ISSN 1512-1232

Analysis of UWB Multiple Access Modulation Scheme using Pulse Position Modulation

Vikas Goyal[1], B.S. Dhaliwal[2]
[1]Dept. of Electronics & Communication Engineering, Guru Kashi University, Talwandi Sabo, Bathinda, India
vikas312002@gmail.com
[2]Dept. of Electronics & Communication Engineering, Guru Kashi University, Talwandi Sabo, Bathinda, India
dhaliwal_bs@rediffmail.com

Abstract: *Ultra-wideband (UWB) uses narrow band pulses of nano-seconds to provide high data rate communications .These narrow pulses spread the energy across a wide frequency band that is why it is called ultra-wideband. In this paper, we will discuss the UWB pulse modulation and multiple access modulation schemes using Pulse Position Modulation technique .The simulations are done in MATLAB software.*

Keywords: *PAM,PPM, PPM-TH.*

I. Introduction

UWB transmission is a signal that occupies a bandwidth of greater than 500 MHz or having a fractional bandwidth larger than 20% as compared to narrowband signal which typically have a fractional bandwidth less than 1%. Because of the short duration of the pulses, the spectrum of the UWB signal can be several gigahertz's wide. One of the most popular pulse shape for UWB communication system is the Gaussian pulse or a derivative of the Gaussian pulse due to mathematical convenience and ease of generation. The Gaussian pulse is defined as

$$p(t) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{\frac{(t-\mu)^2}{2\sigma^2}} \quad -\infty < t < \infty \quad (1)$$

where σ is the standard deviation of the Gaussian pulse, and μ is the location in time for the midpoint of the Gaussian pulse in seconds [3][4].

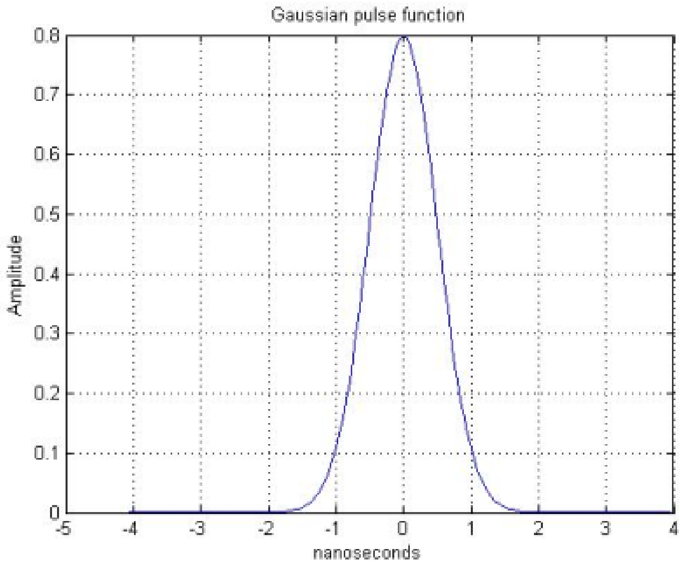


Fig.1. Gaussian pulse

ISSN 1512-1232

II. Modulation techniques

UWB signals are obtained by either applying the Pulse Position (PPM), Pulse Amplitude (PAM), Bi-Phase modulation.

A. PPM Modulation

In PPM modulation, each pulse is delayed or sent in advance of a regular time scale. A binary communication system can be established with a forward or backward shift of the pulse in time. The data is encoded by adding an extra time shift ''δshift'' to the impulse as shown in Fig. The binary PPM signal is given by

$$s(t) = \sum_{k=-\infty}^{\infty} a_k \; p\left(t - kT_f \; \pm \delta_{shift}\right) \tag{2}$$

where the data modulation is done by small shifts in the pulse position δshift, p(t) is the UWB pulse and Tf is the frame duration.

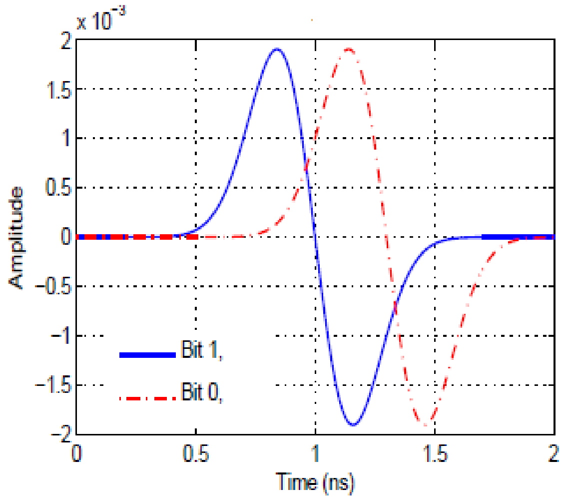


Fig.2. PPM Modulation

B. PAM Modulation

The second data modulation scheme is pulse amplitude modulation (PAM), which is based on encoding the data in the amplitude of the impulses. The PAM modulated signal can be written as:

$$s(t) = \sum_{k=-\infty}^{\infty} a_k \; p\left(t - kT_f\right) \tag{3}$$

where a_k is the amplitude of the pulse p(t) and T_f is the frame duration [7].

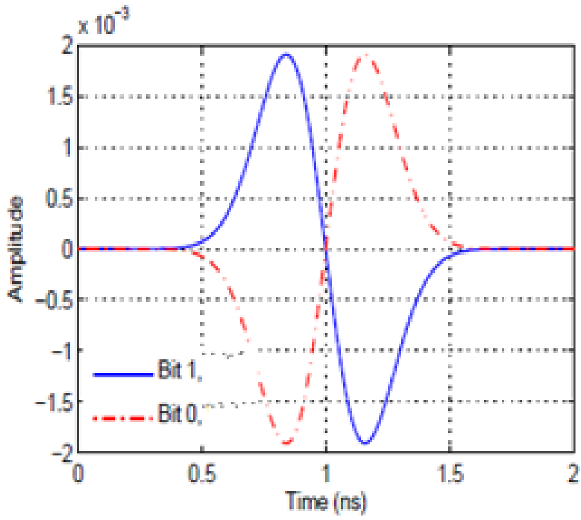


Fig.3. PAM Modulation

ISSN 1512-1232

C. On-off keying (OOK)

A common modulation method is on-off key modulation where we send a pulse only for a positive pulse represents a “1” and no pulse is sent for “0”.

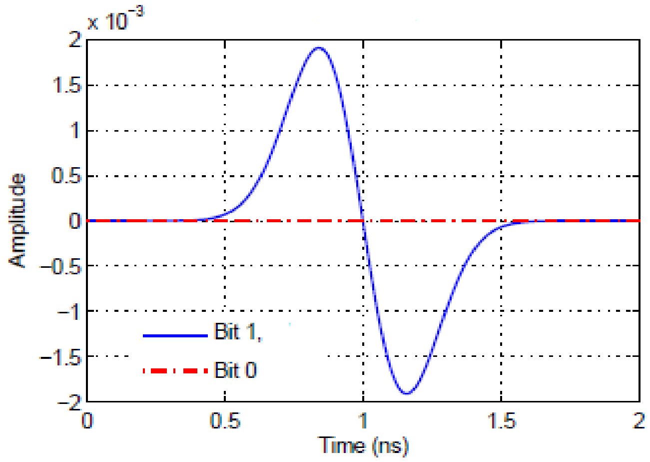


Fig.5. On-off keying Modulation.

III. Multiple Access Modulation techniques

To minimize the potential interference from UWB transmissions and provide multiple access capability, a randomizing technique is applied to the transmitted signal. This makes the spectrum of the UWB signal more noise-like. The two main randomizing techniques used for single band UWB systems are time-hopping (TH) and direct-sequence (DS) and these techniques can be used in conjunction with all the modulation techniques described earlier in this paper we will consider the design considerations of UWB transmitter using Pulse Position Modulation Time Hopping (PPM-TH) multiple access modulation scheme [7][8]

A. Time Hopping(TH)

This technique is in variation to time division multiple access (TDMA). In TDMA a frame is divided into N time slots allowing N users to share a single link. A user is assigned a time slot and transmits in the same time slot each frame. Time hopping adds a variation to this by changing the time slot from frame to frame according to the user’s code. Also when used with UWB more than one pulse is typically used to represent a data symbol. In the TH scheme, the position of each impulse is determined by a pseudo-random (PR) code. In this way, more energy is allocated to a symbol and the range of the transmission is increased. Besides, different users, distinguished by their unique TH code, can transmit at the same time.

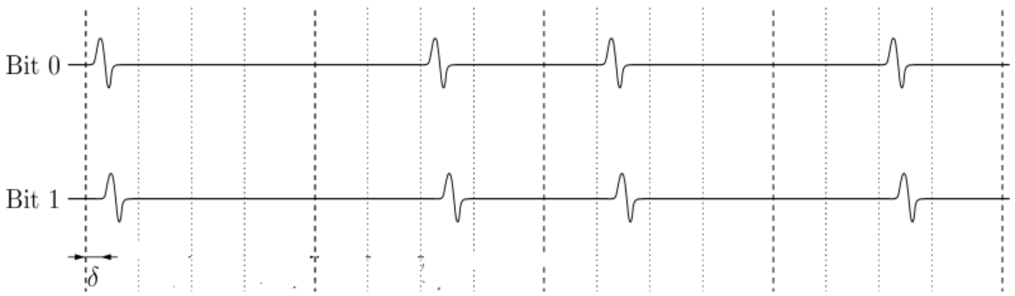


Fig.6. Different positions attained by TH Pulses while representing bits, δ= Pulse position shift

ISSN 1512-1232

IV. PULSE POSITION TIME HOPPING TRANSMITER DESIGN MODEL

A. PPM-TH-UWB Transmitter

The digital information contained in the bits needs to be mapped to the analog pulses which are transmitted and this is done via the help of modulation. The most common modulation technique for UWB is the pulse position modulation (PPM). In PPM each pulse is delayed or sent in advance of the regular time scale. So depending on the data bits, the pulse can be delayed accordingly. PPM is advantageous because of its ease of controlling the delay and simplicity. However, fine time resolution is necessary in UWB system to modulate pulses which are in sub nanosecond range. The spectral peaks with PPM along with Gaussian pulse can cause interference with other RF systems and hence the signal must be time shifted. This time dither is introduced with the help of PN codes.

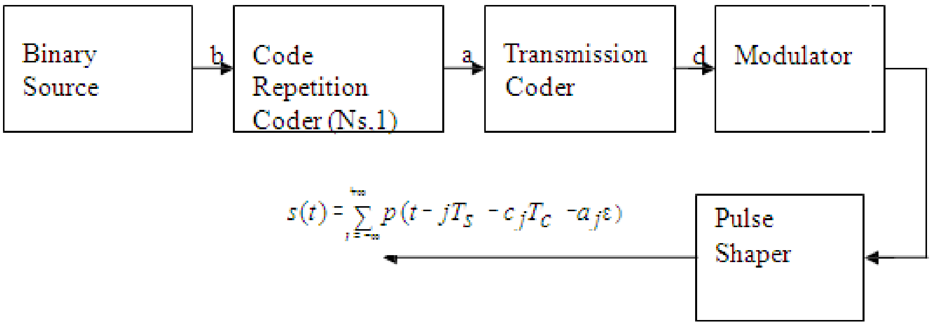


Fig.7. PPM-TH-UWB Transmitter

The binary source generates the bits to be transmitted at rate $R_b = 1/T_b$ .given to code repetition coder which introduces redundancy and acts as channel coder. It repeats the bits generated by the binary source Ns times so the bits are now generated at the rate $R_{cb} = N_s/T_b$ .The transmission coder generates a PN (pseudo random code) with a period N_p and applies this code to the repeated bits generating a new sequence of bits

$$d_j = c_jT_c + a_j\varepsilon \quad (4)$$

where, T_c is the chip time

c_j is the pseudo random code.

The shift generated by PPM the modulator is $a_j\varepsilon$.

The pulse shaper generates a pulse with impulse response p(t) such that the output of the pulse shaper filter is non-overlapping pulses . The Gaussian derivative pulses is used for this purpose.

The signal at the output of the PPM-TH-UWB transmitter is represented as

$$s(t) = \sum_{j=-\infty}^{+\infty} p(t - jT_s - c_jT_c - a_j\varepsilon) \quad (5)$$

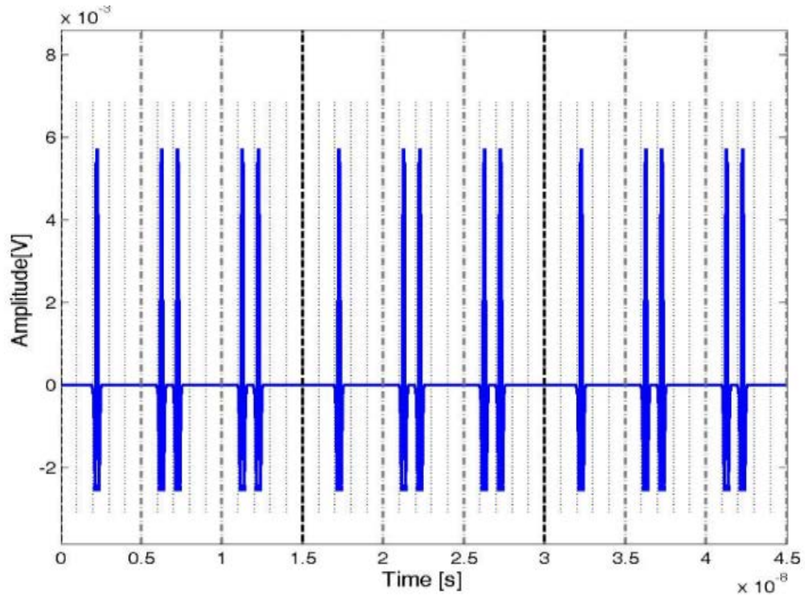
where, c_jT_c = time dither introduced by the TH code,

$a_j\varepsilon$ = time shift introduced by the PPM modulator,

one bit duration $T_b = T_S N_S$

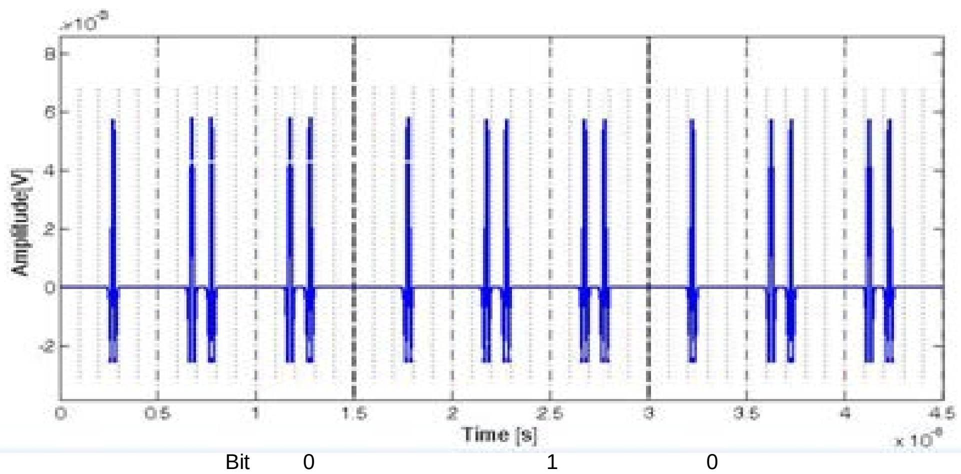
This signal s (t) is transmitted by the UWB transmitter over the channel and received at the receiver end.

The above described model is created using MATLAB software and the transmitted signal is generated using PPM-TH multiple access modulation scheme using the following parameters (Pow=30,fc=50e9,numbits=3,Ts=3e9,Ns=5,Tc=1e-9,Ns=5,Tc=1e-9,Np=5,Tm=0.5e-9,and dPPM=0.5e-9), where Pow = Average transmitted power (dBm), fc = sampling frequency, numbits = number of bits generated by the source, Ts = frame time, i.e. average pulse repetition period, Ns = number of pulses per bit, Tc = chip time , Np = periodicity of the Time Hopping code, Tm = pulse duration [s], dPPM= time shift introduced .



Bit 0 1 0

Fig.8. Transmitted PPM-TH-UWB before modulation



Bit 0 1 0

Fig.9.Transmitted PPM-TH-UWB after Modulation

V. Conclusion

In this paper the UWB modulation basic and multiple access modulation techniques are explained and we have generated the UWB transmitter model using Pulse position modulation time hopping multiple access modulation scheme and successfully obtained the pulse before and after the

ISSN 1512-1232

modulation which can be utilized as a signal to be sent over the channel to obtain optimal results in comparison to the pulses sent using basic modulation schemes in reducing the interference over channel All the results obtained are in accordance with the theory .

References

[1] M. Z. Win and R. A. Scholtz, "Ultra-wide bandwidth time-hopping spread-spectrum impulse radio for wireless multiple-access communication". IEEE Transactions on Publication Date: Volume: 52, Issue: 10, Oct. 2004, pp. 1786- 1796.

[2] Federal Communications Commission, "Revision of Part 15 of the commission's rules regarding ultra-wideband transmission systems, FIRST REPORT AND ORDER," *ET Docket 98-153*, *FCC 02-48*, pp. 1–118, February 14, 2002.

[3] Vikas Goyal, "Pulse Generation and Analysis of Ultra Wide Band System Model", GESJ Computer Sciences and Telecommunications, vol.2 (34), 2012, pp.3-6.

[4] Vikas Goyal, B.S Dhaliwal,"Optimal Pulse Generation for the Improvement of Ultra Wideband System Performance," Int. Conf. Recent Advances In Engineering And Computational Sciences, IEEE Explore digital library with, ISBN: 978-1-4799-2291-8 held at UIET, Punjab University, Chandigarh, March 6-8, 2014

[5] R. Saadane, A. Khafaji, M. Wahbi, B. El Bhiri, D. Aboutajdine, "Ultra wide bandwidth radio channel indoor propagation and path loss analysis based on measurements," *Conf. Multimedia Computing and Systems*, pp. 259-263, 2009

[6] M. Welborn and J. McCorkle, "The importance of fractional bandwidth in ultra-wideband pulse design," *Proc. IEEE Int. Conf. Communications*, vol. 2, pp. 753–757, April 2002.

[7] J. G. Proakis, *Digital Communications*. New York: McGraw-Hill,5th ed., 2001.

[8] M. Ghavami, L.B. Michael, "A novel UWB pulse shape modulation system", *Wireless Personal Communications*, Vol. 23, pp. 105-120, 2002.

[9] T. Rappaport, "Wireless Communications Principles and Practice", Pearson Education, 2nd ed., 2004.

Article received: 2015-04-17