BER Performance Analysis of TH-PPM UWB Communication System in an AWGN channel

Raafat K. Oubida
Electrical Engineering Department, University of Babylon

Abstract

In this paper, is presented the evaluation of the ultra wideband (UWB)communication system performance analysis in terms of bit error rate (BER) in a time hopping pulse position modulation scheme (TH PPM) in the additive white Gaussian noise (AWGN) channel. Most of the researches topics with UWB concepts are based on Pulse Position Modulation with Time Hopping (TH-PPM) but one of the weaknesses of TH-PPM is its BER performance. The simulation results demonstrate that bit error probability performance of TH-PPM UWB communication system improved when increase the number of pulses per information bit.

Key words: TH-PPM, Ultra Wideband, Performance, BER

الخلاصة

في هذا البحث ،تم تقييم وتحليل الأداء من ناحية تصحيح الخطا لنظام الاتصالاتTH-PPM UWB. في قناةAWGN معظم البحوث التي تركز على مفاهيم هذا النظام تعتمد على طريقة التضمين نوع TH-PPM ولكن من عيوب هذه الطريقة هو الأداء من ناحية تصحيح الخطا الـ .BER.تظهر النتائج بوضوح تحسن الأداء للنظام من خلال الحصول على الـ BER قليلة عند زيادة عدد النبضات.N_s

I Introduction

In recent years, wireless communications have widespread uses for many purposes, not only for professional applications but also for many fields in our daily life and in consumer electronics (CE).

UWB is a new technology that has increase interest in the area of wireless communications.[Scholtz1993],[Win & Scholtz 2000],[Martret & Giannakis 2000],

[Kaiser 2004] because of its low cost and low power consumption potentials but high data rates and large channel capacity.[Siwiak .2001], [Siwiak 2001].

In April 2002, US Federal Communications Commission (FCC) after extensive commentary from industry, the FCC issued its first report and order on UWB technology, thereby provided regulations to support deployment of UWB wireless communication systems. According to the definition of FCC, signals with fractional bandwidth, (FBW) greater than twenty percent of their central frequency or as signals with bandwidth more than 500MHz of the spectrum, whichever is less. [Federal Communications Commission.2002].

UWB has tradition been emitted by radiating pulses that are very short in time. This technique is called Impulse Radio (IR) allows the construction of modems without RF components, which allows simpler and cheaper transceivers [Martret & Giannakis 2000], [Siwiak 2001].and [Gabriell et.al 2004]

The use of spread-spectrum (SS) techniques such as Time-hopping (TH) technique can be applied to all of the modulation techniques, to prevent collisions among different users where each user is assigned a time hopping sequence. A specific modulation scheme might however be more appropriate in some cases for one or the other depending on spectrum shapes and characteristics. Therefore, a common modulation scheme used in UWB communications system is TH-PPM [Win & Scholtz1998].

Most of the researches topics with UWB concepts are based on Pulse Position Modulation with Time Hopping (TH-PPM), but one of the weaknesses of TH-PPM is it is the performance in terms of bit error rate (BER).

In the recent past, several researchers have reported the performance analysis of TH-PPM UWB systems in AWGN channels under different conditions and environments ([Win & Scholtz 2000], [Forouazan et al 2002], [Durisi & Benedetto 2003], [Bastidas et al 2003], and [Zhang et al 2003]).

There are many factors and parameters having a great influence on the performance analysis of the system and this paper illustrates the role of number of pulses per information bit *Ns*. Then, the performance of the TH-PPM-UWB system is analyzed over AWGN simplified channel model. Finally, the simulation results demonstrate that bit error probability performance of TH-PPM UWB communication system improved when increase the number of pulses per information bit.

II System Model

In this section, system model of TH-UWB combined with PPM scheme will be described. We assume that the model is synchronized. The block diagram used in our system is shown in Figure 1.

The process starts at the first block which is the channel encoder (repetition code method). A binary sequence *b* is information bit sequence, and after the channel encoder repeats each bit *Ns* times and generates a binary sequence *a* .

The transmission encoder in the second block generates a new sequence *d* by applying an integer valued called time hopping code *c* to *a*. A new sequence is obtained, which is denoted as $d_j = c_j T_c + \varepsilon a_j$, these two elements are constant terms. The third block is the PPM modulator. It receives the sequence *d* and produces a series of Dirac pulses. The fourth block is the pulse shaper which has an impulse response $p(t)$. At the end of the generating process we get the transmitted signal $x_{tr}(t)$ in the TH-PPM UWB system is described by the following model [Durisi G. and Benedetto S.: 2003]:

$$x_{tr}(t) = \sum_{j=-\infty}^{+\infty} p(t - T_s - c_j T_C - \varepsilon a_{[j/N_s]}) \qquad (1)$$

Where

$p(t)$: is the impulse response of the pulse generator, it could be a UWB pulse transmitting information bits.

Ts : is frame time, i.e. average pulse period

c_j : is time hopping code

T_C : is the time duration of the *j*th pulse

ε : is PPM shift

$a_{[j/N_s]}$: is the information bit, where $a_{[j/N_s]} \in \{0,1\}$

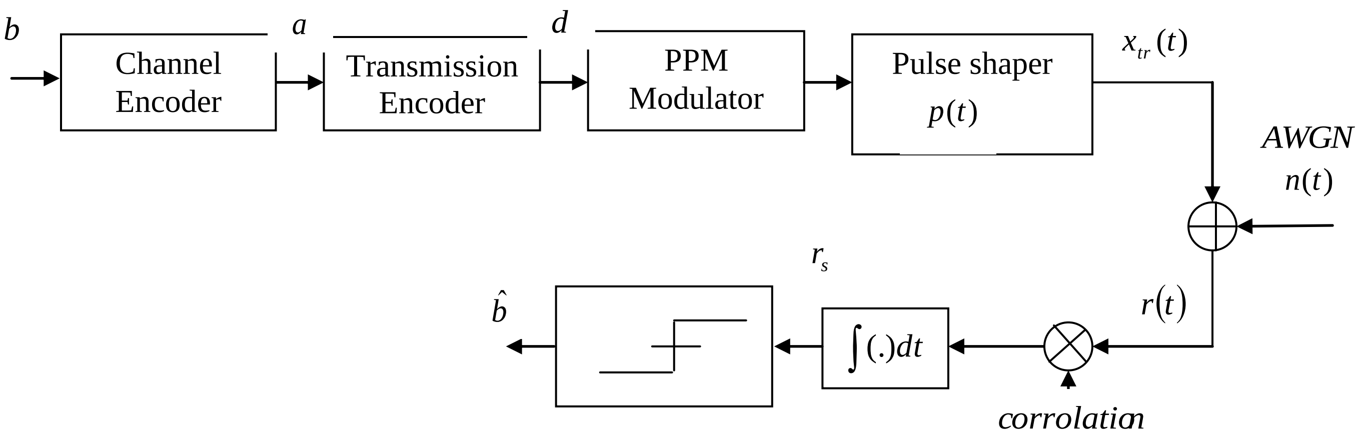

Figure 1: System model block diagram

The optimum receiver for a single bit of a binary modulated impulse radio signal in AWGN is a correlation receiver defined as below:

$$r(t) = \alpha x_m(t - \tau - c_j T_c) + n(t) \tag{2}$$

where

$$x_m = \begin{cases} p_o(t) & bit\,is\,0 \\ p_o(t-\varepsilon) & bit\,is\,1 \end{cases},$$

$p_o(t)$ is the pulse without PPM modulation

τ : is the propagation time delay of direct path.

The correlation mask can be expressed as,

$$m(t-\tau) = p_o(t - \tau - c_j T_c) - p_o(t - \tau - c_j T_c - \varepsilon) \tag{3}$$

The received sequence r_s is given by:

$$r_s = \int_{\tau}^{\tau+T_s} r(t).m(t-\tau)dt$$

$$r_s = a\sqrt{E_b} + n \qquad if\ r_s \quad bit\,is\,0 \tag{4}$$

$$r_s = -a\sqrt{E_b} + n \qquad if\ r_s \quad bit\,is\,1$$

Where E_b is the energy per bit, and n represents the zero-mean white Gaussian noise. This received sequence will be input to the detector.

III Simulation Results

. The expression for the Gaussian pulse is [Gabriell et.al 2004]

$$p(t) = \exp\left[-2\pi\left(\frac{t}{\tau_p}\right)^2\right] \tag{5}$$

By taking the second order derivative of the Gaussian pulse, this is expressed as

$$p(t) = \left[1 - 4\pi\left(\frac{t}{\tau_p}\right)^2\right]\exp\left[-2\pi\left(\frac{t}{\tau_p}\right)^2\right] \qquad (6)$$

where τ_p is the shaping factor of the pulse.

System parameter values in simulation as shown below in Table 1:

Parameters	Value
Sampling frequency [GHz]	50
Average transmitted power[dBm]	-30
Periodically of the TH code	3000
Receiver	Correlation
Channel model	Zero-mean (AWGN)
Modulation scheme	PPM
Multiple access	TH
Time shift for PPM(ns)	0.5
Pulse shape	Gaussian 2nd derivative
Frame time [ns]	3

Table 1: System parameter values in simulation

The simulation results are plotted as BER versus. SNR (Eb/N0) (dB) in Figure 2.The simulations performed also assume synchronization between the transmitter and receiver. Obviously, when increase the number of pulses per information bit lead to improve BER performance.

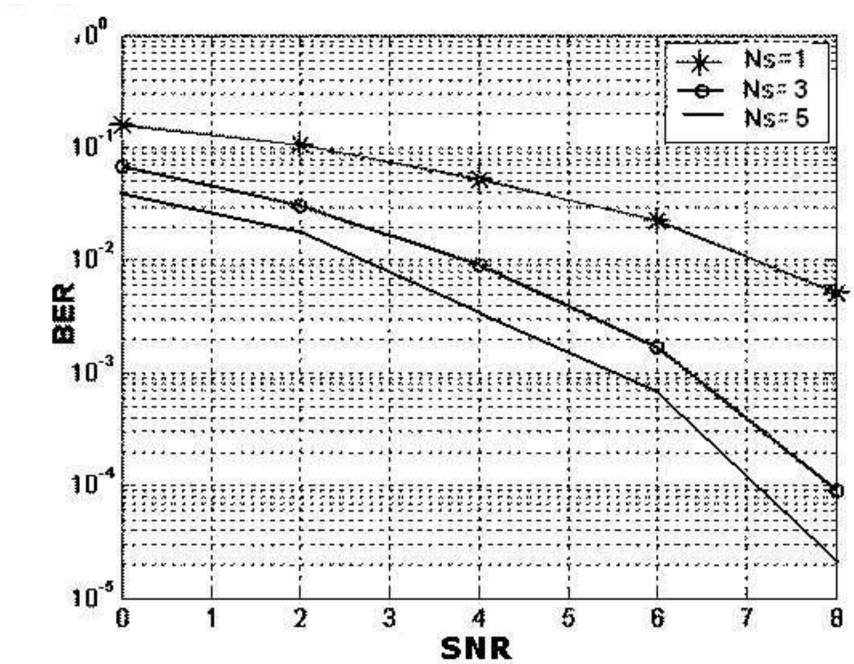

Figure2: BER performance of TH-PPM-UWB system

IV Conclusion

There are many factors and parameters having a great influence on the performance analysis of the system and this paper illustrates the role of number of pulses per information bit.*Ns*. Then, the performance of the TH-PPM-UWB system is analyzed over AWGN simplified channel model. Finally, the simulation results show the performance improvement in terms of BER of TH-PPM UWB communication system due to the increase the number of pulses per information bit.

References

Bastidas et al 2003, ‘‘Performance of UWB PPM in Residential Multi-Path Environments’’, Proc. IEEE VTC’03, pp. 2307- 2311.

Durisi & Benedetto: 2003 ‘‘Performance evaluation of TH-PPM UWB systems in the presence of multi-user interference’’, IEEE Communications Letters, Vol. 5, pp. 224-226.

Federal Communications Commission.2002 *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.

Forouazan et al 2002 "Performance Analysis of Time-Hopping Spread-Spectrum Multiple-Access Systems: Uncoded and Coded Schemes," IEEE Trans. Wireless Commun., vol.1, pp.671-681.

Gabriell et.al 2004, Understanding Ultra Wide Band. Radio Fundamentals. Prentice Hall PTR.

Kaiser 2004, UWB communications systems "a comprehensive overview." EURASIP.

Martret & Giannakis 2000, “All-digital PAM impulse radio for multiple access through frequency-selective multipath,” in *Proc. IEEE Global Telecomm. Conf.*, pp. 77–81.

Scholtz 1993., “Multiple access with time-hopping impulse modulation,” in *MILCOM*.

Siwiak 2001, Ultra-Wide Band Radio: Introducing a New Technology, Spring IEEE Vehicular Technology Conference (VTC), Vol.2, pp. 1088-1093'.

Siwiak 2001, Ultra-Wide Band Radio: The Emergence of an Important RF Technology, Spring IEEE Vehicular Technology Conference, Vol. 2' pp.69-172.

Win & Scholtz 1998 "Impulse radio: How it works". *IEEE Comm. Letters*. , 2(1): 10-12.

Win & Scholtz 2000, "Ultra-Wide Bandwidth Time-Hopping Spread-Spectrum

Impulse Radio for Wireless Multiple-Access Communications," *IEEE Trans. Commun.*, vol. 48, no. 4, April 2000, pp. 679 –689.

Zhang et al 2003, "New results on the capacity of M-ary PPM ultra wideband systems," in Proc. IEEE International Conference on Communications, 2003, vol.4,pp.2867-2871.