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Performance Analysis of Spatially Multiplexed MIMO System

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Abstract: In SISO (single input and single output) system, refers to have only one input and one output. Here only one antenna is used at receiver and transmitter side. SISO are relatively simple to design and implement. They are of low cost and used in wide range of applications. However, SISO systems are poor in performance and deliver low data rate. So we'll prefer MIMO (multiple input and multiple output) over SISO as it gives better spectral efficiency, improved reliability and good coverage. In MIMO we use multiple antennas at transmitter and receiver side which is known as Spatial Multiplexing(SM) which enhances the data rate. In the paper the performance of spatial combining MIMO system is analysed. Matlab used for simulation.
Keywords: BPSK, SM-MIMO, Rayleigh, AWGN, ZF Equalizer.

I. INTRODUCTION

MIMO widely employed as usage data is huge in wireless communications. It uses several antennas at two sides i.e, transmitter side and receiver side. MIMO is used to rise capacity of the system. Here we use Spatial Multiplexing technique which simultaneously transmits multiple data streams. This technique is used to increase the data transmission rate. SM-MIMO systems are preferred due to their reduced hardware complexity. They have the ability to increase the channel capacity compared to SISO systems.

In this paper we mainly discuss about BER (Bit Error Rate), different type of modulations, SISO systems, MIMO systems, Spatial Multiplexing, why is MIMO chosen over SISO etc. MIMO system also improves reliability. Some of the advantages of MIMO are higher data rate, Time diversity, Reduces signal distortion, higher accuracy, reducing the impact of fading and so on.

MIMO systems have become popular in telecommunications due to increasing traffic demands. They have different configurations such as 2x2 MIMO, 3x3 MIMO, 4x4 MIMO so on. In this paper we are using 2x2 MIMO and 4x4 MIMO systems.

II. LITERATURE SURVEY

In this paper we discussed about the analysis of Bit Error Rate (BER) for M-ary PSK i.e, BPSK, QPSK, 8-PSK scheme over Rayleigh fading channel in wireless communication systems. As we know that fading refers to rapid fluctuations in signal amplitude due to multipath propagation. Rayleigh fading is one environment in wireless systems. This model is used by wireless devices. This study shows the changing BER for BPSK, QPSK and 8-PSK. We know that BER is defined as the ration of error bits to transmitted bits. BER is considered as the most important measure of transmission quality. But the main limitation here is the Inter channel interference is expressively large in M-ary PSK. With respect to BPSK, it is more sensitive to phase variations. And also it is hard to implement if the phase is relatively small.

The use of multiple antennas in Wireless communications at both transmitter side and receiver side is known as MIMO i.e, Multiple-Input-Multiple-Output. It has many benefits such as multiplexing, diversity gain and antenna gain. But it has one drawback regarding the increase in complexity and cost. This is due to the Inter channel interface and need for multiple RF chains.

To overcome this challenges we use a technique called as Spatial Modulation(SM) technique [5]. This technique offers a hybrid approach to achieve high data rates with reduced complexity and cost compared to general MIMO systems. Several papers illustrated the MIMO enhancements [7-10].

III. SYSTEM MODEL

MIMO systems are widely used in telecommunications due to the increasing demand for data transmission. They offer significant performance improvements compared to SISO. MIMO systems utilize multiple antennas to provide high data rates and diversity, without the need to install fixed antennas at the source and destination. These improve the performance and provide high data rates. The coherence time and coherence bandwidth are used to classify channel conditions, which are dependent on the Doppler shift and delay spread of multipath components. Fading distributions, such as Rayleigh fading, are commonly used to model amplitude distribution and obtain statistical properties of SNR.

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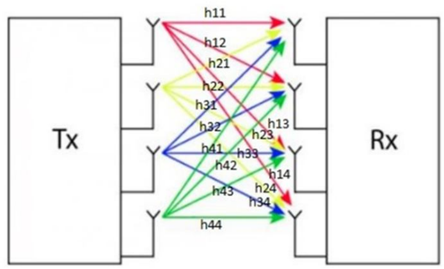

Figure 1: Block Diagram of MIMO

There are several modulation techniques used in communication systems and PSK (Phase Shift Keying) modulation techniques are some of the most widely used.

The most common PSK modulations are:

1) BPSK (Binary Phase Shift Keying): uses two phases to show binary digits 0 and 1.
2) In QPSK, the carrier signal is phase-shifted by 90, 180, 270 or 360 degrees to represent four possible binary combinations of two bits at a time.
3) In 8PSK, the carrier signal is phase-shifted by 45, 90, 135, 180, 225, 270, 315, or 360 degrees to represent eight possible binary combinations of three bits at a time.

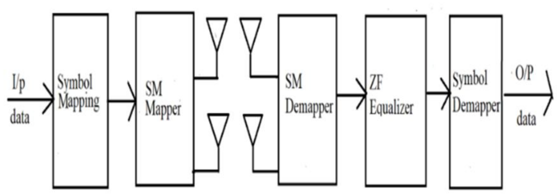

Figure 2: Block diagram of SM-MIMO

In the proposed system Rayleigh Channel used.

$$p_\gamma(\gamma) = \frac{1}{\bar{\gamma}} e^{\frac{-\gamma}{\bar{\gamma}}}, \quad \gamma \geq 0$$

The ZF (Zero Forcing) equalizer used in digital communications to solve the effects of ISI due to multipath. The basic idea of the ZF equalizer is to invert the channel frequency response, which means that the equalizer amplifies the received signal at each frequency by the inverse of the channel frequency response at that frequency. This has the effect of cancelling out the distortion caused by the channel and restoring the transmitted signal to its original form. The ZF equalizer can be implemented using a tap delay line and a set of coefficients that are calculated based on the channel frequency response. The tap delay line represents the delayed versions of the received signal, and the coefficients are used to weight each delayed version of the signal before adding them together to form the equalized signal.

IV. IMPLEMENTATION OF SM-MIMO

A. At Transmitter

Step1: User data is generated.
Step2: Data is modulated using BPSK, QPSK, 8PSK modulations.
Step3: Modulated data is given to Spatial Multiplexing block.
Step4: Data which is to be transmitted is divided into group's i.e, S1, S2- Group 1 S3, S4 – Group 2 and so on.
Step4: After spatial multiplexing, S1 is given to Antenna1 and S2 is given to Antenna2.
Step5: In the same way, S3 is given to Antenna1 and S4 is given to Antenna2.

B. At Receiver

Step1: The data is given to ZF Equalizer.
Step2: Equalizing the received symbols with ZF equalizer.
Step3: Here the ZF Equalizer compensates the channel effect.
Step4: The data is given to demodulator.
Step5: Then the BER graph is plotted.
Step6: Performing hard decision decoding and count the bit errors
Step7: Plot the graph.

V. RESULTS

Simulation parameters are shown below.

Table 1: Comparison of different Modulation of MIMO System

Modulation	BPSK	QPSK	8PSK
Eb/N0	[0,5,10,15,20,25]	[0,5,10,15,20,25]	[0,5,10,15,20,25]
No of Tx antennas (nTx)	2	2	2
No of Rx antennas (nRx)	2	2	2
Modulation order	2	4	8
Channel	Rayleigh	Rayleigh	Rayleigh
No of bits(N)	10000	10000	10000

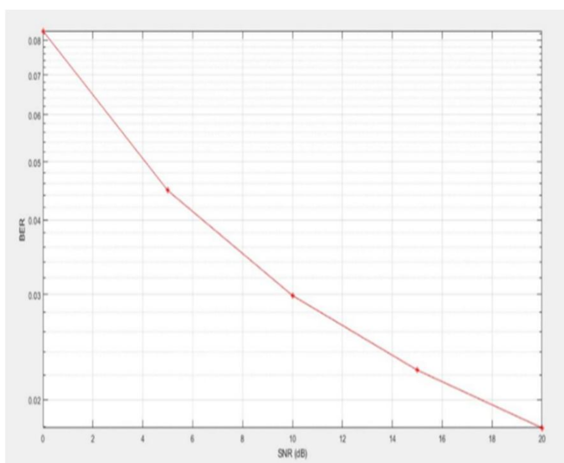

Figure3: performance of SISO system over AWGN

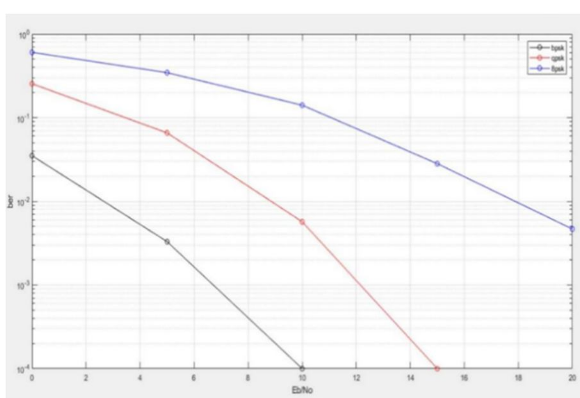

Figure4: Comparison of BPSK, QPSK, 8-PSK modulations over SISO system

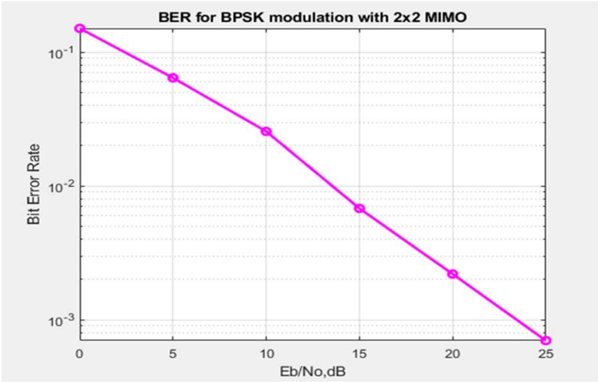

Figure5: BER plot using BPSK Modulation

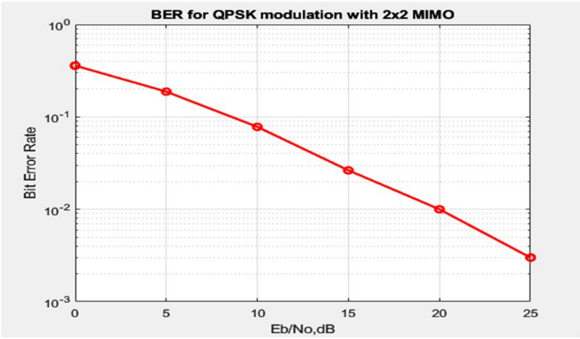

Figure6: BER plot using QPSK Modulation

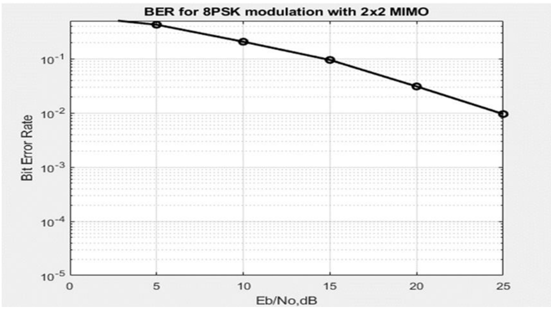

Figure7: BER plot using 8-PSK Modulation

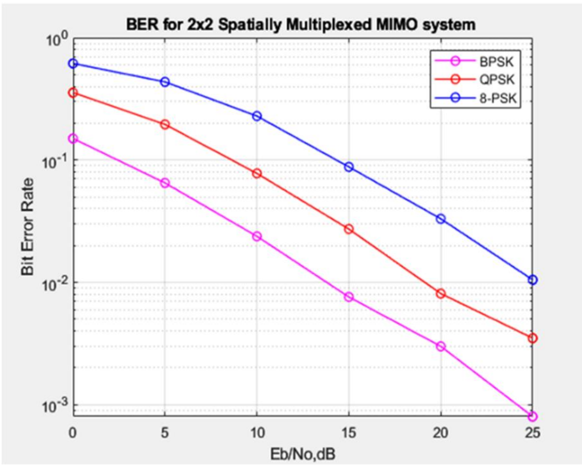

Figure8: BER for 2x2 spatially multiplexed MIMO system

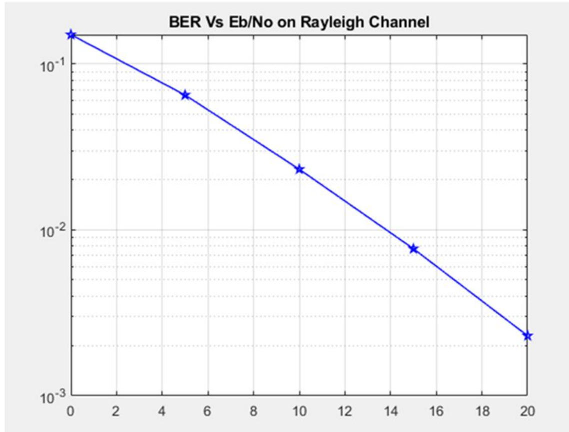

Figure9: BER plot using BPSK modulation for 4x4 MIMO system

VI. CONCLUSION

MIMO is a most important method for wireless systems. In this paper system implemented with BPSK, QPSK, 8-PSK schemes and Rayleigh fading channel. The Bit Error Rate (BER) is analysed for Rayleigh channel. Results shows that when mapping order increases leads to increase in error. 4X4 system improves the BER performance.

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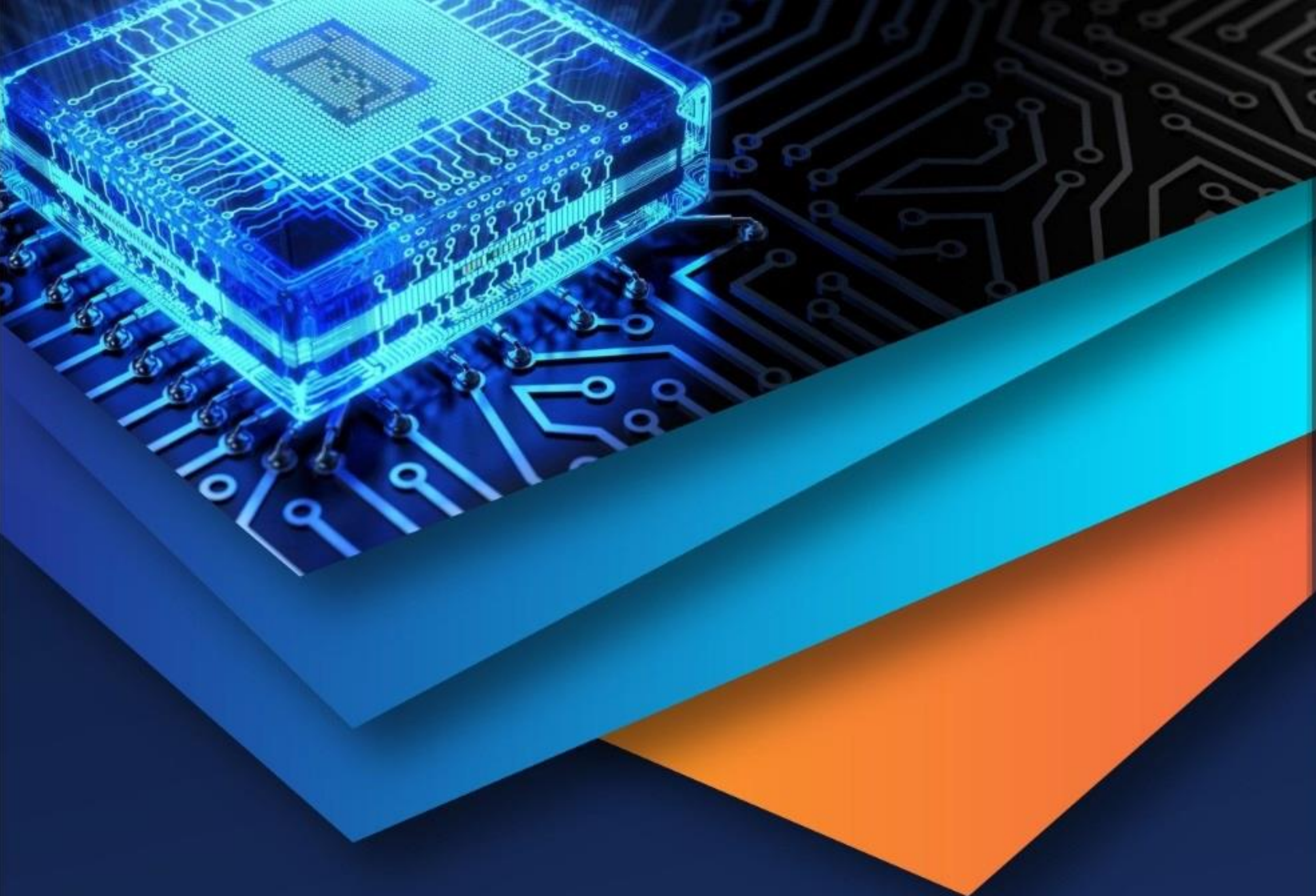

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