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Ultra Wideband PAM Modulation and Reception in UWB Multi Path channel Using Rake Configurations

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***Abstract*:** Ultra-wideband (UWB) employs very narrow band pulses of nano-seconds duration to provide high data rate communications. Pulses spread the energy over a wide frequency because of that it is called ultra-wideband. Ultra wideband (UWB) technology is very useful for both communication and sensing applications, uses the radio spectrum differently than the majority of radio communication technologies. In this paper, we will discuss the brief introduction of UWB communication, its transmission and reception using rake receiver configurations in IEEE UWB multipath Channel. All the required simulations are carried out using MATLAB software.

Keywords* — *UWB, PAM-DS, ISI, MRC.

I. Introduction

UWB transmission is a signal, that occupies a bandwidth of more than 25% of a center frequency, or more than 1.5GHz greater The basic element in UWB radio technology is the use of Gaussian monocycle as shown in figure 1. in both time and frequency.

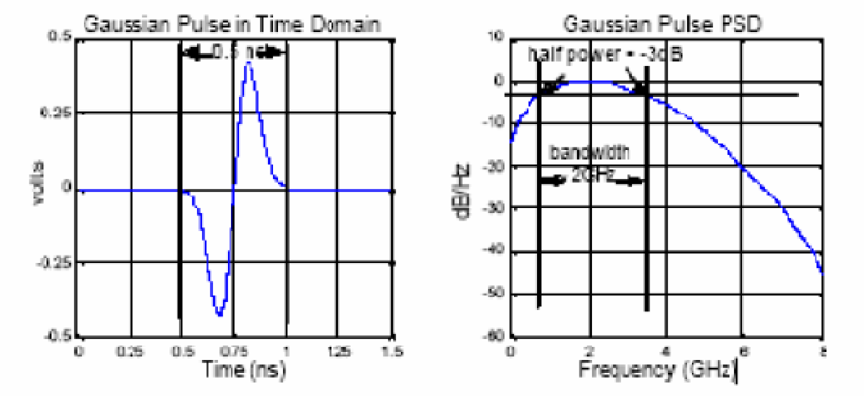


Fig.1.UWB bandwidth in time & frequency domain

UWB signals may be generated by a great variety of methods and the most popular pulse shape for UWB communication system is the Gaussian pulse or a derivative of the Gaussian pulse due ease of generation. So my present work starts with generating the UWB signal by using the Gaussian pulse 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 [4][5].

II. UWB transmiter

In this paper we will consider the design considerations of UWB transmitter using Pulse Amplitude Modulation Direct Sequence (PAM-DS) multiple access modulation scheme. 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.

A binary sequence is generated at the same rate, $R_b = 1/T_b$ and the first part of the system is a repetition coder which repeats each bit Ns times and generates a new binary bit sequence a at a rate of $R_{cb} = N_s/T_b = 1/T_s$ bits/s. Redundancy is also introduced in this way. The next step is the binary series part of the system where the sequence a+ is transformed into a which is composed of binary antipodal symbols (±1). code c consisting of (±1)'s and with period N_p to the sequence a. A new sequence d=a*c is generated, consisting of dj = ajcj .

Sequence d then enters the PAM-modulator where a sequence of Dirac pulses positioned at j T_s is generated at a rate $R_p = N_s/T_b = 1/T_s$.

The pulses enters the pulse shaper as the shapers main task is making sure that the output is a sequence of strictly non-overlapping pulses

The signal at the output of the PAM-DS transmitter is represented as

$$s(t) = \sum_{j=-\infty}^{+\infty} d_j\, p(t - jT_S) \quad (2)$$

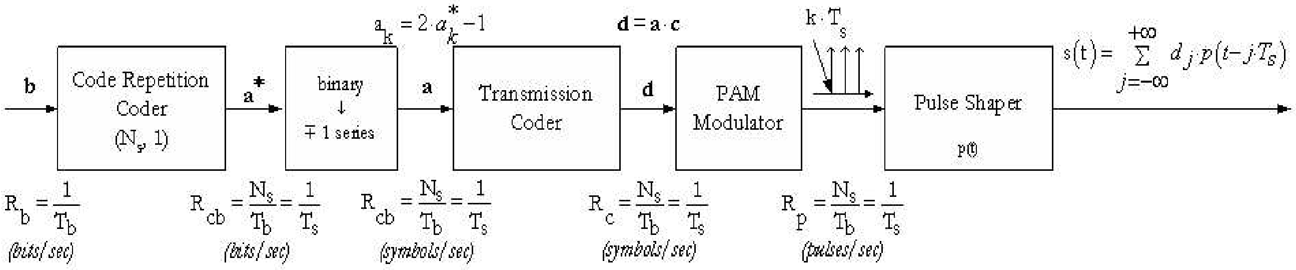


Fig.2. PAM-DS-UWB Transmitter

The above described model is created using MATLAB software and the transmitted signal is generated using PAM-DS multiple access modulation scheme using the following parameters

(Pw=30,fc=50e9,numbits=3,Ts=3e9,Ns=5,Tc=1e-9).

where Pw = Average transmitted power (dBm), fc = sampling frequency, numbits = number of bits generated by the source ,Ts = frame time, pulse repetition period , Ns = number of pulses per bit.

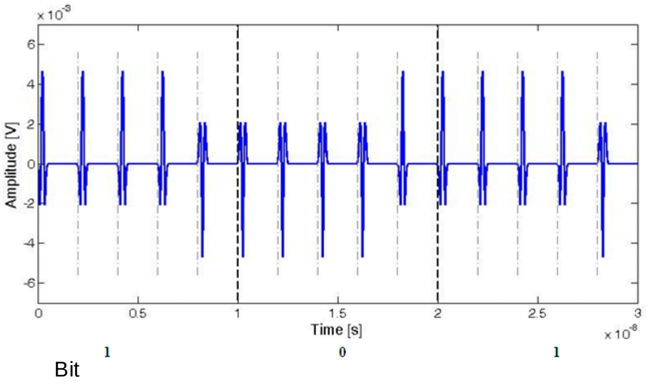


Fig.3.UWB PAM-DS after modulation with time shift of 0.5e-9 s.

III. IEEE UWB Multipath Channel Model

The signal transmitted by the transmitter reaches the receiver via the channel. The channel affects the signal by attenuating it, delaying it and distorting it. The UWB signals have a very large bandwidth in the order of 500MHz and the signals constitute of pulses. The traditional channel models do not work for the UWB signals as they assume the attenuation due to materials and other propagation effects to be constant over the bandwidth.

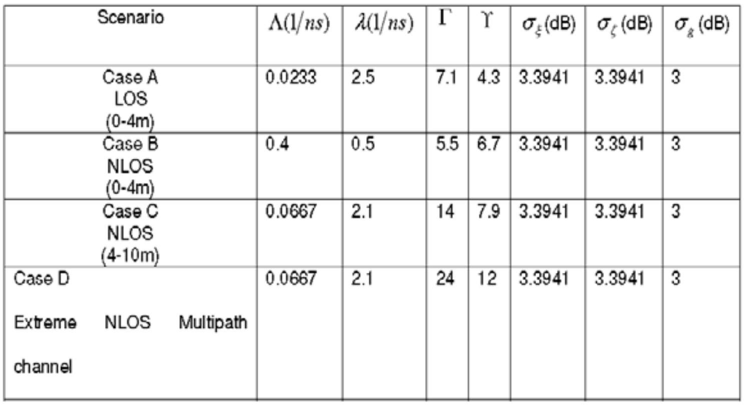
AS UWB signals have a very large bandwidth the effects are not constant over the entire band. In UWB signals, each pulse may go through distortion in addition to the distortion in the total received signal.

Also it has the presence of multiple paths between transmitter and receiver which introduces complexity at both channel model and receiver structure**.** The channel exhibits time-varying properties that must be taken into account into the channel model. Distortion is also present for indoor transmissions where propagation is perturbed by a number of interfering objects.

IEEE 802.15.3a proposed a UWB multipath channel model. The multipath components arrive at the receiver in groups, called clusters, with Poisson distribution. The path (ray) within each cluster also arrives with Poisson distribution.[6] The channel impulse response is given by:

$$h(t) = X \sum_{l-1}^{L} \sum_{n-1}^{M} \alpha_{nl} \; \delta(t - T_l - \tau_{nl}) \quad (4)$$

where L is number of clusters, M is number of paths within a cluster, α_{nl} is the multipath gain of the nth path corresponding to *l*th cluster. T_l is delay of *l* th cluster and τ_{nl} is the time delay of nth ray of the *l*th cluster. The amplitude fading is defined as $\alpha_{nl} = P_{nl}.\epsilon_l \beta_{nl}$, where P_{nl} is the sign of the coefficient and takes 1 with equal probability and accounts for signal inversions due to reflections. ϵ_l is the fading associated with the *l*th cluster. β_{nl} , is the fading associated with the nth ray of the *l*th cluster. Using this model IEEE came up with initial set of values for different environmental scenarios. The list is as shown in the table below.



Scenario	$\Lambda(1/ns)$	$\lambda(1/ns)$	Γ	Υ	σ_ξ (dB)	σ_ζ (dB)	σ_g (dB)
Case A LOS (0-4m)	0.0233	2.5	7.1	4.3	3.3941	3.3941	3
Case B NLOS (0-4m)	0.4	0.5	5.5	6.7	3.3941	3.3941	3
Case C NLOS (4-10m)	0.0667	2.1	14	7.9	3.3941	3.3941	3
Case D Extreme NLOS Multipath channel	0.0667	2.1	24	12	3.3941	3.3941	3

Table1. IEEE UWB Channel model parameters

IV. UWB Receiver

The primary task of a receiver is to collect the received signal which is an attenuated, distorted and delayed version of the transmitted signal, and decode the useful signal from it. The UWB signal is composed of non-overlapping pulses with each pulse having a specific pulse duration within a given time interval. However, the channel can affect the transmitted signal introducing varying delays and thus causing inter-symbol interference. The multi-paths will also result in delayed replicas of the signal causing ISI. Moreover, when we consider the case of multiple users transmitting at the same time, the signal of one user can be interference to that of other user [3].

The multi-path delayed and attenuated versions of the transmitted signals can be efficiently separated at the receiver and then combined in order to improve the signal-to-noise ratio with the help of a RAKE receiver that collects the delayed versions of the original signal by providing each of multi-path signals a separate correlation receiver.

The RAKE receiver consists of a correlator, which converts the received signal into set of decision variables, $\{Z\}$ and detector makes a decision on which signal is transmitted based on the decision variable. The transmitter sends M different waveforms $Sm(t)$ with m=0,1…,M-1.The received signal is cross-correlated with the M possible transmitted waveforms and the maximum over the M resulting values is selected as the transmitted signal.The received signal can be represented as

$$r(t) = r_u(t) + n(t) \qquad (5)$$

where, $r_u(t)$ is the useful signal at the receiver and $n(t)$ is additive noise assumed to be Gaussian process with PSD /2

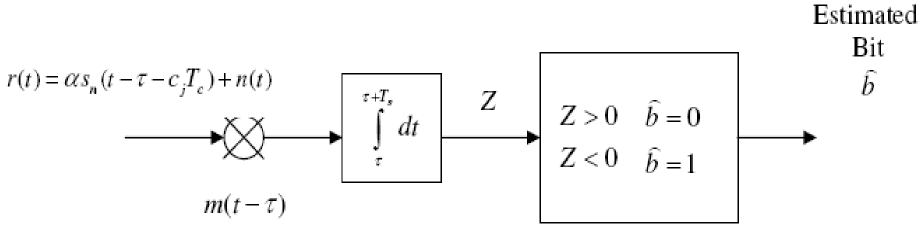


Fig.4. Single correlator scheme for 2PAM-TH-UWB Receiver.

V. Receiver Configurations

The different replicas of the transmitted pulse are combined using the Maximum Ratio Combining (MRC) in which weighting factors are applied to the different contributions to maximize the SNR.The typical RAKE receiver configurations considered in this section are the Ideal or All RAKE, Selective RAKE and Partial RAKE. All RAKE (ARAKE) collect the energy of signal from all the resolvable multi-path contributions, the Selective RAKE (SRAKE) combines the best paths out of L paths and PRAKE on the other hand combines the first arriving paths without making any selection decisions on the incoming multi-path contributions using Maximal Ratio Combining (MRC).

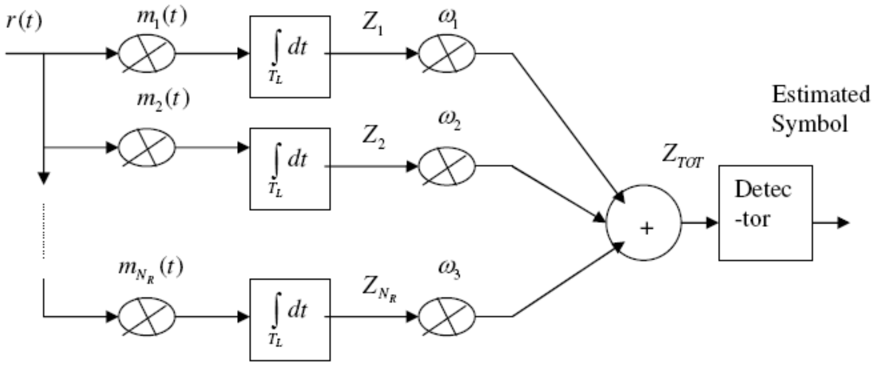


Fig.4. RAKE Receiver with parallel correlators

The transmitter, channel model and the receiver are simulated using MATLAB. The modulation scheme used is binary pulse amplitude modulation and the results achieved for code repetition of 3 with 2 branches for the Ideal, Selective and the Partial RAKE receivers.

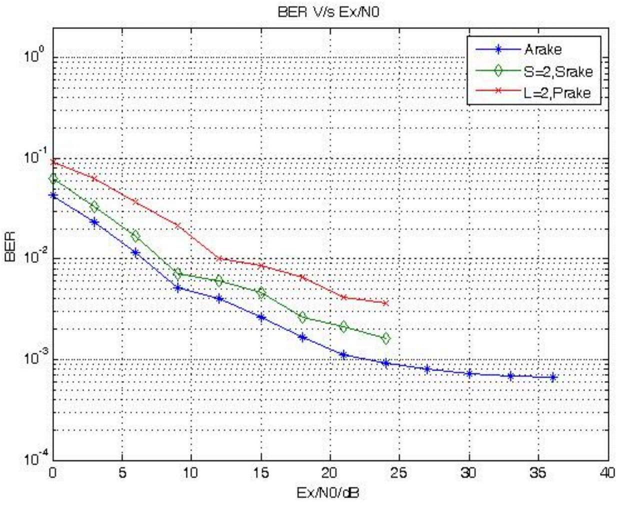


Fig.5. Analysis of 2PAM-DS-UWB for Ns = 3 with 2 Branches

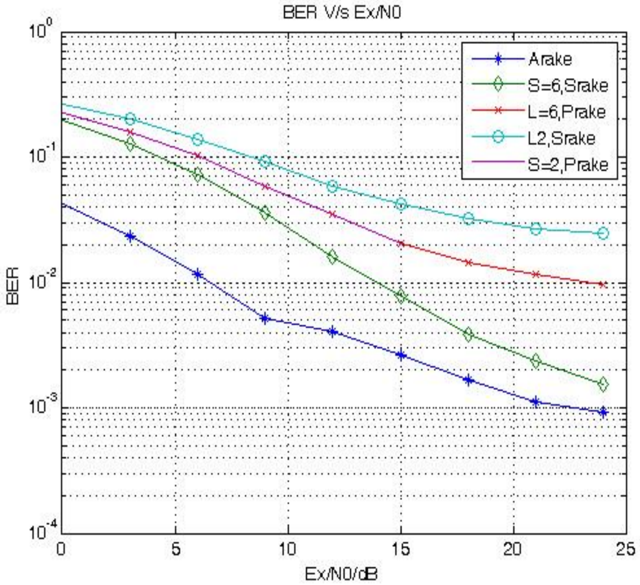


Fig.6. Analysis of 2PAM-DS-UWB for Ns = 3 with 2and 6 Branches

VI. Conclusion

In this paper all the basics of UWB modulation transmission and reception are explained in the presence of UWB multi path channel model .We have generated the 2PAM-UWB transmitter modulation pulses and the 2PAM-UWB receiver using rake receiver configurations. The results obtained for the rake receiver configurations shows that The Ideal RAKE Receiver gives the best results since it processes all the multi-path contributions resolved at the receiver but difficult to be implemented practically. While PRAKE is easy to implement but shows lower performance as compared to SRAKE and Ideal one. The PRAKE with 6 branches gives results similar to SRAKE with 2 branches. So depending upon the requirement and taking into account the cost of implementation the rake configuration can be chosen.

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] Hao Zhang, “Performance and Capacity of PAM and PPM UWB Time-Hopping Multiple Access Communications with Receive Diversity” *Department of Electrical & Computer Engineering*, University of Victoria, BC, Canada V8W 3P6,2005.

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

[5] 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

[6] J. R. Foerster (2005), “The effects of multipath interference on the performance of UWB systems in an indoor wireless channel,”in *Proc. IEEE 53rd Vehicular Technology Conference(VTC ’05)*, Rhodes, Greece ,vol. 2, pp. 1176–1180.

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

[8] T. Rappaport, “Wireless Communications Principles and Practice”, Pearson Education, 2nd ed., 2004.

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