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Performance Analysis of MIMO OFDM System under Different Fading Channels

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Abstract:
In this paper fading channel is analyzed by using different modulation techniques. In the proposed approach channel estimation and data detection methods for different MIMO-OFDM systems analyzed on Rayleigh and Rician fading channel. and propose work Multiple Input Multiple output communication system is combined with Orthogonal Frequency Division Multiple to achieve high data transmission rate over wireless channels. In this work 16-QAM modulation format with Gaussian shows better values of BER.

Keywords: MIMO, OFDM, QAM Modulation

I. INTRODUCTION

The most common wireless technologies use electromagnetic wireless telecommunications, such as radio. there are various types of fixed, mobile, and portable applications, including two-way radios, cellular telephones, personal digital assistants (PDAs), and wireless networking. other examples of applications of radio wireless technology include GPS units, garage door openers, wireless computer mice, keyboards and headsets, headphones, radio receivers, satellite television, broadcast television and cordless telephones. Wireless networking (e.g. the various types of unlicensed 2.4 GHz Wi-Fi devices) is used to meet many needs. Another common use is for mobile networks that connect via satellite. A wireless transmission method is a logical choice to network, a LAN segment that must frequently change locations. It will give a backup communication in case of emergency situations [1].

MIMO: The Multiple Input Multiple Output (MIMO) systems are equipped with multiple antennas at both the transmitter and receiver side in order to improve communication performance, in contrast to conventional communication systems with only one antenna on the transmitter and one antenna on the receiver. A MIMO system offers significant increases in data throughput and link range without additional bandwidth or transmits power. Multiple Input Multiple Output (MIMO) systems are a natural extension of developments in antenna array communication. While the advantages of multiple receive antennas, such as gain and spatial diversity have been known. The advantages of MIMO communication, which exploits the physical channel between many transmitter and receiver antenna, are currently receiving significant attention. MIMO systems provide a number of advantages over single antenna to single antenna communication [2]. Sensitivity to fading is reduced by the spatial diversity provided by multiple spatial paths. Under certain environmental conditions, the power requirements associated with high spectral-efficiency communication can be significantly reduced by avoiding the compressive region of the information-theoretic capacity bound. Here, spectral efficiency is defined as the total number of information bits per second per Hertz transmitted from one array to the other side of the channel [3].

OFDM: Orthogonal Frequency Division Multiple Access is a multiple access scheme employed in various communication systems for transmission of data. OFDMA has been selected by various standards like IEEE as its physical layer interface for next-generation wireless communication systems. OFDMA is a multichannel system in which many orthogonal sub-carrier signals which are closely spaced and having overlapped spectrum are employed for transmission of information. These orthogonal subs–carriers do not interfere with each other and provide robustness to channel fading and Inter Symbol Interference (ISI) [4]. Subcarrier signals are used to carry the input data. These subcarrier signals are generated using the SyQuest criterion for the multi-carriers. The data to be transmitted is first divided into different parallel data streams respectively for each of the sub-carrier. Each of the sub-carrier is modulated by using modulation schemes like QPSK, QAM, and BPSK at the low symbol rate. Each modulation techniques have their own set of advantages which are offered to the communication system. An OFDM system also employs other operations like IFFT, FFT, addition, and removal of the cyclic prefix, serial-to-parallel as well as parallel-to-serial conversion, digital to analog and analog to the digital conversion process[5].

MIMO-OFDM: MIMO-OFDM systems provide higher data rates, improve communication performance, support a large number of users with flexibility in Quality of Service (QoS) and provide high-quality transmission in comparison with the existing ones. Also, coding is being done on OFDM symbols to achieve further improved performance from the systems. But in order to fulfill these requirements, some constraints have to be very well addressed such as limited availability of frequency spectrum, availability of total transmit power and nature of wireless channels. Also, all these advantages come at the cost of high complexity in the system[6].

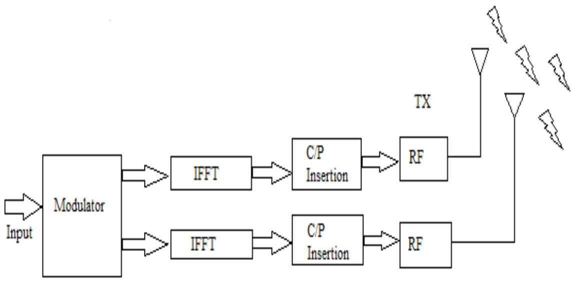

Figure. 1.1Block Diagram of OFDM Transmitter

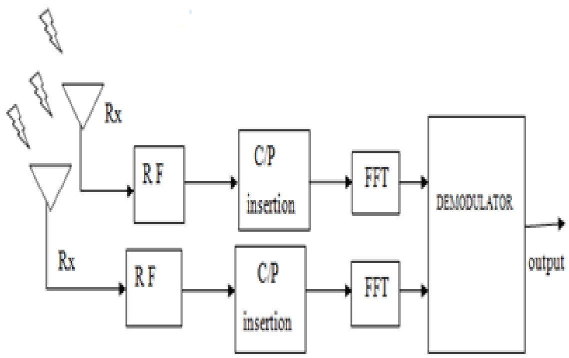

Figure .1.2Block Diagram of OFDM Receiver

3. PROPOSED METHODOLOGY

This section describes the proposed methodology of this work. Greatest advantage a MIMO system holds today is the stark increase in channel capacity in the wireless communication system which has changed all the power, capacity equations in the recent past and this is the reason why MIMO system is being used in major communication system all over the world. Whereas Orthogonal Frequency Division Multiplexing (OFDM) is a most popular communication system in high-speed encoding digital data on multicarrier frequencies. MIMO system has annihilated Shannon Hartley theorem of maximum capacity which has been ruling the world for the last few years.

Step1: In this step, Channel modeling of the MIMO system.

Step2: Implement the OFDM system in this step.

Step3:Implementation of MIMO-OFDM system.

Step4: Apply the Shannon Theorem.

MIMO system has pierced the Shannon Hartley Theorem which gave maximum channel capacity for single antenna system. For a binary symmetric channel with parameter $p < 0.5$ and for any constants$\delta, \gamma > 0$, where n is sufficiently large, the following holds:

CONDITION 1: For $k<n(1 - H(p) - \delta)$ there exists (k; n) encoding and decoding functions such that the probability of the receiver fails to obtain the correct message is at most for every possible k-bit input messages.

CONDITION 2: There are no number (k; n) encoding and decoding functions with $k>n(1 - H(p) + \delta)$ such that theprobability of decoding correctly is at least for a k-bit input message chosen uniformly at random.

Where, p is the probability density function.

$\delta and \gamma$are the constants.

Alternatively Shannon Theorem is defined as ,"channel capacity C, meaning the theoretical highest upper bound on the information rate (excluding error correcting codes) of clean (or arbitrarily low bit error rate) data that can be sent with a given average signal power S through an analog communication channel subject to additive white Gaussian noise of power N", is

$$C = B\log_2\left(1 + \frac{S}{N}\right) \qquad (3.21)$$

Where,

C is the channel capacity in bits per second.

B is the bandwidth of the channel in hertz.

S is the average received signal power over the bandwidth.

N is the average noise or interference power over the bandwidth.

S/N is the signal-to-noise ratio.

4. CHANNEL DESCRIPTION

AWGN: This is a channel model in which the only impairment to communication is a linear addition of wideband or white noise with a constant spectral density and a Gaussian distribution of amplitude. The model doesn't account for fading, frequency selectivity, interference, nonlinearity or dispersion. However, it produces simple mathematical models which are helpful for gaining information of the underlying behavior of a system before these other phenomena are considered.

Rayleigh: This is a statistical model to see the effect of fading on the propagation of radio signal in an environment, as used by wireless devices. Rayleigh fading models assume that the magnitude of a signal that has passed through such a transmission medium (also called a communications channel) will vary arbitrarily or fade, according to a Rayleigh distribution the radial component of the sum of two uncorrelated Gaussian random variables. Rayleigh fading is considered as a reasonable model for tropospheric and ionospheric signal propagation as well as the effect of heavily built-up urban environments on radio signals. Rayleigh fading is best applicable when there is no dominant propagation along a line of sight between the transmitter and receiver. If there is a dominant line of sight, Rician fading is of relevance.

Rician:

Rician fading is a stochastic model for radio propagation in which fading is caused by the partial cancellation of a radio signal by itself the signal arrives at the receiver by several different paths (hence exhibiting multipath interference) and at least one of the paths is changing (increasing or decreasing). Rician fading occurs when one of the paths, typically a line of sight signal, is much stronger as compared to others. In Rician fading, the amplitude gain is characterized by a Rician distribution. Rayleigh fading is the specialized model for stochastic fading when there is no line of sight signal and is sometimes considered as a special case of the more generalized concept of Rician fading. In Rayleigh fading, the amplitude gain is characterized by a Rayleigh distribution. A Rician fading channel can be described by two parameters: K and Ω. K is the ratio between the power in the direct path and the power in the other, scattered, paths. Ω is the total power from both paths Ω = v2 + 2σ2 and acts as a scaling factor to the distribution.

Rician distributed with parameters

$$v^2 = \frac{K}{K+1}\Omega \text{ and } \sigma^2 = \frac{\Omega}{2(1+K)}$$

The resulting PDF then is:

$$f(x) = \frac{2(1+K)x}{\Omega} \exp\left(-K - \frac{(k+1)x^2}{\Omega}\right) I_o \left(2\sqrt{\frac{K(K+1)}{\Omega}} x \right) \quad (1)$$

Where, '$I_o(.)$' is the 0^{th} order modified Bessel function of the first kind. The Rician K-factor is defined as the ratio of signal power in dominant component over the (local-mean) scattered power. The K-factor is between 4 and 12 dB approximately.

5. RESULT

Bit Error Rate: It is the rate on which the error has occurred during the data transmission in digital communication. It is very simple to calculate by dividing the total number of errors by total data send. If the bit error rate is less in number than the communication channel is more reliable. BER is mainly affected by noise, distortion, and attenuation in the channel.

SNR: It is ration between the signal and noise. In this, we calculate the signal power to the level of noise power. If the SNR ratio is high then it means it contains more useful information and less noisy data. In this section, we investigate the performance of MIMO OFDM, for different PSK and QAM modulations in different fading channels. MATLAB program is used to obtain results and calculated BER (Bit error rate) for various SNR (Signal to Noise Ratio).

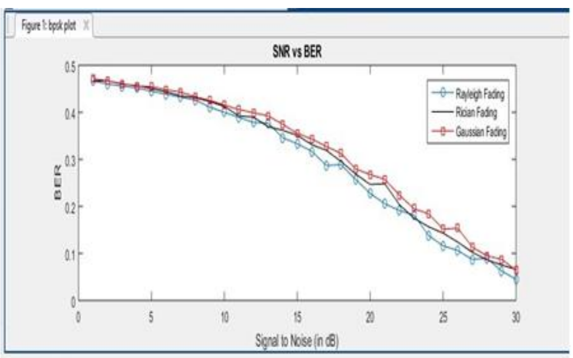

Figure.1.3: Graphical comparison of BER for BPSK for different fading channels

In figure 1.3 comparison of BER with SNR is performed on BPSK for different fading channel. The value of signal to noise ratio is changed according to the BER rate.

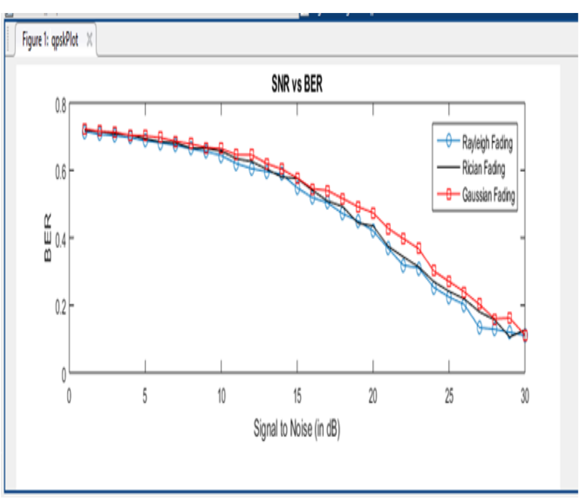

Figure.1.4. Graphical comparison of BER for QPSK for different fading channels

In figure 1.4 comparison of BER with SNR is performed on QPSK for different fading channel. The value of signal to noise ratio is changed according to the BER rate. The maximum value of SNR is in Gaussians Fading.

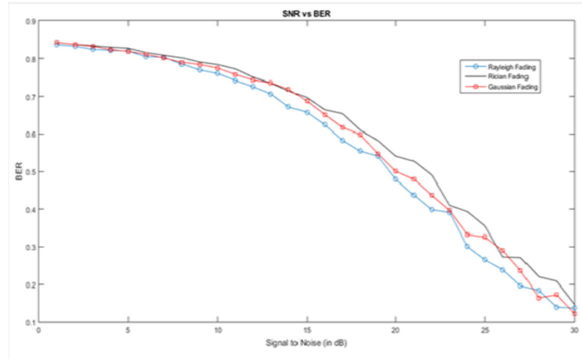

Figure.1.5. Graphical comparison of BER for QAM for different fading channels

In figure 1.5 comparison of BER with SNR (Signal-to-noise ratio) is performed on QAM for different fading channel. The value of signal to noise ratio is changed according to the BER rate.The maximum value of SNR is in Racians Fading and minimum is at Rayleigh fading.

6.CONCLUSION

In wireless technology biggest challenge is to overcome the effect of fading which is responsible for intersymbol interference. MIMO technology has been used to cope up with this problem of multipath fading. In this work, the capacity of MIMO system has been enhanced beyond Shannon capacity by increasing number of transmitting and receiving antenna. Increasing half wave dipoles in antenna array linearly increases the channel capacity of MIMO system. Hence multiple antennae increase channel capacity. OFDM is a promising solution for achieving high data rates in the mobile environment, due to its resistance to ISI, which is a common problem found in high-speed data communication. Amultiple-input-multiple-output (MIMO) communication System combined with the or thogonal frequency division multiplexing (OFDM) modulation technique can achieve reliable high data rate transmission over broad band wireless channels. It is computationally efficient due to the use of FFT techniques to implement modulation and demodulation functions. The performance of MIMO-OFDM is tested for modulation techniques namely BPSK, QPSK, and 16-QAM using MATLAB- R2015a. We conclude that BPSK modulated MIMO - OFDM system achieves better SNR results for Rayleigh channel in comparison to Gaussian and Rician fading where Rician is better than Gaussian channel. Also in 16-QAM modulation format, Gaussian shows better BER values in comparison to Rician Fading whereas Rayleigh shows lowest BER values.

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