Performance of BER with Different Diversity Techniques for Millimeter-Wave Communication System

Nagma Parveen, Rafiqul Islam, Khaizuran Abdullah, Rounakul Islam Boby

Abstract— In a communications system, a diversity technique is used to enhance the reliability of a message signal by using at least two channels with different characteristics. In this paper, all four possible scenarios are considered: Single-input and single-output (SISO), single input and multi-output (SIMO), multiple-input and single-output (MISO), Multiple-input and multiple output (MIMO) systems. Antenna arrays will be used to reduce BER and improve the performance of the system using array gain in the line of sight channel for 60 GHz frequency in an indoor scenario. Single input and single output are investigated before analysis of multiple inputs and multiple output channel in the line of sight (LOS) and multipath propagation. MATLAB simulation has been performed using BPSK modulation. The comparative studies show that the performance of the MIMO diversity technique is more reliable in terms of BER to improve the performance and efficiency of the communication system.

Keywords— BER, Diversity, Millimeter wave, MIMO, and Antenna Arrays

I. INTRODUCTION

The Next generation of wireless communication needs high data rates and the reliable transmission link. The frequencies range between 3 and 300 GHz called millimeter band of frequencies is attracting more to overcome the shortage of spectrum and to meet the high demand for cellular applications [1]. There are several motivations for wanting to use mm-wave frequencies some of them listed by [2] [3]; The radio spectrum at mm-wave frequencies is still rather undeveloped, and more bandwidth is available at these frequencies. The security and spatial resolution is better at mm-wave frequencies since the small wavelength allows modest size antennas to a small have beam width. An abundance of widely available spectrum surrounding the 60 GHz operating frequency can support high-rate and unlicensed wireless communications. Many researchers have considered 60 GHz to improve the performance and efficiency of the system [4]–[8]. Therefore, the signal is deployed at 60 GHz using 4 element Uniform Linear Array antenna with half-length spacing.

A received signal is distorted due to channel condition or multipath channel. Various factors that affect the received signal such as multipath, medium type, refraction from objects, noise and climatic factors. To improve system performance in fading channels diversity technique is used to decrease the fading effect. Some of them are: Frequency diversity, Time diversity, Polarization diversity, Angle diversity, Antenna/Spatial diversity. Multiple antennas are used to send signals with information at the transmitter to receive at the receiver to provide multiple independent fading paths in space diversity. Spatial diversity is widely used as it is simple, cost effective, easy to implement and also reduces fast fading and inter-channel interference effects in the wireless network system [9]. For the implementation of MIMO wireless communication systems physical diversity techniques such as time, space, frequency and polarization have been very much used. In wireless communication Space diversity is one among the diversity schemes which includes two or more antennas to improve the quality and reliability of the wireless link between the transmitter and receiver [10][11]. Currently, the systems with four different types can be considered as diversity (input and output are considered as number of antennas).

In SISO communication systems two antennas one as a transmitter as a source and another for the receiver as the destination are used as shown figure 1. In SISO, the signal is faded more which results in high BER and poor communication link. The other communication system such as SIMO, MISO, and MIMO are used to mitigate the fading effect and improve the performance in terms of BER, Capacity, security and energy efficiency.

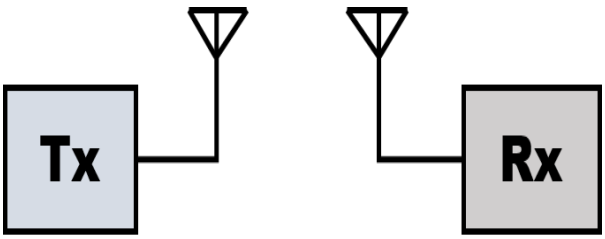

Figure 1: SISO Communication System

In SIMO communication systems one antenna is used as a transmitter, and two or more antennas are used at the receiver as shown in figure 2 which is also referred to as receive diversity. The most common used receive diversity

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techniques are Maximum Ratio Combining, Selection combining to enhance the framework of a receiver to various signals at the receiver to mitigate the fading effect.

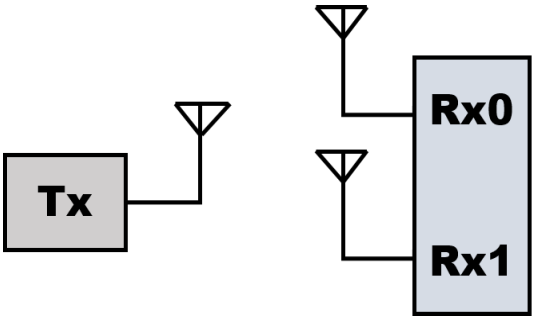

Figure 2: Single Input Multiple Output

In MISO communication systems two or more antenna is used at the transmitter and one antenna at the receiver side as shown in figure 3 which is also referred to as transmit diversity. Here, the same data is transmitted twice from the transmitter, and the receiver get optimized the data which results in less loss signal and improve the performance of the system. A simple transmit diversity technique with two transmit antennas and one receive antenna was proposed which give diversity order same as to maximal-ratio receiver combining [12]. A performance analysis of a transmit diversity in terms of BER for Rayleigh channel using 16 QAM modulation was studied [13]. The advantage of MISO is that various signals and coding is moved to the receiver from the transmitter.

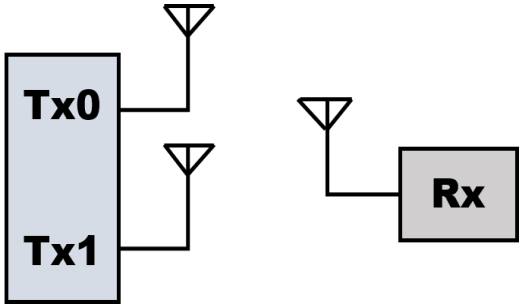

Figure 3: Multiple Input Single Output

In MIMO communication systems two or more antennas are used at the transmitter, and two or more antennas are used at the receiver side as shown in figure 4. MIMO diversity technique provides high capacity and data rate with less loss of signal which results in a reduction of BER. Channel estimation and equalizers are used in MIMO channel to mitigate the fading effect. In MIMO wireless system analysis the BER performance with different modulation schemes [14].In millimeter wave communication system for a MIMO channel, a coding Technique was proposed using minimum mean square error and successive interference cancellation [15]. The low correlation between the multipath of the MIMO system improves channel capacity and performance was studied [16]

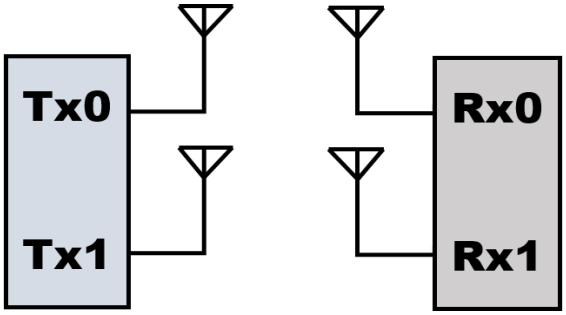

Figure 4: Multiple Input and Multiple Output

The primary objective of the paper is to investigate the BER performance of all the diversity techniques scenario in both LOS and multipath propagation using antenna arrays to provides transmit and receive diversity during transmission in millimeter wave communication system.

II. SYSTEM MODEL

Figure 5 represents the overview of the system model. The system is deployed at 60 GHz in the line of sight propagation (LOS) and Multipath propagation channel. The transmitter is placed at a distance of 100 meters in an indoor scenario. Digital modulation such as BPSK is performed before the data is transmitted. Antenna arrays have been used to reduce the BER as they consist of multiple elements which provide multiple inputs and outputs.

The array gain for ULA is higher in the millimeter wave communication system at 60 GHz was studied to mitigate the fading effect by considering both transmitter and receiver diversity[17] .In wireless communication antenna array based system have high potential and primary factor for this antenna coupling of closed spaced antenna arrays at transmitter and receiver. [18],The transmitter and receiver array of 4 element ULA with half wavelength spacing is considered. In general, the channel is multipath with both transmitter and receiver array; hence a multipath channel is considered. For multipath channel, we have assumed 1000 frames, and each frame consists of 10,00 bits. The demodulation will be performed to recover back the signals at the receiver. Then BER is calculated, and results are plotted using MATLAB simulation [19].

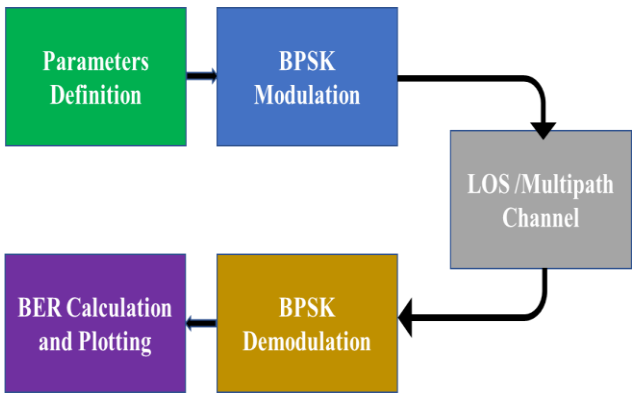

Figure 5: Overview of the System model.

III. RESULTS AND DISCUSSION

3.1 Single Input and Single Output (SISO)

The performance of the SISO channel was analyzed as a benchmark before analyzing different scenarios such as SIMO, MISO, and MIMO. The figure 6 shows the BER curve for SISO channel in LOS propagation and multipath propagation. The results show that the BER curve falls much slighter with the increasing energy per bits' value for multipath when compared to LOS. Therefore, when number of paths increases between the transmitter and receiver one antenna at both transmitter and receiver is not sufficient to mitigate the fading effect, so the number of antennae has to be two or more both at transmitter and receiver.

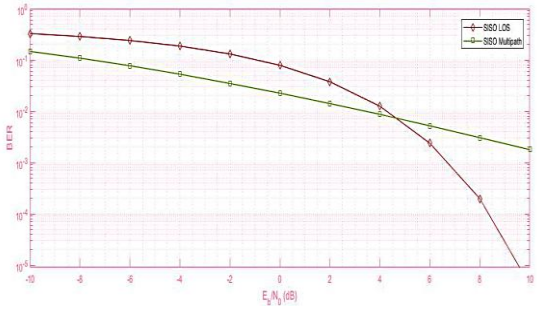

Figure 6: BER analysis for SISO Communication System

3.2 Single Input and Multiple Output (SIMO)

Figure 7 shows the performance analysis of BER for SIMO communication system in LOS and Multipath channel. The results show that when receiver diversity is applied at the receiver with receiver array for LOS and multipath channel the curve for the multipath channel is steeper than LOS propagation. Hence with array gain and diversity gain at the receiver the communication system performance is enhanced in terms of BER. At the receiver, there are more received signals the combining weight technique is applied such as MRC to match the channel response at the receiver. Here we assume that the channel response is known by the receiver so that the received signals are not out of phase with the transmitted signal.

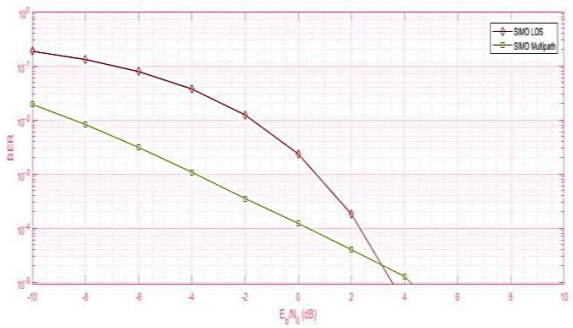

Figure 7: BER analysis for SIMO Communication System

3.3 Multiple Input and Single Output (MISO)

Figure 8 shows the performance analysis of BER for MISO communication system in LOS and multipath propagation. The transmit array applied for both propagations. The curve for LOS propagation is better when compared to multipath propagation for MISO channel because the transmit power is distributed among multipath channels and there is one copy of the received signal. Hence it is required to amplify the signal at the transmitter to achieve the equivalent gain, but it is costly. The performance for the MISO system in LOS propagation is similar to performance for SIMO in LOS propagation with a gain of 6DB.

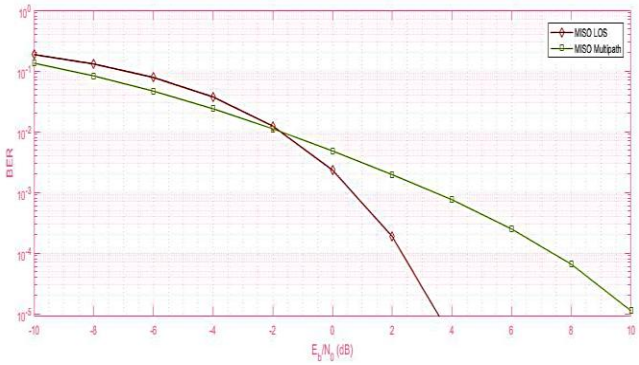

Figure 8: BER analysis for MISO Communication System

3.4 Multiple Input and Multiple Output (MIMO)

Figure 9 shows the performance analysis of BER for MIMO system in LOS and multipath propagation. The Curve shows that the performance of the MIMO system is much better when compared with SISO, MISO and SIMO system for both LOS and multipath propagation. The performance of multipath propagation is better when compared with LOS propagation because both transmitter and receiver array at both sides of transmission improve the performance of the system. The MIMO LOS propagation system gives the 12 dB Gain when compared with SISO and other systems; hence MIMO system are better to improve the performance of the system in terms of BER for the communication system.

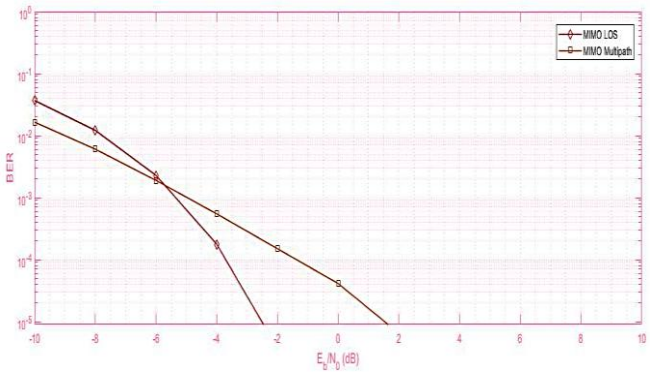

Figure 9: BER analysis for MIMO Communication System

IV. CONCLUSION

This paper gives the highlights the importance of MIMO diversity technique when compared with other diversity techniques. The performance in terms of BER is very good for MIMO communication system with array gain and diversity gain both at transmitter and receiver. The MIMO

multipath propagation performance in terms of BER is much appreciated in replace of LOS propagation because nowadays the number of customers for a communication system is increasing exponentially to meet the capacity of more customers with less loss of data MIMO diversity technique can be considered for future generation. The coding algorithms and other techniques such as beamforming, channel estimation equalizer can be applied to MIMO system to enhance the performance of the communication system.

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