SSRG International Journal of Electrical and Electronics Engineering (SSRG-IJEEE) – volume1 issue 3 May 2014

Techniques for Improving BER and SNR in MIMO Antenna for Optimum Performance

Vaishali W.Sonone [1] , Dr.N.B.Chopade[2]
[1](JSPM's Rajarshi Shahu College of Engineering, II Shift Polytechnic, Tathawade, Pune)
[2](Pimpri Chinchwad College of Engineering, Akurdi, Pune)

ABSTRACT

The use of multiple antennas for diversity, including MIMO (Multiple Input Multiple Output) is one of the most promising wireless technologies for broadband communication applications. This antenna system is a vital study in today's wireless communication system especially when the signal propagates through some corrupted environments. In our paper new techniques of improving bit error ratio and signal to noise ratio are discussed.Intersymbol interference is a major limitation of wireless communications. It degrades the performance significantly if the delay spread is comparable or higher than the symbol duration. To remove ISI, equalization needs to be included at the receiver end. The most popular equalization algorithms are zero forcing (ZF) equalizer and minimum mean square (MMSE) equalizer and maximum ratio combining equalizer.

Keywords- *MIMO (Multiple Input Multiple output), MMSE (Minimum Mean Square Error), MRC (Maximal Ratio Combining), ZF (Zero Forcing) ISI (Inter Symbol Interference), SNR (Signal to Noise Ratio), BER (Bit Error Ratio).*

I. *INTRODUCTION*

The use of multiple antenna technique has gained overwhelming interest throughout the last decade. The idea of using multiple antenna configurations instead of a single one has proven to be successful in enhancing data transfer rate, coverage, security and the overall performance of radio networks. In recent years high data rate techniques have gained considerable interests in communication systems. Signal –to-noise ratio (SNR) is defined as the ratio of the desired signal power to noise power. SNR indicates the reliability of link between the transmitter and receiver. The most meaningful criterion for evaluation of performance of communication systems is the bit error rate (BER). A bit error rate is defined as the rate at which errors occur in a transmission system. This can be directly translated into the number of errors that occur in a string of a stated number of bits. The development of next-generation wireless communication systems requires broadband and multiband devices for multi-functionality and faster data transfers, while maintaining good efficiency, low weight, low cost, and easy manufacturing. In this context, bit error rate and signal to noise ratio has become a real challenge for antenna designers. This paper discusses the merits of the MIMO system and the techniques used for improving BER performance and SNR. In MIMO wireless communication, an equalizer is used to recover a signal that suffers from Inter symbol Interference (ISI) and the BER characteristics is improved and a good SNR can be obtained. Different equalization techniques are discussed in this paper.

II. *ANALYTICAL MODEL FOR MIMO*

MIMO is a narrowband technology. For the H Channel matrix we have **y = Hx + n.**

The number of independent channels that a signal travels from the sender to the receiver is called as the diversity gain . The proper operation of MIMO systems requires careful design, with the encoded signals received from each transmitting antenna and the multiple communication channels achieving specified orthogonally conditions.

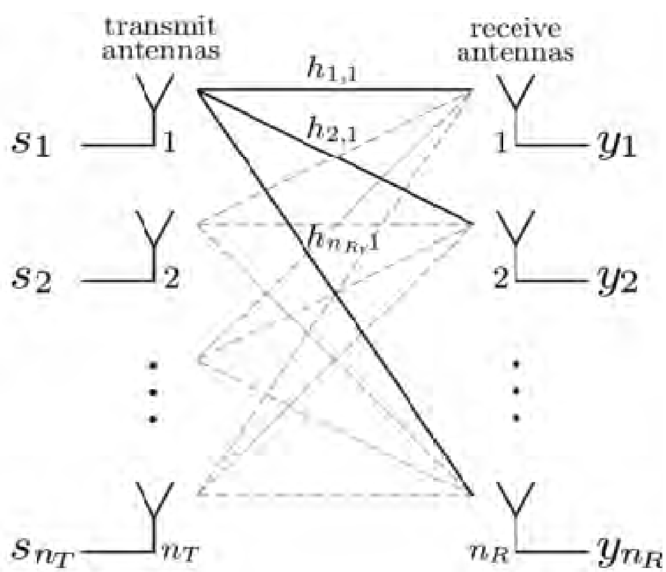

Fig.1.A MIMO Channel with nT transmit and nR receive antennas

III *EQUALIZATION TECHNIQUES*

In MIMO wireless communication, an equalizer is employed which is a network that makes an attempt to recover a signal that suffers with an Inter symbol Interference (ISI) and improves the BER characteristics and maintains a good SNR. The different equalization techniques are:

ZERO FORCING (ZF) EQUALIZER:

Zero Forcing Equalizer refers to a form of linear equalization algorithm used in communication systems which applies the inverse of the frequency response of the channel. This form of equalizer was first proposed by Lucky. The Zero-Forcing Equalizer applies the inverse of the channel frequency response to the received signal, to restore the signal after the channel. The name Zero Forcing corresponds to bringing down the intersymbol interference (ISI) to zero in a noise free case. This will be useful when ISI is significant compared to noise. It has many useful applications.

For a channel with frequency response F(f) the zero forcing equalizer C(f) is constructed by C(f) = 1 / F(f).

Thus the combination of channel and equalizer gives a flat frequency response and linear phase

F(f)C(f) = 1. If the channel response (or channel transfer function) for a particular channel is H(s) then the input signal is multiplied by the reciprocal of it.

In reality, zero-forcing equalization is not a better equalization technique because channel impulse response has finite length. Another reason is, at some frequencies the received signal may be weak. To compensate, the magnitude of the zero-forcing filter ("gain") grows very large. As a consequence, any noise added after the channel gets boosted by a large factor and destroys the overall signal-to-noise ratio.

MINIMUM MEAN SQUARE ERROR (MMSE) EQUALIZER

In statistics and signal processing, a minimum mean square error (MMSE) estimator is an estimation method which minimizes the mean square error (MSE) of the fitted values of a dependent variable, which is a common measure of estimator quality. Minimum mean-square error equalizer, which does not usually eliminate ISI completely but instead, minimizes the total power of the noise and ISI components in the output. The MMSE estimator is then defined as the estimator achieving minimal MSE.

The Minimum Mean Square Error (MMSE) approach tries to find a coefficient which minimizes the criterion, solving, If N0 is zero in Zero forcing equalizer then the MMSE equalizer reduces to Zero Forcing equalizer. By keeping the number of Transmission antenna fix if the receiver antenna will be increased then the BER Performance will be better.

If the noise term is zero, the **MMSE** equalizer reduces to Zero Forcing equalizer.

MAXIMAL-RATIO COMBINING EQUALIZER:

Various techniques are known to combine the signals from multiple diversity branches. Maximal ratio combining equalizer represents a theoretically optimal combiner over fading channels as a diversity scheme in a communication system. Theoretically, multiple copies of the same information signal are combined so as to maximize the instantaneous SNR at the output. Out of several diversity techniques MRC is preferred due to the fact that it maximizes the correct reception and reduces intersymbol interference (ISI) .In Maximum Ratio combining each signal branch is multiplied by a weight factor that is proportional to the signal amplitude. That is, branches with strong signal are further amplified, while weak signals are attenuated. In telecommunications, maximal-ratio combining is a method of diversity combining in which: - (a) The signals from each channel are added together. (b) The gain of each channel is made proportional to the RMS signal level and inversely proportional to the mean square noise level in that channel. (c) Different proportionality constants are used for each channel. It is also known as ratio-squared combining and pre-detection combining.

Comparison has been done between three mentioned techniques. This can be done by comparing BER of three techniques for 2 x 2 equalizers as shown in figure no. 2

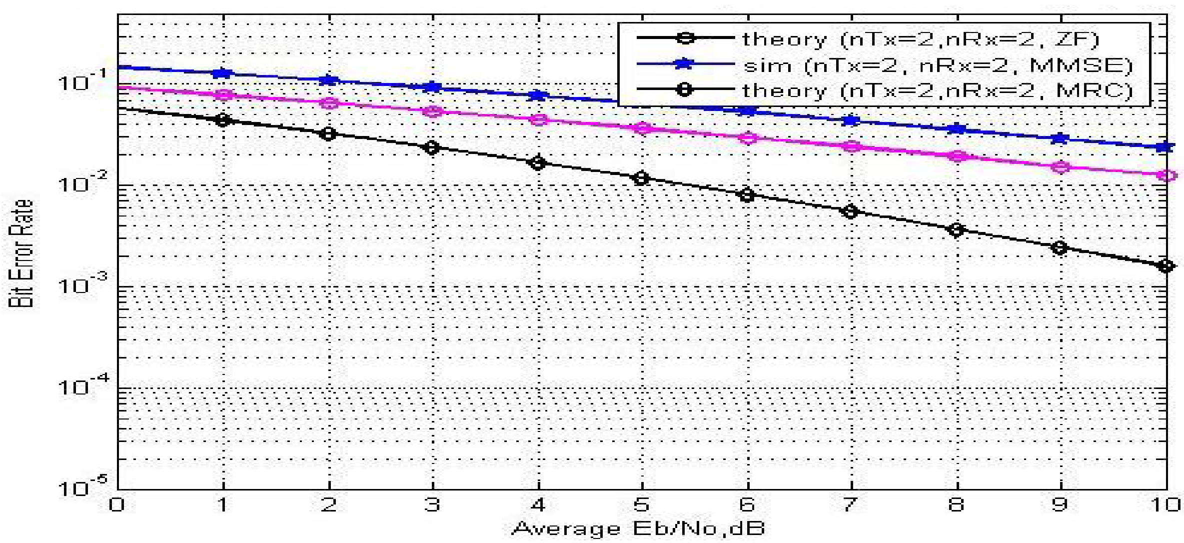

Fig.2 Plot for BER for BPSK modulation for MMSE, MRC and ZF Equalizer for (2×2) MIMO system

IV. *RESULTS & DISCUSSIONS*

Equalization Techniques are of importance in the design of high data rate wireless systems. They can combat for intersymbol Interference even in mobile fading channels with high efficiency. Zero forcing Equalizer performs well only in theoretical assumptions that are when noise is zero. This also helps to achieve data rate gain.

Minimum Mean Square Equalizer not only excludes ISI components but also minimizes the total power of noise as shown in fig no.2 as compared to Zero Forcing Equalizer that results in lowering the chances of incorrect decisions resulting in enormous interference cancellation and there is a less improvement in the Bit Error Rate.

It is observed that the Bit Error Rate of MMSE equalizer based receiver is less as compared to Zero Forcing Equalizer. The BER for Theoretical MRC is 0.0581, Simulated MMSE is 0.0925 and for Theoretical ZF is 0.1464. This shows that MRC has lower BER as compared to MMSE in every case.

V. CONCLUSION

To conclude this paper provides the complete knowledge of the key issues in the field of mobile communication. When data is transmitted at high bit rates over mobile radio channels, the channel impulse response can extend over many symbol periods which leads to intersymbol Interference. The ultimate goal is to provide universal personal and multimedia communication without regard to mobility or location with a high data rates. To achieve such an objective a strong equalization technique is taken. The receiver scheme is based on MMSE. Bit Error Rate performance for MIMO-MMSE in correlated Rayleigh flat fading channel is better than Zero Forcing Equalizer. The performance is compared with the three types of equalizer based receiver namely MRC, MMSE and ZF. The Zero Forcing Equalizer removes all ISI and is ideal only when the channel is noiseless. When the channel is noisy, the Zero Forcing Equalizer has a tendency to amplify the noise and is much suited for static channels with high SNR. Though MMSE is a balanced linear equalizer it does not eliminate ISI completely but instead minimizes the total power of the noise and ISI components in the output. The MMSE equalizer gives minimum BER values for corresponding Eb /No values. As the number of transmitters is less and more increasing in number and BER decreases for a particular value of Eb/No value. BER performance of MRC Equalizer is superior then MMSE Equalizer. The BER values from fig.2 are 0.0581 for MRC and 0.0925 for MMSE. It is inferred that the MRC equalizer is the best of the three equalizer.

REFERENCES

[1] H. Zhang, H. Dai, Q. Zhou, and B. L. Hughes, 2006 on the “Diversity-multiplexing tradeoff for ordered SIC receivers over MIMO channels,” IEEE International Conference on Communications (ICC), Istanbul, Turkey.

[2] K. Cho and D. Yoon, 2002,on “The general BER expression of one and two-dimensional amplitude modulations," IEEE Transactions on Communications, vol. 50.

[3] N.Satish Kumar, Dr.K.R.Shankar Kumar, “Performance Analysis of M*N Equalizer based Minimum Mean Square Error (MMSE) Receiver for MIMO Wireless Channel”, International Journal of Computer Applications (0975 – 8887) Volume 16– No.7, February 2011.

[4] Wireless Communications (Principles & Practice), second edition by Theodore S. Rappaport.

[5] John A.C Bingham, “Multicarrier modulation for data transmission: An idea whose time has come.” IEEE Communication Magazine, May 1990, vol.28, issue 5, pp 5-14.

[6] Hongliang Mao, Yukui pei and Ning Ge, “Full Diversity Achieving MMSE Frequency-Domain Equalizer for Single-carrier Block Transmission with DSSS”, IEEE, 2012.