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Performance comparision of 2×1 and 2×2 Differential STBC and Implementation of DSTBC on Digital Video Broadcasting Sattelite

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Abstract— The demand for wireless communication systems with high data rates has dramatically increased in recent years. MIMO system at both the ends multiple Antennas are used is an efficient solution for future wireless communication system. STBC have been proposed by pioneering work of Altamonte's code. The Alamouti'scode provide full diversity and full data rate in case of two transmit antennas. DSTBC is used when perfect channel is not available at transmitter or receiver. DSTBC is a generalization of differential coding to multiple antenna system. DVB is the digital video broadcasting system used for terrestrial network. DVB-S is abbreviation of Digital video broadcasting for satellite network to overcome the bandwidth requirement and wireless communication. The coding scheme is RS code and convolution code.

Keywords— DSTBC-Differential Space Time Block Code, DVB-S- Digital Video Broadcasting Satellite, QPSK- Quadrature Phase Shift Keying, MPEG 2- Moving Picture Expert Group 2, FEC-Forward Error Control, QEC- Quasi Error Control.

I. INTRODUCTION

Differential space time block coding scheme is a natural generalization of differential coding idea to multiple antenna systems. When the situation arises as high mobility environment or when channel conditions channel rapidly, accurate channel estimation might be costly and complex .In this type of situation new STBC scheme known as Differential STBC is used. Based on differential modulation has been proposed by Taraokh and Jafarkhani. DSTBC can recover transmitted sequence without need of channel estimation. Two consecutive transmitted symbols are encoded in to phase differences and the receiver recovers the transmitted symbols by comparing their phase differences of currently received symbol and previously received symbol.

II. DIFFERENTIAL STBC SCHEME

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2.1 DSTBC Encoder

The block diagram of DSTBC encoder based on orthogonal design shown in below figure (4). For simple case there are two transmitting antennas and one receiving antenna. The transmitter Tx1 and Tx2 sending two symbols J_0 and J_1 respectively. These symbols are encoded according to Alamouti's model. At time t1, J0 and J1 are sent from transmitter 1 and transmitter 2 respectively. At time t2, J0 and J1are sent from antenna 1 and 2 respectively. The following data symboles are then encoded according to different data schemes.

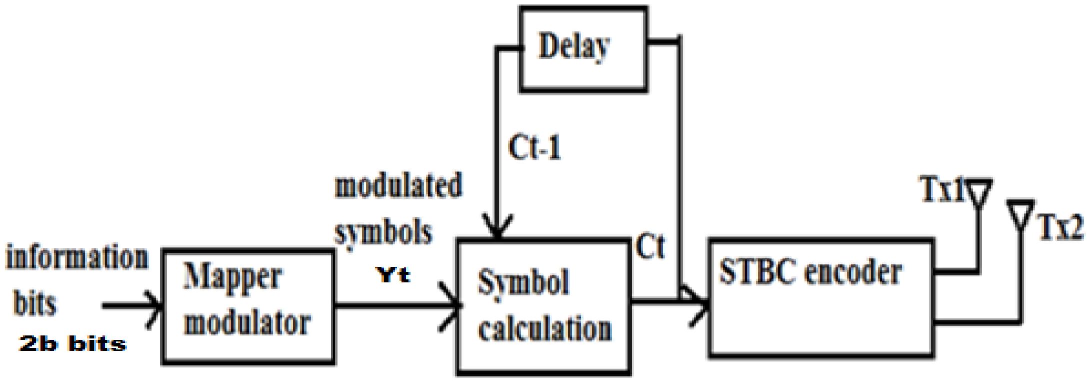

Figure 1 DSTBC Encoder

For any given constellation say A, there are 2^{2m} distinct coefficient vectors that corrospond to M^2 distinct signal vectors.

The magnitude of X_t must be unity. For BPSK modulation, the set U is the coefficient vector.

$$U = \{(1,0),(0,1),(0,-1),(-1,0)\}$$
(1)

The input to the STBC block would be,

$$(C_z) = \begin{pmatrix} C_1 \\ C_2 \end{pmatrix}$$
(2)

Both vectors are orthogonal to each other and coded data to be transmitted from individual antennas.

$$U_1(C_t) = \begin{pmatrix} C_1 \\ C_2 \end{pmatrix}$$
(3)

$$U_2(C_t) = \begin{pmatrix} c_2^* \\ -c_1^* \end{pmatrix}$$
(4)

Assume that C_{t-1} is transmitted for $(t-1)^{th}$ block. Calculation of C_t is given below.

$$C_t = y_1 U_1 C_{t-1} + y_2 U_2 C_{t-1}$$
(5)

2.2. DSTBC Decoder

This section provides the DSTBC decoding for two transmit antennas and one receives antenna. The received signals are R_1 nd R_2 as follows.

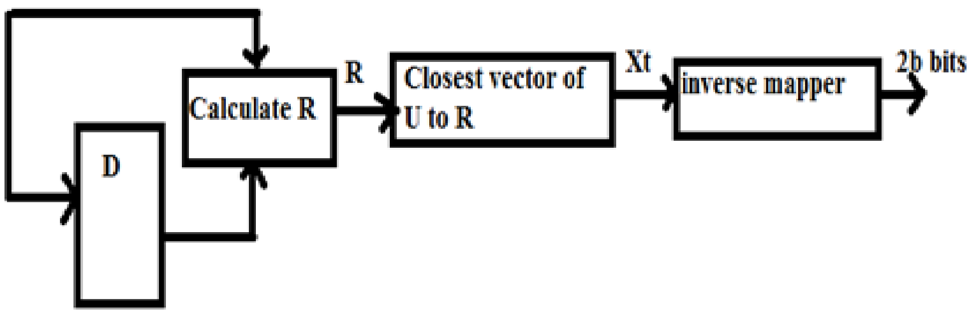

Figure 2 DSTBC Decoder

n_1 and n_2 are noise for block 1. The R vector is given by below equation

$$R = \begin{pmatrix} C_1 \\ C_2 \end{pmatrix} \quad (6)$$

$$C_1 = r_{t-1}^* r_1 + r_{t-2} r_2^* \quad (7)$$

$$C_2 = r_2^* r_{t-1} - r_1 r_{t-2}^* \quad (8)$$

The decoder would find the closest match for vector Xt in U. Consider the matching vector is estimate of transmitted vector. To decode the 2b bits/information bits, Xt is reverse mapped using inverse mapping function modulator.

III. DIGITAL VEDIO BROADCASTING SATTELITE

DVB is digital video broadcasting; European Standard (Telecommunication series) has been produced by the Joint Technical Committee (JTC) of the European Broadcasting Union (EBU), the European Telecommunications Standards Institute (ETSI). The System uses Quaternary Phase Shift Keying (QPSK) modulation and concatenated error protection strategy based on a convolution code and a shortened Reed-Solomon (RS) code. The convolution code is able to be configured flexibly, allowing the optimization of the system performance for a given satellite transponder bandwidth. The System is suitable for different satellite transponder bandwidths. Compatibility with Moving Pictures Experts Group-2 (MPEG-2) coded TV services, with a transmission structure synchronous with the packet multiplex. The multiplex flexibility allows the use of the transmission capacity for a variety of TV service configurations, including sound and data services. All service components are Time Division Multiplexed (TDM) on a single digital carrier.

3.1. Functional block diagram of DVB-S.

The System is defined as the functional block of equipment performing the adaptation of the baseband TV signals, from the output of the MPEG-2 transport multiplexer, to the satellite channel characteristics. The System is directly compatible with MPEG-2 coded TV signals. The modem transmission frame is synchronous with the MPEG-2 multiplex transport packets. If the received signal is above Carrier to Noise and Carrier to Interference threshold, the Forward Error Correction (FEC) technique used in the System to provide a "Quasi Error Free" (QEF) quality target. The QEF means less than one uncorrected error-event per transmission hour, corresponding to Bit Error Ratio (BER) = 10^{-10} to 10^{-11} at the input of the MPEG-2 demultiplexer. Transmissions of digital multi-programmed TV services will use satellites in both the FSS and the BSS bands. The choice of transponder bandwidth is a function of the satellite used and the data rates required by the service. For satellite TV, there are two bands: C band - 4 to 8 GHz and Ku band - 12 to 18 GHz and the bandwidth is about 27 to 50 MHz The input interface is single transport stream with MPEG-2. The forward error correcting code is reed Solomon coding and bit interleaving by convolution coding.

3.1.1 DVB-S Transmitter

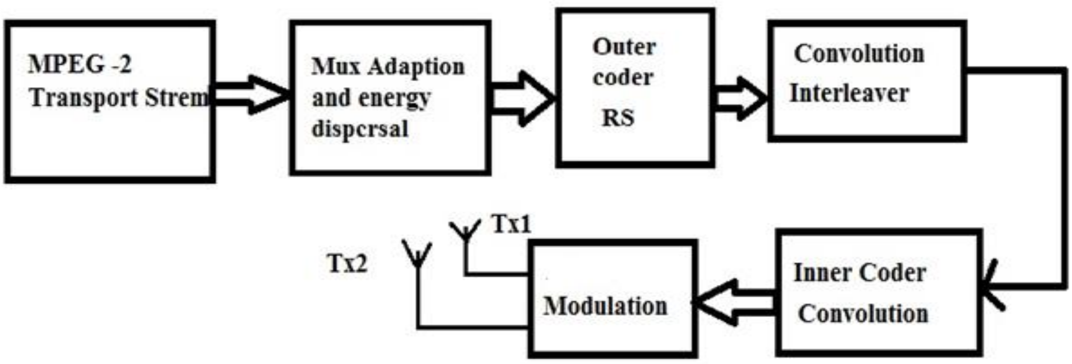

Figure 3 Block diagram of DVB-S transmitter

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3.1.2 Source coding and MPEG-2 transport stream

Inputs are may be compressed video, compressed audio, and data streams are multiplexed into MPEG program streams (MPEG-PSs). One or more MPEG-PSs are united together into an MPEG transport stream (MPEG-TS); this is the basic digital stream which is being received by TV sets or home Set Top Boxes (STB).

Bitrates for the transported data depend on a number of coding and modulation parameters. If the received signal is above C/N and C/I threshold, the forward error correction technique is to provide quasi error free (QEF) quality target. The system input stream is organized in fixed length as shown in figure 4.

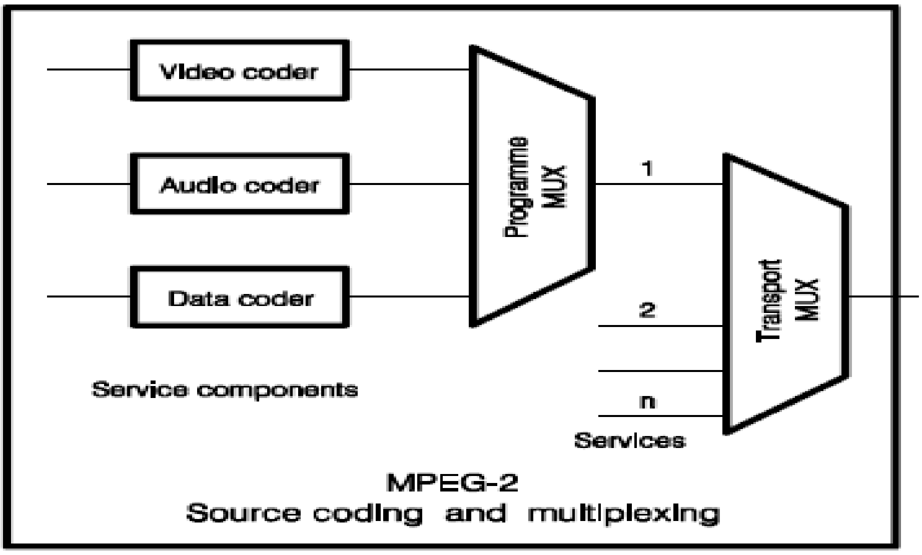

Figure 4 source coding and MPEG-2 transport stream

3.1.3 Multiplexing adaption and energy dispersal

The MPEG-2 transport stream is multiplexed and becomes 188 bytes. This include one sync-word byte (47 HEX). The process at transmitting side shall always start from MSB (0) of sync word byte (01000111).

The data of MPEG-2 multiplex will be randomized in accordance with figure 5.

Load the sequence 100101010000000 in to PRBS resister as in figure 4.3 can be initiated at the start of every eight transport packets. To provide initialization, the MPEG-2 sync byte of the first transport packet in a group of eight packets is bitwise inverted from 47 hex to B8 hex. This process is known as Transport Multiplex Adaption. The period of PRBS sequence is 1503 bytes.

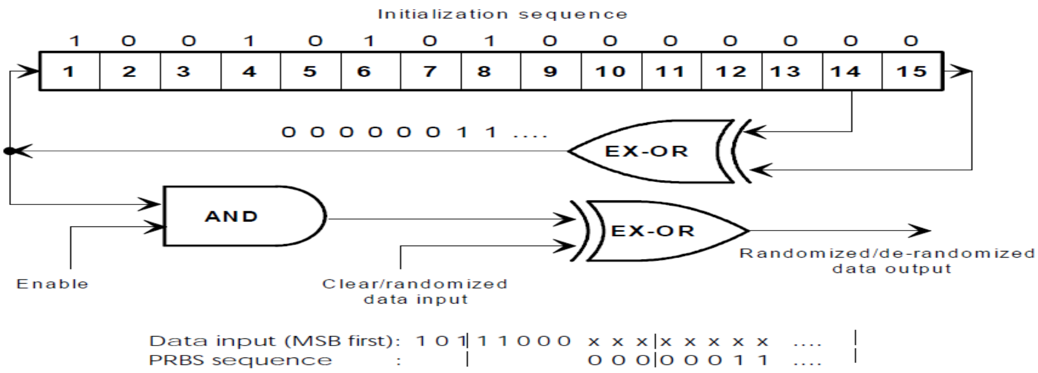

Figure 5 Randomizer/ Derandomizer for multiplexing adaption

Figure 6 MPEG-2 transport packet

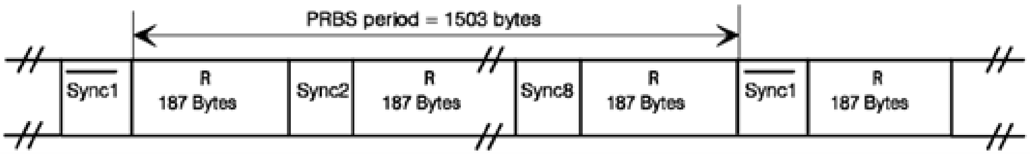

Figure 7 Randomized transport packet

3.1.4 Outer coder Reed Solomon

Reed Solomon RS (204, 188, T=8) is shortened from original RS code by adding 51 bytes (all set to 0), before the information byes at the input of encoder. This RS is applied to each randomized transport packet (188 byte) of figure 8. RS coding also applied to sync byte.
After completion of RS coding 51 null bytes will be discarded.

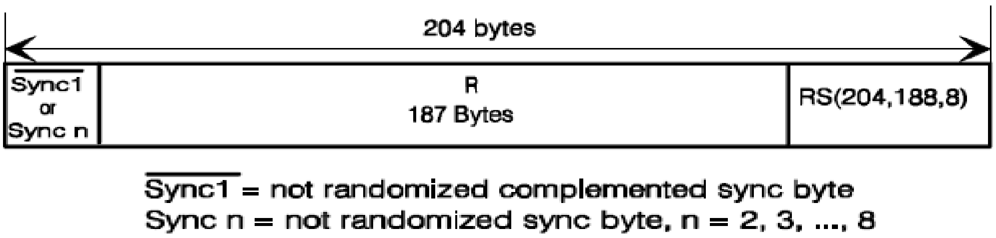

Figure 8 Reed Solomon error protected packet

3.1.5 Convolution Interleave and Deinterleave

The convolution interleaving frame can be composed of overlapping error protected packets and can be delimited by MPEG-2 sync byte. The interleaver is composed of I=12 branches cyclically connected to input byte stream by input switch. Each branch is in FIFO (First In First Out) manner in shift register. The depth (M J) cells. Where M=17=N/I, N= 204= error protected frame length. I is interleaving depth and J is branch index. The cell of FIFO contains 1 byte and the input and output switches are synchronized.

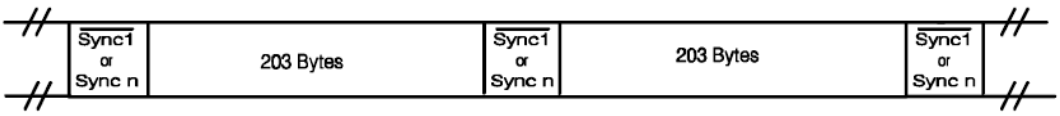

Figure 9 Convolution Interweaver

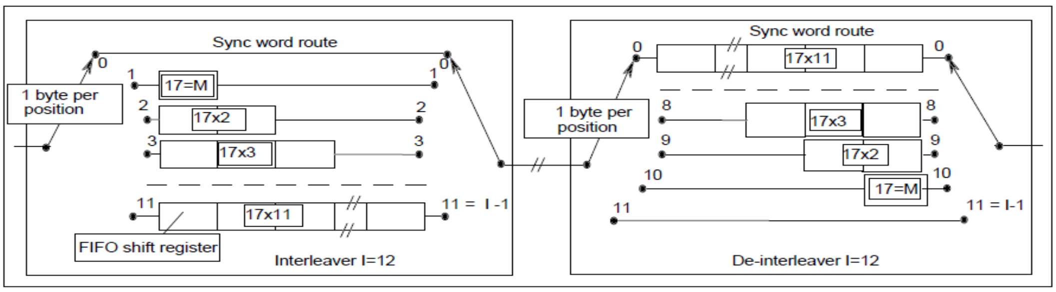

Figure 10 Conceptual diagram of Interleave and Deinterleaver

3.1.6 Inner Coding Convolution

The system allow for a range of punctured convolution codes based on a ½ rate with constraint length K=7. The system allow convolution coding with code rates of ½, 2/3, ¾, 5/6, 7/8.

3.1.7 Modulator

The modulation scheme is used in DVB-S is Phase shift keying method.

3.2. DVB-S Receiver

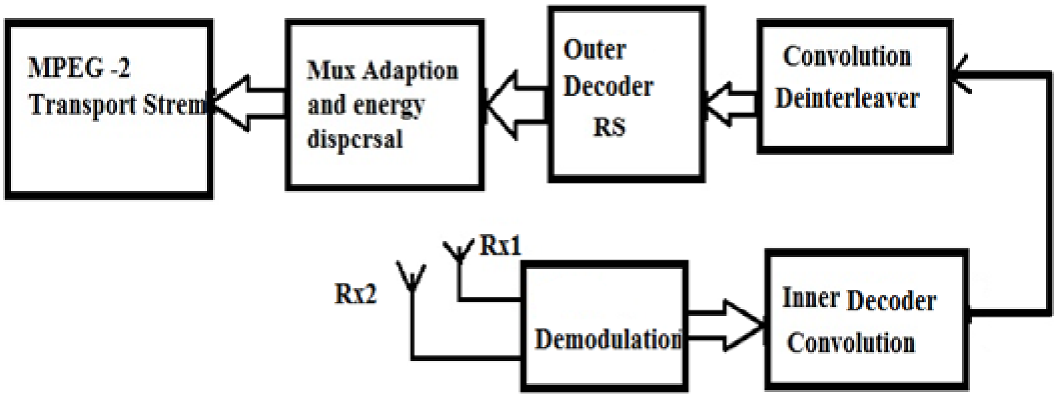

Figure 11 Block diagram of DVB-S Receiver

IF interface unit performs the demodulation function and the analog to digital conversion.
Matched filter is the complementary pulse shaping filtering of raised cosine type according to the roll-off. The Finite Impulse Response (FIR) digital filter provides equalization of the channel linear distortions in the IRD.
Carrier recovery unit recovers the demodulator synchronization. The probability of slips generation over the full C/N range of the demodulator should be very low.
Inter convolution decoder is first level error protection decoding. It should operate at an input equivalent "hard decision" BER in the order of between 10^{-1} and 10^{-2} (depends on the adopted code rate), and should produce an output BER of approximate 2ˆ 10^{-4} or lower. This output BER corresponds to QEF service after outer code correction. It is possible for system that this unit makes use of "soft decision" information. This unit is used to try each of the code rates and puncturing configurations until lock is acquired.
To decode the MPEG-2 sync bytes, the sync byte decoder provides synchronization information for the de-interleaving.
The convolution de interleave device allows the error bursts at the output of the inner convolution decoder to be randomized on a byte basis. So it is used to improve the burst error correction capability of the outer decoder.
Outer decoder is Reed Solomon decoder provides second level error protection. It provides QEF output in the presence of error burst.

IV. STIMULATION RESULTS

Figure 12 shows the BER and SNR results for 2*2 antennas using 16-QAM. Figure 13 shows the BER results for 2*1 antenna using 16-QAM. By comparing DSTBC for SNR of 6 dB the bit error rate is 0.625 higher for 2*2 antennas than 2*1 antennas. Figure 14 and 15 show the eye diagram of DVB-S transmitter and receiver. Figure 16 shows the Bit Error Rate and Signal to Noise Ratio for DVB-S system. The red curve shows BER and SNR for original DVB-S (theory). The blue curve shows BER vs. SNR for Reed Solomon coding. The gray curve shows the BER vs. SNR of practical result of DVB-S. Figure 17 and figure 18 show the eye diagram of DVB – S transmitter and receiver with DSTBC. Figure 19 shows the BER and SNR values for theoretical and simulation results.

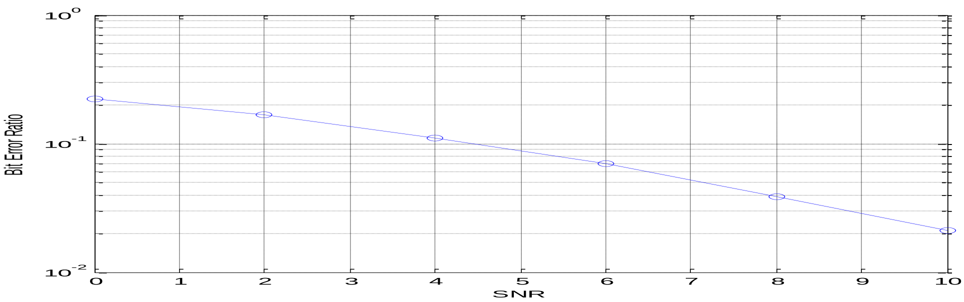

*Figure 12 Simulation Results for 2*1 antennas*

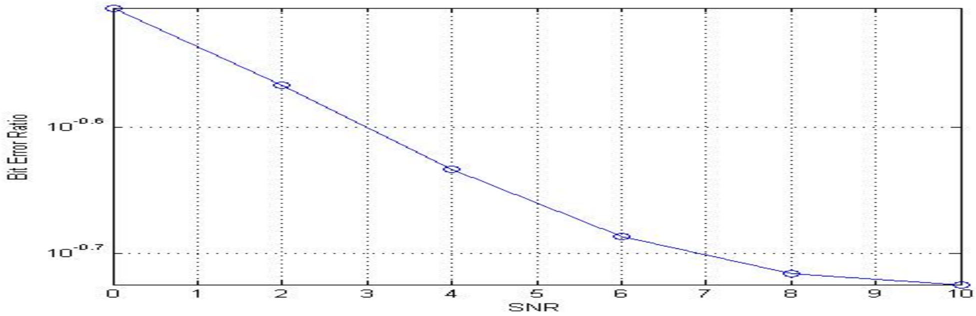

*Figure 13 Simulation Results for 2*2 antennas*

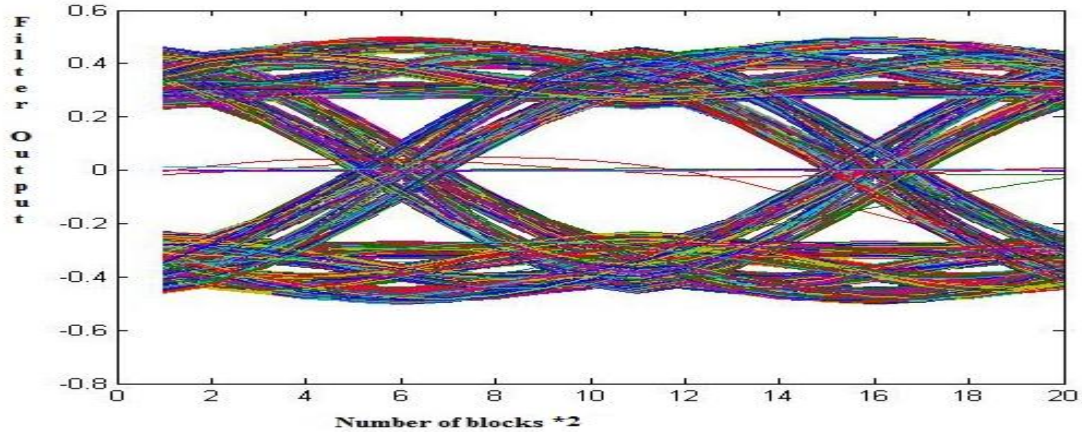

Figure 14 Transmitter eye diagram (without DSTBC)

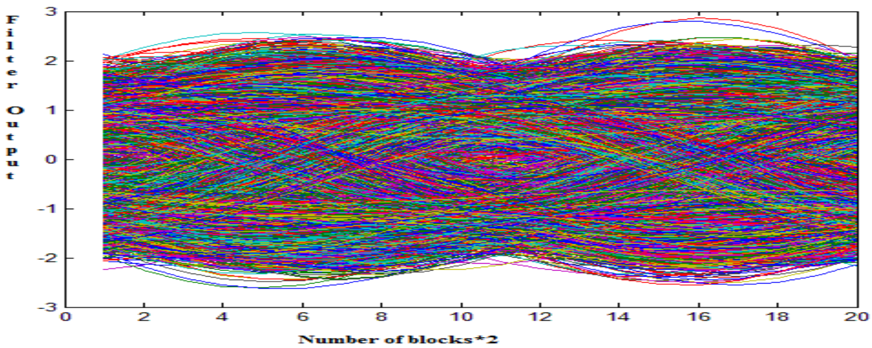

Figure 15 Receiver eye diagram (without DSTBC)

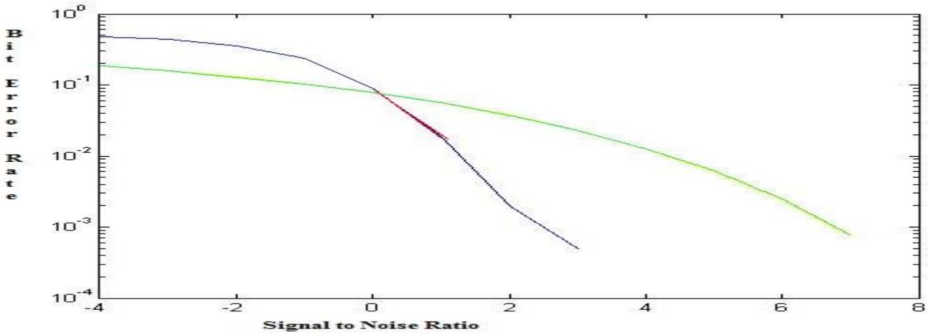

Figure 16 BER vs. SNR of DVB-S (without DSTBC)

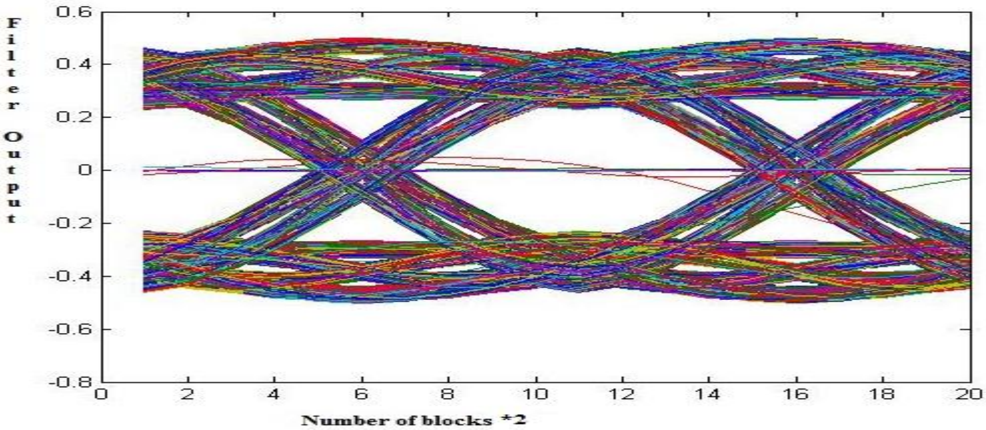

Figure 17 Transmitter eye diagram (with DSTBC)

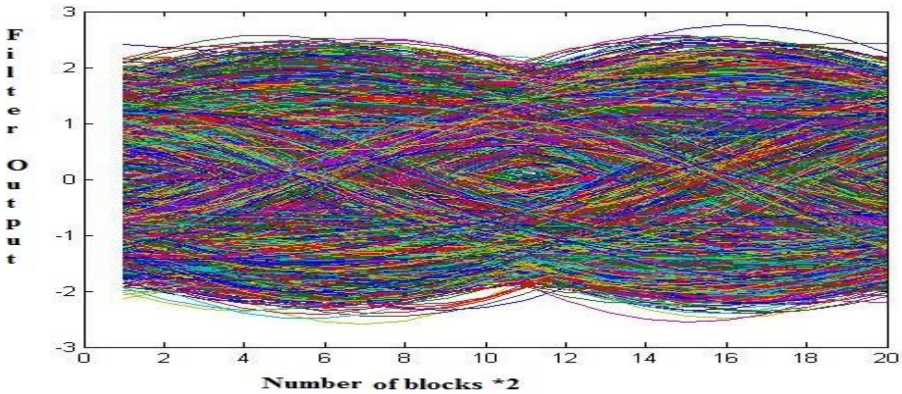

Figure 18 Receiver eye diagram (with DSTBC)

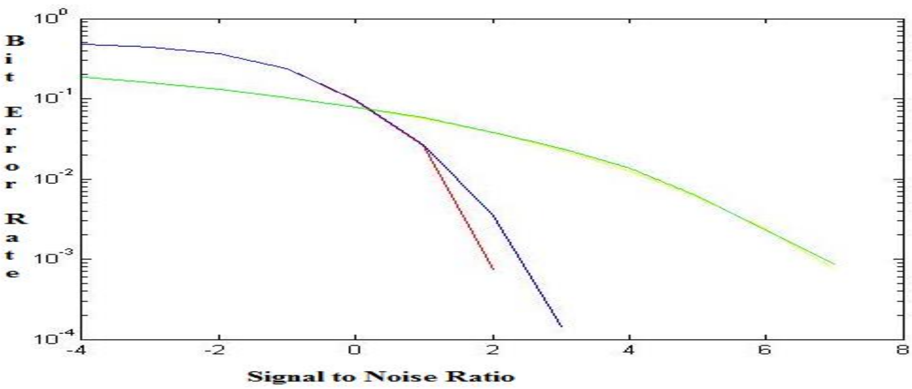

Figure 19 BER vs. SNR of DVB - S (with DSTBC)

V. CONCLUSION

DSTBC with 2 transmit antenna and 2 receive antenna and 2transmit antenna and 1 receive antenna using 16 QAM and AWGN channel. The performance with 2*1 is better as compared to 2*2 antennas. The comparison of two systems (first system in which the data sequence is transmitted in DVB – S system and second system in which the same data sequence is transmitted in DVB – S with DSTBC). The first system considers the case in the channel noise is added. The theoretical result and simulation result for BER and SNR. In second case the channel is considered as Rayleigh multipath fading channel and DSTBC is applied. It is observed that the BER of the received data reduces as the SNR increases in the system.

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