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COMPARISON OF BER AND NUMBER OF ERRORS WITH DIFFERENT MODULATION TECHNIQUES IN MIMO-OFDM WIRELESS COMMUNICATION SYSTEM

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ABSTRACT

This paper provides analysis of BER and Number of Errors for MIMO-OFDM wireless communication system by using different modulation techniques. Wireless designers constantly seek to improve the spectrum efficiency/capacity, coverage of wireless networks, and link reliability. So the performances of the wireless communication systems can be enhanced by using multiple transmit and receive antennas, which is generally referred to as the MIMO technique. Here analysis will be carried out for an OFDM wireless communication system using different modulation techniques and considering the effect and the wireless channel like AWGN, fading. Performance results will be evaluated numerically and graphically using the plots of BER versus SNR and plots of number of errors versus SNR.

KEYWORDS: *OFDM system, Multiple Input Multiple Output System, AWGN, Fading, PSK, QAM, BER.*

I. INTRODUCTION

The history of wireless communication starts from 100 years ago. This technology has removed so many problems associated by cables or cords. Today, it is possible for portable device to transfer data without being physically connected to computer or any other device. Wireless technology makes our life easy and comfortable and also the demand on bandwidth and spectral availability are endless. However, the designers have got difficult task of limited availability of radio spectrum, fading, multi-path, interference, to meet the demand for high data rate.

Multiple-input multiple-output (MIMO) technology is attractive technique in the design of wireless communications systems, and is already at the core of several wireless standards.

By applying MIMO technology, we can directly take advantage of 2 very important properties [8];

1. Diversity.
2. Multiplexing.

Diversity means that the system provide a receiver with multiple copies of the same information bearing signal, the duplicated signals are slightly changed by fading.

1.1 Diversity Techniques

1.1.1 Space Diversity

In this antenna elements are sufficiently spaced apart to achieve independence between the transmitted and received signals. The spatial separation needs to be at least half the wavelength to obtain desired results.

1.1.2 Time Diversity

In this the same information is transmitted in different Time slots with the time slots separated by measures equal to or greater than the coherence time of the channel.

1.1.3 Frequency Diversity

In this the same information is transmitted on different carrier frequencies which are separated by measures equal to or greater than the coherence bandwidth of the channel. The reliability of the network is improved by taking advantage of the space and time diversity while the rate of transmission is improved by multiplexing.

1.2 Propagation Characteristics

In an ideal radio channel, the received signal would consist of only a single direct path signal, which would be a perfect reconstruction of the transmitted signal. However in a real channel, the signal is modified during transmission in the channel. The received signal consists of a combination of attenuated, reflected, refracted, and diffracted replicas of the transmitted signal. On top of all this, the channel adds noise to the signal and can cause a shift in the carrier frequency if the transmitter or receiver is moving (Doppler Effect). Understanding of these effects on the signal is important because the performance of a radio system is dependent on the radio channel characteristics [6] [10].

1.2.1 Attenuation

Attenuation is the drop in the signal power when transmitting from one point to another. It can be caused by the transmission path length, obstructions in the signal path, and multipath effects [10].

1.2.2 Multipath Effects

Rayleigh Fading

In a radio link, the RF signal from the transmitter may be reflected from objects such as hills, buildings, or vehicles. This gives rise to multiple transmission paths at the receiver. The relative phase of multiple reflected signals can cause constructive or destructive interference at the receiver.

Frequency Selective Fading

In any radio transmission, the channel spectral response is not flat. It has dips or fades in the response due to reflections causing cancellation of certain frequencies at the receiver. Reflections off near-by objects (e.g. ground, buildings, trees, etc) can lead to multipath signals of similar signal power as the direct signal. This can result in deep nulls in the received signal power due to destructive interference.

1.2.3 Delay Spread

Delay spread is the time spread between the arrival of the first and last multipath signal seen by the receiver. In a digital system, the delay spread can lead to inter-symbol interference.

1.2.4 Doppler Shift

When a wave source and a receiver are moving relative to one another the frequency of the received signal will not be the same as the source. When they are moving toward each other the frequency of the received signal is higher than the source, and when they are approaching each other the frequency decreases. This is called the Doppler Effect [8].

The outline of this paper is as follows. In Section 2, we provide introduction of OFDM and general structure of OFDM under we study OFDM modulator. In Section 3, we study the modulation techniques used for the performance evaluation of OFDM communication system in terms of BER and Number of Errors. Methodology for the comparison of MIMO-OFDM Communication system is given in Section 4. Section 5 provides simulation results giving the comparison of BER and Number of Errors. Finally, Section 6 presents our Conclusions and Section 7 presents future work.

II. OFDM

OFDM can be seen as either a modulation technique or a multiplexing technique. One of the main reasons to use OFDM is to increase the robustness against frequency selective fading or narrowband interference. In a single carrier system, a single fade or interferer can cause the entire link to fail, but in a multicarrier system, only a small percentage of the subcarriers will be affected [4]. Error correction coding can then be used to correct for the few erroneous subcarriers.

2.1 General Structure

The basic principle of OFDM is to split a high-rate data-stream into a number of lower rate streams that are transmitted simultaneously over a number of subcarriers[10]. The other problem to solve is the intersymbol interference, which is eliminated almost completely by introducing a guard time in every OFDM symbol. This means that in the guard time, the OFDM symbol is cyclically extended to avoid inter-carrier interference. An OFDM signal is a sum of subcarriers that are individually modulated by using phase shift keying (PSK) or quadrature amplitude modulation (QAM) [6]. The symbol can be written as:

$$s(t) = \mathrm{Re}\left\{\sum_{i=-N_s/2}^{\frac{N_s}{2}-1} d_{i+\frac{N_s}{2}} \exp(j2\pi(f_c - \frac{i+0.5}{T})(t-t_s))\right\},\ t_s \le t \le t_s + T \qquad (1)$$

$$s(t) = 0,\ \ t < t_s \text{ and } t > t_s + T$$

Where:
NS is the number of subcarriers
T is the symbol duration
fc is the carrier frequency
The equivalent complex baseband notation is given by:

$$s(t) = \sum_{i=-\frac{N_s}{2}}^{\frac{N_s}{2}-1} d_{i+\frac{N_s}{2}} \exp\left(j2\pi\frac{i}{T}(t-t_s)\right),\quad t_s \le t \le t_s + T \qquad (2)$$

$$s(t) = 0\,,\ \ t < t_s \text{ and } t > t_s + T$$

In this case, the real and imaginary parts correspond to the in-phase and quadrature parts of the OFDM signal. They have to be multiplied by a cosine and sine of the desired frequency to produce the final OFDM signal.

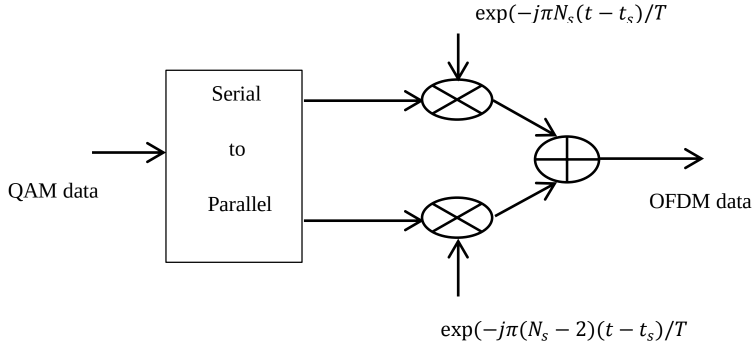

Figure 1. OFDM Modulator

III. MODULATION TECHNIQUES

3.1 Phase Shift Keyed (PSK)

An alternative to imposing the modulation onto the carrier by varying the instantaneous frequency is to modulate the phase. This can be achieved simply by defining a relative phase shift from the carrier, usually equidistant for each required state. Therefore a two level phase modulated system, such as Binary Phase Shift Keying, has two relative phase shifts from the carrier, + or - 90o [6]. Typically this technique will lead to an improved BER performance compared to MSK. The resulting signal will, however, probably not be constant amplitude and not be very spectrally efficient due to the rapid phase discontinuities. Some additional filtering will be required to limit the spectral occupancy. Phase modulation requires coherent generation and as such if an IQ modulation technique is employed this filtering can be performed at baseband.

3.2 QAM

Quadrature amplitude modulation (QAM) is both an analog and a digital modulation scheme. It conveys two analog message signals, or two digital bit streams, by changing (modulating) the amplitudes of two carrier waves, using the amplitude-shift keying (ASK) digital modulation scheme or amplitude modulation (AM) analog modulation scheme. The two carrier waves, usually sinusoids, are out of phase with each other by 90° and are thus called quadrature carriers or quadrature components, hence the name of the scheme. The modulated waves are summed, and the resulting waveform is a combination of both phase-shift keying (PSK) and amplitude-shift keying (ASK)[6], or (in the analog case) of phase modulation (PM) and amplitude modulation. In the digital QAM case, a finite number of at least two phases and at least two amplitudes are used. PSK modulators are often designed using the QAM principle, but are not considered as QAM since the amplitude of the modulated carrier signal is constant. QAM is used extensively as a modulation scheme for digital telecommunication systems. Arbitrarily high spectral efficiencies can be achieved with QAM by setting a suitable constellation size, limited only by the noise level and linearity of the communications channel.

IV. METHODOLOGY

Various steps that has been used to implement the above mentioned design are as follows

a. Generation of data and modulation

1. Declaration of various parameters i.e. number of bits, number of subcarriers, levels of FFT, number of constellations, number of cyclic prefixes and input SNR.
2. Generation of Binary data (data to be transmitted) depending on number of bits.
3. Construction of an object to modulate binary data using PSK and QAM depending on number of constellation and type of input data.
4. Modulation of data on modulator.
5. Conversion of data from serial to parallel.

b. STBC encoding

1. Grouping of data bits at size of 8
2. Again division of grouped bits into size of 4.
3. Formation of 2 data symbol matrix i.e. x1 and x2.
4. Calculation of complex conjugate of both matrix bits so as to form imaginary part of data bits which will be orthogonal from their data bits.

c. Transmission of data

1. Designing of OFDM transmitter so as to transmit the data depending on level of FFT, number of cyclic prefixes and number of bits.
2. Transmission of all 4 digital data symbol matrices using OFDM transmitter.
3. Designing of transmission channel depending on number of bits and number of subcarriers.
4. Insertion of pilot and guard bits.
5. Designing of Additive White Gaussian Noise depending on number of subcarriers, levels of FFT, number of cyclic prefixes.
6. Mixing of transmitted data and AWGN with consideration of effective input SNR.

d. Reception of data

1. Designing of receiver depending upon number of subcarriers, levels of FFT, number of cyclic prefixes.
2. Reception of data with removal of all additional guard and pilot bits.
3. Construction of an object to demodulate binary data using PSK and QAM depending on number of constellation and type of input data.
4. Demodulation of data from modulator.

5. Conversion of data from parallel to serial.
6. Calculation of number of errors by comparing transmitted and received data.
7. Calculation of BER by using number of errors.
8. Plotting of curve indicating value of BER at each input SNR value.
9. Plotting of Transmitted signal mapping Constellation.
10. Plotting of Number of errors at each input SNR value.

V. RESULTS

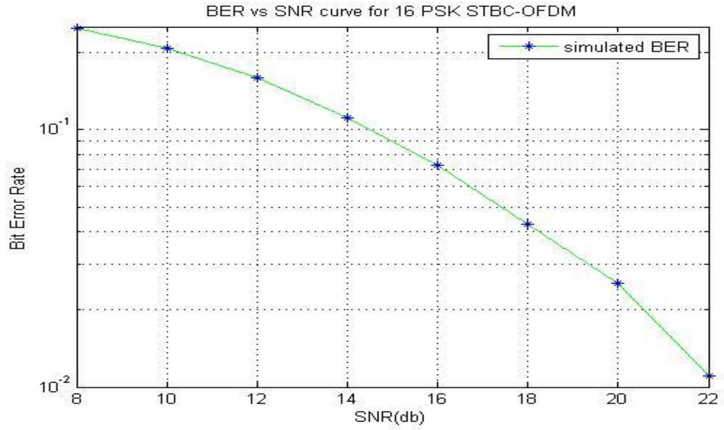

Figure 2. Plot of BER versus SNR for 16 PSK MIMO-STBC-OFDM System

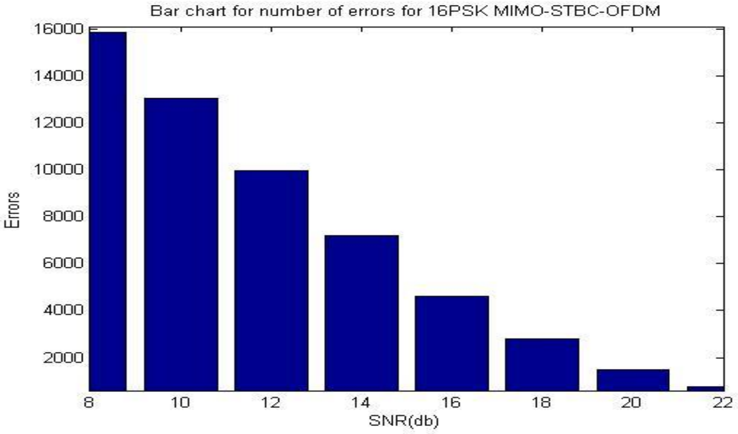

Figure 3. Bar Chart for Number of Errors for 16 PSK MIMO-STBC-OFDM System

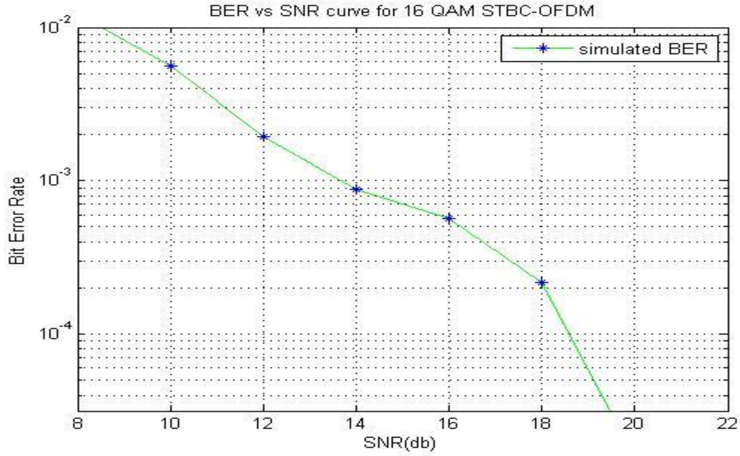

Figure 4. Plot of BER versus SNR for 16 QAM MIMO-STBC-OFDM System

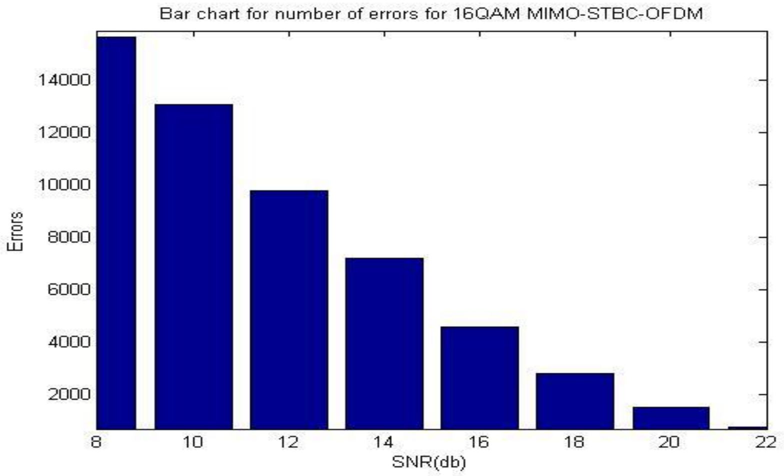

Figure 5. Bar Chart for Number of Errors for 16 QAM MIMO-STBC-OFDM System

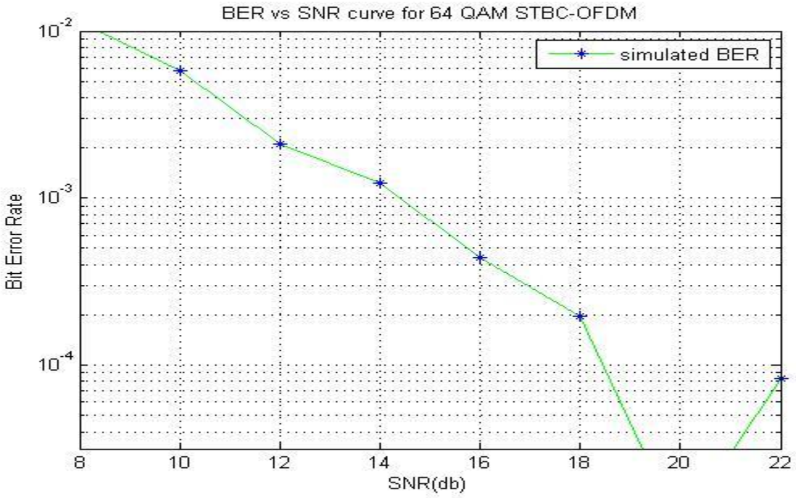

Figure 6. Plot of BER versus SNR for 64 QAM MIMO-STBC-OFDM System

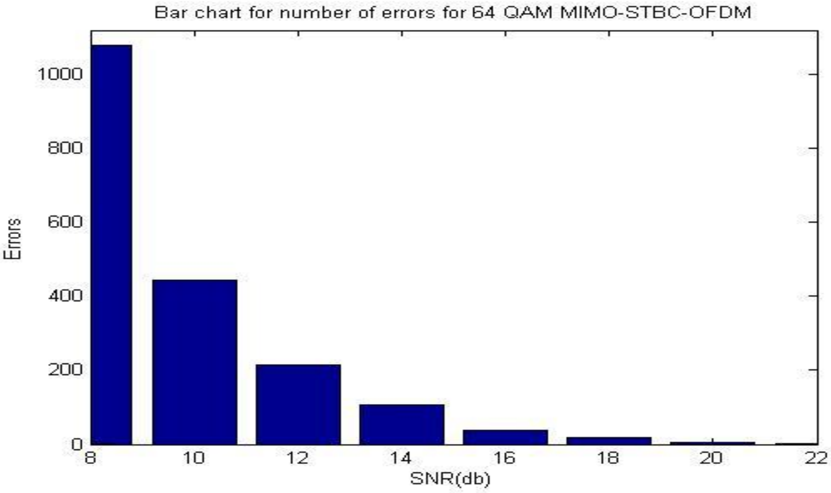

Figure 7. Bar Chart for Number of Errors for 64 QAM MIMO-STBC-OFDM System

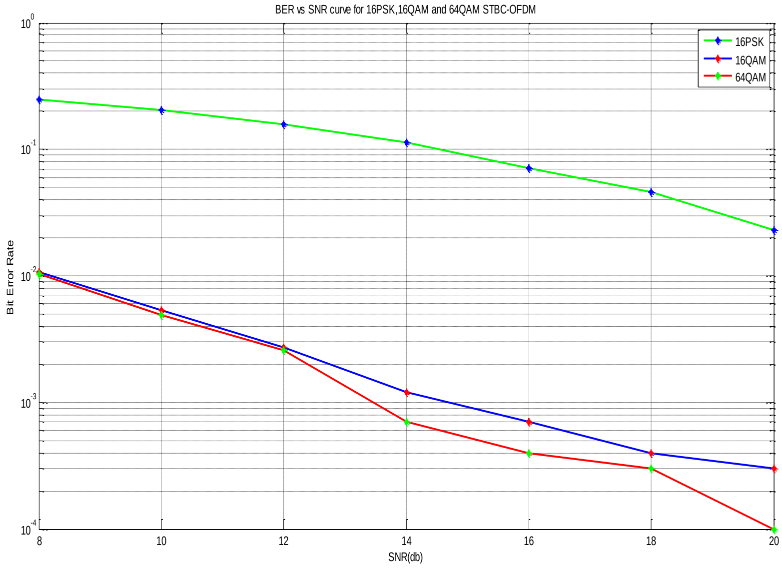

Figure 8. Plot of BER versus SNR for 16 PSK and 16 QAM and 64 QAM MIMO-STBC-OFDM System

Table 1: Comparison of BER and Number of Errors

16-PSK			**16-QAM**		**64-QAM**	
SNR	**BER**	**No. of error**	**BER**	**No. of Error**	**BER**	**No. of Errors**
8 db	0.2454	15998	0.0121	15763	0.0106	1011
22 db	0.0116	804	0	777	0	1

VI. CONCLUSION

After the complete analysis it is concluded that performance of MIMO-OFDM wireless communication system get improves with increase in modulation order. BER and Number of Errors are much larger when we use 16-PSK modulation and these are minimum when we use 64- QAM modulation. So, it can be concluded that 64 QAM MIMO-OFDM is better for maximum throughput and minimum Bit error rate as BER and number of errors are much larger in case of 16 PSK and 16 QAM MIMO-OFDM.

VII. FUTURE WORK

Further works could be done in other schemes which are enhancing both the capacity of channel and diversity. Moreover, MIMO Channel modelling is the key area in wireless system and it needs more work. Future step is to overcome hurdles associated with Blind recognition. CP classifier is purely blind method and it work efficiently in non-cooperative environment at higher value of SNR but at low SNR its performance degrades and Blind CP classifier method is it not able to discriminate two STBC which have same length. So future step is used to improve the system performance and overcome these hurdles.

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