Enhancing MIMO System Performance in Fading Channels Through TAS-MRC With Advanced Error Detection and Correction

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ABSTRACT

The Multiple-input, multiple-output (MIMO) systems are becoming increasingly important in modern wireless communication due to their capacity to increase data speeds and enhance reliability. Using the Transmit Antenna Selection (TAS) and Maximal Ratio Combining (MRC), Manchester coding, and Hamming error correction, this research investigates how to improve MIMO system performance in the presence of fading channels like Rayleigh and Rician. In this study TAS's effect on antenna choice at the receiver end using extensive simulations. The chosen antennas are then used in MRC, a method that mixes signals from various antennas to lessen signal fading. Error correction in transit is handled via Hamming codes, whereas Manchester coding is used to improve error detection. Our results show that the performance of the Bit Error Rate (BER) can be significantly enhanced by combining TAS, MRC, Manchester coding, and Hamming error correction. In this study the BER performance is compared in several scenarios, including those with Rayleigh and Rician fading channels. Our research illustrates the compromises between performance improvement and computational complexity in addition to shedding insight on the synergistic impacts of different strategies. This study also concludes that TAS, MRC, and coding approaches have the potential to importantly improve the robustness and efficiency of MIMO systems. These discoveries help move wireless communication systems forward and point the way for further study.

List of Abbreviations

CSI- Channel-State-Information

FDM- Frequency Division Multiplexing

MIMO- Multiple Input Multiple Output

MRC- Maximum Ratio Combining

MRT- Maximum Radio Transmission

STBC- Space Time Block Coding

SC- Selection Combining

MU- MIMO Multiuser-MIMO

OP- The Outage Probability

PDF- Probability Distribution Function

SER- Symbol Error Rate

BER- Bit Error Rate

SISO- Single-Input Single-Output

SNR- Signal to Noise-Ratio

STD- Switch Transmission Diversity

SIMIMO- Single user- MIMO

TAS- Transmitter Antenna Selection

TDM- Time Division Multiplexing

W- CDMA Wide Band Code Division Multiple Access

Table of Contents

LIST OF FIGURES

List of Table

CHAPTER 1: Introduction

1.1 Introduction

Wireless communication has become an essential component of today's culture, allowing for continuous interaction despite great physical distances. Exploring modern techniques within communication systems is becoming increasingly important due to the ever-increasing need for larger data rates, greater reliability, and greater spectrum efficiency. The potential of Multiple-Input, Multiple-Output (MIMO) systems to make use of spatial diversity and multipath propagation to improve communication performance has garnered them a lot of attention.

MIMO systems, which employ arrays of antennas on both ends of a communication link to transmit and receive data simultaneously may face challenges due to fading channels. These channels introduce amplitude. Phase shifts that can degrade signal quality. To overcome this issue, it is essential to employ a combination of methods.

The main objective of this research is to enhance the performance of MIMO systems when they encounter fading channels. This is achieved by incorporating a combination of Transmit Antenna Selection (TAS) Maximal Ratio Combining (MRC) Manchester coding and Hamming error correction techniques. To determine the antenna, for signal reception Transmit Antenna Selection dynamically chooses one. The signals received from these antennas are effectively combined using Maximal Ratio Combining, which helps minimize the impact of fading.

To enhance error detection capabilities, Manchester coding is introduced to encode bits through changes in signal levels. Additionally, Hamming error correction methods are used to fix erroneous data that has been received.

This work uses thorough modelling and analysis to quantify the gains in terms of Bit Error Rate (BER) performance that result from combining various strategies. The study not only analyses the effectiveness of each strategy but also looks at how they interact with one another and whether there are disadvantages to using them together.

In this section, all the methods break down each into its component parts, explain how these simulations run, show viewers the outcomes, and offer some conclusions. Our hope is that this will shed light on how these methods can be used and how they have significance in modern wireless communication systems.

1.2 Motivation

The reason for this study is to connected world is becoming more and more reliant on wireless communication systems. Higher data speeds, expanded coverage, and consistent connectivity have become increasingly important as wireless technologies have progressed. However, in practice, wireless channels are frequently degraded by fading due to environmental factors and interference. When a signal weakens due to fading, it affects the quality of communications and the user's overall interaction.

The use of MIMO (multiple-input, multiple-output) systems is a viable approach to overcoming these difficulties. MIMO systems can improve signal quality and capacity by mitigating the negative effects of fading due to the spatial diversity provided by several antennas. The entire potential of MIMO systems, however, requires that fading channels be thoroughly addressed.

A technique that has emerged to improve signal quality before merging is known as Transmit Antenna Selection (TAS). [12] Through purposeful signal amplification, Maximal Ratio Combining (MRC) boosts signals even higher. The security of data can also be strengthened by employing modern encoding methods like Manchester coding and Hamming error correction.

The combination of these methods provides a promising path toward improving the efficiency of MIMO systems under real channel constraints. The purpose of this study to contribute new knowledge to the theoretical understanding of TAS, MRC, Manchester coding, and Hamming error correction by examining their interplay, and in doing so, provide useful advice for improving the dependability and efficiency of wireless communication systems.

The goal of this study is to provide solutions that enable communication systems to perform best in real-world circumstances for the benefit of people, businesses, and society at large, thus closing the gap between theory and practice.

1.3 Problem Statement

In the realm of wireless communication, where data is transmitted without the need of cables, this must solve the problem of ensuring that messages are delivered accurately and error-free. When several circumstances are considered where the signals that carried messages may alter suddenly, this task becomes considerably difficult. Picture navigating a crowded location while trying to carry on a discussion clearly over a walkie-talkie. It's possible that the signal will get garbled or lost as it rebounds off structures.

Multi-input, multi-output (MIMO) systems add another layer of complexity to this issue because they function similarly to groups of antennas working together to transmit and receive data. Although MIMO has the potential to enhance communication, it has trouble coping with Rayleigh fading channels, a sort of unpredictable signal shift. These channels weaken and jumble the signals, which in turn causes transmission mistakes.

Finding solutions to improve communication dependability in MIMO systems operating in these challenging Rayleigh fading channels is the main goal of this study issue description. Even if the signals are misbehaving, it's still needed to guarantee that the messages delivered over these systems will reach their intended recipients intact.

Although current methods have been used with some success, they frequently lack the required amount of integration to tackle these complex problems. When it comes to optimizing the antenna subset at the receiver, Transmit Antenna Selection (TAS) has shown promising results. Here using a neat method called Maximal Ratio Combining to solve this issue. It's the same as having several antennas working in tandem to improve signal strength and make them more resilient under harsh conditions. Not only that, but also incorporating Hamming code and Manchester coding. Manchester coding can be used to find any missing or incorrect bits in our messages, and then use Hamming coding, which is like a puzzle solver, to fill in the gaps and make sure everything is in order.

It is hoped that by solving this issue can aid in the development of better wireless communication. The goal of this study is to design a system that will allow messages to move swiftly and reliably across the air, despite barriers such as Rayleigh fading channels.

Research Questions:

These fundamental issues are addressed by this study:

1. Given the wireless propagation environment's specific obstacles, how may MIMO systems running in Rayleigh fading channels be made more reliable?

2. When communicating with multiple users at once, how may Transmit Antenna Selection (TAS) with Maximal Ratio Combining (MRC) be used to minimize the effects of Rayleigh fading and maximize performance?

3. How much better is the Bit Error Rate (BER) in MIMO systems when using a mix of Manchester coding for bit error detection and Hamming code for error correction?

1.4 Objective

The primary objective of this thesis is to enhance the dependability of wireless communication, particularly in the face of obstacles like Rayleigh fading channels, which must be overcome by the signals carrying our messages[13]. To achieve this, a variety of clever methods are designed to improve the communication process at every stage.

This goal can be simplified into the following bullet points:

1. Investigate MIMO Techniques: Analyze the behavior of MIMO systems under different scenarios. When dealing with the unpredictable nature of Rayleigh fading channels, understanding the benefits and drawbacks of these systems is essential.

2.Evaluate the Role that Transmits Antenna Selection (TAS) Plays: Examine how TAS impacts the receiver's ability to make a good antenna choice. Study how TAS improves MIMO system signal reception quality.

2. Employ Maximal Ratio Combining: To figure out the best way to put Maximal Ratio Combining to use. Combining signals from multiple antennas into one larger, more stable signal is the goal of this method. Fading channels cause signals to be weak, but MRC can use it in these conditions.

3. Use the Manchester Coding System: How Manchester coding can help us catch mistakes in the transmissions. To detect errors, this encoding method makes use of sophisticated signal patterns. It is investigating the feasibility of using Manchester coding in MIMO systems to detect fading-channel-induced mistakes.

4. Use the Hamming Code: Hamming code, a miraculous device for correcting erroneous transmissions. This will dive into how to employ MIMO and Manchester coding with Hamming code to fix miscommunications and get reliable data.

5. Test and examine, number: The result of this study is to collect readings of things like bit error rates and signal-to-noise ratios to get a sense of how frequently errors are occurring and how much strength the signal has relative to background noise. The results of these analyses will tell us how efficient our method is.

To improve communication reliability in MIMO systems, especially when dealing with Rayleigh fading channels, attempt to accomplish these goals. It is focused on maintaining the accuracy and timely delivery of your communications, even when the signals are attempting to stop us.

1.5 Scope and Limitation

To improve the dependability of wireless communications, it is needed to identify the areas where it will concentrate the efforts and the obstacles may face. This ensures the focus is where it needs to be and helps us set reasonable goals.

Scope:

MIMO systems, which are like having many antennas on both ends of the communication, will be the primary focus of our research. This study will go into detail about their operation and how they can be utilized to boost communication quality, especially over Rayleigh fading channels.

In this article, Transmit Antenna Selection (TAS) with Maximal Ratio Combining (MRC), an approach to smartly combining signals from many antennas. It will investigate how MRC could reduce fading's negative impact on communication systems and improve their performance as an entire.

Also, Manchester coding and Hamming coding will be the main areas of our study. To improve the accuracy and dependability of the sent data, it will examine how Manchester coding can discover flaws and how Hamming code can rectify those faults.

It also tests the viability of our strategies through computational modeling. Bit Error Rate (BER) and communication dependability will be measured across a variety of use cases to determine the efficacy of our methods.

Restriction:

Despite the possible benefits of this study, it is crucial to recognize some restrictions:

1. simplified nature: Digital simulations will run in a regulated setting. Interference from other devices, difficult terrain, and variable signal levels are all examples of the kinds of real-world situations that may be difficult to simulate in a lab setting.

2. Fading variability: There is some variation in the way that Rayleigh fading occurs. Analysis will be limited to a subset of fading models that may not be representative of all possible fading conditions.

3.Channel Complexity: Complicating factors in wireless channels include reflections, dispersion, and more. Although it is hoped to simulate these features to some degree, they may not be modeled with all their intricacy.

4. Hardware Deployment: Simulation-based analysis is central to our studies. There may be new difficulties and unknowns when applying our findings to actual hardware implementations.

5. Estimating the Channel: It is critical in MRC that channel conditions be estimated appropriately. Channel estimate errors may reduce the effectiveness of this proposed methods.

6. Evolving Contexts: It's possible that our research ignored time-dependent aspects of the wireless environment, such as the effects of moving obstructions and fluctuating signal intensities.

Despite these limitations, this research will provide light on how to best combine MIMO systems with MRC, Manchester coding, and Hamming code to improve the dependability of communications. Recognizing the limits of our study helps pave the way for future developments in wireless communication.

1.6 Significance of the Study

The probable effect of this study on the field of wireless communication is a major reason for its significance. Envision a world where all your vital communications, whether they be texts, phone calls, or videos, are delivered promptly and without interruption. This research is geared toward this end, and it focuses on improving the dependability of communication in a strategic and efficient manner.

In the globalized age, communication serves as a vital link to the people, places, and things that matter most to us. However, obstacles like weak signals, interference, and unanticipated changes in the communication line can cause communications to become garbled or lost. This is especially true in the presence of obstacles encountered by the signal, such as Rayleigh fading channels.

This study wants to find a workable answer to these problems by researching the synergies between Maximal Ratio Combining, Manchester coding, and Hamming code. If our research proves out, it could result in:

1. More Stable and Dependable Communication: The methods that are looking into could strengthen wireless communication systems. If the signal strength is weak, messages should still get through.

2. Improved User Experience: Picture being able to communicate effectively, exchange emails, and share data without having concern about mistakes or interruptions. The results of our study may help make people's interactions more pleasant and efficient.

3. Better Connections: Reliable and constant communication is essential for businesses, emergency services, and regular people. It can assist these vital links by increasing their dependability using better wireless networks.

4. Efficient Data Transmission: Reliable communication is about more than just sending messages; it's also about efficiently transmitting data. These methods have the potential to improve data transmission and reception, leading to more rapid and less costly interactions.

5. Innovations in Technology: The Techniques investigated may be the Foundation for New Wireless Communication Technologies. These results may stimulate additional study and development in the area.

Finally, the importance of the research resides in its ability to improve wireless communication. This study seeks to aid in the building of a more interconnected, productive, and trustworthy communication landscape for all by working to improve communication consistency in the face of challenging conditions.

1.7 Layout of The Report

Chapter 2: will discuss Literature Review, Related works, and comparative analysis.
Chapter 3: System Design and Methodology will discuss architecture operation.
Chapter 4: Results and Discussion.
Chapter 5: Conclusion and Future Directions.

CHAPTER 2: Literature Review

2.1 Introduction

Wireless communication has become a crucial component of today's lives, allowing us to wirelessly connect and share information. Whatever, the signals that convey data can occasionally encounter issues as they travel through the air. Imagine Wi-Fi suddenly becoming sluggish, or a cell-phone call cut out in the middle of an important conversation. These problems are caused by a phenomenon known as "fading."

Fading is like a roller coaster signal. Due to objects like structures, trees, and other obstructions, signals may become weaker or stronger as they move. Rayleigh fading occurs when this happens quickly and unpredictably. This fading can disrupt the signals that is transmitted and received, resulting in errors in the information being delivered.

Researchers have been looking for smart techniques to resolve signal faults to make wireless communication more dependable, especially in difficult settings like Rayleigh fading. MIMO (Multiple-Input Multiple-Output) technology, which uses multiple antennas on both the sending and receiving sides, is one ingenious solution they've been examining.

Consider MIMO to be a group of antennas operating together. Having several antennas can help us deal with fading better, just as having more individuals can speed up problem-solving. However, as with any team, they must collaborate adequately. This is where "Maximal Ratio Combining" (MRC) enters the picture. MRC acts like an orchestra conductor, guiding the antennas to blend their signals together in a way that strengthens the overall movement. MRC makes it possible for humans to hear and convey messages more clearly despite fading by accomplishing this.

Consider a message as turning a light on and off for the time being. The light may flicker in an unsettling manner due to fading at times. This is where "Manchester coding" enters the picture. Manchester coding adds a rhythm to the light, like a heartbeat, making it easier to determine when each piece of information begins and ends. This assists us in detecting communication faults, such as detecting when a flicker does not follow the rhythm.

But what if, despite all the efforts, still make a mistake? This is when the "Hamming code" comes into play. It is like adding extra security to our messages. Consider emailing a pal a secret code. It is chosen to have them repeat the code to ensure they get it. Hamming code is similar in that it adds extra bits to the message so that if there is an error, it can figure out what it should have been. This way, even if some sections of the message are distorted by fading, can still acquire the correct information.

Although these strategies have been examined separately in the past, few have looked at how they can all function together to make communication even more dependable in the face of Rayleigh fading. This is where this thesis comes into play. It examines how combining Maximal Ratio Combining, Manchester coding, and Hamming code can help to overcome fading difficulties and make wireless communication stronger and more reliable. In the next chapters, the study will go deeper into how these concepts are implemented and how they can improve wireless connections even when the signals are playing tricks.

2.2 Related Works

Performance of Maximum ratio combining (MRC) with MIMO Systems for Rayleigh Fading Channel studied by (Suvarna P. Jadhav, 2018) [1] they provide an exact BER (Bit Error Rate) analysis for fading channels with maximal ratio combining (MRC) and imperfect channel estimation at the receive The BERs characteristics for the various transmitting and receiving antennas. If receiving antenna higher than transmit antenna, then it will increase Bit error rate high. The complexity will be higher. Proper error correction coding and decoding techniques are crucial in these cases. Connecting with MRC provides better data rates.

(Kayode, 2010) their study introduces adaptive diversity combining, a decision feedback equalizer/diversity combiner hybrid designed to work with the time-varying, stochastic nature of mobile radio channels [2]. The outcomes demonstrated the reliability that the suggested method is for signal transmission across mobile radio channels. RLS and LMS algorithms were used for training and tracking purposes to combine and equalize the faded signals as part of the adaptive combining diversity processing. This research has demonstrated that the combination of adaptive combining diversity, MRC, with a BPSK modulation scheme can significantly reduce the variable nature of wireless communications. From 16QAM to 256QAM using data rate will be maximized.

(UKEssays., 2018) The Design of Manchester Serial Data Communications Channel has present that This work analyzes the role of the clock divider, the PRBSG, the shift register, and the finite state machine (FSM), and merges them into a Manchester serial data communications channel [3]. It is used for recovering clock signal from the encoded data. The next step is to implement a bit error rate (BER) tester to determine the overall health of the system. A low BER indicates a highly integrated system, while a high BER indicates a poorly coordinated one. Increase transmitter power and reduce bandwidth will provide better data rate and lower hardware interference.

The performance of Manchester source coding in an uplink LDPC channel coding OFDM-based Massive MIMO system has been analyzed by (Alexandru Badea, 2020) [4]. This paper demonstrates that a Massive multiuser MIMO system is proposed in this study, where the number of antennas at the receiver can range from 8 to 12, and Manchester source coding, LPDC channel coding, and OFDM are all employed. Diversity is one method used to mitigate the impact of fading and interference. In this study, employ spatially, or antenna diversity made possible by Massive MIMO, one of several diversity strategies. Improved data rates and improved spectrum efficiency are just two of the benefits that will contribute to the development of the overall performance of the proposed system, despite the complexity generated by the high number of antennas present at both endpoints - both receiver and transmitter.

The author of (Madhukrishna, 2015) has been demonstrate in this paper that the primary goal of this research is to analyze the performance of several modulation schemes used in 4G technologies, including BPSK, QPSK, and M-QAM for M=16, 64, 128, and 256 [5]. Rician fading channel environment is used to evaluate the performance of different modulation schemes using MIMO technique.it provides high data rate with less BER because of higher SNR. The equal of transmitter and receiver antenna will provide some impact that data rate keep constant.

The author of ‘BER Vs Eb/N0 BPSK Modulation over Different Types of Channels’ This paper uses MATLAB simulation to quickly contrast how BPSK performs on various channel types [6]. The first situation is when the transmission signal is degraded by AWGN, the second is when the channel exhibits Rayleigh flat fading, and the third is a simulation of BPSK over a Rician fading channel. The bit error rate (BER), defined as the number of errors per unit of data sent across a channel, can be calculated with the help of this simulation. In the beginning of the simulation, an AWGN channel was used. A comparison was made between the simulation result and Because Rayleigh detectors are sensitive to the magnitude and phase of the received signal, which is formed from a variety of scattered signals during transmission, the BER response over AWGN is faster than the response over Rayleigh, shown by the simulation results.

(Navdeep Kaur,2015) the author of “SNR and BER Performance Analysis of MRC and EGC Receivers over Rayleigh Fading Channel “has present that in this study, they compare the outcomes of the Maximum Ratio Combining (MRC) and Equal Gain Combining (EGC) techniques for analyzing the performance of an uncoded Single Input Multiple Output (SIMO) systems over a Rayleigh fading channel [7]. These combining strategies are evaluated based on their effectiveness in terms of Signal-to-Noise Ratio (SNR) and Bit Error Rate (BER) when employing QAM and PSK modulation schemes. SNR is increased and BER is reduced when more antennas are used at the receiver end. The evaluation of the findings reveals that MRC using QAM modulation performs better than EGC.

The Authors of this article examined the channel performance of mobile communication signals impacted by Rayleigh multipath fading effects by using a noble approach diversity technique [8]. Under the premise that BPSK signals are impacted by the environment's reflection, diffraction, and scattering, the Alamouti scheme's performance and the maximum ratio combining technique's effectiveness are assessed. It has been demonstrated that a wireless MIMO system based on the Alamouti diversity technique and the maximum ratio combining technique can aid in the mitigation of Rayleigh fading channels and can approach AWGN channel performance with constant transmit power. Due to this, multi-antenna MIMO channels have lately emerged as a desirable method to enhance the quality of wireless communications by utilizing spatial diversity at both ends of the link. This method now makes up a sizeable portion of academic study in the present day.

The Authors of this article they study the performance of detection in a wireless full-duplex relaying network using diversity methods such as maximum ratio transmission (MRT) at the source and maximal ratio combining (MRC) at the destination for MIMO signals [9]. It investigates how hardware impairment (HI) at all nodes and residual self-interference (RSI) at the full-duplex relay (FDR) affect things. With the MIMO-FDR system with HI in mind, the paper provides closed-form formulas for important variables like outage probability (OP), throughput, and symbol error rate (SER). The analytical results are verified by Monte Carlo simulations. The results show that HI significantly influences the MIMO-FDR system's OP, throughput, and SER, especially at high data rates. Performance under HI can be considerably improved by using MRT/MRC with more transmit antennas than receive antennas.

In this study, the authors used an EGC, an SC, and an MRC to simulate the BPSK in a Rayleigh fading channel and determine the BER [10]. When compared to the SC and EGC, the MRC fares very well. EGC and SC have similar performance levels when the number of receivers is small, but EGC outperforms SC when the number of receivers is large. Several diversity-combining mechanisms used by the Rayleigh channel are compared. Methods like maximal ratio combining (MRC), selection combining (SC), and equal gain combining (EGC) are considered for coherent reception. The usefulness of these methods is measured with performance progression to ensure peak efficiency.

2.3 Comparative Analysis and Summary

In this thesis, it is studied how to increase communication reliability in MIMO systems using Rayleigh fading channels. The primary goal is to improve the quality of the received signal using Maximal Ratio Combining (MRC), Manchester coding for bit error detection, and Hamming code for error correction. would be best for this project. After reviewing various academic papers and project work, MRC diversity technique would be the best choice.

- TAS with MRC is a technique for combining signals from many antennas that reduces the effects of fading and improves signal quality.
- Manchester coding modifies signal polarity to encode data transitions. Synchronization and bit error detection are its strengths. Manchester coding in the system improves data accuracy.
- Hamming coding can detect and fix data transmission errors. The code's ability to detect and correct single-bit errors shows its potential to improve communication quality.

2.4 Challenges

- Multipath propagation causes unpredictable amplitude and phase changes in Rayleigh fading channels. Fading makes signal quality inconsistent, requiring fresh approaches to deal with it.
- MRC implementation is challenging. Combining multiple antenna signals with different phases and magnitudes is difficult. MRC enhances the signal while removing interference and noise, but it requires skilled engineering.
- Manchester coding detects bit errors but causes synchronization difficulty. In the presence of fading and noise, exact alignment is needed to correctly recognize signal transitions as bits. Hamming code corrects errors but adds data. In low-bandwidth scenarios, balancing error correction performance and data size can be difficult.
- Coordinating these tactics to smoothly integrate into the communication system while optimizing for Rayleigh and Rician fading channel characteristics is complex and requires a deep understanding of their interaction.

CHAPTER 3: System Design and Methodology

3.1 System Design Overview and Components

This chapter details the design of the MIMO communication system and the individual components that improve its performance with respect to the Bit Error Rate (BER). The function, importance, and relationship of each part of the system are described in depth.

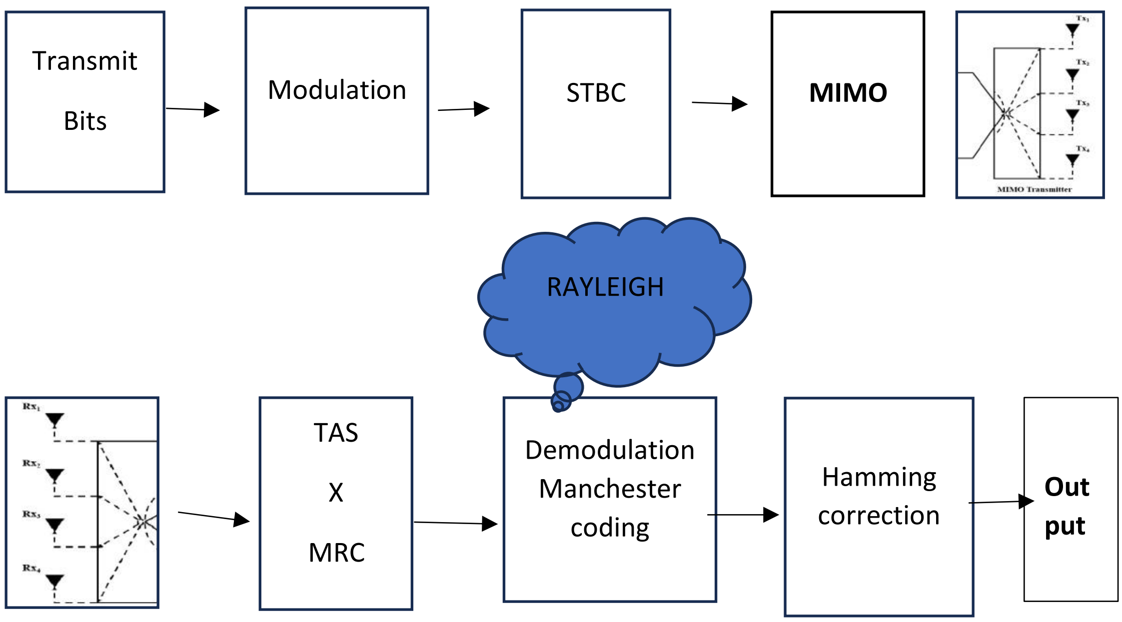


Figure 3.1: system overview and architecture

Architecture overview: The proposed method aims to help with the difficulties of transmitting data across channels that are subject to Rayleigh fading and Rician fading channel. It makes use of several novel techniques to lessen the impact of things like fading, noise, and interference. Modulation, space-time coding, broadcast antenna selection, reception diversity, encoding, and error correction are the backbone of the system. All these parts work together in a well-orchestrated dance to boost BER efficiency as an entire.

BPSK modulation and Data processing: The system is based on the modulation scheme known as binary phase-shift keying (BPSK). Incoming binary data is converted into complex symbols with two-phase states using this technique. To protect the broadcast signal from phase shifts caused by channel fading, it is modulated. The data is encoded by the BPSK modulator so that it can be processed further.

Integration of STBC and TAS: MIMO systems rely heavily on Space-Time Block Coding (STBC) boost diversity and dependability. To reduce the effects of fading and improve signal reception, STBC spreads data encoding across numerous antennas and time intervals. To improve signal quality and robustness against channel variations, TAS chooses the best transmitting antennas spontaneously.

MRC Implementation: At the receiver end, signals from various antennas are combined using the Maximum Ratio Combining (MRC) method. Based on the signal-to-noise ratio (SNR) of each antenna, MRC gives relative importance to each received signal. This method aids in minimizing the effects of noise and fading by maximizing the quality of the signals that are extracted from the transmissions.

Manchester coding Detect error: To improve the system's clock synchronization and self-clocking abilities, Manchester encoding is applied. The encoding procedure creates transitions in the signal at the beginning and end of each bit interval, making it easier to detect the bit boundaries and reducing synchronization problems.

Hamming Code correction: To further improve BER performance, a novel error correction mechanism is provided in addition to conventional error correcting methods. The system may dynamically modify its error correction technique in response to channel conditions and receive signal quality thanks to this mechanism, which blends ideas from pre-existing error correction codes with adaptive algorithms.

3.2 Architecture Procedure

Modulation Equation: Binary phase shift keying (BPSK) converts binary information (0s and 1s) into phase shifts of the carrier signal. Suppose employ a carrier signal with a phase range of 0–180 degrees. The following is an illustration of the BPSK modulation equation.

If the data bit is 0:

$$S(t) = A \cdot \cos(2\pi f_C t)$$

If the data bit is 1:

$$S(t) = A \cdot \cos(2\pi f_C t + \pi)$$

Where,

$S(t)$ is modulated signal at time t.

A is the amplitude of the carrier signal.

Fc carrier frequency.

Data must be preprocessed to conform to the BPSK modulation technique before it can be used. Each one or zero in the binary data is converted into a unique phase shift of the carrier signal. A phase shift of 180 degrees may be represented by the number 1, whereas a change of 0 degrees would be expressed by the number 0.

This processing before guarantees the desired phase shifts in the modulated signal, which makes it resistant to phase changes due to causes like fading.

STBC:

STBC is a method that uses multiple transmit antennas and time slots to encode data, which results in diversity and reduces the impact of fading. The Alamouti technique is a popular implementation of STBC in a 2x2 MIMO system, where use two broadcast antennas and two receive antennas [14].

For a given pair of data symbol S_1 and S_2 at time t. Now Alamouti STBC scheme transmits the following signals:

$$x_1(t) = S_1(t)$$

$$x_2(t) = -S_2^*(t)$$

And at the next time slot $t+1$:

$$x_1(t+1) = s_2(t)$$

$$x_2(t+1) = s_2^*(t)$$

Where $Si(t)$ showing the data symbol at time t for antenna i, and $*$ denotes the complex conjugate.

Transmit Antenna Selection: Maximizing the signal-to-noise ratio (SNR) at the receiver is a typical goal when selecting an antenna. It is possible to mathematically determine the SNR of the i-th antenna by using the formula.

$$S\mathbb{N}R = \frac{|h_i|^2}{\sigma^2}$$

Where,

- $|h_i|^2$ now squared magnitude of the channel coefficient of between the i-th transmit antenna and the receiver.
- σ^2 the variance of the adaptive noise

The Mathematical Representation of Antenna Selection:

[15] Think about a Multiple-Input Multiple-Output (MIMO) system with N transmitters and M receivers. The channel between the transmitter and receiver is represented by the matrix H, and the channel coefficient between antennas i and j is denoted by h_{ij}.

[15] To choose the best, transmit antenna, compute the SNR for each possible transmit antenna i using the previously given formula:

$$S\mathbb{N}R = \frac{|h_i|^2}{\sigma^2}$$

Now the select antenna with the highest SNR is chosen for transmission:

$$K_{opt} = arg\ max_i\ SNR_i$$

Where K_{opt} are the index of the selected optimal transmit antenna.

TAS examines all transmitter's available antennas and determines their SNRs, to put it simply. The antenna with the best signal-to-noise ratio is used to transmit.

MIMO System Architecture and Operation

Consider conversing with a person across a room while there is a lot of background noise. Imagine having two ears as opposed to just one. That way, you can concentrate on the other person's words without being distracted by background noise. In a similar manner, MIMO systems operate.

In a MIMO system,[12] there are antennas on both the sender's side and the receiver's side that act as signal receivers. This means the signals simultaneously transmitting several instead of simply one. It's like having many lanes on a roadway to help automobiles travel more freely.

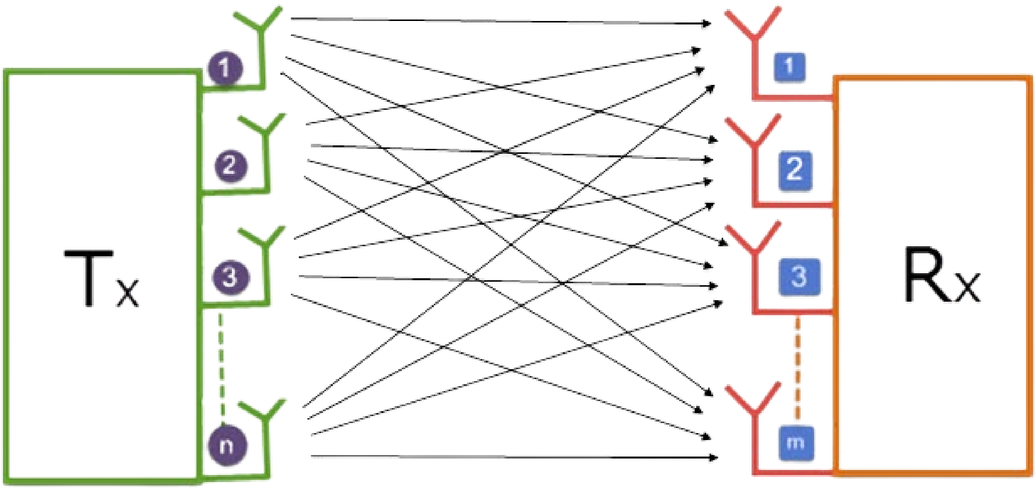


Figure 3.2: MIMO system Structure

Operation:

Data is divided into several pieces before being sent. Each component is transmitted using a different antenna. These components have a variety of flight patterns and have the ability to bounce off objects. All these components are put together once again at the end by the recipient to form the whole message.

Consider it as sending puzzle pieces. To see the entire picture, the receiver must assemble all the components. It can send and receive data better thanks to MIMO systems, especially in environments where signals can bounce and cause confusion.
MIMO systems work together like a team of antennas to ensure that communications move more easily and without as many glitches as possible. Understanding the configuration and operation of MIMO systems can help us get closer to enhancing communication dependability, even in the face of problems like Rayleigh fading.

Rayleigh Fading Channel Model

Let's figure out what makes Rayleigh fading, the process by which wireless signals can become distorted during transmission, tick. Put yourself in a room full of mirrors and imagine throwing a ball in. Each time the ball bounces, its trajectory shifts slightly. Wireless signals, like light, can reflect off solid objects like buildings and trees. Rayleigh fading, a form of signal confusion, is created by this bouncing.

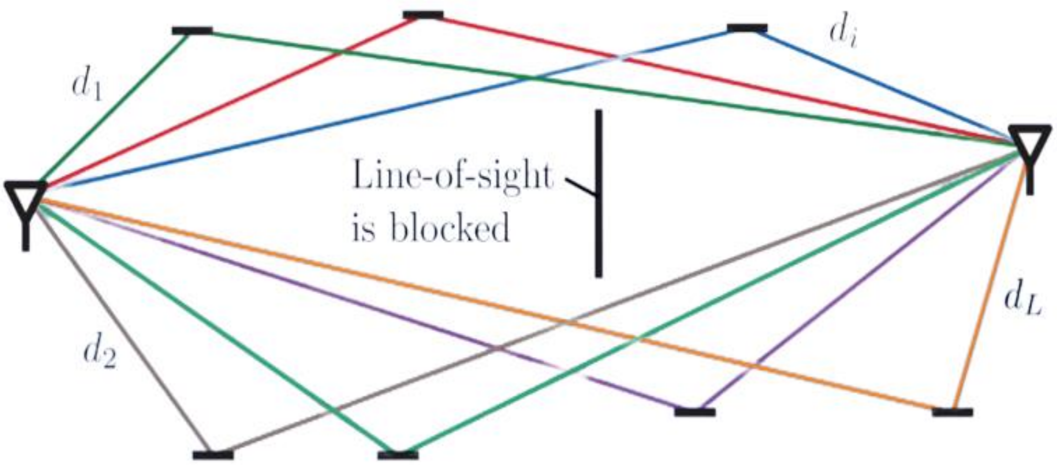
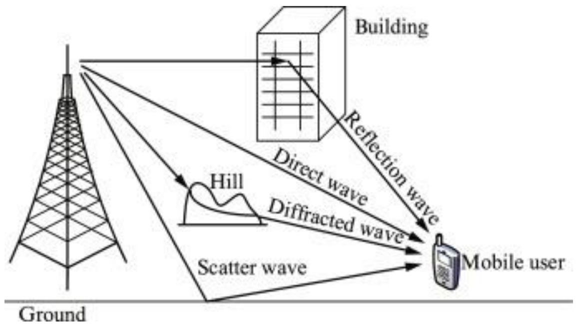


Figure 3.3: Rayleigh Fading

Understanding: In today's wireless world, signals function similarly to communications sent through the air. These signals take various pathways or reflect off surfaces, which causes Rayleigh fading. Since this, the signal can receive fluctuates in strength since it is a combination of the original signal and its reflections. Imagine yourself talking with a friend at the beach. Voice can sometimes be heard perfectly but other times it is lost in the wind. This difference in your friend's ability to hear you is comparable to Rayleigh fading. Communication issues can result from its unpredictable ability to make wireless signals stronger or weaker.



Model: Scientists make use of models, such as simplified graphics, to comprehend Rayleigh fading and its effects on signals. Imagine using a map to find way around an unfamiliar town. The signal changes in strength like a roller coaster, which is a frequent analogy for Rayleigh fading.

This model helps in the ability to forecast whether Rayleigh fading will cause signals to become weaker or stronger. It's like knowing that a roller coaster would cause both excites and falls. It can improve the reliability and toughness of signals even in the presence of Rayleigh fading by understanding this model.

Understanding Rayleigh fading and its channel model, then, is like having an exact map that leads us through the ups and downs of signal strength, assisting us in finding ways to maintain our communications reliable and clear as explore the world of wireless communication.

Receiver site TAS Now: For every transmit antenna, the Signal-to-Noise Ratio measures the received signal's quality. The resulting vector $\gamma = [\gamma_1, \gamma_2, \ldots, \gamma_n]$ represents the total number of transmitting antennas. Each γ_i indicates signal quality at the transmit antenna.

A threshold (θ) is set as a norm for acceptable signal quality. Transmit antennas with SNRs above θ are suitable for selection. The basis of Receiver-Side TAS is a binary selection matrix.

$$W \in \{0, 1\} \wedge (n \, x \, m),$$

where n denotes transmit antennas and m represents receive antennas. Each matrix element W_{ij} is defined as $1 \, if \, \gamma_i \geq \theta \, and \, 0$ like $W_{ij} = 1 \, if \, \gamma_i \geq \theta, and \, W_{ij} = 0$ otherwise.

The selection matrix W rows is reviewed to determine the transmit antennas for signal processing. The antennas with SNR values over θ will be selected.

The receiver's post-TAS signal vector, y_tas , is obtained through matrix-vector multiplication employing the selection matrix W and the original signal vector y. Math: $y\_tas = W \, y$.

Receiver-Side TAS chooses antennas based on SNR, improving SNR and signal quality. This rapid adaptation to channel dynamics improves MIMO system performance in complex wireless propagation environments, particularly when tackling fading and interference.

Maximal Ratio Combining Algorithm: Signal processing with the Maximum Ratio Combiner (MRC) method is widely employed in wireless communication systems, especially when combining signals from many antennas to improve signal quality and mitigate the effects of interference and noise. The MRC algorithm's goal is to improve the signal-to-noise ratio (SNR) by merging and balancing the signals from many antennas.

$$y = h_1x_1 + h_2x_2 + \cdots + h_nx_n + n$$

- Y The signal that was received is y.
- h_i indicates the channel coefficient for the ith antenna, describing how the channel affects, attenuates, and delays the transmitted signal from that antenna.
- x_i is the signal that the ith antenna transmitted.
- n the received signal's extra interference is represented by the number n.

The MRC algorithm's purpose is to combine the received signals in a way that maximizes the resultant signal's SNR. The channel coefficients and their conjugates determine the ideal weights for combining the signals. The total signal

$$z = w_iy_1 + w_2y_2 + \cdots + w_ny_n$$

Where,

- $\boldsymbol{Wi}^*$ Is the weight applied to the signal of the $i-th$ antenna's complex conjugate.
- $\boldsymbol{Yi}$ the signal that the $i-th$ antenna has received.

The signal-to-noise ratio at the receiver's output is maximized through choosing one of the weights. By considering the channel coefficients and guaranteeing the signals are mixed constructively, enhancing the valuable signal components, and reducing the impacts of noise and interference, the optimal weights are determined.
Mathematically optimally weight $i-th$ antenna …….

$$\omega_i = \frac{h_i^*}{\varepsilon_J^n |h_j|^2}$$

Where, $*\, hi\, *$ is weight complex conjugate for the channel coefficient for the ith antenna.

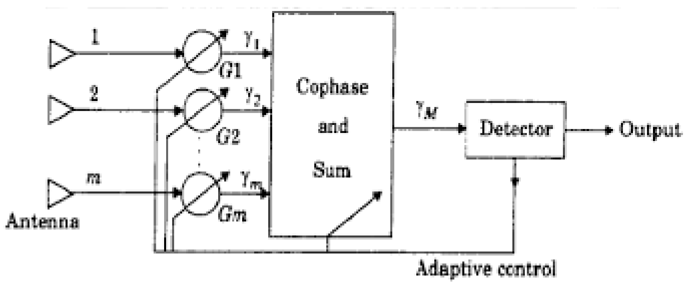


Figure 3.4: Maximal Ratio Combiner

When there is spatial diversity, like in multiple-input multiple-output (MIMO) systems, where there are many antennas at both the transmitter and the receiver, the MRC algorithm benefits. It uses the channels' variety to improve the quality of the transmitted signal. Increased performance, better coverage, and reduced fading are all possible thanks to MRC in wireless networks.

Receiver site MRC: MRC is a method for maximizing the quality of the received signal by combining signals from many antennas. It's the equivalent of using multiple sets of ears to listen to a similar message and piecing together the best elements of each signal to form an improved version of the original.

Mathematically, consider having the N receive antenna and N corresponding signal $Y_1, Y_2 \dots Y_N$, MRC combine this signal using complex weight $W_1, W_2 \dots . W_N$ that are calculated based on the channel condition. The combined signal MRC IS s_{MRC} :

$$s_{MRC} = W_1 Y_1 + W_2 Y_2 + \cdots W_N Y_N$$

The weight W_i are chosen in such a way did they maximize the signal to noise ratio (SNR) of the combine signal s_{MRC} . This allows MRC to emphasize the parts of the receipt signal that have the strongest signal relative to the noise.

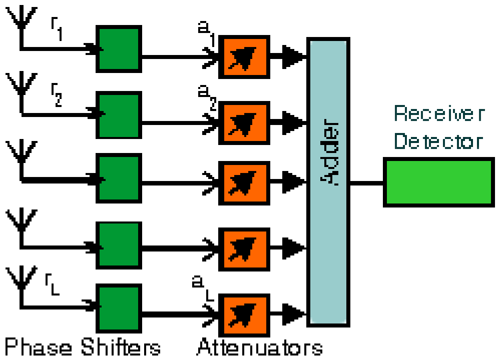


Figure 3.5: MRC Combine

Manchester coding: Let's pretend using Manchester coding to send the binary digits 1 0 1 0. Here are how the bits would be encoded and changed:

Initial Numbers: 1 0 1 0

Manchester Combination key: L-H H-L L-H H-L

- 1 is encoded as an L-to-H transition in the middle up the beat interval.
- 0 is encoded as an H-to-L transition in the middle up the beat interval.

Now let's consider the possibilities of a bit error occurring during transmission Let's say there is a bit flip error, and the received data becomes 1 0 0 0. here how the receive data end the corresponding transition would look:

Received Data: 1 0 0 0

Manchester code: L-H H-H H-H H-H

The initial bit (1) is received and correctly decoded as an L-to-H transition. However, an unanticipated H-to-H transition has occurred since the second bit (0) has been switched to 1. An error in the received data is shown by the transition pattern not matching.

The bit flaws also cause the third and fourth bits to have transitions that are inconsistent with what would be expected from Manchester encoding.

So, it can readily determine the presence of bit errors by analyzing the transitions in the received Manchester coded data. If a transition does not follow the normal L-to-H or H-to-L pattern, the receiving system's error detection systems will take corrective action, such as asking for retransmission of the data.

Hamming code correction:

Suppose transmitting the 4-bit data 1010 through the Hamming (7,4) code, here's what can be done.

Initial Numbers: 1.0.1.0

To explain how the encoding might function**:**

Adding parity bits:

- Bit 1: Parity for 1, 3, 5, and 7
- Bit 2: Parity for 2, 3, 6, and 7
- Bit 3: Parity for 4, 5, 6, and 7

Encoded data: P1 P2 1 P3 0 1 0

Each parity bit in this case is determined according to the number of locations it covers in the encoded data.

Now, let's imagine a transmission fault that causes the 4th bit to be flipped:

Data Received: P1 P2 1 P3 1 1 0

Use the steps under to rectify the issue using the Hamming code:

1. Using the received data for places 1, 2, and 4, calculate the parity bits.

2. Compare the projected parity bits (P1, P2, and P3) to the received parity bits.

3. Identify the determined parity bits that do not match the received parity bits to ascertain the location of the problem.

4. Flip the bit to the location where the fault was found.

In this case, let's calculate the parity bits using receive data:

• P1 = XOR of bits 1, 3, 5, and 7 = 1 XOR 1 XOR 1 XOR 0 = 1

• P2 = XOR of bits 2, 3, 6, and 7 = 0 XOR 1 XOR 1 XOR 0 = 0

• P3 = XOR of bits 4, 5, 6, and 7 = 1 XOR 1 XOR 1 XOR 0 = 1

N Comparing this calculate this parity bit with receive parity bit:

• P1: Figured out 1, received 1 (Match)

• P2: Figured out 0 and received 1 (1 error)

• P3: Figured out 1, received 1 (Match)

The mistake is in the second parity bit (P2), which is the fourth spot in the data that was received. The mistake is in the fourth bit.

Data that has been fixed: P1 P2 1 P3 0 1 0

Original data: 1 0 1 0

3.3 Preview Literature Data Analysis

The author of this paper analyzes and contrasts several methods of wireless signal sending and receiving [11]. They used several different communication channels and evaluated the system's responsiveness under a variety of scenarios.

They began by comparing three different types of signal transmission: BPSK, QPSK, and M-QAM. All of these "languages" are used by gadgets to communicate with one another. To achieve this, they intentionally exposed these languages to varying degrees of signal fading. When impediments and interference cause changes in signal strength, something known as "signal fading" occurs.

They studied Rayleigh, Rician, and Sakagami-m fading signals. These variations are like the signals' experience of varying weather. The devices' ability to communicate will be tested in a variety of conditions.

The research studied several methods of wireless signal transmission and reception. They conducted tests of these strategies with varying numbers of antennas and signal attenuation environments. In general, their results were consistent with their predictions, demonstrating the efficacy of these strategies.

Table 3.1: BER rate over Rayleigh fading channel.

Antenna Selection	**BER**		
	BPSK	QPSK	16-QAM
Tx: 1 Rx: 2	0.00823	0.0547	0.35321
Tx: 1 Rx: 4	0.00047	0.0047	0.1563

Whenever increase Receiver branches the Ber rate significantly decrease. Like BPSK was 0.00817 for 1x2 MIMO and now increase 1x4 MIMO the BER 0.0002 hugely decrease.

Table 3.2: BER rate over Rician fading channel.

Antenna Selection	BER		
	BPSK	QPSK	16-QAM
Tx: 1 Rx: 2	0.00516	0.0544	0.3362
Tx: 1 Rx: 4	0.0001	0.00507	0.1286

Whenever increase Receiver branches the Ber rate significantly decrease. Like BPSK was 0.00517 for 1x2 MIMO and now increase 1x4 MIMO the BER 0.000 hugely decrease.

3.4 Component Requirements

- Data generator
- BPSK Modulation
- Space-Time-Block-code
- TAS With MIMO
- Rayleigh fading channel.
- Maximal-Ratio-Combiner
- Manchester coding
- Hamming Code

3.5 System Implementation

Now, understand how communication system is based on, it can discuss how to put it into operation. Putting the system into practice involves putting theoretical concepts into action. It is done as follows:

1. Getting Right Tool: It can't even begin without the right tools. Antennas, transmitters, receivers, and computers all fall under this category. Software that helps in the design, simulation, and testing of the system is also required.

2. Turning Data into signal: The initial step is to convert the information into signals that can be transmitted. To do this, employ a technique known as Binary Phase-Shift Keying (BPSK). The effect is like encrypting data with a pattern designed for use in adverse conditions.
3. Combining technique: For this purpose, integrate Transmit Antenna Selection (TAS) with Space-Time Block Coding (STBC). TAS selects the finest antennas to send from, and STBC helps us distribute the data between them in an efficient manner. It's like having brain confidence that works to boost the strength of the signal.
4. Bringing signal Together: The receiver's task is to combine the signals coming from several antennas. Maximum Ratio Combining (MRC) is the name of the method applied here. It's like having a bunch of mates all chime in with the same information and then choosing out the most concise details from each.
5. Syncing the Bits: Manchester encoding is another technique that is adopted. This can be thought of as inserting timing signals between data bits to guarantee correct interpretation. Even if the signals are a little confused, this helps us make sense of the message.
6. Correcting Mistake: Developed an advanced system to detect and correct inaccurate information. It's like having a robot friend who reads through messages and fixes any typos it detects. This guarantees that our data will make it in one piece, regardless of any hiccups that may occur on the route.
7. Simulation and Resulting: Carry out simulations before applying our technique in actual circumstances. This serves as an opportunity to test how effectively the system operates.
8. Facing problems: In addition, it must overcome obstacles. It is needed to figure out effective strategies to make use of the potentially high computer power requirements of some methods. Additionally, keeping everything in time can be challenging, especially when signals fluctuate due to fading.

CHAPTER 4: Result and Analysis

4.1 Introduction

The purpose of this study is to figure out the Bit Error Rate (BER) for different modulation techniques, such as Binary Phase Shift Keying (BPSK), Quadrature Phase Shift Keying (QPSK), and 16-Quadrature Amplitude Modulation (16QAM), under different fading situations. In this study, the Rayleigh and Rician fading channel models are considered. Between 0 and 20 dB, the Signal-to-Noise Ratio (SNR) is looked at.

Space-Time Block Coding (STBC) with the Alamouti scheme, TAS with Maximum Ratio Combining (MRC) are used to measure how effectively BER works. The aim of these diversity methods is to make communication more reliable in places where signals are weak. The BER of BPSK is looked at for both transmit and receive diversity in different fading situations so that the simulated results can be compared to what the theory says should happen.

The study additionally looks at how well the results for BER for BPSK modulation match up with those for Rayleigh fading. The study also looks at how BER changes when the Rician fading model is in play. This is achieved by looking at different values of the Rician factor (K) and the amount of fading (mover).

The study expands its analysis into several modulation schemes, including BPSK, QPSK, and 16QAM, using Alamouti STBC in a multiple-input multiple-output (MIMO) configuration. Both Rayleigh and Rician fading channels are considered while evaluating these modulation techniques. When these systems use the TAS with MRC diversity technique under the same fading conditions, the BER performance of these schemes is likewise studied.

4.2 Impact of TAS with MRC BER reduction

Rayleigh fading channel:

Parameter sitting-

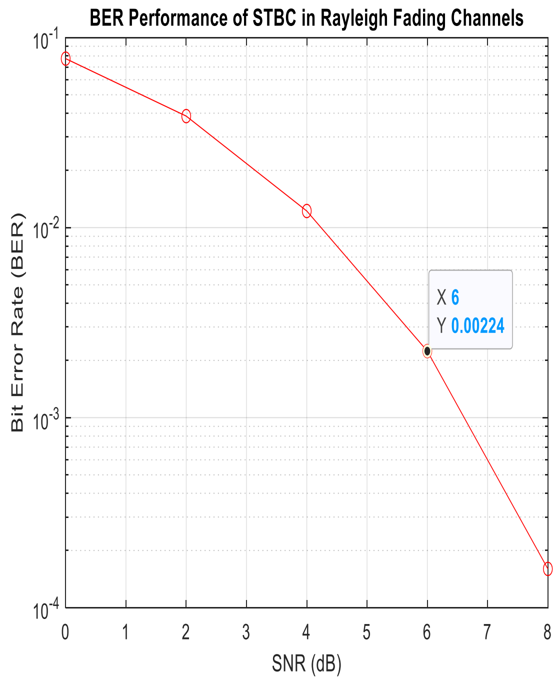
Transmitter (Tx) = 1

Receiver (Rx) = 2

Transmitting Bit = 100000

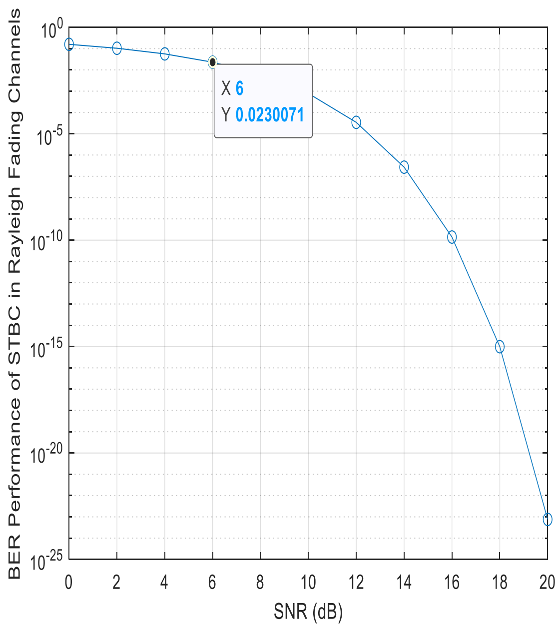
SNR = 0: 2: 20

Here Transmit Antenna Selection (TAS) do the main role to reduction of BER. TAS collects the highest SNR signal from the multiple signal that is received by Receiver Antenna. As the signal contains the highest SNR value that provides the low BER rate among the other signals. When Maximal Ratio Combiner and TAS are used in this operation the combine technique receives the best signal at the receiver end of the antenna. As a result, this study finds the desire output of the operation.



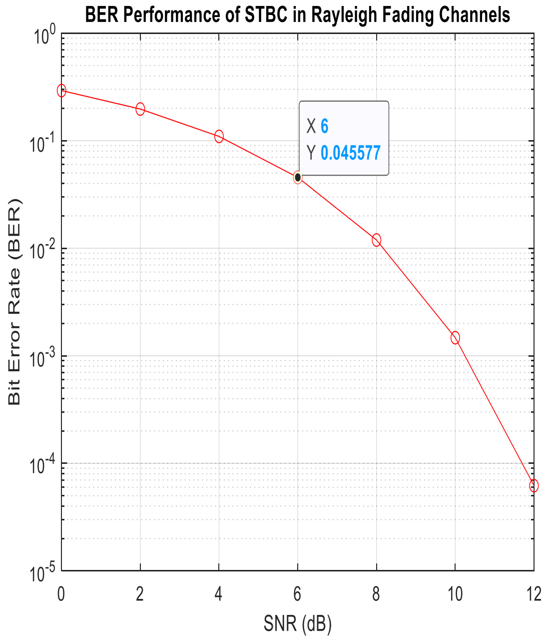
BPSK: (1X2) MIMO in this case BER performance of STBC in Rayleigh fading that provide minimum BER 0.00217 for considering 6 dB. In this fading channel it must use STBC and Receiver site TAS with MRC to improve the BER. MRC combines the all-transmitted signal at the receiver end and selects the highest amplitude signal as the final output which provides the better BER of the data.

Figure 4.1: BER of BPSK over Rayleigh fading channel.



QPSK: In this study of QPSK modulation over (1X2) MIMO system with the Rayleigh Fading channel provide slightly higher BER from BPSK modulation at the same channel and parameter. As QPSK can transmit more data than BPSK modulation the BER also increases. QPSK provide high data rate because of QPSK send 2 bit per symbol,

Figure 4.2: BER of QPSK over Rayleigh fading channel.



16QAM: QAM provide high data rate and it also add huge noise that extremely create high BER. But TAS with MRC Minimize BER also on MIMO, that hugely decrease BER. 16QAM Provide high data rates and greater spectrum efficiency compared to QPSK & BPSK due to increased symbol density. BER rate slightly higher than BPSK & QPSK.

Figure 4.3: BER of 16QAM over Rayleigh fading channel.

Now for (1x2) MIMO in Rayleigh fading system BPSK BER rate 0.00224 and QPSK slightly higher BER rate like 0.023007 and significantly higher error rate in 16QAM is 0. 04557.The main them is whenever modulation parameter increases data rate increase but also increase BER rate.MRC improve BER highly in this case

1x4 MIMO: Here, increasing the Receiver antenna at that point in MIMO system. It's a 1x4 MIMO that represents Transmit antenna 1 and Receiver antenna 4. That's a highly improved BER rate in this case. Increasing antenna that's helping to catch signal in the Receive site.

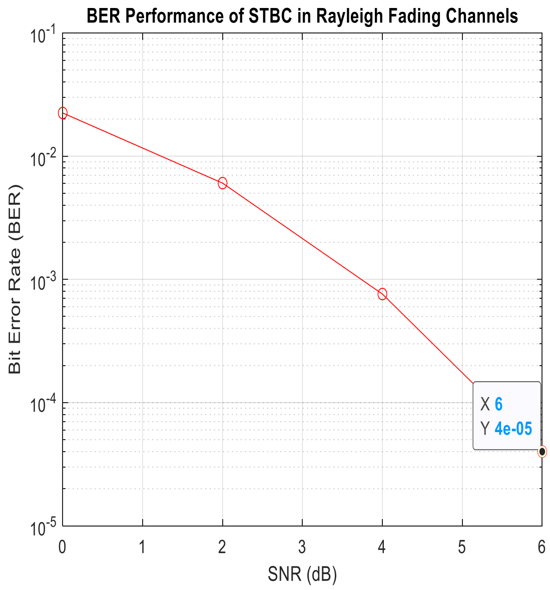
Parameter sitting-

Transmitter (Tx) = 1

Receiver (Rx) = 4

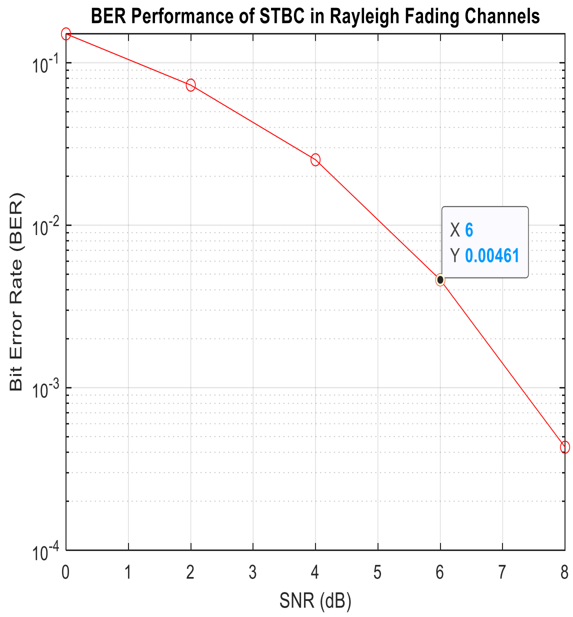
Transmitting Bit = 100000

SNR = 0: 2: 20



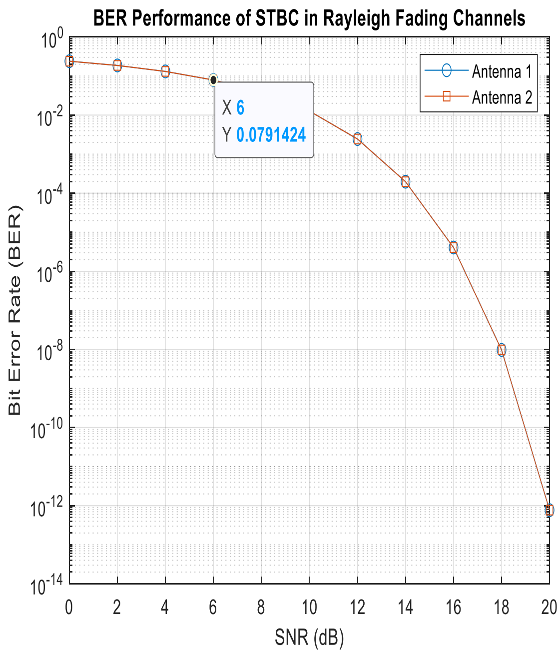
BPSK: (1X4) MIMO in this case BER performance of STBC in Rayleigh fading that provide minimum BER 0.0004 for considering 6 dB. In this fading channel When increasing receiver antenna BER rate hugely decrease. TAS chosen best SNR for getting better BER rate. Increasing antenna to catch easily signal. That signal sent to MRC. that improve BER.1X4 MIMO provide better BER rate than previous one.

Figure 4.4: BER of BPSK(1X4) over Rayleigh fading channel.



QPSK: In this study of QPSK modulation over (1X4) MIMO system with the Rayleigh Fading channel provide slightly higher BER from BPSK modulation at the same channel and parameter. BER rate 0.00461 that slightly higher than BPSK. But data rate gain efficiently for increasing Receiver antenna.

Figure 4.5: BER of QPSK(1X4) over Rayleigh fading channel.



16QAM: (1X4) MIMO in this case BER performance of STBC in Rayleigh fading that provide minimum BER 0.07914 for considering 6 dB. 16-QAM provide high data rate and it also add OBSTACLE noise that extremely create high BER. But MRC Minimize BER also on MIMO, that hugely decrease BER, provide more buffering.

Figure 4.6: BER of 16QAM (1X4) over Rayleigh fading channel.

Rician fading channel:

Parameter sitting-

Transmitter (Tx) = 1

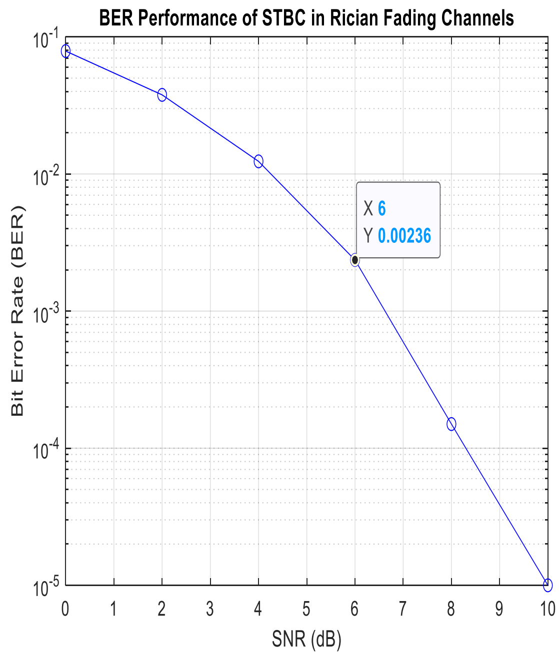
Receiver (Rx) = 2

Transmitting Bit = 100000

SNR = 0: 2: 20

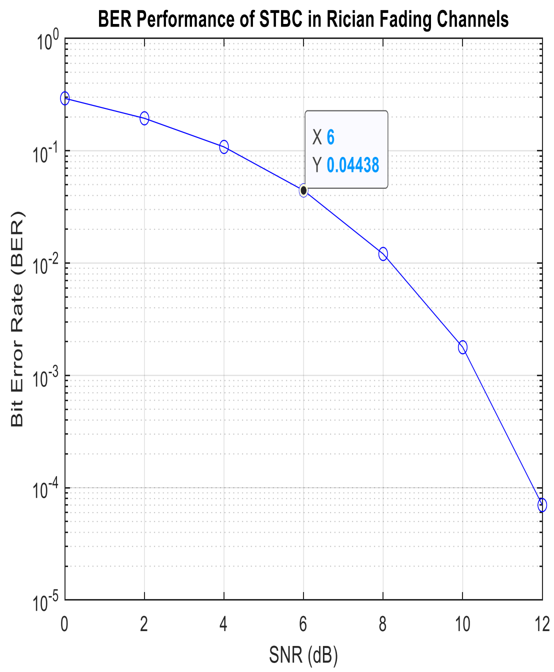
K = 1

Now Rician fading channel has slightly getting better output most of the time Rician fading channel used in rural area. That means it has less scattering in this section that's get better BER rate.



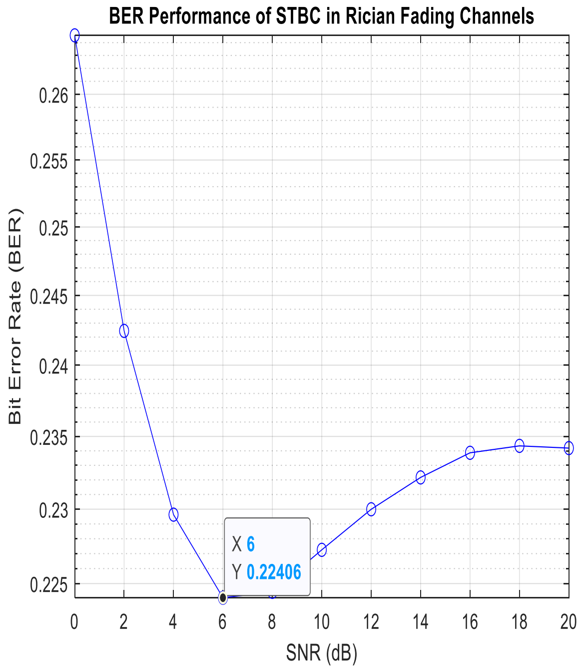
BPSK: (1X2) MIMO in this case BER performance of STBC in Rician fading that provide minimum BER 0.00228 for considering 6 dB that slightly better than Rayleigh fading channel. In this fading channel using STBC, TAS with MRC to improve the BER. MRC combines the all-transmitted signal at the receiver end and selects the highest amplitude signal as the final output which provides the better BER data.

Figure 4.7: BER of BPSK over Rician fading channel.



QPSK: In this view of QPSK modulation over (1X2) MIMO system with the Rician Fading channel provide slightly higher BER from BPSK modulation at the same channel and parameter. Transmitting more data than BPSK modulation the BER also increase. For few obstacles it gets better BER. (1X2) MIMO in this case BER performance of STBC in Rician fading that provide minimum BER 0.04438 for considering 6 dB that slightly better than Rayleigh fading channel.

Figure 4.8: BER of QPSK over Rician fading channel.



16QAM: 16-QAM provides high data rate and it also add OBSTACLE noise that extremely create high BER. BER rate 0.22406 that is highest BER rate for QAM modulation in Rician channel. The enhanced symbol diversity of 16-QAM makes it most resistant to Rician fading than QPSK & BPSK. All of three perform similarly under Rayleigh fading, with no clear advantage for 16QAM.

Figure 4.9: BER of QPSK over Rician fading channel.

1x4 MIMO: Here, Increasing the Receiver antenna at that point in MIMO system. It's a 1x4 MIMO that represents Transmit antenna 1 and Receiver antenna 4. That's a highly improved BER rate in this case. Increasing antenna that's helping to catch signal in the Receive site.

Parameter sitting-

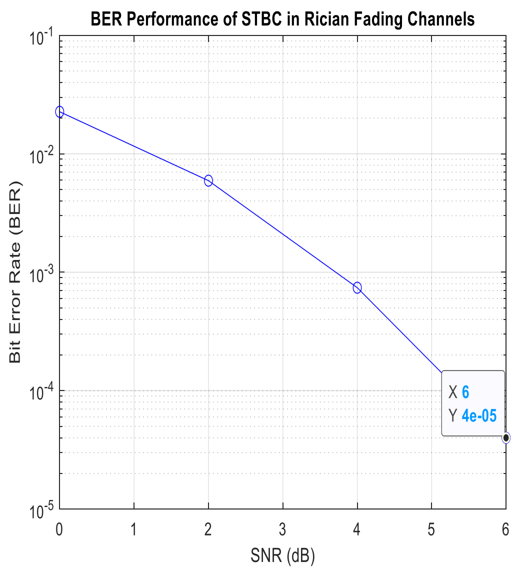
Transmitter (Tx) = 1

Receiver (Rx) = 4

Transmitting Bit = 100000

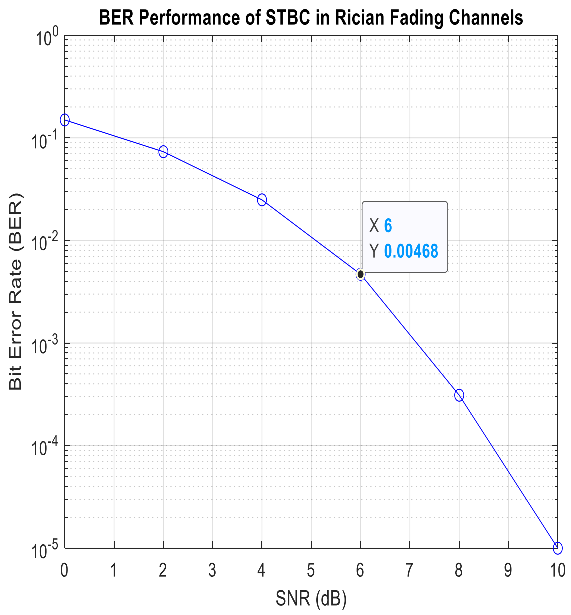
SNR = 0: 2: 20

K =1



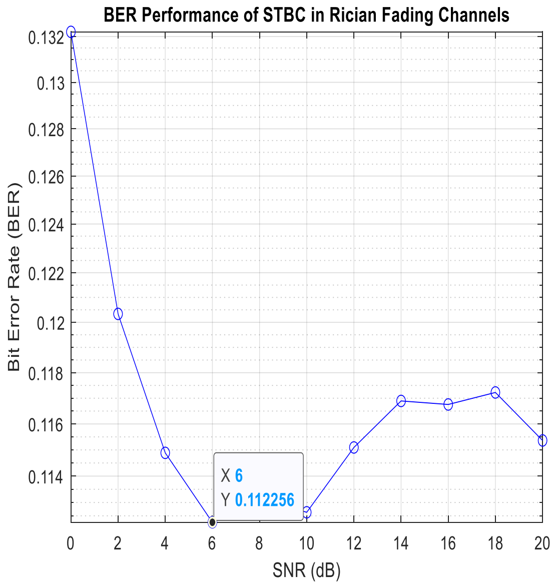
BPSK: In this analysis, BPSK over Rician fading channel BER rate highly reduce because of minimum line of sight and less fading. (1x4) MIMO MRC improve the BER. MRC sum of the all-transmitted signal at the receiver end and select the highest amplitude signal as the final output which provide the better BER data. BER rate 0.00004 is hugely decrease.

Figure 4.10: BER of BPSK(1x4) over Rician fading channel.



QPSK: QPSK modulation over (1X4) MIMO system with the Rician Fading channel provide unlike higher BER from QPSK modulation at the same channel and parameter. As transmitting more data than BPSK modulation the BER also increase. It provides 0.0004 BER for 6 dB. For few obstacles

Figure 4.11: BER of QPSK (1x4) over Rician fading channel.



16QAM: In this view of 16QAM modulation over (1X4) MIMO system with the Rician Fading channel provide slightly higher BER from BPSK and QPSK modulation at the same channel and parameter. For few obstacles it gets better BER. (1X4) MIMO in this case BER performance of STBC in Rician fading that provide minimum BER 0.11225 for considering 6 dB that slightly better than Rayleigh fading channel.

Figure 4.12: BER of 16QAM (1x4) over Rician fading channel.

Table 4.1: BER rate over Rayleigh fading channel with TAS.

Antenna Selection	BER		
	BPSK	QPSK	16-QAM
Tx: 1 Rx: 2	0.00224	0.023007	0.045577
Tx: 1 Rx: 4	0.0004	0.00461	0.07914

.

Table 4.2: BER rate over Rician fading channel with TAS.

Antenna Selection	BER		
	BPSK	QPSK	16-QAM
Tx: 1 Rx: 2	0.00228	0.04438	0.22406
Tx: 1 Rx: 4	0.0004	0.00468	0.11256

Analysis: The Ber rate decreases slightly because of increasing Receiver Branches and for TAS. This TAS receives the highest SNR signal that provides basically better BER. Here using different modulation technique BER results in increasing slightly from BPSK to QPSK and 16QAM. Added the Maximal Ratio Combiner technique with the modulation scheme, the performance of the BER result has efficiently improved several times than the previous output. In this table, it is found the (1x2) MIMO the BER for BPSK is 0.00224 which is perform better in (1x4) MIMO is 0.0004 BER in BPSK at the Rician Fading Channel. It also found that the improvement of BER is higher in Rician Fading channel than Rayleigh Fading channel.

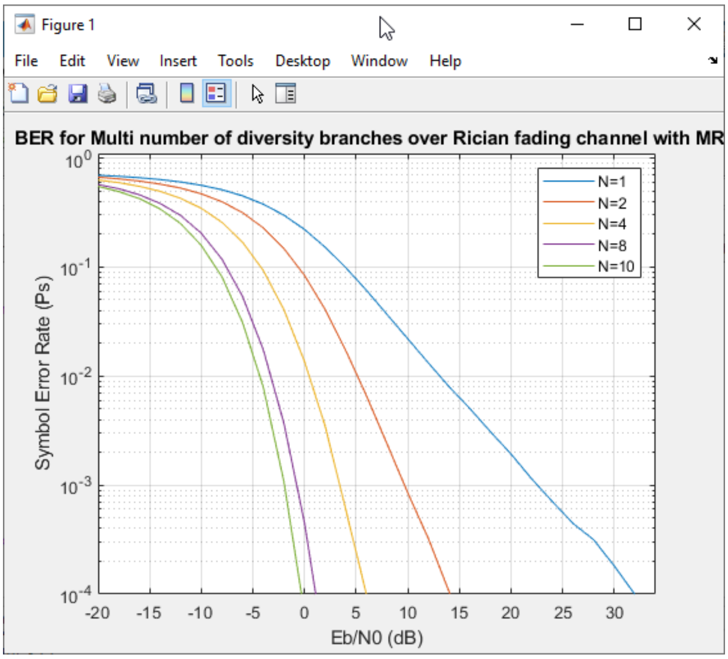


Figure 4.13: BER performance in changing diversity branches

Here is shown that the BER performance can also be improved by increasing the number of diverse branches. Take N= 1,2,4,8…. and it is examined BER is improved gradually. When use Diversity Branches with Maximal Ratio combining technique in this operation Number of diversity increase and the Bit Error Rate performance also improve.

4.3 BER Performance Enhancement through Manchester coding

Detection:

Here do the operation to trasmitting a data set of 20000 bits in a Rayleigh fading channel and examined that detect 18 bits error in the Reciver end. It also figure out the number and postion of the error bits in the transmitted data.

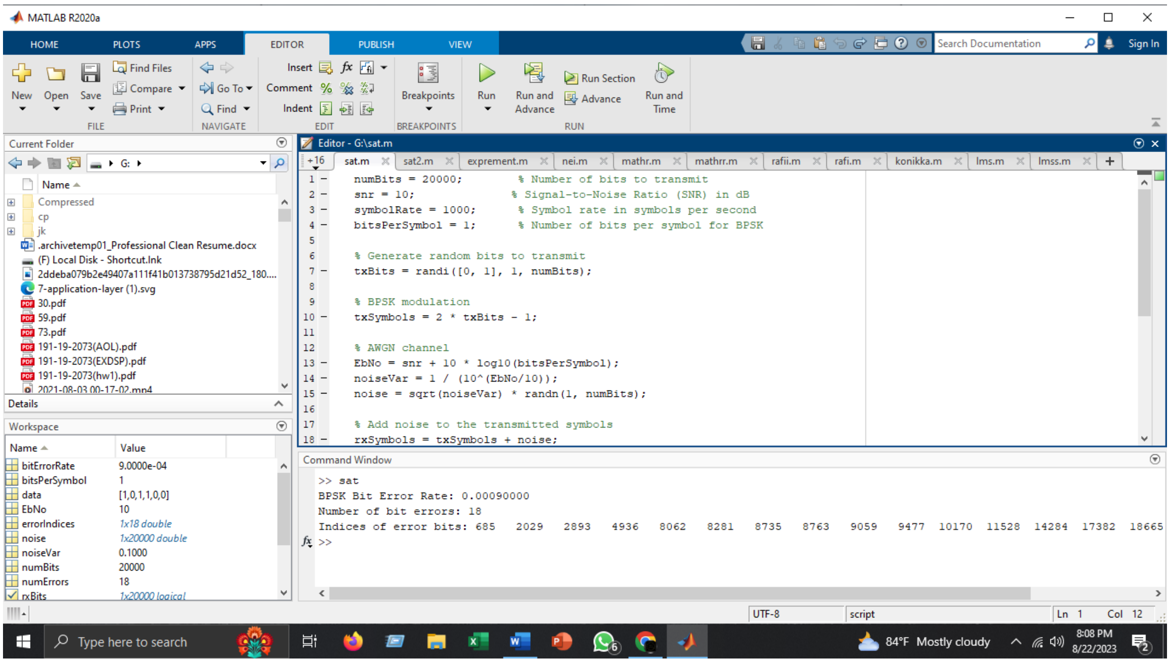


Figure 4.14: MATLAB code to find the number of error bits in a transmitted signal.

Detection Result:

Manchester Algorithm Technique to find the Error Bits in data set.

Suppose the data set is [1 0 1 0].

After the modulation and received the data Error bits is [1 0 0 0]

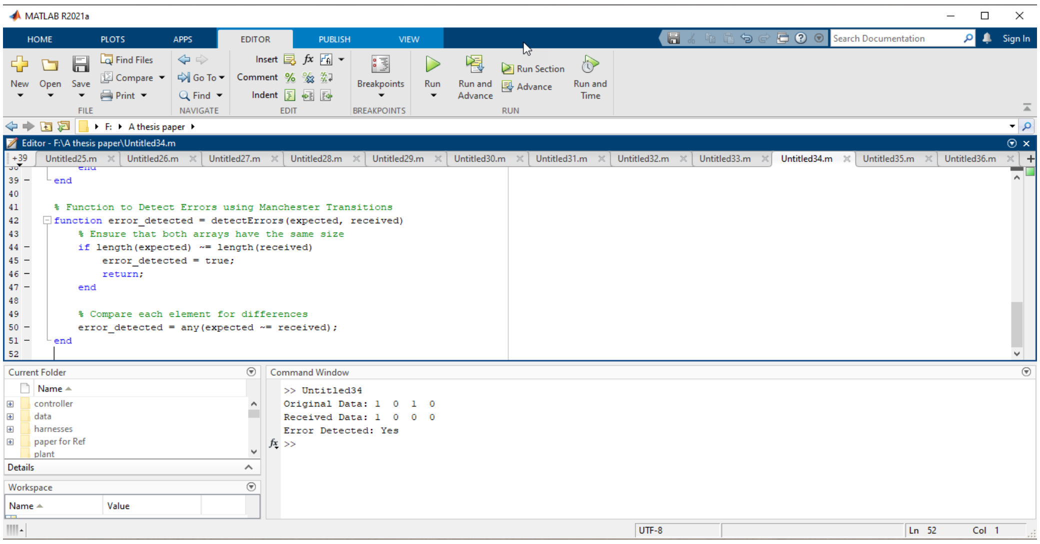


Figure 4.15: Manchester Algorithm to find the error Bits.

4.4 Error Correction with Hamming Code

Correction Result:

Using the **Haming Code Correction Algorithm** can recover the errors in bits of transmission of data.

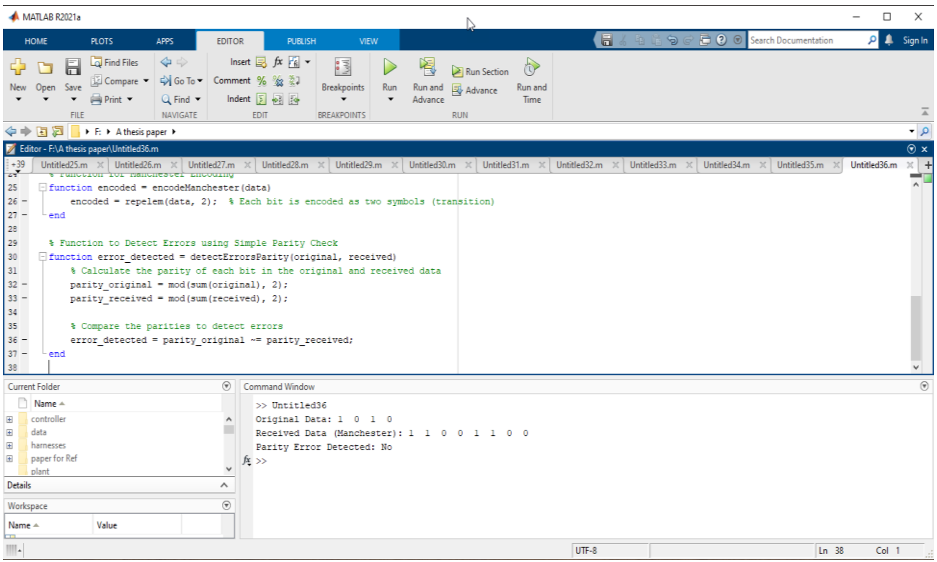


Figure 4.16: Hamming code to Correct the error bits.

Manchester Coding is a binary encoding method that ensures self-clocking and helps with error detection by using transitions (edges) to represent data bits. Transitions in the beginning or half-way of each bit's transmission indicate "0" or "1," respectively. Each bit is broadcast over a fixed time. Any disruption in the transitions during decoding suggests that the data received may have been erroneous.

Mistake-correcting codes called Hamming Codes give sent data more redundancy for mistake detection and correction. 4 bits of data are encoded into 7 bits with 3 parity bits in a (7,4) Hamming code. The placement of parity bits is done so that there are an equal number of '1' bits in each position (including parities). Analyzing the parity patterns allows the detection and correction of single-bit mistakes. These codes enhance data integrity by making it possible to spot and fix transmission mistakes.

CHAPTER 5: Conclusion

5.1 Conclusion

The main objective of this research was to find ways to decrease the Bit Error Rate (BER) to improve the dependability of communications in adverse conditions. As a result, this study developed an integrated communication system that combines several approaches. Data was first converted into signals employing BPSK, QPSK, QAM modulation, and then signal propagation and antenna choice were improved using Space-Time Block Coding (STBC) and Transmit Antenna Selection (TAS). Signal quality was improved by Maximum Ratio Combining (MRC) and Manchester encoding, and faults in the data were corrected with an adaptive error correction technique. The BER rate significantly gets better result after increasing receiver branches. It is shown that the Rician fading channel has slightly better results than Rayleigh channel. The results of the operation proved the efficiency of our total system. It greatly reduced the risk of mistakes and improved the dependability of communication. Wireless networking and IoT gadgets are only two examples of where this approach could be useful.

5.2 Future Works

There are many exciting avenues to investigate in the future of communication systems. This study can go into advanced error correction techniques that adaptively deal with a variety of mistakes. Another option is to implement dynamic technique adaptation, which would allow our system to respond immediately to new circumstances. By using machine learning, it can better foresee and combat signal problems. Finding solutions to reduce our system's usage of energy without sacrificing performance is also crucial. It could be improved with field testing in various locations. The development of secure and interoperable networks is another fascinating topic of study. Finally, our system has the potential to collaborate with new technologies such as 5G and the Internet of Things. With further effort in these areas, it can make communication even more efficient and reliable.

REFERENCE

[1] Suvarna P. Jadhav, Vaibhav S. Hendra, "Performance of Maximum ratio combining (MRC) MIMO Systems for Rayleigh Fading Channel" Int J Sci Res Publ 3(2) (ISSN: 2250-3153),2018.

[2] Kayode, Adeyemo & Raji, Teslim." Bit error rate analysis for wireless links using adaptive combining diversity", ResearchGate, Page 20, Vol 1,2010

[3] UKEssays, "Design of Manchester Serial Data Communications Channel. Retrieved "from https://www.ukessays.com/essays/engineering/design-manchester-serial-data-communications-2218.php?vref=1, (November 2018)

[5] Reddy, AR & Ratak Onda, Madhu Krishna, "Performance Study of 4G Modulation Schemes with MIMO in Rician Channel" 10.13140/RG.2.1.4134.5361,2015.

[6] Hamdi, Mustafa & Mohammed, Mohammed." BER Vs Eb/N0 BPSK Modulation over Different Types of Channels", Australian Journal of Basic and Applied Sciences. 12. 31-38. 10.22587/ajbas.2018.2.5.7.",2018

[7] Kaur, N. "SNR and BER Performance Analysis of MRC and EGC Receivers over Rayleigh Fading Channel". *International Journal of Computer Applications*, *132*, 12-17,2015

[8] Ullah, Muhammad Sana & Uddin, Mohammed Jashim. "Performance Analysis of Wireless MIMO System by Using Alamouti's Scheme and Maximum Ratio Combining Technique." 8. 019-024.2011.

[9] Nguyen, Ba & Nguyen-Kieu, Tam & Hoang, Tran & Tran, Phuong & Vozňák, Miroslav, "Analysis of MRT/MRC diversity techniques to enhance the detection performance for MIMO signals in full-duplex wireless relay networks with transceiver hardware impairment. Physical Communication". 42. 101132. 10.1016/j.phycom.2020.101132,2020

[10] International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 06 Issue: 03 | www.irjet.net p-ISSN: 2395-0072 © 2019, IRJET | Impact Factor value: 7.211 | ISO 9001:2008 Certified Journal | Page 2314 Simulation and Performance Estimation of BPSK in Rayleigh channel using SC, MRC and EGC diversity techniques Hina Khatoon1, R.K. Chi.Mar 2019.

[11] Tiwari, Keerti & Saini, Davinder." BER performance comparison of MIMO system with STBC and MRC over different fading channels. 2014 International Conference on High Performance Computing and Applications", ICHPCA 2014. 10.1109/ICHPCA.2014.70453072,014.

[12] Ali, Noor & Abdalla, Kamelia & Alrufaiaat, Sameer," BER Performance Improvement of Alamouti MIMO-STBC Decoder Using Mutual Information Method. Journal of Physics", Conference Series. 1530. 012016. 10.1088/1742-6596/1530/1/012016,2020.

[13] Salamea, Hugo & Torres, Dalton & Cardenas, Pablo & Urrea, Claudio, "Implementation of the Hamming code for the detection and correction of errors in a telerobotic system using an industrial communication protocol", 1-6. 10.1109/ANDESCON50619.2020.9272049,2020.

[14] Forster, R.., "Manchester encoding: Opposing definitions resolved. Engineering Science and Education Journal', 9. 278 - 280. 10.1049/esej:20000609,2001.

[15] Rimalapudi, Sarvendranath.," Transmit Antenna Selection in Underlay Spectrum Sharing: Role of Power Adaptation, Interference Constraint, and Channel State Information", 10.13140/RG.2.2.30572.08326,2020.

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