IJERSS | Volume 2 | Issue 2 | FEB 2015

Research Paper

A NOVEL APPROACH TO REDUCE BER IN MIMO SYSTEM

HEALTH SCIENCE

Keywords: Multi input Multi output (MIMO), Bit Error Rate (BER), Additive White Gaussian Noise (AWGN), Equalizer, Zero Forcing (ZF), Minimum mean square error (MMSE), Signal to Noise Ratio (SNR)

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ABSTRACT

Multi-input Multi-output (MIMO) systems are today regarded as one of the most promising research areas in wireless communications. MIMO System comes with improved spectral efficiency (Multiplexing gain), link reliability (diversity gain), coverage (diversity, array gain),BER reduction, high data rate, beam forming etc. In this paper, we will present certain methods of reduction of BER in MIMO system with higher data rates in the AWGN channel. This increased data rate can be achieved without the need of additional bandwidth or transmit power, provided that sufficient multipath diversity is present. Here we are using two different equalization technique to reduce BER. A Synthesis scheme is investigated in order to find a BER which allows reaching good performance in term of error probability with a reasonable complexity. This task is achievable using MMSE equalization technique.

I. INTRODUCTION

MIMO system is widely used application in today's world due to efficient transmission of large bit stream with less probability of error. As the demand increases, competition between all the operator increases due to this each operator is going to do improvement in their techniques to provide there user high transmission rate, transmission range, transmission reliability services within the limited bandwidth. We are using MIMO system to provide high data rate with less BER.A typical MIMO system utilizes multiple antennas to transmit simultaneously several independent data streams to the receiver end. This will obviously yield inter-stream interference since the reception of each stream at the receiver will be disturbed not only by noise but from the interference of other streams as well. Joint detection and decoding can be employed to separate and recover the transmitted data in the best possible manner. Unfortunately, this approach has huge complexity which grows exponentially as the number of antennas increases, thus prohibiting its implementation in a real time system. It is obvious that one has to turn into computationally efficient but less effective techniques, thus incurring a performance-complexity trade-off. Our main focus in this paper is to minimize BER as low as much possible. We design a real time MIMO system for 4x4 antennas with channel gain matrix is known at receiver in an AWGN channel environment and comparing BER for different equalization technique. We are using V-BLAST architecture for providing maximum diversity & multiplexing gain. Firstly, we calculate BER without using any equalizer, then with zero forcing equalizer, after that with MMSE equalizer.

II. MIMO SYSTEM

A. MIMO Architecture

As the name suggested MIMO, it is a technology evolution where Multiple-Input transmitting and Multiple Output receiving antenna are used. The data stream from a single user is de-multiplexed and fed into the transmitting antennas all of which radiate in the same frequency band.By sharing the same frequency band the spectral efficiency becomes very high. The receiver is assumed to have ideal channel estimates so it can separate and decode the symbols transmitted from each antenna. The ability to separate out the symbols is due to the fact that in a scattering environment, the signals received at each receiving antenna from each transmitting antenna appear to be uncorrelated. The received signal vector maybe represented as

$$Y = HX + N \qquad (1)$$

Where Y represent N_r dimension (4x1) received signal matrix, X represent N_t dimension (4x1) transmit signal matrix, H represent (4x4) channel gain matrix, N is additive white Gaussian noise.

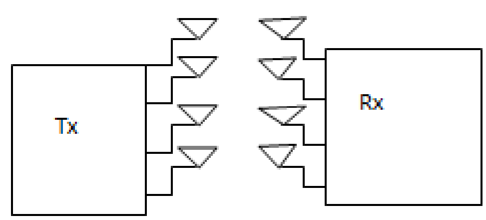

Fig. 1. MIMO System Model

B. Importance of MIMO System

The performance improvements resulting from theuse of MIMO systems are due to array gain,diversity gain and multiplexing gain.

Array Gain: Array gain is the average increase in the signal-to-noise ratio (SNR) at the receiver that arises from the coherent combining effect of multiple antennas at the receiver or transmitter or both.An important characteristic of an array is the change of its radiation pattern in response to different excitations of its antenna elements. Unlike a single antenna whose radiation pattern is fixed, an antenna array's radiation pattern, called the array pattern, can be changed upon exciting its elements with different currents (both current magnitudes and current phases). This gives us a freedom to choose (or design) a certain desired array pattern from an array, without changing its physical dimensions. Diversity Gain: Diversity gain improves the fading channel impairment. Multiplexing Gain: The capacity gain is also referred to as multiplexing gain. One option is to obtain capacity gain by decomposing the MIMO channel into parallel channels and multiplexing different data streams onto these channels. This increases the multiplexing gain.

C. MIMO Channel Capacity

MIMO channel capacity, which equals the maximum data rate that can be transmitted over the channel with arbitrarily small error probability. Channel capacity depends on what is known about the channel gain matrix or its distribution at the transmitter and/or receiver. In our case channel gain matrix H is known at receiver, which is helpful in best estimating of transmitted signal. The capacity of a MIMO channel is an extension of the mutual information formula for a SISO channel to a matrix channel. Specifically, the capacity is given in terms of the mutual information between the channel input vector X and output vector Y.

$$C = \max I(X;Y) = \max\,[H(Y) - H(Y|X)] \qquad (2)$$

III. EQUALIZER DESIGN

Equalization compensates intersymbol interference which is created by multipath within time dispersive channels. If the modulation bandwidth exceeds the coherence bandwidth of the radio channel, ISI occurs and modulation pulses are spread in time into adjacent symbols. An equalizer within a receiver compensates for the average range of expected channel amplitude and delay characteristics. Equalizers must be adaptive since the channel is generally unknown and time varying.

A. Design of Zero forcing Equalizer

For The ZF receiver is a linear receiver. It behaves like a linear filter and separates the data streams and thereafter independently decodes each stream. We assume that the channel matrix **H** is invertible and estimate the transmitted data symbol vector as

$$\hat{s} = (H^H H)^{-1} H x = H^{\dagger} s \qquad (3)$$

Where † represents pseudoinverse.

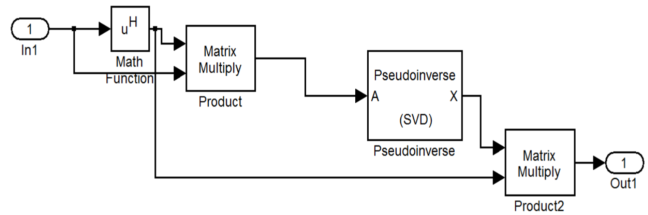

Fig. 2. Zero Forcing Equalizer

B. Designing of MMSE Equalizer

Zero-forcing equalizer removes ISI completely (in the case of infinite equalizer length) but it does not take into account noise, which may lead to serious noise enhancement at the equalizer output. A different solution taking into account noise is the equalization using minimum mean-square error (MMSE) criterion.The MMSE equalizer frequency function can be written as:

$$H_{Eq}(f) = \frac{1}{H(f) + \frac{N_0}{2}} \qquad (4)$$

Where $H(f)$ is the channel frequency function.

The solution of the linear MMSE is given by:

$$\hat{s} = B \times r = (\frac{1}{SNR} I_{Nr} + H^H H)^{-1} H^H \times r \qquad (5)$$

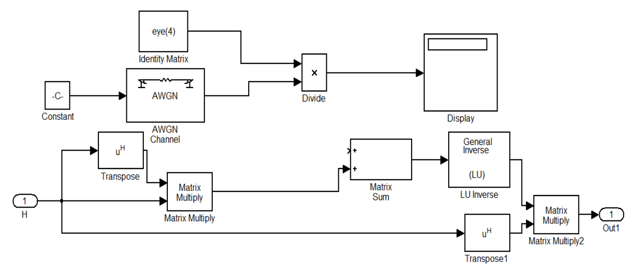

Fig. 3. MMSE Equalizer

V. SIMULATIONRESULT

Finally we present simulation result in order to assess the error rate performance of both the equalizer. In our simulation, we used following specifications.

Modulation Scheme: QPSK

Number of transmitting antennas: 4

Number of receiving antennas: 4

Channel: Static and complex Gaussian

Sampling time: 0.125sec

A. BER calculation without equalizer

TABLE I:BER without any equalizer

SNR	Simulation Time (sec)	BER	Wrongly received bits	Total transmitted bits
5 dB	T=100	0.4419	354	800
5 dB	T=500	0.4631	1853	4000
5 dB	T=1000	0.4668	3735	8000
10 dB	T=100	0.4444	356	800
10 dB	T=500	0.4619	1848	4000
10 dB	T=1000	0.4636	3709	8000

B. BER calculation with Zero forcing equalizer

TABLE II:BER with ZF equalizer

SNR	Simulation Time (sec)	BER	Wrongly Received bits	Total transmitted bits
5 dB	T=100	0.2097	168	800
5 dB	T=500	0.2142	857	4000
5 dB	T=1000	0.2048	1639	8000
10 dB	T=100	0.02871	23	800
10 dB	T=500	0.02349	94	4000
10 dB	T=1000	0.0225	180	8000

C.BER calculation with MMSE equalizer

TABLE III:BER with MMSE equalizer

SNR	Simulation Time (sec)	BER	Wrongly Received bits	Total transmitted bits
5 dB	T=100	0.02372	19	800
5 dB	T=500	0.02724	109	4000
5 dB	T=1000	0.02487	199	8000
10 dB	T=100	0.002497	2	800
10 dB	T=500	0.000499	2	4000
10 dB	T=1000	0.00025	2	8000

VI. CONCLUSION

Based on the simulation result shown above, we can summarized this work as. Of two methods discussed in this paper, the performance of zero forcing detector is poor. Its bit error rate is comparatively high. However its complexity is low. The Simulink results show that BER decreases drastically with MMSE and also it can be easily implemented. Practically MMSE detection is the best suitable method for MIMO communication system.

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