PERFORMANCE ELEVATION CRITERIA OF RS CODED OFDM TRANSMISSION OVER NOISY CHANNEL

Abhishek Katariya, Neha Jain, Amita Yadav

***Abstract*—OFDM has recently been applied widely in wireless communication system due to its high data rate transmission capability with high bandwidth efficiency. Error control codes are used to protect information from errors that can occur during transmission Reed Solomon (RS) codes is one of the most important and best known classes of non binary [5].In the present study a simulink of RS are done using single carriers transceivers, to observe the performance of RS code and choose the effective parameters that can improve OFDM system. Evaluation of Bit Error Rate (BER) performance for RS code as a function of code rate and block size are tested. This testing is applied to single carrier system with different channel model using QPSK technique. BER performance over Rayleigh channel and Rician channels are done respectively. In this paper, the system throughput of a working OFDM system has been enhanced by adding RS coding. The bit error rate (BER) performance degradation of OFDM system is investigated in different channel. We consider the effects of BER both in Rayleigh and Rician. The environment theoretical approximate calculation method is also derived of BER for binary using quaternary phase shift keying (QPSK) modulation schemes in OFDM systems. In addition, the method of BER calculation is validated by simulinks. In this paper Improvement of performance elevation criteria of RS coded OFDM TRANSMISSION over noisy channel is analyzed using simulink. The Simulink Communication tool and basic library tools are use with standard values in IEEE802.11A.**

***Keywords*— BER, OFDM, RS Code, Fading Channels, QPSK, Simulinks**

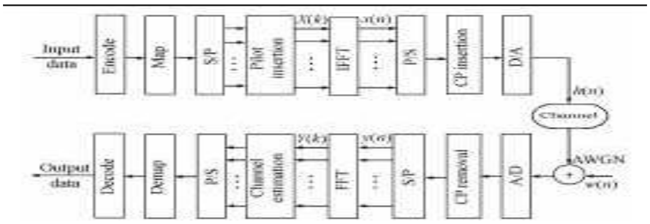
I. Introduction

Several Technologies are considered to be candidates for future applications such as orthogonal frequency division multiplexing (OFDM), which is a special from of multicarrier transmission where all the subcarriers are orthogonal to each other orthogonal frequency division multiplexing (OFDM) has become a popular modulation method in high speed wireless communications [3].

OFDM has recently been applied widely in wireless communication system due to its high data rate transmission capability with high bandwidth efficiency some of the main advantages of OFDM is that the modulation and demodulation can be done using inverse fast fourier transmission (IFFT) and fast fourier transmission (FFT) operations, which are computationally efficient. Also one other significant advantage is that its multipath delay spread tolerance and efficient spectral usage by allowing overlapping in the frequency domain [1, 2]. OFDM enables robust multiple access technology to combat the impairment of wireless channels, especially of multipath fading, delay spread and Doppler shifts. Because of its significant advantages in frequency efficiency, OFDM has been a very popular technique for more efficient data communication [7]. In this work the performance evaluation of Orthogonal Frequency-Division Multiplexing –Fast Fourier Transform (OFDMFFT) in wireless channel models. The rest of the paper is organized as follows. Section 2 presents OFDM system model, Section 3 Present work, Section 4 presents IEEE 802.11A specifications [4] Section 5 presents RS code. The Simulation results are presented in Section 6, Section 7 concludes the paper

II. OFDM SYSTEM MODEL

Typical baseband system of OFDM is illustrated in Fig.1 Binary input data is first encoded by a forward error correction code. Then the encoded data is mapped onto QPSK (Quadrature Phase Shift Keying) After inserting pilot, the data sequence X=[X0 X1 ….XN-1]T is transformed into time domain signal by IFFT (Inverse Fast Fourier Transform). Following IFFT block, guard time, which is chosen to be larger than the expected delay spread, is inserted to prevent ISI (Inter-Symbol Interference).After parallel to serial transform, the transmitted signal will pass through the multipath fading channel with AWGN (Additive White Gaussian Noise).At the receiver, Y= [Y0 Y1….YN- 1]T is obtained after serial to parallel transform, CP (Cyclic Prefix) removing and FFT (Fast Fourier Transform) [9].



[Fig: 1 OFDM base band system on pilot channel estimation]

Manuscript received March 9, 2011.

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III. PRESENT WORK

Error control codes are used to protect information from errors that can occurs during transmission. RS Code is one of the most important and best known classes of non binary Bose Chaudhuri – Hoequenghen (BCH) codes which are capable of correcting burst errors. RS code is a type of forward error correction (FEC) codes used in data transmission for real time application. Their current uses include deep space communication, compact disc recording, cellular communications and digital broadcasting. Popularity stems in part from the existence of encoding and decoding algorithms that are simple to implement in hardware. In addition to their practical uses, these codes also have a nice theoretical structure for proving the feasibility of certain coding and storage scheme. Reed Solomon (RS) code are used for the non binary and binary encoding schemes, respectively the fading channels considered are Rayleigh or Rician. In the present study a simulink of RS are done using single carriers transceiver to observe the performance of RS code and choose the effective parameters that can improve OFDM system. Evaluation of Bit Error Rate (BER) performance for RS code as a function of cod rate and block size are tested. This testing is applied to single carrier system with different channels model using QPSK technique. BER performance over Rayleigh channel and Rician Channels are done respectively. In this paper Improvement of performance elevation criteria of RS coded OFDM TRANSMISSION over noisy channel is analyzed using simulink. The Simulink Communication tool and basic library tools are use with standard values in IEEE802.11A

IV. IEEE 802.11 SPECIFICATIONS

IEEE 802.11 is a set of standards carrying out wireless local area network (WLAN) computer communication in the 2.4, 3.6 and 5 GHz frequency bands. The IEEE 802.11a standard specifies an OFDM physical (PHY) layer that splits an information signal across 52 separate subcarriers. Four subcarriers are pilot subcarriers and the remaining 48 subcarriers provide separate wireless pathways for sending the information in a parallel fashion. The resulting subcarrier frequency spacing is 0.3125 MHz (for a 20 MHz bandwidth with 64 possible frequency slots). The basic parameters for OFDM systems as per IEEE 802.11a standard are given in Table 1.

[Table: 1 OFDM TIME BASE PARAMETER IN IEEE802.11a]

Parameter	Value
FFT size(nFFT)	64
Number of subcarrier(nDSC)	52
FFT sampling frequency	20MHz
Subcarrier Frequency	3125KHz
Subcarrier index	{-26to-1, +1to+26}
Data symbol durationT_d	32 µs
Cyclic prefix duration T_{cp}	0.8 µs
Total symbol duration T_s	4µs
Modulation	QPSK
Codeword length	15
Message length	15

V. RS CODE

RS Codes are one of the most popular error –correcting codes in digital communication and data storage systems. RS Code is a type of forward error correction (FEC) codes used in data transmission for real time application. Reed Solomon (RS) codes are a class of non binary codes which have strong burst and erasure error correcting capabilities [10]. Their current uses include deep space communication, compact disc recording, cellular communications and digital broadcast. Popularity stems in part from the existence of encoding and decoding algorithms that are simple to implement in hardware. In addition to their practical uses, these codes also have a nice theoretical structure for proving the feasibility of certain coding and storage scheme. Reed Solomon (RS) codes are a non binary codes; that is we can describe them in terms of symbols rather than bits. That is, RS codes can achieve very large minimum distance. Hence, RS codes are used for correcting burst errors in communication medium, it doesn't mean that RS codes will correct only evenly spaced errors. RS codes can also correct randomly occurring errors found wide ranging applications throughout the fields of digital communication and storage [11]. RS codes are systematic linear block codes specified as RS (n, k), with m bit symbols. This means that the encoder takes k data symbols of m bits each, appends n - k parity symbols, and produces a code word of n symbols (each of m bits) from the field GF (2n). The maximum block length n is equal to 2n-1 symbols for classical RS codes (or 2n symbols for singly extended RS codes). Often, the symbol size is taken to be 8 bits (m = 8) so that n will be 255 (or 256for singly extended RS codes)

A. Description of RS Coding

Since RS codes are cyclic codes, encoding in systematic form is analogous to the binary encoding procedure. We can think of shifting a message polynomial, m(X), into the rightmost k stages of a codeword register and then appending a parity polynomial p(X), by placing it in the leftmost n – k stages. Therefore we multiply m(X) by Xn-k, thereby manipulating the message polynomial algebraically so that it is right-shifted n - k positions.

Next, we divide Xn-k m(X) by the generator polynomial g(X), which is written in the following form:

$$X^{n-k}\, m(X) = q(X)\, g(X) + p(X) \quad (1)$$

where q(X) and p(X) are quotient and remainder polynomials, respectively. As in the binary case, the remainder is the parity. It can also be expressed as follows:

$$P(X) = X^{n-k}\, m(X) \text{ modulo } g(X) \quad (2)$$

The resulting codeword polynomial, U(X) can be written As:

$$U(X) = p(X) + X^{n-k}\, m(X) \quad (3)$$

Hence the resulting codeword U(X) is transmitted in the wireless channel (Sklar, 2001) [6].

B. *Description of RS Decoding*

The Reed Solomon decoder tries to correct errors and/or erasures by calculating the syndromes for each code word. Based upon the syndromes the decoder is able to determine the number of errors in the received block. Syndrome Computation (S1, S2, S2t)

i. Let the transmitted code be

U (X) = u0+u1X+..+un-1Xn-1 -------------- (4)

ii. Let the received code be

R (X) =r0+r1X+..+rn-1Xn-1 -------- (5)

iii. Syndrome is the result of parity check performed on The r(X) to determine whether r(X) is a valid member of Codeword polynomial

iv. Error pattern e(X)=r(x)-u(X) ---------- (6)

Hence e(x)=ej1Xj1+ej2Xj2+…+ejvXjv

Here ej1,ej2…ejv are error values and Xj1,Xj2,….Xjv are error location The computation of syndrome symbol can be described as:

Si=r(X) | X=αi = r(αi) i=1, …, n-k ---------- (7)

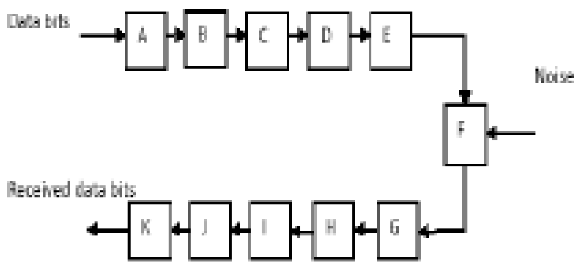
r(X) = U(X) + e(X) ------------ (8)

Then r(X) evaluated at each of the roots of g(X) should yield zero only when it is a valid codeword. Any errors will result in one or more of the computations yielding a nonzero result.

VI. SIMULINK

A. *Simulink Model*

Since the main goal of this research paper was to simulink the OFDM system by utilizing RS code. The block diagram of the entire system is shown in "Figure 2".



[Figure2. Simulink model of RS OFDM]

Here A = encoder, B = QPSK modulation, C = serial to parallel converter, D = IFFT, E = parallel to serial converter, F = channel with noise, G = serial to parallel converter, H = FFT, I = parallel to serial converter, J= QPSK demodulation and K = RS decoder [12].

B. *Simulink Parameters*

[Table:2 Simulink Parameters]

Parameter	Value
Sample Per Frame	44
Sampling Time	1.8182e-006 sec
PN Sequence	[1 0 0 0 0 1 1]
Sampling Time T_{pns}	2.5806e-006
Codeword length	15
Message length	15
Modulation	QPSK

C. *Algorithms of Simulinks*

We measured the performance of the RS coded OFDM through MATLAB simulink. The simulink follows the procedure listed below:

1. Generate the information bits randomly.
2. Encode the information bits using a RS encoder with the specified generator matrix.
3. Use QPSK to convert the binary bits, 0 and 1, into complex signals (before these modulation use zero padding).
4. Performed serial to parallel conversion.
5. Use IFFT to generate OFDM signals, zero padding is being done before IFFT.
6. Use parallel to serial convertor to transmit signal serially.
7. Introduce noise to simulink channel errors. We assume that the signals are transmitted over an Rayleigh and Rician channels. The noise is modeled as a Guassian random variable with zero mean and variance σ2. The variance of the noise is obtained as:

$$\sigma^2 = \frac{1}{2 * E_b / N_o}$$

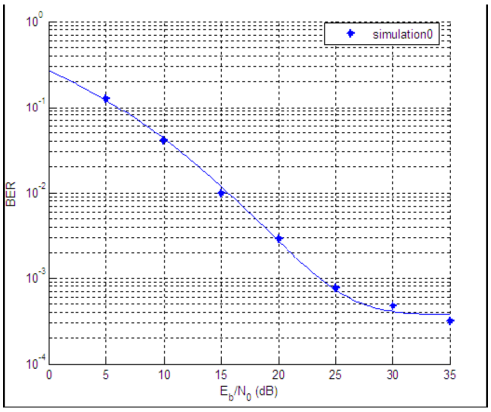
A built-in MATLAB function randn to generate a sequence of normally distributed random numbers, where randn has zero mean and 1 variance. Thus the receive ignal at the decoder is: X' = noisy (X) Where noisy (X) is the signal corrupted by noise.

8. At the receiver side, perform reverse operations to decode the received sequence.
9. Count the number of erroneous bits by comparing the decoded bit sequence with the original one.
10. Calculate the BER and plot it.

VII. RESULT

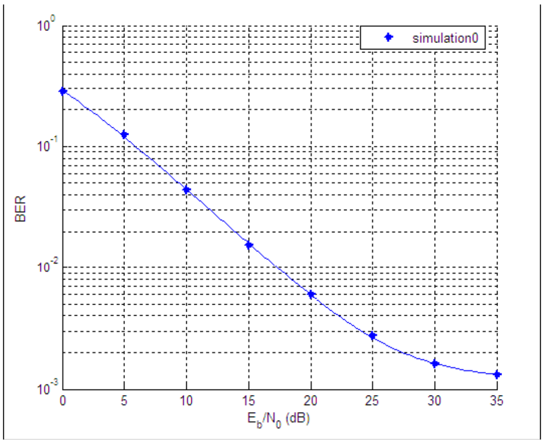
The OFDM system is developed, analyzed, and simulink in Matlab . The performance results for such system in different channel respectively Rayleigh and Ricianusing RS coding and QPSK modulation. The graphs of BER vs Eb/No performance of OFDM system under Raleigh and Rician channel without coding and using RS coding are shown in figure (3),(4) and (6), (7) respectively. BER v/s SNR Comparison of OFDM system under Rayleigh and Rician channel for without coding and using RS coding are shown in figure (5), (8) respectively.

A. BER Performance of Rayleigh Channel Without Coding



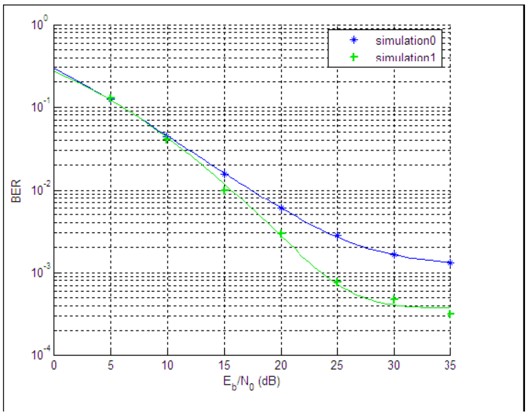
[Fig: 3 BER v/s SNR performance of OFDM system under Rayleigh channel without RS Coding]

B. BER Performance of Rayleigh Channel with Coding



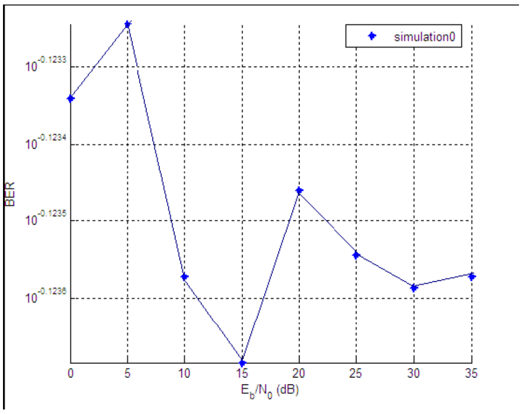
[Fig: 4 BER v/s SNR performance of OFDM system under Rayleigh channel using RS Coding]

C. BER Performance of Rayleigh Channel with and without Coding



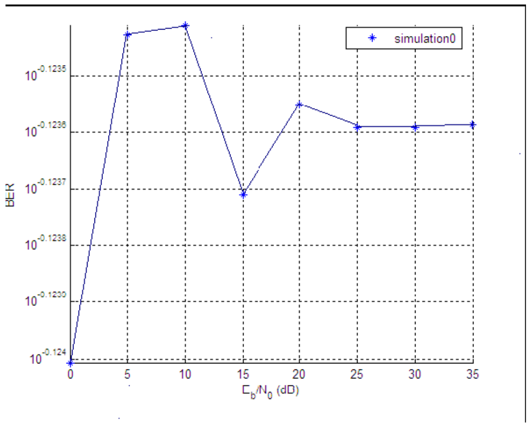
[Fig 5: BER v/s SNR Comparison of OFDM system under Rayleigh channel for without coding and using RS coding]

D. BER Performance of Riclan Channel without Coding



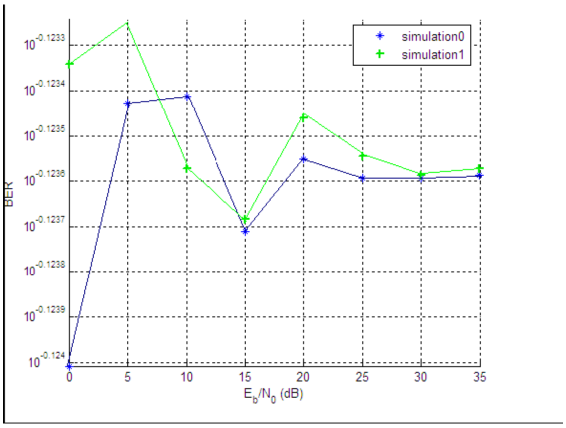
[Fig 6: BER v/s SNR performance of OFDM system under Rician channel using RS Coding]

E. BER Performance of Riclan Channel with Coding



[Fig:7 BER v/s SNR performance of OFDM system under Rician channel using RS Coding]

F. BER Performance of Riclan Channel with and without Coding



[Fig 8: BER v/s SNR Comparison of OFDM system under Rician channel for without coding and using RS coding]

VIII. CONCLUSION

BER performance over Rayleigh channel and Rician channels are done respectively. In this paper, the system throughput of a working OFDM system has been enhanced by adding RS coding. The bit error rate (BER) performance degradation of OFDM system is investigated in different channel. We consider the effects of BER both in Rayleigh and Rician. The an environment theoretical approximate calculation method is also derived of BER for binary using quaternary phase shift keying (QPSK) modulation schemes in OFDM systems. In addition, the method of BER calculation is validated by simulinks. In this paper Improvement of performance elevation criteria of RS coded OFDM TRANSMISSION over noisy channel is analyzed using simulink. The Simulink Communication tool and basic library tools are use with standard values in IEEE802.11A.

REFERENCES

[1] Ramjee Prasad, "OFDM for Wireless Communications systems", Artech House Publishers, 2004.
[2] L. Hanzo, M. Munster, B.J. Choi, T. Keller, "OFDM & MCCDMA for Broadband Multiuser Communications, WLANs and Broadcasting" John Wiley Publishers, 2003.
[3] Omar Al-Askary, "Coding and Iterative Decoding of Concatenated Multi-level Codes for the Rayliegh Fading Channel", Ph. D Thesis in Radio Communication Systems, Stockholm, Sweden, 2006.
[4] IEEE 802.11 detailed documentation available at IEEE website http://standards.ieee.org/getieee802
[5] C. Xu(2007), "Soft Decoding Algorithm for RS-CC Concatenated Codes in WiMAX System", IEEE 65th Conference on Vehicular Technology VTC 2007, pp. 740-742.
[6] Bernard Sklar (2001), "Digital Communication Fundamentals and Applications", 2nd edition, Prentice Hall Inc.
[7] L. Zou, "Automatic Detection of the Guard Interval Length in OFDM System", Journal of Communications, vol. 1, no. 6, pp. 28-32, Spt. 2006.
[8] O.Daoud, A.-R Al-Qawasmi, "Efficient Performance Of Cofdm-Based DVB-T," in IEEE International Multi-Conference on Systems, Signals and Devices, 2009, pp. 1-4.
[9] Zhu Qi Li Hao Feng Guangzeng "performance analysis of channel estimaton on for LDPC – coded OFDM system in multipath fading channel" JOURNAL OF ELECTRONICS (CHINA), Vol.23 No.6 Nov 2006.
[10] S. Roman, "Coding and Information Theory". Springer- Verlag, 1992.
[11] L. Biard and D. Noguet (2008), "Reed Solomon Codes for Low Power Communication", Journal of Communications, vol. 3, no. 2, pp. 13-21.
[12] M. K. GUPTA, VISHWAS SHARMA, "To improve bit error rate of turbo coded OFDM transmission over noisy channel, **Journal of Theoretical and Applied Information Technology** © 2005 – 2009 JATIT
[13] John G. Proakis, Masoud Salehi, "communication system using MATLAB" Thomson Asia Pvt. Ltd., Singapore, 2003.
[14] T. Rappaport, " Wireless Communications Principles and Practice", Prentice Hall, 1996.
[15] Iskander, Cyril-Daniel, "A MATLAB-based Object-Oriented Approach to Multipath Fading Channel Simulation", a MATLAB Central submission available in www.mathworks.com.