TH-PPM and TH-BPSK-UWB Performance Using UWB Channel-1 with Delay Estimation

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Abstract-- **In this paper, the performance of TH-PPM-UWB and TH-BPSK-UWB for a single-user link is compared, using the newly proposed, realistic UWB channel model from IEEE 802.15. It presents the channel delay estimation result and assesses the performance of rake receiver using UWB SV channel model-1. Since TH-UWB is more difficult to synchronize, the conclusion is that TH-PPM-UWB performs better than TH-BPSK-UWB for high-speed indoor links.**

***Index Terms*--The Channel Delay Estimation,, Rake-Receiver, SV channel, TH-PPM, TH-BPSK .**

I. Introduction

THE increasing demand for high data rate services in multi- media applications necessitates the adoption of very wide waveform and Ultra-Wideband (UWB) seems to be suitable technology for such applications. FCC has defined UWB as any radio system that has fractional B.W. greater than 20% [1][2]. Second derivative of Gaussian pulse is used as UWB pulse [3]. Fig - 1 shows the Gaussian pulse and its spectrum that is used for the simulation results presented here.

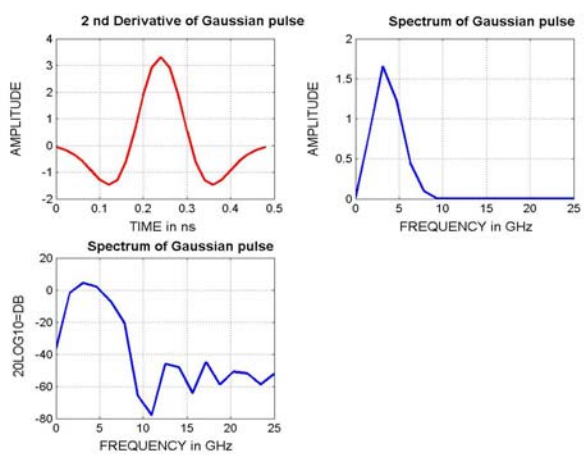

Fig 1. A second derivative of Gaussian Pulse

The paper is organized as follows.

Section II gives insights into UWB channel model. Section III gives analytical formulation of TH-2PPM UWB and TH-BPSK UWB. Section IV presents rake receiver and channel delay estimation analysis for UWB SV Channel model. Section V concludes the work done in this paper.

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II. UWB Channel

The IEEE UWB channel model is based on the SV (Saleh–Valenzuela) model, where multipath components arrive in clusters. This multipath channel can be expressed as [1]

$$h(t) = X \sum_{l=0}^{L} \sum_{k=0}^{K} \alpha_{k,l} \delta(t - T_l - \tau_{k,l}) \tag{1}$$

where the real-valued multipath gain is defined by $\alpha_{k,l}$ for cluster L and ray K. There are four different models, CM1, CM2, CM3 and CM4, for different channel characteristics.

This paper assesses the performance of rake receiver using SV channel model-1, which gives Line of sight communication, over the distance of 0 to 4 meters. The impulse response of SV channel- 1 is shown in fig 2 [3].

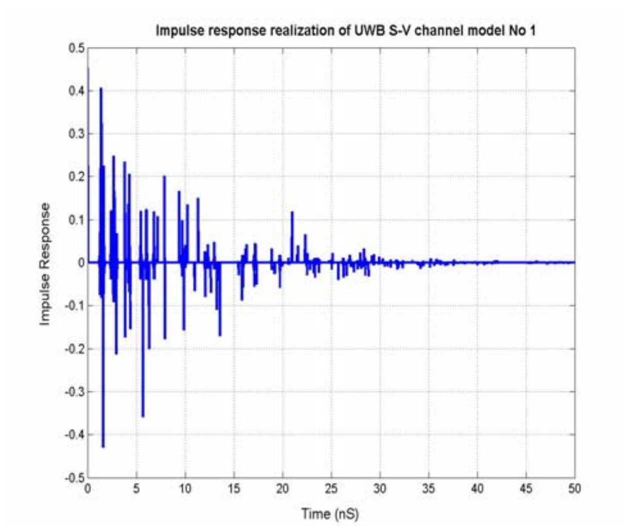

Fig 2 Impulse response of SV channel model 1

III. TH-PPM AND TH-BPSK UWB

Commonly used modulation techniques in Impulse Radio are Pulse Position Modulation (PPM) and Pulse Amplitude Modulation (PAM). In addition to modulation, in order to change the shape of the spectrum, data symbols are encoded using pseudorandom (PN) codes introducing time delay in generated pulses, which leads to Time-Hopping UWB. Bit sequence generated by binary source is repeated by repetition code block by Ns times to provide Ns number pulses per bit. In this simulation Ns=1 and 4. Transmitter coder generates random time hopping code with cardinality Nh=3 and Np=Ns = periodicity. Binary PPM modulator introduces time shift of δ_{ppm}=0.5 nsec. In a TH scheme, the symbol duration Ts is split into N frames with 1 pulse per frame. Within each frame, the pulse can take M equi-probable positions. This signal has the same spectrum as a M-PPM signal with the same PRF and uncorrelated modulated data. [3]. Fig. 3 shows TH-PPM waveform for bits 0 and 1 with 1 frame/symbol.

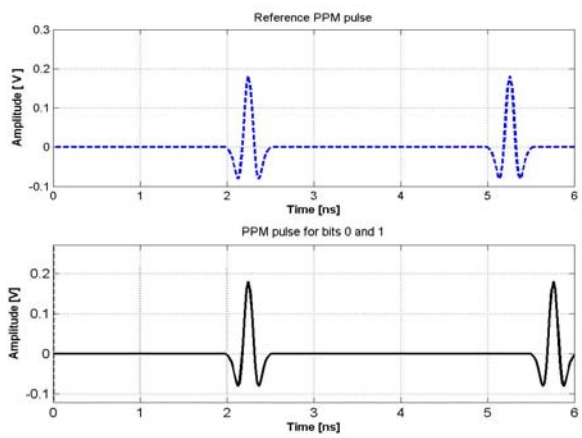

Fig 3 Transmitted TH-PPM pulses for bits 0and 1

Basic Gaussian pulse is described by the following expression [3].

$$p(t) = \pm \frac{1}{\sqrt{2\pi r^2}} e^{\frac{r^2}{2\sigma^2}} = \pm \frac{\sqrt{2}}{\alpha} e^{\frac{\pi 2 r^2}{\alpha^2}} \qquad (2)$$

$$\alpha = \sqrt{4\pi\sigma^2}$$

Considering pulse width = Tm= 0.5ns, chip time = Tc= 1ns, k=bit 0 or 1, Cj = Time hopping code (e.g. 0,1,2 etc), N= number of frames/symbol then TH-PPM signal is given by

$$S_k(t) = \sum_{j=o}^{N} p(t - j*Tc*Nh - Cj*Tc - k\delta_{ppm}) \qquad (3)$$

To transmit bit '0', S_0 (t) is transmitted (δ_{ppm} = 0 i.e. k = 0)

$$S_0(t) = \sum_{j=o}^{N} p(t - j*Tc*Nh - Cj*Tc) \qquad (4)$$

To transmit bit '1', S_1 (t) is transmitted (δ_{ppm} = 0.5ns i.e. k=1)

$$S_1(t) = \sum_{j=o}^{N} p(t - j*Tc*Nh - Cj*Tc - \delta_{ppm}) \qquad (5)$$

For TH-BPSK, instead of δ_{ppm} shift, transmitted signal is multiplied by b (t) = ±1 for bits '0' or '1'. Fig 4 shows TH-BPSK waveform for bits 0 and 1.

$$S_k(t) = b(t) * \sum_{j=o}^{N} p(t - j*Tc*Nh - CjTc) \qquad (6)$$

$$S_k(t) = \pm \sum_{j=o}^{N} p(t - j*Tc*Nh - Cj*Tc) \qquad (7)$$

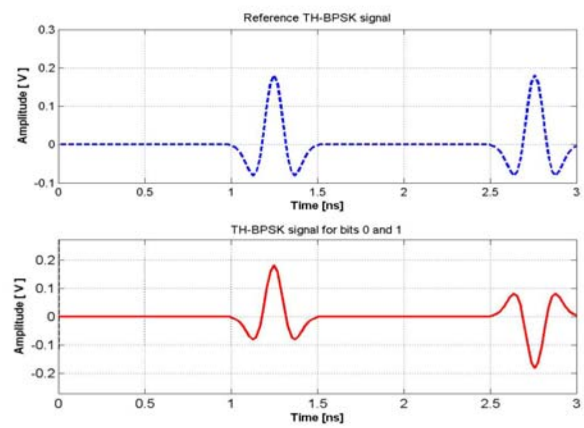

Fig 4 Transmitted TH-BPSK pulses for bits 0and 1

IV. RAKE RECEIVER AND DELAY ESTIMATION

Very wide bandwidth of short duration UWB pulse resolves several multipath components. The average total received energy is distributed between numbers of multipath arrivals. In order to capture this energy, the rake receiver with multiple arms, one for each resolvable path is used [4]. Fig 5 shows delay estimation for two multipaths using SV channel. In this simulation 1 and 2 finger rake performance is studied for TH-PPM and TH-BPSK techniques. The required delay, by the RAKE is estimated using sliding window approach, by stepping through the delays in intervals of 20 psec. Fig 6 shows BER performance for comparing hard/soft decision at the TH-PPM receiver It also shows that using more number of pulses per bit, improves BER. Fig 7 shows BER performance curve of TH-PPM, for rake with fingers 1, 2 and 3, for 1000 transmitted bits. Figs 8 compare the BER performance of TH-PPM and TH-BPSK

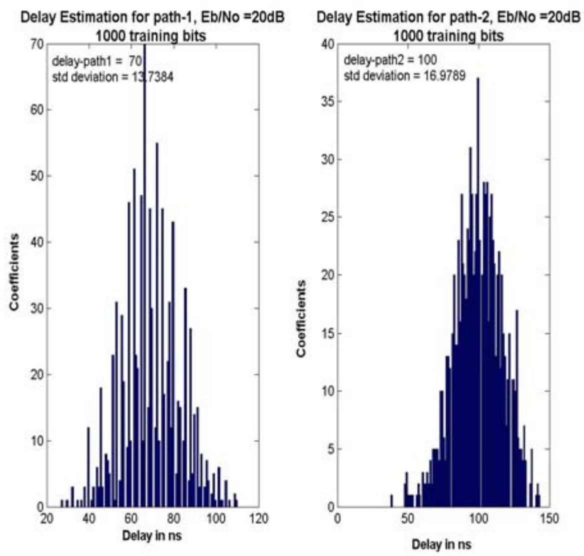

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Fig 5 Channel delay estimation for SNR (EB/No) = 20dB

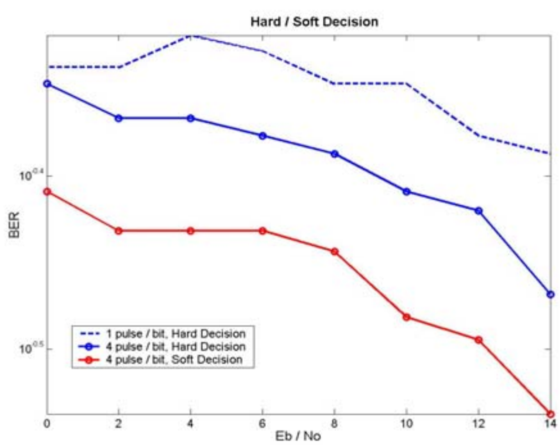

Fig 6 BER with 1 and 4 pulses per bit with hard and soft decision

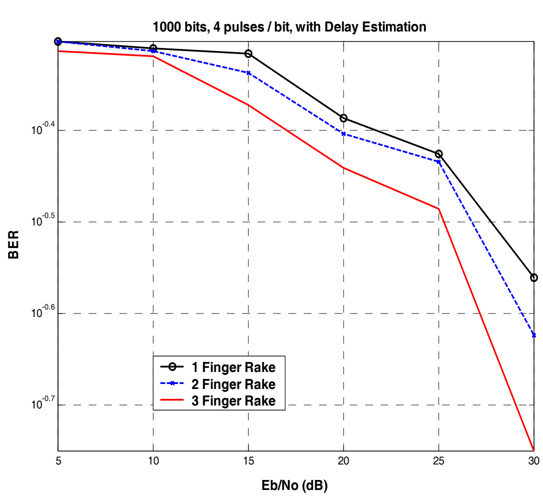

Fig 7 BER for Transmitted bits =1000, with 4 pulses per bit

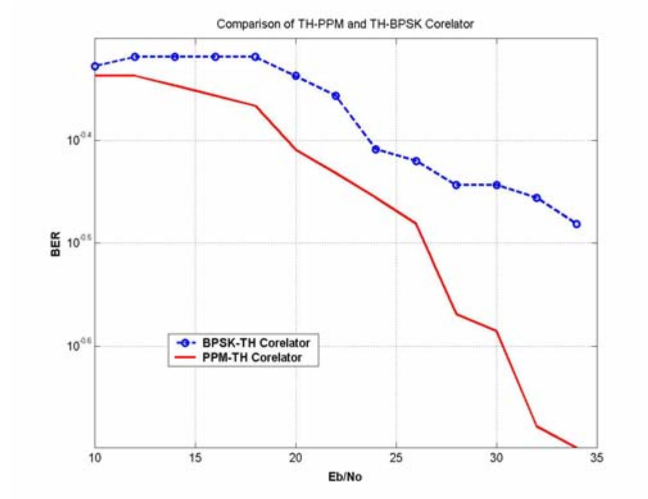

Fig 8 BER for TH-BPSK and TH_PPM using correlator

V. CONCLUSION

The following conclusions are drawn from this study:

- With max of 3 fingers, rake receiver performance was optimum giving BER of approx 1 e–3, for TH-PPM modulation.
- Soft decision and using more No of pulses per bit, improves BER
- The estimation of channel delay improved with the number of training bits and Eb/No.
- TH-PPM performs better than TH_BPSK giving less bit error rate.

VI. REFERENCES

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VII. BIOGRAPHIES

Joanne Gomes was born in Sangli district of Maharashtra, India on June 16, 1966. She graduated in engineering from PVP Institute of Technology, Sangli, and studied her masters in engineering at the University of Mumbai. Her employment experience included the industries such as ACE Electronics, Emmanuel Electronics, Mumbai and an academic institute, St. Francis Institute of Technology, Mumbai. Her special fields of interest included embedded systems and wireless networking.