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Implementation of MIMO-OFDM with Zero Forcing Equalization

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Abstract: - In wireless communication, the receiver side BER strongly affected by channels noise, interference, distortion, synchronization error and wireless multipath fading channels, Multiple-input and multiple-output (MIMO) and system is the use of multiple antennas at both the ends to enhance spectral efficiency while channel equalization is mandatory to mitigate the effects of channel induced distortions. The obtained results demonstrate that spatial diversity along with the equalization significantly improves the error performance in frequency selective wireless fading channels. In this Paper, we propose a MIMO system with Orthogonal Frequency Division Multiplexing (OFDM) with zero forcing equalization. This Paper presents, a simulation system is implemented using different fading communication channel to study the performance analysis of Bit Error rate (BER) Vs Signal to Noise ratio (SNR).

Key Words: — ***Orthogonal Frequency Division Multiplexing (OFDM), Multiple Input Multiple Output (MIMO), Space Time Block Coding (STBC), fading, Bit Error Rate (BER).***

I. INTRODUCTION

Wireless communication operations, such as long-range communications that are impossible or impractical to implement with the use of wires. In the term is commonly used in the telecommunications industry to refer to telecommunications systems which use some form of energy (radio waves, acoustic energy, etc.) to transfer information without the use of wires. Information is transferred in this manner over both short and long distances communication.

The development of next generation mobile telecommunication systems the 4th in line - was inspired by the increasing user demands considering the data rate in 3G standards. Key feature of the 4G systems lies on the physical layer access. In a basic communication system, the data are modulated onto a single carrier frequency. The available bandwidth is then totally occupied by each symbol. OFDM has been adopted in several wireless standards such as digital audio broadcasting (DAB), digital video broadcasting, the standard IEEE 802.11a LAN standard and the IEEE 802.16a MAN standard. OFDM is also being pursued for dedicated short-range communications for the road side to vehicle communications and as a potential candidate for fourth generation (4G) mobile wireless systems.

The multiple antennas can be used at the transmitter and receiver, arrangement called a Multiple Input Multiple Output technique. The multiple input multiple output (MIMO) system takes advantage of the spatial diversity that is obtained by spatially separated antennas in a dense multipath scattering environment. The multiple input and multiple output schemes may be implemented in a number of different ways to obtain either a diversity gain to combat signal fading or to obtain a capacity gain. A multiple input multiple output techniques are three categories. It first aims to progress the power efficiency by maximizing spatial diversity. Techniques include delay diversity, STBC and STTC. In the second class uses a layered method to increase capacity. For example, of such a system is V-BLAST suggested through Foschini. where full spatial diversity is usually not achieved. A finally, the third type exploits the knowledge of communication channel at the transmitter system. The channel coefficient matrix using SVD and uses these decomposed unitary matrices as pre- and post-filters at the transmitter and the receiver to achieve near capacity [3].

To combat the effect of frequency selective fading, multiple input multiple output is generally combined with orthogonal frequency-division multiplexing system, which transforms the frequency-selective fading channels into parallel flat fading sub channels, as long as the cyclic prefix inserted at the beginning of each orthogonal frequency-division multiplexing symbol is longer than or equal to the channel length. The signals on each subcarrier can be easily detected by a one-tap frequency domain equalizer. In cases where a short cyclic prefix (CP) is inserted for growing bandwidth efficiency, before because of some unforeseen channel behavior scheme, the effect of frequency-selective fading cannot be completely eliminated, and inter carrier interference and inter symbol interference will be introduced. The signals on each subcarrier can be easily detected by a one-tap time domain equalizer. Equalization techniques are thus important in multiple input multiple output-orthogonal frequency-division multiplexing access systems.

These multiple input multiple output wireless technique, combined with orthogonal frequency-division multiplexing, in have allowed for the easy transmission of symbols in time, or frequency and space. Now different coding systems have been developed [2]. The example is the Alamouti Space Time Block code which could extract spatial and temporal diversity. And many other codes have also been proposed which have been able to achieve some or all of the available diversity in the channel at various transmission rates.

The space time block coding (STBC) is a technique used in wireless communications system to transmit multiple copies (data) of a data stream across a number of antennas and to exploit the various received versions of the data to improve the reliability of data-transfer system. The fact that the transmitted signal must traverse a possibly difficult environment through scattering, reflection, refraction and so on and may then be additional corrupted by thermal noise in the receiver means that some of the received copies of the data will be 'better' than others technique. This redundancy results in a higher chance of being able to use one or extra of the received copies to correctly decode the received data. In fact, space combines all the copies of the received signal in an optimal way to extract as much information from every of them as possible.

There are two main types of space-time codes, namely space-time block codes and space-time trellis codes. Space-time block codes operate on a block of input symbols, in producing a matrix output whose columns characterize time and rows represent antennas system [4]. It is contrast to single-antenna block codes for the AWGN channel communication, and space-time block codes (STBC) do not generally provide coding gain, and unless concatenated with an outer code. These code symbols are generated by the space-time encoder in such a way that coding gains, as well as high spectral efficiency are achieved. Their main feature is the provision of full diversity by very simple decoding scheme. The Space-time coding finds its application in cellular communications system well as in wireless local area networks.

II. Basics Of Equalization Under Frequency Selective Channels

The concept of equalization is fundamentally very important to mitigate the effects of noise and distortions induced by a channel. The block of a digital communication system with an equalizer is shown below

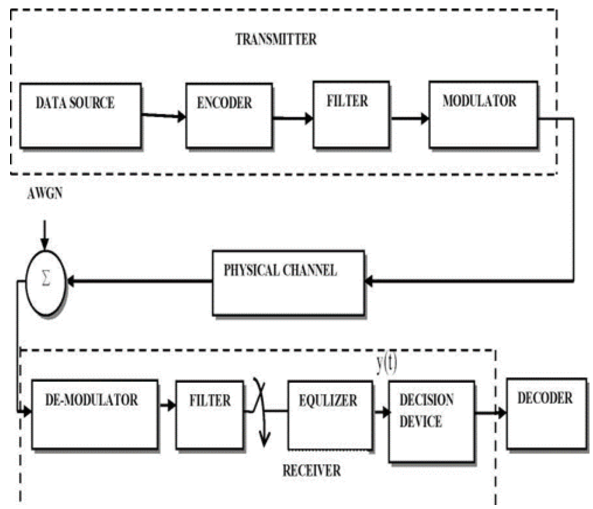

Fig.1 Block Diagram Digital Communication with Equalizer

The equalizer tries to mitigate the effects of the wireless channels that cause distortions at the receiver. It can be seen that the equalizer acts just prior to the receiver after sensing what the channel has done to a signal. In mobile radio channels always changes and multipath causes time dispersion of the digital information is known as inter-symbol-interference, it makes too difficult to detect the actual information at the receiver. Moreover, it cannot be rectified even by increasing the signal power at the transmitting end. Therefore, such errors are called **irreversible errors.** The only way out is to reverse the detrimental effects using equalizers so as to improve the reliability of communication through wireless and broadcast modes.

Let the channel have an impulse response h(t). Since any practical system can sense the channel in the discrete time domain, therefore the channel impulse response can be re-considered as h(n). Let the channel in the frequency domain be H(z). Then the output of the channel is:

$$y(n) = x(n) * h(n) \qquad (1)$$

$$Y(z) = X(z).H(z) \qquad (2)$$

Where, * stands for convolution

x(n) is the input to the channel

y(n) is the output of the channel

The aim at design of an equalizer is the design of a system with a transfer function

$$E(z) = \frac{1}{H(z)} \qquad (3)$$

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There are several ways in which the system with the transfer function E(z) can be practically implemented. The different techniques result in different equalizer structures. Different equalizer structures can be Linear Equalizers, MLSE Equalizers, Zero Forcing Equalizers, Adaptive Equalizers, and Decision Feedback Equalizers etc.

III. MIMO SYSTEMS

In multiple-input multiple-output (MIMO) communications, the system is equipped with multiple antennas at both the transmitter and the receiver technique. The multiple antenna scheme gives a more reliable performance through array gain, diversity and spatial multiplexing. These concepts are briefly discussed below.

The growing demand of multimedia services and the progress of Internet related contents lead to increasing interest to high speed communications network. The requirement for flexibility and wide bandwidth imposes the use of efficient transmission systems that would fit to the characteristics of wideband channels especially in wireless environment where the channel is very challenging process. In wireless environment the signal is propagating since the transmitter to the receiver along number of different paths, collectively referred as multipath communication. While propagating the signal power drops of due to the following effects: a path loss, macroscopic fading and microscopic fading. The fading of the signal can be mitigated by different diversity methods. To obtain diversity, in signal is transmitted through multiple independent fading paths in time, frequency or space and combined constructively at the receiver.

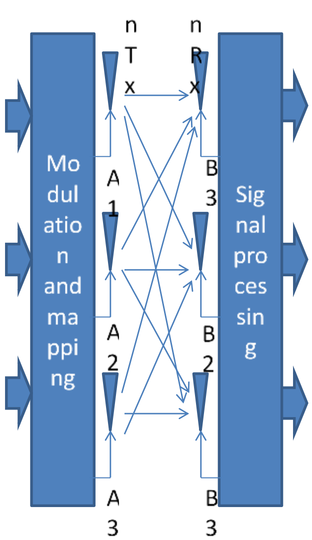

Fig.2. Block Diagram of a generic MIMO system with no. of transmitters and no. of Receivers

$$Rxx = E\{XX^H\} \qquad (4)$$

Orthogonal frequency division multiplexer transforms the frequency-selective fading channels into parallel flat fading sub channels, as long as the cyclic prefix inserted at the beginning of each orthogonal frequency division multiplexer(OFDM) symbol is longer than or equivalent to the channel length.

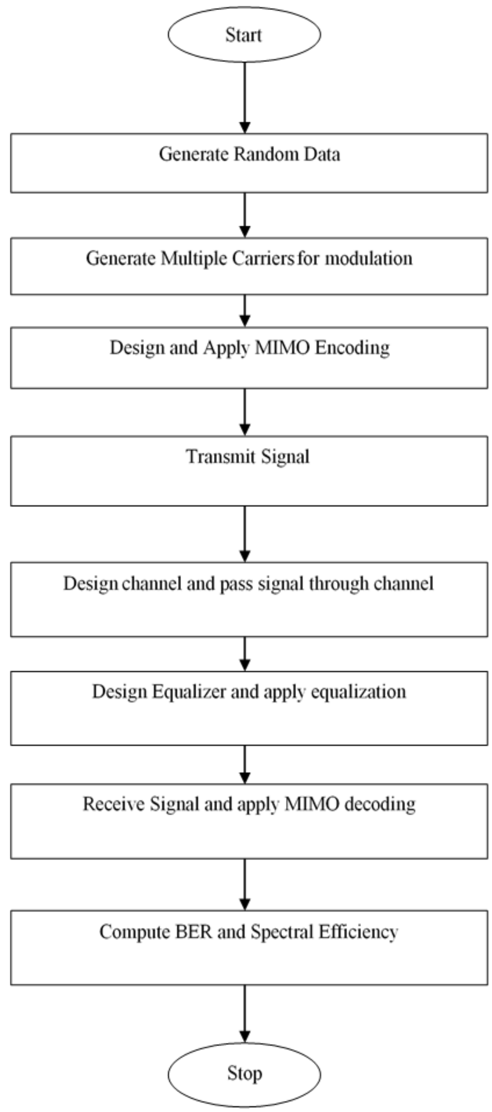

Fig.3. Flowchart of Proposed Algorithm

The channel length means the length of impulse response of the channel as discrete sequence. Signals on each subcarrier can be easily detected by a frequency domain and time-domain equalizer. Then the effect of frequency-selective fading cannot be completely eliminated, and inter-carrier interference and inter-symbol interference will be introduced in the received signal. The equalization techniques that could flexibly detect the signals in both cases are thus important in MIMO-OFDM systems [18].

The proposed algorithm can be thought to be the combination of MIMO for different channel models. The channel models used in this study are AWGN, Nakagami, Rayleigh and Rician. The flowchart of the proposed algorithm is given below. Space time block coding (STBC) is used in this case for implementing the Alamouti Scheme for MIMO.

IV. SIMULATION RESULTS

The BER performance for different fading channels is shown below. The BER and SNR curve for AWGN channel are shown below

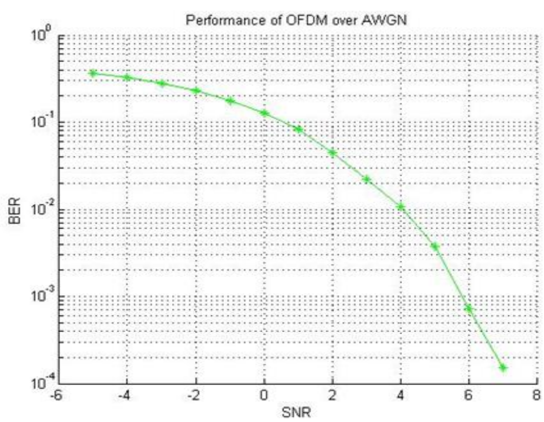

Fig.4. Performance of OFDM over AWGN channel

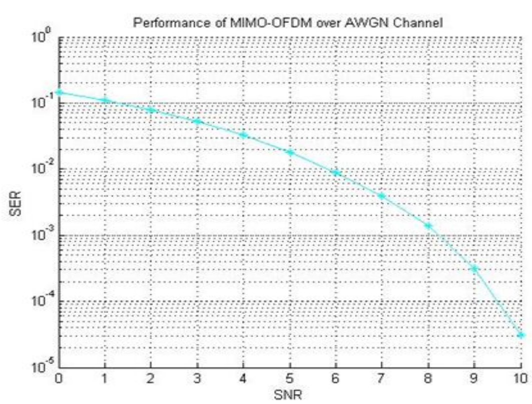

Fig.5. Performance of MIMO-OFDM over AWGN channel

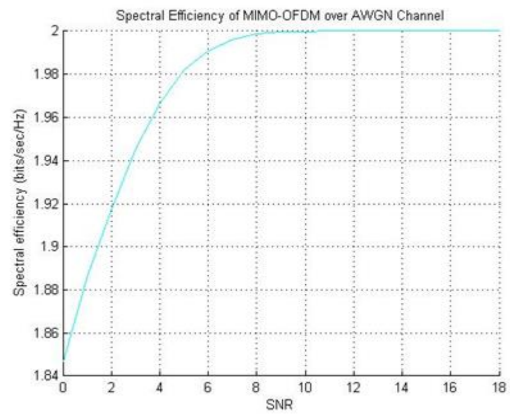

Fig.6. Spectral Efficiency of MIMO-OFDM over AWGN channel

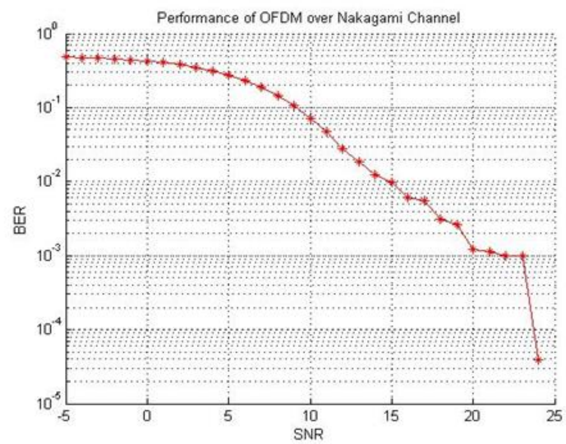

Fig.7. Performance of OFDM over Nakagami channel

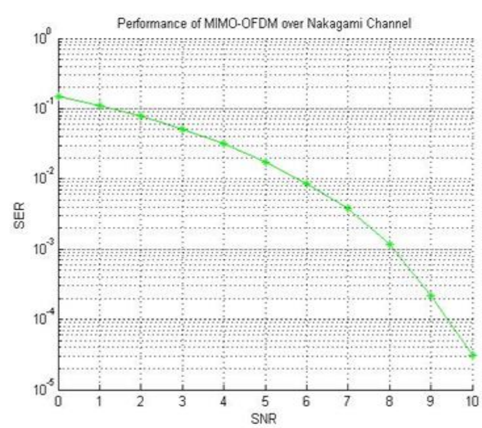

Fig.8. Performance of MIMO-OFDM over Nakagami channel

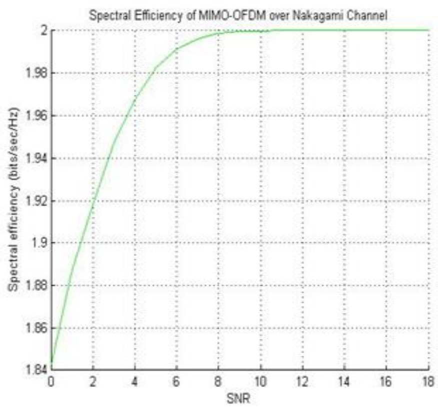

Fig.9. Spectral Efficiency of MIMO-OFDM over Nakagami channel

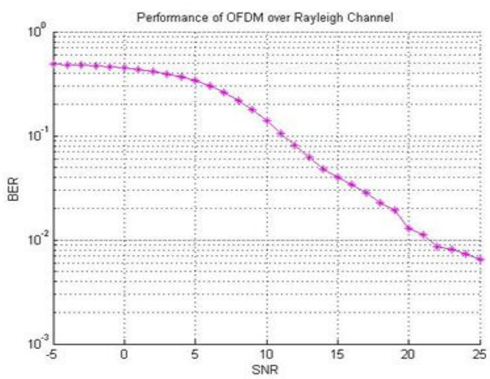

Fig.10. Performance of OFDM over Rayleigh channel

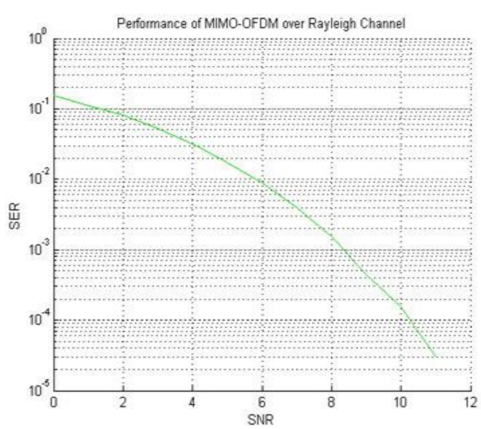

Fig.11. Performance of MIMO-OFDM over Rayleigh channel

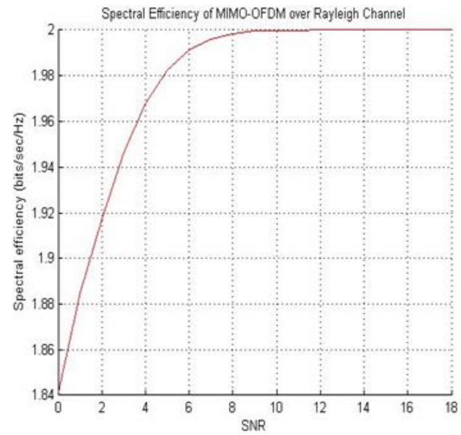

Fig.13. Spectral Efficiency of MIMO-OFDM over Rayleigh channel

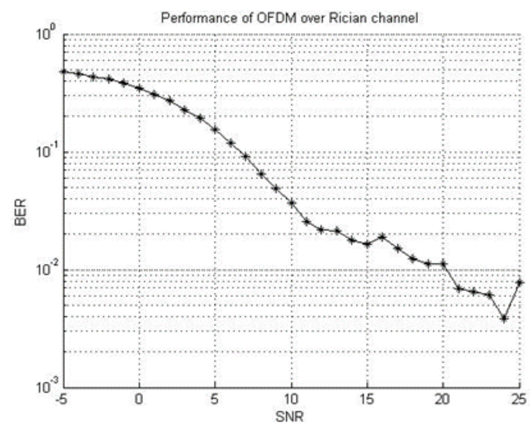

Fig.14. Performance of OFDM over Rician channel

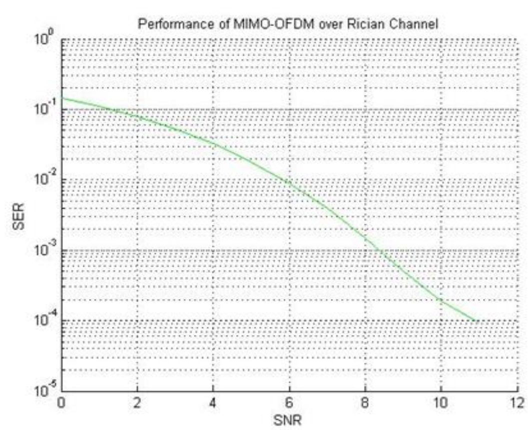

Fig.15. Performance of MIMO-OFDM over Rician channel

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Fig.16. Spectral-Efficiency of MIMO-OFDM over Rician channel

V. Conclusion

The Alamouti Scheme of using multiple transmitters and multiple receivers has been used, which makes the system see several channels between the different permutations of the multiple transmitters and receivers. This enhances channel capacity and hence improves spectral efficiency. It has been practically implemented using Space Time Block Coding.

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