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Research Papers

BIT ERROR RATE ANALYSIS OF STBC OVER SUI FADING CHANNEL

[1]DATTUKUMAR PATEL AND [2]NARENDRA YADAV

[1]M.Tech.Student, Dept. of Electronics and Communication, RIET Jaipur, Rajasthan, India.
[2]H.O.D of Dept. of Electronics and Communication, RIET Jaipur, Rajasthan, India.

Abstract

STBC use multi antenna for transmit and receiver side .There are multi path fading and Doppler effect. STBC use SUI Channel Model for simulation analysis of error probability. SUI channel model was proposed to simulate the fixed broadband wireless access channel environments. This channel model serial embraces 6 channel models that are grouped into 3 categories according to 3 typical different outdoor terrains. So analysis of different terrain channel and compare result for Rayleigh channel. SUI channel use simulation different antenna pattern. The BER measurements satisfy most scenarios of the MIMO channel performance.

KEYWORDS:
MIMO(Multi input multi output), STBC(Space time block code), SUI(Stanford University Interim) Channel Model

INTRODUCTION

MIMO wireless systems can provide increased channel capacity in rich multipath environments. With the increasing need for very high-speed data links, extensive MIMO channel model investigations have recently focused on frequency flat fading and frequency-selective fading issue. In theory, MIMO signals propagate over an independently and identically distributed (i.i.d.) multipath fading channel that results in a linearly increasing channel capacity with the minimum number of transmit and receive antennas. In reality, the inter-sub channel coupling in the antenna arrays is critical to the capacity degradation, especially in a line-of-sight (LOS) indoor multipath propagation environment, interpreted as the channel matrices. Therefore, modelling the radio channel accurately is essential for system design and performance evaluation.SUI Channel has three terrain type A,B,C are same as those defined earlier for Erceg model. The multipath fading is modelled as a tapped delay line with 3 taps with non-uniform delays. The gain associated with each tap is characterized by a Rician Distribution and the maximum Doppler frequency.

II. SPACE TIME BLOCK CODE

A) Alamoutis simple STBC code: Alamouti invented the simplest of all the STBCs in 1998[1], although he did not code in the term "space time block code" himself. It was designed for a two transmit antenna system and has the coding matrix:

$$C1 = \begin{bmatrix} x_1 & -x_2^* \\ x_2 & -x_1^* \end{bmatrix}$$

where * denotes complex conjugate.

It is readily apparent that this is a rate-1 code. It takes two time-slots to transmit two symbols. Using the optimal decoding scheme discussed below, the bit-error rate (BER) of this STBC is equivalent to 2nR-branch maximal ratio combining (MRC). This is a result of the perfect orthogonality between the symbols after receive processing. There are two copies of each symbol transmitted and nR copies receive.

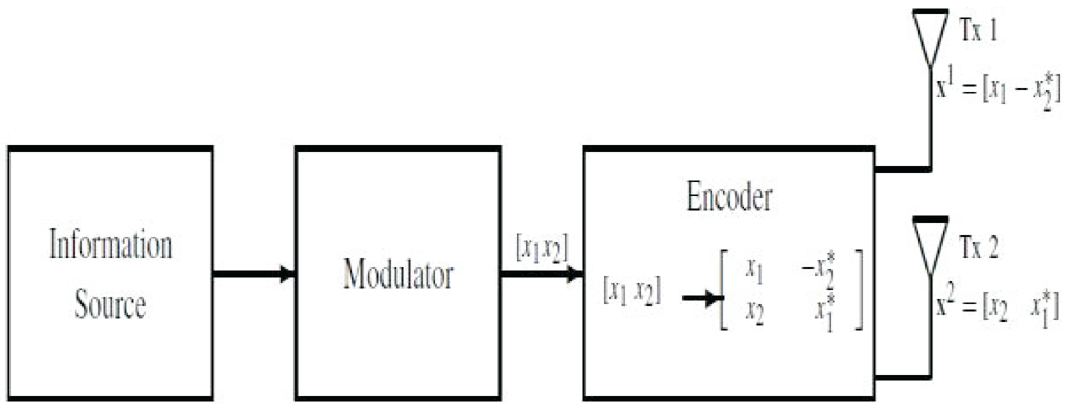

fig. 1. Alamouti Transmitter

This is a very special STBC. It is the only orthogonal say that it is the only STBC that can achieve its full diversity gain without needing to sacrifice its data rate. Strictly, this is only true for complex modulation symbols. Since almost all constellation diagrams rely on complex numbers however, this property usually gives Alamouti's code a significant advantage over the higher-order STBCs even though they achieve a better error-rate performance.

B) Decoding: A Two-Branch Transmit Diversity with One Receiver Fig. 1 shows the baseband representation of the new two branch transmit diversity scheme. The scheme uses two transmit antennas and one receive antenna and may be defined by the following three functions:

The encoding and transmission sequence of Information symbols at the transmitter.
The combining scheme at the receiver.
The decision rule for maximum likelihood detection.

III. SUI CHANNEL MODEL

Each of SUI-channel correspond to particular terrain category A,B and C. Type A terrain category include SUI-5,6 (hilly/heavy tree density),Type B include SUI-3,4 (moderate tree density) and Type C include SUI-1,2 (flat/light tree density).

Table- 1 Different terrain types

Terrain	SUI Channel
C	SUI-1.SUI-2
B	SUI-3.SUI-4
A	SUI-5.SUI-6

The structure is general for Multiple Input Multiple Output (MIMO) channels and includes other configurations like Single Input Single Output (SISO) and Single Input Multiple Output (SIMO) as subsets. The SUI channel structure is the same for the primary and interfering signals. Input Mixing Matrix that correlation between input signals if multiple transmitting antennas are used. Tapped Delay Line Matrix is the multipath fading of the channel. The multipath fading is modelled a tapped-delay line with 3 taps with non-uniform delays. The gain associated with each tap is characterized by a distribution (Ricean with a K-factor > 0, or Rayleigh with K-factor = 0) and the maximum Doppler frequency. Output Mixing Matrix correlation between output signals if multiple receiving antennas are used. Obviously, the system performance would vary greatly with the terrain where it is deployed, which leads to a different predefined threshold levels. Furthermore, even in one terrain type, some factors, such as antenna height, beam forming, and Doppler frequency, would cause different system performance. SUI channel 4 parameters shown in Table 2.

Table-2 SUI Channel-4(Terrain-B)

SUI-4 Channel

	Tap 1	**Tap 2**	**Tap 3**	
Delay	0	1.5	4	µs
Power (omni ant.)	0	-4	-8	dB
90% K-fact.(omni ant.)	0	0	0	
Doppler	0.2	0.15	0.25	Hz
Antenna Correlation: ENV = 0.3 **Gain Reduction Factor:** GRF = 4dB **Normalization Factor:** F_{omni} = -1.9218 dB,	**Terrain Type:** B **Omni antenna:** τ_{RMS}= 1.257 µs, overall K: K = 0.2 (90%)			

Physical scenario for SUI Channel:

1.A cell size of 4 mail (6.4)
2.BTS antenna height: 50ft
3.MS antenna height: 10ft
4.BTS Antenna Beamwidth: 120 deg
5.MS Antenna Beamwidth: 50 deg
6.Vertical Polarization only

IV. SIMULATION STEP

The approach to coding for a task can therefore differ significantly depending on the goal. For the purpose of demonstrating the model implementation, we concentrate on the core channel simulation, i.e. the result of our code is to produce channel coefficients at an arbitrary (channel) sampling rate.1) Power distribution: We use the method of filtered noise to generate channel coefficients with the specified distribution and spectral power density. For each tap a set of complex zero-mean Gaussian distributed numbers is generated with a variance of 0.5 for thereal and imaginary part, so that the total average power of this distribution is 1. This yields a normalized Rayleigh distribution (equivalent to Ricean with K=0) for the magnitude of the complex coefficients. If a Ricean distribution (K>0 implied) is needed, a constant path component m has to be added to the Rayleigh set of coefficients. The ratio of powers between this constant part and the Rayleigh (variable) part is specified by the K-factor. For this general case, we show how to distribute the power correctly by first stating the total power P of each tap:

$$P = |m|^2 + \sigma^2$$ ------------------------1

Where m is the complex constant and the variance of the complex Gaussian set. second, the ratio of power is

$$K = \frac{|m|^2}{\sigma^2}$$ -------------------------2

From the equation, we can find the power of complex Gaussian and the power of constant part as

$$\sigma^2 = P\frac{1}{K+1} \text{ and } |m|^2 = P\frac{1}{K+1}$$ --------------3

From eqns.3 we can see that for K=0 the variance becomes P and the constant part power diminishes, as expected .Note that we choose a phase angle of 0° for m in the implementation.

2)Doppler Spectrum: The random components ofthe coefficients generated in the previous paragraph have a white spectrum since they are independent of each other (the autocorrelation function is a Dirac impulse). The SUI channel model defines a specific power spectral density (PSD) function for these scatter component channel coefficients called ' rounded' PSD which is given as

$$S(f) = \begin{cases} 1 - 1.72f_0^2 + 0.785f_0^4 & |f_0| \le 1 \\ 0 & |f_0| > 1 \end{cases}$$

$$\text{Where } f_0 = \frac{f}{fm}$$ -------4

To arrive at a set of channel coefficients with this PSD function, we correlate the original coefficients with a filter which amplitude frequency response is derived from eqn. 4. As

$$|H(f)| = \sqrt{S(f)}$$ --------------------5

We choose to use a non-recursive filter and the frequency-domain overlap-add method for efficient implementation. We also have to choose some filter length which determines how exact and smooth our transfer function is realized by the filter. Since there are no frequency components higher than fm, the channel can be represented with a minimum sampling frequency of 2fm, according to the Nyquist theorem. We therefore simply define that our coefficients are sampled at a frequency of 2. The total power of the filter has to be normalized to one, so that the total power of the signal is not changed by it. The mean energy of a discrete-time process x(k) is

$$E\{|X(k)|^2\} = \frac{1}{N}\sum_{k=1}^{N}|x(k)|^2 = \int_{-\pi}^{\pi} S_{xx}(e^{j\Omega})d\Omega$$

$$\text{Where } \Omega = \frac{2\pi f}{f_s}$$ --------------6

We note that the PSD function given in eqn.4 is not normalized.

3)Antenna Correlation: The SUI channel models define an antenna correlation, which has to be considered if multiple transmit or receive elements, i.e. multiple channels, are being simulated. Antenna correlation is commonly defined as the envelope correlation coefficient between signals received at two antenna elements. The received baseband signals are modelled as two complex random processes X (t) and Y(t) with an envelope correlation coefficient of

$$\rho_{env} = \left| \frac{E\{(X-E\{X\})(Y-E\{Y\})^*\}}{\sqrt{E\{|X-E\{X\}|^2\}E\{|Y-E\{Y\}|^2\}}} \right| \text{ --------------7}$$

Note that this is not equal to the correlation coefficient of the envelopes (magnitude) of two signals, a measure that is also used frequently in cases where no complex data is available. Since the envelope correlation coefficient is independent of the mean, only the random parts of the channel are of interest. In the following we therefore consider the random channel components only, to simplify the notation.SUI channel we recommend setting all tap correlations equal to the antenna correlation. To generate a sequence of random state vectors with specified first order statistics (mean vector μ and correlation matrix R), we can use the following transformation.

$$\tilde{V} = R^{1/2}V + \mu \text{ -----------------------8}$$

where V is a vector of independent sequences of Gaussian-distributed random numbers with zero mean and identical variance. The correlation matrix R is defined and factored as:

$$R = E\left\{\begin{bmatrix} 1 & r_{12} \\ r_{12}^* & 1 \end{bmatrix}\right\} = R^{1/2}R^{H/2} \text{ -------9}$$

If we use eqn. 8 to correlate complex sequences, not all correlations between real and imaginary parts of the input sequences are set according to the specified envelope correlation coefficient. To correlate complex sequences, we therefore split each complex sequence into real and imaginary part and correlate the real-valued sequences. For example, to correlate two complex sequences X and Y, the input vector V and the correlation matrix R are set as:

$$V = \begin{bmatrix} Re\{X\} \\ Im\{X\} \\ Re\{Y\} \\ Im\{Y\} \end{bmatrix}, \; R = \begin{bmatrix} 1 & 0 & \rho_{env} & \rho_{env} \\ 0 & 1 & \rho_{env} & \rho_{env} \\ \rho_{env} & \rho_{env} & 1 & 0 \\ \rho_{env} & \rho_{env} & 0 & 1 \end{bmatrix}$$

To implement correlated channels in our simulation, first two independent but equally distributed set of channel coefficients are created following the procedures. Then we use eqns.8 and 9 to correlate the random signals of equivalent taps in these two channels. In a general vector or matrix channel, correlation coefficients can be defined between all sub-channels.

1)Observation Rate: For some purposes it can be required or useful to have the SUI channel coefficients at an arbitrary chosen observation rate, i.e. the data rate of a communication system. This can be done easily by re sampling the channel data to the specific sampling rate.

IV. SIMULATION RESULTS

In this section, BER performance of the STBC for different SUI fading channel. I can observe different terrian SUI channel continuous performance decrease from channel 1 to 6 show in figure 1.BER for alamouti STBC BPSK modulation for different terrian channel and rayleigh fading channel show in figure 2,3 4.Terrian-C (channel 1,2) performance better then Rayleigh Channel because factor k>0.Terrian-B and terrian-A performance decrease compare to Rayleigh channel. Figure 5 notice that the performance increase number of antenna receiver side increase but complexity also increase.

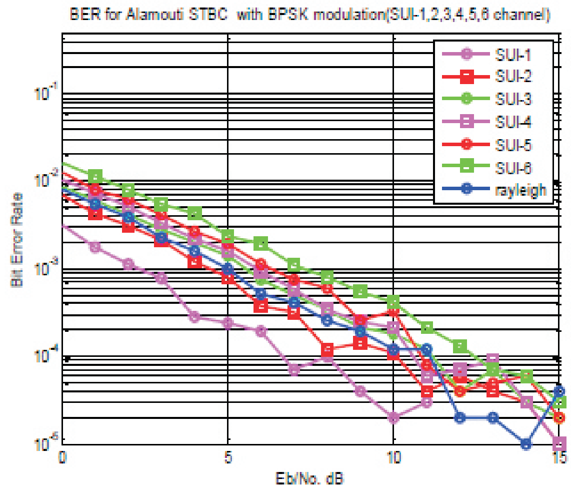

Fig.1. BER for SUI channel-1, 2, 3,4,5,6

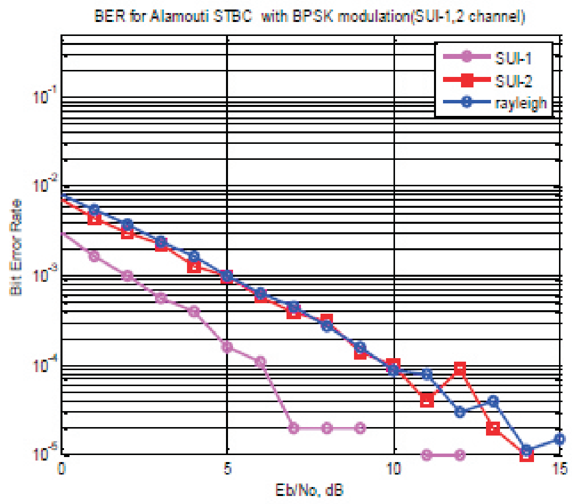

Fig.2. BER for SUI channel-1,2 (Terrain-C)

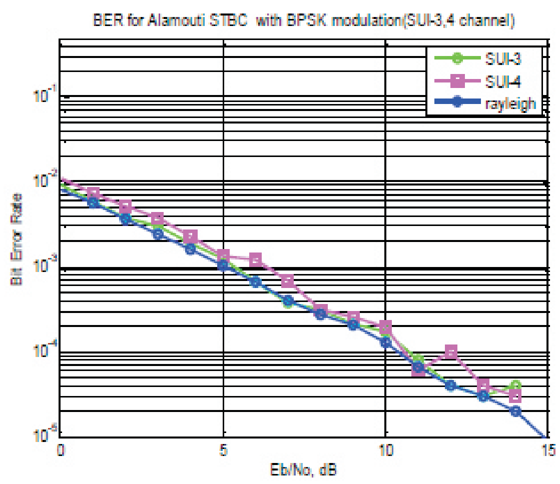

Fig.3. BER for SUI channel-3,4(Terrain-B)

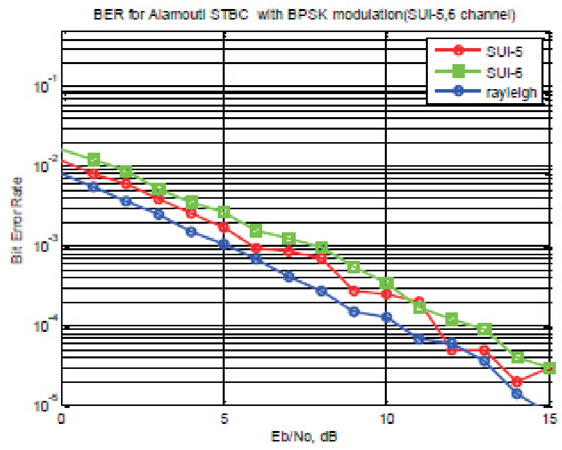

Fig.4. BER for SUI channel-5,6(Terrain-A)

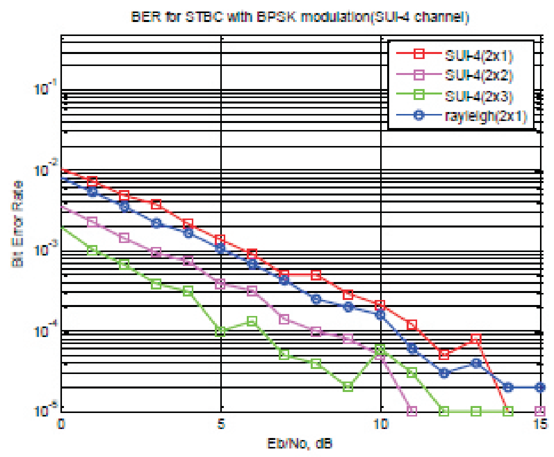

Fig.5. BER for SUI Channel-4 to different receive antenna

V. CONCLUSION

In this paper I have describe the concept of STBC. I have also studied the SUI fading channel and examined the performance of the Alamouti STBC with different SUI fading channel. I observe the performance of two and three receivers for moderate terrian-B (channel 4).Obtained result have shown that increase number of antenna lead to better performance in term BER versus SNR.

VI. REFERENCE

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