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OPTIMUM TIME SHIFT AUTOCORRELATION FOR TIME HOPPING UWB SYSTEM USING PPM TECHNIQUE **The role of participation in decision-making to**

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Abstract

This paper presents the optimum time shift of Pulse Position Modulation (PPM) to achieve minimum autocorrelation and consequently minimum bit error rate, in time hopping UWB communication system. The minimum autocorrelation is calculated for the famous pulses used in UWB, the Gaussian pulses, from zero order to fifth order. The obtained result is achieved by MATLAB simulation for practical TH-UWB system.

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I. Introduction

Obviously the data rate in the newer systems is going up and the applications of near-body wireless communication are becoming important. However, the gap between the transmission speed needs and the data rate that can be offered still exists. As example we need over 100 Mbps wireless links capable of maintaining multiple MPEG-2 streams or even higher quality video streams, which is the new requirement for a home network or a Personal Area Network (PAN). But, the existing systems like 3G or WLAN cannot meet this specification. Therefore, a new wireless transmission standard is required, and to be reliable with this high data rate which is the UWB (Ultra WideBand) system [5]

UWB signals are defined as signals having a fractional bandwidth of at least 0.25 or occupying at least 1.5 GHz spectrum. These two factors are modified to 0.20 fractional bandwidth and 0.5 GHz spectrum. The fractional bandwidth his defined as [5]:

$$\eta = 2 \cdot \frac{f_{H\_10dB} - f_{L\_10dB}}{f_{H\_10dB} + f_{L\_10dB}}$$

where f_{H_10dB} and f_{L_10dB} represent the highest and lowest -10dB bandwidth frequencies of the signal spectrum respectively.

The goal of this paper is to reach to the optimum time shift used in PPM of TH-UWB which making minimum BER. We will calculate the optimum time shift in all Gaussian pulses from zero to fifth order which is used in generation of the TH-UWB PPM. Section II, gives an analytical description of UWB signals, with a definition of time hopping spreading approaches and different Gaussian Pulses. In section III, we introduce the PPM as a modulation for UWB and the correlation between different Gaussian pulses. In section IV, our simulation results and then we close the paper by the conclusion in section V.

II. Analytical Description of TH-UWB

The general formula for an UWB signal representing data transmission flow in the time domain is given by [6]:

$$s(t) = \sum_{k=-\infty}^{+\infty} \sum_{j=1}^{N_f} w_{b[k]}(t - kT_b - jT_f - (c_w)_j T_c - \tau_\delta b[k])(c_p)_j$$

where k is the data bit index, N_f is the number of frames each single data bit is divided into, *b[k]* is the value of the k^{th} data bit. It can assume values {0, 1}, $w_{b[k]}$ is the UWB pulse waveform used to transmit the bit "*b[k]*", T_b is the time duration of the data bit, T_f is the time duration of each of the N_f frames composing the data bit, that is: $(T_f = T_b / N_f)$, $(c_w)_j$ is a Pseudo-Random (PR) code that gives the time location of the pulse transmitted in the j^{th} frame, T_c is the chip length, which reserved for a single pulse. Once the physical length T_p of the pulse is defined, the inequality $T_p < T_c$ must be satisfied, τ_δ is the time shift that can be assigned to the pulse used to transmit data bit "1" (used as a modulation index for pulse position modulation) and $(c_p)_j$ is a PR code that gives the polarity of the pulse transmitted in the j^{th} frame. It can assume values {+1, −1}.

In the Time Hopping (TH) approach the instant of pulse transmission is defined by the PR code c_w. In this case the processing gain which is define as the ratio between the data bit length T_b and the chip length T_c, is also increased by the low transmission duty cycle. The PR code is used to separate the users according to the Code Division Multiple Access (CDMA), and to smooth the spectrum. However, if the pulse repetition interval is fixed, lines (due to non smoothing) will appear in the spectrum. The separation between consecutive spectral lines is inversely proportional to the pulse repetition interval [6]. Fig. 1 shows the characterizing of the TH spreading approach

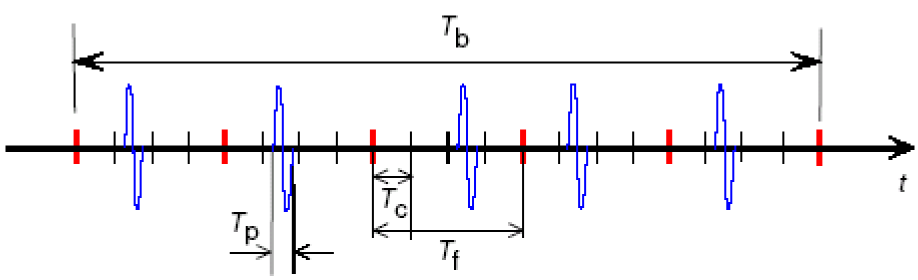

Fig. 1 Typical behavior of a TH-UWB signal.

The category of the waveforms often used to obtain the ultra wideband spectra is based on a Gaussian pulse and its derivatives. We have the definition of a so-called "Gaussian pulse zero order"[5]

$$w_{G_0}(t) = \frac{1}{\sqrt{2\pi}\sigma} \exp(-\frac{t^2}{2\sigma^2})$$

The other UWB waveforms can be obtained by differentiating $w_{G_0}(t)$ against t as

$$w_{G_n}(t) = \frac{d^n}{dt^n} w_{G_0}(t)$$

where the pulse duration T_p is equal to 2 π σ and σ is the variance. Figures 2 and 3 show the Gaussian pulses from zero order to fifth order in both time and frequency domain respectively.

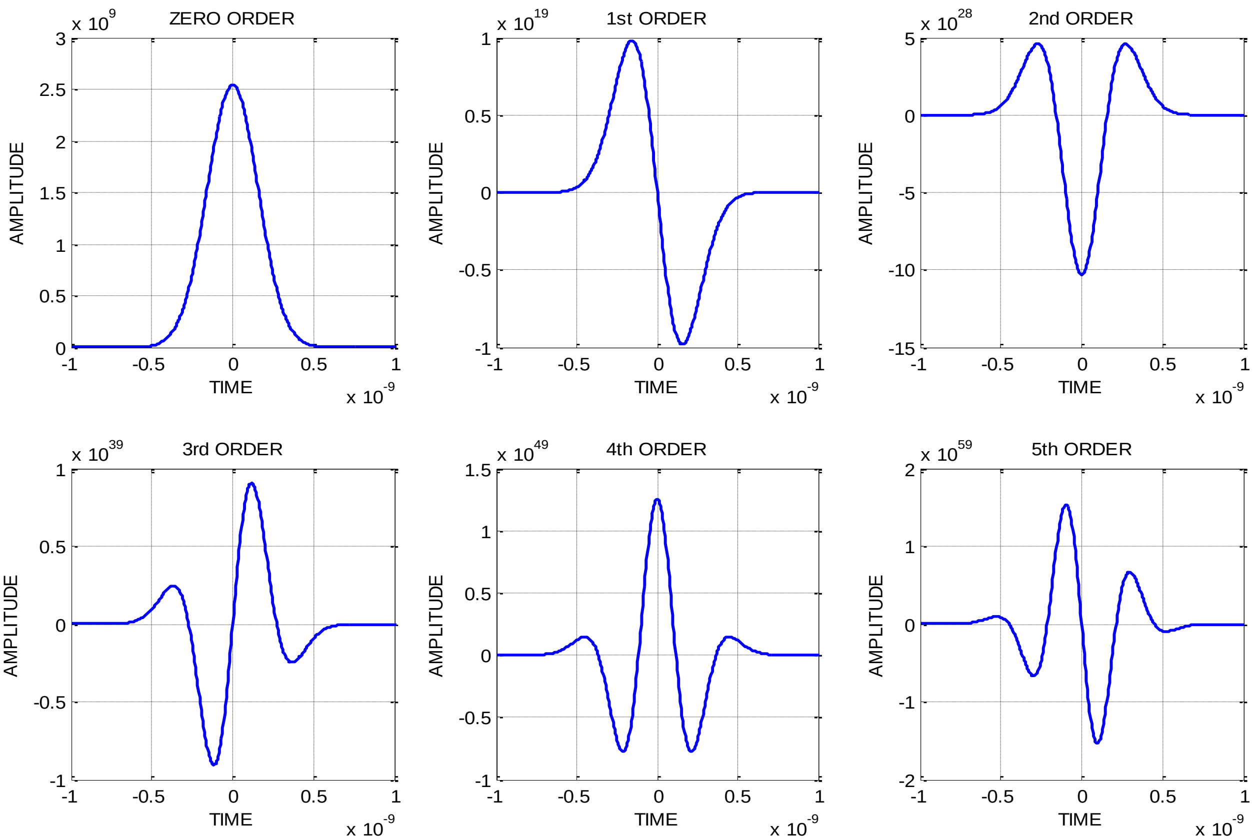

Fig. 2 Gaussian pulses from zero order to fifth order in time domain

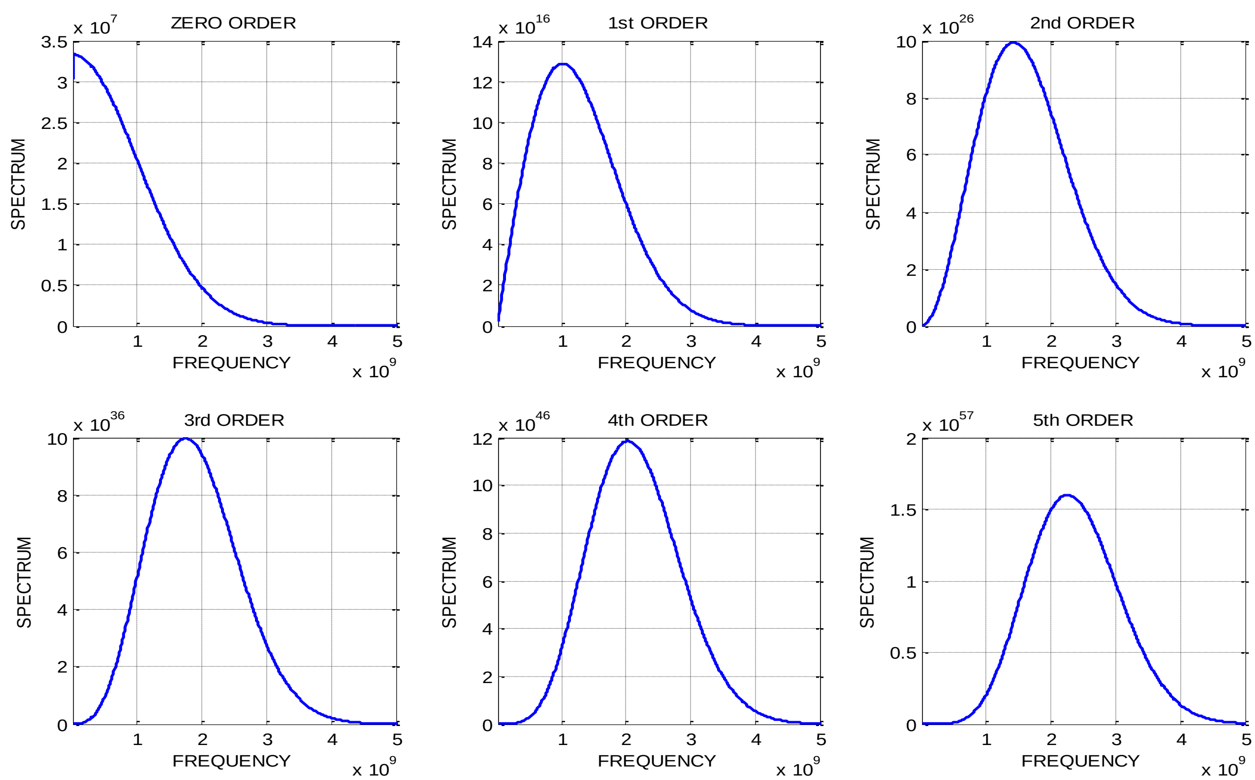

Fig. 3 Gaussian pulses from zero order to fifth order in Frequency domain

III. PPM and Autocorrelation for TH-UWB

In the PPM modulation, fig. 4. the particular bit chosen to be transmitted influences the time position of the UWB pulse. That is, while bit "0" is represented by a pulse originating at time instant 0 and bit "1" is then delayed of a fixed amoun t of time from 0. This delay (also referred as "time shift") and can be defined as a function of the length of the pulse as follows [6]

$$\tau_\delta = \delta \cdot T_p$$

where T_p is the length of the pulse, and δ represents the modulation index. The pulses characterizing this modulation can be represented as:

$$\begin{cases} w_0(t) & = & w(t) \\ w_1(t) & = & w\left(t - \tau_\delta d_j\right) \end{cases}$$

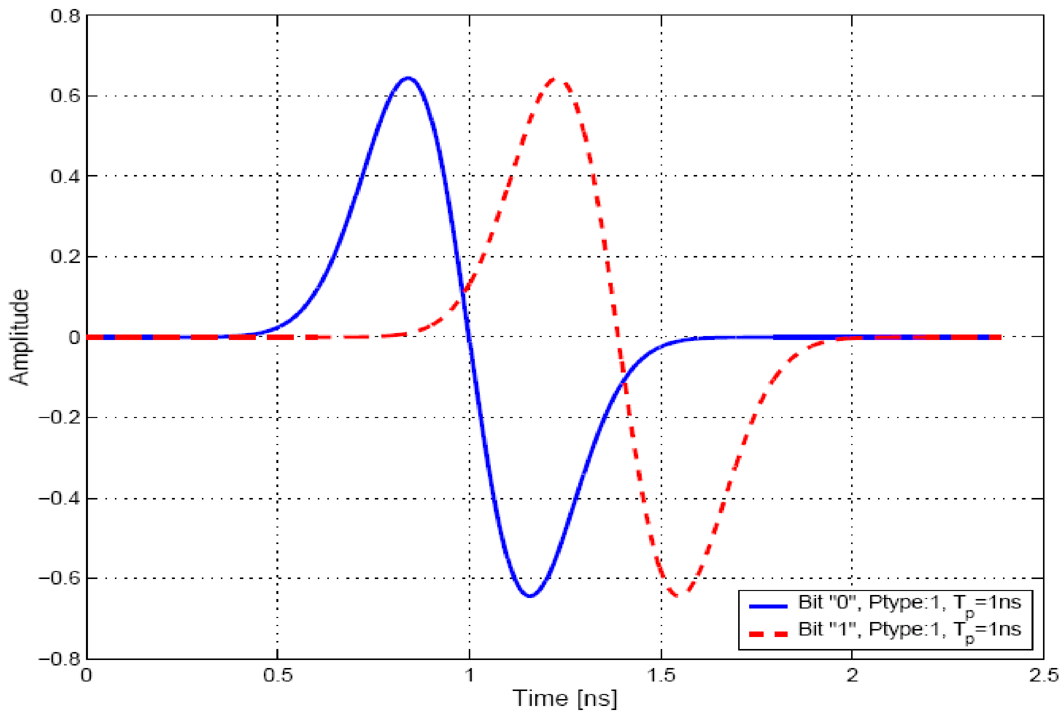

Fig. 4 PPM Modulation

The value of δ can be chosen according to the autocorrelation characteristics of the pulse. The autocorrelation function ρ (t) of a transmitted pulse waveform w_{tr} is analytically defined as:

$$\rho(t) = \int_{-\infty}^{+\infty} w_{\mathrm{tr}}\left(\delta T_{\mathrm{p}}\right) w_{\mathrm{tr}}\left(t - \delta T_{\mathrm{p}}\right) \mathrm{d}\delta.$$

The Gaussian pulse and its derivatives show negative values of autocorrelation, thus offering the possibility of performing non-orthogonal PPM, which has better performance compared to orthogonal PPM. Fig. 5 shows different values of autocorrelation of the Gaussian pulses with the relative time shift $\delta = \tau_\delta / T_p$

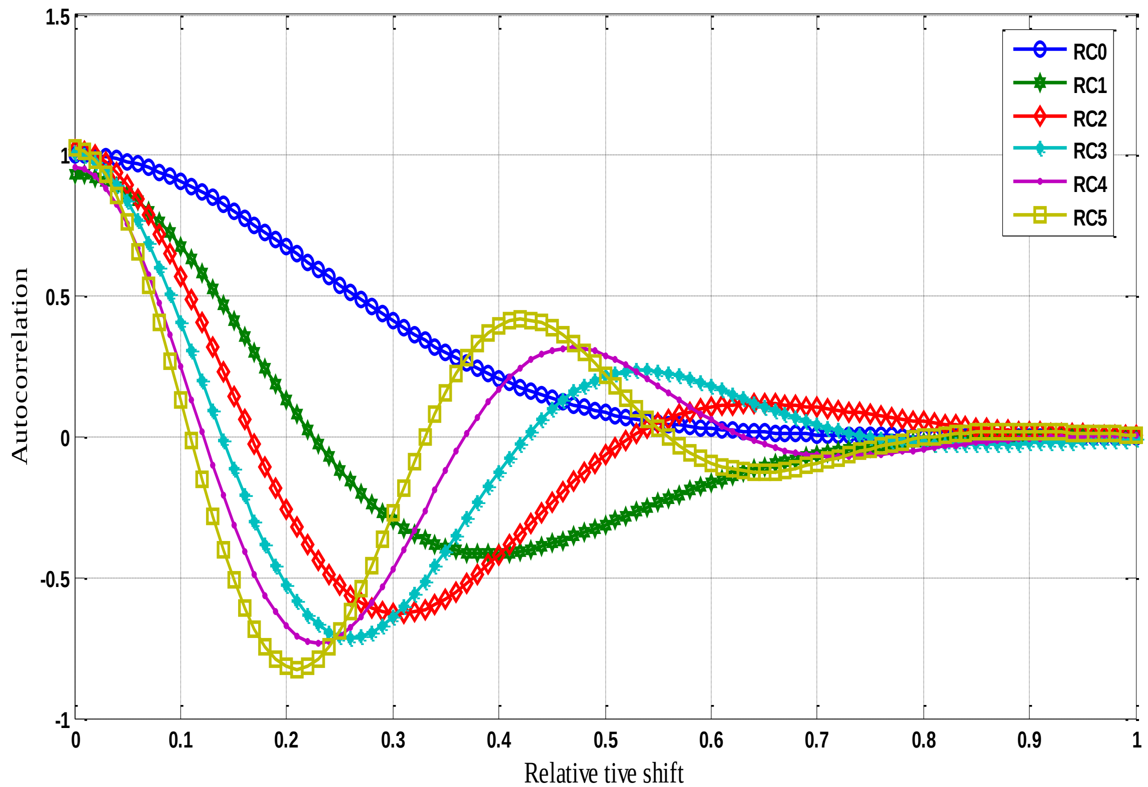

Fig. 5 Values of the autocorrelation of Gaussian pulses.

Fig. 5 illustrates the minimum time shift for each Gaussian pulse and the table 1 shows the optimum value of the time shift for each order of Gaussian pulses

Table 1 Optimum values of time shift for Gaussian pulses

Order	**Optimum relative time shift δ**
Zero	0.50
First	0.35
Second	0.30
Third	0.25
Fourth	0.25
Fifth	0.20

IV. The Simulation Results

The comparison between the different relative time shift used by Gaussian pulses in TH-PPM is shown in Fig. 6, the simulations are used MATLAB TH-PPM practical system in AWGN channel which pulse duration = 0.2 nsec, and it is clear the results which get in table 1.

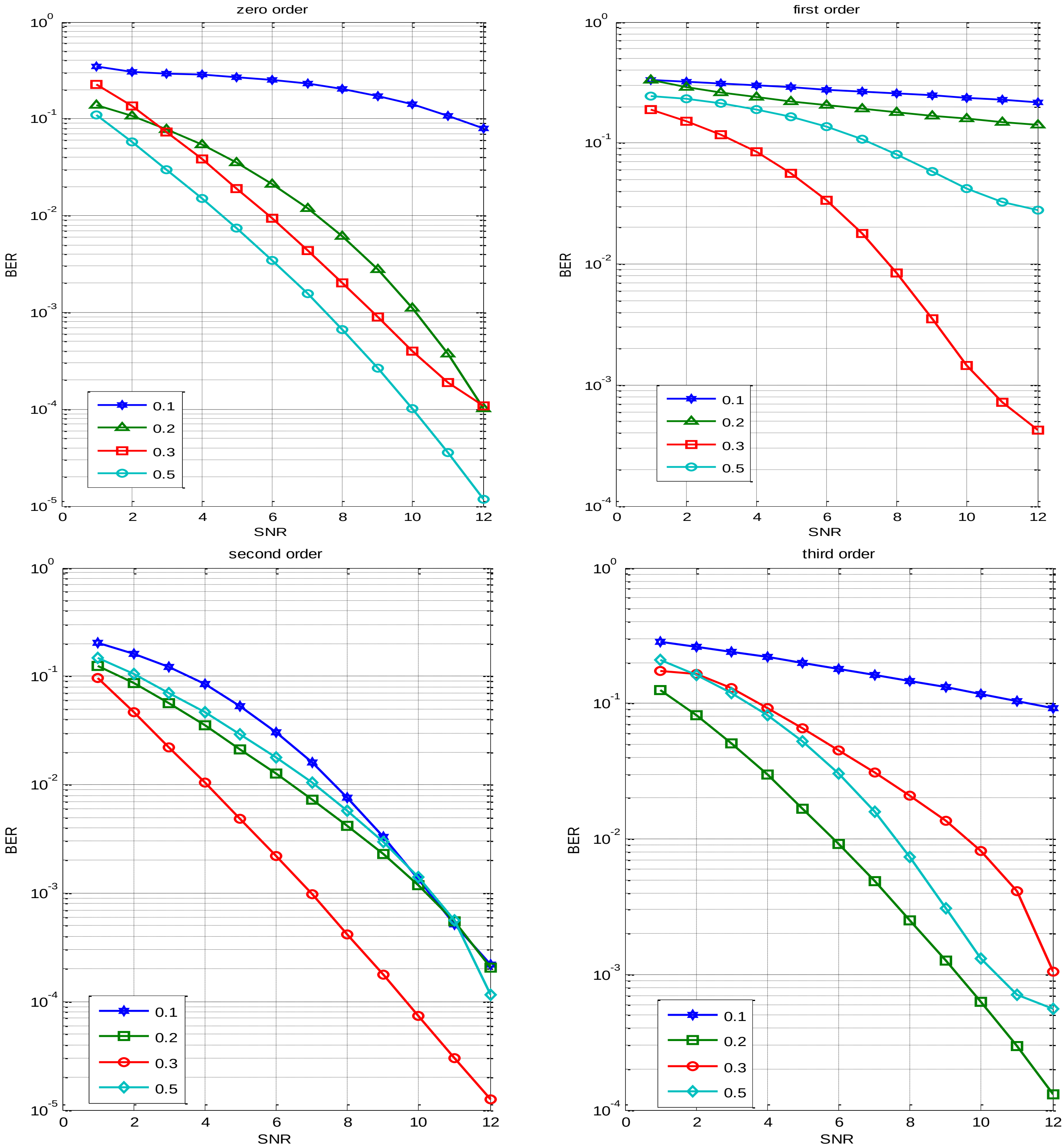

Fig. (6-a) BER performance for zero to third order Gaussian pulses

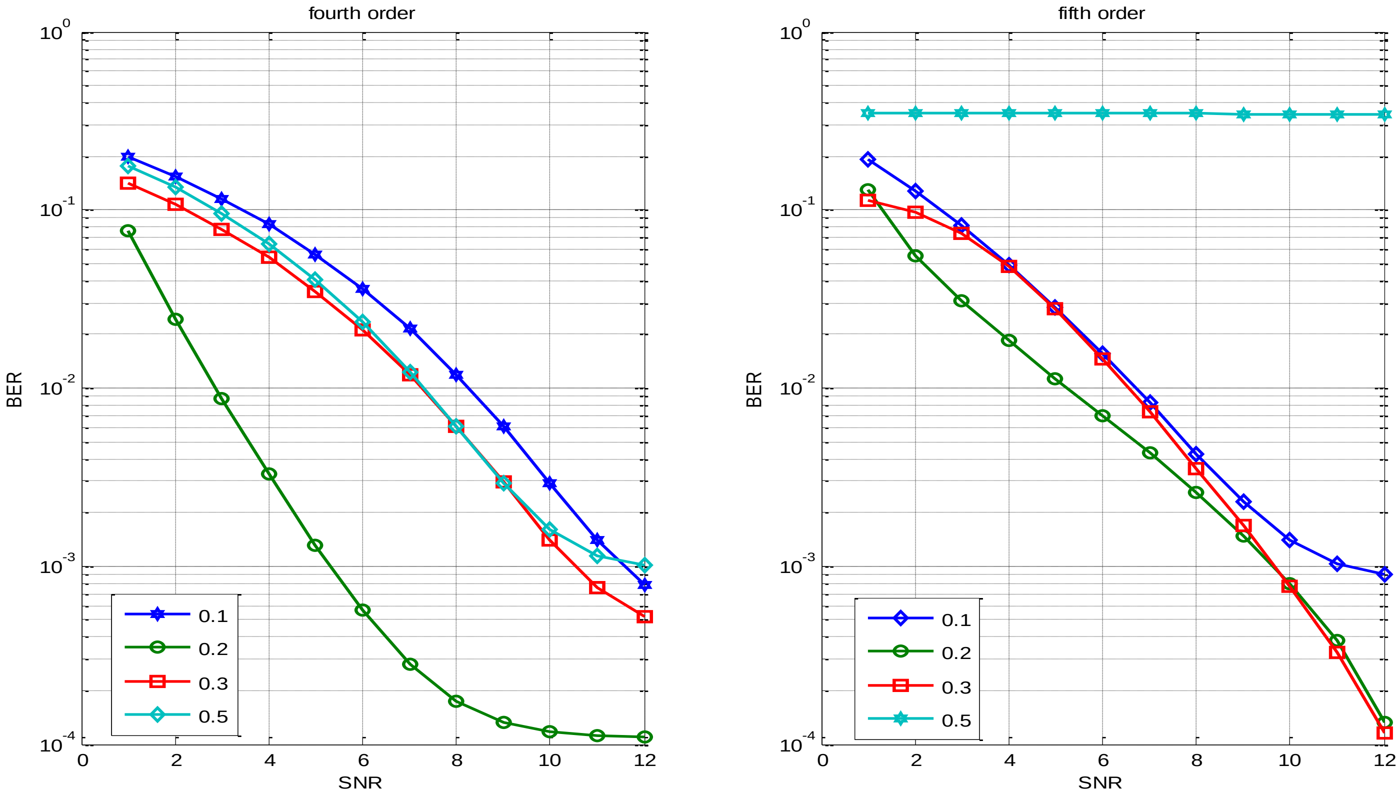

Fig. (6-b) BER performance for fourth and fifth order Gaussian pulses

V. Conclusion

This paper obtained the optimum time shift of PPM technique used by TH-UWB systems. The optimum time shift is compute by calculate the relative time shift which achieved minimum autocorrelation of Gaussian pulses from zero order to fifth order which are used by TH-UWB system, and then the MATLAB simulation results prove that this optimum time shift achieved minimum BER.

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