ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 3, Issue 12, June 2014

Performance Analysis of Selective Combining Diversity over Rayleigh Fading Channel in Wireless Communication

Neelam Yadav, Neeraj Kumar, Neeraj Rathi
M-Tech Scholar, SGT Institute of Engineering and Technology, Gurgaon, Haryana
Assistant Professor, SGT Institute of Engineering and Technology, Gurgaon, Haryana

Abstract:* *In this paper, we use the selective combining diversity over Rayleigh fading channel is presented. Different diversity techniques are available in the literature. Different techniques behave differently with different coding techniques. Here, diversity analysis of the Rayleigh fading channel is presented in Space time block codes (STBC). We are using the system model of the space time block codes to analysis the effect of diversity present in the wireless communication system. Bit error rate (BER) and signal to noise ratio (SNR) are the control parameters used to analysis the performance of selective combining diversity over Rayleigh fading Channel. Simulation result shows that the bit error rate versus EbNo is presented in presence of selective combining diversity in Rayleigh channel. Result also shows that the signal to noise ratio (SNR) goes on increases with the increase the number of receiver antenna. The result reveals that the wireless communication system has better performance when space time block coding (STBC) technique is used for receive diversity. Result shows that as the number of receiver goes on increases bit error rate also goes on decreasing.

Index Terms: **Space time block coding (STBC), Diversity Techniques, Selective combining diversity, Rayleigh fading, Bit error rate (BER).**

I. INTRODUCTION

To improve the performance of a wireless transmission system in which the channel quality fluctuates, suggested that the receiver be provided with multiple received signals generated by the same underlying data [1]. It is known that diversity combining is an effective technique to combat multipath fading in wireless communication systems. There are three conventional combining methods: selection combining (SC), maximal-ratio combining (MRC), and equal-gain combining (EGC). Among the three combining methods, SC is the simplest, but gives the worst performance by selecting the best diversity branch, such as the one with the largest instantaneous signal-to-noise ratio (SNR). The major requirement for broadband wireless communications has been reliable high-data-rate services. This motivates research toward developing efficient coding and modulation schemes that improve the quality and bandwidth efficiency of wireless systems [2]. In wireless links, multipath fading causes performance degradation and constitutes the bottleneck for increasing data rates. Space-time (ST) coding has been proved effective in combating fading, and enhancing data rates [3]-[7]. We focus on space-time coding (STC) schemes defined by Tarokh et al [3][6][7], and Alamouti [8], which introduce temporal and spatial correlation into the signals transmitted from different antennas without increasing the total transmitted power or the transmission bandwidth. For systems using space-time block codes (STBCs) and maximum-likelihood (ML) detection/decoding, it is well known that the diversity order is not sensitive to the i.i.d. Rayleigh fading channel [9]-[11]. In this paper, we use the selective combining diversity over Rayleigh fading channel is presented. Different diversity techniques are available in the literature. Different techniques behave differently with different coding techniques. Here, diversity analysis of the Rayleigh fading channel is presented in Space time block codes (STBC) [3]. We are using the system model of the space time block codes to analysis the effect of diversity present in the wireless communication system. Bit error rate (BER) and signal to noise ratio (SNR) are the control parameters used to analysis the performance of selective combining diversity over Rayleigh fading Channel. The rest of thr paper is organized as follows: Section II presents the different diversity techniques. Section III presents the system model for space time codes. Description of space time block code (STBC) is presented in Section IV. Rayleigh fading channel is presented in section V. Section VI, simulation results are presented with bit error rate and signal to noise ratio are performance criteria. Finally, conclusions are reflected in Section VII.

II. DIVERSITY TECHNIQUES

Space Diversity

If the receiver has multiple antennas, the distance between the receiving antennas is made large enough to ensure independent fading. This arrangement is called space diversity. Space separation of half of the wavelength is sufficient to obtain two uncorrelated signals

Polarization Diversity

Antennas can transmit either a horizontal polarized wave or a vertical polarized wave. When both waves are transmitted simultaneously, received signals will exhibit uncorrelated fading statistics. This scheme can be considered as a special case of space diversity because separate antennas are used. However, only two diversity branches are available, since there are only two orthogonal polarizations.

Angle Diversity

Since the received signal arrives at the antenna via several paths, each with a different angle of arrival, the signal component can be isolated by using directional antennas. Each directional antenna will isolate a different angular component. Hence, the signals received from different directional antennas pointing at different angles are uncorrelated.

Frequency Diversity

Signals with different carrier frequencies far apart with each other are possibly independent. The carrier frequencies must be separated enough so that the fading associated with the different frequencies are uncorrelated. For frequency separations of more than several times the coherence bandwidth, the signal fading would be essentially uncorrelated.

Time Diversity

When the same data are sent over the channel at different time instants, the received signals can be uncorrelated if the time separations are large enough. The required time separation is at least as great as the reciprocal of the fading bandwidth, which is two times the speed of the mobile station divided by the wavelength. Hence, the time separation is inversely proportional to the speed of the mobile station. For the mobile station stationary, time diversity is useless. This is contrast to all of the other diversity types discussed above because they are independent of the speed of the mobile station.

III. SPACE TIME CODING

Consider a mobile communications system where the base station is equipped with *n* antennas and the remote unit is equipped with *m* receive antennas At each time slot *t*, signals c_t^i, *i*=1,2,….,n are transmitted simultaneously from the *n* transmit antennas. The channel is flat-fading and the path gain from transmit antenna *i* to receive antenna *j* is denoted by h_{ij}. The path gains are modelled as samples of independent complex Gaussian random variables with variance 0.5 per real dimension, i.e., $h_{ij} \sim N(0,1)$, as we assume that signals received at different antennas experience independent fading. In this report, we will consider modelling the path gins in slow Rayleigh fading. For slow fading, it is assumed that the path gains are constant during a frame of length L and vary from one frame to another, i.e., channel is quasi-static.

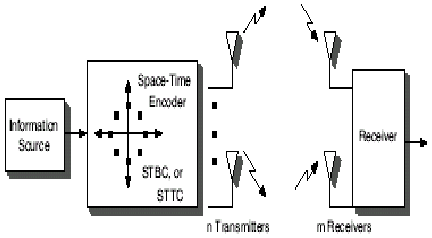

Fig 1 STC System Model

At time t, the signal r_t^j received at antenna j is given by

$$r_t^j = \sum_{i=1}^{n} h_{i,j} c_t^i + \eta_t^j \qquad (1)$$

Where the noise samples η_t^j are zero mean complex Gaussian with variance $\sigma^2 = 1/(2E_s/N_o) = 1/2SNR$ per dimension. The average energy of the symbols transmitted from each antenna is normalized to one, so that the average power of the received signal at each receive antenna is n.

It is assumed that channel state information is only available at the receiver, who uses it to compute the decision metric

$$\sum_{t=1}^{l} \sum_{j=1}^{m} \left| r_t^j - \sum_{i=1}^{n} h_{i,j} c_t^i \right|^2 \qquad (2)$$

over all code words $c_1^1 c_1^2 \ldots c_1^n c_2^1 \ldots c_2^n c_l^n \ldots c_l^n$ and decide in favour of the code word that minimizes the sum.

IV. PACE-TIME BLOCK CODES

Alamouti proposed a simple transmit diversity scheme [3], which improves the signal quality at the receiver on one side of the link by simple processing across two transmit antennas at the opposite end.

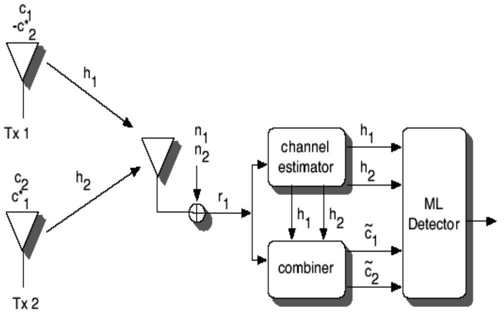

Fig 2 Transmit Diversity Scheme

At a given symbol period, two signals are simultaneously transmitted from the two antennas, namely c_1 from the first antenna, Tx1, and c_2 from the second antenna, Tx2. In the next symbol period, signal ($-c_2^*$) is transmitted from Tx1 and signal c_1^* is transmitted from Tx2, where * denotes complex conjugation. Let $h_1(t)$ denote the path gain from Tx1 to the receiver; similarly let $h_2(t)$ be that from Tx2 to the receiver. If we assume that fading is constant across two consecutive symbols, we can write

$$\begin{aligned} h_1(t) &= h_1(t+T) = h_1 = \alpha_1 \exp j\theta_1 \\ h_2(t) &= h_2(t+T) = h_2 = \alpha_2 \exp j\theta_2 \end{aligned} \tag{3}$$

where T is the symbol period. The received signals are

$$\begin{aligned} r_1 &= r(t) = h_1 c_1 + h_2 c_2 + \eta_1 \\ r_2 &= r(t+T) = -h_1 c_2^* + h_2 c_1^* + \eta_2 \end{aligned} \tag{4}$$

where r_1 and r_2 are the received signals at time *t* and *t*+T. The combiner combines the received signals as follows:

$$\begin{aligned} \tilde{c}_1 &= h_1^* r_1 + h_2 r_2^* = (\alpha_1^2 + \alpha_2^2) c_1 + h_1^* \eta_1 + h_2 \eta_2^* \\ \tilde{c}_2 &= h_2^* r_1^* - h_1 r_2^* = (\alpha_1^2 + \alpha_2^2) c_2 - h_1 \eta_2^* + h_2^* \eta_1 \end{aligned} \tag{5}$$

and sends them to the maximum likelihood detector, which minimizes the following decision metric

$$|r_1 - h_1 c_1 - h_2 c_2|^2 + |r_2 + h_1 c_2^* - h_2 c_1^*|^2 \tag{6}$$

over all possible values of c_1 and c_2. Expanding this, and deleting terms that are independent of the codeword's, the above minimization reduces to separately minimizing

$$|r_1 h_1^* + r_2^* h_2 - c_1|^2 + \left(\alpha_1^2 + \alpha_2^2 - 1\right) |c_1|^2 \tag{7}$$

for detecting c_1 and

$$|r_1 h_2^* - r_2^* h_1 - c_2|^2 + \left(\alpha_1^2 + \alpha_2^2 - 1\right) |c_2|^2 \tag{8}$$

for decoding c2. Equivalently, using the notation $d^2(x,y) = (x-y)(x^* - y^*) = |x-y|^2$. The decision rule for each combined signal $\tilde{c}_j$; j = 1;2 becomes: Pick c_i if and only if (iff)

$$\left(\alpha_1^2 + \alpha_2^2 - 1\right) |c_i|^2 + d^2(\tilde{c}_j, c_i) \leq \left(\alpha_1^2 + \alpha_2^2 - 1\right) |c_k|^2 + d^2(\tilde{c}_j, c_k), \quad \forall i \neq k$$

(9)

For QAM signals (equal energy constellations), this simplifies to

$$d^2(\tilde{c}_j, c_i) \leq d^2(\tilde{c}_j, c_k), \qquad \forall i \neq k \tag{10}$$

V. AYLEIGH FADED CHANNEL

Let the transmitted signal be a symbol represented by a level A and it modulates a carrier $\cos(2\pi f_c t)$. Therefore the ideal signal at the receiver is the transmitted signal with additive noise. But because of the multipath propagation the received signal is a sum of the entire received signal from all the propagation paths. Therefore the received signal can be represented as

$$Y(t) = A \sum_{i=1}^{N} a_i \cos\left(2\pi f_c t + \theta_i\right) \tag{11}$$

Where a_i is the attenuation in the signal and θ_i is the time varying phase. It can be seen from that the random variations in $\theta_i(t)$ will have a significant effect. The attenuation also affects the signal power of the received signal but not as much as the variations in phase.

The above equation can be rewritten as

$$Y(t) = A\left[\left(\sum_{i=1}^{N} a_i \cos\theta_i\right) \cos 2\pi f_c t - \left(\sum_{i=1}^{N} a_i \sin\theta_i\right) \sin 2\pi f_c t \right] \tag{12}$$

In Eq(12) the terms sum of $a_i \cos \theta_i$ and $a_i \sin\theta_i$ are two random variables which are due to large number of independent random variables . Using the central limit theorem these components can be modeled as Gaussian random processes X1(t) and X2(t). Then the eq(12) can be written as

$$Y(t) = AR(t)\cos(2\pi f_c t + \theta(t)) \tag{13}$$

Where R(t) is characterized as a random variable with a specific probability density function and q(t) is a uniform random variable between -p to p. In Eq(13) R(t) has an effect on the signal envelope and qi(t) has an effect on the phase of the received signal.

The fading is characterized by the pdf of R(t). If the envelope of the faded received signal is Rayleigh distributed then the channel is said to have *Rayleigh fading*. In a Rayleigh fading channel it is assumed that the received signals at the receiver due to multiple reflections and no direct line of sight dominant component.

The expression used to calculate the theoretical values of the probability of error for a Rayleigh fading environment is given below,

$$P_e = \frac{1}{2}\left(1 - \sqrt{\frac{\gamma}{1+\gamma}}\right) \qquad (14)$$

Where γ is the average value of SNR.

VI. IMULATION RESULTS

The simulation is carried out using Alamouti space time block coding scheme. The Bit Error Rate are compared for Rayleigh channel. At the Transmitter, Firstly, the number of symbols to be transmitted and signal to noise ratio is determined. The simulation is carried out by using selective combining diversity.

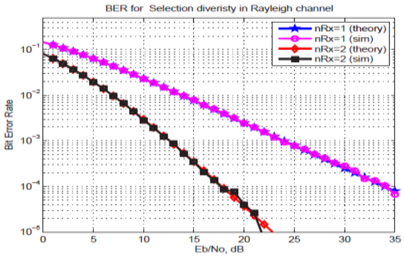

Fig: 3 BER versus Eb/N0 performance of Selective combining diversity of space time block coding.

Fig: 3 shows the BER versus Eb/N0 performance of Selective combining diversity of space time block coding. The probability of outage is the probability that the output *SNR* falls below a threshold the *SNR* of all elements is below the threshold.

$$P_{out}(\gamma_s) = \left[1 - e^{-\gamma_s/\Gamma}\right]^N$$

Fig: 4 shows the SNR for different number of receive antenna using Selective combining diversity of space time block coding.

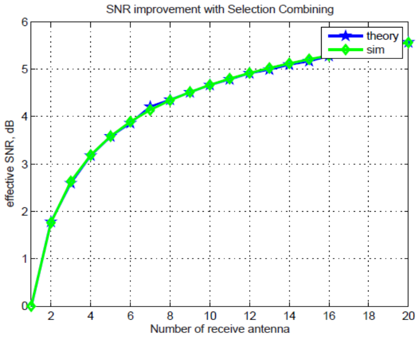

Fig: 4 shows the SNR for different number of receive antenna using Selective combining diversity of space time block coding

VII. CONCLUSIONS

In this paper, we use the selective combining diversity over Rayleigh fading channel is presented. Different diversity techniques are available in the literature. Different techniques behave differently with different coding techniques. Here, diversity analysis of the Rayleigh fading channel is presented in Space time block codes (STBC). Simulation result shows that the bit error rate versus EbNo is presented in presence of selective combining diversity in Rayleigh channel. Result also shows that the signal to noise ratio (SNR) goes on increases with the increase the number of receiver antenna. The result reveals that the wireless communication system has better performance when space time block coding (STBC) technique is used for receive diversity.

REFERENCES

[1] Simon Haykin, "Communication Systems" - 3rd edition, John Wiley & Sons, Inc., 1994.

[2] John G. Proakis, "Digital Communications" - 2nd Edition, McGraw Hill Book Company, 1989.

[3] V. Tarokh, H. Jafarkhani, and A. R. Calderbank, “Space–Time Block Coding for Wireless Communications: Performance Results” IEEE journal on selected areas in communications, vol. 17, no. 3, March 1999.

[4] Z. Liu, G. B. Giannakis, B. Muquet, and S. Zhou, “Space-time coding for broadband wireless communications,” Wireless Syst. Mobile Comput., vol. 1, no. 1, pp. 33–53 Jan.–Mar. 2001.

[5] A. F. Naguib, N. Seshadri, and R. Calder bank, “Increasing date rate over wireless channels,” IEEE Signal Processing Mag., vol. 17, pp. 76–92, May 2000.

[6] V. Tarokh, H. Jafarkhani, and A. R. Calder bank, “Space-time block codes from orthogonal designs,” IEEE Trans. Inform. Theory, vol. 45, pp. 1456–1467, July 1999.

[7] V. Tarokh, N. Seshadri, and A. R. Calder bank, “Space-time codes for high data rate wireless communication performance criterion and code construction,” IEEE Trans. Inform. Theory, vol. 44, pp. 744–765, Mar. 1998.

[8] S.M. Alamouti, "Simple transmit diversity technique for wireless communications", IEEE Journal on Select Areas in Communications, vol. 16, pg. 1451-1458, 1998.

[9] G. J. Foschini, Jr. and M. J. Gans,"On limits of wireless communication in a fading environment when using multiple antennas," Wireless Personal Commun. Proc.6, Pg.311-335, 1998.

[10] Zhang Xiaodi ; Beaulieu, N.C., "SER and outage of threshold-based hybrid selection/maximal-ratio combining over generalized fading channels”, IEEE Transactions on Communications, Vol: 52 , Issue: 12 , Pag: 2143 – 2153, 2004.

[11] Feng Xu ; Lau, F.C.M. ; Dian-Wu Yue, "Diversity order for amplify-and-forward dual-hop systems with fixed-gain relay under Nakagami fading channels”, IEEE

Transactions on Wireless Communications, Vol: 9 , Issue: 1 , Pag: 92 – 98, 2010.