RESEARCH ARTICLE OPEN ACCESS

BER Performance of OFDM-QAM over AWGN and RICAIN Channels Using Error Correcting Codes

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ABSTRACT
In this paper, the performance of OFDM - QAM system by using error correcting codes (Convolutional, Reed Solomon and Interleaving) schemes that are used to encode the data stream in wireless communications using AWGN and RICIAN channels has been reported here. OFDM is presented for wireless communications we curing basic OFDM and affined modulations, as well as techniques to improve the performance of OFDM for wireless communications. Various simulations are performed to detect the best BER performance of each of the QAM system; OFDM-QAM and OFDM-QAM with Error Correction and to use the best outcomes to model the OFDM-QAM, Their effect of improving the total BER can be noticed due to the benefits of OFDM-QAM with correcting codes.
Keywords – Orthogonal frequency division multiplexing (OFDM), AWGN channel, RICIAN channel.

I. INTRODUCTION

In wireless industry a major evaluation is occurring from narrowband, circuit-switched network to broadband, IP centric network. 3rd Generation system has been rolled in many countries as it has high data rate, as well as high spectral efficiency. LTE [1] establish as the latest towards the 4th generation (4G) step of radio technologies. It is designed to increase the capacity and speed of mobile communications. OFDM is the most exciting development in the period of this evaluation. Multicarrier transmission or multiplexing like frequency division multiplexing (FDM) has come into technology in 1950s. But high spectral efficiency and low cost implementation of FDM has been possible in 1970s and 1980s with the aid of Digital Fourier Transform (DFT) [2]. OFDM is special type of multicarrier transmission where the total information bit stream is transmitted using several lower rate subcarriers which are orthogonal in nature in order to avoid inter carrier interference. In a single carrier system, a single fade can fail the entire link. But in multi carrier system, the effect of noise on a particular frequency affects only a small percentage of the total information [3].

This paper focuses upon the performance comparison of OFDM system in AWGN channel and Rician fading channel. The rest of the paper is organized as follows . Section II presents a brief introduction of OFDM system. Section III gives OFDM System Specifications in brief. Section IV presents the Error Correcting Codes Simulation results are presented in section V and Section VI concludes the paper.

II. OFDM SYSTEM IN BRIEF

OFDM is basically a multicarrier modulation process where the bit stream that is linearly modulated using PSK or QAM technique is divided into a number of substerams each occupying a bandwidth less than the total signal bandwidth. Orthogonality between the subcarriers is obtained by IDFT that ensures zero cross correlation between them ensuring zero inter carrier interference (ICI). Thus during extracting information from one subcarrier, the effect of the adjacent subcarriers are null although the subcarriers are overlapping. Thus the total bandwidth requirement is also less for an OFDM system. The number of substreams is chosen in such a manner so that each subchannel has a bandwidth less than the coherence bandwidth of the channel. As a result the sub channels experience flat fading , inter symbol interference (ISI). ISI can be completely eliminated using the concept of cyclic prefix [4] . The generated multilevel data stream is demultiplexed into N parallel streams using serial-to-parallel converter. Each parallel data stream has a rate of (1/NT) bits/s and each will modulate one of the N orthogonal subcarriers. After the OFDM modulation the task is to remove ISI within each OFDM symbol and that is achieved by inserting a guard interval. This guard interval is also known as cyclic prefix which is basically a copy of the last part of OFDM symbol. This way the transmitted symbols are made periodic ,which plays an important role in identifying frames correctly and also helps to avoid ISI & ICI. The reception process is just reverse of the transmission process [4] . Figure 1 illustrates the OFDM transmitter & receiver.

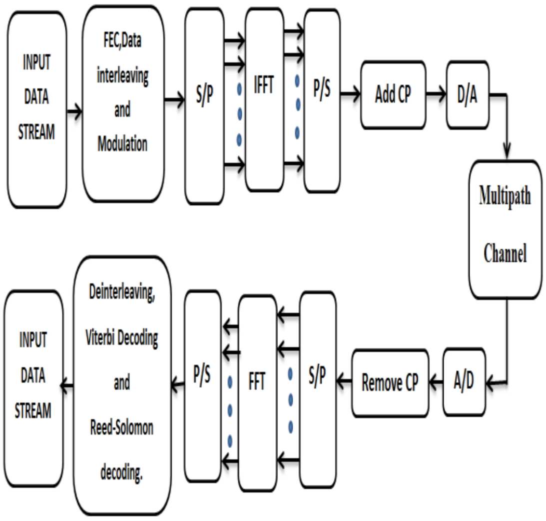

FIGURE 1.OFDM TRANSMITTER & RECEIVER [8]

III. OFDM SYSTEM SPECIFICATIONS

The main components of the OFDM technology are presented by describing the tasks performed in the communication system model , its parameters given in table (1) that consists of :-

-Generation of random bit data , that models a downlink burst consisting of an integer number of OFDM symbols.

- FEC, consisting of a Reed-Solomon (RS) outer code concatenated with a rate-compatible inner convolutional code (CC).

- Data interleaving . The Matrix Interleaver block performs block interleaving by filling a matrix with the input symbols row by row and then sending the matrix contents to the output port column by column.

Table 1: The basic parameters for OFDM systems

Parameters	Values
FFT Size	256
Nominal channel B.W	3.5MHz
CP	0.1250
Number Of Subscribers	192
K-factor	3
Discrete path delay vector (s)	[0 0.9]*1e-6
Average path gain vector (dB)	[0 -16]
Eb/N0 (dB)	0-60
Coding	RS-CC- INTERLEAVING
Noise Channel	AWGN, Rician
Modulation Schemes	16-QAM, 64-QAM

- Modulation, using the specified 16-QAM or 64-QAM constellations.

- OFDM transmission using 192 sub-carriers, 8 pilots, 256-point FFTs, and 0.125 cyclic prefix length.

IV. ERROR CORRECTING CODES

A. REED-SOLOMON CODES (RS)

Reed-Solomon codes that use m-bit symbols instead of bits. A message for an [n,k] Reed-Solomon code must be a k-column Galois array in the field GF(2^m). Each array entry must be an integer between 0 and 2^m-1. The code corresponding to that message is an n-column Galois array in GF(2^m). The code word length n must be between 3 and 2^m-1 [7].

B. INTERLEAVING

The Matrix Interleaver block accomplishes block interleaving by filling a matrix with the input symbols row by row and then sending the matrix contents to the output port column by column[7].

C. CONVOLUTIONAL CODES (CC)

Convolutional codes are extensively used for real time error correction. Convolutional coding is done by combining the fixed number of input bits. The input bits are stored in fixed length shift register and they are combined with the help of mod-2 adders. This operation is equivalent to binary convolution and hence it is called convolutional coding. The ratio R=k/n is called the code rate for a convolutional code where k is the number of parallel input bits and n is the number of parallel decoded output bits, m is the symbolized number of shift registers. Shift registers store the state information of convolutional encoder, and constraint length (K) relates the number of bits upon which the output depends[6].

V. SIMULATION MODEL

A full system model was implemented in 2012-$MATLAB^{TM}$ according to the above described system for different models. Performance analysis is done for different models by taking random data stream of defined length for each of the coding techniques [8]. Here we transmit our data by using OFDM technique in which large number of closely-spaced orthogonal sub-carriers are used to carry data. Each sub-carrier is modulated with a conventional modulation scheme. Here we have used M-QAM modulation and demodulation for all the simulations. The encoded data is then passed through Gaussian channel and Rician channel that add noise to the symbols produced by the encoder. In AWGN channel E_b/N_0 dB denotes the information bit energy to noise power density ratio. The simulation is performed between E_b/N_0 and at the y-axis we plot the bit error rate (BER). Simulation model of OFDM system using M-QAM (where M is 16, 64) as baseband modulation along with AWGN and Rican fading channel is shown in Figure 2.

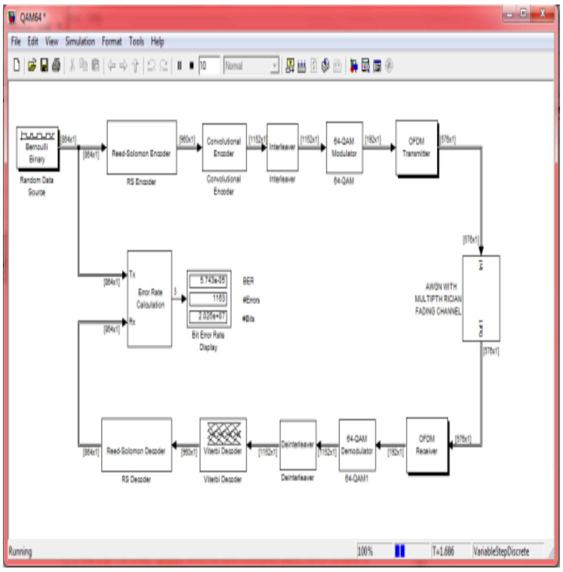

Figure 2: Simulation model of OFDM system

A. M-QAM over AWGN and RICIAN channels with OFDM system.

BER vs E_b/N_0 plots for [16QAM-OFDM & 64QAM-OFDM] over AWGN and RICIAN channels without channel coding .

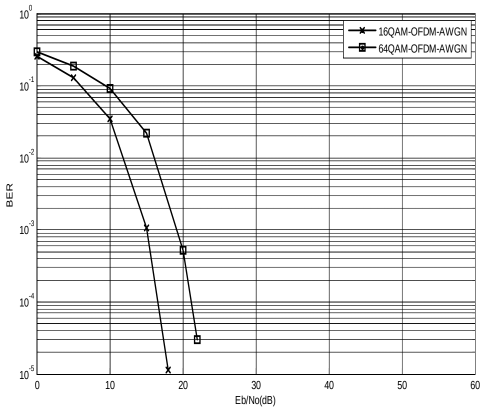

Figure 3: BER vs E_b/N_0 plots for [16QAM-OFDM &64QAM-OFDM] AWGN channel

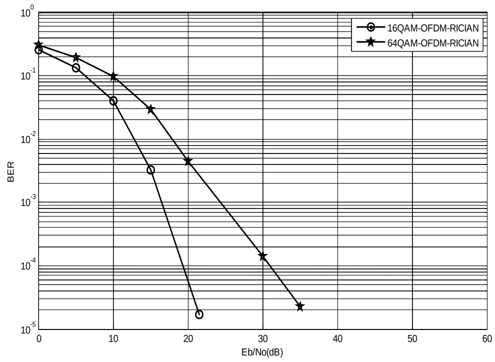

Figure 4: BER vs E_b/N_0 plots for 16QAM-FDM &64QAM-OFDM] RICIAN channel

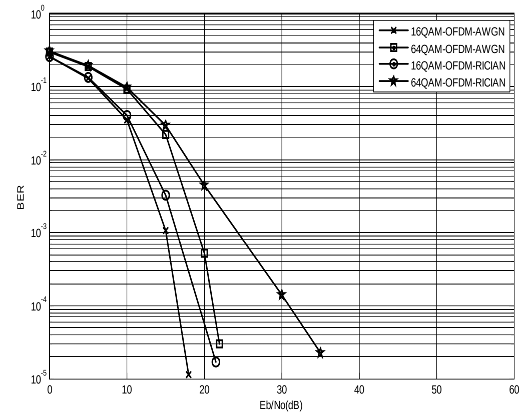

Figure 5: BER vs E_b/N_0 plots for [16QAM-OFDM &64QAM-OFDM] AWGN and RICIAN channel

Here Figure 3 depicts the performance of 16-QAM and 64-QAM in normal AWGN channel. When the signals of different techniques are passed through the normal AWGN channel, the BER increases as the value of M increases. The value of M increases means more number of bits are combined to make a symbol & these bits are packed more closely in the signal constellation . When the same signal is transmitted through Rician channel the BER increases in the same manner figure 4 i.e. a higher the value of M implies a greater error rate.

Figure 5 presents BER performance of the 16-QAM and 64-QAM over both AWGN and RICIAN channels with OFDM system .

Table (2) shows the improvement for 16,64-QAM over AWGN and Rician without coding.

Table 2: E_b/N_0 improvement for M-QAM in AWGN and Rician channel in OFDM system without coding

Modulation	E_b/N_0 at AWGN when BER = 10^{-4}	E_b/N_0 at Rician when BER = 10^{-4}
16-QAM	16 dB	18.5 dB
64-QAM	21 dB	31 dB

B. M-QAM over AWGN and RICIAN Channels with OFDM system using channel coding .

BER vs E_b/N_0 plots for [16QAM-OFDM & 64QAM-OFDM] over AWGN and RICIAN channels with channel coding .

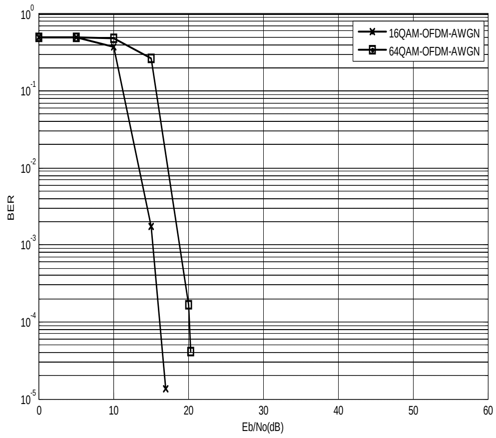

Figure 6: BER vs E_b/N_o **plots for [16QAM-OFDM&64QAM-OFDM] AWGN channel using channel coding .**

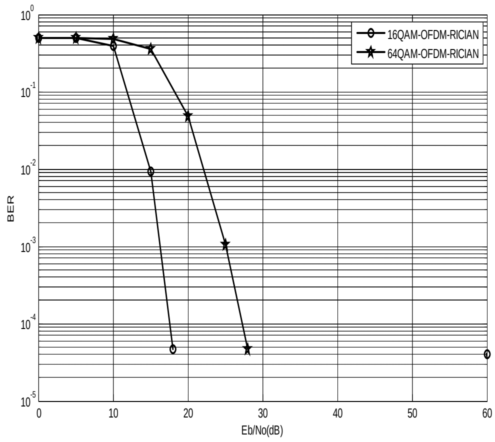

Figure 7: BER vs E_b/N_o **plots for [16QAM-OFDM &64QAM-OFDM] RICIAN channel using channel coding**

Here Figure 6 depicts the performance of 16-QAM and 64-QAM in normal AWGN channel. When the signals of different techniques are passed through the normal AWGN channel, the BER increases as the value of M increases. The value of M increases means more number of bits are combined to make a symbol & these bits are packed more closely in the signal constellation . When the same signal is transmitted through Rician channel the BER increases in the same manner figure 7 i.e. a higher the value of M implies a greater error rate. Figure 8 presents BER performance of the 16-QAM and 64-QAM over both AWGN and RICIAN channels with OFDM system .Table (3) shows the improvement for 16,64-QAM over AWGN and Rician with coding.

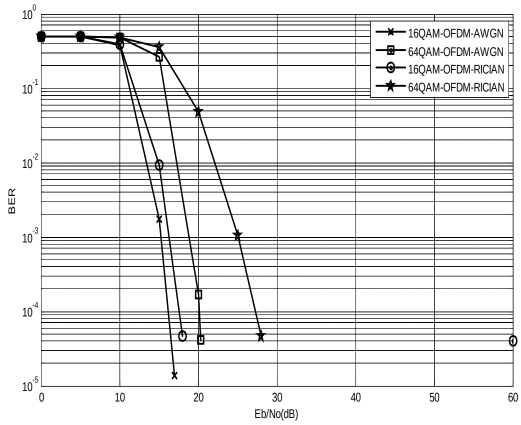

Figure 8: BER vs E_b/N_o **plots for [16QAMOFDM &64QAM-OFDM] AWGN and RICIAN channel using channel coding**

From figure 8 it is clear that the performance with coding outperforms that of non-codes. It can be seen that with coding curve show less flattening effect and has a better slope than the other two codes. It is clear that BER performance with coding is much better than without coding .

Table 3: E_b/N_o **improvement for M-QAM in AWGN and Rician channel in OFDM system**

Modulation	E_b/N_o at AWGN when BER = 10^{-4}	E_b/N_o at Rician when BER = 10^{-4}
16-QAM	16 dB	18 dB
64-QAM	19.5 dB	27.5 dB

From table (3) as compared to table (2) improvement of over 3 dB is obtained when using coding for the case of Rician and 64QAM.

VI. CONCLUSION

In this paper, Error Correction codes have been used for comparing the BER performance on AWGN channel and Rician channel. Bit Error Rate of convolutional codes, RS codes and Interleaving has been discussed. In this paper, simulation of different combination of modulating technique. The best outcomes of each of the two were used to model channel with coding. The simulation results show the outperformance of the QAM-OFDM when compared to the same model without it , provide a better result on same modulation.

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