ISSN No. 0976-5697

Volume 5, No. 5, May-June 2014

International Journal of Advanced Research in Computer Science

RESEARCH PAPER

Available Online at www.ijarcs.info

# Performance Comparison of SER and SNR using different states of PSK in presence of various noises

Amit J. Dhamangaonkar
Department of Electronics & Communication Engineering
Rukmani Devi Institute of Technology & Science
Bhopal, India

Vinay Gupta
Department of Electronics & Communication Engineering
Rukmani Devi Institute of Technology & Science
Bhopal, India

Rajneesh Kumar Karn
Professor, Electrical Engineering
Radharaman Institute of Technology & Science
Bhopal, India

*Abstract*: To enhance the data rates of next generation wireless communication operating in frequency selective fading environments, the combination of orthogonal frequency division multiplexing (OFDM) and multiple input multiple output (MIMO) is proved to produce improved results. To analyze this combination, various changes in baseband signal processing are required which includes time and frequency synchronization, channel estimation and diversity gain. In this paper, a noise interference reduction technique for the improvement of high data rate in traditional space time coding technique (STTC) has been proposed. These codes generate the points of the constellation with the same probability. Therefore, the systematic search for good codes can be reduced to in this class. Finally, the performance of proposed techniques 2-state, 4-state and 16-state codes is evaluated by simulation and described by the Symbol Error Rate (SER) over fast Rayleigh fading channels with AWGN floor. Reduced noise based estimation schemes are widely favored as their implementation is relatively simple and most current wireless standards already provide for their use. Training sequences for multiple transmit antennas require properties of zero (or very low) cross correlation between sequences transmitted from different transmit antennas.

***Keywords:*** STTC; Symbol Error Rate; Signal to Noise Ratio; Orthogonal frequency division multiplexing.

## I. INTRODUCTION

In the past, the communication systems like telephony and telegraphy etc, were all analog and use electrical wires. They are hence the examples of wired communication system. With further development, the focus shifted towards digitization of the communication system. A major breakthrough in this field with the advent of the wireless technology is due to the invention of radio system. Since then, wireless technology has evolved at a fast pace and hence revolutionized the field of wireless communication system. The explosive growth of wireless communications is creating the demand for high-speed, reliable, and spectrally efficient communication over the wireless medium. There are several challenges in attempts to provide high-quality service in this dynamic environment. These pertain to channel time-variation and the limited spectral bandwidth available for transmission. Various domestic and foreign researchers have presented a lot of work in this field to enhance the data rates.

T. M. Hien et al [1] proposed 4-PSK Balanced STTC with two transmit antennas which deals with the field of STTC modulated PSK signal with two transmit antennas. T. M. Hien et al [2] extended his work with a new class of balanced 4-PSK STTC for two and three transmit antennas. T. Nakagawa et al [3] deals with STTC multiple input-multiple output-OFDM and is concerned with 64-state 16-QAM space-time trellis code (STTC), which uses two transmitting antennas and applied to a 2x2 MIMO-OFDM system for outdoor mobile transmission in the 800-MHz band. N. Kumaratharan et al [4] has given site diversity technique for MC-CDMA by using STTC coded signal as the combination of multiple antennas and multicarrier code division multiple access (MC-CDMA) is a strong candidate for the downlink of future mobile communications.

Kabir Ashraf, Noor M Khan et al [5] provided comparison of performance of Alamouti ST Codes with different STTC over Rayleigh Fading Channels. This paper deals with different STTC based Almouti ST over Rayleigh fading channel and demonstrates the performance comparison of Alamouti space-time codes with different Space-Time Trellis Codes (STTC) codes in the Rayleigh fading channel environment.

Yi Gong and K**.** B. Letaief et al [6] presented the advantages of STTC over Nakagami fading channel as Space-time trellis codes and proposed an efficient method to provide both transmit diversity and coding gains for high-data-rate wireless communications.

Jinho Choi et al [7] deals with antenna diversity as the author demonstrated the transmit antenna diversity (TAD) for the downlink channel to improve the performance of wireless communications using multiple transmit antennas. Ashutosh Sharma, Poonam Sinha et al [8] has given detailed analysis of STTC over Nakagami and Rayleigh fading as authors are concerned to analyze the performance of STTC codes in both Rayleigh and Nakagami fading channel model and compare the performance of STTC codes for both Rayleigh and Nakagami fading channel environment.

Vahid Fotohabady, Fatin et al [9] presented with MIMO multicarrier system for Nakagami and Rayleigh fading channel model as the combination of orthogonal frequency division multiplexing (OFDM) signal processing and multiple-input multiple-output (MIMO) is regarded as a promising solution for enhancing the data rates of next-generation wireless communication systems operating in frequency- selective fading environment.

Neetu Sood, Ajay K Sharma & Moin Uddinet al [10] demonstrated the performance of OFDM-BPSK and QPSK based system with and without channel estimation over Nakagami fading channels.

In this paper, minimization of symbol error rate (SER) on the consideration of signal to noise ratio (SNR) with the multiple set of STTC has been considered. And author has evaluated the performance of STTC in two different modes i.e. AWGN (Additive white Gaussian noise) and ZF (Zero forcing). In AWGN the bit error rate generally increases so in this work, author has minimized the AWGN noise with transmitted code and load variance of space time code in respect of channel gain.

## II. SPACE TIME TRELLIS CODE

In order to provide high data rate transmission while efficiently combating fading effects, various techniques such as adaptive antennas and space-time processing have been studied. There have been a number of proposals that use multiple antennas at the transmitter side with appropriate signal processing and offer antenna space diversity for the downlink. Among them, space-time trellis coding is an attractive and promising solution, which achieves bandwidth efficient transmit diversity by using specially designed channels codes at the transmitter end in combination with some additional signal processing at the receiver [6].

Space Time Trellis Coded Modulation (STTCM) is obtained by combining channel coding with the Multiple Input Multiple Output (MIMO) concept to improve the data rate and the reliability of wireless communications. Many performance criteria have been established to maximize both diversity and coding gain of STTC. The rank and determinant criteria for slow fading channels and the Euclidian distance and the product distance criteria for fast fading channels [2][1]. Convolution encoders with the same structure but with different weighting coefficients are assigned to transmitting multiple branches in STTC. The state transitions of the encoders are therefore the same, but their outputs differ, according to the past inputs. A maximum-likelihood series estimator (i.e., a Viterbi decoder) can be applied at the receiving side.

We consider the case of $2^n$-PSK space-time trellis encoder as shown on Figure 1.

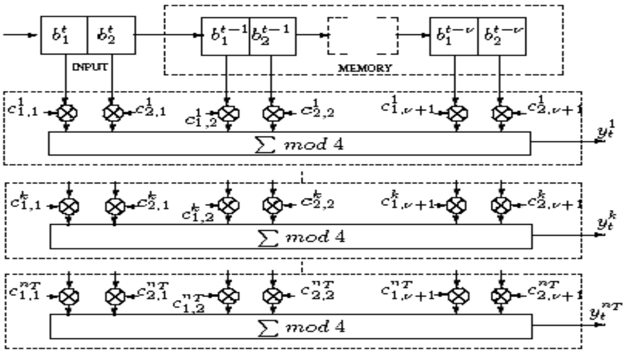

Figure 1: ST trellis encoder with 4-PSK and $n_T$ Transmit antennas

This encoder is composed of one input block of $n$ bits and $v$ memory blocks of $n$ bits. At each time $t$, all the bits of a block are replaced by the $n$ bits of the previous block. The $i^{th}$ bit $b^{t-j+1}$ $i$, $i = 1. .... . n$, of the $j^{th}$ block, $j = 1. \ldots . v + 1$, is associated to $n_T$ multiplier coefficients $c^k{}_{i,j}$, $k = 1. \ldots . n_T$, where $n_T$ is the number of transmit antennas. A ST trellis encoder is thus classically defined by its generator matrix **C** of $n_T \times n(v + 1)$ coefficients

$$C = \begin{bmatrix} c_{1,1}^1 & c_{n,1}^1 \ldots\ldots\ldots & c_{n,v+1}^1 \\ c_{1,1}^k & c_{n,1}^k \ldots\ldots\ldots & c_{n,v+1}^k \\ \vdots & \vdots & \vdots \\ c_{1,1}^{nT} & c_{n,1}^{nT} \ldots\ldots\ldots. & c_{n,v+1}^{nT} \end{bmatrix}$$

The encoder outputs for the $k^{th}$ antenna are computed as [11][12]

$$y_t^k = \sum_{i=1}^{n} \sum_{j=1}^{v+1} b_t^{t-j+1} c_{i,j}^k \quad \text{mod } 2^n \qquad \ldots..1\text{ a}$$

When diversity gain is small, the rank and determinant criteria will determine the performance. When the diversity gain is large (with more number of antennas), the Euclidean distance criterion will determine the performance of STTC in terms of BER [4]

The encoder outputs for the $k^{th}$ antenna are computed as [11][12]

The encoder outputs for the $k^{th}$ antenna are computed as [11][12]

$$y_t^k = \sum_{i=1}^{n} \sum_{j=1}^{v+1} b_t^{t-j+1} c_{i,j}^k \quad \text{mod } 2^n \qquad \ldots..1\text{ a}$$

When diversity gain is small, the rank and determinant criteria will determine the performance. When the diversity gain is large (with more number of antennas), the Euclidean distance criterion will determine the performance of STTC in terms of BER [4]

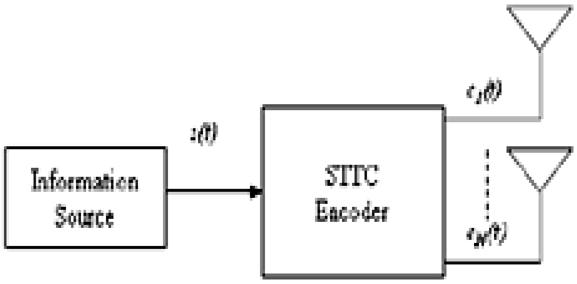

Figure 2: STTC Encoder

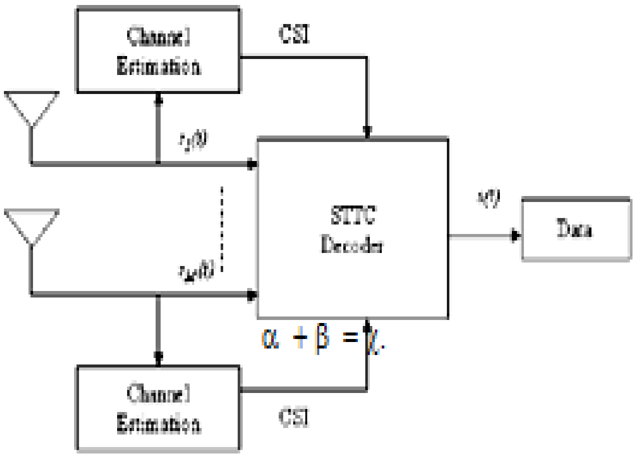

Figure 3: STTC Receiver

A typical S'TTC based wireless system has an encoder, pulse shaper, modulator and multiple transmit antennas at the transmitter, and the receiver has one or more receive antennas, demodulator, channel estimator and STTC decoder. We consider a mobile communication system with $n_T$ transmit antennas and $n_R$ receive antennas. The space-time trellis encoder encodes the data *s*(*t*) coming from the information source and the encoded data is divided into $n_T$ streams of data.

$C_T^1 \;\; C_T^2 \ldots\ldots\ldots\ldots C_T^{Nt}$

Each of these streams of data passes through a pulse shaper before being modulated. The output of modulator *i* at time slot *t* is the signal $C_T^T$, which is transmitted through transmit antenna *i*. Here $n_T$ $1 \leq i \leq n_T$. The transmitted symbols have energy $E_T$. We assume that the $n_T$ signals are transmitted simultaneously from the antennas. The signals have transmission period *T*. In the receiver, each antenna receives a superposition of $n_T$ transmitted signals corrupted by noise and multipath fading. Let the complex channel coefficient between transmit antenna i and receive antenna j have a value of $h_{ij}(t)$ at time *t*, where $1 \leq i \leq n_R$. The received signal at antenna j, j=1,2,......., $n_R$ is

$$r_t = \sqrt{E_s} \sum_{i=1}^{n} h_{i,j}(t) c_t^i(t) + n_t^j \qquad \ldots..1b$$

Where $\eta_t^j$ is additive white Gaussian noise (AWGN) at receive antenna ***j*****,** which has zero mean and power spectral density $N_0$ and, $h_{ij}(t)$ channel coefficient between transmit and receive antennas. Time, frequency and spatial diversity are the traditional strategies to combat multipath fading, which is a major obstacle to high data rates over mobile communication channels. STTCs are represented in a number of ways, such as the trellis form or generator matrix form most codes are presented in trellis form but for a systematic code search, the generator matrix form is preferable. The generator matrix representation is also used for convolution codes. However the generator matrix notation of space time trellis codes (STTC) is little different than that used for convolution codes. Two input bits enter the encoder every symbol period. The input streams are multiplied by the branch coefficients, which can be put into a matrix form.

Let the input symbol stream to the encoder is [2 3 2 1 0 1 ……..]. Initially the encoder is in state "0". Thus "0" will be transmitted from the first antenna, the second antenna transmits "2" and the encoder goes into state "2" In this way for this input symbol stream the output for the 4-PSK STTC is as follows:

Table 1 4-PSK 4-State STTC

| | **Output symbols** | | | |
|---|---|---|---|---|
| State | Input<br>0 | Input<br>1 | Input<br>2 | Input<br>3 |
| 0 | 00 | 01 | 02 | 03 |
| 1 | 10 | 11 | 12 | 13 |
| 2 | 20 | 21 | 22 | 23 |
| 3 | 30 | 31 | 32 | 33 |

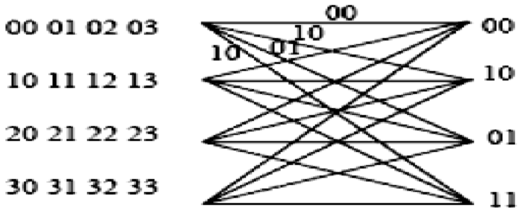

Figure 4: Trellis diagram

It is assumed that the STTC codeword is given by

$C=(C_1^1 C_1^2 .. C_1^{nt} C_2^1 C_2^2 .. C_2^n .. C_L^1 C_L^2 \ldots C_L^{nt}) \quad \ldots 1c$

Where *l* is the frame length. We consider a maximum likelihood receiver, which may possibly decide on an erroneous code word ***e*****,** given by

$e=(e_1^1 e_1^2 \ldots e_1^{nt} e_2^1 e_2^2 \ldots e_2^n \ldots e_L^1 e_L^2 \ldots e_L^{nt}) \quad .......1d$

We can write the difference code matrix, the difference between the erroneous codeword and the transmitted codeword as follows

$$B(c,e) = \begin{bmatrix} e_1^1 - c_1^1 & e_2^1 - c_2^1 & \ldots\ldots & e_L^1 - c_L^1 \\ e_1^2 - c_1^2 & e_2^2 - c_2^2 & \ldots\ldots & e_L^2 - c_L^2 \\ e_1^3 - c_1^3 & e_2^3 - c_2^3 & \ldots\ldots & e_L^3 - c_L^3 \\ \vdots & \vdots & & \vdots \\ e_1^{nt} - c_1^{nt} & e_2^{nt} - c_2^{nt} & \ldots\ldots & e_L^{nt} - c_L^{nt} \end{bmatrix}$$

Figure: 5

The difference matrix *B*(*c*, *e*) has dimension $n_t$ x *l*. we know that to achieve the maximum diversity order $n_T n_R$ ( $n_R$ receive antennas, $n_T$ transmit antennas) matrix *B*(*c*,*e*)must have full rank for all possible code words c and e . If *B*(*c*,*e*) has minimum rank r over the set of pairs of distinct code words then the diversity will be r $n_R$ [10].

## III. RESULTS AND DISCUSSIONS

The proposed noise reduction in balanced STTC for OFDM is simulated by using MATLAB 7.8.0. MATLAB is a strong mathematical tool which provides help to engineers to solve, model, simulate the problems and find solutions assuming environment in to mathematical equations. It is standard engineering tool as it perform many different tasks using different tool box relevant to different particular cases e.g. Control systems, signal processing, image processing, communication systems, and supports complex matrix manipulation, simulation etc. In different research field it provides platform for learning and comparison of theoretical hypothesis and simulated values. It even provides support to nonlinear system calculations and result.

This section presents comparisons of the STTC based MIMO-OFDM systems developed in MATLAB. In the simulation process, the goal was to reach a symbol error rate (SER) of at least $10^{-5}$ to evaluate the performances of the systems. Therefore for each SNR at least 2,50,000 information bits were simulated for each system. One run of sending about 2,50,000 bits for all SNR values is called a Monte Carlo run. The systems were simulated for a specified number of Monte Carlo runs and the results were averaged such that the SER curves were smooth enough for evaluation.

The results of this paper are based on M-ary PSK modulation technique over fast Rayleigh fading channel. We have simulated the proposed approach for 2-PSK (M = 2), 4-

PSK (M = 4), 16-PSK (M = 16) and the number of OFDM subcarriers are assumed to be 124. Moreover in our result we have considered that there is perfect channel state information (CSI) at both transmitter and receiver so that maximum diversity is confirmed. Fig 5. illustrates the noise reduction in balanced STTC for OFDM based Rayleigh channel with 2-PSK modulation scheme in terms of symbol error rate (SER) and signal to noise ratio (SNR) gain while Fig 6. and Fig 7. represent the evaluation of same codes but with 4-PSK and 16-PSK modulation schemes. We simulate the result with 2 transmit and 2 receive antennas and the decoding of the signal STTC codes are simulated by using three different decoding techniques, these are MMSE (minimum mean square error), ZF (zero forcing) and ML (maximum likelihood) using soft decision decoding with viterbi algorithm. Our result shows that out of these three decoding techniques the ML decoding using viterbi algorithm gives much better result than MMSE and ZF decoding. Moreover our result shows that the 16-PSK modulation scheme can reduce more noise than 2-PSK and 4-PSK for same codes having similar antennas and similar bit rate.

A brief view for various simulation parameters are listed in the following table:

Table 2: Various simulation parameters

| | |
|---|---|
| Modulation scheme | 2-PSK, 4-PSK, 16-PSK |
| Number of subcarrier for OFDM | 124 |
| Symbol length | 64 |
| Channel estimation | Perfect |
| Signal estimation | Correlated |
| Channel | Fast Rayleigh fading channel with AWGN floor |
| Decoding techniques | MMSE, ZF, Soft decision ML |

Table 3: Comparison of 4-PSK

| Previous Result [2] | | Our Result | |
|---|---|---|---|
| Error rate probability | Signal to noise ratio (SNR) in dB | Error rate probability | Signal to noise ratio (SNR) in dB |
| $10^{-1}$ | 10dB | $10^{-1}$ | 5 dB |
| $10^{-2}$ | 13dB | $10^{-2}$ | 15 dB |
| $10^{-3}$ | 13dB | $10^{-3}$ | 19 dB |
| $10^{-4}$ | 00dB | $10^{-4}$ | 22 dB |
| $10^{-5}$ | 00dB | $10^{-5}$ | 24 dB |

Figure 5 The relation of symbol error rate (SER) and SNR gain with 2- state PSK and conditions taken for decoding are MMSE and ZF and reduction of noise in transmission state

Table 4: Comparison of 16-PSK STTC

| Previous Result [2] | | Our Result | |
|---|---|---|---|
| Error rate probability | Signal to noise ratio (SNR) in dB | Error rate probability | Signal to noise ratio (SNR) in dB |
| $10^{-1}$ | 8 dB | $10^{-1}$ | 6 dB |
| $10^{-2}$ | 10dB | $10^{-2}$ | 16.5 dB |
| $10^{-3}$ | 11.8 dB | $10^{-3}$ | 21dB |
| $10^{-4}$ | 00 dB | $10^{-4}$ | 24 dB |
| $10^{-5}$ | 00 dB | $10^{-5}$ | 25 dB |

Table 5: Comparison of 16-PSK STTC

| Previous Result [2] | | Our Result | |
|---|---|---|---|
| Error rate probability | Signal to noise ratio (SNR) in dB | Error rate probability | Signal to noise ratio (SNR) in dB |
| $10^{-1}$ | 8 dB | $10^{-1}$ | 6 dB |
| $10^{-2}$ | 10dB | $10^{-2}$ | 16.5 dB |
| $10^{-3}$ | 12 dB | $10^{-3}$ | 21dB |
| $10^{-4}$ | 13 dB | $10^{-4}$ | 24 dB |
| $10^{-5}$ | 00 dB | $10^{-5}$ | 25 dB |

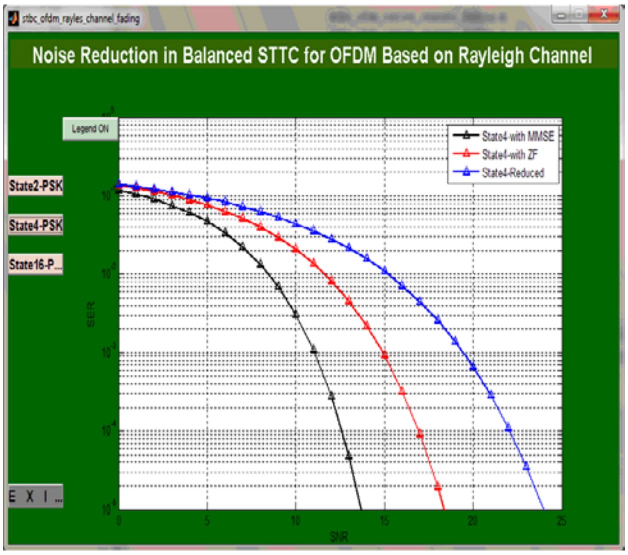

Figure: 6

Figure 6 The relation of symbol error rate (SER) and SNR gain with 4- state PSK and conditions taken for decoding are MMSE and ZF and reduction of noise in transmission state

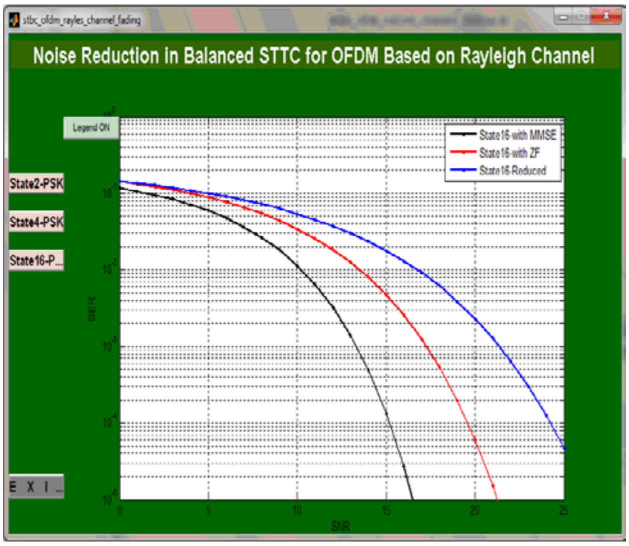

Figure: 7

Figure 7 The relation of symbol error (SER) rate and SNR gain with 16- state PSK and conditions taken for decoding are MMSE and ZF and reduction of noise in transmission state Results for the proposed noise reduction in balanced STTC of OFDM based on Rayleigh fading shows that the proposed method gives better performance as compared to the various existing schemes [2][1]. Our result shows that there is a significant improvement in performance in terms of error rate probability with respect to SNR gain. The comparison is based on 4-state and 16-state PSK modulation scheme. Our simulation demonstrates that there is a increase in SNR gain over less corrupted symbols which is considered to be satisfactory in performance as compared to [2][1].

The following are the comparison values of error rate probabilities versus SNR gain that are count in proposed scheme and in [2][1] for various 4-state and 16-state PSK modulation scheme.

## IV. CONCLUSION

In this paper a noise interference reduction technique for the improvement of high data rate in traditional space time coding technique (STTC) has been proposed which is a new technique of 2-PSK, 4-PSK, 16-PSK balanced STTC for multiple transmit antennas. These codes generate the points of the constellation with the same probability. Therefore, the systematic search for good codes can be reduced to this class. A method to design the balanced codes has been described here. Finally, the performance of all these 2-state, 4-state and 16-state codes is evaluated by simulation and described by the Symbol Error Rate (SER) over fast Rayleigh fading channels with AWGN floor.

Reduced noise based estimation schemes are widely favored as their implementation is relatively simple and most current wireless standards already provide for their use. Training sequences for multiple transmit antennas require properties of zero (or very low) cross correlation between sequences transmitted from different transmit antennas.

## V. REFERENCES

[1]. T M Hien Ngo, Gheorghe Zaharia, St´ephane Bougeard, Jean Franc¸ois H´elard, “A new class of balanced 4-PSK STTC for two and three transmit antennas”, IEEE July 2007.

[2]. T M Hien Ngo, Gheorghe Zaharia, St´ephane Bougeard, Jean Franc¸ois H´elard, “4-PSK Balanced STTC with two transmit antennas”, IEEE transaction on wireless communication, pp. 1693-1697, 2007

[3]. T Nakagawa, Kazuhiko Mitsuyama, Kohei Kambara, and Tetsuomi Ikeda, “Performance of a 2x2 STTC-MIMO-OFDM in 800-MHz-band Urban Mobile environment”, IEEE International Conference on Advanced Technologies for Communications, pp. 300-303, 2009.

[4]. N.Kumaratharan, S.Jayapriya and P.Dananjayan, “STTC based STBC Site Diversity technique for MC-CDMA system”, IEEE Second International conference on Computing, Communication and Networking Technologies, 2010.

[5]. Kabir Ashraf, Noor M Khan, “Performance Comparison of Alamouti ST Codes with different STTC over Rayleigh Fading Channels”, 26th International Review of Progress in Applied Computational Electromagnetics (ACES), September. 2009, California, USA.

[6]. Yi Gong and K. B. Letaief “Performance of Space-Time Trellis Coding over Nakagami Fading Channels” IEEE Vehicular. Tech. Co & pp. 1405-1409, Spring 2001.

[7]. Jinho Choi “Performance Analysis for Transmit Antenna Diversity With/Without Channel Information”, IEEE transaction on vehicular technology, Vol. 51. No.1, pp. 101- 113, January 2002.

[8]. Ashutosh Sharma, Poonam Sinha, “Performance Analysis of Space Time Trellis Codes Over Nakagami Fading & Rayleigh Fading Channels: With Comparative analysis”, International Journal of Computer Applications, Volume 7–No.7, October 2010.

[9]. Vahid Fotohabady, Fatin Said, “Comparison of the Rayleigh and Nakagami Fading Channels MIMO Multicarrier System” IEEE transaction on wireless communication, pp. 295-300, 2011.

[10]. Neetu Sood, Ajay K Sharma & Moin Uddin, “On Channel Estimation of OFDM BPSK and -QPSK over Nakagami-m Fading Channels”, Signal Processing: An International Journal (SPIJ), Volume. 4, No. 4, pp. 239-246.

[11]. Upena Dalal. “Wireless communication, New Delhi,” First edition Oxford university press 2009.

[12]. Scalar B., “Digital Communication, Fundamentals and Applications” Second Edition, Pearson Education, 2001.

[13]. Trenter W. H. , Shanmugan S. S., Rapaport T. S., Kosbar K. L., “Principles of Communication System Simulation with Wireless Applications”, First Ed., Pearson Education, 2004

[14]. John G. Proakis and Masoud Salehi “ Digital communications”, Fifth edition Mcgraw- hill international edition 2008.

[15]. Taub & schilling “Principles of communication system”, second edition, Tata Mcgraw-hill edition, 2005.

[16]. Simon Haykins “Communication system”, fourth edition, wiley student edition, john wiley and sons Inc, 2004.