ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology
(IJARTET) Vol. 8, Issue 4, April 2021

Experimental Analysis on Base Band Digital Signal by using SWT for Removal of Wavelet Noise

T.Thivagar[1], N.Nagalakshmi[2]
Assistant Professor, Department of Electronics and Communication Engineering , Arasu Engineering College, Kumbakonam, India [1]
Assistant Professor, Department of Electronics and Communication Engineering , Arasu Engineering College, Kumbakonam, India [2]

Abstract: The article establishes a set of research indicates the removal of the wavelet noise in baseband digital signals using SWT. In order to enhance the performance of correlation process in the time domain by using non- linear filtering technique especially in wavelet domain. The expected outcome is to enumerate the cross correlation between coefficients of the received signals in filtered wavelet system with respect to the input digital signals. The simulations occurred by comparing the wavelet received signals to the optimum receiver signals.

Keywords: Stationary Wavelet Transformation, Pulse Amplitude Modulation, Wavelet Domain Matched Filter.

I. INTRODUCTION

Now-a –days, Digital baseband transmission systems which plays an important role in various communication systems such as telecommunication, communication networks, mobile communication, optical communication etc., The characteristic features of these systems are detailed extensively in the literature[1-2].Communication system generally suffers from the line noise and inters symbol interference. In order to rectify these issues by using pulse shaping and matched filter detection inthe transmitted pulses. This research describes the usage of wavelet decomposition and non-linear filtering techniques for the detection of base band digital signals.

The cross-correlation in wavelet domain can be achieved by using DWT coefficients [2].By applying the wavelet based de-noising approach to the receiver signal which provides the enhanced performance with additive White Gaussian Noise.

The paper which includes the following chapters. Chapter II which gives the description of generation and detection of the baseband signals. The chapter III which explains the discrete wavelet transform and wavelet filtering techniques. The chapter IV describes implementation of wavelet in receiver domain chapter V includes the simulation by using MATLAB and its results and chapter VI explains the conclusion and future work.

II. BASEBAND COMMUNICATION SYSTEM

The baseband communication systems which compromises of transmission of binary data in the form of pulses. Pulse amplitude modulator maps binary data into analog waveform which varies only in amplitude the mathematical description for PAM signals can be expressed as

$$X_{PAM}(t) = \sum_{K=0}^{\infty} a_k g(t - KT) \quad (1)$$

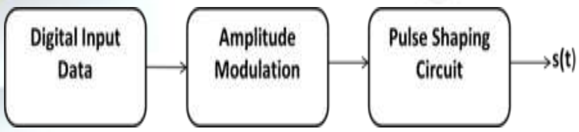


Fig.1. Block diagram of PAM signal generation

From equation (1) $a_k$is signal amplitude and denotes the sequence of transmitted information symbols from the source. The notation $g(t)$represents the shape of the pulses which may be selected in order to control the spectral characteristics 'T' is the time. Fig.1 shows the process of PAM signal generation. If uncorrelated information is occurs, then the power spectrum for PAM signal is given by

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology
(IJARTET) Vol. 8, Issue 4, April 2021

$$X_{PAM}(f) = \frac{\sigma_a^2}{T}|G(f)|^2 \qquad (2)$$

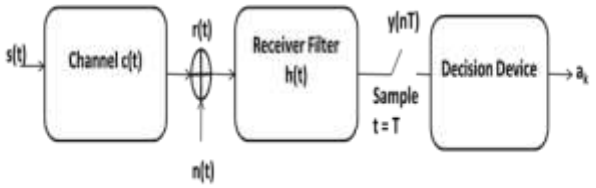


Fig.2. Block diagram of PAM signal reception

Here the $X_{PAM} = \frac{\sigma_a^2}{T}$ when the power spectrum of the uncorrelated information and G(f) is the spectrum of pulse train g(t). Fig.2 represents the block diagram of PAM signal in receiver mode. The transmitted PAM signal $x_{PAM}(t)$ is transmitted through the baseband channel, it can be described by a c(f). Then the received signal can be characterized by

$$r(t) = \sum_{K=0}^{\infty} a_k h(t - KT + \omega(t)) \qquad (3)$$

The term h (t) denotes the convolution between the pulse shape and impulse response of the channel that is h(t)= g(t)* c(t) and ϖ(t) represents the additive noise in the baseband channel. Generally, the filter at receiver and is matched to received signal pulse. Hence the output becomes,

$$y(t) = \sum_{K=0}^{\infty} a_k m(t - KT) + y(t) \qquad (4)$$

Here m (t) denotes the signal pulse of the filter in the receiver end and v(t) is response of the filter to additive noise ϖ(t). Equation (4) can be modified with samples at nT to the Threshold detector. The input for the threshold detector is given by

$$y(nT) = \sum_{K=0}^{\infty} a_k\, m(nT - KT) + (nT) \qquad (5)$$

Assuming the coefficient m(o)=1, Equation (5) may be written as

$$y = a_n + \sum_{K=0}^{\infty} a_k\, p(nT - KT) + \omega(nT) \quad (6)$$

The term a_n denotes the desired information symbol at the k^{th} sampling symbol. The remaining terms in the summation part defines interference in the band limited channel. The amount of noise and intersymbol interference leads to cross in the threshold detector. By using filter at both transmitter and receiver side to reduce these effects. For the zero ISI condition, the receiver for bandlimited channel which behaves as correlator (or) matched filter. By characteristics feature of this receiver, [5, 6, 7, 8] the matched filter has an impulse response

$$h(t) = s(T - t), 0 \le t \le T \qquad (7)$$

In absence of intersymbol interference, the sampled received signal at the output of the optimum matched filter can be expressed as

$$y(m) = x_0 a_m + V_m \qquad (8)$$

where

$$x_0 = \int_{-\varpi}^{\varpi} \left|G_{T\,(f)}\right|^2 df = \mathcal{E}_g$$

and Vm represents the additive Gaussion noise with zero mean and variance of $\sigma_v^2 = \mathcal{E}_g No/2$. The probability of bit error for digital PAM in a band limited, additive white Gaussian noise channel in absence of ISI is obtained from following expression [8].

$$P_M = \frac{2(M-1)}{M} Q\left(\sqrt{\frac{2\mathcal{E}_g}{N_o}}\right) \qquad (9)$$

Taking energy of the signal, $\mathcal{E}_g = \frac{\mathcal{E}_{av}}{(M^2-1)}$ $\mathcal{E}_{av} = K\mathcal{E}_{bav}$ is average energy per symbol and $\mathcal{E}_{bav}$ is average energy per bit.

$$P_e = Q\left(\sqrt{\frac{2\mathcal{E}_g}{N_o}}\right) \qquad (10)$$

The above equation shows that probability of error at the threshold detector depends upon the signal to noise ratio, not depends on the characteristics of noise and transmitted signal the function of Q is given by

$$Q(x) = 1/\sqrt{2\pi} \int_x^{\infty} e^{u^2/2} du \qquad (11)$$

The function 'Q' is inversely proportional to its argument for a average signal energy, if noise level increases which leads to higher probability of error in PAM signal. To reduce/minimize the ISI in the band limited channel, the pulse shape is chosen to establish fast roll off of the frequency response. According raised cosine spectrum, the pulse shape in the time domain is represented by

$$g(t) = \frac{\sin \pi t/T}{\frac{\pi t}{T}} \cdot \frac{\cos 2\pi t/T}{\frac{(1-4\alpha^2 t^2)}{T^2}} \qquad (12)$$

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology
(IJARTET) Vol. 8, Issue 4, April 2021

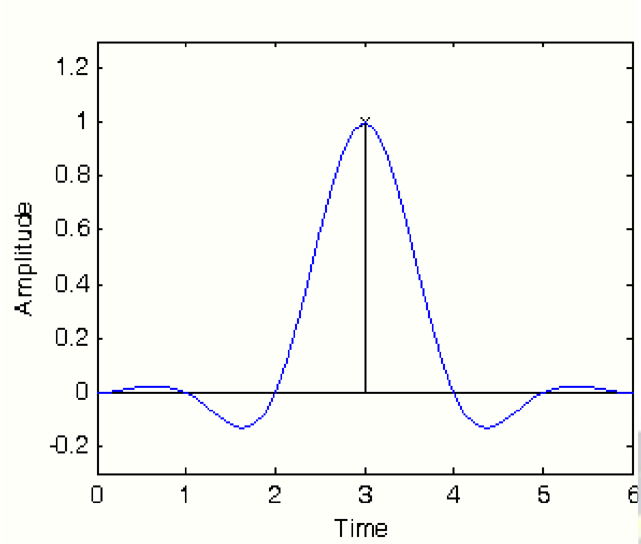


Fig.3. Graphical representation of Raised cosine pulse in the time domain

The parameter such as '∞' ,0< ∞ < 1 is the roll- off factor. By this factor, controls the bandwidth of the pulse. The raised cosine pulse in the time domain which is shown in fig 3. The filter at receiver end must be matched to the pulse shape of the signal.

III. WAVELET ANALYSIS

A. The Discrete Wavelet Transform:

The discrete wavelet transform of a given sequence can be expressed as [10].

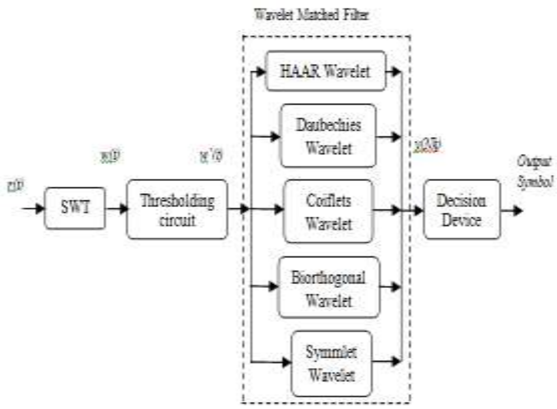
$$W(a,b)= \sum_n \frac{1}{\sqrt{a}} x(n)\ \varphi * \frac{(n-b)}{a} \quad (13)$$

The notation 'a' denotes the scale factor and it is represented in the form, $a=a_o^J$ for J=0, 1,2,…. The Notation 'b' denotes the translation in discrete time. The function of wavelet $\varphi_{ab}(n) = \varphi\{\frac{(n-b)}{a}\}$ is enlarged in time domain when value of 'J' increases.The bandwidth of the discrete wavelet transform is always half of the preceding measurement at every successive scale. According Nyquist's rule, the signals can be sample at half the rate. Hence the value of the parameter 'b' can be reduced to $b=k.2^J$. The value of 'k' must be an integer. Due to change in value of 'b' the output of DWT loads to change by a factor of two at every successive scale. These variation of 'a' and 'b' which loads to produce the decimated DWT that must be an orthogonal and time variant [10].

In order to represent the data in the wavelet domain, disintegrating the set of 'N' data values by the DWT output in the matrix of N co-efficient. By using these matrix, reconstruct the original input from the corresponding wavelet function. If the co-efficient is large, it represents the better correlation of input with respect to wavelet decomposition. On another hand, the co-efficient is small which represents the poor correlation of input with the wavelet decomposition. The wavelet co-efficient can be represented by

$$W(k)= (w_1,w_2,\ldots.w_N) \quad (14)$$

Fig.4.Wavelet Domain Matched Filter (WMF)



receiver using wavelet filters – Block Diagram.

The threshold is define as

$$T_u=\sigma\sqrt{2\log(N)} \quad (15)$$

Here σ is the standard noise deviation and 'N' denotes the number of co-efficients. In this paper, Assume N=256 and it leads the $T_u$value is also large. Because universal threshold method is suitable for the very large 'N'. Two popular methods of threshold namely(soft and hard) are used to calculate the threshold level with respect to coefficients of the decomposition. Hard threshold method, fix all the co- efficient below the threshold value to zero and keep the resulting co-efficient by the threshold value. In this article, proposed matched filter using the hard thresholding in order to produce better performance.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology
(IJARTET) Vol. 8, Issue 4, April 2021

IV. FILTERING OF WAVELET COEFFICIENTS

The wavelet noise removal technique can be specified by following steps: (1) Data transform from DWT into wavelet domain. (2) Applying Non-linear threshold to the coefficients of DWT (3) Finally perform the inverse wavelet transform on these DWTcoefficients. As the result of inverse wavelet transform, produces the filtered waveform. For the wavelet domain matched filter (WMF) does not perform the third step, rather the filtered coefficients of DWT are handled by the wavelet filter at receiver end (h(k)). These wavelet receive filter is devised as the matched filter formulated from the reversed version of wavelet coefficients w(k) of the transmitted signal xPAM (t) and it is giben by

$$H(k)=W(N-K) \qquad (16)$$

(BER) and signal-to noise ratio (SNR) for the pulse amplitude modulated signal comparing the matched filter in the time domain and wavelet domain. The implementation of wavelet matched filter using symlet 8 wavelet and hard threshold method and consider the value of threshold as σ/2. And 64 wave coefficients were implemented in the co-relation process. From the experimentation, we found that most of the energy signal of PAM was maintained in these coefficients. Simulation between the TMF receiver and WMF receiver using some noise scale. Pulse shaping filter can formed 256 samples per symbol. By using Eqn.11, PAM waveforms were generated.

Fig.5. Comparison of SNR value of five different filters for the phase noise

In each trial, randomly selected one of two polar PAM signals with additive white Gaussian noise which contributes the simulated output. More simulation trials using various occurrences of AWGN signals were conducted at SNR range from -6dB to 10dB. In order to produce better bit error rate curve, more number of trials were established. The eye diagrams of raised cosine pulse with and without the additive noise signal respectively. Compute the wavelet coefficients of the

The output of matched filter results in the correlation among the denoised wavelet coefficients and the prestored coefficient of DWT of the transmitted PAM signals.

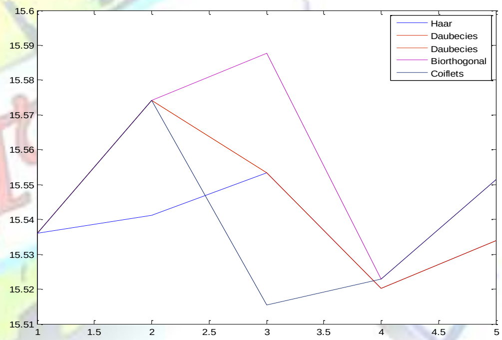
$$Y(K=N)=W'(k)*h(k) \qquad (17)$$

The block diagram of the wavelet receiver with wavelet denoising and wavelet received filter shown in fig.4

V. EXPERIMENTS AND RESULTS

The performance comparison between the time domain matched filter (TMF) receiver and the wavelet time domain matched filter using MATLAB software. This comparison was done by using Monte Carlo simulations. Fig 5 shows the bit error rate

received signals and then wavelet de-noising technique



were applied. After the completion of the wavelet filtering and then correlates with coefficients of transmitted PAM signals (from eqn.16)

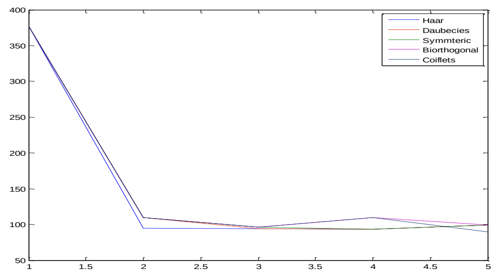


Fig.6. Comparison of SNR value of five different

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology
(IJARTET) Vol. 8, Issue 4, April 2021

filters for the burst noise

By using eqn. 2, the bit error rate was calculated and the comparison between the time domain mach filter and wavelet matched filter shown in Fig.6 from the experimental observation the performance of wavelet matched filter did not exceed the time domain matched filter(TMF) but gives improved processing speed.

VI. SUMMARY AND FUTURE WORK

This article gives the performance comparison between the wavelet based receiver to the optimum detector for the raised cosine pulses with additive White Gaussian Noise and then computing the cross correlation between the DWT coefficients of the noisy signal and that of transmitted PAM signal. The performance of the standard cross correlationof noisy signal is announced by using wavelet noise removal process. Simulation result of proposed wavelet domain matched filter receiver with classical correlations was given.Future scope of this article, consider noise source rather than AWGN and additional baseband signals to analysis the performance

REFERENCE

[1]. D. Donoho and I. Johnston, "Adapting to Unknown Smoothness via Wavelet Shrinkage," Journal of the American Statistical Association, Dec 1995, Vol.90, No. 4 32, Theory and Methods

[2]. A. Bruce, H. Gao, Wave Shrink: Shrinkage Functions and Thresholds," Technical Report,StatSci Division, MathSoft Inc., 1995

[3]. R. Barsanti, T. Smith, R. Lee, "Performance of a Wavelet-Based Receiver for BPSK and QPSK Signals in Additive White Gaussian Noise Channels, Proceedings of 39th Southeastern Symposium on System Theory, Macon, GA, 2007

[4]. R. Barsanti, E. Spencer, J. Cares, L. Parobek, "Feature Matching and Signal Wavelet Analysis", Proceedings of 38th Southeastern Symposium on System Theory, Cookville, TN, 2006

[5]. J. Proakis, M. Salehi, Contemporary Communication Systems Using Matlab®, PWS Publishing Company, Boston, MA, 1998

[6]. S. Haykin, Communication Systems, John Wileys & Sons, Inc., New York, 1994

[7]. J. Proakis, Digital Communications, McGraw-Hill, Inc., New York, 1995

[8]. J. Proakis, M. Salehi, Communication Systems Engineering, Prentice Hall Inc., New Jersey, 2002

[9]. R. McDonough, A. Whalen, Detection of Signalsin Noise, Academic Press, San Diego, Ca, 1995

[10]. V. Wickerhauser, Adapted Wavelet Analysis from Theory to Software, A.K. Peters, Ltd.,Massachu setts, 1994

[11]. D. Lee Fugal, Conceptual Wavelets in Digital Signal Processing, available at www.ConceptualWavelets.com

BIOGRAPHY

T.Thivagar is Assistant Professor of Department of Electronics and Communication Engineering at Arasu Engineering College, Kumbakonam, Tamilnadu, India. He passed BE in Electronics and Communication Engineering from Shri Angalamman college of Engineering and Technology in 2014 and M.Tech in Communication System Engineering from B.S.Abdur Rahman University in 2016

N.Nagalakshmi is Assistant Professor of Department of Electronics and Communication Engineering at Arasu Engineering College, Kumbakonam, Tamilnadu, India. She passed BE in Electronics and Communication Engineering from Arasu Engineering college in 2011 and M.Tech in Communication System Engineering from PRIST University in 2013