DOI: 10.21917/ijct.2012.0071

PERFORMANCE ANALYSIS OF MIMO-SPACE TIME BLOCK CODING WITH DIFFERENT MODULATION TECHNIQUES

Shubhangi Chaudhary[1] and A.J. Patil[2]
[1]*Department of Electronics and Telecommunication, Cummins College of Engineering for Women, India*
Email: shubhangirc@yahoo.com
[2]*Department of Electronics and Telecommunication, Shri Gulabrao Deokar College of Engineering, India*
Email: anilj48@gmail.com

Abstract
MIMO Diversity is the technique which takes the advantage of multipath and mitigates the effect of fading and increases signal strength. Space Time Block code (STBC) is used in Multiple Input Multiple Output (MIMO) system to improve the performance by maximizing diversity gain. In this paper Math Works-SIMULINK platform is used for simulation. The performance of MIMO, Space Time Block Code (STBC) with different modulations, such as M-ary Phase Shift Keying (M-PSK), Binary phase shift modulation (BPSK), Quadrature phase shift modulation (QPSK), 8-PSK, and M-ary Quadrature Amplitude Modulation (M-QAM), 16-Quadrature Amplitude modulation (16-QAM) and 64-Quadrature Amplitude modulation (64QAM), 256-Quadrature Amplitude modulation (256-QAM) are studied on the basis of bit error rate (BER), signal-to-noise ratio (SNR) and error probability.

Keywords:
MIMO, STBC, Alamouti, OFDM, BER

1. INTRODUCTION

The goals of wireless communications are narrower bandwidth, lower power consumption, higher data rates, and error free data links. In wireless communication, there is a demand, not only for voice and data services, but also for multimedia services. Transmit diversity scheme employing Space-Time Block Code (STBC) helps to increase number of antennas. This scheme has been presented by Alamouti [1]. He also showed the possibility of implementing such a scheme for a 2x2 MIMO system and pointed to a generalization of 2xM MIMO system, where M is the number of receiving antennas. This scheme has been modified by Tarokh et. al. [2], [3] to increase order of diversity in Multiple Input Multiple Output (MIMO). Multiplexing schemes are more robust when SNR of received signal is high enough, while MIMO diversity scheme shows satisfactory performance at low SNR conditions [4]. MIMO diversity scheme provides higher reliability while MIMO multiplexing gives higher throughput. The STBC produces the best performance at low range to medium range of SNR whereas spatial multiplexing (SM) provides high throughput at high SNR [4]-[6], [8], [9].

The overall effects of multiple inputs multiple output system can be summarized in terms of reduction of the bit error rate increase in system capacity and more efficient use of the transmitted power.

Multiple Input Multiple Output Orthogonal Frequency Division Multiplexing (MIMO-OFDM) is widely used in several standards adopted worldwide. IEEE® 802.11, IEEE® 802.16 and HiperMAN are some examples. These standards are also known by their commercial designations: Wi-Fi, Imax, and HiperLAN, respectively.

This paper describes a wireless transmission using the concept of MIMO. MIMO using Space-Time Block Coding (STBC) technique has been used with different digital modulations, such as, M-PSK and M-QAM techniques. This technique is capable of providing spectrally efficient and flexible data rate access.

2. SPACE-TIME BLOCK CODING

Space-Time Block Coding (STBC) is based on the scheme presented by Alamouti [1]. This scheme provides transmit and receive diversity to MIMO system (Fig.1). This figure shows Maximal Ratio Receive Combining (MRRC) scheme. The scheme uses two transmit antennas and one receive antenna and may be defined by the following three functions:

- Encoding and deciding transmission sequence information Symbols at the transmitter
- Combining signals with noise at the receiver
- Maximum likelihood detection

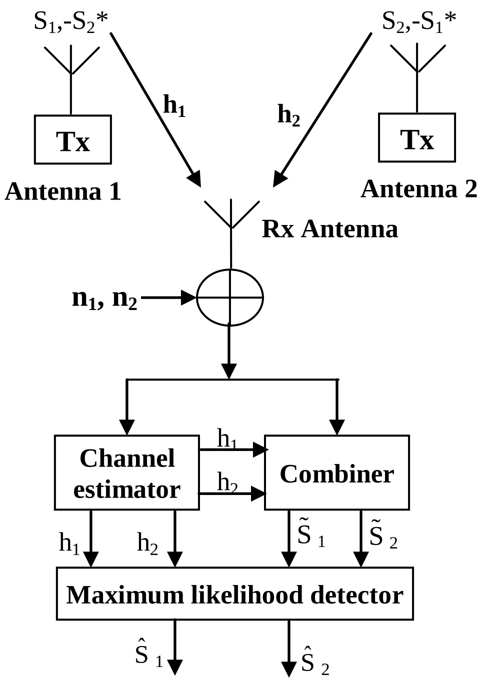
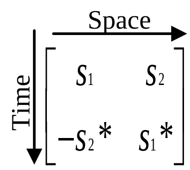


Fig.1. Almouti's Scheme

In Alamouti STBC, two different symbols are simultaneously transmitted from the two antennas during any symbol period. During the first time period, the first symbol in the sequence, S_1, is transmitted from the upper antenna 1 while the second symbol, S_2, is simultaneously transmitted from the lower antenna 2. During the next symbol time the signal $-S_2^*$ is transmitted from the upper antenna and the signal S_1^* is transmitted from lower antenna. This sequence is shown in Table.1.

Table.1. The encoding and transmission sequence for Alamouti STBC scheme

	Tx_1	Tx_2
Time t	S_1	S_2
Time t+T	$-S_2^*$	S_1^*



Transmission Matrix

The received signals can then be expressed as,

$$r_0 = r(t) = h_1 s_1 + h_2 s_2 + n_1 \quad (1)$$

$$r_1 = r(t + T) = - h_1 s_2^* + h_2 s1^* + n_2 \quad (2)$$

where, r_0 and r_1 are the received signals at time t and t + T and n_1 and n_2 are complex random variables representing receiver noise and interference. The combiner signals S_1 and S_2 are then sent to the maximum likelihood detector.

$$S_1 = h_1^* r_0 + h_2 r_1 \quad (3)$$

$$S_2 = h_2^* r_0 - h_1 r_1^* \quad (4)$$

The actual transmitted symbols, S_1 and S_2 are recovered at the receiver requires knowledge of the channel coefficients, h_1 & h_2. These channel coefficients are often estimated at the receiver.

3. SIMULATION

The model of MIMO is as shown in Fig.2. At first, the incoming data streams are modulated by using M-PSK and M-QAM digital modulation techniques. This signal is passed through Space-Time Block Coder (STBC). Now all the modulated streams travel through the channel and then first decoded by STBC decoder and then demodulated M-PSK and M-QAM digital demodulation to get the received signal.

3.1 TRANSMITTER

The data is generated from a random source, consists of a series of ones and zeros. The generated data is passed on to the next stage to the symbol mapping.

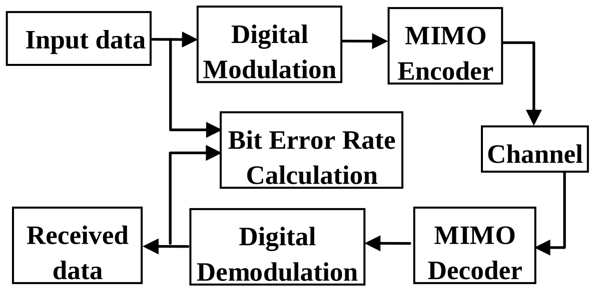


Fig.2. SIMULINK Simulation Model

3.1.1 Modulation:

The incoming data streams are modulated by using M-PSK and M-QAM digital modulation techniques [5], [8], [9]. In this an M message bits are encoded by transmitting a single pulse in one of 2M possible time-shifts. This is repeated every T seconds, such that the transmitted bit rate is M/T bits per second. There are six modulation techniques used for it that are Binary phase shift modulation (BPSK),Quadrature phase shift modulation (QPSK), 8-PSK, 16-Quadrature Amplitude modulation(16-QAM) and 64-Quadrature Amplitude modulation (64QAM), 256-Quadrature Amplitude modulation (256-QAM). The no. of points on constellation is related to the no. of QAM.

3.1.2 MIMO Encoder:

Space-Time Block Coding (STBC) based on Alamouti scheme [1] to provide transmit and receive diversity (Fig.1). In the transmission matrix S_1 and S_2 represents two consecutive OFDMA symbols. This signal is passed through Rayleigh multipath fading channels.

3.2 RECEIVER

3.2.1 MIMO Decoder:

In the STBC decoder received signals were combined by Maximal Ratio Combiner (MRC) and detected by Maximum-Likelihood (ML) detector.

3.2.2 Demodulation:

Demodulator converts the waveforms created at the modulation to the original transformed bits. The demodulator is used for decision rules with the goal of making a decision about which bit “zero” or “one”, was sent.

4. SIMULATION RESULTS

The simulations were performed using SIMULINK® R2010b from Math Works [7]. The result of STBC model for two digital modulation techniques namely M-PSK Fig.3 and M-QAM Fig.4 is tested with Simulink. The adaptive modulation techniques used in the STBC are BPSK, QPSK, 16-QAM, 64-QAM and 256-QAM respectively. Binary Phase Shift Keying (BPSK) is more power efficient and needs less bandwidth. On the other hand 64-Qadrature Amplitude Modulation (64-QAM) has higher bandwidth with very good output. Scatter plot is less noisy for digital modulation with STBC than without STBC as shown in Fig.7, Fig.8, Fig.9 and Fig.10. Thus BER is less for digital modulation with STBC than without STBC as shown in

Fig.11 and Fig.12. Throughput is more for M-QAM than M-PSK with STBC as shown in Fig.5 and Fig.6.

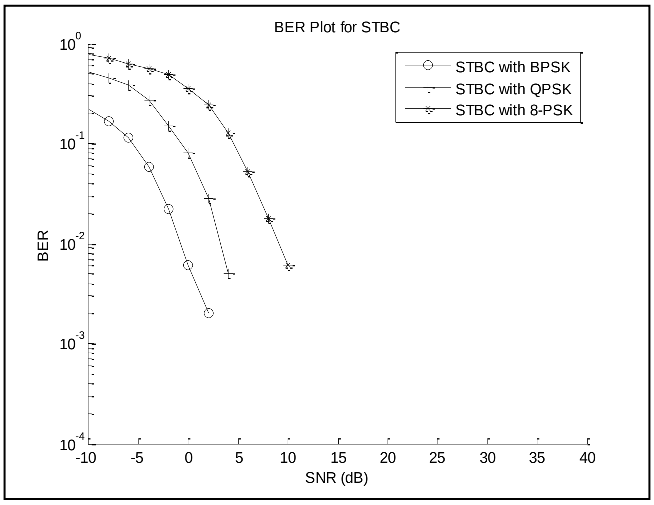


Fig.3. BER Plot for STBC with M-PSK

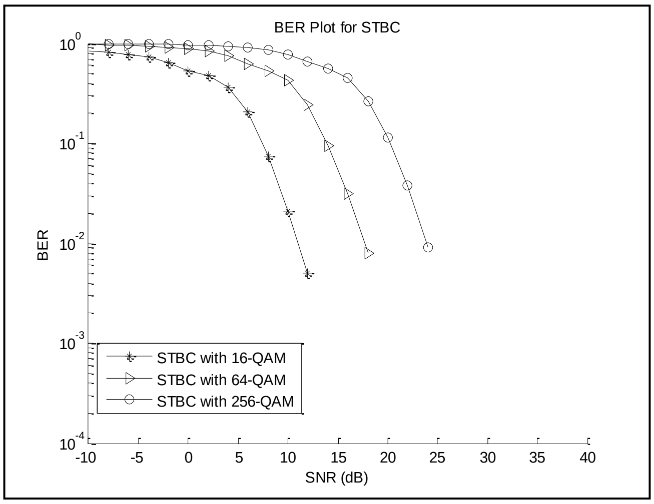


Fig.4. BER Plot for STBC with M-QAM

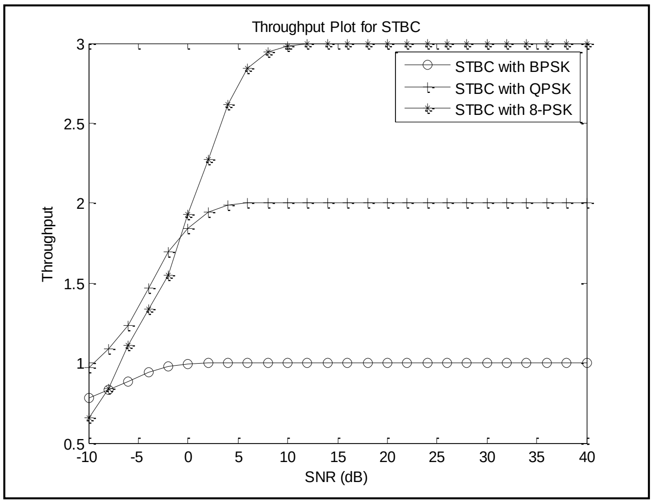


Fig.5. Throughput Plot for STBC with M-PSK

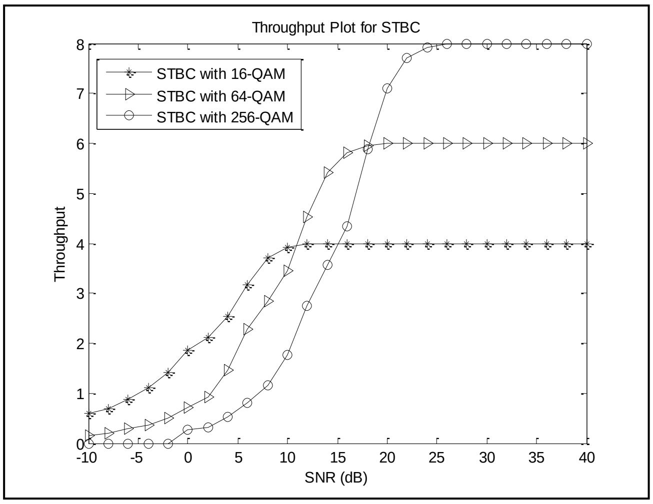


Fig.6. Throughput Plot for STBC with M-QAM

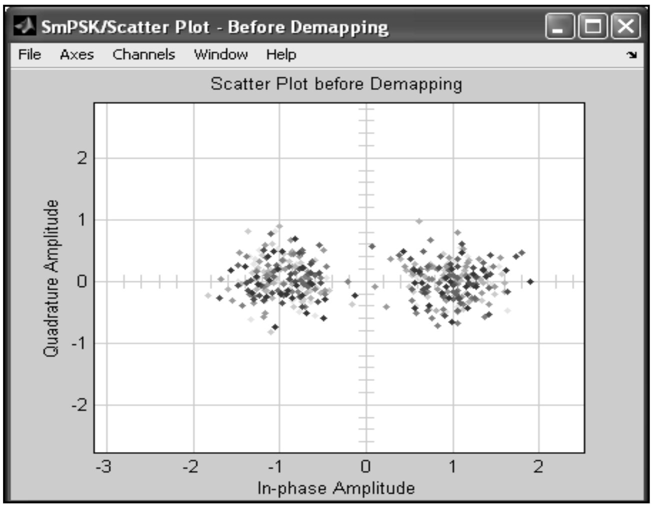


Fig.7. Scatter plot of BPSK without STBC for SNR = -1 dB

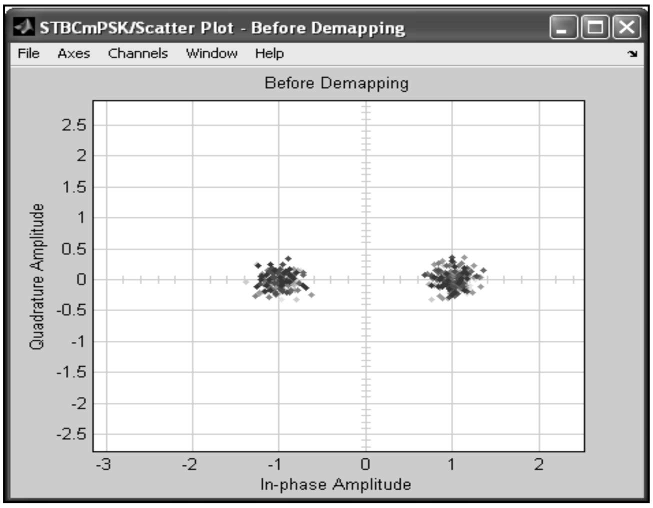


Fig.8. Scatter plot of BPSK with STBC for SNR = -1 dB

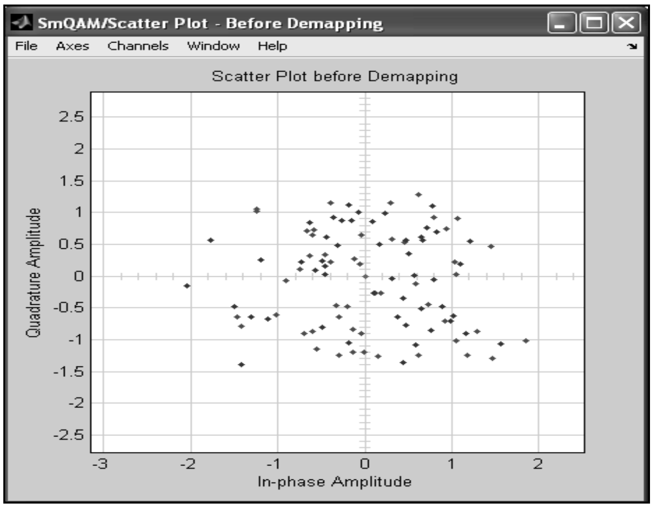


Fig.9. Scatter plot of 256-QAM without STBC for SNR = 24 dB

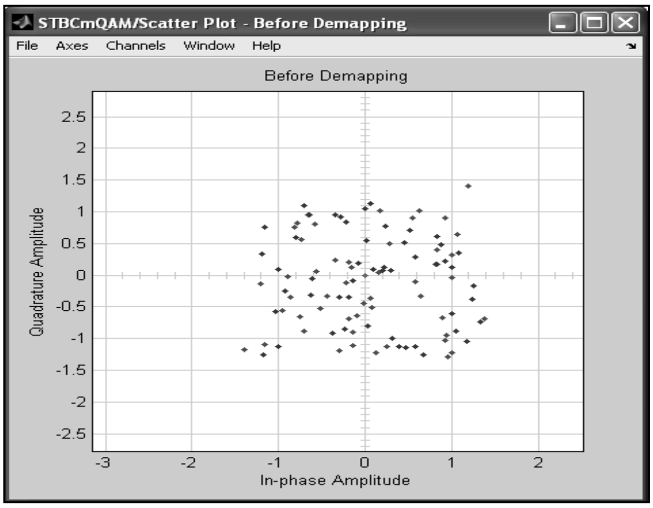


Fig.10. Scatter plot of 256-QAM with STBC for SNR = 24 dB

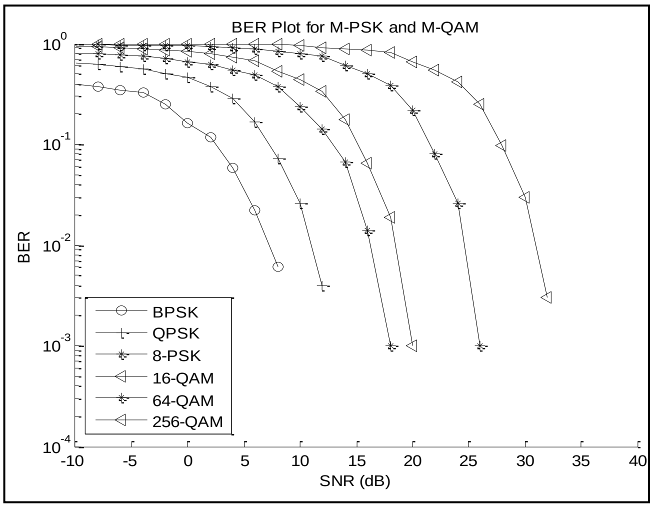


Fig.11. BER performance of Digital Modulation: M-PSK and M-QAM without STBC

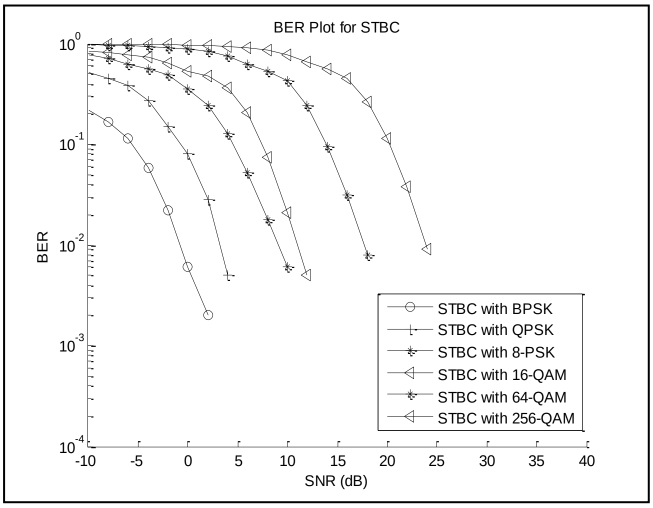


Fig.12. BER performance of STBC with Digital Modulation: M-PSK and M-QAM

Table.2. Comparison of SNR for with and without STBC under Modulation Technique

Digital Modulation	SNR for BER 10^{-2} without STBC	SNR for BER 10^{-2} with STBC
BPSK	~ 7.5 dB	~ (- 1) dB
QPSK	~ 11	~ 3
8PSK	~ 16	~ 9
16-QAM	~ 18.5	~ 11
64-QAM	~ 24.8	~ 17.5
256-QAM	~ 31	~ 24

5. CONCLUSION

Space-time block codes with lower modulation order always gave low bit-error-rate when compared with space-time block codes that employ higher order modulation methods.

The result shows that Bit Error Rate (BER) of STBC with 256-QAM is less for high SNR and BER with BPSK is less for low SNR. While the throughput of STBC with 256-QAM is more as compare to STBC with BPSK at higher SNR value.

Thus STBC with BPSK is more power efficient and need less bandwidth, but for near Base station STBC with higher modulation has higher bandwidth and more power.

Thus Space Time Block Code with digital modulation can be employed in multi antenna system to increase the reliability and throughput. This is the basic model for MIMO Research.

REFERENCES

[1] S.M. Alamouti, "A simple transmitter diversity technique for wireless communications", *IEEE Journal on Selected Areas Communication*, Vol. 16, No. 8, pp.1451–1458, 1998.

[2] V. Tarokh, N. Seshadri, and A.R. Calderbank, "Space-time codes for high data rate wireless communication: performance criterion and code construction", *IEEE*

Transactions on Information Theory, Vol. 44, No. 2, pp.744-765, 1998.

[3] V. Tarokh, H. Jafarkhani, and A.R. Calderbank, "Space-time block codes for orthogonal designs", *IEEE Transactions on Information Theory*, Vol. 45, No. 5, pp.1456-1467, 1999.

[4] A. Paulraj, R. Nabar and D. Gore, "*Introduction to Space-Time Wireless Communications*", Cambridge University Press, 2003.

[5] J.G. Andews, A. Ghosh and R. Muhamed, "*Fundamentals of WiMAX Understanding Broadband Wireless Networks*," Prentice Hall, 2007.

[6] R.W. Heath Jr. and A.J. Paulraj, "Switching Between Diversity and Multiplexing in MIMO Systems", *IEEE Transactions on Communications*, Vol. 53, No. 6, pp. 962-968, 2005.

[7] Simulink Getting Started Guide.

[8] http://www.mathworks.com/help/pdf_doc/simulink/sl_gs.pdf

[9] Arunabha Ghosh, David R. Wolter, Jeffrey G. Andrews and Runhua Chen "Broadband Wireless Access with WiMax/8O2.16: Current Performance Benchmarks and Future Potential", *IEEE Communication Magazine*, Vol. 43, No. 2, pp. 129-136, 2005.

[10] Chan-Byoung Chae, Antonio Forenza, Robert W. Heath, Matthew R. McKay and Iain B. Collings, "Adaptive MIMO Transmission Techniques for Broadband Wireless Communication Systems", *IEEE Communications Magazine*, Vol. 48, No. 5, pp. 112-118, 2010.