Journal of the Korean Institute of Illuminating and Electrical Installation Engineers Vol. 21, No.2, pp. 34~39 February 2007 논문 21-2-6

Review on RF Performance of Ultra Wide Band Device

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Abstract

UWB(Ultra Wide Band) system for high speed and high accurate location has been studying actively. This paper presents the design and implementation of RF transceiver for DS-CDMA(Direct Sequence-Code Division Multiple Access) UWB device. Major components of RF transceiver such as Low Noise Amplifier(LNA) and Band Pass Filter(BPF) are designed and then fabricated to meet wideband characteristics. The RF transceiver was implemented by the use of the fabricated components and commercial devices after carrying out performance simulation. Through the performance evaluation of the UWB RF transceiver with W-CDMA signal, the approach of design, implementation and evaluation of RF transceiver which is available to DS-CDMA UWB system is verified.

Key Words : Ultra Wide Band, DS-CDMA, LNA, BPF

1. Introduction

Recently, studies on Ultra Wide Band(UWB) have been under going very actively as technology for high speed, low power consumption, accurate location information, and low-cost data transmission.

The UWB is suitable for short distance communication requiring high speed and large capacity of data transmission since it spreads from DC to several GHz. The UWB technology has been developed largely for distance measurement, military communication device and signal detection in under-ground [1].

The Federal Communications Commission(FCC) defined UWB system as a system having Fractional Bandwidth of 20[%] above or RF bandwidth of 500[MHz] above in 2002 [2]. In the beginning, Impulse method using short pulse was suggested as an implementation method [3]. For the flexible application of bandwidth, Multiband-Orthogonal Frequency Division Multiplexing(MB-OFDM) and Direct Sequence-CDMA(DS-CDMA) methods have been on the discussion in International Standard Committee these days [4].

In specific, the DS-CDMA method has an advantage of low power level and good security since it spreads the signal with wideband sequence. In this paper, the interface and performance requirements of RF transceiver for UWB system based on DS-CDMA are introduced.

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Date of submit : 2006. 8. 29
First assessment : 2006. 9. 5, Second : 2006. 10. 24
Completion of assessment : 2006. 11. 6

Major components such as Low Noise Amplifier(LNA) and Band Pass Filter(BPF) are designed and fabricated to meet UWB characteristics. By using the fabricated RF components and commercial devices, the RF transceiver for UWB system was designed and implemented. The simulation was carried out to analyze the performance of the transmitting and receiving path. In order to evaluate the performance of the implemented RF transceiver, the W-CDMA signal generator and signal analyzer were used. The design and implementation approach of RF transceiver were verified by comparing the measurement results with the requirements.

2. Performance Requirements of RF Transceiver for DS-CDMA UWB

The FCC of U.S.A. released the spectrum emission of UWB system on the frequency band of 3.1~10.6[GHz] and Korea also defined the spectrum emission in domestic as in figure 1.

For the transmitting distance, main system parameters such as antenna gain, antenna hight, direction, bandwidth, carrier frequency and data rate are considered. For the receiver performance, noise figure and the ratio of signal to noise(S/N) should be included.

In general, Propagation model proposed by A. Kamerma is used for Indoor model as in eq. 1.

$$L_{path} = 20 \log (4r/\lambda),\ r\ 8[m]$$
$$= 58.3 + 33 \log(r/8),\ r > 8[m] \qquad (1)$$

Here, λ([m]) is wave length and r([m]) is distance.

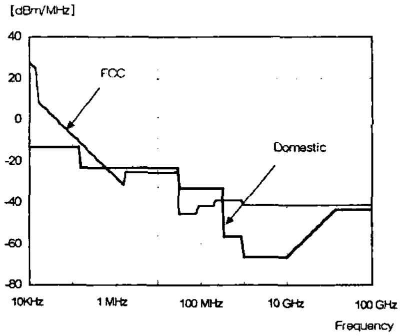


Fig. 1. Spectrum emission mask of UWB in Domestic and U.S

Attenuation characteristic over frequency and distance is shown in figure 2.

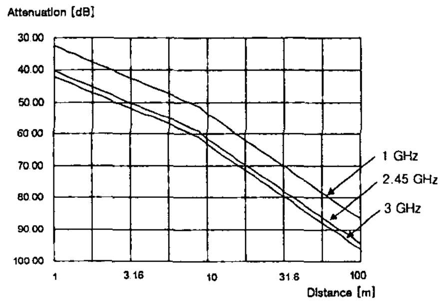


Fig. 2. Attenuation characteristic over frequency and distance for Indoor model

The maximum allowable path loss in UWB system can be written by as follow.

$$L_{path}\,[dB] = PT + GT + GR + (S/N)_{req} + PG - 10 \log_{10}(N_0 W) - NF - M \qquad (2)$$

Here, P_T is maximum transmitting power, G_T is antenna gain of transmitter, G_R is antenna gain of receiver, $(S/N)_{req}$ is required minimum S/N of demodulator, PG is processing gain(bandwidth/ data rate), N_0 is thermal noise/Hz(-174[dBm/Hz]), W is bandwidth, NF is noise figure of receiver, M is demodulating margin. Parameters for path loss calculation of UWB system are summarized in table 1.

Table 1. Path loss parameters for UWB system

Item	Domestic	FCC
P_T	1.78[dBm]	27.18[dBm]
G_T	0[dBi]	0[dBi]
G_R	0[dBi]	0[dBi]
$(S/N)_{req}$	14.1[dB] (for BER 10-4)	14.1[dB]
N_0	-174[dBm/Hz]	-174[dBm/Hz]
W	2[GHz]	1[GHz]
$10\ \log_{10}(N_0W)$	-81[dBm]	-81[dBm]
PG	23[dB] (for 10 Mbps)	23[dB] (for 10 Mbps)
NF	10[dB]	10[dB]
M	10[dB]	10[dB]
Max. L_{path}	*77.38[dB]*	*102.78[dB]*

After considering above parameters, the requirements of RF transceiver performance for DS-CDMA UWB system are summarized in table 2.

Table 2. RF performance requirements for DS-CDMA UWB

Item	Requirement	Unit
Frequency	3.1~5.1	[GHz]
Output level of TX	-10	[dBm]
Antenna gain of TX	0	[dBi]
Input level of TX	0	[dBm]
Antenna gain of RX	0	[dBi]
Input level of RX	-50~-80	[dBm]
Noise Figure	7	[dB]
Output level of RX	0	[dBm]

Analog signal from Modem is modulated with QPSK and then is amplified with power amplifier. After being amplified, the signal is filtered and then transmitted through antenna. The received RF signal is low noise amplified and then demodulated with QPSK. The demodulated analog signal is applied to Modem after passing through Automatic Gain Control(AGC) process. The block diagram of RF transceiver is shown as in figure 3.

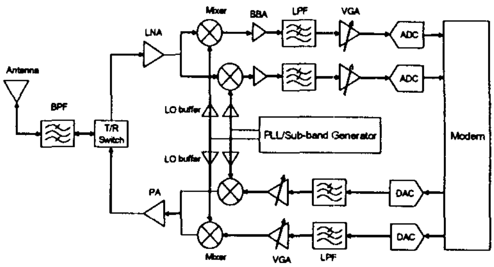


Fig. 3. RF transceiver block diagram for DS-CDMA UWB system

3. RF tranceiver implementation and performance evaluation

The design and implementation of Low Noise Amplifier(LNA) which is one of RF main components is introduced..

The LNA is designed by using 90[°] 3[dB] Branch Line Coupler and parallel balanced amplifier to get high gain, low reflection and low noise figure for the wide band as in figure 4.

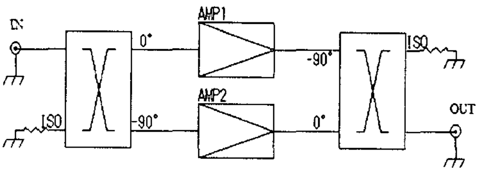


Fig. 4. Proposed structure of LNA

After considering input matching and output matching of LNA for high gain and low noise figure from 3.1~5.2[GHz], the design simulation is performed with Serenade simulator. In the process of simulation, S11 and S22 of 18[dB] below and S21 of 32[dB] above are selected as target values for UWB bandwidth, 3.1~5.2[GHz]. The simulation results are shown in figure 5.

After taking consideration of design approach using simulation results, the UWB LNA is implemented as in figure 6.

The measurement results showed NF of 2~

3[dB], gain of 28~32[dB] as in figure 7. Those values are good enough to meet performance requirements of LNA for UWB system. The difference of values between simulation and measurement results is expected to be produced by dielectric constant and commercial amplifier characteristics.

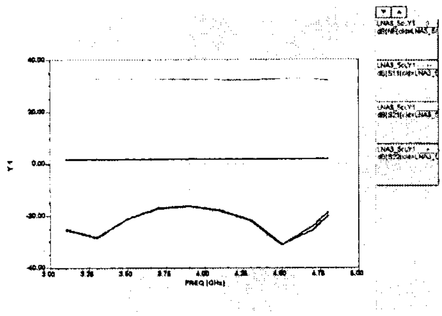


Fig. 5. Simulation results of LNA

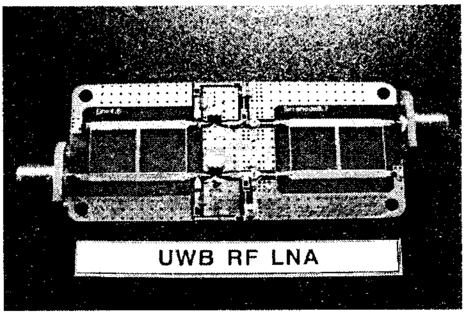
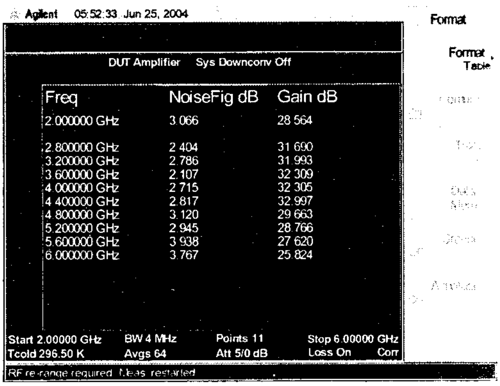


Fig. 6. The implementation of LNA



Freq	NoiseFig dB	Gain dB
2.000000 GHz	3.066	28.564
2.800000 GHz	2.404	31.690
3.200000 GHz	2.786	31.993
3.600000 GHz	2.107	32.309
4.000000 GHz	2.715	32.305
4.400000 GHz	2.817	32.997
4.800000 GHz	3.120	29.663
5.200000 GHz	2.945	28.766
5.600000 GHz	3.938	27.620
6.000000 GHz	3.767	25.824

Fig. 7. Measurement result of LNA

The bandpass filter is realized with Butterworth 5 pole Microstrip to get stop-band attenuation of 30[dB] above and pass-band attenuation of 2[dB] below as in figure 8.

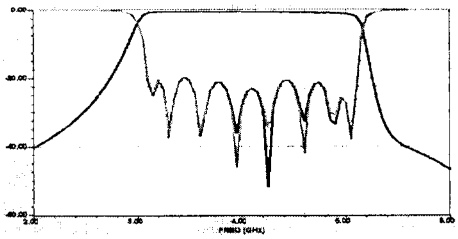


Fig. 8. Simulation result of band pass filter

The implemented band pass filter is shown in figure 9.

Measurement results showed reflection of 13[dB] and pass band attenuation of 2[dB] as in figure 10.

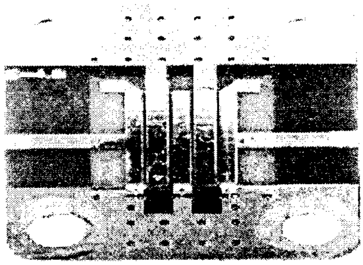


Fig. 9. Implemented band pass filter

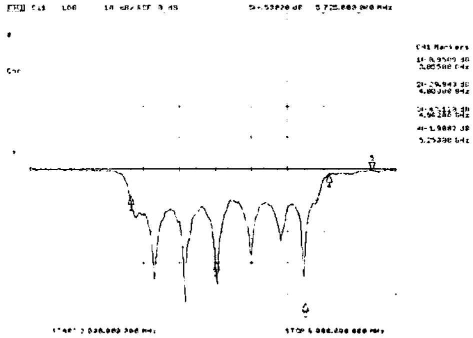


Fig. 10. Measurement results of BPF

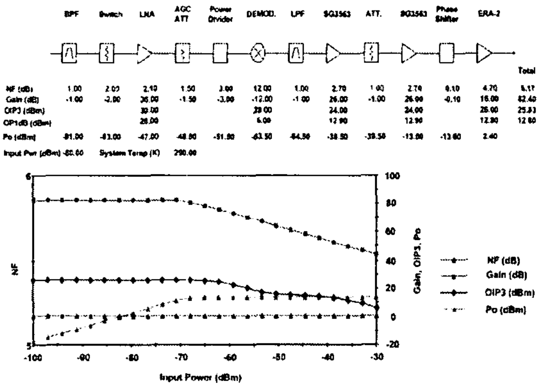


Fig. 11. Simulation results of receiving path

With the implemented main components and commercial components, RF transceiver for DS-CDMA UWB is desgned and then implemented.

For the analysis of receiving characteristics of RF transceiver, the level diagram was set up and then simulation was done through Syscal.4. As a result, the pass gain of -82.4[dB] and the noise figure of 5.1[dB] were obtained as in figure 11.

In the same manner, transmitting path was analyzed. The simulation results showed gain of 0[dB], output level of 0[dBm] and Output 1[dB] compression point(OP1[dB]) of 8[dBm]. as in figure 12.

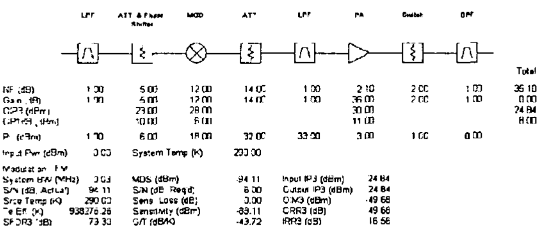


Fig.12. Simulation results of transmitting path

On the basis of simulation results, the RF transceiver was implemented as in figure 13. The transceiver has receiving path, transmitting path and frequency synthesizer.

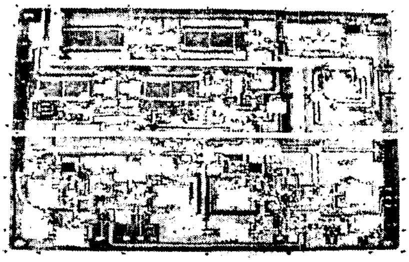


Fig. 13. Implemented RF transceiver for DS-CDMA UWB

In order to evaluate the transmitting performance, W-CDMA signal source and signal analyzer were used.

The spectrum characteristic and constellation of transmitter were measured at 3.978[GHz] as in figure 14 and figure 15, respectively. Error Vector Magnitude(EVM) of 9.33[%] was measured.

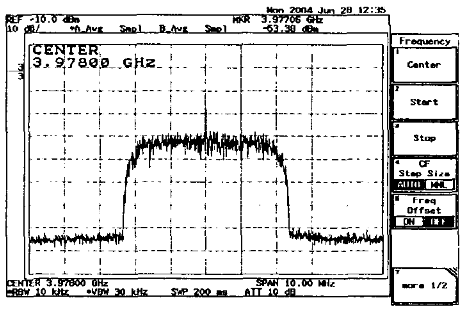


Fig. 14. Spectrum characteristic of transmitting path

Fig. 15. Measured spectrum and constellation of UWB RF transmitter

The measured EVM value of 9.33[%] met the requirement of 17.5[%] below in W-CDMA system [5].

The test configuration of UWB RF receiving characteristic is shown in figure 16. For the automatic gain control(AGC) operation, input signal level of -80~-50[dBm] was applied to antenna port and then the receiving signal was demodulated in code domain at the input of Analog to Digital Converter(ADC). Measurement result is shown in figure 17.

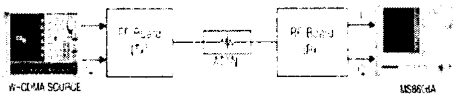


Fig. 16. Test configuration of UWB RF receiving characteristic

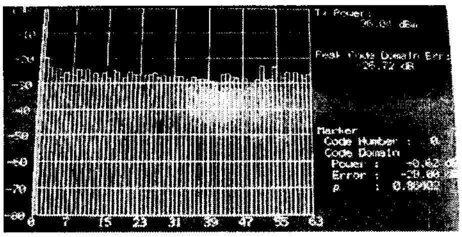


Fig. 17. Demodulation result of RF receiver

The measutrd peak code domain error of -26[dB] was good enough comparing with W-CDMA requirement of -15[dB] below [6].

4. Conclusions

This paper described the functions and performance requirements of DS-CDMA UWB RF transceiver.

By the use of implemented components and commercial devices, the RF transceiver was designed and then implemented. The spectrum characteristic and signal quality of RF transmitter were evaluated with W-CDMA signal source and signal analyzer. The AGC operation and demodulation results in code domain were reviewed for RF receiver performance.

The test results are good enough to meet performence requirements of RF transceiver for DS-CDMA UWB device.

This research was supported by University IT Research Center Project(INHA UWB-ITRC), Korea.

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◇ Biography ◇

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