

BER PERFORMANCE ANALYSIS OF OFDM-BPSK, QPSK, QAM OVER RAYLEIGH FADING CHANNEL & AWGN CHANNEL

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Abstract- Bit error rate is a key property of the digital communication system. Various types of modulation methods like ASK, BPSK, QPSK are used in the digital information transmission system. BER can be demarcated as the number of received bits of a data stream over a communication channel that can be affected due to noise, interference and distortion or bit synchronization errors. This paper mainly focuses the performance of OFDM -BPSK,-QPSK and -QAM system by using forward error correcting codes (convolutional, reed Solomon coding as well as concatenated coding) schemes. These codes are normally used to encode the data stream that can be passed through communication channels resembling AWGN channel, Rayleigh fading channel, Ricean fading, log-normal shadow fading etc. We have adopted AWGN channel, Rayleigh fading channel. We have illustrated the basic OFDM and associated modulation methods to improve the performance of OFDM for wireless communications (OFDM). We also have performed various simulations in Matlab to find out the best BER performance of each of the Convolutional and Reed-Solomon codes and used these best consequences to model the RS-CC concatenated codes. By concatenating two different codes we can get the effect of improving the total BER due to benefits of RS codes which are supportive in correcting burst errors, whereas convolutional codes are good enough for correcting random errors that appear in noisy channels.

Index Terms- Inter symbol interference (ISI), multicarrier (MC), Concatenated codes, Orthogonal frequency division multiplexing (OFDM); Convolutional codes (CC), Reed-Solomon codes (RS).

I. INTRODUCTION

It is increasingly believed that OFDM results in an improved downlink multimedia service require high data rate communications, but this condition is significantly limited by inter-symbol interference (ISI) due to the existence of the multiple paths. There are many multicarrier modulation techniques. OFDM modulation is considered as the most hopeful technique to combat this problem [4]. Orthogonal frequency-division multiplexing (OFDM) is a process of encoding digital data on multiple carrier frequencies. OFDM has developed into a widespread scheme for wideband digital communication, whether wireless or over copper wires, used in solicitations such as digital television and audio broadcasting. In wireless, satellite, and space communication systems, reducing error is acute. Wireless medium is quite different from the corresponding item using wires and provides several advantages, such as; mobility, better productivity, low cost, easy installation facility and scalability. On the other hand, there are some limitations and disadvantages of various transmission channels in wireless medium between receiver and transmitter wherever transmitted signals arrive at receiver with different power and time delay owing to the reflection, diffraction and scattering effects. In addition the BER (Bit Error Rate) value of the wireless medium is relatively high. These drawbacks sometimes lead destructive effects on the wireless data transmission performance. As a result, error control is necessary in these applications. During digital data transmission and storage operations, performance

criterion is commonly determined by BER. It is the ratio of the number of error bits to the number of total bits. Noise in transmission medium disrupts the signal and causes data corruptions. Relation between signal and noise power is described with SNR (signal-to-noise ratio). Generally, SNR is explained with signal power/BER. It means, the less the BER result is the higher the SNR and the better communication quality [1], [5].

II. OFDM SYSTEM

Orthogonal frequency-division multiplexing (OFDM) is a method of digital modulation in which a signal is split into several narrowband channels at different frequencies. It efficiently embraces multiple performances for fourth generation system [2].

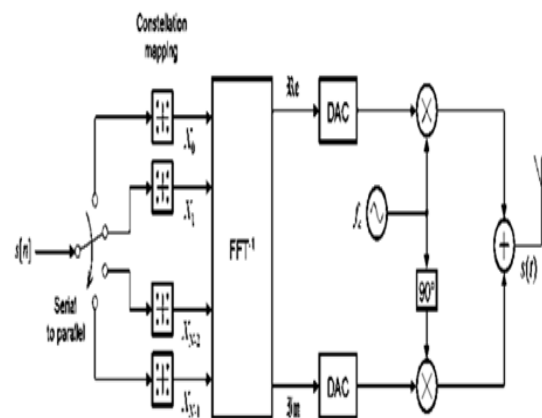


Fig.1 A simple OFDM transmitter

OFDM is fundamentally identical to coded OFDM (COFDM) and discrete multi-tone modulation (DMT), and is a frequency-division multiplexing (FDM) scheme used as a digital multi-carrier modulation technique. The word "coded" comes from the use of forward error correction (FEC) [3]. A large figure of closely spaced orthogonal sub-carrier signals are used to carry data [1] on several parallel data streams or channels. Each sub-carrier is modulated with a conventional modulation scheme (such as quadrature amplitude modulation or phase-shift keying) at a low symbol rate. OFDM system is capable of mitigating a frequency selective fading channel to a set of parallel flat fading channels. OFDM is invariably used in conjunction with channel coding (forward error correction), and almost always uses frequency and/or time interleaving.

Frequency (subcarrier) interleaving increases resistance to frequency-selective channel conditions such as fading. For example, when a part of the channel bandwidth fades, frequency interleaving ensures that the bit errors that would result from those subcarriers in the faded part of the bandwidth are spread out in the bit-stream rather than being concentrated. Similarly, time interleaving ensures that bits that are originally close together in the bit-stream are transmitted far apart in time, thus mitigating against severe fading as would happen when travelling at high speed. So, our motivation behind this paper is to study the performance of OFDM system using flat fading channel of AWGN channel.

III. AWGN & RAYLEIGH FADING CHANNEL

High data rate communication over additive white Gaussian noise channel (AWGN) is limited by noise. The received signal in the interval $0 \leq t \leq T$ may be expressed as

$$R(t) = Sm(t) + n(t) \quad (3-A)$$

Where, $n(t)$ denotes the sample function of additive white Gaussian noise (AWGN) process with power-spectral density.

Rayleigh fading is a practical model when there are many bits and pieces in the environment that scatter the radio signal before it arrives at the receiver.

The central limit theorem holds that, if there is sufficiently much scatter, the channel impulse response will be well-modeled as a Gaussian process irrespective of the distribution of the distinct components.

If there is no dominant component to the scatter, then such a process will have zero mean and phase evenly distributed between 0 and 2π radians. As a result the envelope of the channel response will be Rayleigh distributed.

IV. ERROR CORRECTING CODES

A. Convolutional code (CC)

Convolutional codes are used broadly in numerous applications in order to accomplish reliable data transfer, covering digital video, radio, mobile communication, and satellite communication. These codes are habitually implemented in concatenation with a hard-decision code, mainly Reed Solomon. Prior to turbo codes, such edifices were the most efficient, coming closest to the Shannon limit. To convolutional encode data, start with k memory registers, each holding 1 input bit. Unless otherwise specified, all memory registers start with a value of 0. The encoder has n modulo-2 adders (a modulo 2 adder can be implemented with a single Boolean XOR gate, where the logic is: $0+0=0$, $0+1=1$, $1+0=1$, $1+1=0$), and n generator polynomials — one for each adder (see figure below). An input bit m_1 is fed into the leftmost register. Using the generator polynomials and the existing values in the

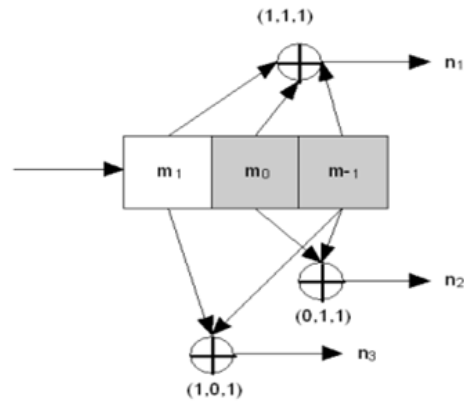


Fig.2 Rate 1/3 non-recursive, non-systematic convolutional encoder with constraint length 3

remaining registers, the encoder outputs n bits. Now bit shift all register values to the right (m_1 moves to m_0 , m_0 moves to m_{-1}) and wait for the next input bit. If there are no remaining input bits, the encoder continues output until all registers have returned to the zero state.

B. Reed-Solomon code (RS)

Reed-Solomon codes are block-based error correcting codes [18] with a wide range of applications in digital communications and storage. Reed-Solomon codes are used to correct errors in many systems including Storage devices (including tape, Compact Disk, DVD, barcodes, etc.), satellite communications etc.

The Reed-Solomon code is essentially a family of codes: For every choice of considerations q , n , and k , there is a Reed-Solomon code that has an alphabet of size q , a block length $n < q$, and a message length $k < n$. In addition, the alphabet is deduced as the finite field of order q . q has to be a prime power. In the most

useful parameterizations of the Reed–Solomon code, the block length is usually some constant compound of the message length, that is, the rate $R=k/n$ is some constant. The block length is equal to or one less than the alphabet size, that is, $n=q$ or $n=q-1$. For hands-on uses of Reed–Solomon codes, it is common to use a finite field F with 2^m elements. In this case, each symbol can be denoted as an m bit value [17].

C. Concatenated code (RS)

As the two codes i.e. Convolutional codes and Reed Solomon codes have different characteristic in terms of handling the errors, therefore their concatenation lead to give benefits in BER performance Typically, the inner code is not a block code on the other hand a soft-decision convolutional Viterbi-decoded code with a short constraint length[13]. For the outer code, a longer hard-decision block code, frequently a Reed-Solomon code with eight-bit symbols, is used[14],[18]. The larger symbol size makes the outer code more robust to error bursts that can ensue due to channel impairments[14],[18]. An interleaving layer is usually added between the two codes to spread error bursts across a wider range [18].

V. RESULTS & SIMULATION

A full system model was implemented in MATLAB™ conferring to the above described system for different coding techniques. Performance analysis is completed for different code rates by taking random data stream of well-defined length for each of the coding systems. Here we transmit our information or data by using OFDM technique. Fig. 3 shows the estimation of carrier frequency offset and timing offset of OFDM systems under the AWGN channel. Fig.4, 5 and 6 shows the BPSK, QAM and QPSK modulated signal from the message signal (input bit stream) adopting modulation techniques respectively.

A. Convolutional Code simulation

We have performed the simulations for only convolutional codes with different combination of modulation method for AWGN channel and Rayleigh fading channel and code rates, i.e. BPSK, 4 QAM, 8 QAM, 16QAM. The block length (n) taken is 171 and trace back length as 2. From fig.7 and 8, it can be seen that when we move lower modulation arrangement, i.e. BPSK to higher modulation scheme, i.e. QAM the BER performance decrease for the reason that we combined large no. of bit to form a symbol. For same modulation technique BER performance is different for different code rate. $\frac{E_b}{N_0} = 0: 18$ db.

B. RS Code Simulation

Next we have performed the simulations for RS codes for different block lengths and different modulation technique. We can see from fig.9, as the block length increases the BER performance improves also it can be seen from the graph that the performance also improves for small values of code rate and when the

modulation complexity increase then BER performance decrease. The RS code, which is well suited for correction of burst errors, shows a poor BER performance for lower SNR values. Here $N=7$, $K=4$ and decision method is hard.

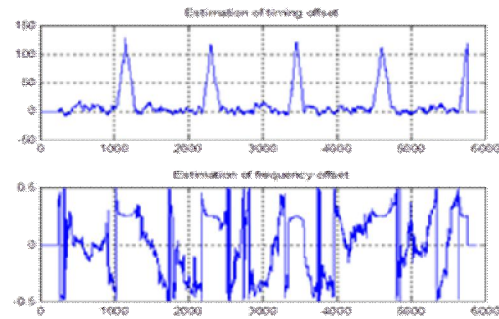


Fig.3 Estimation of carrier frequency offset and timing offset of OFDM systems

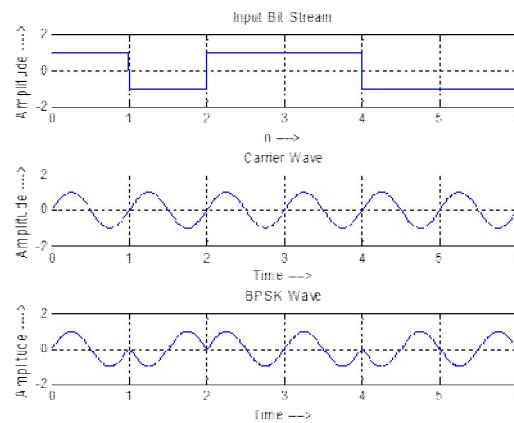


Fig.4 BPSK modulated signal

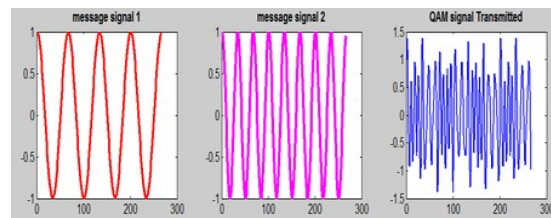


Fig.5 Quadrature amplitude modulated signal

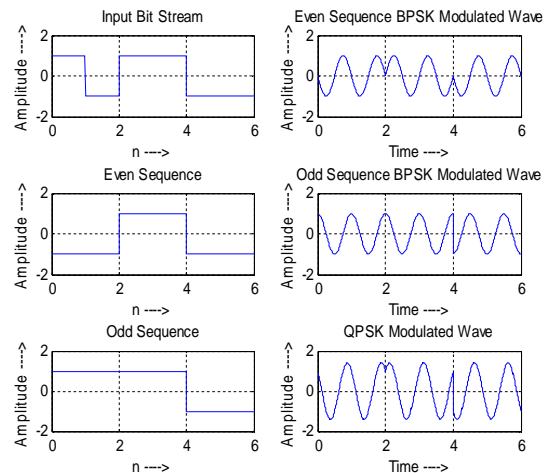


Fig.6 QPSK modulated signal

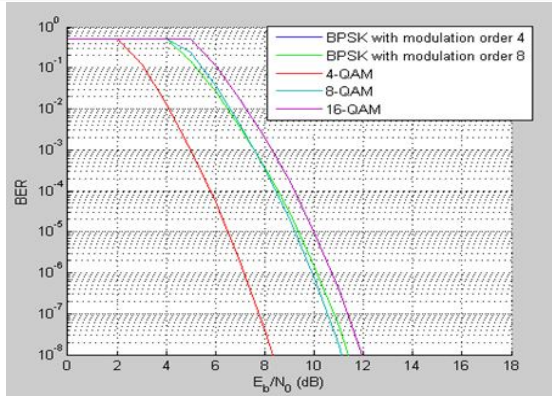


Fig.7 BER performance in AWGN channel for different modulation (for convolutional codes)

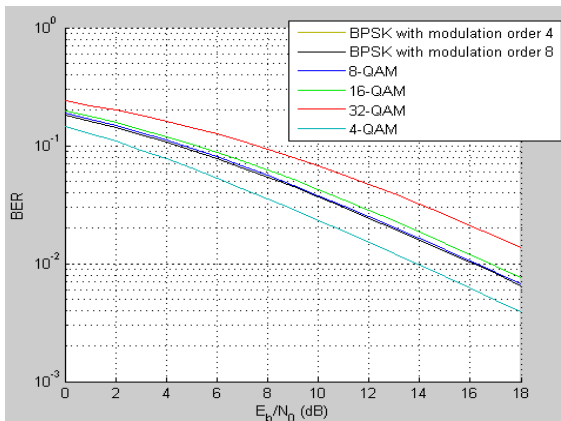


Fig.8 BER performance in Rayleigh Fading channel for different modulation (for convolutional codes)

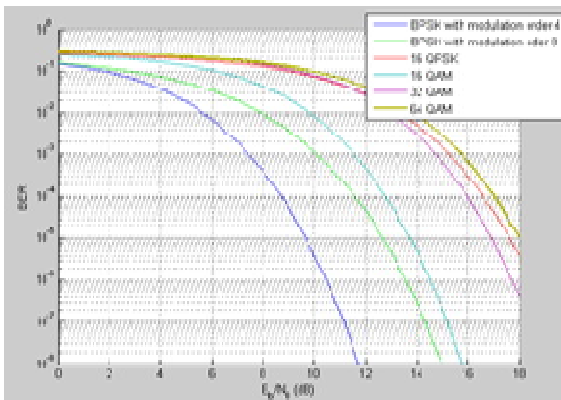


Fig.9 BER performance in AWGN channel for different modulation (for RS codes)

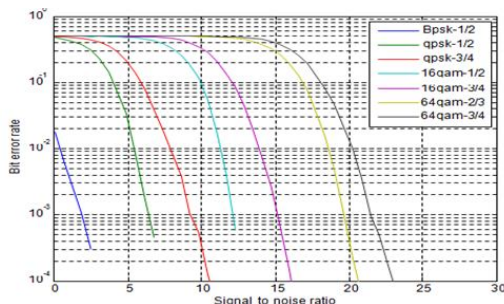


Fig.10 BER performance on AWGN channel using RS-CC FEC

C. Concatenated Code Simulation

We have also implemented simulation for

Concatenated codes. Here the outer code is RS code wherever the inner code is Convolutional code. The information bits go into the Reed Solomon encoder and the output of an RS encoder is the input of the Convolutional encoder. For the judgment of simulation results for single RS code and convolution code with the concatenated codes, we have the previous two results which we acquired from the RS and CC simulations made earlier in this paper. From fig.10, it can be declared that the performance of RS-CC concatenated code outperforms that of non-concatenated codes. It can be understood that RS-CC curve shows less flattening effect and has a better slope than the other two codes.

CONCLUSION

In this paper, different Forward Error Correction codes have been used for comparing the BER performance on AWGN channel and Rayleigh channel. Bit Error Rate of convolutional codes and RS codes has been discussed. In this case, we simulate different combination of modulating procedure with the code rate. The best outcomes of each of the two were used to model the concatenated codes. We have compared the performance of concatenated for data transmission. The simulation results check the outperformance of the concatenated codes RS-CC when compared to CC and RS codes provide a better result on same modulation and code rate.

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