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A Review: BER Performance Analysis of OFDM system using Reed-Solomon Codes

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***Abstract*—** In this paper, present the performance analysis of the orthogonal frequency-division multiplexing (OFDM) communication system in term of BER (bit error rate) using Reed-Solomon (RS) codes with and without Interleaver (IL) over 16-QAM modulation schemes through AWGN. The RS coding scheme and interleaver has strong ability to correct the burst errors and random errors, and has been broadly used in wireless communication system design. The significance of random interleaver is to improvement the BER performance over other interleaver scheme is proposed. The transmission data is realized with 64-FFT and 64-IFFT technique. The whole MATLAB simulation results show that the RS coded OFDM system with IL scheme performs the better BER as compared to RS coded OFDM system without IL. The code rate of RS encoder also affected the BER performance of OFDM system in both schemes with and without IL. In both proposed simulation system, the BER performance increases with increases the code rate of the system.

***Keywords*—**AWGN channel, Code rate, FFT, IFFT, OFDM, QAM, Reed-Solomon code

I. INTRODUCTION

OFDM has been broadly studied by the communication engineering and considered as a hopeful technology for future digital communication system which appropriate for high rate of data transmission. OFDM is a frequency division multiplexing scheme used as a digital multi-carrier modulation method with high spectral efficiency and in turn, high data rate. In multi-carrier modulation scheme, the OFDM technique is become broadly used in wireless communication system. Orthogonal sub-carriers are involved in OFDM system to avoids inter symbol interference (ISI) [8]. In this system the overall data transmitted in parallel stream to achieving high data rate. Thus the symbol time will be larger than the delay spread and by orthogonal property only desired signal will received at receiver side. Inverse Fast Fourier Transform (IFFT) and Fast Fourier Transform (FFT) are the important blocks of OFDM to implementation it into digital domain [8]. IFFT converts frequency domain to time domain samples at transmitter side. Usage of IFFT at the transmitter removes the necessity of distinct sinusoidal converters to generate orthogonal sub-carriers.

The coded OFDM system with interleaving scheme performed better as compared to uncoded OFDM system [1]. M. Chen et al., [2] used RS codes with and without interleaver in OFDM system and the performance of the system compared through Single Mode Fiber (SMF), the BER performance of RS with interleaver coded OFDM has better as compared to RS coded OFDM system without interleaver. K. Sanjeev et al., [3] used RS codes over Quadrature Phase Shift Key (QPSK) modulation to evaluate the BER performance for different code rates. C. Kotchasarn [4] adopted OFDM system in broadband power line communication, analyzed the loss parameter and BPSK modulation at different connection distances. Simon et al., [5] implemented single convolutional encoder using puncturing with interleaving. Chaturvedi et al., [6] analysed the BER performance in OFDM system over AWGN channel by different interleaver scheme. In this paper, an OFDM system is considered according to coded OFDM system specifications over AWGN channel. To improve the data rate in OFDM communication system channel coding schemes are designed. BER performance of coded OFDM system using RS encoder with and without interleaving schemes are analyzed to find out the best technique from them. Random interleaver, 16-QAM modulation and AWGN channel is used for design coded OFDM system in

this paper. The paper is organized in the following manner: Section II describes in detail the simulation setup for coded OFDM system. Section III summarized the simulation results and its analysis discussion. Section IV presents conclusion and future enhancement.

II. SIMULATION SETUP

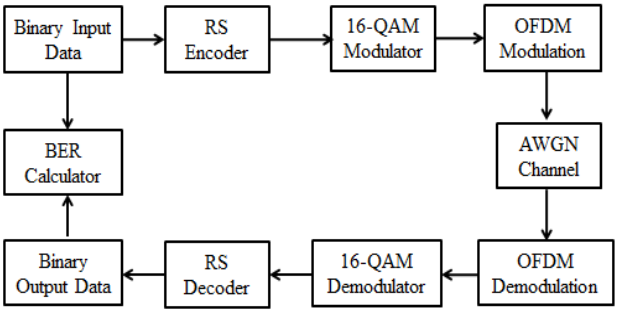

Figure 1. Basic block diagram of OFDM communication system using RS encoder without interleaver.

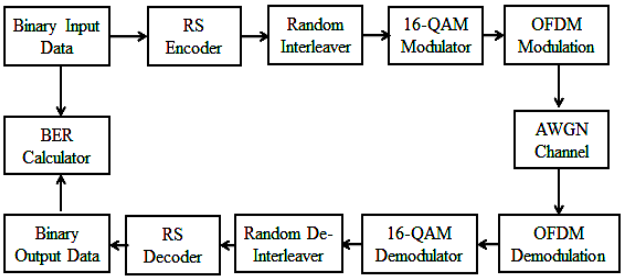

Figure 2. Basic block diagram of OFDM communication system using RS encoder with Random interleaver.

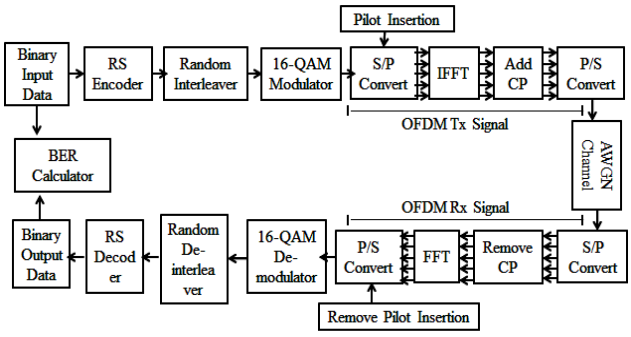

Figure 3. Proposed simulation structure of coded OFDM communication system.

This section gives a detailed description structure of the simulation coded OFDM communication system with simulation parameters using MATLAB® software.

The structure of the OFDM communication system using RS encoder without interleaver and with interleaver is shown in Fig. 1 and Fig. 2. In Fig. 1, the incoming data bits stream first gives to RS encoder, then 16-QAM modulation, then OFDM modulation system and finally OFDM modulated data are transmitted over AWGN channel. Similarly in Fig. 2, the random interleaver is used after RS encoder. The OFDM demodulator, 16-QAM demodulation, random de-interleaver and RS decoder is employed at receiver side of the system to recover the data bits stream.

TABLE I. SIMULATION PARAMETERS FOR CODED OFDM COMMUNICATION SYSTEM

OFDM system parameters	Description
Coding scheme	Reed-Solomon coding
Total data	187200
Encoder	RS(255, 85), RS(255, 128), RS(255, 170)
Number of sub-carriers	52
Size of IFFT/FFT points	64
Number of pilot insertion	12
Cyclic prefix	16 bits (rate=1/4)
Modulation	16-QAM
Channel	AWGN
Decoding	Berlekamp-Massey decoding

The whole simulation proposed structure of the coded OFDM communication system described as shown in Fig. 3. The OFDM block consist by IFFT/FFT, Pilot insertion and Cyclic prefix. The binary input data gives to RS encoder (n, k) [7] with different code rates as k/n and the random interleaver with *state=0* [7]. After 16-QAM modulation operation, the Pilot Insertion is prepared by adding zeros in channels of OFDM. It is the single frequency group of data symbol insert between transmitted data over AWGN channel for tracking at receiver. The function of IFFT is to conversion of high rate data to low rate data by using parallel transmission and maintain the overall high data rate and also converts the data of frequency domain into time domain for the transmission. The Cyclic prefix or Guard Interval is a periodic addition in an OFDM symbol by added to the front of OFDM symbol in the transmitted signal and it removed at the receiver side before the applying demodulation function. The reverse scheme is applied at receiver side by RS decoding, random de-interleaving, 16-QAM demodulation and OFDM demodulation. Three RS encoders, RS (255, 85), RS (255, 128) and RS (255, 170) are performed in transmitter side. The 64 size of IFFT with 52 sub-carrier and 52 numbers of bits per symbol are used to carry the information. 12 pilot insertions are added by adding zeros. After operation of IFFT, a 16-point cyclic prefix is inserted. The whole coded OFDM communication system parameters used in the MATLAB simulation are given in Table I. The overall simulations are carried out BER at different signal-to-noise ratio (SNR).

III. SIMULATION RESULTS AND ANALYSIS

In this section, the MATLAB simulation results are obtained from proposed coded OFDM communication system are presented. The simulation result for coded OFDM system using RS encoder without interleaver and analyzed the impact of RS encoder code rate on the BER probability curve. Fig. 4 shows the BER probability curve of coded OFDM system at different RS encoder code rate RS (255, 85) of rate 1/3, RS (255, 128) of rate 1/2 and RS (255, 170) of rate 2/3. The simulation resulted values of this

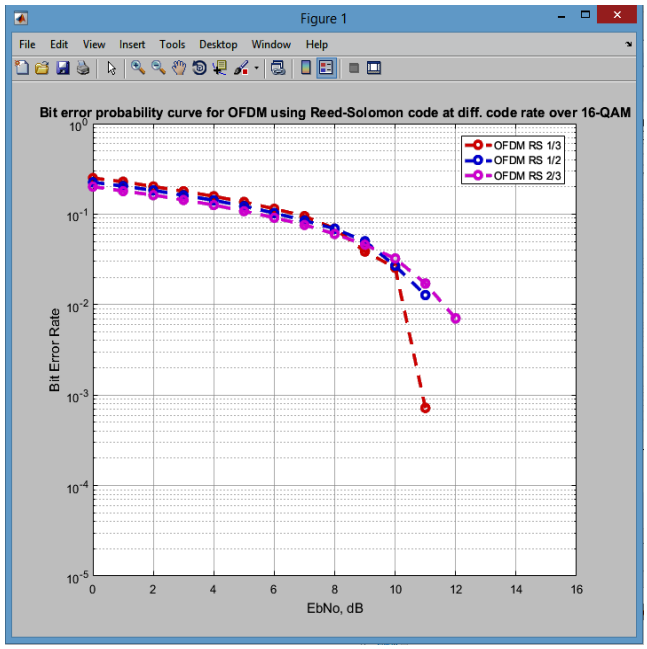

Figure 4. BER Probability curve coded OFDM communication system without random interleaver approach.

system obtained are shown in Table II.

TABLE II. RESULTED VALUES OF CODED OFDM COMMUNICATION SYSTEM WITHOUT RANDOM INTERLEAVER

SNR in (dB)	BER value of Reed-Solomon encoder with code rate		
	RS 1/3	RS 1/2	RS 2/3
0 dB	0.2502	0.2252	0.2015
1 dB	0.2277	0.2039	0.1797
2 dB	0.2017	0.1830	0.1624
3 dB	0.1790	0.1614	0.1435
4 dB	0.1574	0.1421	0.1260
5 dB	0.1361	0.1225	0.1080
6 dB	0.1145	0.1028	0.0913
7 dB	0.0949	0.0849	0.0761
8 dB	0.0691	0.0689	0.0604
9 dB	0.0386	0.0501	0.0459
10 dB	0.0256	0.0268	0.0323
11 dB	0.0007	0.0127	0.0171
12 dB	0	0	0.0070

The RS encoder RS(255, 85) of code rate 1/3≈0.33 at E_b/N_o 10dB gives BER value 0.0256 and it is slightly better as compared code rate 1/2≈0.50 and code rate 2/3≈0.67. After 10dB the BER probability curve decreases sharply in RS 1/3.In second approach of the simulation for coded OFDM system using RS encoder with random interleaver and analyzed the BER probability curve is shown in Fig. 5. The resulted BER probability curve of this type approach system shows that the RS encoder RS(255, 85) of code rate 1/3≈0.33 with random interleaver at E_b/N_o 10dB gives BER value 0.0050 and it is quite better as compared to compared code rate 1/2≈0.50 and code rate 2/3≈0.67. After 9dB the BER probability curve decreases sharply in RS 1/3. The simulation resulted values of this approach system with

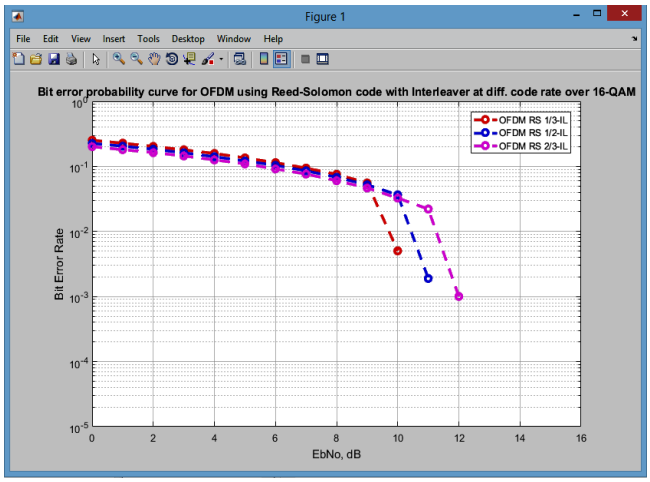

Figure 5. BER Probability curve coded OFDM communication system with random interleaver approach.

random interleaver obtained are shown in Table III.

TABLE III. RESULTED VALUES OF CODED OFDM COMMUNICATION SYSTEM WITH RANDOM INTERLEAVER

SNR in (dB)	BER value of Reed-Solomon encoder with code rate		
	RS 1/3-IL	RS 1/2-IL	RS 2/3-IL
0 dB	0.2522	0.2260	0.2014
1 dB	0.2272	0.2046	0.1808
2 dB	0.2027	0.1834	0.1630
3 dB	0.1798	0.1619	0.1449
4 dB	0.1579	0.1411	0.1260
5 dB	0.1351	0.1212	0.1094
6 dB	0.1143	0.1041	0.0915
7 dB	0.0941	0.0857	0.0764
8 dB	0.0756	0.0681	0.0604
9 dB	0.0556	0.0522	0.0466
10 dB	0.0050	0.0365	0.0326
11 dB	0	0.0019	0.0221
12 dB	0	0	0.0010

The comparison of the coded OFDM communication system using RS encoder without random interleaver and with random interleaver is shown in Fig. 6 and examined that the coded OFDM communication system with random interleaver yields the best BER probability curve as compared to OFDM system without random interleaver.

IV. CONCLUSION

The impact of RS encoder of code rate in coded OFDM communication system with and without random interleaver

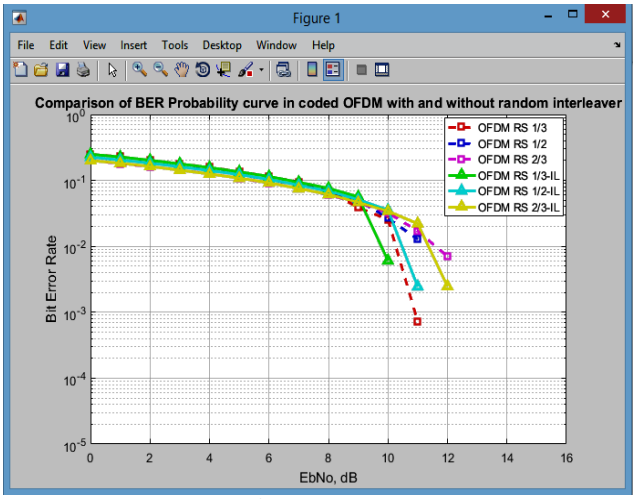

Figure 6. Comparison of BER Probability curve coded OFDM communication system with and without random interleaver.

has been studied. From the simulation results of MATLAB® software, it may conclude that the BER probability performance of coded OFDM communication system with interleaver provides better performance than without interleaver system. It may also conclude, the BER probability also increases with respect to code rate value of RS encoder from 1/3 to 2/3 for both approaches of coded OFDM communication system.

Future work could focus on enhancement of the BER performance in coded OFDM communication system by using particular channel encoding/ decoding, IFFT/ FFT and modulation schemes.

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