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Performance Analysis and Comparison of Zero - forcing SIC and MMSE SIC for MIMO Receivers using BSPK and 16- QAM Modulation methods.

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***Abstract*— This paper investigates the benefits of successive interference cancellation (SIC) based detectors over linear detectors. MIMO receiver with SIC, is simulated using two different modulation schemes namely BPSK and 16- QAM modulation methods. The receiver design is less complex in nature. The simulation results obtained at Signal processing laboratory shows that by combining SIC with MMSE or SIC with ZF provide better BER performance characteristics than normal receiver consisting simple MMSE or ZF respectively.**

***Keywords*— Bit error rate (BER), Multiple Input –Multiple Output (MIMO), BPSK, 16-QAM, Zero Forcing (ZF), Successive Interference Cancellation (SIC), SNR.**

I. INTRODUCTION

Successive interference cancellation receivers identify which transmit antenna has the best channel and try to detect the symbol sent by that antenna. Once detected, that symbol is subtracted from the received information at other antennas and then the best symbol is detected among the remaining antennas. SIC is based on subtraction of interference of already detected element say‘s’ from the received signal vector x. When SIC is applied, the order of detection is more important to the over all performance of the detecting scheme. To determine a good detection order the co-variance matrix of the estimation error is used

II. ZERO FORCING WITH SIC ALGORITHM

Zero forcing receiver [5], is a Simple linear MIMO receiver, with low computational complexity. It minimizes the interference but suffers from noise enhancement. ZF receiver works best with high SNR level. Zero forcing method is based on the calculation of pseudo inverse of channel matrix H.

The received vector is given in equation 1.1 and can be represented in matrix notation as follows:

$$\begin{pmatrix} y_1 \\ y_2 \end{pmatrix} = \begin{pmatrix} h_{1,1} & h_{1,2} \\ h_{2,1} & h_{2,2} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} + \begin{pmatrix} n_1 \\ n_2 \end{pmatrix} \quad 1.1$$

or Equivalently,

$$y = Hx + n \quad 1.2$$

To solve for x, we need to find a matrix W which satisfies $WH = I$. The Zero Forcing (ZF) detector for meeting this constraint is given by,

$$W = (H^H H)^{-1} H^H \quad 1.3$$

where W - Equalization Matrix and
H - Channel Matrix

The decoding Algorithm consists of three recursive parts:

1. Ordering: To determine the transmitted stream with lowest error variance.
2. Interference Nulling: Estimation of the strongest transmitted signal by Nulling out all weaker signals.
3. Interference cancellation: Demodulate the data bits, subtract their contribution from the received signal vector and return to the ordering step.

III. MMSE-SIC ALGORITHM

A minimum mean square error (MMSE) estimator approach minimizes the mean square error (MSE), which is a common measure of estimator quality. The main feature of MMSE equalizer is that it does not usually eliminate ISI completely but, minimizes the total power of the noise and ISI components in the output. Let x be an unknown random variable, and let y be a known random variable. An estimator x^ (y) is any function of the measurement y, and its mean square error is given by

$$MSE = E\,\{(X\hat{} - X^2)\} \quad 1.4$$

where the expectation is taken over both x and y.

The MMSE estimator is then defined as the estimator achieving minimal MSE. In many cases, it is not possible to determine a closed form for the MMSE estimator. In these cases, one possibility is to seek the technique minimizing the MSE within a particular class, such as the class of linear estimators. The linear MMSE estimator is the estimator achieving minimum MSE among all estimators of the form $AY + b$. If the measurement Y is a random vector, A is a matrix and b is a vector. The Minimum Mean Square Error **(**MMSE**)** approach tries to find a coefficient W which minimizes the criterion is given by,

$$E\,\{[W_{y-x}]\,[W_{y-x}]^H\} \quad 1.5$$

Where W - Equalization Matrix
H - Channel Matrix and
n - Channel noise
y- Received signal.

To solve for *x*, we need to find a matrix *W* which satisfies *WH =I*. The Minimum Mean Square Error (MMSE) detector for meeting this constraint is given by,

$$W = [H^H H + N_o I)^{-1} H^H \qquad 1.6$$

At very high SNR level decorrelator completely suppress the interference, therefore it provides better performance at higher SNR level. Now in low SNR level condition, the maximal ratio combining receiver provides better performance. Therefore in order to design an optimal receiver it is necessary to converge these two advantages in a single receiver.

In MMSE receiver these two features are optimally combined. MMSE receiver is another type of linear detector which minimizes the mean squared error between the transmitted symbols. MMSE detector helps to jointly minimize both the noise and interference or we can say that the MMSE detector seeks to balance between cancellation of the interference and reduction of noise enhancement. Therefore MMSE detector outperforms the ZF detector in the presence of noise.

The decoding algorithm consist of 3 parts as similar to ZF –SIC detector.

1. Compute the weighting matrix W Find the smallest pth diagonal entry. Permute the Pth Column of H to be the last column and permute the rows of W accordingly.
2. From the estimate determine elements of s.
3. If Nt -1 >0 go back to step 1.

IV. SIMULATION RESULTS AND DISCUSSIONS

The following simulations are done for various mxn MIMO antenna configurations keeping the flat fading Raleigh channel and vary the modulation schemes.

Two sections of simulation Analysis is carried out .Simulation analysis 1 based on BPSK modulation for ZF and ZF SIC based Receivers. Simulation analysis 2 is carried out for MMSE and MMSE –SIC based receivers using 16- QAM modulation techniques.

A. Simulation Analysis- 1

Figure 1 shows the BER analysis 2x2 MIMO using BPSK for ZF and ZF SIC Receiver.

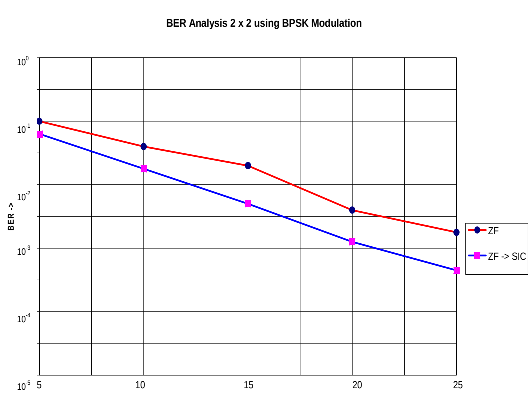

Figure 1 BER analysis 2x2 MIMO using BPSK for ZF and ZF SIC Receiver

It is observed that ZF SIC based receiver performs better than ordinary ZF. The same is observed when the number of receiving antennas is increased to 4. Figure 3 shows that when the number of transmitters is increased from 2 to 4 still ZF SIC based receiver shows a better BER characteristics. Hence from the simulation results it is inferred that ZF-sic is performing better than ordinary ZF.

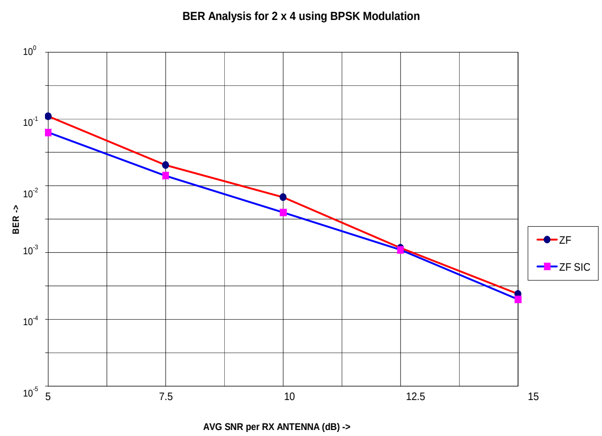

Figure 2 BER analysis 2x4 MIMO using BPSK for ZF and ZF SIC Receiver.

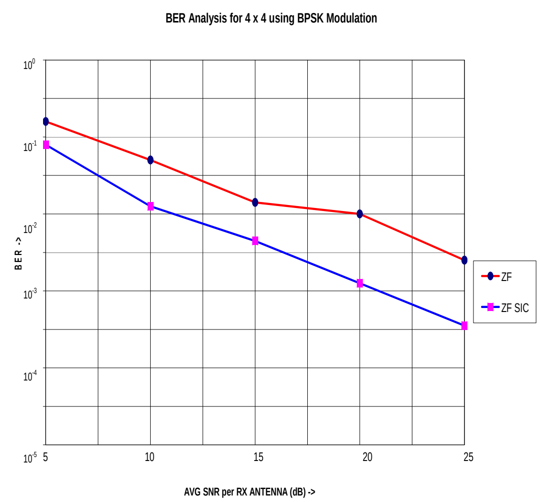

Figure 3 BER analysis 4x4 MIMO using BPSK for ZF and ZF SIC Receiver.

B. Simulation Analysis- 2

In this analysis MMSE and MMSE SIC based receivers are considered. The analysis is done as similar to ZF and ZF –SIC case. Figure 4 shows the receiver set with 2x2 configuration using BPSK.When the performance is considered, there is a much improvement around 5 db when comparing to ordinary MMSE.Figure 5 shows the graph for 2x 4 configuration flat Raleigh fading using BPSK.Even in this case MMSE-SIC based detection performs better. Figure 6 show a similar graph in which the antenna configuration is varied as 4x4 and also shows MMSE-SIC with a better BER performance than MMSE.

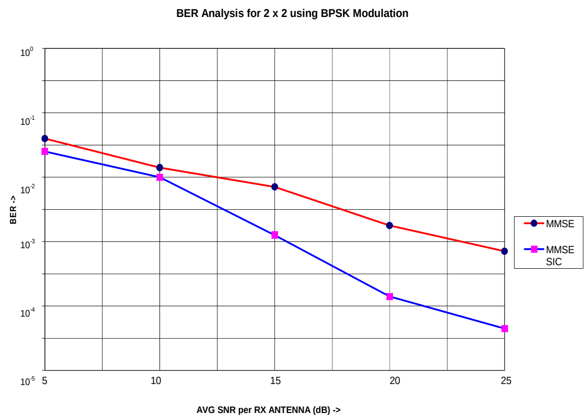

Figure 4: BER analysis of 2x2 MIMO using BPSK for MMSE and MMSE SIC based receiver

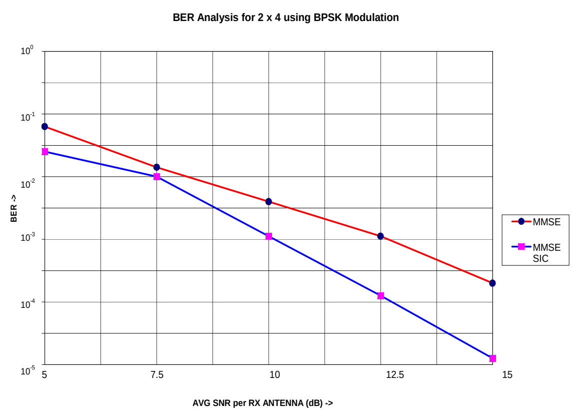

Figure 5: BER analysis of 2x4 MIMO using BPSK for MMSE and MMSE SIC based receiver

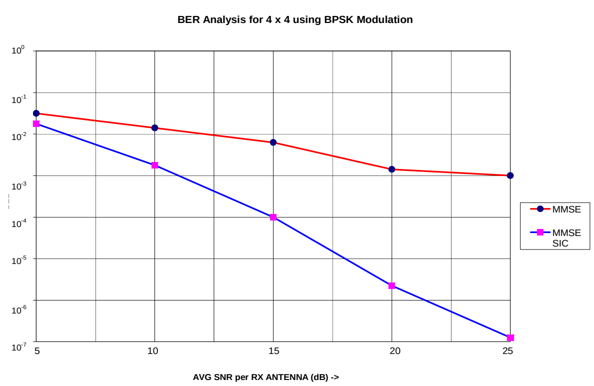

Figure 6: BER analysis of 4x4 MIMO using BPSK for MMSE and MMSE SIC based receiver

C.Simulation analysis- 3:

Figure 7 shows the bit error performance characteristics for 2x2 flat fading Raleigh channel using 16 QAM methods. This also shows MMSE-SIC is much better than MMSE detector. Figure 8 shows the consolidated graph for all the detectors schemes namely ZF, ZF-SIC, MSE and MMSE-SIC using BPSK method. It is inferred that MMSE-SIC outperforms ZF and ZFSIC receiver. Figure 9 shows the consolidated BER analysis 2x2 MIMO using 16 QAM modulation scheme. Even this also shows that MMSE is better.

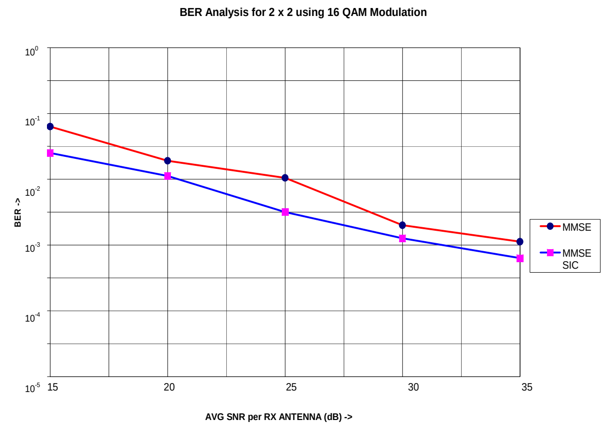

Figure 7: BER characteristics for 16 QAM for ZF and ZF SIC Receiver.

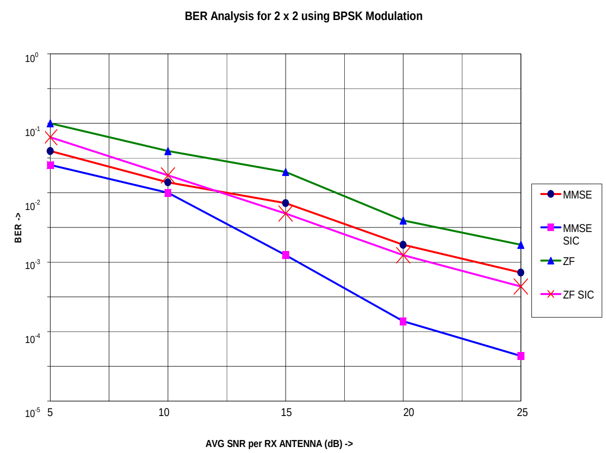

Figure 8: Consolidated output BER analysis 2x2 MIMO using BPSK for Linear and ZF SIC Receiver.

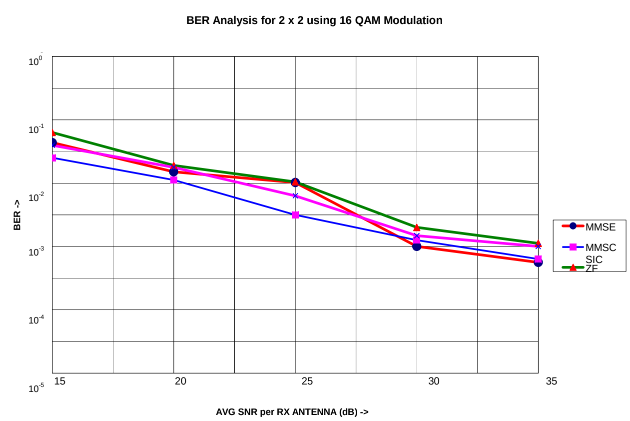

Figure 9: Consolidated output BER analysis 2x2 MIMO using 16 QAM for linear and ZF SIC Receiver.

V. CONCLUSION

In this paper we investigated about the BER performance analysis of ZF, ZF-SIC, MMSE –MMSE-SIC MIMO receivers. It is inferred that MMSE-SIC based receiver out perms both ZF and ZF-SIC detectors. ZF-SIC Out performs ZF detectors. Hence ZF-SIC is a strong detector. Thus it is concluded MMSE-SIC receiver provide better performance with respect to ZF-SIC receiver. For consideration of 5 dB SNR, the performance of MIMO system with MMSE-SIC receiver is not only better than MMSE,ZF and ZF-SIC receiver but also provide better overall system performance with the increasing diversity order .

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REFERENCES

[1] D. Gesbert, M. Shafi , D. S. Shiu, P. Smith, A. Naguib, “From Theory toPractice: An overview of MIMO space-time coded wireless systems”.IEEE Journal on Selected Areas in Communications, VOL. 21,NO.3 ,Apr 2003.

[2] G. J. Foschini and M. J. Gans, “On limits of wireless communicationsin a fading environment when using multiple antennas,” Wireless Personal Communication., vol. 6, pp. 311-335, Mar. 1998.

[3] Junqiang Shen, and Zhi Ding,, Zero-Forcing Blind Equalization Based on Subspace Estimation for Multiuser Systems, IEEE transactions on communications, vol. 49, no. 2, february pp-262-271.,2001

[4] Kai Wu, Lin Sang, He Wang, Cong Xiong, Detection Algorithm for VBLAST Systems with Novel Interference Cancellation Technique,IEEE Vehicular Technology Conference, VTC Spring 2009,

[5] Ronald B¨ohnke and KarlDirk Kammeyer, SINR Analysis for VBLAST With Ordered MMSE-SIC Detection IWCMC’06, Vancouver, British Columbia, Canada..,2006

[6] Luo Z, Liu S, Zhao M, Liu Y, A Novel Optimal Recursive MMSE-SIC Detection Algorithm for V-BLAST Systems. In IEEE Proceedings of International Conference on Communications (ICC), Istanbul, Turkey,June 2006.