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Performance Analysis of MIMO-OFDM system with Zero Forcing Receiver

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Abstract

Next generation wireless communication technologies require multimedia service such as internet services, speech, image and mainly high data rate with high mobility. Orthogonal Frequency Division Multiplexing (OFDM) is an efficient method for 4G wireless systems because it promises data rates up to one Gbps stationary conditions and up to about 100 Mbps under vehicular conditions. The Multiple Input and Multiple Output (MIMO) technique provides increased link capacity, spectral efficiency and high data rate. MIMO is used to increase the diversity gain and to enhance the system capacity on time-variant and frequency-selective channels. Combining these two technique resulting MIMO-OFDM system to get the advantage of both the technologies. In this paper, Zero Forcing receiver is used to analyze the performance of MIMO-OFDM system. Simulation results show that improved Bit Error Rate (BER)is obtained with MIMO-OFDM system than the OFDM system. In addition Bit Error Rate (BER) performance is also investigated for different number of transmitting and receiving antennas and different modulation techniques.

Keywords: *Orthogonal Frequency Division Multiplexing (OFDM), 4G, Multiple Input and Multiple Output (MIMO), MIMO-OFDM, Zero Forcing receiver, Bit Error Rate (BER)*

1. Introduction

Second generation (2G) digital mobile communication system has better performance, but the bandwidth is restricted. For accessing high speed and reduce buffering time 3G technology has developed. But with the continuous development of data, images, video, and other multimedia applications, the available data rate will be quickly saturate. This increases the demand of bandwidth. The 4G system comes into the picture to enhance the data rate and cover the whole earth. In 4G OFDM is used where the available spectrum is divided into many overlapping carriers which can save fifty percent bandwidth. In frequency selective channel, delay spread of the channel impulse response introduces inter-symbol interference (ISI) in a single carrier system, which causes severe system performance degradation. OFDM effectively counters the channel delay spread by converting channel into a number of overlapping but mutually orthogonal sub-channels in frequency domain. By sending information in parallel with larger symbol durations, OFDM systems avoid the ISI significantly and increase data rate [1-3]. In order to transmit data with high speed and high capacity, the wireless communication should have very high spectrum efficiency and the capacity of overcoming the channel fading in the environment of multi-path channel. It is very difficult to match these requests for the traditional modulation technique, but the MIMO-OFDM system can meet the requirements. The data rate can be further increased via the exploitation of the MIMO technique. MIMO offers additional parallel channels in spatial domain to boost the data rate. Hence, MIMO-OFDM is a promising combination for the high data requirement of future wireless systems [4,5]. The rest of the paper is organized as follows: Section 2 describes the transmitter and receiver model for MIMO-OFDM system. Performance results are shown in section 3 and paper is concluded in section 4.

2. System Model

System model consists of MIMO-OFDM transmitter and MIMO-OFDM receiver, described in next section

2.1 MIMO-OFDM Transmitter

MIMO-OFDM is a 4G system model. It is used to enhance the data rate transmission between transmitter and receiver. There are different MIMO techniques which make possible to transmit data through multiple antenna and receive data through multiple antenna. For MIMO technique Space Time Block code is used.

Fig.1 shows simulation model of MIMO-OFDM transmitter model. Randomly generated data are processed in each block of the simulation model.

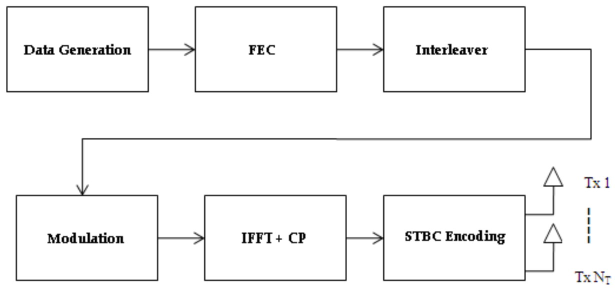

Fig.1OFDM Transmitter Model

The multicarrier modulated signal is obtained after IFFT processing. The OFDM modulated signal is given by

$$s(k) = \sum_{i=1}^{M} s_k \, e^{2\pi k \Delta f t} \qquad 0 \le t \le T_s \tag{1}$$

Where T_s, Δf and M are the symbol duration, the subcarrier space, and number of subcarriers of the OFDM signals, respectively. These multicarrier modulated signals are encoded by STBC encoding technique. Finally, these signals are transmitted through multiple transmitting antennas.

2.2 MIMO-OFDM Receiver

Receiver model of MIMO-OFDM with N_T transmit antennas and N_R receive antennas is shown in Fig-2. Space–time processing converts the transmitted symbol or data stream $\{s_n\}$ into N_T substreams $\{s_k^{(m)}\}$ and transmitted through different antennas. The signal at receiving antennas is given by [3]

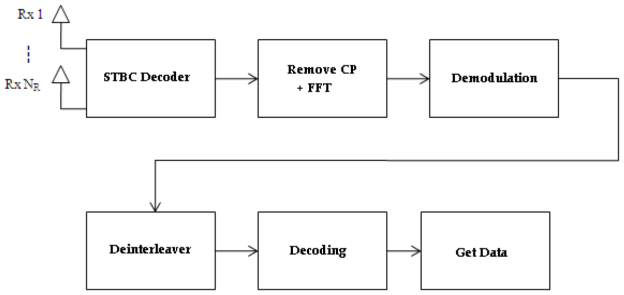

Fig.2OFDM Receiver Model

$$r_k^i = \sum_{m=1}^{N_T} H_k^{(i,m)} \, s_k^m + \eta_k^i \tag{2}$$

For $i = 1, \dots, N_R$, where $H_k^{(i,m)}$ denotes the frequency response t the kth subchannel corresponding to the mth transmit and the ith receive antenna, and η_k^i is the channel noise at the kth subchannel of the ith receive antenna. Received signal is decoded by STBC decoder.

For STBC decoder Zero Forcing (ZF) receiver is used. The received signal can be expressed as

$$r = Hs + \eta \tag{3}$$

For perfect channel state information (CSI) estimated sequence r_e is given by

$$r_e = G\,(Hs + \eta) \tag{4}$$

Where $G = (H^H H)^{-1} H^H$ denotes pseudo inverse matrix. This output is passes through the every block of the receiver model. Finally after channel decoding we get the data.

3. Simulation Results

Physical layer of mobile WiMAX is simulated for MIMO-OFDM system by MATLAB. The OFDM simulation parameters are given in Table 1. The system used for simulation employs RS and convolution channel coding.

Table 1 OFDM parameters of fixed WiMAX

S.No	Parameters	Values
1	FFT size	256
2	Number of used data subcarrier	192
3	Number of pilot subcarrier	8
4	Number of null/guardband subcarrier	56
5	Cyclic prefix	1/4
6	Coding rate	½, ¾

In Fig-3 comparison is shown among the transmitting antennas (N_T = 2) and receiving antennas (N_R = 1, 2 and 4) for 16 QAM modulation techniques. From the results it is observed that improvement in BER with increasing receiving antennas.

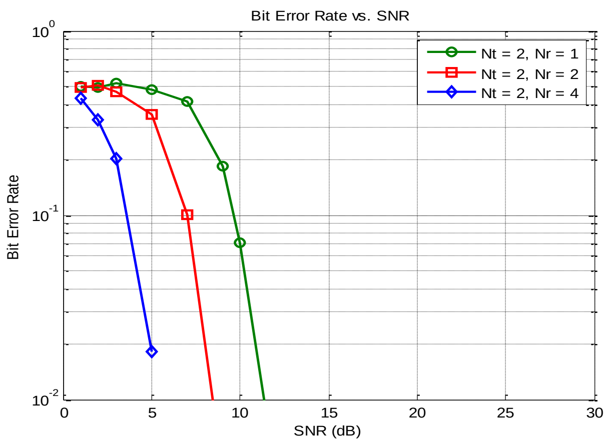

Fig.3 BER versus SNR for 16 QAM, overall rate r = ½.

BER of OFDM system for different modulation techniques is compared in Fig-4, 5 and 6 at N_T = 2 and receiving antennas N_R = 1, 2 and 4 respectively. BER for 16QAM overall rate r = 3/4 is better than the 16QAM overall rate r = ½ and QPSK overall rate r = ¾.

BER of OFDM system for with MIMO and without MIMO technique is compared in Fig-7 and 8 for different modulation techniques. From results it is clear that with MIMO technique BER is less than the without MIMO technique.

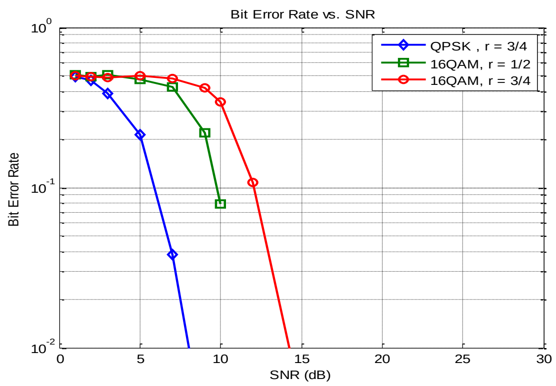

Fig.4 BER versus SNR at $N_T = 2$, $N_R = 1$.

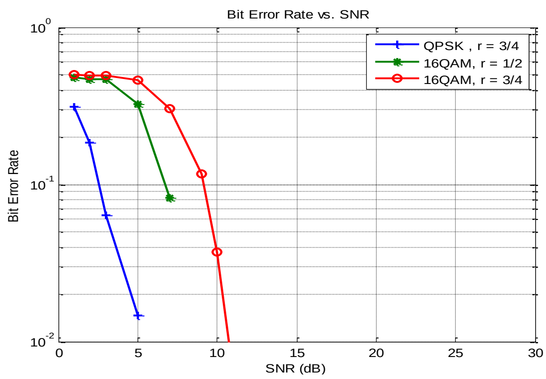

Fig.5 BER versus SNR at $N_T = 2$, $N_R = 2$.

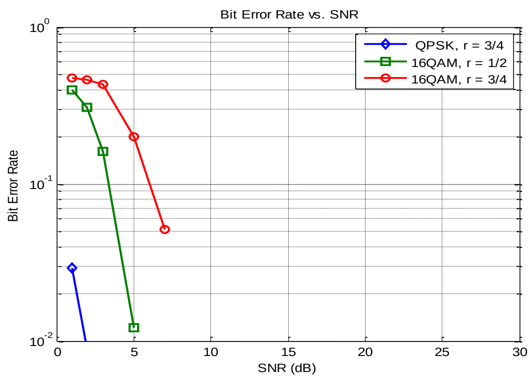

Fig.6 BER versus SNR at $N_T = 2$, $N_R = 4$.

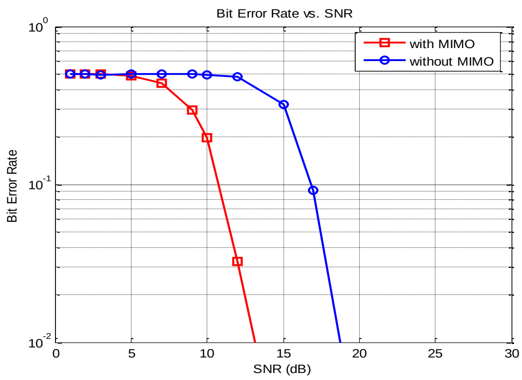

Fig.7 BER versus SNR for64QAM, overall rate r = 2/3, $N_T = 2$, $N_R = 4$.

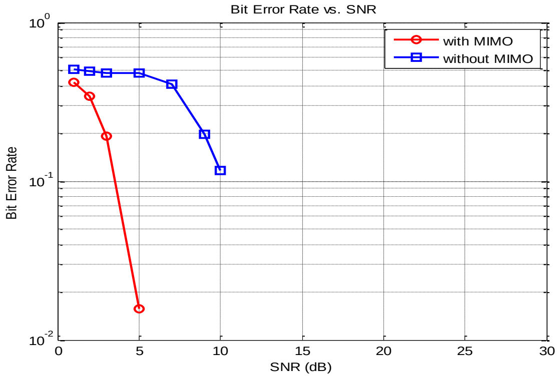

Fig.8 BER versus SNR for 16QAM, overall rate r = 1/2,N_T = 2, N_R = 4.

Conclusions

In this paper MIMO-OFDM with ZF receiver is investigated. Simulation results show that improved Bit Error Rate (BER) is obtained with MIMO-OFDM system than the OFDM system. In addition Bit Error Rate BER performance is also investigated for different number of transmitting and receiving antennas and different modulation techniques. Performance of system also improves by increasing transmitting and receiving antennas. On comparing the performance among the different modulation techniques, it is shown that minimum BER can be achieved with the lower modulation technique.

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