PERFORMANCE OF MIMO IN THE PRESENCE OF DIFFERENT NOISES AND DIFFERENT MODULATION TECHNIQUES

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Abstract

In radio, multiple-input and multiple-output (MIMO) is a method for multiplying the capacity of a radio link. It refers to a practical technique for sending and receiving more than one data signal simultaneously over the same radio channel by exploiting multipath propagation. MIMO has become an essential element of wireless communication standard including IEEE 802.11N(Wi-Fi),HSPA+(3G), WiMAX(4G) and long term evolution(LTE 4G). MIMO achieves space measurements to improve wireless systems capacity, range and reliability. It offers increase in the data throughput and link range without any additional bandwidth or transmitting power.

The performance of the system can be evaluated by using Bit Error Rate(BER). So, to find the performance of MIMO in this we are calculating the BER by using the different noises and different modulation techniques . Different noises like AWGN, Thermal noise, Phase noise and different modulation techniques BPSK(Binary Phase Shift Keying), QPSK (Quadrature Phase Shift Keying) ,QAM(Quadrature Amplitude Modulation) etc.. at each BER is calculated . Finally the different the BER's are compared.

Keywords : AWGN, Thermal noise, Phase noise, BPSK, QPSK, QAM, BER.

I. INTRODUCTION

The term wireless communication was introduced in the 19th century and wireless communication technology has developed over the subsequent years. It is one of the most important mediums of transmission of information from one device to other devices. In this technology, the information can be transmitted through the air without requiring any cable or wires or other electronic conductors, by using electromagnetic waves like IR, RF, satellite, etc.

In the present days, the wireless communication technology refers to a variety of wireless communication devices and technologies ranging from smart phones to computers, tabs, laptops, printers. This article gives an overview of wireless communication and types of wireless communications.

In the present days, wireless communication system has become an essential part of various types of wireless communication devices that permits user to communicate even from remote areas. There are many devices used in wireless communication like mobiles which include GPS, WIFI, ZIGBEE wireless technology, satellite television, Bluetooth etc.

II. IMPORTANCE OF WIRELESS COMMUNICATION:

Wireless communication involves the transmission of information over a distance without the help of wires, cables or any other forms of electrical conductors.

Wireless communication is a broad term that incorporates all procedures and forms of connecting and communicating between two or more devices using a wireless signal through wireless communication technologies and devices.

- The transmitted distance can be anywhere between a few meters (for example, a television's remote control) and thousands of kilometers (for example, radio communication).
- Wireless communication can be used for cellular telephony, wireless access to the internet, wireless home networking, and so on.

- Other examples of applications of radio wireless technology include GPS units, keyboards and headsets, headphones, radio receivers, satellite television, broadcast television.

III. Multi input and Multi Output (MIMO):

In wireless communication, MIMO contains some existing methods.

They are:

SISO(single input single output): SISO Systems or the single input, single output communication systems is the simplest form of the communication system out of all four in which there is single transmitting antenna at the source and a single receiving antenna at the destination. SISO systems are used in multiple systems like Bluetooth, WIFI, radio broadcasting, TV etc.

SIMO(single input multiple outputs): SIMO or the Single input and multiple output form of wireless communication scheme in which there are multiple antennas are present at the receiver and there is single transmitting antenna at the source. Digital TV, Wireless local area networks, metropolitan area networks etc

MISO(multiple inputs single output): MISO or the multiple input and single output is a scheme of RF wireless communication system in which there are multiple transmitting antennas at the source and single receiving antenna at the system like SIMO but at the destination, receiver has a single antenna.

MIMO (multiple inputs, multiple outputs) is an antenna technology for wireless communications in which multiple antennas are used at both the source (transmitter) and the destination (receiver). The antennas at each end of the communications circuit are combined to minimize errors and optimize data speed. MIMO is one of several forms of smart antenna technology, the others being MISO (multiple inputs, single output) and SIMO (single input, multiple outputs). MIMO technology has aroused interest because of its possible applications in digital television (DTV), wireless local area networks (WLANs), metropolitan area networks (MANs), and mobile communications. MIMO techniques are used today in technologies like Wi-Fi and LTE, and new standards like LTE advanced.

A signal propagated between a transmitter and receiver is often affected by fading. One major source of fading is multipath propagation, where different copies of the signal partially cancel each other out at certain times and points in space. This attenuation decreases the signal to noise ratio (SNR), which in turn increases the number of errors. This increase in errors decreases the effective throughput of the signal, thereby weakening the RF link.

Advantages of MIMO:

- The higher data rate can be achieved with the help of multiple antennas and SM (spatial multiplexing) technique. This helps in achieving higher downlink and uplink throughput.
- It helps in achieving reduction in BER (Bit Error Rate) due to application of advanced signal processing algorithms on the received data symbols by multiple antennas.
- The techniques such as STBC (Space Time Block Coding) and BF (Beam forming) when employed in MIMO system helps achieving extension of cell coverage.
- MIMO based system minimizes fading effects seen by the information travelling from transmit to receiver end. This is due to various diversity techniques such as time, space and frequency.
- There is lower susceptibility of tapping by unauthorized persons due to multiple antennas and algorithms.
- The system with MIMO offers high QOS (Quality of Service) with increased spectral efficiency and data rates.
- The wide coverage supported by MIMO system helps in supporting large number of subscribers per cell.

IV. NOISES IN MIMO:

Noise is unwanted sound judged to be unpleasant, loud or disruptive to hearing. Noise is an indistinguishable from sound, as both are vibrations through medium, such as air or water. It can refer to any random fluctuations of information that hinders perception of an expected signal. In communication systems, noise is an

error or undesired random disturbance of a useful information signal. The noise is a summation of unwanted or disturbing energy from natural and sometimes man-made sources.

AWGN NOISE:

Additive White Gaussian noise (AWGN) is a basic model used in information theory to mimic the effect of many random processes that occur in nature. Additive refers to it is added to any noise that might be intrinsic to the information system. White refers to the idea that it has uniform power the frequency band for the information system. It is an analogy to the color white which has uniform emissions at all frequencies in the visible spectrum.

THERMAL NOISE:

In communication, thermal noise has a major influence to the quality of the receiver. The lower the thermal noise the higher and more expensive is receiver sensitivity. Thermal noise is approximately white, meaning that its power spectral density is nearly equal throughout the frequency spectrum. The amplitude of the signal has very nearly a Gaussian probability density function. A communication system affected by thermal noise is often modeled as an additive white Gaussian noise (AWGN) channel. The presence of noise degrades the signal quality. For the analog system the signal quality is measured by the parameter, signal to noise ratio (SNR) and for a digital system the signal quality by the parameter, bit error ratio (BER).

PHASE NOISE:

Phase noise is the frequency domain representation of rapid, short-term, random fluctuations in the phase of a waveform, caused by time domain instabilities, but in this we are placing the block of phase noise in order to measure the performance of MIMO.

V. MODULATION TECHNIQUES:

QAM

Quadrature Amplitude Modulation or QAM is a form of modulation which is widely used for modulating data signals onto a carrier used for radio communications. It is widely used because it offers advantages over other forms of data modulation such as PSK, although many forms of data modulation operate alongside each other.

QPSK

This technique is also known as quaternary PSK, quadriphase PSK or 4-PSK. QPSK refers to a type of phase modulation technique where there are four states involved. It uses four points on the constellation diagram, equispaced around a circle. Since QPSK has four phases, it can encode two bits per symbol, thereby increasing the data rate.

VI. PROPOSED METHOD:

Our main aim is to construct a 2x2 MIMO. So, two transmitters and receivers are connected to the channel to increase the reliability of the system. QPSK modulation has been used and BER is calculated in the presence of different noises and different modulations.

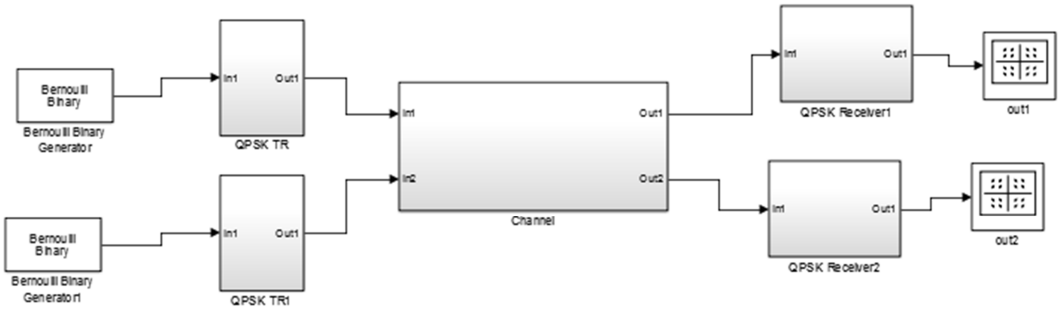

Fig1: 2X2 MIMO

QPSK TRANSMITTER:

This block maps groups of bits in the input vector to integers in the output vector. *M* defines how many bits are mapped for each output integer. The QPSK Modulator Baseband block modulates using the quaternary phase shift keying method. The output is a baseband representation of the modulated signal. The Raised Cosine Transmit Filter block up samples and filters the input signal using a normal raised cosine FIR filter or a square root raised cosine FIR filter. The block's icon shows the filter's impulse response.

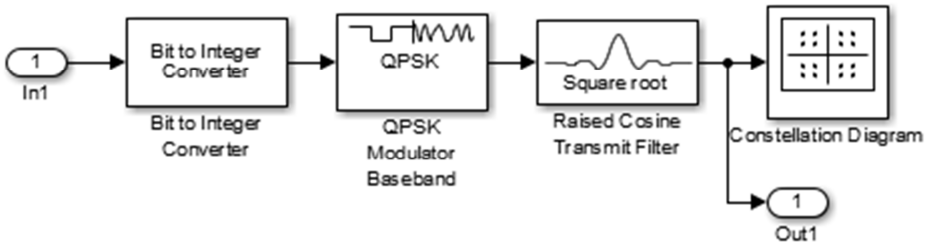

Fig2 : QPSK TRANSMITTER

CHANNEL:

AWGN Channel adds white Gaussian noise to the signal that passes through it. The relative power of noise in AWGN channel is described by the quantities such as:

- Signal-to-noise ratio (SNR) per sample. This is the actual input parameter to the AWGN function.
- Ratio of bit energy to noise power spectral density (E_b/N_o).
- Ratio of symbol energy to noise power spectral density (E_s/N_o)

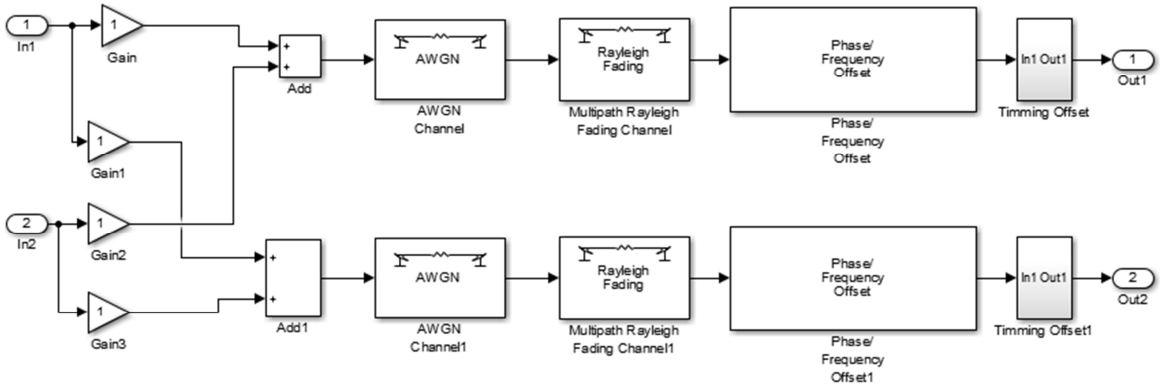

Fig3 : Channel

QPSK RECEIVER:

The QPSK Demodulator Baseband block demodulates a signal that was modulated using the quaternary phase shift keying method .The input is a baseband representation of the modulated signal .The input must be a complex signal. This block accepts a scalar or column vector input signal. This block maps each integer in the input vector to group of bits in the output vector.

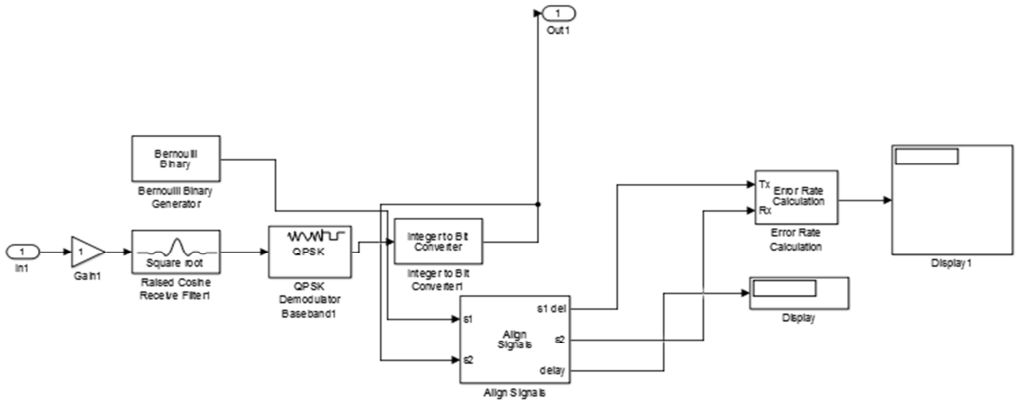

Fig 4 : QPSK Receiver

ERROR RATE CALCULATION:

The Error Rate Calculation block compares input data from a transmitter with input data from a receiver. It calculates the error rate as a running statistic, by dividing the total number of unequal pairs of data elements by the total number of input data elements from one source.

Here fading and Doppler effect is introduced. But the BER is not reduced. So, OSTBC encoder and OSTBC combiner is introduced at the transmitter and receiver side to reduce the BER.

The Gauss error function is defined as

$$\text{erf}(x) = \frac{1}{\sqrt{\pi}} \int_{-x}^{x} e^{-t^2}\ dt$$

$$= \frac{2}{\sqrt{\pi}} \int_{0}^{x} e^{-t^2}\ dt$$

The complementary error function is defined as

$$\text{erfc}(x) = 1 - \text{erf}(x)$$

$$= \frac{2}{\sqrt{\pi}} \int_{x}^{\infty} e^{-t^2}\ dt$$

FRAME ERROR RATE CALCULATION:

This block compares input data from a transmitter with input data from a receiver. It calculates the error rate as a running statistic, by dividing the total no. of unequal pairs of data elements by the total no. of input data elements from one source. If the input is bits then it computes bit error rate, if the input is symbols then it computes symbol error rate.

VII. RESULT

This project analyzes the performance of MIMO by using BER. BER is also compared in the presence of different noises like AWGN, phase noise, thermal noise etc. From the 2x2 MIMO block diagram,

Fig 5, 6 shows the constellation diagrams of both transmitter1 and 2.By adding the noise to the signal in channel fig7 and 8 shows the constellation diagram channel1 and 2.Fig 9 and 10 shows the constellation diagram of receiver1 and 2.At the receiver, the transmitted signal is obtained with less noise.

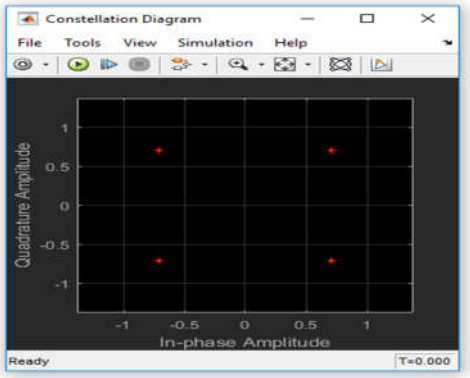

Fig 5: CONSTELLATION DIAGRAM OF TRANSMITTER1

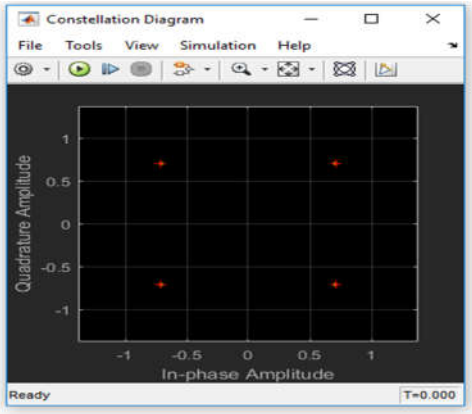

Fig 6: CONSTELLATION DIAGRAM OF TRANSMITTER2

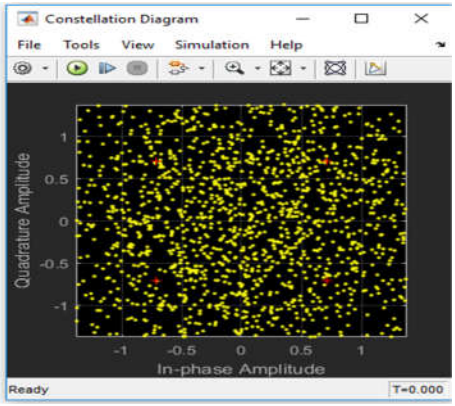

Fig 7: CONSTELLATION DIAGRAM OF CHANNEL1

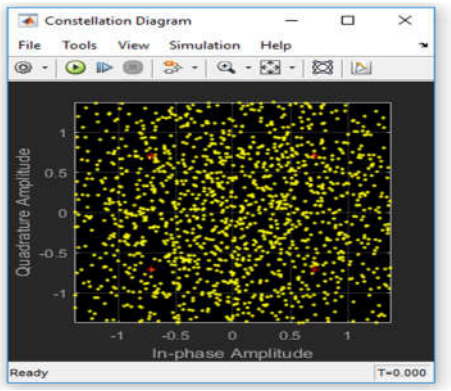

Fig 8: CONSTELLATION DIAGRAM OF CHANNEL2

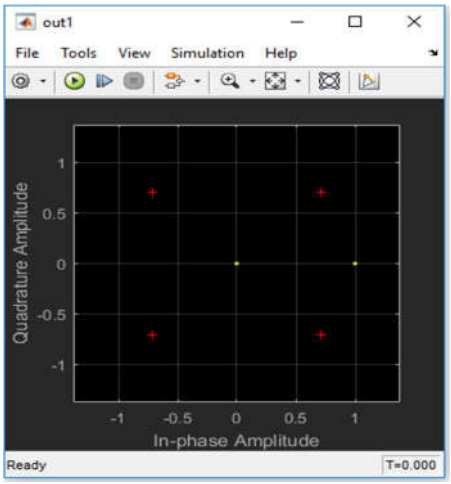

Fig 9: CONSTELLATION DIAGRAM OF RECEIVER1

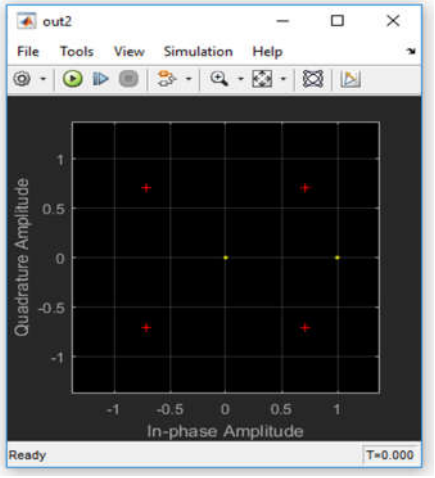

Fig 10:CONSTELLATION DIAGRAM OF RECEIVER2

TABULAR FORM OF SNR VERSUS BER:

S.NO	$SNR=E_b/N_o$	BER
1.	5	0.5059
2.	7	0.5039
3.	10	0.502
4.	11	0.5
5.	12	0.498
6.	13	0.4961
7.	14	0.4922
8.	15	0.4902
9.	16	0.4883

TABLE 1: SNR VS BER

As the SNR increases, signal power increases and noise power decreases which results to the decrease in bit error rate.

TABULAR FORM OF BER IN OSTBC-MIMO

S.NO	No of transmitting antennas	No of receiving antennas	Bit Error Rate	
			AWGN	AWGN+PHASE NOISE
1.	2	2	0.1893	0.1903
2.	2	3	0.1344	0.1346
3.	2	4	0.09201	0.09427
4.	3	2	0.07602	0.07517
5.	3	3	0.04852	0.04862
6.	3	4	0.03436	0.0345
7.	4	2	0.04417	0.04419
8.	4	3	0.02555	0.0261
9.	4	4	0.01939	0.01979

TABULAR COLUMN :3

BER VALUES FOR QPSK WITH ENCODING:

S.NO	No of transmitting antennas	No of receiving antennas	BER
1.	2	2	**0.013**
2.	2	3	**0.07**

3.	2	4	**0.06**
4.	3	2	**0.028**
5.	3	3	**0.018**
6.	3	4	**0.014**
7.	4	2	**0.0169**
8.	4	3	**0.01**
9.	4	4	**0.009**

TABULAR COLUMN :4

BER VALUES FOR QAM WITH ENCODING:

S.NO	No of transmitting antennas	No of receiving antennas	BER
1.	2	2	**0.015**
2.	2	3	**0.0154**
3.	2	4	**0.004342**
4.	3	2	**0.0068**
5.	3	3	**0.0050**
6.	3	4	**0.00062**
7.	4	2	**0.0012**
8.	4	3	**0.00081**
9.	4	4	**0.00168**

TABULAR COLUMN:5

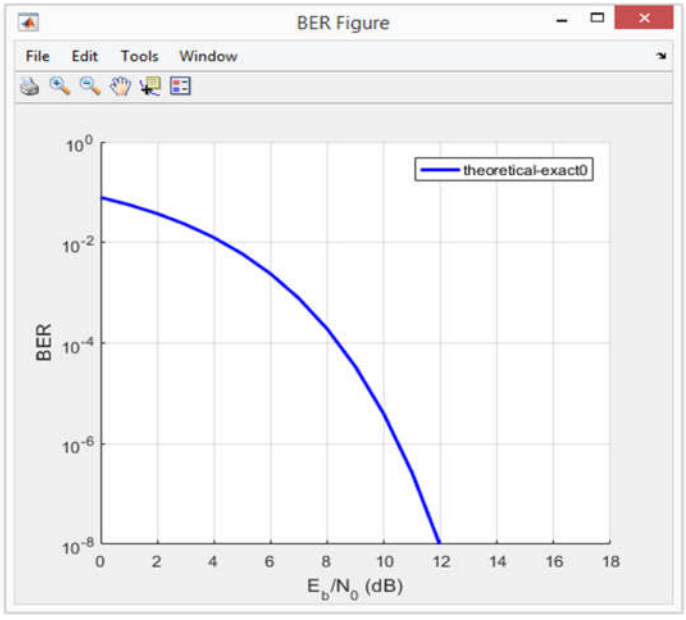

Fig 11: WAVEFORM FOR BER VS SNR

CONCLUSION :

By increasing the number of antennas leads massive MIMO or Large-Scale Antenna Systems combined with OFDM is a frequency division multiplexing scheme used as a digital carrier modulation method. The low symbol rate of OFDM makes use of guard interval between symbols making it possible to eliminate Inter symbol interference and signal to noise ratio improvement. So, by using OFDM modulator and demodulator BER is still reduced.

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