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BER Improvement in Rayleigh Fading SIMO Channel Using Hybrid Diversity Combining Technique

Praksheksha Sharma
Student, Department of ECE
PIT Kapurthala, PTU Main Campus
Jalandhar, India
psharma8590@gmail.com

Avtar Singh Buttar
Associate Professor, Department of ECE
PIT Kapurthala, PTU Main Campus
Jalandhar, India
danshavtar@rediffmail.com

Abstract**—** In this paper, Hybrid Diversity Combining Technique for a wireless system using Binary Phase Shift Keying (BPSK) in a Rayleigh Fading Single-Input-Multiple-Output (SIMO) channel is proposed. In Hybrid technique, the hybridization of Selection Combining (SC) and Maximal Ratio Combining (MRC) is done. An algorithm is developed for implementation on wireless system. All the three basic standalone combining techniques Selection Combining (SC), Equal Gain Combining (EGC) and Maximal Ratio Combining (MRC) are also considered and Bit Error Rate (BER) for Hybrid Diversity Combining technique and basic standalone combining techniques are computed and simulated. Antenna diversity (Receive diversity) is used by using multiple antennas at the receiver side and single antenna at transmitter side. The BER performance of Single-Input-Multiple-Output (SIMO) channel using a Hybrid Diversity Technique to that of the standalone combining techniques is minimized**.**

Keywords**—** Selection Combining (SC); Equal Gain Combining (EGC); Maximal Ratio Combining (MRC); Single-Input-Multiple-Output(SIMO) ; Bit Error Rate(BER)

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I. Introduction

Over the last few decades, there has been tremendous increase in the demand of wireless technologies all over the world. With the increase in number of users, it is becoming more and more difficult to mitigate the needs of increasing number of user's demand for text, video and efficient data rate. The basic requirement in this scenario is to provide the better performance at the user end. Random noise, fading effects and Doppler Shift deteriorates the signal strength in the wireless channel.[1] As a result, the Bit Error Rate (BER) increases at the receiving end, which leads to lower the data rate. To maintain the required signal strength, various diversity techniques are used such as Time Diversity, Frequency Diversity, Polarization Diversity, Space Diversity and Angle Diversity[2]. It is further coming in hybrid forms to improve the wireless system throughput. Mostly Space Diversity is used to overcome the effect of fading. In the space diversity technique, multiple copies of the signal are sent towards the receiver .In this way multiple copies of the signal are received at the receiver which are combined using various diversity combining technique[3]s. The three main diversity combining techniques are Selection Combining (SC), Equal Gain Combining (EGC) and Maximal Ratio Combining (MRC).[6]Out of these three combining techniques Maximal Ratio Combining is the best, as numerous researchers have investigated hybrid forms of various existing combining techniques to form an efficient hybrid diversity combining method. The most commonly investigated techniques are Hybrid Selection / Maximal Ratio Combining (HS-MRC) and Hybrid Selection/Equal Combining (HS-EGC)[9] [10] [11] [12]. In this paper, an efficient Hybrid Diversity Combining technique is considered and is implemented on SIMO Rayleigh Fading Channel. In the Hybrid approach hybridization of Selection combining and Maximal Ratio combining is done to improve the required signal strength. The main phenomenon used in the proposed technique requires the addition of the dominating signal outputs of the receiver. In fact, few antennas are selected out of the given antennas. In nut-shell, the noise factor is reduced to some extent by adding selected antenna signals. In selection procedure, the signals which have strong SNR are selected and the weak signals having less SNR are rejected. An efficient algorithm is designed to implement the Hybrid Diversity Combining technique. The remainder of the paper is organized as follows: Section II describes the Hybrid Diversity Combining Technique and algorithm of this technique is given in section III. The section IV outlines the implementation and simulation results. Finally, the conclusions and future directions are outlined in Section V.

II. Hybrid Diversity Combining Technique

In the Hybrid Diversity Combining technique, the hybridization of Selection Combining (SC) and Maximal Ratio Combining (MRC) is done. The Hybrid Diversity Combining technique selects the particular antenna outputs and rejects the other ones. The main motive behind this technique is to reject

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the signals having large noise and adding the signals with lower noise. In this way the overall performance of the system is increased. The basic model for hybrid diversity combining technique is given as follows:

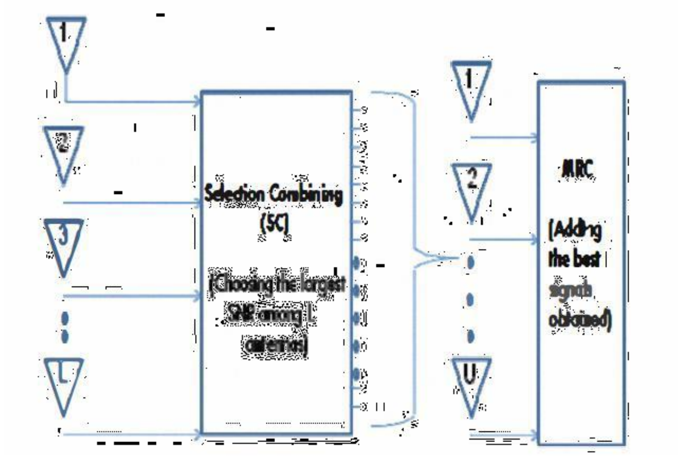

Figure 1: Hybrid Diversity combining

In Hybrid Diversity combining, all the signals reaching the receiver are not added. Firstly few antennas with strong outputs are selected and other antennas are rejected. Then the selected outputs obtained from the selected antennas are combined using Maximal Ratio Combining. In this way both the Selection Combining and Maximal Ratio Combining are done at the receiver end. So in this way rejecting the weak signals and selecting the strong signal in the final combining the signals increase the system throughput to the great extent. The main important step in implementation of the Hybrid diversity combining technique is the selection of antennas. So the major consideration here is to select the best antennas. The total throughput of the system will depend on the selection of the antennas.

III. Algorithm for Hybrid Diversity Combining Technique

The Hybrid Diversity Combining technique is implemented on a SIMO system and the performance analysis is done using BER calculations. Our focus here is to understand the algorithm that has been designed to select the number of antennas and how we are selecting the antennas at first step of the hybrid technique. The algorithm that is designed to implement the proposed technique involves the following steps:

Step I: Initiate the total number of bits and total number of antennas.

Step II: Modulate the signal that has to be transmitted into the channel.

Step III: Add the channel into the signal and also add noise.

Step IV: Select the number of antennas according to the designed algorithm

Step V: Select the outputs from the selected antennas and reject the outputs of all the other antennas.

Step VI: Combine the outputs selected from the selected antennas using Maximal Ratio combining.

Step VII: Calculate the BER by comparing the input and output signals.

The above steps are the steps of the basic algorithm that is used to select the best antennas out of the total number of the received antennas and hence cancelling out the weak signals having large noise and selecting the strong signals. In this way this algorithm helps in increasing the throughput of the system.

IV. Simulation and Results

Hybrid Diversity Combining technique is implemented and simulate on a SIMO Rayleigh Fading Channel using MATLAB software Platform. The simulation is done by generating a random stream of data and using a BPSK coding technique. The performance evaluation parameter is BER. Here Receive diversity is used. The number of antennas used at receiver side and also the number of bits transmitted are changed on each simulation to check the Performance of different techniques using various set of the input parameters. So the Hybrid Diversity Combining Technique and the all three standalone existing techniques are implemented on the SIMO Rayleigh fading channel and BER performance of all the techniques are compared.

Table 1
Input Parameters taken for Simulation

Parameter Used	Value
Number Of Bits	1000-100000
Number of Antennas	2-10
Range of SNR	0-20 dB
Type Of Modulation	BPSK
Performance Evaluation Parameter	Bit Error Rate (BER)

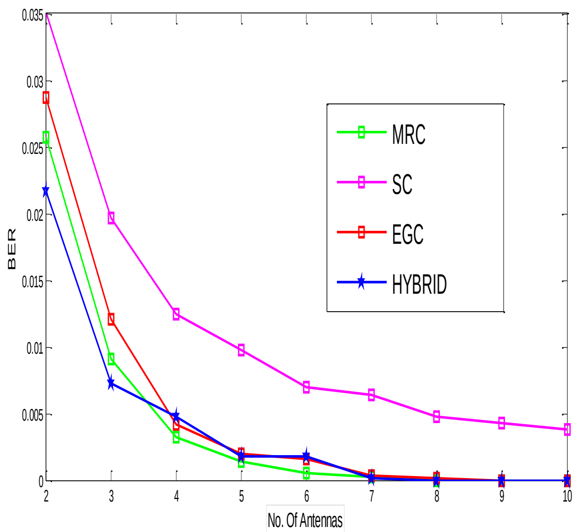

Figure 2: Comparison of BER performance of various Diversity combining techniques using 1000 bits

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In Figure 2, the comparison of BER performance of various existing standalone combining techniques is done with the Hybrid Diversity combining Technique. Here the various diversity schemes are simulated using 1000 bits of data and the number of receiving antennas are varied from 2 to 10.Pefromance of all the diversity schemes is investigated. It can be clearly seen that the Hybrid diversity combining technique is performing better than SC at all the number of antennas. When number of antennas is less the Hybrid Diversity Combining technique is even giving better performance than EGC and MRC.

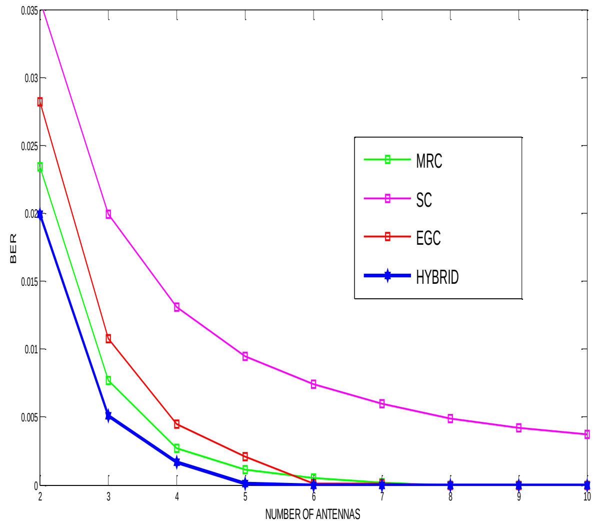

Figure 3: Comparison of BER performance of various Diversity combining techniques using 100000 bits

In Figure 3, the various diversity schemes are simulated using 100000 bits of data and the numbers of receiving antennas are varied from 2 to 10. Here also it can be seen that the Hybrid Diversity Combining Technique is outperforming all the existing stand alone diversity combining techniques at all the number of antennas. So, it is seen that when the data bits have increased Hybrid Diversity Combining Technique is giving better performance than all the other techniques.

It is a well known fact that the Maximal Ratio Combining gives the best performance amongst all the existing Diversity Combining methods. So an exhaustive evaluation of all the simulations is done and BER performance of the the Hybrid diversity Combining Technique is compared with the BER performance of Maximal Ratio Combining. Input parameters taken for the simulation are number of bits, number of antennas and SNR. The values of BER are calculated by changing the number of antennas, number of bits and changing the values of SNR. An exhaustive analysis gives the following results:

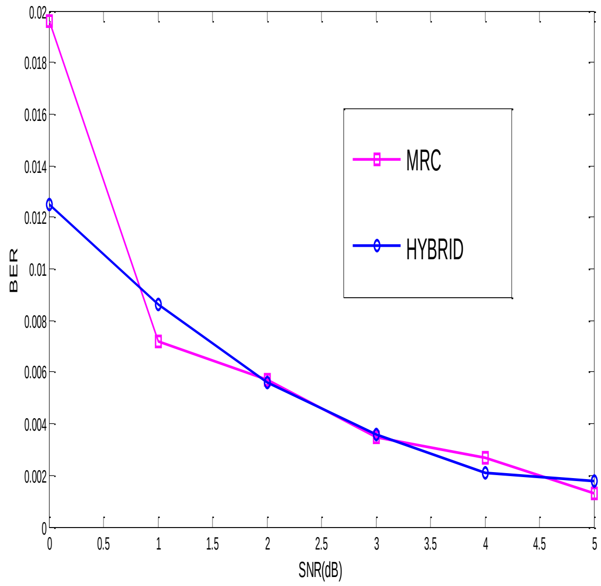

Figure 4: BER vs. SNR plot for Hybrid Diversity technique and MRC using 1000 bits

Figure 4 shows that when the number of bits transmitted is 1000 then the Hybrid Diversity technique is giving better performance than MRC when the SNR is low. At all the other values of SNR both the techniques are giving almost same performance.

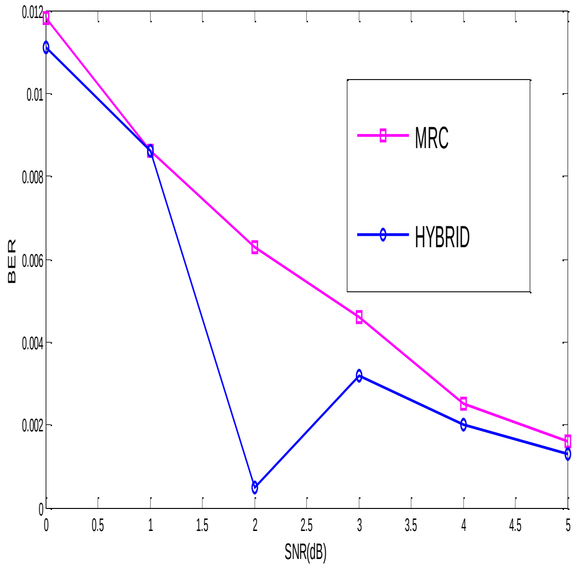

Figure 5: BER vs. SNR plot for Hybrid Diversity technique and MRC using 10000 bits

In Figure 5, the BER vs. SNR plot of Hybrid Diversity combining technique and MRC is shown using 100000 bits. It can be clearly seen that using 100000 bits of data the Hybrid Diversity Technique is performing better than MRC at all the values of SNR.

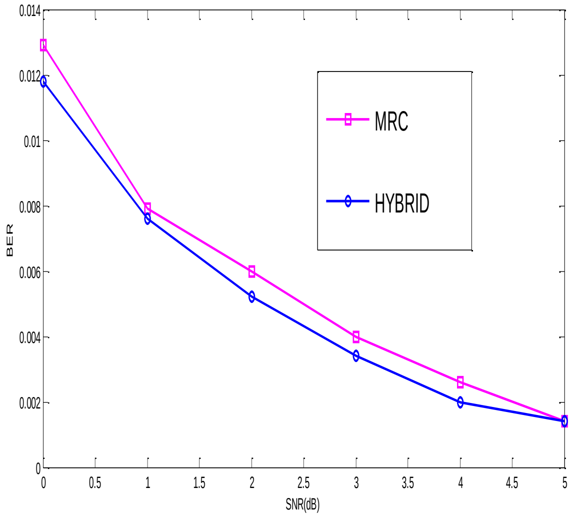

Figure 6: Comparison of Performance of Hybrid Diversity Combining Technique and MRC

In Figure 6, an exhaustive analysis of the BER performance of Hybrid Diversity Combining technique and MRC is done. It can be clearly seen that Hybrid Diversity Combining Technique is giving better performance at all the values of SNR as compared to MRC.

V. Conclusion

It has been observed that by using the Hybrid Diversity Combining technique (when number of bits are moderate) at a very low SNR values, the Bit Error Rate(BER) obtained is very less as compared to already existing stand alone diversity combining techniques.. In other words we can say that when number of bits that has to be transmitted is less, the Hybrid Diversity Combining technique is performing better than all the stand alone diversity combining techniques at low values of SNR. So, it clearly indicates that in a very high noise environment, the Hybrid Diversity Combining Technique can really prove to be useful. It has also been observed that with less number of antennas the proposed technique is performing better .As the data bits that are transmitted are increased, the Hybrid Diversity Combining technique outperforms even MRC at all the values of Signal to Noise Ratio (SNR). So it can be said that when large data is to be transmitted the Hybrid Diversity Combining technique performs better than MRC. So It can be concluded that at very low SNR regime (when noise is more) the Hybrid Diversity Combining Technique performs better (with moderate bits of data). For a large transmitted data BER performance of the Hybrid Diversity Combining Technique is better than existing techniques for all the values of SNR.

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