BER Performance of OFDM Technique using RS Coding for Wireless Communication Systems

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Abstract

Orthogonal frequency division multiplexing (OFDM) is becoming the most important modulation technique for wireless communications. High capacity and variable bit rate information transmission with high bandwidth efficiency are just some of the requirements that the modern transceivers have to meet in order for a variety of new high quality services to be delivered to the customers. Digital modulation techniques contribute to the evolution of our mobile wireless communications by increasing the capacity, speed and quality of wireless networks. But the BER is the major part of any modulation technique. In this paper, the BER performance of various modulation techniques like BPSK, QPSK, 8-PSK and 16- PSK is analyzed using RS coding implementation under AWGN channel.

Keyword: *OFDM, RS coding, AWGN, BER etc.*

I. INTRODUCTION

Wireless communications is an emerging field, which has seen enormous growth in the last several years. So to fulfill that requirement the advance modulation formats in terms of bandwidth competence are required to support higher data rates which are not supported by current systems. In recent time many new applications are emerging, not just in the wired environment, but also in the mobile one that need fast speed. However, demands of the wireless multimedia broadband system are anticipated within both public and private sector [2]. High data rate transmission over mobile or wireless channels is required by many applications. However, the symbol duration reduces with the increase of the data [4]. In past, only low bit-rate data services are available to the mobile users that use only radio signal. The main problem with reception of radio signals is fading caused by multipath propagation. Also, there are inter-symbol interference (ISI), shadowing, and interference [15]. This makes link quality changes periodically. OFDM is a powerful modulation technique used to achieve a high data rate and is able to eliminate inter-symbol interference (ISI) [3].Many wireless standards have adopted the OFDM technology as a mean to increase dramatically future wireless communications. The reason behind OFDM's increased popularity is the desire for faster wireless technologies and the increase in multimedia applications, which require higher speeds. OFDM is a wideband modulation scheme that is specifically able to cope with the problems of the multipath reception. This is achieved by transmitting many narrowband overlapping digital signals in parallel, inside one wide band. Increasing the number of parallel transmission channels reduces the data rate that each individual carrier must convey, and that lengthens the symbol period. Frequency division multiplexing and WDM are the very much popular in order to transmit high data rates over longer distances. In WDM systems all the channels are separated by a frequency band and analog filtering is needed in order to de-multiplex the different wavelength channels [1]. The OFDM is deriving from FDM and it is the advanced version of FDM Technique. It seems to be the optimal form of a multicarrier modulation scheme. It employs modern digital modulation technique FFT (Fast Fourier transform), which inherently avoids bank of oscillators, demodulators and filters [2]. OFDM is the modulation technique used in many new broadband communication schemes, including digital television, digital audio broadcasting, ADSL, 4G mobile communications and wireless LANs [3].

II. OFDM PRINCIPLE AND GENERATION

Multimedia communication has a rather large demand upon bandwidth and quality of service (QoS) compared to what is available today to the mobile user. Bitrates for multimedia span from a few Kb/s, for voice, to about 20 Mb/s for HDTV, or even more in the peaks [2]. Orthogonal Frequency Division Multiplexing or OFDM is a multicarrier modulation format that is being used for many of the latest wireless and telecommunications standards. OFDM has been adopted in the Wi-Fi arena where the standards like 802.11a, 802.11n, 802.11ac [7].OFDM is a frequency-division multiplexing (FDM) scheme used as a digital multi-carrier modulation method [15]. OFDM signal consists of a number of closely spaced modulated carriers. In OFDM, the computationally efficient Fast Fourier transform (FFT) is used to transmit data in parallel over a large number of orthogonal subcarriers [10]. However, OFDM uses the spectrum much more efficiently by spacing the channels much closer together. This is achieved by making all the carriers orthogonal to one another, preventing interference between the closely spaced carriers. The orthogonality allows simultaneous transmission on a lot of sub-carriers in a tight frequency space without interference from each other [8]. Each sub-carrier is modulated with a conventional modulation scheme (such as QAM or PSK) at a low symbol rate, maintaining total data rates similar to conventional single-carrier modulation schemes in the same bandwidth. OFDM is similar to FDMA in that the multiple user access is achieved by subdividing the available bandwidth into multiple channels that are then allocated to users [9]. Figure 1 shows the difference of sub carrier representation between FDM and OFDM.

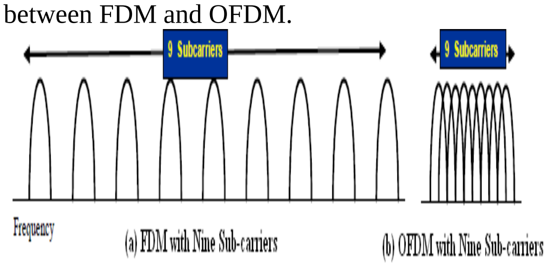

Figure1: FDM vs OFDM Sub Carrier Representation

The primary advantage of OFDM over single-carrier schemes is its ability to cope with severe channel condition without complex equalization filters. Channel equalization is simplified because OFDM may be viewed as using many slowly modulated narrowband signals rather than one rapidly modulated wideband signal. The low symbol rate makes the use of a guard interval between symbols affordable, making it possible to eliminate inter-symbol interference (ISI) and utilize echoes and time-spreading to achieve a diversity gain, i.e. a signal-to-noise ratio improvement. OFDM requires very accurate frequency synchronization between the receiver and the transmitter; with frequency deviation the sub-carriers will no longer be orthogonal. Any non-linearity will cause interference between the carriers as a result of inter-modulation distortion.

A. OFDM Transmitter:

The block diagram of OFDM transmitter is shown by figure 2. It consists of serial to parallel, mapping, IFFT, Guard Interval and DAC. The transmitter section converts the digital data to be transmitted, into a mapping of the sub-carrier's amplitude and phase using modulation techniques. The spectral representation of the data is then transformed into the time domain using an IFFT which is much more computationally efficient and used in all practical systems [11, 12]. The addition of a cyclic prefix to each symbol solves both ISI and inter-carrier interference (ICI) [13]. The digital data is then transmitted over the channel.

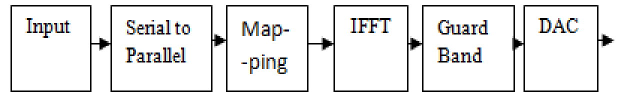

Figure 2: Block Diagram of OFDM Transmitter [6]

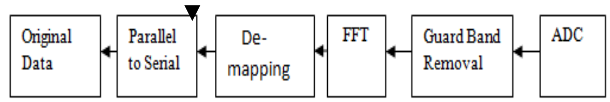

Figure 3: Block Diagram of OFDM Receiver [6]

B. OFDM Receiver:

The OFDM receiver block diagram is shown by figure 3. It consists of parallel to serial, De-mapping, FFT, Guard Interval removal and ADC block. The receiver performs the reverse operation to that of the transmitter. The amplitude and phase of the sub-carrier are then selected and converted back to digital data. The Fast Fourier Transform transforms a cyclic time domain signal into its equivalent frequency spectrum. This is done by finding the equivalent waveform, generated by a sum of orthogonal sinusoidal components. The amplitude and phase of the sinusoidal components represent the frequency spectrum of the time domain signal.

III. RS CODING

Reed–Solomon codes are a group of error-correcting codes that were introduced by Irving S. Reed and Gustave Solomon in 1960 [14]. The Reed–Solomon code is a [n, k, n − k + 1] code; in other words, it is a linear block code of length n (over F) with dimension k and minimum Hamming distance n − k + 1. The Reed–Solomon code is optimal in the sense that the minimum distance has the maximum value possible for a linear code of size (n, k); this is known as the Singleton bound. The error-correcting ability of a Reed–Solomon code is determined by its minimum distance, or equivalently, by n-k, the measure of redundancy in the block. If the locations of the error symbols are not known in advance, then a Reed–Solomon code can correct up to $\frac{(n-k)}{2}$ erroneous symbols, i.e., it can correct half as many errors as there are redundant symbols added to the block. Sometimes error locations are known in advance are called erasures. A Reed–Solomon code (like any MDS code) is able to correct twice as many erasures as errors, and any combination of errors and erasures can be corrected as long as the relation $2E + S \leq n - k$ is satisfied, where E is the number of errors and S is the number of erasures in the block. A Reed-Solomon decoder can correct up to t symbols that contain errors in a codeword, where 2t = n-k. Given a symbol size *s*, the maximum codeword length (n) for a Reed-Solomon code is $n = 2^s - 1$. They have many applications, the most prominent of which include consumer technologies such as CDs, DVDs, Blu-ray Discs, QR Codes, data transmission technologies such as DSL and WiMAX, broadcast systems such as DVB and ATSC, and satellite communication also.

IV. CHANNELS IN WIRELESS

Different type of channel that can be used for the Modulation and Propagation of radio signal are AWGN, Rayleigh and Rician Fading Channel.

A. AWGN Channel:

Additive White Gaussian Noise (AWGN) channel is a Channel Modal used for analyzing modulation schemes used for transmission of radio OFDM Signal. In this Modal the channel adds a white Gaussian noise to the OFDM signal which is passing through it. By this the signal gets two properties [8]. Amplitude frequency response is flat, means signal pass through channel without any amplitude loss and having infinity bandwidth. Phase frequency response is linear, so no phase distortion of frequency components. In AWGN channel the Received Signal is simplified to: r(t) = s(t) + n(t) Where r(t) is received signal and n(t) is the Additive White Gaussian Noise.

B. Rayleigh Fading Channel:

This type of channel is used when there is no direct path between transmitter and receiver. If there is no line of site then the constructive and destructive nature of Multipath Signal in flat fading can be approximated by Rayleigh Distribution. The received signal can be given as r(t) = s(t)*h(t) + n(t) ;Where r(t) is the received signal, h(t) is the random channel matrix and n(t) is the Additive White Gaussian Noise [8].

V. RESULTS

The simulation results using MATLAB performed on OFDM system under various modulation formats like QPSK, BPSK and 16 PSK etc. The performance for various BER vs. SNR plots for all the essential modulation with and without RS coding. The parameters that can be set at the time of initialization are the number of simulated OFDM symbols, CP length, modulation, range of SNR values and channel models for simulation. The input data stream is randomly generated. The channel used here in the model Additive White Gaussian Noise (AWGN) channel model. The figure 4 shows the transmitted and receiver data using OFDM modulation technique. The transmitted and the receiving data are same hence accuracy is more.

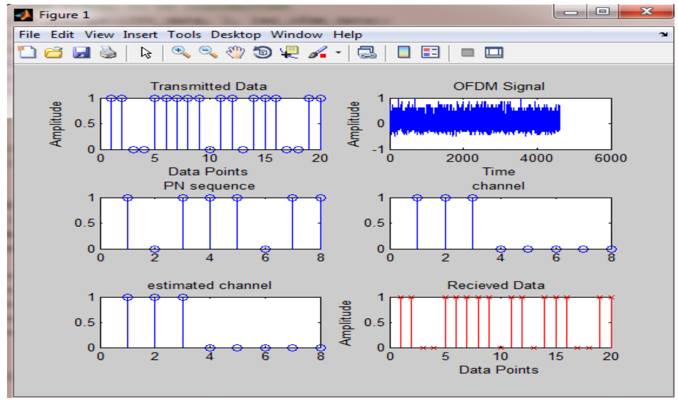

Figure 4: Transmitted and Receiver Data

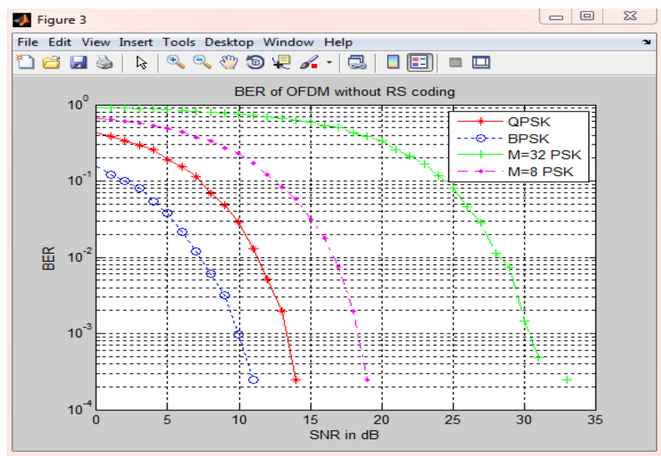

Figure 5: BER of OFDM without RS Coding

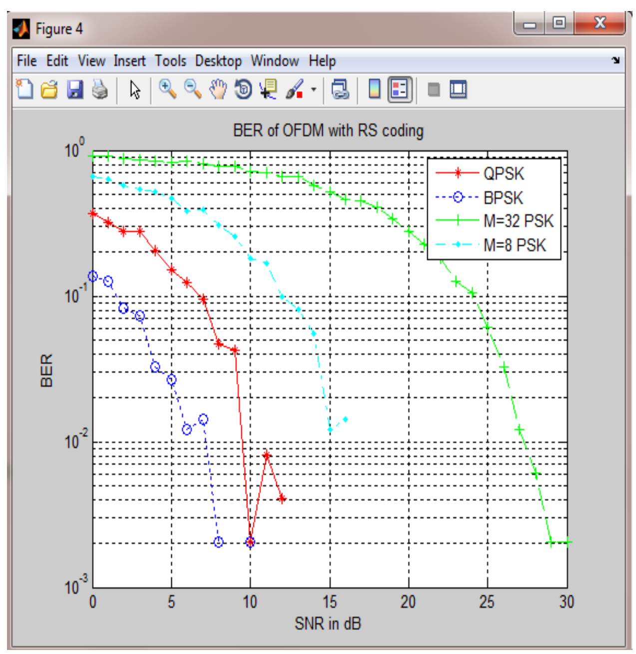

Figure 6: BER of OFDM with RS Coding

The figure 5 shows the result of model without RS coding and figure 6 shows the performance of BER of OFDM with RS coding. The performance of the system under BPSK modulation is quite satisfactory as compare to other modulation techniques in AWGN channel which is smaller than that of other modulation techniques when RS coding is used.

VI. CONCLUSION

OFDM can be considered as promising technique to reduce the effects of multipath fading in wireless communications. OFDM is a powerful modulation technique to achieve high data rate and is able to eliminate ISI. It is computationally efficient due to its use of FFT techniques for implementing modulation and demodulation functions. But there is a problem of BER (bit error rate) which cause the error in data. The solution to this problem is to increase the value of the SNR so, that the effect of the distortions introduced by the channel will also goes on decreasing, as a result of this, the BER will also decreases at higher values of the SNR. In this paper, the BER performance of an OFDM system under digital modulation schemes, namely BPSK, QPSK, 8- PSK and 16-PSK, over an AWGN channel using MATLAB by implementation RS coding and Without RS coding. The results show that the BER performance of BPSK using RS coding has a better than other modulation techniques used.

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