Selection of pulse for ultra wide band communication (UWB) system

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Abstract*—UWB (Ultra Wide Band) technology is a reliable transmission scheme for wireless communication with high data rates. UWB is defined as signals with fractional band width more than 20% of its central frequency or as signals with bandwidth more than 500MHZ. UWB can be characterized with ultra-short duration pulses called monopulses which has excellent immunity in interference from sensitivity or multi path effects or fading problems. Pulse shaping and baseband modulation schemes are two of the main determinant factors for its performance evaluation. The objective of the paper is to examine different types of pulse shaping and modulation schemes for UWB performance evaluation. By considering three different types of pulses and modulation techniques the BER (bit error rate) performance of the modulation techniques are evaluated in the presence of the AWGN (additive white Gaussian noise).Depending upon the BER, we decide the which modulation and pulse are considered for UWB system.

Keywords—ultra wide band(UWB), Gaussian pulse, AWGNchannel.

I. *INTRODUCTION*

Ultra-wideband is a wireless communication technique. It is also called impulse radio, impulse radar or carrier free ultra high-resolution scheme. UWB consists of more than 20% of its central frequency, which is much higher than the conventional communication technology. It can be used in short data transmission range with high bandwidth and high speed interconnection by using larger portion of its spectral band without multipath or narrow band fading problems. UWB transmits very short data pulses and during the middle of the data transmission pulses, it does not require any power. Because of its extremely short duration of pulses, it is immune or invulnerable from sensitivity or multipath effects or fading problems, whereas, existing wireless systems suffers because of those problems. During the short data pulse communication, UWB spreads the energy of the signal from D.C. frequency range to medium-to-high gigahertz (*K and Ku* band) frequency range and occupies several gigahertz bandwidths. Unlike other traditional radio transmission systems, UWB is a baseband transmission scheme where information is encoded in baseband signal and does not require a continuous carrier frequency. Thus, UWB does not suffer from problems including sensitivity to multipath propagation like carrier-based modulation systems do. In general, modulation process is used in communication system to smooth the spectrum of a signal. Modulation process prevents the system from interference of the existing narrowband and wideband signals. UWB uses modulation scheme consists of very short duration (nanosecond) pulses called monopulses. Monopulses spread the signal energy uniformly over a few gigahertz frequencies and make low duty cycle pulse train and consume very low power. Impulse Radio is one of the popular implementations of the UWB technology. Impulse Radio modulation schemes are consist of monopulses. These narrow pulses spread the energy of the signal over a few gigahertzes, which make the signal ultra wideband. Monopulse pulses are spaced apart in time uniformly about a hundred to a thousand times the pulse duration, which make pulse train low-duty-cycle. The lower the duty cycle, the lower power an Impulse Radio consumes. The monopulse pulse train carries no information at that point. Additional processing is necessary to modulate the monopulse pulse train in order to transmit information. The main difference between the spread spectrum (SS) and UWB systems is that the wide bandwidth in a UWB waveform is produced by pulse duration and pulse shaping, not by spreading with a chipping or hoping sequence as in direct sequence and frequency hopping spread spectrum (FH-SS). In FH-SS, the carrier frequencies of the individual users are varied by pseudorandom number (PN) sequence. A SS system takes a baseband signal with a few kilohertz bandwidth and modulates it with a wideband encoding signal. The encoding signal distributes the baseband signal over a larger bandwidth.

UWB is a time domain concept and uses time frequency distribution. It can directly generate wide bandwidth signals using Fourier Transform from its extremely short pulses by using its pulse duration and pulse shaping. Unlike spread spectrums unity constant duty cycle, UWB pulses consist of very small duty cycle. In general, there are two ways to transmit the impulse signals in UWB technology without any interruption. First one is to transmit pulses with continuous time varying multiple access systems, such as code division multiple access (CDMA). The second one is to divide the signal spectrum in very small frequency bands, which can be added and dropped as necessary. UWB's ability is to provide high data rate links with immunity from multipath interference and noise, high channelization, simple economic circuit, and ultra low power spectral density with wider bandwidth already have attracted the communication industries. UWB technology has potential to fulfill the communications need for extremely large data rate at very low power spectral densities over short distances, which makes it a candidate for short-range communication applications. Recently, optimal receivers, which are also called pulse correlation receivers (PCR), have been getting extra attention and momentum in communication industry because of the improvement of UWB technology. UWB is becoming more and more attractive for applications in radar, communications, and geolocations. The choices of pulse shaping and modulation schemes are important design consideration for any UWB system. Fontana et. al. has reported that there has not enough work done in modulation and pulse shaping study for UWB and he had shown some descent efforts only on pulse shapes for PPM schemes. There are many modulation schemes and pulse shaping exists and it is now important to define which one is the best for UWB in which situation. Which one can be universal modulation and pulse shaping scheme for UWB. In this study, the BER performances of three pulse shapes are compared for three modulation schemes.

II. AVAILABLE PULSE FOR UWB SYSTEM

Pulse shape is an important agenda for UWB, because it is a baseband technology, and its spectrum is determined by the pulse shape and pulse width. A UWB pulse shape consists of two factors. First one is to spread the energy in frequency to minimize the power spectral density and the interference. Second one is to avoid a dc component to maintain the antenna radiation efficiency.

Three different monopulse pulse shapes are

- Gaussian monopulse,
- Gaussian second derivative which is also known as Scholtz monocycle or Rayleigh monocycle,
- RZ Manchester

These three pulses do not have dc component and consist of wide 3-dB bandwidths. They also have balanced positive and negative excursions.

Gaussian first derivative pulse is the most popular pulse shape. Gaussian first derivative has one zero crossing.
In time domain Gaussian monopulse can be expressed as

$$w(t) = A\pi f_c t e^{-2(\pi f_c (t-t_c))^2}$$

Gaussian second derivative monopulse can be expressed as follows:

$$w(t) = A(1-4\pi(f_c(t-t_c))^2)e^{-2\pi(f_c(t-t_c))^2}$$

Gaussian second derivative has two Zero crossing. As we increasing the order, the zero crossing will increased by one.

In time domain RZ Manchester monopulse can be expressed as

$$w(t) = \begin{cases} -\sqrt{\dfrac{A}{\tau}} & (t_c + \dfrac{\tau}{6} < t \le t_c + \dfrac{\tau}{2}) \\ 0 & (t_c - \dfrac{\tau}{6} < t \le t_c + \dfrac{\tau}{6}) \\ +\sqrt{\dfrac{A}{\tau}} & (t_c - \dfrac{\tau}{2} < t \le t_c - \dfrac{\tau}{6}) \end{cases}$$

here, *A* is the amplitude, *fc* is the center frequency, which is the reciprocal of the monopulse duration, and *tc* is the time shift. Figure 1 shows various pulse shape for UWB system.

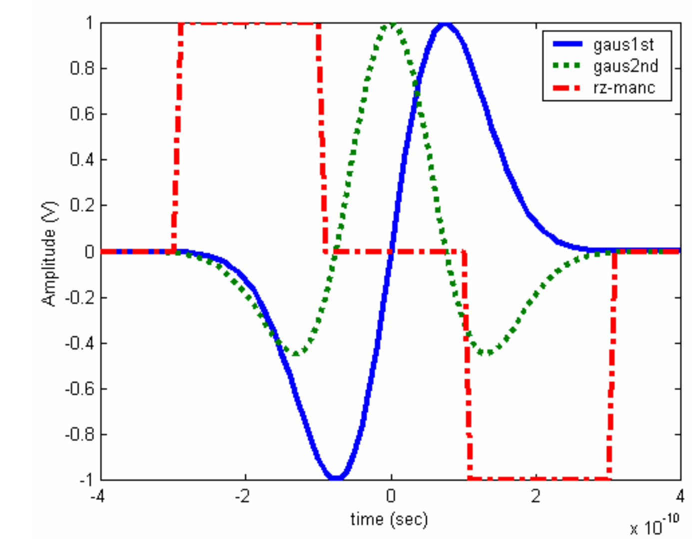

Figure 1. Pulse Shape for Different Waveform

III. MODULATION SCHEME

Here, we considered three modulation schemes for UWB system. All three modulation schemes are digital. Modulation is a process used in communication to prevent the system from interference. We used first derivative of Gaussian pulse as a carrier signal for modulation. Data may be any random digital signal.

1. *Pulse Position Method (PPM)*

Pulse-position data modulation can be expressed as:

$$s^{(k)}(t) = \sum_j w(t - jT_f - c_j^{(k)} T_c - \delta d^{(k)}_{[j/Ns]})$$

where, *cj* is the time hopping code sequence, with an additional time shift of *cjTc* to the *jth* pulse. δ is the modulation factor indicates data symbol “1” for each additional time shift and “0” without any additional time shift. *d(k)* is the binary (*0 or 1*) symbol stream data sequence. Figure 2 shows data for pulse position modulation system.

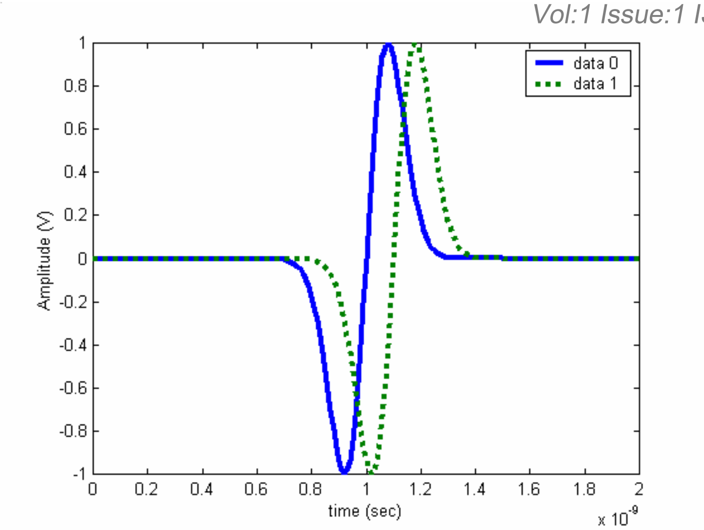

Figure 2. PPM data using Gaussian first derivative

2. *On-Off keying*

On-off shift keying data modulation can be expressed as follows

$$s^{(k)}(t) = \sum_j d^{(k)} w(t - jT_f)$$

In OOK modulation scheme, the data symbol "1" indicates the presence of a pulse, and "0" indicates no pulse data symbol. Figure shows OOK data modulation using Gaussian first derivative monopulse. Figure 3 shows data for ook modulation.

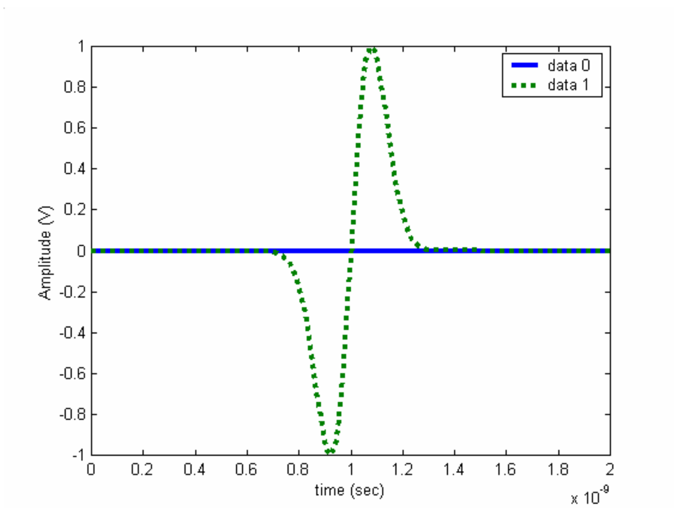

Figure 3. Gaussian first derivative with OOK data

3. *Binary Phase Shifting Keying*

BPSK data modulation can be expressed as follows

$$s^{(k)}(t) = \sum_j w(t - jT_f - \phi)$$

where, ϕ is the phase. In BPSK modulation scheme, the data is carried in the polarity of the pulses. The phase value of zero degrees indicates the data symbol "1", and 180 degrees phase value indicates the data symbol "0". Figure 4 shows data for BPSK modulation system.

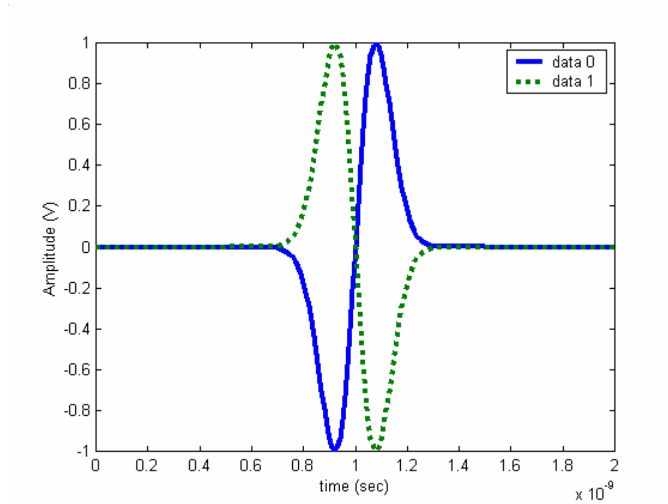

Figure 4. BPSK data with Gaussian first derivative

IV. SIMULATION RESULT

In this paper, three modulation scheme and three pulse shaping techniques are considered and their effects are investigated in the presence of UWB technology by using bit error rate (BER) technique. The BER is well-accepted performance test for traditional wireless communications schemes for different modulation techniques in UWB technology, a comparison is also made in the presence of AWGN. Figure 5 shows BER performance for various modulation system.

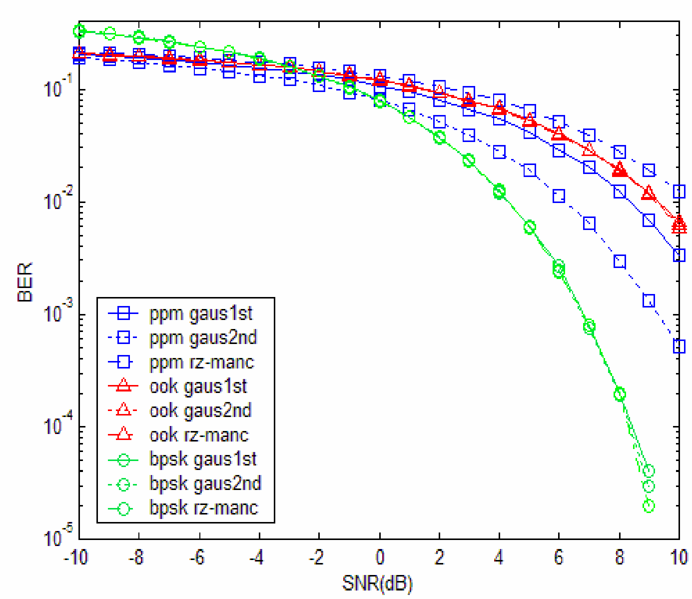

Figure 5. BER performances in AWGN channel

V. CONCLUSION

This study is focused on the basics of UWB such as modulation schemes and pulse shaping. To fulfill the objective of this study, three different types of pulse shaping and three different types of modulation schemes for UWB radio are considered for performance evaluation. Simulation techniques are used and comparisons are made for all pulse shapes and modulation schemes using BER performance evaluation in the presence of AWGN channel for UWB. The results show that the shape of the waveform affects the BER performances of PPM scheme in AWGN channel while it has a small effect on the performance of OOK and BPSK modulation schemes. The BER performance of BPSK modulation scheme using RZ-Manchester pulse turned out to be the best in AWGN channel. The performance of these binary modulation schemes in multipath, effect of jitter and the performance of M-ary modulation schemes deserves further studied. Bandwidth efficiency also can be considered in the new study.

VI. CONCULSION

[1] Moe Z. Win and Robert A. Scholtz, "On the Robustness of Ultra-Wide Bandwidth Signals in Dense Multi-path Environments", *IEEE Communication Letter*, Vol. 2, No.2, pp: 51-53, February 1998.

[2] X. Chen and S. Kiaei, "Monocycle shapes for ultra wideband system," In the procedding of IEEE International Symposium on Circuits and Systems, Scottsdale, AZ, USA, Vol. 1, pp: 597 –600, May 2002.

[3] L. Zhao and A. Haimovic, "Performance of ultrawideband communications in the presence of interference," *IEEE Journal on Selected Areas in Communications*, Vol. 20, No. 9, pp: 1684-1691, December 2002

[4] Jeffrey H.Reed, "Introduction to Ultra-Wideband communication system", *Prentice Hall Publication.*

[5] Sharda Mungale, Prof R.D.Thakare, "Comparative Evaluation of Different Modulation Schemes in UWB," Second International Conference on Emerging Trends in Engineering and Technology, ICETET-09, IEEE Computer society, pp:1201-1205.

[6] J. G. Roakis, Digiral Commsnicarions, McCraw-Hill. New York, 2001.