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PERFORMANCE EVALUATION OF DIFFERENT MODULATION SCHEMES FOR ULTRA WIDE BAND SYSTEMS

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Ultra-wideband (UWB) signals with a large bandwidth has some advantages like multipath immunity, low transmission power, good resolution for ranging and detecting geo locations, as well as it can resist to narrow-band interference. These signals are used for transmission in short distance with high throughput. In this paper, we have analyzed different modulation schemes for performance comparison in terms of BER with UWB Gaussian second derivative monopulse and wavelet-based monopulse. The simulation results demonstrate that wavelet-based monopulse provides better performance in comparison to the other two monopulses.

K e y w o r d s: UWB, Gaussian monopulse, wavelet-based monopulse, BER, E_b/N_o, PPM, BPSK

1 INTRODUCTION

Ultra wideband (UWB) is a wireless technology which is capable of transmitting large amounts of digital data over a wide spectrum of frequency band with very low power for a short distance. As it uses extremely wide transmission bandwidth, the UWB signal has the potential for improving the ability to measure location and range accurately, high multiple-access capability, extremely high data rate at short ranges and easier material penetrations. For its extremely low duty cycles, it is immune from multipath effects and fading problems, whereas existing wireless systems suffer those problems [2]. In 2002, the US Federal communications Commission (FCC) approved unlicensed use of the spectral band of UWB from 3.1 to 10.6 GHz with a transmitted power spectral density (PSD) less than −41.0 dBm/MHz for indoor wireless communication. Due to the low power density, the distance of UWB communication system is limited to a few meters to tens of meters. Moreover, the effective isotropic radiated power (EIRP) for UWB communication must comply with the regulation defined by Federal Communications Commission (FCC) to coexist with many existing wireless communication systems [11]. It also requires the optimal receiving characteristics, which is to say high fidelity at the receiver side [12].

The main candidates for UWB modulation scheme can be classified into two basic categories; they are time-based modulation and shape-based modulation [3]. Pulse position modulation (PPM) is an example of time-based modulation whereas Binary Phase Shift Keying (BPSK), On-Off Keying (OOK) and pulse Amplitude Modulation (PAM) are the examples of shape-based modulation technique.

Here, we considered different popular modulation schemes such as Binary Phase Shift Keying (BPSK), Pulse Position Modulation (PPM) and On-Off Keying (OOK). In this paper, Pulse position modulation (PPM) has been considered as a suitable M-ary modulation scheme for its fine time resolution [10]. With PPM, the data modulates the position of the transmitted pulse within an assigned window in time [9]. Here, we estimate the performance of UWB communication system through simulation for M-ary PPM in the presence of additive white Gussian noise (AWGN) channel.

For performance analysis, two types of waveforms; namely, wavelet based monopulse and the 2nd derivative Gaussian pulse are considered in this paper. The BER analysis of the UWB M-ary PPM in additive white Gaussian noise channel for the wavelet based monopulse shows that the lower order modulation scheme gives better result compared to the higher order modulations.

2 UWB PULSE SHAPES AND MODULATION

The most widely studied and implemented pulse shapes for UWB communication are Gaussian first derivative, Gaussian second derivative, Wavelet-based monocycle and Manchester monocycle .The choice of pulse shape is a most important consideration in the design of UWB communication systems. The fractional bandwidth of a pulse is defined as the ratio of the signal bandwidth (BW) measured at a fixed power level relative to the peak level at its center frequency [18].

In this paper, Gaussian second derivative and wavelet based monocycle pulses are considered as UWB signal and the transmission of these signal affects the performance of different modulation schemes in the presence of AWGN and Rayleigh fading channel. Gaussian second derivative pulse is considered because its high fractional bandwidth will allow the UWB system to experience much less fading in multipath environment. Again, wavelet based monopulse has the advantage of reduced

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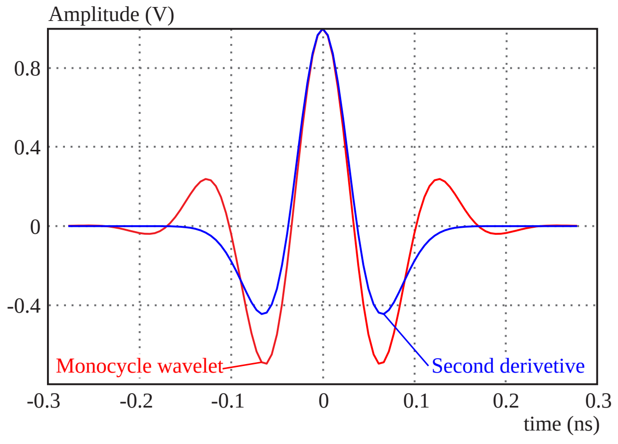

Fig. 1. Pulse shapes in time domain

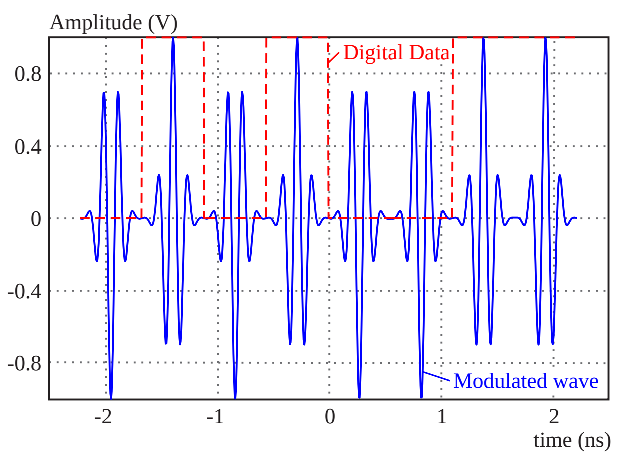

Fig. 2. Pulse train for BPSK modulation using wavelet-base monopulse

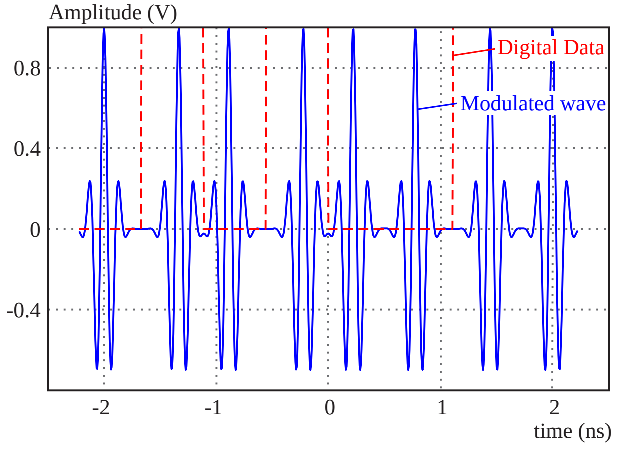

Fig. 3. Pulse train for BPPM modulation using wavelet-base monopulse

interference, which then results in an improved BER performance. These pulse shapes enable the use of a RAKE receiver to receive a stronger signal.

The wavelet based UWB signal can be defined as [1].

$$w(t) = A_p \exp\Big(-b\big(\frac{t-\tau}{a}\big)^2\Big) \times \cos\Big(k\pi\big(\frac{t-\tau}{a}\big)\Big). \qquad (1)$$

For large bandwidth, the parameters of (a, f_0) can be chosen as: $f_0 = 0.57$, $a = 7.7444 \times 10^{-11}$. The value of $b = 0.5$ is selected in between 0 to 1 ns to meet the FCC emission mask. We also use 2nd order Gaussian pulse because it is the most currently adopted pulse that meet the appropriate UWB operation which is usually generated by the equation

$$w(t) = 2\frac{A}{T_{au}}\sqrt{e}(t-T_c)e^{-2\left[\frac{t-T_c}{T_{au}}\right]^2}. \qquad (2)$$

Here, $w(t)$ is a Gaussian second derivative pulse where pulse duration or width is much smaller than pulse repetition period, so it can produce low duty cycle operation. According to Fig. 1, the Gaussian second derivative has two zero crossing points and the relative bandwidth decreases with the increasing of the center frequency [2].

3 UWB MODULATION SCHEMES

In general UWB signal is designed to smooth the spectrum of the signal and protect the system from radio interference to the existing narrowband and wideband signals. The wavelet-based monopulse is used to generate pulse train which is modulated using BPSK, PPM and OOK. M-ary PPM modulation scheme needs a very fine time resolution.

3.1 BPSK Modulation Scheme

BPSK is the modulation technique where two different phase values indicate two different data symbols. This modulation scheme can be expressed as follows

$$S^{(k)}(t) = \sum_j w(t - jT_f - \varphi)\,, \qquad (3)$$

where, φ is the phase which has the values of 0 and 180 degrees for data symbol 1 and 0 respectively. For a given data sequence like {0 1 0 1 0 0 1 1} we can obtain the wavelet-based pulse train for BPSK as in Fig. 2.

3.2 PPM Modulation Scheme

BPPM is the modulation scheme where an additional time shift is used to indicate the change of data symbol. The PSD of PPM can be smoothed by using PN sequence, and the parameters may be chosen to move discrete spectral lines so as to minimize interference into other communication signals [18]. These PN sequence can be used to serve many users simultaneously which provides multiple access (MA) facilities. PPM also offers UWB multiple access communications using AWGN channel with combined transmission capacity of several hundreds of Mbps at BER rates in the range from 10–4 to 10–7 using moderate complexity receivers.

BPPM can be expressed as follows

$$S^{(k)}(t) = \sum_j w\big(t - jT_f - c_j^{(k)}T_c - \delta d^{(k)}[j/N_s]\big) \qquad (4)$$

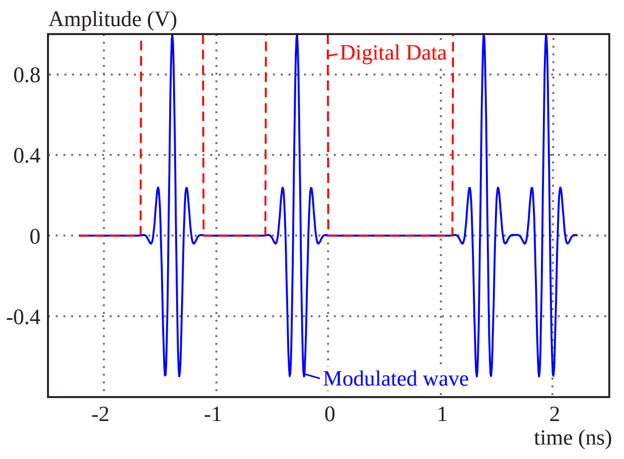

Fig. 4. Pulse train for BPPM modulation using wavelet-based monopulse

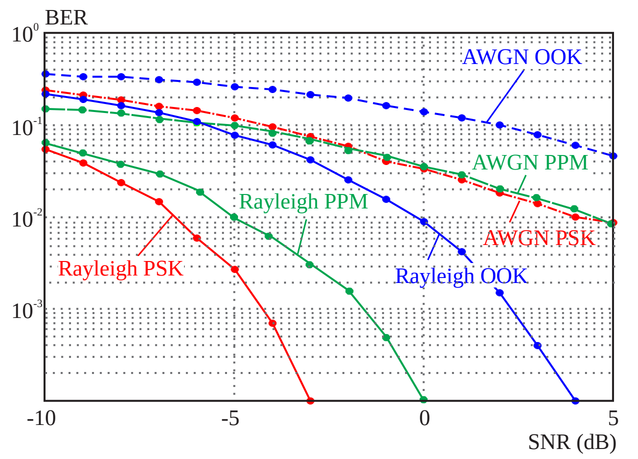

Fig. 5. BER performances for AWGN and Rayleigh channel

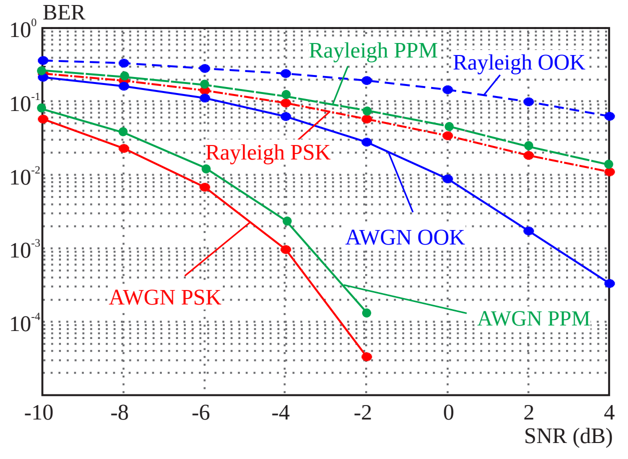

Fig. 6. BER performances in AWGN and Rayleigh channel for three modulation schemes for wavelet based monopulse

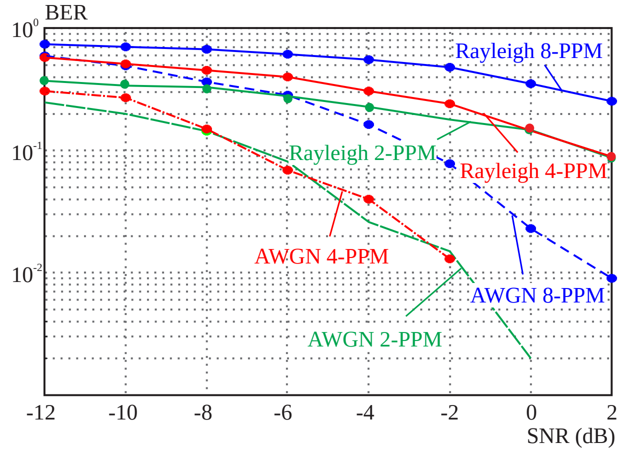

Fig. 7. BER performances for M-ary PPM modulation scheme for wavelet based monopulse

where, $C_j = 0$, since no chip sequence is used and δ is the modulation factor which indicates 1 for additional time shift and 0 for no time shift. For a given data sequence like $\{0\ 1\ 0\ 1\ 0\ 0\ 1\ 1\}$ we can obtain the wavelet-based pulse train for BPPM as in Fig. 3.

3.3 OOK Modulation Scheme

OOK is the modulation technique where the data symbol '1' represents the presence of a pulse and '0' data symbol indicates no pulse. On-off keying modulation can be expressed as follows

$$S^{(k)}(t) = \sum_j d^{(k)} w(t - jT_f)\,. \qquad (5)$$

For a given data sequence like $\{0\ 1\ 0\ 1\ 0\ 0\ 1\ 1\}$ we can obtain the wavelet-based pulse train for OOK as in Fig. 4.

Our present work focuses on the BER performances of three basic pulse shapes in PPM scheme and wavelet based monopulse turned out to be the best pulse-shape which gives the best BER result. Thus we can say that wavelet-based monopulse is the best UWB pulse shape which can be used for UWB transmission using PPM scheme.

4 SIMULATION RESULT

In this paper, three different modulation schemes for two different UWB pulses- Gaussian second derivative and wavelet based monocycle pulse are considered for performance evaluation. The performance is compared in the presence of AWGN and Rayleigh fading channel.

Figure 5 shows that the BER performance of BPSK modulation scheme which gives better performance in AWGN channel as compared to PPM and OOK modulation techniques. That means, for equal energy per bit, BPSK has greater inter-symbol distance than BPPM. Thus BPPM requires more energy to achieve the same bit error rate than BPSK and PPM offers advantages over OOK for Gaussian second derivative pulse shape. Also AWGN channel gives better performance than Rayleigh fading channel for three modulation schemes.

By considering wavelet based monocycle pulse, the BER (bit error rate) performance of the three modulation techniques are compared in the presence of the AWGN (additive white Gaussian noise) and Rayleigh fading channel.

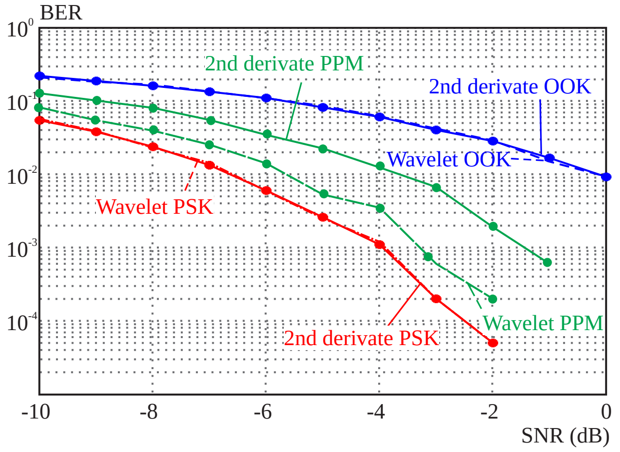

Fig. 8. BER performances in AWGN channel using wavelet based and Gaussian second derivative monopulse

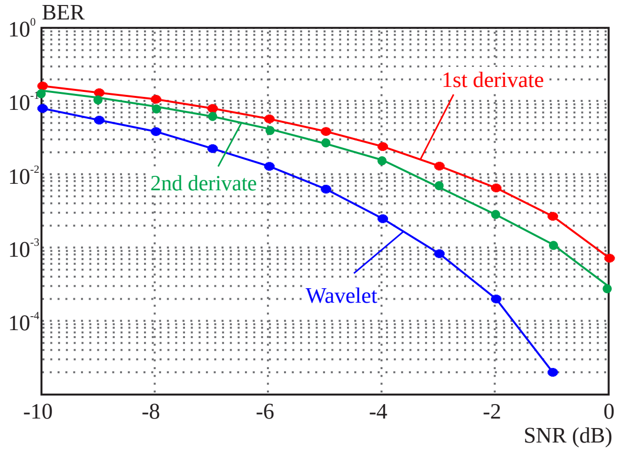

Fig. 9. BER performances for PPM modulation scheme for three monopulses

Figure 6 shows that BPSK gives the best performance for wavelet based monopulse in the presence of AWGN channel. Thus AWGN channel is better for the transmission of BPSK modulated pulse. OOK has the highest energy level to achieve the same bit error rate over BPSK and PPM for Rayleigh channel. We can summarize that BPSK modulation in AWGN channel environment gives the best performance of all three modulation schemes.

Figure 7 shows the BER comparison for three PPM schemes; such as Binary PPM, 4-PPM and 8-PPM. 2-PPM has greater inter-symbol distance than 4-PPM and 8-PPM. Thus 4-PPM and 8-PPM require more energy to achieve the same bit error rate than 2-PPM. Moreover, the performance of UWB transmission in AWGN channel is better than Rayleigh fading channel for PPM modulation schemes.

Figure 8 shows the BER performances of wavelet based monopulse and Gaussian second derivative monopulse in AWGN channel for three modulation schemes. It can be noticed from the figure that the performances are same for PSK and OOK which means pulse shape does not affect the performance in PSK and OOK. For PPM wavelet based monopulse gives the better performance than Gaussian second derivative monopulse.

Figure 9 shows the BER performances of three monopulses – Gaussian first derivative, Gaussian second derivative and wavelet-based monopulse using PPM modulation. As AWGN channel gives the better performance than Rayleigh channel, thus we considered AWGN channel for this analysis. The simulation result shows that the wavelet based monopulse gives the best performance among the three monopulses.

5 CONCLUSION

In this paper, we have analyzed and compared the performances of two different UWB signal such as wavelet based mono-pulse and Gaussian second derivative monopulse. In AWGN channel these two wave-shapes have the same performances for PSK and OOK modulations, but wavelet based monopulse has the better performance for PPM modulation. Again, comparing the two pulse shapes, we get that wavelet-based monopulse gives the best BER performance. Moreover, we examined the BER performance of wavelet based monopulse for M-ary PPM schemes and the simulation results prove that the lower order modulation scheme gives better performance than the higher order schemes.

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