PERFORMANCE OF SPACE TIME BLOCK CODE OVER MIMO CHANNEL

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ABSTRACT

In wireless transmission, diversity techniques are used to mitigate degradation in the error performance due to the multipath fading. To improve the signal to noise ratio, with space diversity, multiple input multiple output (MIMO) is used at the emitter and receptor. This research paper is about of MIMO transmission with space-time block code with Matlab simulation.

Keyword: *antenna, SNR, STTC, MIMO, STBC*

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1. INTRODUCTION

In wireless transmission, space diversity, is the most technology in which multiple antennas are used in both the transmission and reception. Diversity gain can also be achieved by space-time coding (STC) at the transmit side, which requires only simple linear processing in the receiver side. Space Time Bloc Code is the famous Space Time Coding family with low complexity. At the receiver, all signals can be recombined to improve transmission by high signal to noise ratio. This article is about, performance of the space-time bloc code [1].

2. MIMO TRANSMISSION

The MIMO channel with N_T transmitter antenna and N_R receiver is defined as matrix H of dimension N_T x N_R expressed as [1]:

$$\boldsymbol{H} = \begin{pmatrix} h_{11} & h_{12} & \cdots & h_{1N_T} \\ h_{21} & h_{22} & h_{23} & \vdots \\ \vdots & \vdots & \ddots & \vdots \\ h_{N_R 1} & h_{N_R 2} & \cdots & h_{N_R N_T} \end{pmatrix} \quad (1)$$

Where h_{kl} with $1 \leq k \leq N_R$; $1 \leq l \leq N_T$ represents the complex gain of the link between the $l^{\text{-th}}$ transmitting antenna to the $k^{\text{-th}}$ receiving antenna.

The input-output relationship over *H* as expressed as:

$$Y = HX + B \quad (2)$$

Where, *X* is the signal vector for the transmit side, *Y* for the receive side and B is the noise.

2.1 Transmitter antenna technology

There are many methods to transmit signals from different emitter antennas. These methods can, be classified into two groups as, spatial multiplexing and space-time coding technology.

- **Spatial multiplexing**

This is a multiplexing technique in which several independent data streams are multiplexed on each antenna at the same time. This technique improves channel capacity significantly because more data is sent. For two transmitting antennas, the first bit may be transmitted on the first antenna while the second is on the second.

Each space stream should then have its own pair of transmit/receive antennas at each end of the radio link. Minimum number of reception or transmitter antennas limit the number of simultaneous transmissions [2].

- **Space times coding**

For space–time code, transmission is, over time and over space. They are used to improve the reliability of a wireless communication link by transmitting redundant information across time between the antennas. The aim is to increase the signal-to-noise ratio at reception through redundancy.

Space-time codes fall into one of two primary classes: space-time block code (STBC) and space-time trellis code (STTC).

STTCs are distinct from STBCs because STTCs have memory and the encoder’s output is a function of the current and previous blocks of data. Space-time trellis code fit in the category of convolutional codes. In general, STTC achieve better performance than STBC, at the expense of more complexity [3].

2.2 Receiver antenna technology

With spatial multiplexing, antenna number used at the receiver must be the same as antenna number in transmitter. At the receiver, Zero Forcing (ZF), Minimum Mean Square Error (MMSE) or Successive Interference Cancellation (SIC) are used.

For space-time coding, at the receiver, linear decoder with recombining technique are used if antenna number is great than one. There are more several recombining technic such as Maximal Ratio Combining (MRC), Equal Gain Combining (EGC), Selective Combining (SC) and Switch and Stay Combining (SSC) [4].

3. SPACE TIME BLOCK CODE

In space-time block code, the data stream is transmitted in blocks.

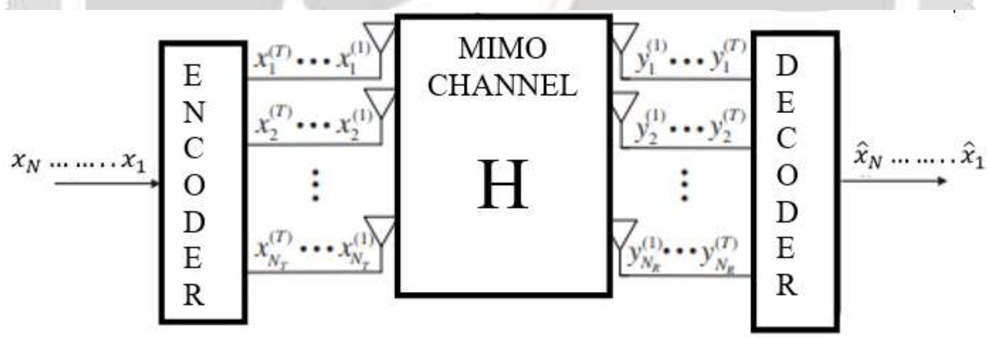

Fig -1: Space Times Coding

At the emitter, a symbol stream $\{x_i\}_{i=1}^{N}$ is encoded into $\left\{x_{i=1}^{(t)}\right\}_{i=1}^{N_T}$ and at the receiver, $\{\hat{x}_i\}_{i=1}^{N}$ is the estimated symbols by using the received signal $\left\{y_{i=1}^{(t)}\right\}_{i=1}^{N_T}$

With STBC, blocks of symbols are encoded over time and N_T antenna by space-time codeword matrix X expressed as [5]:

$$\boldsymbol{X} = \begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1p} \\ x_{21} & x_{22} & \cdots & \vdots \\ \vdots & \vdots & \ddots & \vdots \\ x_{j1} & x_{j2} & \cdots & x_{jp} \end{pmatrix}; 1 \le k \le p;\ 1 \le j \le N_T \quad (03)$$

Matrix X is a complex-orthogonal matrix.

The rate of an STBC encoder is defined as [1]:

$$R = n/T \quad (04)$$

Where, n is the number of independent symbols transmitted during each STBC codeword and T is time duration.

For, the most popular STBC called Alamouti code, at a given symbol period, two symbols from the modulator are transmitted by two antennas [6].

The space-time matrix X is defined by:

$$\boldsymbol{X} = \begin{pmatrix} x_1 & -x_2^* \\ x_2 & x_1^* \end{pmatrix} \tag{05}$$

At the receiver, the received signal is defined as:

$$[y_1 \quad y_2] = [h_1 \quad h_2]\begin{bmatrix} x_1 & -x_2^* \\ x_2 & x_1^* \end{bmatrix} + [z_1 \quad z_2] \tag{06}$$

Where $[h_1\ h_2]$ is the channel matrix.

$$\begin{bmatrix} y_1 \\ y_2^* \end{bmatrix} = \begin{bmatrix} h_1 & h_2 \\ h_2^* & -h_1^* \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} z_1 \\ z_2^* \end{bmatrix} \tag{07}$$

The decoding of STBC requires knowledge of the channel. Multiplying both sides of Equation (06) by the Hermitian transpose of the channel matrix H, decoding signal is expressed as:

$$\begin{bmatrix} h_1^* & h_2 \\ h_2^* & -h_1 \end{bmatrix}\begin{bmatrix} y_1 \\ y_2^* \end{bmatrix} = \begin{bmatrix} h_1^* & h_2 \\ h_2^* & -h_1 \end{bmatrix}\begin{bmatrix} h_1 & h_2 \\ h_2^* & -h_1^* \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} h_1^* & h_2 \\ h_2^* & -h_1^* \end{bmatrix}\begin{bmatrix} z_1 \\ z_2^* \end{bmatrix} \tag{08}$$

$$\begin{bmatrix} \tilde{y}_1 \\ \tilde{y}_2 \end{bmatrix} = (|h_1|^2 + |h_2|^2)\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} \tilde{z}_1 \\ \tilde{z}_2 \end{bmatrix} \tag{09}$$

6. SIMULATION

During simulation with MATLAB, all proprieties of MIMO STBC transmission are defined by:

Simulation 1

- Phase Shift Keying Modulation : 8-PSK
- Rate STBC : 3/4
- $N_T = 3$ and $N_R = 1$
- Signal to noise ratio : 5 dB, 10 dB, 15 dB and 20 dB

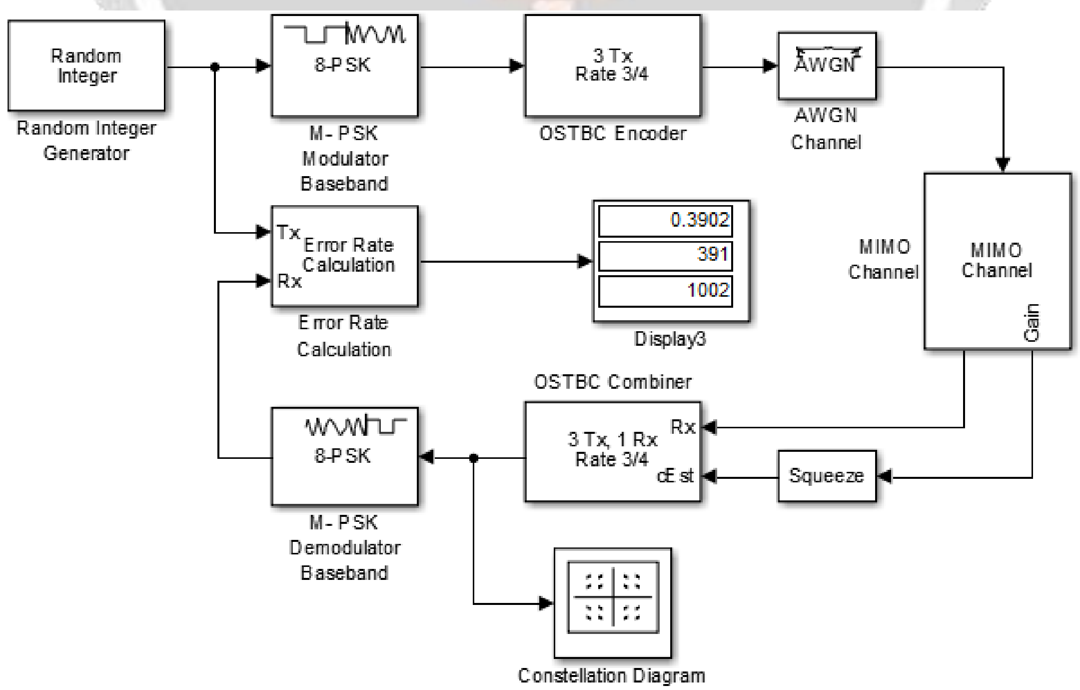

Fig -2: 8-PSK with STBC, $N_T = 3$, $N_R = 1$

Simulation 2

Phase Shift Keying Modulation : 8-PSK

- Rate STBC : 3/4
- $N_T = N_R = 3$
- Signal to noise ratio(SNR): 5 dB, 10 dB, 15 dB and 20 dB

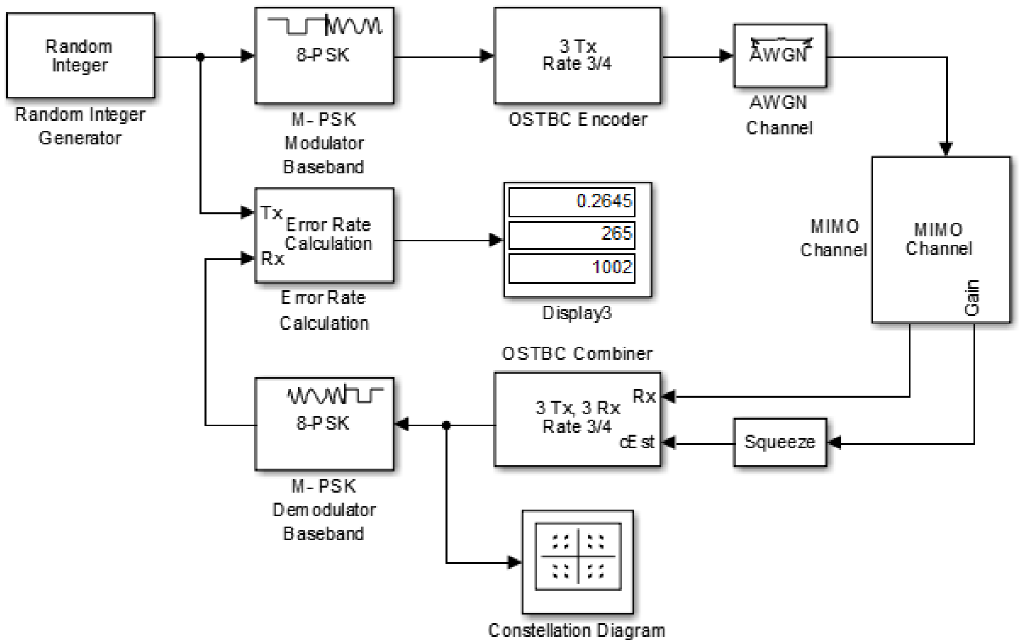

Fig -3: 8-PSK with STBC, N_T = 3, N_R =3

Simulation 2

Phase Shift Keying Modulation : 8-PSK

- Rate STBC : 1/2
- $N_T = 3$, $N_R = 1$
- Signal to noise ratio (SNR) : 5 dB, 10 dB, 15 dB and 20 dB

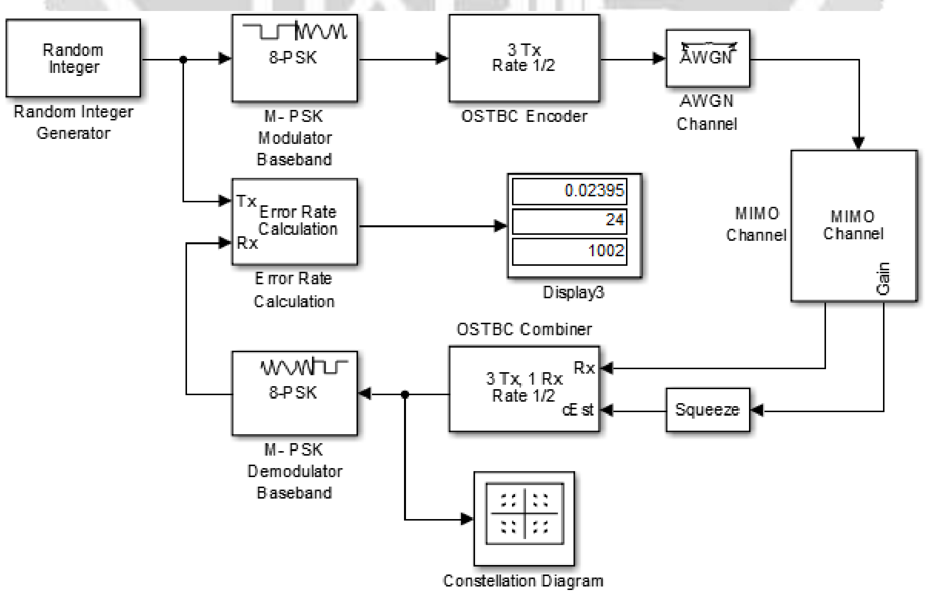

Fig -4: 8-PSK with STBC, N_T = 3, N_R =1 and rate = 1/2

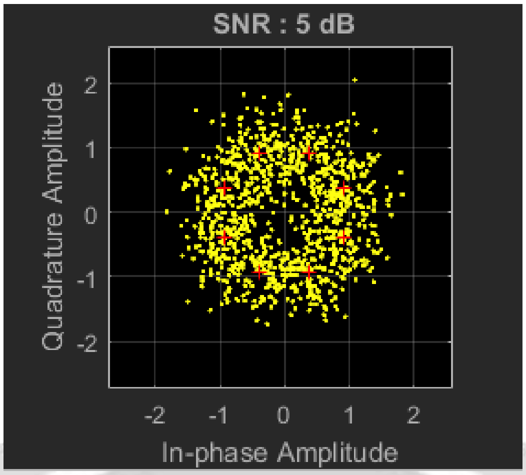

Fig -5: STBC transmission with SNR = 5 dB, N_T = 3 and N_R =3

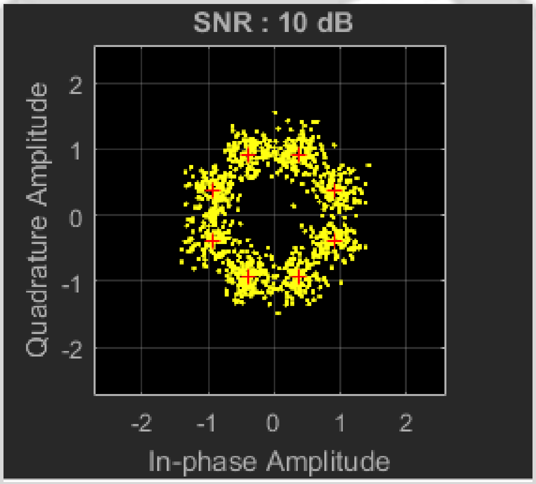

Fig -6: STBC transmission with SNR = 10 dB, N_T = 3 and N_R =3

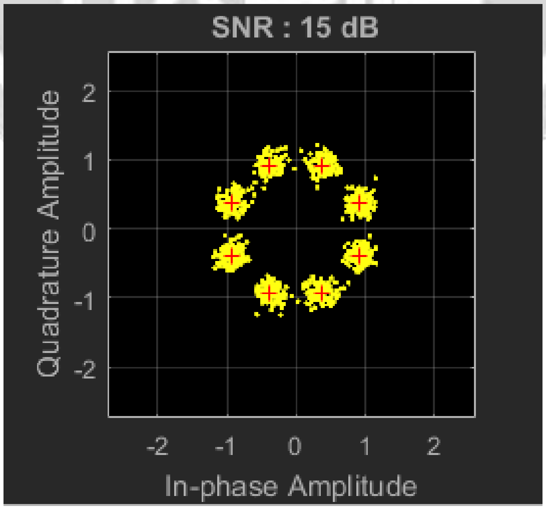

Fig -7: STBC transmission with SNR = 15 dB, N_T = 3 and N_R =3

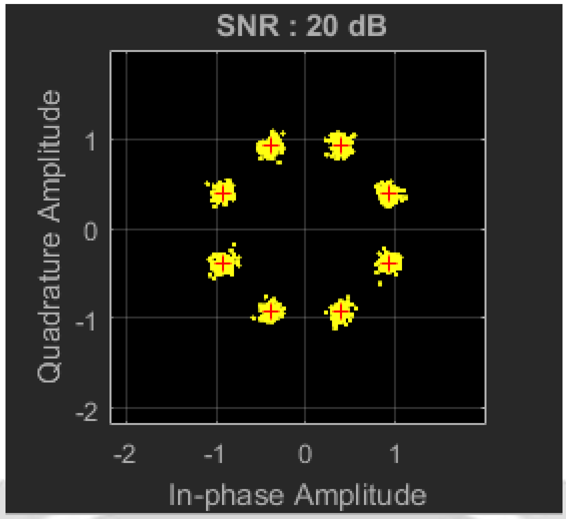

Fig -8: STBC transmission with SNR = 20 dB, N_T = 3 and N_R =3

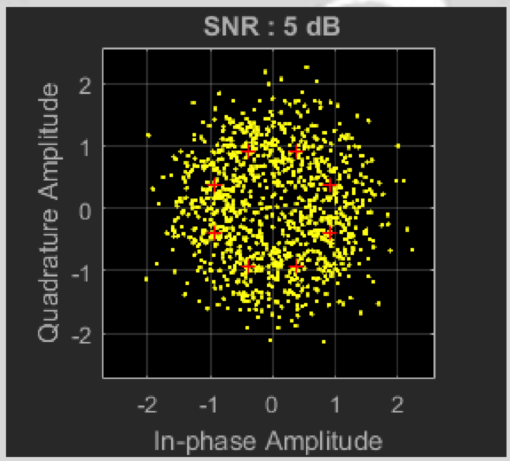

Fig -9: STBC transmission with SNR = 5 dB, N_T = 3 and N_R =1

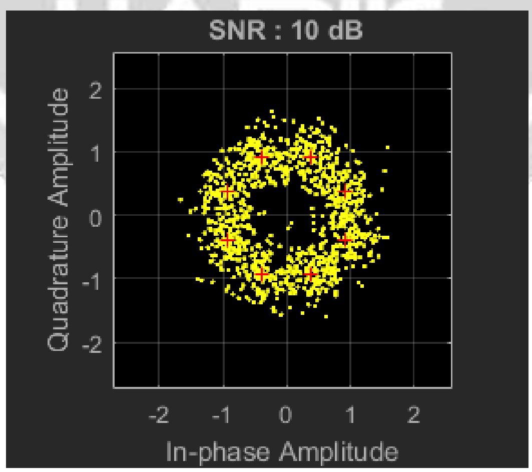

Fig -10: STBC transmission with SNR = 10 dB, N_T = 3 and N_R =1

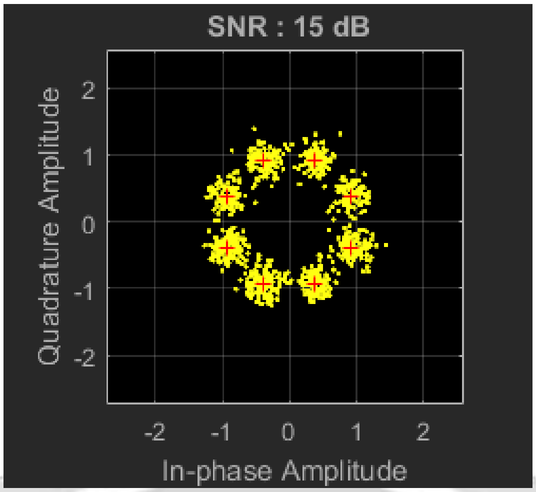

Fig -11: STBC transmission with SNR = 15 dB, N_T = 3 and N_R =1

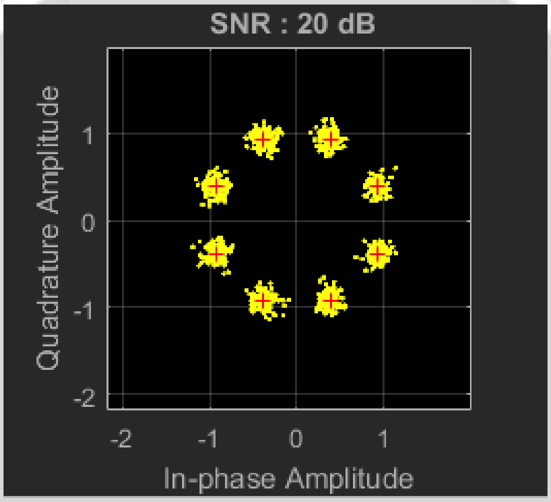

Fig -12: STBC transmission with SNR = 20 dB, N_T =3 and N_R =1

Table -1: Symbol Error Rate with N_R =1 or N_R = 3 and rate =3/4

SNR	5 dB	10 dB	15 dB	20 dB
N_R = 1	0.3902	0.1188	0,007984	0
N_R = 3	0,2555	0,06188	0	0

Table -2: Symbol Error Rate with rate =1/2

SNR	5 dB	10 dB	15 dB	20 dB
N_R = 1	0.48	0.2375	0,02395	0

7. RESULTS

With Fig -5, Fig -6, Fig -7, Fig -8, Fig -9, Fig -10, Fig -11 and Fig -12, transmission with Space-Time Block Code is efficient even for low signal-to-noise ratio values. With tabs -1 and -2, the transmission quality increases with the number of antennas at the receiver and depends on the value of the encoding rate.

8. CONCLUSION

Space diversity improves the quality of wireless transmission. For space-time block code, performance depends on the number of transmitting antennas and the encoder rate. At the receiver, the decoder consists of a linear processor. With the best recombination technology like Maximum Ratio Combining at the receiver, performance increases.

9. REFERENCES

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