The Interference Measurement Analysis between 3.412 GHz Band Broadcasting System and UWB Wireless Communication System

Hong-Jong Song[1] · Dong-Ku Kim[2]

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 geo-location, 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 wireless systems sharing the frequency bands such as Broadcasting system. This paper experimentally evaluates the interference from two kinds of UWB sources, namely a orthogonal frequency division Multiplex UWB source and an impulse radio UWB source, to a Broadcasting transmission system. The receive power degradations of broadcasting system are presented. From these experimental results, we show that in all practical cases UWB system can coexist 35 m distance in-band broadcasting network.

Key words : UWB(Ultra-Wideband), Broadcasting Relay System, UWB Emission Effects, Interference Measurement, Coexistence.

Ⅰ. Introduction

Ultra Wide-band(UWB) technology was studied a lot of interest in the communication research and development area. UWB service supports for the high data rates, low-power transmissions, low cost, robustness to multi-path fading, and excellent range resolution(geo-location) capabilities. UWB service can be used in the design of wireless local and personal area networks providing advanced integrated multimedia services to nomadic users within personal area[1].

Fig. 1 show the FCC UWB definition mask. UWB signals are generated using sub-nanosecond pulses thus spreading energy over very large frequency band. An

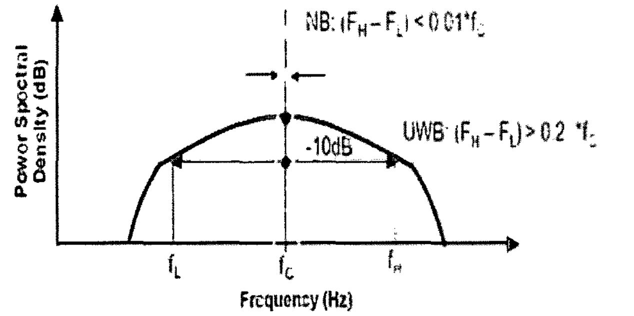

Fig. 1. *FCC UWB definition mask.*

UWB radio signal occupies bandwidth is greater than 20 % of a center frequency or more than 500 MHz. 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 3～5 GHz band have been already presented in the literature and in regulatory forum[2].

The FCC rulings proposed a radiated power limit from UWB devices of −41.25 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 3.412 GHz broadcasting service have not been well covered in the literature. This is probably not surprising. This on air relay service is not used frequently because of the using a broadcasting station

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special issue. For example, sports events, outdoor entertainment, etc.···In this experiment, we want to know the interference effect of the 3.412 GHz broadcasting service from the Impulse & OFDM UWB system.

Some experiments have been performed. For example[4], the effect of a prototype UWB communication system meeting IEEE requirements on a wireless system was examined.

Ⅱ. Experiment System Descriptions

2-1 Victim System

The victim used in this study is a Broadcasting relay system that is interfaced between broadcasting center station and broadcasting relay station. The receiver carrier frequency is 3.412 GHz. The broadcasting receive signal was connected with a RF cable for measuring the S/N ratio as a result of the UWB interference effect.

2-2 UWB System Characteristics

The Impulse & OFDM UWB transmitter employed in this experiment use parameter values of Table 1, Table 2.

The Impulse UWB spectral characteristic is shown in Fig. 2 which is generated by The Time Domain Corp. (PulseON200TM). The OFDM UWB spectral characteristics are shown in Fig. 3, Fig. 4 that is generated by The Wisair Corp. Incase of the ch.1 off UWB signal spectrum, It is known the OFDM UWB variable output characteristic. In this measurement set-up, UWB transmitter is almost satisfied with FCC Part 15 emission regulation for practical usage[3].

2-3 Comparison of Emission Masks of UWB System

Table 1. Impulse UWB characteristics.

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

Table 2. OFDM UWB characteristics.

Pulse Repetition Frequency(PRF)	9.6 MHz
Center Frequency(Radiated)	Variable (3ch.)
Bandwidth(10 dB radiated)	528 MHz
EIRP	−41.25 dBm

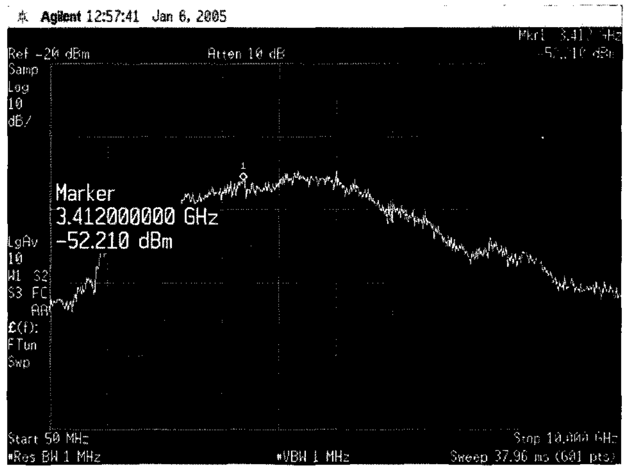

Fig. 2. Impulse UWB signal spectrum.

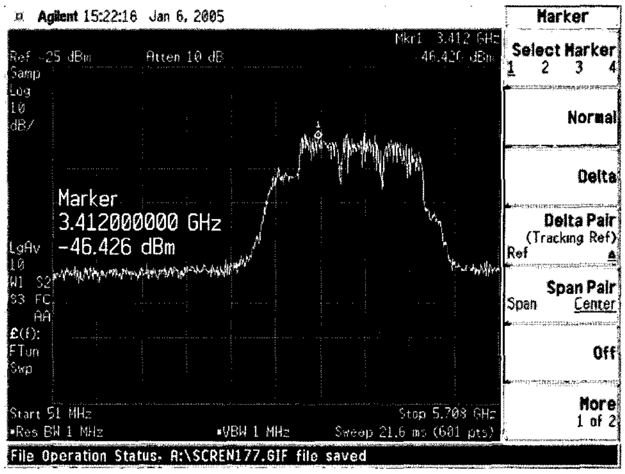

Fig. 3. OFDM UWB signal spectrum.

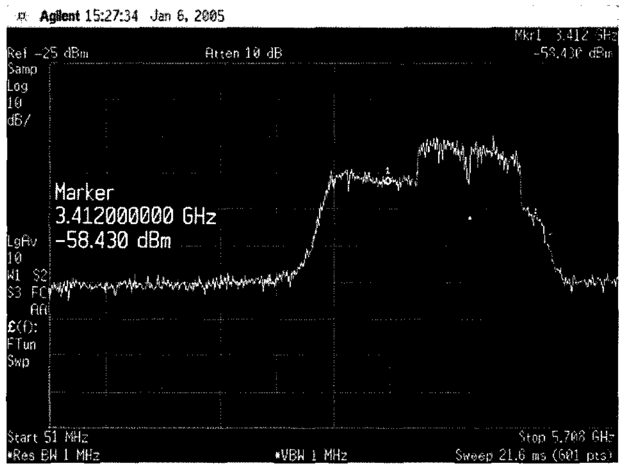

Fig. 4. Ch.1 off OFDM UWB signal spectrum.

The main UWB applications foreseen are said to be wireless connections for home audio/video equipment

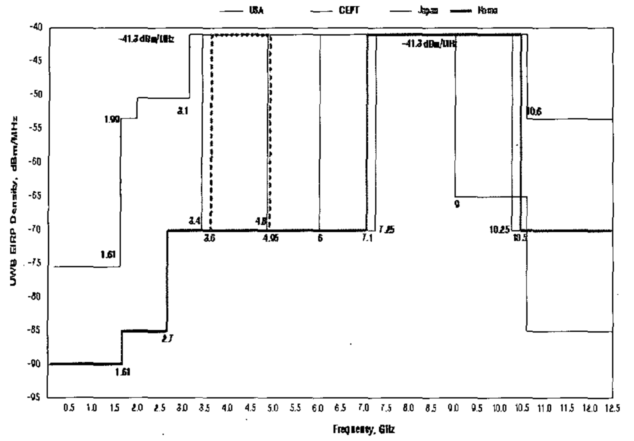

Fig. 5. Proposed emission masks.

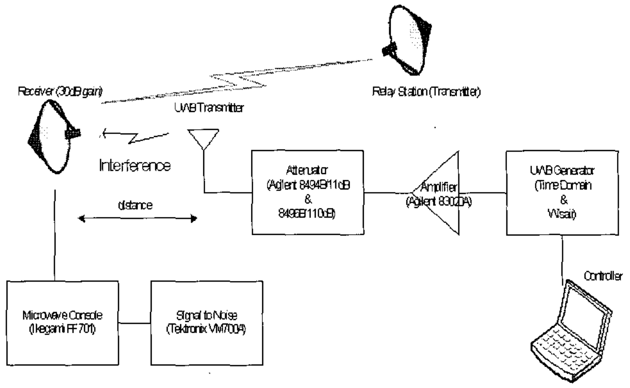

Fig. 6. Conceptual diagram of interference measurement set-up.

and WLAN, although broadcasting service is not ruled out in the longer term. In Feb. 2003, the FCC reconfirmed the provisional mask(Fig. 5), at −41.25 dBm/MHz mean power density from 3.1∼10.6 GHz, for a further period of evaluation[5]. This FCC report agrees that capacity would be impacted but states that operators should incorporate higher margins. It cites that interference from incase of mobile service could legally have spurious levels as high as −13 dBm/MHz, forgetting that industry requirements are much tighter than this[6].

While the European Commission appears to be adopting a similarly proactive stance towards UWB, the radio regulatory body CEPT has been adopting a more cautious approach. Studies have indicated that interference to 5 GHz WLAN could cover 5 m distance causing significant problems in meetings and offices. ETSI is in the process of producing a formal request for spectrum for UWB. ITU will report on UWB studies this year. By this time however major market areas of the world will probably have decided which way to go[7].

2-4 Interference Measurement System

This paper presents experimental results of the coexistence test with these two different systems. The main goal of this work is to determine how the performance of 3.412 GHz band broadcasting relay service is degraded in the existence of the UWB device in the neighborhood.

The measurement configuration employed in this experiment is described in Fig. 6. The receiving antenna was received direct signal from the Relay station that was 3.412 GHz. It is interface Microwave Console(Ikegami PF701) & Signal analyzer(Tektronix VM700A) for the receiving power check. The output of the UWB Signal generator is interface amplifier(Agilent 83020A) & attenuator(Agilent 8494B/8496B) for generating the precision output UWB power also UWB Signal generator is controlled by the Notebook PC. 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.

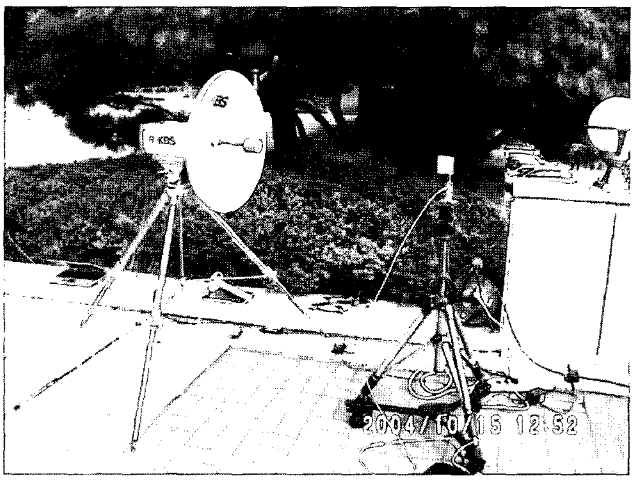

Fig. 7. Measurement set-up of interference between Broadcast relay and UWB.

Ⅲ. Experimental Results and Discussion

According to this experiment result, it is −49.3 dB which is the received level from the relay station.

In case of the relay received level variation as a function of impulse UWB distance(Fig. 8). We know that the impulse UWB system has not interference effects more than 35 m distance to the broadcasting relay service.

In case of the relay received level variation as a function of impulse UWB power attenuation(fixed distance: 2 m) (Fig. 9). We know that the Impulse UWB system has not interference effects more than 20 dB

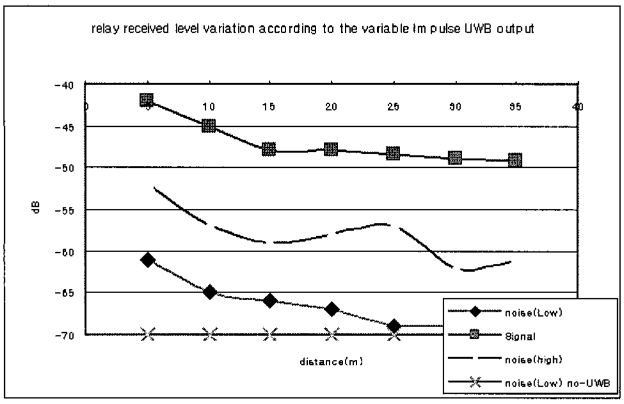

Fig. 8. Relay received level variation as a function of distance(Impulse UWB).

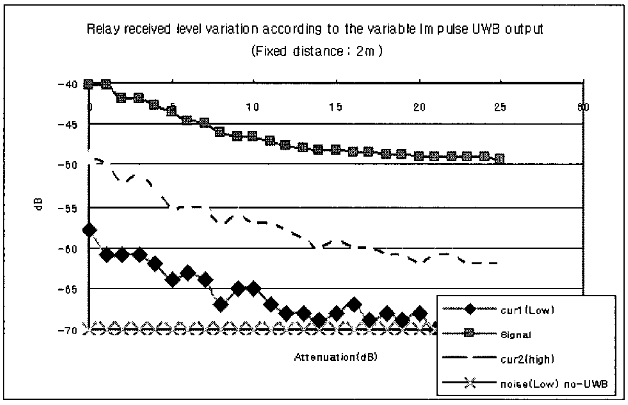

Fig. 9. Relay received level variation as a function of power attenuation(Impulse UWB). (Fixed distance: 2 m)

power attenuation at the 2 m fixed distance to the broadcasting relay service.

In case of the relay received level variation as a function of OFDM UWB distance(Fig. 10). We know that the OFDM UWB system has not interference effects more than 30 m distance to the broadcasting relay service.

In case of the relay received level variation as a function of OFDM UWB power attenuation(fixed distance: 2 m) (Fig. 11). We know that the OFDM UWB system has not interference effects more than about 27 dB power attenuation at the 2 m fixed distance to the broadcasting relay service.

In case of the relay received level variation as a function of ch.1 off OFDM UWB distance(Fig. 12). We know that the OFDM UWB system has not interference effects more than 15 m distance to the broadcasting relay service.

In case of the relay received level variation as a function of ch.1 off OFDM UWB power attenuation

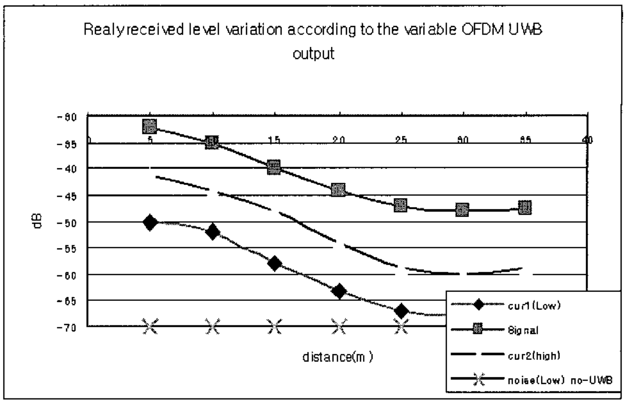

Fig. 10. Relay received level variation as a function of distance(OFDM UWB).

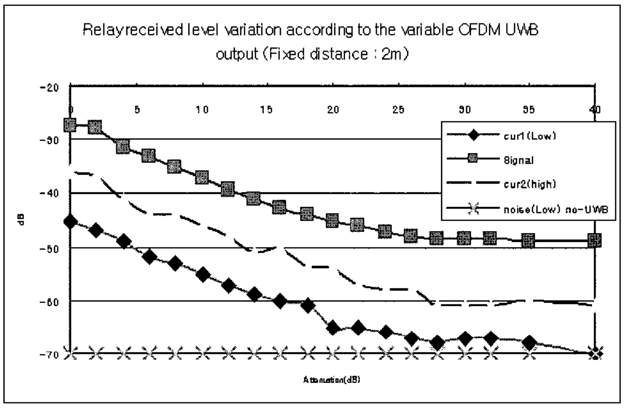

Fig. 11. Relay received level variation as a function of power attenuation(OFDM UWB). (Fixed distance: 2 m)

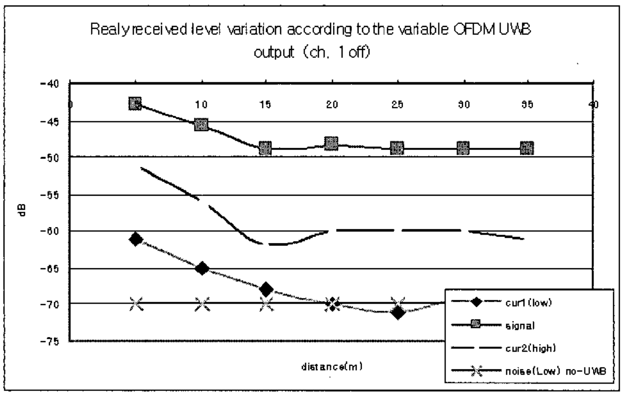

Fig. 12. Relay received level variation as a function of distance(ch.1 off OFDM UWB).

(fixed distance: 2 m) (Fig. 12). We know that the OFDM UWB system has not interference effects more than 35 dB power attenuation at the 2 m fixed distance to the broadcasting relay service.

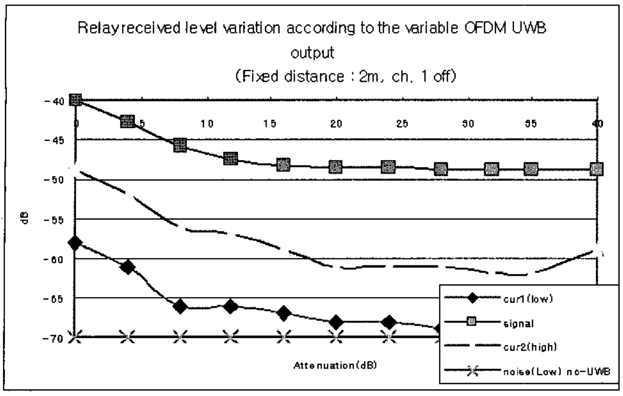

Fig. 13. Relay received level variation as a function of power attenuation(ch.1 off OFDM UWB). (Fixed distance: 2 m)

Ⅳ. Conclusion

In this paper we study the coexistence issues between an UWB-based communication system and a 3.412 GHz broadcasting relay system.

The Relay system's received level is variable according to the UWB system's distance variation. We know that the Impulse, OFDM UWB system has not interference effects more than 35 m, 30 m, 15 m(ch.1 off OFDM UWB system) distance to the broadcasting relay service.

Incase of the relay received level variation according to the UWB system's variable attenuation. We know that the impulse, OFDM UWB system has not interference effects more than −20 dB, −27 dB, −35 dB(ch.1 off OFDM UWB system) attenuation to the broadcasting relay service(fixed distance: 2 m) (ch.1 center frequency: 3.39 GHz).

According to the experiment result, we know that the OFDM UWB system has less effect on broadcasting relay system. With OFDM UWB system, interference effects distance to the broadcasting relay service can be shortened by max. 20 m and attenuation can be diminished by max. 15 dB.

Due to the very large UWB signal bandwidth, the assessment of the possible interference is 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.

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References

[1] R. Giuliano, F. Mazzenga, and F. Vatalaro, "On the interference between UMTS and UWB systems", *2003 IEEE Conferences on Ultra Wideband Systems and Technologies*, pp. 339-343, Nov. 2003.

[2] J. R. Hoffman et al., "Measurements to determine potential interference to GPS receivers from ultra-wideband transmission systems", *NTIA Report 01-384*, Feb. 2001.

[3] FCC 02-48 First Report and Order(R&O), Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems: FCC, Feb. 2002.

[4] Intel, General-Atomics, "C-band satellite interference measurement at TDK RF test range", *IEEE 802.15 WG for Wireless Personal Area Networks*, Jan. 2004.

[5] FCC 03-33 Memorandum, Opinion & Order, FCC, Feb. 2003.

[6] J. P. Van't Hof, D. D. Stancil, "Ultra-wideband high data rate short range wireless links", *IEEE Vehicular Technology Conference*, pp. 85-89, 2002.

[7] ITU-R TG1/8 Chairman report

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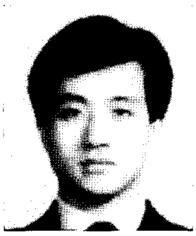

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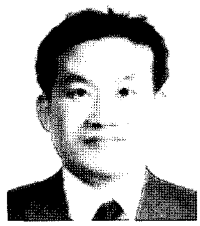

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