Evaluation of Antenna for UWB Systems in Terms of Bit Error Rate

Shinya Abe [1], Naohiro Takahashi [1], Takayuki Sasamori [2], Teruo Tobana [2], and Yoji Isota [2]
[1] Graduate School of Systems Science and Technology, Akita Prefectural University
Yurihonjyo, Akita, 015–0055 Japan, m09b001@akita-pu.ac.jp
[2] Faculty of Systems Science and Technology, Akita Prefectural University
Yurihonjyo, Akita, 015–0055 Japan

1. Introduction

Recently, ultra-wideband (UWB) wireless systems for short-range and high-speed wireless communications have great interest. Since the Federal Communications Commission (FCC) allocated the frequency band from 3.1 GHz to 10.6 GHz for unlicensed UWB applications in 2002, feasible design and implementation of UWB system has become a competitive topic of wireless telecommunications. UWB is considered using at various wireless communications, such as high-speed file transfer between PC peripherals, streaming transmission between AV equipments, sensor using a position detection and in-vehicle radar for collision prevention. Various types of antennas have been introduced for UWB systems, and they have been evaluated by conventional characteristics such as input impedance, gain and the radiation pattern in many cases. However, there are few papers which evaluated UWB antenna using the bit error rate (BER) systematically [1]– [3].

In this paper, we evaluate transmission characteristics of the printed disc monopole antenna (PDMA) which proposed for UWB applications in terms of BER [4]. In addition, the influence on the BER characteristic by three kinds of input pulse waveforms with different frequency bandwidth is investigated.

2. BER Calculation

Fig. 1 shows the procedure for analyzing system performance considering influence of the UWB antenna and waveform of input pulse. First, we generate a input binary data stream using binary phase shift keying (BPSK) modulation. The impulse radio UWB with cosine roll-off pulse of three types of frequency bandwidth are evaluated. The cosine roll-off pulse can be represented as

$$s(t) = \frac{\sin(\pi Bt)}{\pi Bt} \cdot \frac{\cos(\alpha\pi Bt)}{1-(2\alpha\pi Bt)^2} \cdot \cos(2\pi f_c t) \tag{1}$$

where α is the roll-off factor, B is the pulse bandwidth and f_c is the center frequency of the modulating wave. In this paper, the frequency band from 3.1 GHz to 10.6 GHz (based on spectrum mask of FCC), from 3.4 GHz to 4.8 GHz and from 7.25 GHz to 10.25 GHz (based on Japanese domestic spectrum mask) are called full-band, low-band and high-band, respectively. Fig. 2 and 3 show the time-domain waveform and spectrum of a full-band pulse, respectively, whose roll-off factor is 0.25, bandwidth is 7.5 GHz and center frequency is 6.85 GHz. Next, the transmitted pulse stream is converted to frequency domain by Fourier transform (FFT), thus effects of transmission coefficient (S_{21}) between transmitting and receiving antennas can be used to calculate received waveform in frequency domain. The transmission characteristic is measured by a vector network analyzer in an anechoic chamber. The received time-domain pulse stream can be obtained by inverse Fourier transform (IFFT). Finally, by comparing the transmitted and received pulse stream under additive white Gaussian noise (AWGN), the performance of overall UWB system can be evaluated in terms of BER.

3. Results and Discussions

Fig. 4 illustrates the configuration of the PDMA [4]. The PDMA consists of an circular disc radiator and a microstrip line on the top side of a dielectric substrate and a rectangular ground plane on the bottom side. In order to decrease the dimension of the disc radiator, the ground plane is notched.

Fig. 5 shows the measured reflection coefficient (S_{11}) as a function of frequency for the PDMA. and a patch antenna. It can be seen that the input impedance of the PDMA is well matched as the −10 dB return loss bandwidth covers the entire UWB band. The reflection coefficients for a half-wavelength dipole antenna and a rectangular patch antenna are also shown in Fig. 5 for the sake of comparison with the PDMA. As shown in this figure, the center frequency of the dipole antenna is 5.3 GHz and a −10 dB return loss bandwidth is 17 %. On the other hand, the center frequency of the microstrip antenna is 4.9 GHz and a bandwidth is 0.8 %.

Fig. 6 shows the measured transmission coefficients (S_{21}) as a function of frequency for the PDMA, the dipole antenna and the patch antenna. The distance between transmitting and receiving antennas is 1 m. In the cases of the PDMA and the patch antenna, the transmitting and receiving antennas allocate as face to face each other. The transmission loss in the free space expressed as $(\lambda/4\pi d)^2$ is also shown in this figure. Note that the transmission coefficient for the PDMA is the smallest of the three in a large frequency band. Moreover, in the fairly large frequency band, the transmission coefficient for the PDMA is smaller than the transmission loss in the free space.

The BER performance of the impulse radio UWB system using the input pulse waveform for the frequency band of full-band, high-band and low-band are illustrated in Fig. 7–9, respectively. The results of the BER performance for the PDMA, the dipole antenna and the patch antenna with bit rate of 500 Mbps are presented. In Fig. 7, it is observed that the BER is small in order of the PDMA, the dipole antenna and the patch antenna in the case of the frequency band of full-band. As shown in Fig. 8, in the case of high-band, it can be seen that the difference between the BER performance for the PDMA and the dipole antenna is very small in spite of the difference in the transmission coefficients. It appears that the it is due to the distortion of the received signal for the dipole antenna is reasonably small. The BER of high-band for the patch antenna is lower than the case of full-band. It is shown in Fig. 9 that the BER performance for the dipole antenna is slightly lower than the PDMA. This result seems to be caused by that the transmission loss for the PDMA is smaller than the dipole antenna in the frequency band around the center frequency of the low-band input pulse. The BER of low-band for the patch antenna is almost same as the case of full-band.

4. Conclusion

In this paper, the broadband transmission characteristic of the PDMA which proposed for UWB applications has been evaluated in terms of BER. The BER calculation using the measured transmission coefficient was explained. The BER performances for the PDMA, the dipole antenna and the patch antenna are compared with each other. In the case for the frequency band of full-band and high-band, it was shown that the BER performance for the PDMA is the lowest in the three. The results of the BER simulation make the PDMA very attractive candidate for the UWB applications.

References

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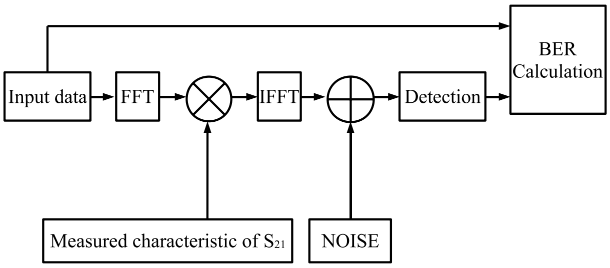

Figure 1: Flowchart for BER simulation.

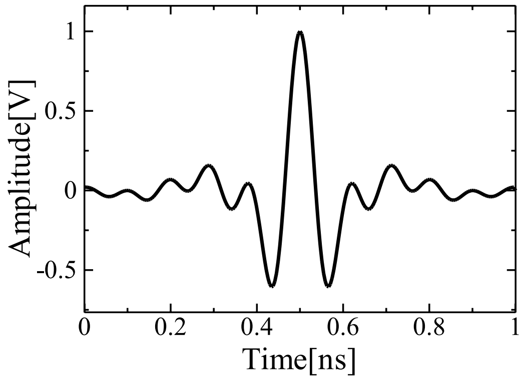

Figure 2: Waveform of cosine roll-off pulse for the full-band in the time domain.

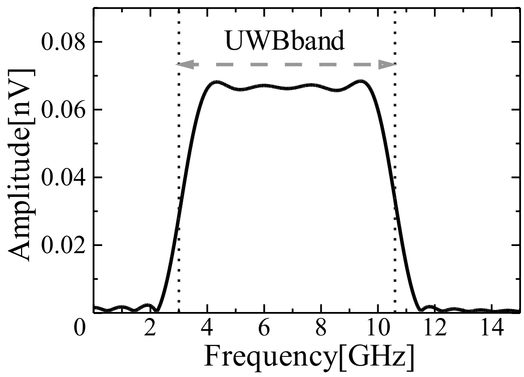

Figure 3: Spectrum of the source pulse for the full-band.

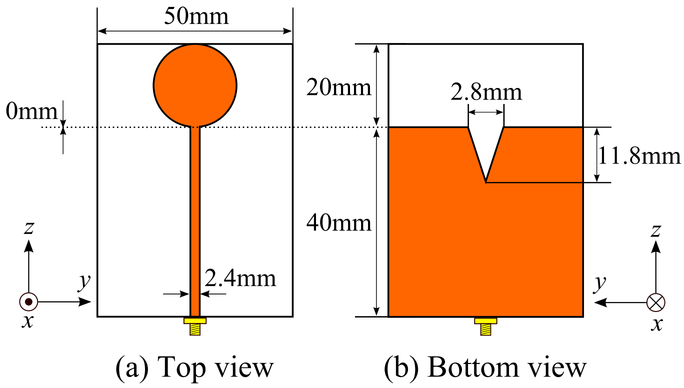

Figure 4: Configration of the PDMA.

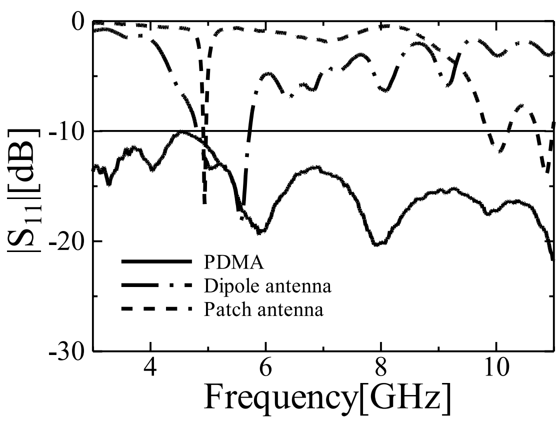

Figure 5: Reflection coefficient.

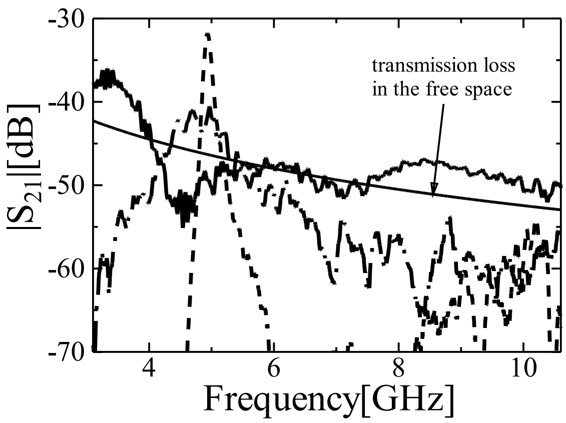

Figure 6: Transmission coefficient.

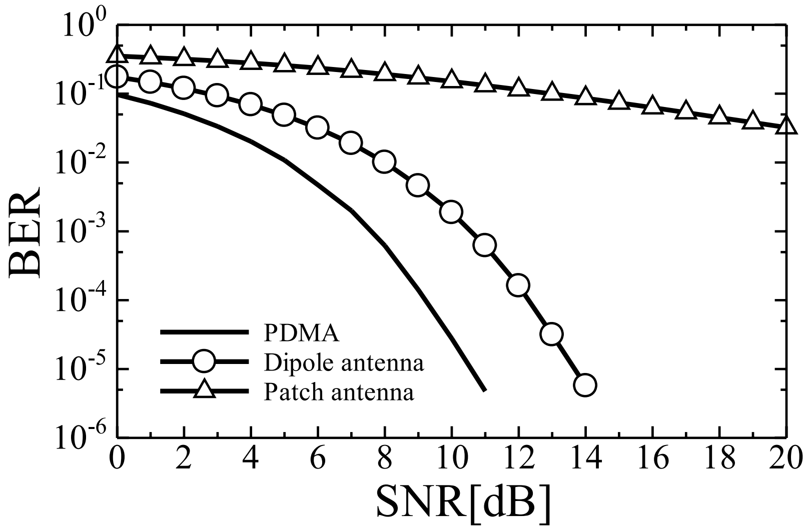

Figure 7: BER performance for the full-band pulse. Bit rate is 500 Mbps.

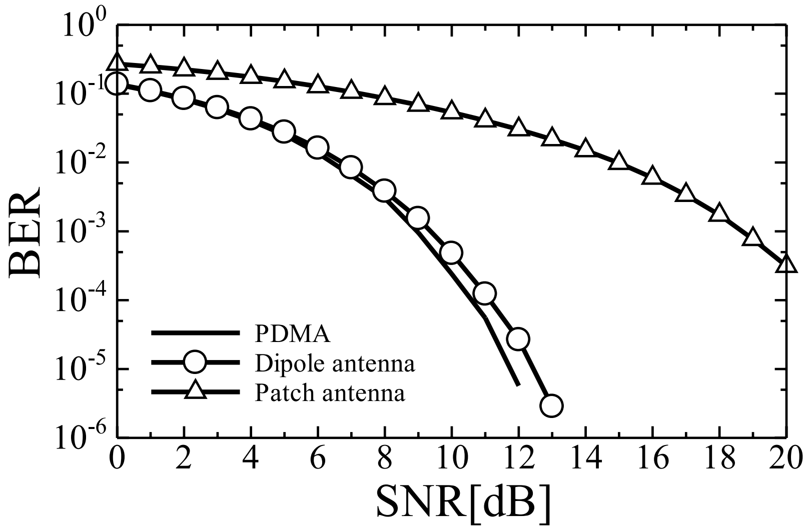

Figure 8: BER performance for the high-band pulse. Bit rate is 500 Mbps.

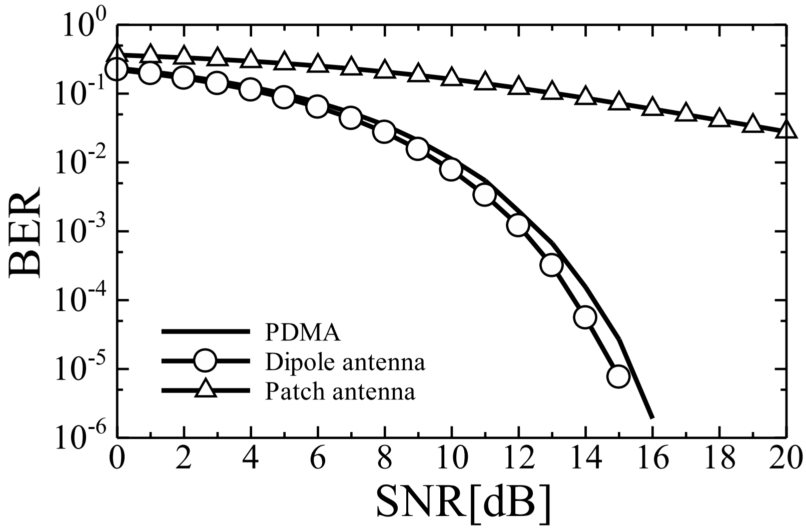

Figure 9: BER performance for the low-band pulse. Bit rate is 500 Mbps.