]	UWB off	UWB on	
-62.3	-94	1	-	-	21
-72.3	-103	4	-9.8	-11.4	31
-74.3	-104	7	-10	-11.6	33
-77.3	-104	0.5	-9.7	-10.6	36

Table 4. Measurement Results for K-PCS

UWB Jamming Level [dBm, Peak.]	Minimum PCS Rx Level[dBm] For FER=0.5%	PCS Terminal Pilot Ec/Io		Path loss [dB]
		UWB off	UWB on	
-57.3	-101.9	-10.0	-12.0	16
-59.3	-102.9	-10.0	-12.0	18
-61.3	-103.9	-10.0	-11.8	20
-63.3	-104.9	-10.0	-11.8	22

V. Conclusion

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.

In this paper we study the coexistence issues between an UWB-based system and a CDMA cellular and Korean PCS terminal for the worst scenario with the weak signal area. The measured allowable distance between victims with minimum receiving signal, -104dBm, and impulse UWB is 1.65m and 0.15m for CDMA cellular and K-PCS system, respectively. If the victims are located at normal environment, about -95 ~ -100dBm area, the distance between UWB device and victims will be decreased compared to the result of this paper. The effects of other type sources such as DS-CDMA or MB-OFDM UWB and aggregate effects will be studied in the future.

We show that in all practical cases UWB system can coexist with mobile terminal without causing any dangerous interference.

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