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# Performance Analysis of Space-Time Trellis Coding (STTC) based on Maximal Ratio Combining and Equal Gain Combining diversity Techniques

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***Abstract:*** ***In this paper, we use the maximal ratio combining (MRC) diversity and equal gain combining (EGC) diversity to evaluate the performance of space time trellis coding (STTC). Different diversity techniques are available for the analysis of space time codes. This paper presents the two diversity techniques to measure the performance of the space time trellis codes Bit error rate (BER) and signal to noise ratio (SNR) are the control parameters used to analysis the performance of the maximal ratio combining diversity and equal gain combining diversity with Rayleigh fading Channel. Simulation result shows that the bit error rate versus EbNo is presented in presence of the maximal ratio combining diversity and equal gain combining diversity in Rayleigh channel. The result reveals that the wireless communication system has better performance when space time trellis coding (STTC) technique is used for receive diversity.***

***Index Terms:*** **Space time trellis coding (STTC), Diversity Techniques, maximal ratio combining (MRC) diversity, equal gain combining (EGC), Bit error rate (BER).**

## I. INTRODUCTION

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].

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).

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 maximal ratio combining (MRC) diversity and equal gain combining (EGC) diversity to evaluate the performance of space time trellis coding (STTC). Different diversity techniques are available for the analysis of space time codes. This paper presents the two diversity techniques to measure the performance of the space time trellis codes Bit error rate (BER) and signal to noise ratio (SNR) are the control parameters used to analysis the performance of the maximal ratio combining diversity and equal gain combining diversity with Rayleigh fading Channel.

The rest of this paper is organized as follows: Section II presents the system model of space time trellis coding. Section III presents the space time trellis codes (STTC). Maximal ratio combining is presented in section IV. Section V, gives the detail of equal gain combining. In Section VI, simulation results are presented with bit error

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rate and signal to noise ratio are performance criteria. Finally, conclusions are made.

## II. SYSTEM MODEL: SPACE TIME TRELLIS CODING (STTC)

A mobile communication system where the base-station is equipped with antennas and the mobile is equipped with antennas [3]. Data is encoded by the channel encoder, the encoded data goes through a serial-to-parallel converter, and is divided into *n* streams of data. Each stream of data is used as the input to a pulse shaper. The output of each shaper is then modulated. At each time slot *t*, the output of modulator *i* is a signal $c^i_t$ that is transmitted using transmit antenna (*Tx* antenna) *i* for $1 \leq i \leq n$. We emphasize that the *n* signals are transmitted simultaneously each from a different transmit antenna and that all these signals have the same transmission period *T*. The signal at each receive antenna is a noisy superposition of the *n* transmitted signals corrupted by Rayleigh fading. It is assumed that the elements of the signal constellation are contracted by a factor of $\sqrt{E_S}$ chosen so that the average energy of the constellation is 1.

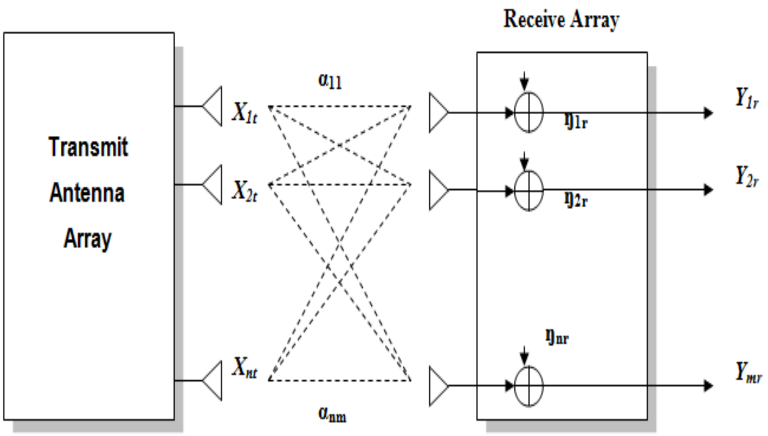


**Fig 1 STTC System Model**

At the receiver, the demodulator computes a decision statistic based on the received signals arriving at each receive antenna $1 \leq j \leq m$. The signal $d^j_t$ received by antenna at time is given by

$$d_t^j = \sum_{i=1}^{n} \alpha_{i,j} c_t^j \sqrt{E_S} + \eta_t^j \qquad (1)$$

where the noise $\eta_t^j$ at time t is modelled as independent samples of a zero-mean complex Gaussian random variable with variance $N_0/2$ per dimension. The coefficient $\alpha_{i,j}$ is the path gain from transmit antenna to receive antenna. It is assumed that these path gains are constant during a frame and vary from one frame to another (quasistatic flat fading).

## III. SPACE-TIME TRELLIS CODES

Space-Time Trellis Codes (STTC) [4][5] uses several convolution codes to achieve correlation in temporal and spatial dimension. The receiver performs a kind of maximum-likelihood sequence estimation, e.g. by means of a Viterbi algorithm, to decode the received signals. Hence possible code sequences are given by a trellis, coding gain is achieved. These codes have shown considerable performance gains for wireless communication at the expense of a rising decoding effort with increasing numbers of transmit antennas or trellis states.

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Space-time trellis codes [2] encode the input symbol stream into an output vector symbol stream. Unlike space-time block codes, space-time trellis codes map one input symbol at a time to an $M_t$x1 vector output. Since the encoder has memory, these vector code words are correlated in time. Decoding is performed via maximum likelihood [12][13] sequence estimation.

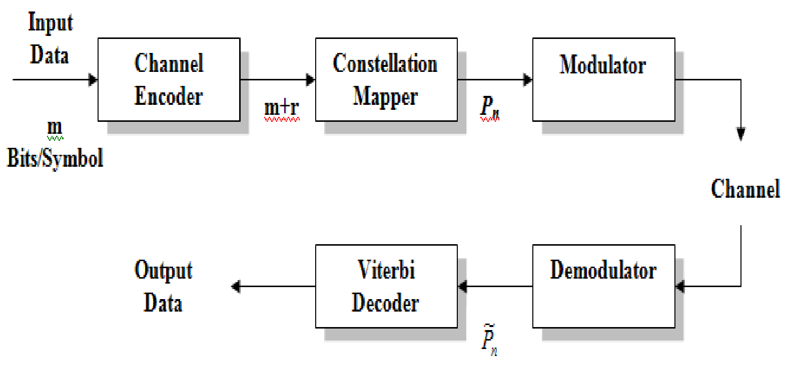


**Fig 2 STTC System**

Fig. 2 shows a general block diagram for a STTC system. The input data bits coming at the rate of m bits/symbol are encoded by a channel (convolutional) encoder, to produce m+r bits which are mapped with the help of a constellation mapper to give on of the possible states of the encoder. This is then further modulated using techniques like PSK, FSK,QAM etc. and transmitted through $N_t$ transmit antennas to the channel, where the signal gets corrupted by noise. At the receiving end, $N_r$ receive antennas are used to receive the transmitted signal which is then demodulated and the resultant noise affected signal is fed to a Viterbi Decoder. It is a maximum likelihood (ML) decoder that gets back the original signal by construction a trellis structure. The decoder is designed such as to minimize the error due to noise or any other factors.

## III. MAXIMAL RATIO COMBINING (MRC)

Maximal Ratio Combining (MRC)[14][15] obtains the weights that maximizes the output *SNR*, i.e., it is optimal in terms of SNR. Writing the received signal at the array elements as a vector *x*(*t*), and the output signal as *r*(*t*). Since the signal *u*(*t*) has unit average power, the instantaneous output SNR is

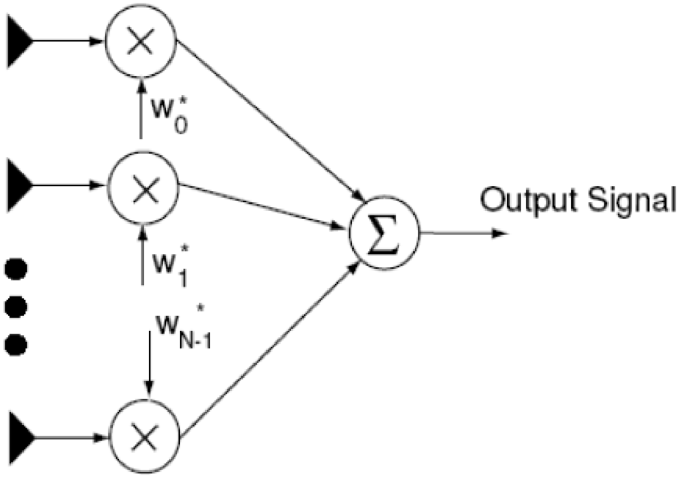


**Fig: 3 Diversity Combining System**

$$\gamma = \frac{|\mathbf{w}^{\mathbf{H}}\mathbf{h}|^2}{\mathbf{E}\{|\mathbf{w}^{\mathbf{H}}\mathbf{n}|^2\}} \tag{2}$$

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The expected value of the output *SNR* is therefore *N* times the average *SNR* at each element, i.e.

$$E\{\gamma\} = N\Gamma \tag{3}$$

## IV. EQUAL GAIN COMBINING (EGC)

This technique requires the weights to vary with the fading signals, the magnitude of which may fluctuate over several 10s of *dB*. The equal gain combiner sidesteps this problem by setting unit gain at each element. In the equal gain combiner [16] the noise and instantaneous *SNR* are given by

$$P_n = \mathbf{w}^{\mathbf{H}}\mathbf{w}\sigma^2 = N\sigma^2, \tag{4}$$

$$E\{\gamma\} = \frac{1}{2N\sigma^2}\left[2NP_0 + N(N-1)\frac{\pi P_0}{2}\right] \tag{5}$$

The equal gain combiner results in an improvement in *SNR* that is comparable to that of the optimal maximal ratio combiner. The *SNR* of both combiners increases linearly with *N*.

## V. SIMULATION RESULTS

The simulation is carried out using space time trellis coding (STTC) 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.

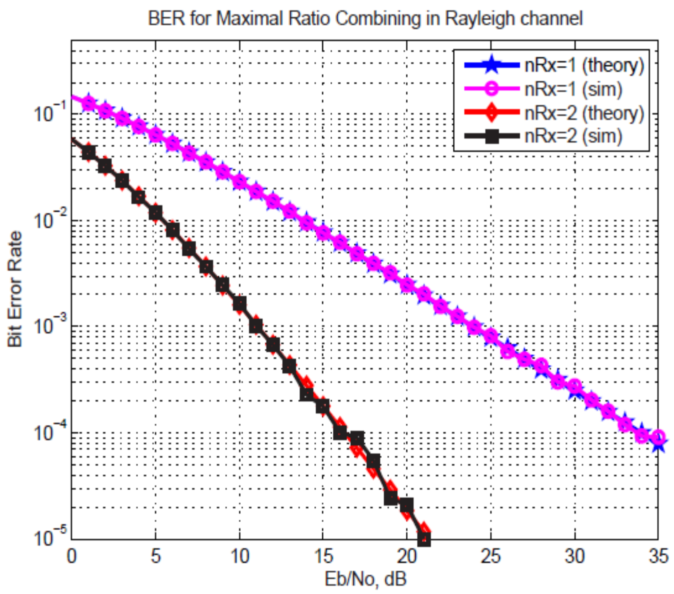


**Fig: 4 BER versus Eb/N0 performance of Maximal Ratio combining diversity of space time trellis coding**

The simulation is carried out by using maximal ratio combining and Equal Gain Combining. Fig: 4 shows the BER versus Eb/N0 performance of Maximal Ratio Combining diversity of space time trellis coding. Fig: 5 shows the SNR for different number of receive antenna using Maximal Ratio combining diversity of space time trellis coding. Fig: 6 shows the BER versus Eb/N0 performance of equal gain Combining diversity of space time trellis coding. Fig: 7 shows the SNR for different number of receive antenna using equal gain combining diversity of space time trellis coding.

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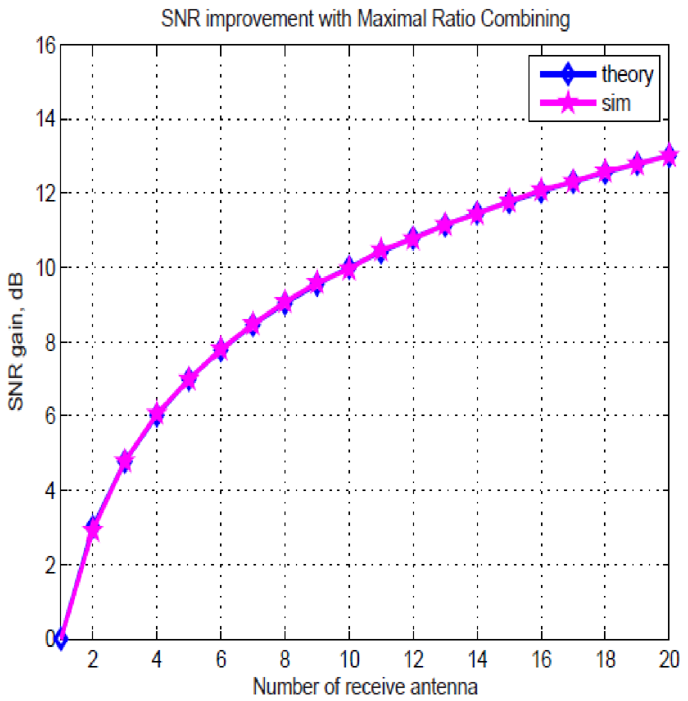


**Fig: 5 SNR for different number of receive antenna using Maximal Ratio combining diversity of space time trellis coding**

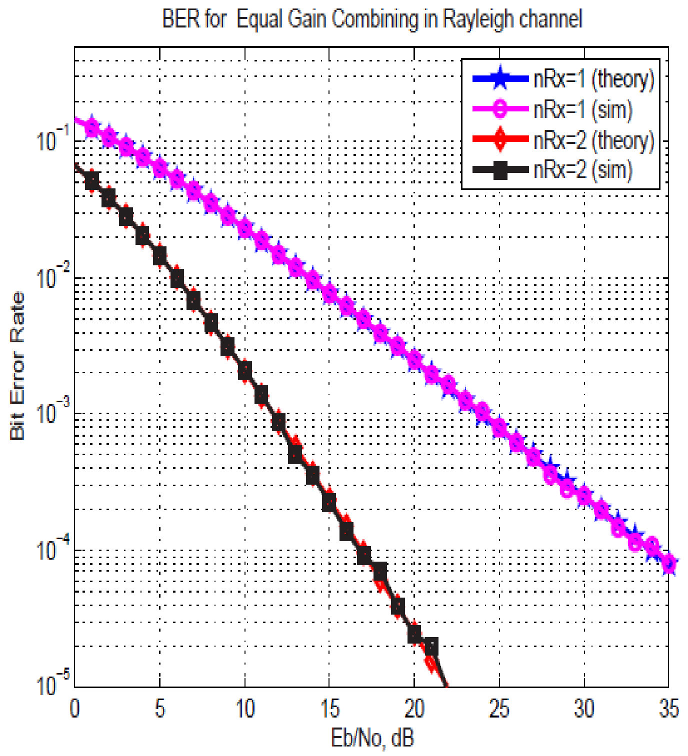


**Fig: 6 BER versus Eb/N0 performance of equal gain combining diversity of space time trellis coding**

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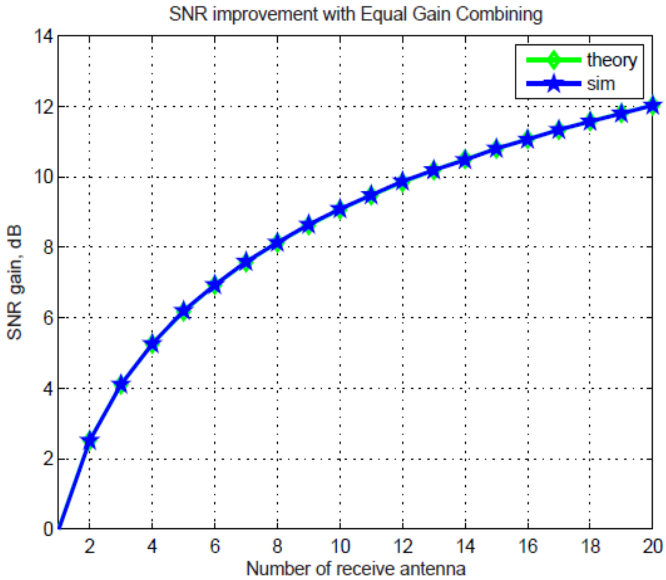


**Fig: 7 SNR for different number of receive antenna using equal gain combining diversity of space time trellis coding**

## V. CONCLUSIONS

In this paper, we use the maximal ratio combining (MRC) diversity and equal gain combining (EGC) diversity to evaluate the performance of space time trellis coding (STTC). Simulation result shows that the bit error rate versus EbNo is presented in presence of the maximal ratio combining diversity and equal gain combining diversity in Rayleigh channel. The result reveals that the wireless communication system has better performance when space time trellis coding (STTC) technique is used for receive diversity.

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