Performance Analysis on the Effect of the Adjacent Channel Interference in OFDM systems

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Abstract

In Korea, 2.3GHz frequency band is allocated for a new mobile data service called the WiBro (Wireless broadband) and assigned to 3-operators. So, it is important to investigate the effect of the adjacent channel interference caused by the other operators and service. In this paper, the effect of adjacent channel interference by adjacent operator and other conventional WLAN is evaluated, taking into account the nonlineary of RF components. The amplifiers are employed the polynomial based model and confirmed its spectrum spreading phenomenon due to their nonlinearity. Also the Wireless Broadband service system are implemented in the physical layer to evaluate the interference effects of the other operators and service with the varying width of the guard band and relative power between operators.

1. INTRODUCTION

In Korea, the WLL (Wireless Local Loop) Service providing voice, data service by using wireless communications has allocated at 2.3GHz frequency bands. But the practical use of WLL service is inactive, Government did pronounce that it is withdrawn. Recently, it has been allocated for a new mobile data service called the WiBro (Wireless Broadband) service that is based on OFDMA/TDD scheme, which is expected to be deployed in the future.

The Wireless Broadband service using the 2.3GHz frequency band pay low rates than other wireless internet service using existing phone and this service offers high speed mobility than WLAN.

As shown in Fig1, 9 channels will be assigned to 3-operators and the figure is the example of frequency channel plan for the Wireless Broadband system.

C operator may suffer from adjacent channel interference from WLAN service existing 2.4GHz band and from B operators. A, C operator may suffer from two kinds of interference and B operator may suffer from interference between the operators.

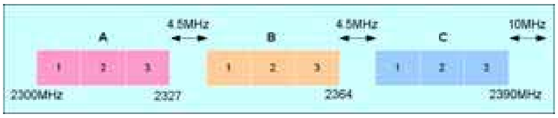


Fig. 1: The The example of frequency channel plan for the Wireless Broadband system

It is important to investigate the effect of the adjacent channel interference caused by the WLAN system and other Wireless Broadband system operator for the successful operation of new communication service. It may be used to determine an appropriate frequency separation between the operators and the two data services.

In this paper, we developed a software simulator to evaluate the effect of adjacent channel interference from the other Wireless Broadband operator and WLAN system on the conventional portable interference service, taking into account the nonlineary of RF components. Among the various RF components, the power amplifier and low-noise amplifier are known to dominate the adjacent channel interference. Here, we employed the polynomial based model for the amplifiers and confirmed its spectrum spreading phenomenon due to their nonlinearity. Also, we implemented the physical layer of the Wireless Broadband System using the C-language and integrated them into the software simulator which can evaluate the interference effects of the Wireless Broadband system with the varying width of the guard band and relative power ratio between the operators.

2. MODELLING OF THE WIRELESS BROADBAND SYSTEM

Heading Fig2 show the block diagram of simulator for evaluating the effect of interference on conventional Wireless Broadband system. There are transmitter module and receiver module of Wireless Broadband system. Also the interference source, the other Wireless Broadband transmitter module or WLAN transmitter, is added at the channel.

The Wireless Broadband system is technique of OFDM (Orthogonal Frequency Division Multiplexing) method. It provides that each subcarrier do adaptive modulation according to channel environment. There are QPSK, 16QAM, 64QAM in the modulation method. An OFDM symbol period (including cyclic prefix) is 115.2μs and composed by 1024 subcarrier. This system is fixed frame structure having the

Fig2. Block diagram of the simulator for evaluating the effect of interference on the conventional portable internet system

Table1. The basic parameter of OFDM system

System parameter	value
System bandwidth	10MHz
Sampling frequency(Fs)	10MHz
Dimension of FFT(N_{FFT})	1024
Used subcarrier number	864
Data subcarrier number	768
Pilot subcarrier number	96
Frequency interval of subcarrier	9.765625kHz
Effective symbol time	102.4μs
CP time	12.8μs
OFDM symbol time	115.2μs
TDD fame length	5ms

frame length of the 5msec and the basic parameters are shown such as table1.

The modulator and demodulator of the WLAN are model1ed according to 802.11b WLAN standard. The simulink is used for the simulation tool. There are four modulation formats and data rated defined in IEEE 802.11b. The data rates include the basic rate, the extended rate, and enhanced rate. The basic rate is defined, as 1Mbps modulated with DBPSK, and the extended rate is 2Mbps DQPSK modulated. The 11-bit Barker word is used as the spreading format for the basic and extended rate as described for the DSSS PHY. The enhanced rate is defined to operate at 5.5Mbps and 11Mbps using CCK modulation and packet binary convolutional coding (PBCC). PBCC is an option in the standard for those networks requiring enhanced performance. Frequency agility is another option defined in IEEE 802.11b. As with the 1 and 2Mbps DSSS PHY, this option enables existing IEEE 802.11 FHSS 1Mbps networks to be interoperable with 11 Mbps CCK high rate networks [2]. In case of DSSS method, there are four modulation method according to the transmission rate as like Table2 [2,3].

Table2. The Modulation method according to transmission rate

Transmission Rate(Mbps)	Modulation method
1	DBPSK+DS
2	DQPSK+DS
5.5	DQPSK+CCK
11	DQPSK+CCK

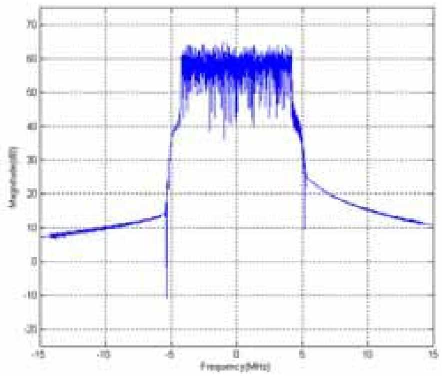
The nonlinearity of transmitter's power amplifier and receiver's low-noise amplifier is known to dominate the adjacent channel interference. In this paper, the power amplifier is modeled by using the polynomial method. If the nonlinearity of power amplifier is not large, for example class A or class AB power amplifier can be approximated as

$$y(t) = a_1 x(t) + a_3 x^3(t) \quad (1)$$

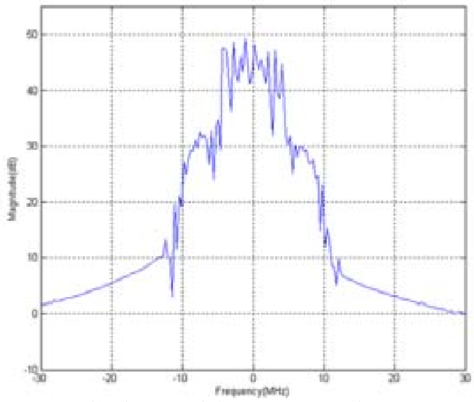
Where $x(t)$ is the input signal of the power amplifier and $y(t)$ is the output signal. a_1 , a_3 are determined by the characteristic of amplifier. a_1 express the gain of amplifier and can be obtained from the gain of the given amplifier. a_3 can be determined by using the relation between a_1 and $P_{out,1dB}$ [4,5,6]. It can be express as

$$a_3 = -\frac{0.145 \times |a_1|^3 \times 10^{-0.1}}{20 \times P_{out,1dB}} \quad (2)$$

The coefficient of amplifier is obtained from the data sheet of the PA(Power Amplifier) HFA3925 [7] and identical as $a_1 = 25.12$, $a_3 = -3238.5$



(a) The transmitting power = 17.5dBm



(b) The transmitting power = 20.5dBm

Fig3. The spectrum signal of Wireless Broadband system

The LNA(Low Noise Amplifier) of the receiver is modeled by using 3-order polynomial model and it's coefficients are as $a_1 = 5.01, a_3 = -3633.6$ from the data sheet of the HFA3424[8]. The output signal spectrum of Wireless Broadband system is shown at Fig3. Fig3 (a) is case with transmitting power is 17.5dBm and represent that the bandwidth is 10MHz. On the other hand, Fig3 (b) represents that the transmitting power is 20.5dBm and confirmed its spectrum spreading phenomenon due to their nonlinearity as the transmitting power increases.

3. MODELLING A STUDY ON THE EFFECT OF ADJACENT CHANNEL INTERFERENCE

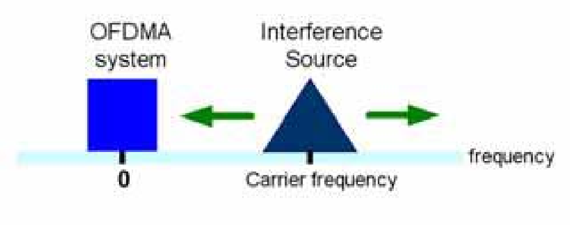
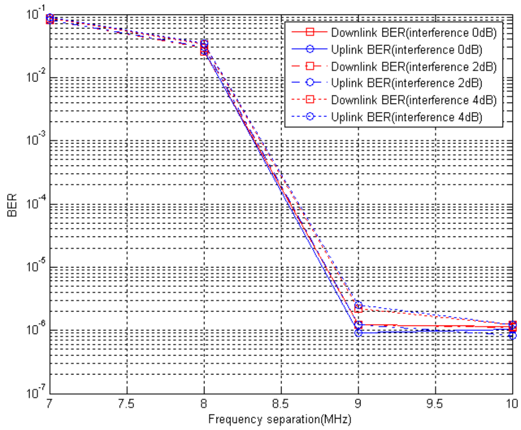
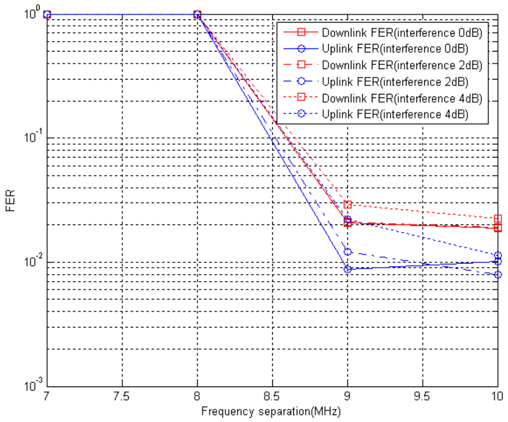


Fig4. The spectrum of OFDM system and Interference Source

Fig5 show BER/FER performance of the Wireless Broadband system according to frequency separation as varying the carrier frequency of the interference source as shown in Figure4.
The transmitting power of the Wireless Broadband system is 17.5dBm and employed the polynomial based model for amplifiers and considered its spectrum spreading phenomenon due to their nonlinearity. The six users are assumed in the simulation. One frame is composed with 42-OFDM symbol, 27-symbol is used at the down link and the other symbol is used at the up link. In the OFDM symbol composed the down link, two symbols are used preamble and the others are used to transmit user data.
The channel noise power is adjusted as BER performance for uplink and downlink of the Wireless Broadband system is 10^{-6}. The table 3 represents the Eb/No value which the BER performance become 10^{-6} for uplink and downlink according to modulation mode. The value of Eb/No is 10.3dB for 64QAM modulation mode to meet the above simulation condition.

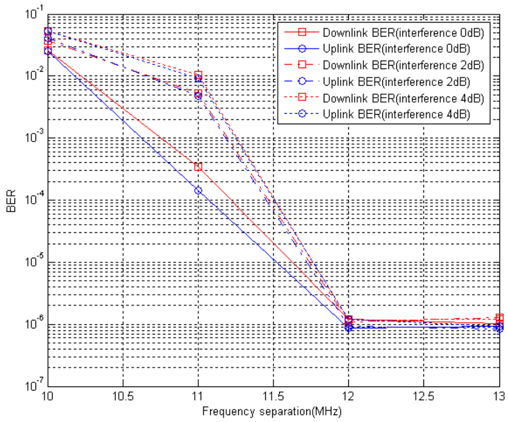


(a) 64-QAM, BER performance

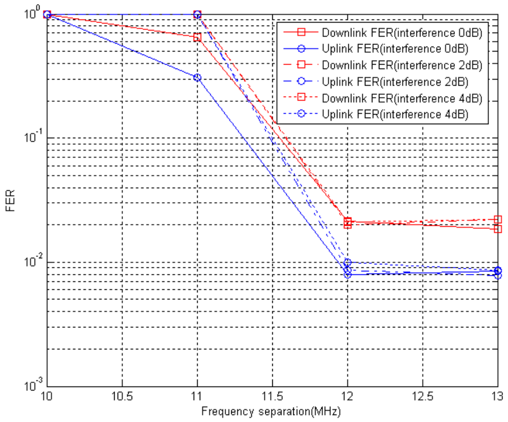


(b) 64-QAM, FER performance

Fig5. BER/FER performance with the varying frequency separation between wireless broadband systems



(a) 64-QAM, BER performance



(b) 64-QAM, FER performance

Fig6. BER/FER performance with the varying frequency separation between wireless broadband system and WLAN

The transmitting power of the interference source varies as like 0, 2, 4dB larger than the victim Wireless Broadband system. The bandwidth of Wireless Broadband system is 4.3MHz as considering that the number of subcarriers is 864. So the carrier frequency separation between two Wireless Broadband systems is about 8.6MHz if no guard band between two systems.

Table3. The Eb/No value for BER=10^{-6}

	Up-link	Down-link
QPSK 1/2	2.9dB	2.7dB
16QAM 1/2	5.6dB	5.4 dB
64QAM 1/2	10.3dB	10.3dB

As shown Fig5, the degradation of performance is occurred if the carrier frequency separation between two Wireless Broadband systems is less than 9MHz. BER/FER performance is better, as frequency separation between two communication systems is wider. Also it is confirmed that BER/FER performance is poor as the relative interference power increasing.

Fig6 show BER/FER performance of the Wireless Broadband system according to carrier frequency separation between adjacent WLAN systems.

The transmitting power of the interference source is 17.5dBm same as Wireless Broadband system. The bandwidth of WLAN is about 7.425MHz considering roll-off factor is 0.35. So the carrier frequency separation between Wireless Broadband system and WLAN is about 11.725MHz if guard band between two systems is zero. Fig. 6 shows that the BER/FER performance becomes poor as the carrier frequency separation between Wireless Broadband system and WLAN system is less than 12MHz. Also it has some variation according to the modulation mode.

4. CONCLUSION

We developed a software simulator to evaluate the effect of adjacent channel interference on Wireless Broadband systems using 2.3GHz frequency bands. We considered of the nonlineary of RF components and the power amplifier and low-noise amplifier are known to dominate the adjacent channel interference among the various RF components. Here, we employed the polynomial based model for the amplifiers and confirmed its spectrum spreading phenomenon due to their nonlinearity. We evaluate the interference effects of the Wireless Broadband service with the varying width of the guard band and relative power between the two Wireless Broadband system operators. Also it is evaluated by the WLAN system. This result can be used to determine the guard band and the transmitting power of the Wireless Broadband service in the point of the spectrum efficiency.

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