DWT Highlighted Concatenated Multi Band Orthogonal Frequency Division Multiplexing (MB-OFDM)-Upgraded Enactment

Avila.J[1], K.Thenmozhi[2]

[1] Assistant Professor, ECE, School of Electrical & Electronics Engineering, SASTRA University, India

[2]Associate Dean, ECE, School of Electrical & Electronics Engineering, SASTRA University, India

Abstract-This study aims at enhancing the performance of the Multiband OFDM system by implementing various techniques. As a first step the Fast Fourier Transform and Inverse Fast Fourier Transform blocks are alternated by Wavelet transform. The main advantage of wavelet transform is the need of cyclic prefix is eliminated as it takes care of Inter symbol interference (ISI) and Inter carrier interference ICI). Second it up thrusts its positions in terms of an efficient system adhering to high data rates only when the order of the wavelet families involved in the process remains conducive. In wireless system the channel being air, is prone to noise, Owing to which the output of the channel is erroneous. As a consequence the error control codes are used which targets at removing the errors from the transmitted bit. Single error control codes are not suitable for high noisy conditions and as a consequence to improve the coding gain concatenation of error control codes is preferred. This study focusses on concatenating convolutional codes with turbo codes. All these techniques enhance the performance of the Multiband OFDM system and make it more appropriate for high data rate wireless applications. In addition the system is trained using neural network .The system is trained using Back propagation algorithm.

Keywords- Multiband OFDM (MB-OFDM), Fast Fourier Transform (FFT), Wavelet Transform, Convolutional code, Turbo code, Concatenated code, Quadrature Phase shift Keying(QPSK), Neural network.

I.INTRODUCTION

In the year 2002, the Federal Communications commission announced that a wide band of frequency spectrum as unlicensed spectrum known as Ultra Wide Band (UWB). To overcome the difficulties faced in handling such a huge spectrum a new candidate named Multiband Orthogonal Frequency division Multiplexing (MB-OFDM) came into existence. Some of its salient features are supporting high data rates, consuming very less power and less silicon space[1]. All these features made it more popular. The frequency plan of UWB is as follows: the entire spectrum is split into five divisions. Each division consists of 3 sub-divisions and the last division alone has 2 sub-divisions. As a total there are 14 sub-divisions. There are 128 sub carriers. Out of 128 subcarriers 100 is allotted for data transmission, 12 subcarriers are utilized for piloting purpose, 10 subcarriers as guard tones and 6 subcarriers are employed as null tones. The subcarrier spacing is 4.125MHz.The block diagram of MB-OFDM is as shown in figure 1.

The input data sequence is first randomized by the scrambler and then encoded by the channel coder. Error control codes are mainly used to combat multipath fading in communication channels[2]. Error control codes are added to the message for reliable communication. To compensate heavy noise conditions concatenation of the error control code is done which improves the coding gain[3]. This study focusses on concatenation of convolutional code with turbo code. The encoding procedure of convolutional code is as follows. After obtaining the generator polynomial the input information sequence is applied to the encoder which consists of shift registers. The data's are encoded using the generator polynomial.The process is repeated. The encoded data is then transmitted. At the receiver side the Viterbi decoder calculates the path metrics. The process is repeated until the last stage is obtained. The tracing back process decodes the data and maximum likelihood path is used for tracing back[4,5]. Turbo Codes are based on convolutional codes. They are obtained by concatenation of convolutional codes. The concatenation can be either parallel or serial. The convolutional codes are separated by an interleaver. The message is given as input to convolutional encoder. Interleaving of the data sequence is performed. Interleaving increases the weights of the codeword. The input to the second convolutional encoder is the output of interleaver[6]. The code bits and the parity bits from both the convolutional encoders are multiplexed and given to the next stage[7]. The modified candidate of Viterbi algorithm is soft-output Viterbi algorithm (SOVA). The transmitted message is estimated by the decoder by using one of the two encoded streams in the form of log likelihood ratio.

The encoded bits are passed through an interleaver where they are interleaved by a 3 stage inter-leaver to provide robustness against burst error. The output of the interleaver is given to baseband modulator. The output of the mapper is passed to inverse fast Fourier transform (IFFT) block where they get converted to OFDM symbols by the OFDM modulator[8]. The noise assumed in this study is Additive White Gaussian noise (AWGN). At the receiver the reverse operation like demodulating, decoding is performed to get back the information sequence[9].

The contribution of this study is to implement four wavelet families namely Haar, Daubechie, Symlet and Coiflet in MB-OFDM system along with concatenated error control codes. Analysis is done with various orders of wavelet families. Finally the system is trained using neural network.

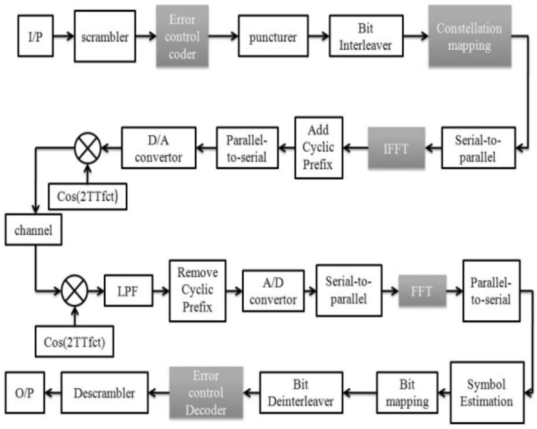

Fig. 1. Block diagram of Multiband Orthogonal frequency division multiplexing (MB-OFDM system)

II. PROPOSED METHODOLOGY

A.Wavelet Transform

The block diagram of modified Multiband OFDM is as shown in the figure 2. The IFFT and FFT blocks in the transmitter and receiver are replaced by IDWT and DWT block respectively. The wavelet transform is preferred because if offers more advantages than Fast Fourier Transform. Wavelet transform performs well on both time and frequency domains whereas Fourier transform perform on frequency domain. In addition no local information is available. Adjusting of windows based on the frequency components is possible in wavelet transform [10]. Also it has multi-resolution representation capability. All these features make wavelet transform more popular in many areas like image processing, information hiding, signal processing etc [11]. The two basic steps in DWT are filtering and scaling. First the input signal is split into two components by passing it through a low pass filter and high pass filter. High pass filter gives accurate results and low pass filter output gives approximate values. Then they passed through a decimator to improve the scaling. The process is repeated until the target is reached. Finally the coefficients are added to get the results. Haar wavelet is the simplest one in the wavelet family. It gains popularity because of its fast nature and simple structure[12]. It is two elements wide. Haar wavelet is not suited for audio applications.Daubechie wavelet is complex and expensive than Haar. They have linear frequency responses and non-linear phase response. They have the highest number of vanishing moments. They have even index D2-D20.Index represents the number of coefficients. The scaling coefficients are

$$d4 = 1 - \sqrt{3}/4\sqrt{2},\ d2 = 3 + \sqrt{3}/4\sqrt{2},\ d3 = 3 - \sqrt{3}/4\sqrt{2},\ d1 = 1 + \sqrt{3}/4\sqrt{2} \qquad (1)$$

Wavelet coefficients are obtained by reversing the order of scaling coefficients and changing the sign of the second term. The wavelet coefficients are

$$c_0 = d_3, c_1 = d_4, c_2 = d_1, c_3 = d_2 \qquad (2)$$

The scaling and wavelet functions could be obtained from the inner product of data and coefficients.Symlet wavelet transform are modified version of Daubechie. They are more symmetric and have even index number. In addition they have minimal phase[13].Coiflet wavelet is more symmetric than the above wavelets.

B. Constellation mapping

Quadrature phase shift keying is the modulation technique in which two bits make one symbol and it is modulated using any one (0,90,180,270 degree) of the carrier phase shifts. The QPSK signal is given by [14]

$$y(t) = z_0(t)\sqrt{p}\cos(2\pi f_0 t) + z_e(t)\sqrt{p}\sin(2\pi f_0 t) \quad (3)$$

$z_0(t)$ represents the odd bits

$z_e(t)$ represents the even bits

$\sqrt{p}$ is the amplitude

The probability of error is given by (4)

$$P = erfc\ \sqrt{E_b / 2N_0}$$

E_b is the energy

N_0 is the noise

$erfc$ represents the complementary error function

C. Neural networks

A neural network is an exact replica of the human brain. Brain is the interconnection of numerous basic elements called neurons. Similar to the human brain the neural network has many processing units interconnected together to bring the neuron structure. The main function of neural networks is to predict the events happened as uncertain. The structure will respond to the input given and train the system to the predefined target. There are various training algorithms to train the network. One such algorithm named Back propagation algorithm (BPN) is used in this study. As the name implies the errors are propagated backwards and it tries to minimize the error. The process is repeated until the target is reached. This is useful in places where the network doesn't have a feedback[15]

Table 1 Neural network training parameters

Parameters	Back propagation algorithm
Number of layers	3
Transfer function	Transig & logsig
Training Epoch	420
Learning rate	0.05
Training goal	10^{-4} *forencoder*, 10^{-6} *fordecoder*

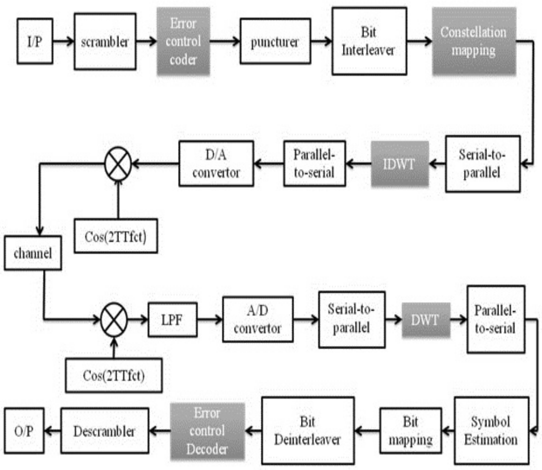

Fig. 2. Block diagram of the proposed method

III RESULTS AND DISCUSSION

In this study all the results are plotted using MATLAB. Results are concluded for the bit error rate (BER) versus Eb/N_0 curve plotted for the multiband OFDM system. First the simulation compares the coded and uncoded system.Then it compares the performance of the system by varying various parameters.

Figure 3 gives the comparison between uncoded multiband OFDM system and coded multiband OFDM system and it is clear that coded multiband OFDM yield better performance.

Figure 4 gives the concatenated output of convolutional code with Turbo code using Haar wavelet transform and Quadrature phase shift keying(QPSK). It is clear that concatenated codes give better performance. Lesser Eb/N_0 indicates that less amount of energy is spent in transmitting the data.

Figure 5 gives the concatenated output of convolutional code with Turbo code using Daubechie wavelet transform and Quadrature phase shift keying (QPSK) modulation scheme. Because of the improved coding gain it outperforms than single code.

Figure 6 gives the concatenated output of convolutional code with Turbo code using Symlet wavelet transform and Quadrature phase shift keying(QPSK). For a given BER of 10^{-2} there is a significant improvement in Eb/N_0.

Figure 7 gives the concatenated output convolutional code with Turbo code using Coiflet wavelet transform and Quadrature phase shift keying(QPSK). In all the four case concatenated output gives better performance that single code.

Figure 8 gives the output for various orders of Daubechie wavelet. It is clear that as order increases better results could be obtained. With the increase in order there is an increase in filter length which in turn increases the approximation level.

Figure 9 gives the output for various orders of Symlet waveform. As the order increases Eb/N_0 decreases.

Figure 10 shows the output for various orders of Coiflet waveform. Regularity increases with the increase in order.

Figure 11 and figure 12 gives the neural network trained encoder part and decoder part of multiband OFDM (MB-OFDM)system. Back propagation algorithm is used to train the network. It is trained for the parameters that are listed in table 1. For the encoder the target is set as 10^{-4} and for the decoder the target is set as 10^{-6}.Here the epoch is set as 420.It is a benchmark for the number of iterations. Learning rate is set as 0.05. It is a small trigger for the network to reach the goal. In this study the number of layers is fixed as 3. Greater the number of hidden layers better is the result and at the same time it takes more time to converge.The meeting point of the curve with the target concludes that the goal is reached. Once trained the system can make predictions in the future data which is helpful in making decisions at the earliest

IV CONCLUSION

In this study the performance comparison of DWT based MB-OFDM is carried out for various wavelet families. In addition the result's are plotted for various orders of the wavelet families. Increase in order yields better results. Convolutional code concatenated with turbo code is used to combat the channel noise and it is concluded that with the use of concatenated code instead of single code the error reduces which automatically improves the performance of the system. In this study QPSK modulation scheme is proposed .Proper choice of constellation mapper is necessary based on the application. All these techniques (wavelet, FEC, constellation mapper) make MB-OFDM a perfect solution for high data rates. The encoder part and decoder part of the system is trained using neural network. The system is trained using back propagation algorithm (BPN).

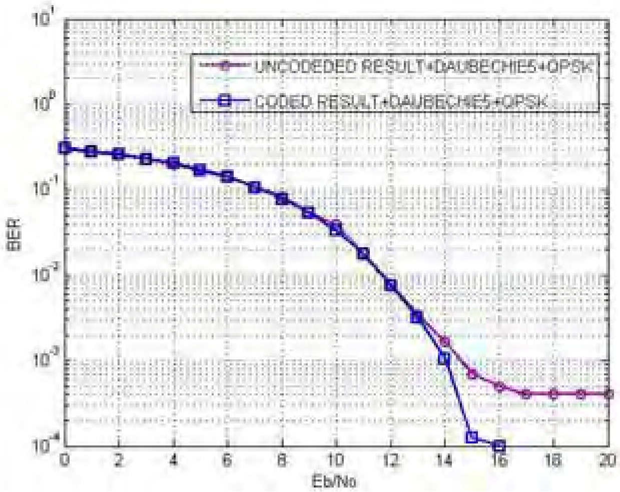

Fig. 3.Comparison between un-coded and coded system

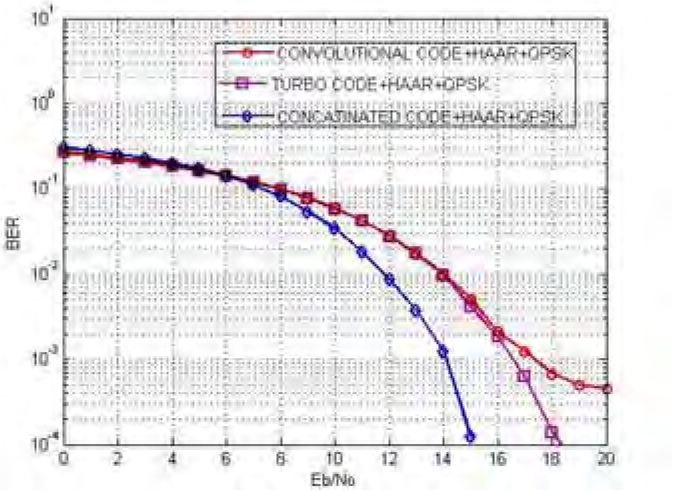

Fig. 4. Concatenated output of convolutional code and turbo code using Haar transform

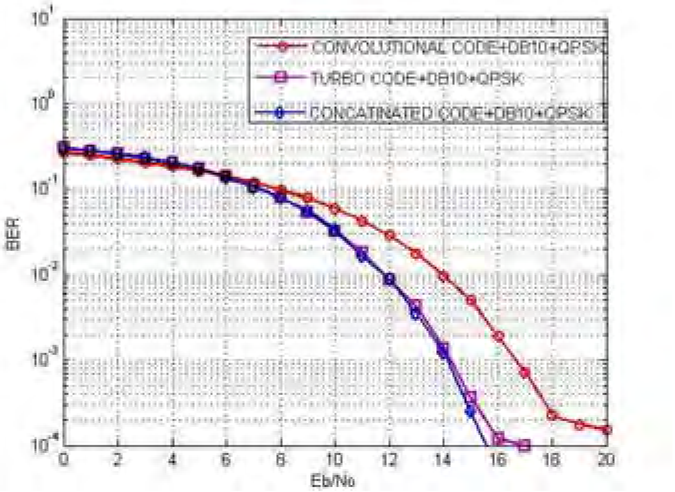

Fig. 5. Daubechie transform based Concatenation of convolutional code and turbo code

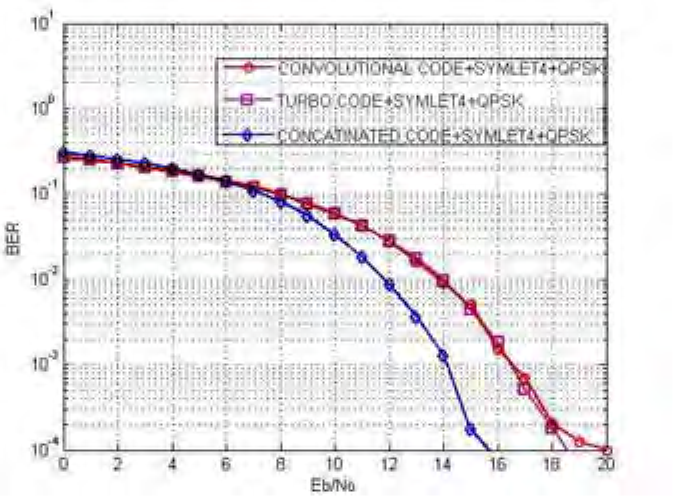

Fig. 6. Symlet transform based Convolutional code concatenated with Turbo code

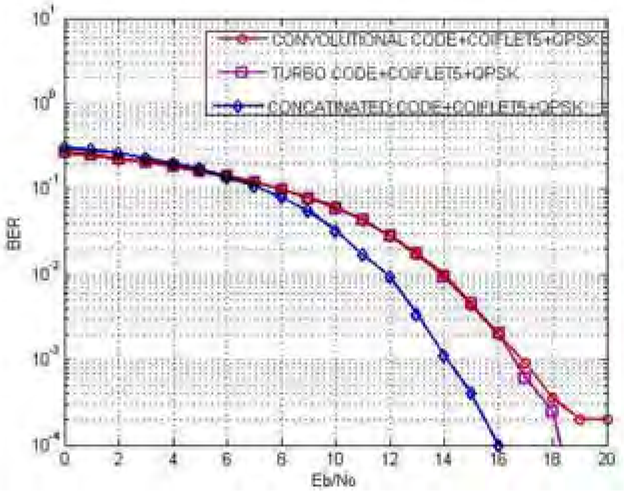

Fig .7.Concatenated output using Coiflet transform

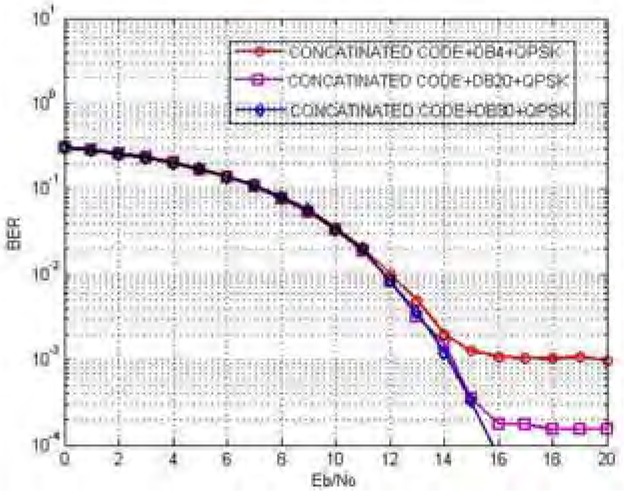

Fig. 8.Comparison of various orders of Daubechie wavelet transforms

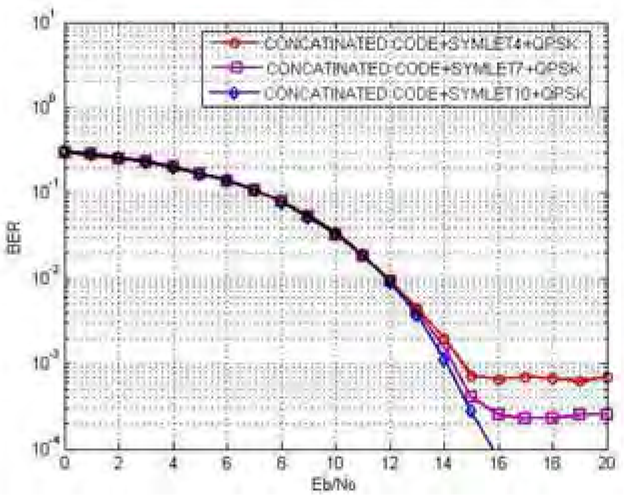

Fig. 9.Comparison of various orders of Symlet

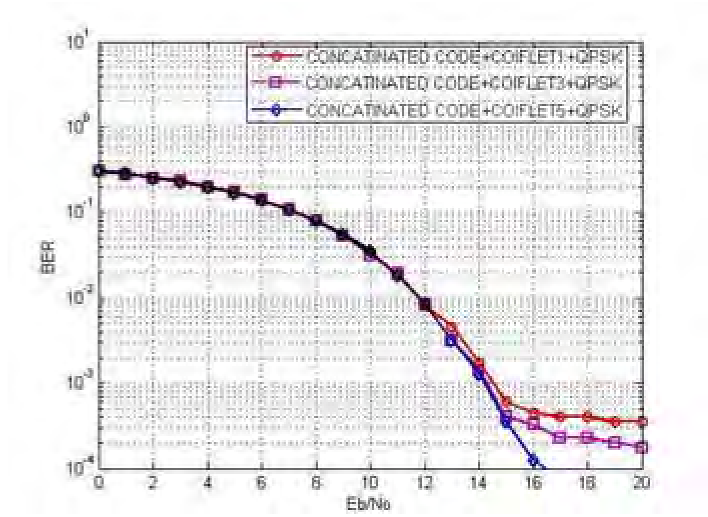

Fig. 10. Comparison of various orders of Coiflet

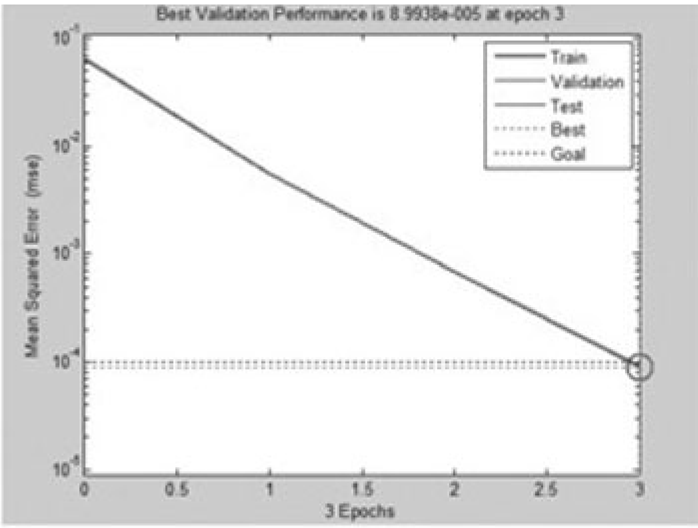

Fig.11. Artificial neural network (ANN) graph for the encoder part

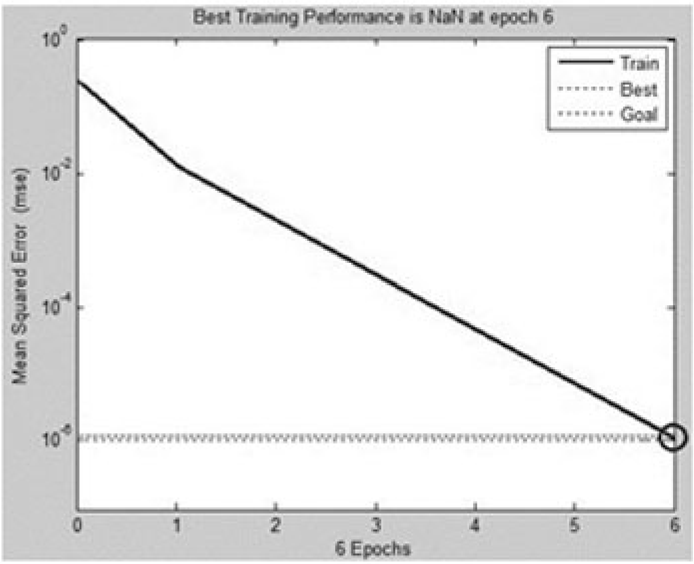

Fig .12.Artificial neural network (ANN) graph for decoder part

References

[1] Jaiganesh balakrishnan, Anuj Batra, and Anand Dabak, 2003. “A multiband OFDM system for UWB communication”. IEEE conference on ultrawide band systems and technology,November 16-19,2003, pp:354-358.DOI : 10.1109/UWBST.2003.1267863

[2] Praveenkumar, P., R. Amirtharajan, K. Thenmozhi and J.B.B. Rayappan, 2012. “Regulated OFDM-role of ECC and ANN: A review”. J. Applied Sci., 12: 301-314. DOI**:** 10.3923/jas.2012.301.314.

[3] Avila, J., E.Praveen and Brinda varadharajan,.2012. “ANN assisted-Augumentation of AIC for MIMO Multiband OFDM System”. IEEE International conference on Advances in Engineering, Science and Management, March 30-31, 2012,Nagapattinam, India, pp: 228-232.

[4] Nyirongo,N., W.Q.Malik, and D.J.Edwards 2006. “Concatenated RS-Convolutional Codes for Ultrawideband Multiband-OFDM”. IEEE International Conference on ultrawideband, September 24-27,2006,Waltham,MA ,pp:137 - 142. DOI:10.1109/ICU.2006.281529

[5] Viraktamath, S.V., and G.V.Attimarad, 2010. “Impact of constraint length on performance of convolutional CODEC in AWGN channel for image application”. International journal of Engineering, Science and technology.,2(9): 4696-4700.

[6] Stéphane Y. Le Goff ,2002.” Bandwidth-efficient turbo coding over Rayleigh fading channels”. International Journal of Communication Systems., 5(7):621-633.

[7] Vafi. S, Wysocki. T and Abolhasan.M,2009. “Serially Concatenated Turbo Codes”.Fifth International Conference on Wireless Communications, Networking and Mobile Computing (WiCOM’09), September 24-26,2009,Beijing, China, pp: 1-4. DOI:10.1109/WICOM.2009.5303570

[8] Thenmozhi, K., P. Praveenkumar, R. Amirtharajan, V. Prithiviraj, R. Varadarajan and J.B.B. Rayappan, 2012. “OFDM+CDMA+Stego = Secure Communication: A Review”. Research Journal of Information Technology, 4: 31-46.DOI**:** 10.3923/rjit.2012.31.46 . URL**:** http://scialert.net/abstract/?doi=rjit.2012.31.46

[9] Anuj Batra, Srinivas Lingam, and Jaiganesh Balakrishnan, 2006. “Multiband OFDM: A cognitive radio for UWB”. Proceedings of International symposium on circuits and system, May 21-24,2006,Island of Kos, pp:4094-4097.DOI: 10.1109/ISCAS.2006.1693529

[10] Zheng Xiaodong, Huang Xinghan and Wang Ming, 2005. “Object edge smoothing by wavelet transformation”. Information technology Journal.,4(4):451-455

[11] Sadam Alwadi, Mohd Tahir Ismail and Samsul Ariffin Abdul Karimal, 2011. “Discovering Structure breaks in Amman stocks market”. Journal of Applied science., 11(7):1237-1278.

[12] Mohamed I Mahmoud,I.M.Moawad, Salah Deyab and H.Fatma Elfouly, 2007. “Comparison between Haar and Daubechies Wavelet Transformions on FPGA Technology”.World Academy of Science, Engineering and Technology.,6(3):16-22.

[13] Mahesh S. Chavan, Nikos Mastorakis, Anjusha N. Chavan and M. S. Galkwad, 2011.”Implementation of SYMLET Wavelets to Removal of Gaussian Additive Noise from Speech Signal”. Tenth International conference on Recent Researches in Communications, Automation, Signal Processing, Nanotechnology, Astronomy and Nuclear Physics, 2011,Cambridge,U.k,pp:37-41.

[14] Bernard Sklar and Pabitra Kumar Ray, 2001. Digital communication-Fundamentals and applications, second edition, Pearson education.

[15] [15]. Avila, J., E.Vinoth and K.Thenmozhi, 2012.” Anti -Interference for anti corroupt 3G spectrum-A multi carrier approach”. IEEE International conference on computer communication and Informatics, January 10-12,2012, Coimbatore, India.,pp:478-481. **DOI:** 10.1109/ICCCI.2012.6158853