Performance Analysis of 2x2 MIMO using V-blast Coding Architecture

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***Abstract*: MIMO systems have now become a key technology in wireless communications as it provides significantly high data rates. It creates multiple paths between the transmitter and receiver to enable more data to travel in a single unit of time thus leading to increase in data rates. V-BLAST scheme has got multiple transmitters. The data stream is divided in substreams and is transmitted independently through multiple transmitters. This paper will give an overview of V-BLAST technique from theoretical point of view and its practical implementation. It envisages on the selection of desirable modulation scheme in terms of BER, system throughput and outage probability for SISO and MIMO channel with V-BLAST architecture.**

***Keywords*: Bit error rate (BER), Multiple-Input Multiple-Output (MIMO), Phase shift keying (PSK), Successive Interference Cancellation (SIC), Zero Forcing (ZF)**

I. Introduction:

Multiple-Input Multiple-Output (MIMO) can offer high capacity to wireless systems, and the capacity is increased as the number of bits that are transmitted per second are increased and it keeps on increasing till the number of receiving antennas is greater than equal to the number of transmitting antennas. [1] There are many different schemes that can be applied to the MIMO system, the V-BLAST algorithm has become a potential alternative due to its excellent complexity performance tradeoff besides the complexity performance tradeoff, the V-BLAST algorithm is also considered to be a scheme which effectively exploits the MIMO potentials. This paper aims to exploit the V-BLAST algorithm [2] introduce many ideas regarding coding and design principles for the V-BLAST system, for example, Space-Time Coding reference proposed a low-complexity Zero Forcing (ZF) decoding approach for the V-BLAST Space Time Block Codes (STBC) system. Some V-BLAST systems perform detection and decoding layer by layer in a successive way at the receiver, a low-complexity detector with Successive Interference Cancellation (SIC) is used. The interest is on the bit error rate and performance while using different detection methods. Zero Forcing (ZF) is used as detection algorithms [3]. SIC is introduced instead of joint detection in order to reduce the complexity. We also investigated several methods to minimize the influence of the error propagation, which is considered to be the key problem to SIC for a given channel matrix H, zero-forcing enhances the noise. V-BLAST is a practical approach to achieve spatial multiplexing. Its decoder consists of ordering , interference cancelation, and interference nulling. There is a trade-off between the complexity of the decoding and the achieved diversity going from linear decoding methods to V-BLAST and to ML decoding, the diversity gain and the decoding complexity increase simultaneously [4-6]. The objective is to demonstrate the concept and feasibility of a V-BLAST channel coding architecture system, and investigate how its performance is changed by varying some of its major parameters like various M-PSK schemes. This objective is met by developing a MATLAB program to simulate a basic V-BLAST system. The flow chart to design the MATLAB code is as shown in Fig.1.

II. Performance Analysis for Different m-ary Schemes for SISO Channels

The first step is defining all the parameters in our system: the number of symbols to be transmitted (N), the SNR range for the simulation in dB (ebno) after defining all the parameters the modulator is set to M-PSK dimension, the random value generator is randomized and a random input is generated according to the number of symbols, and the interleaver is initialized. Then the simulation starts from the first SNR point. Uuencoded bits (a frame) are generated and they are modulated using M-PSK (BPSK, QPSK, 16PSK and 8PSK).

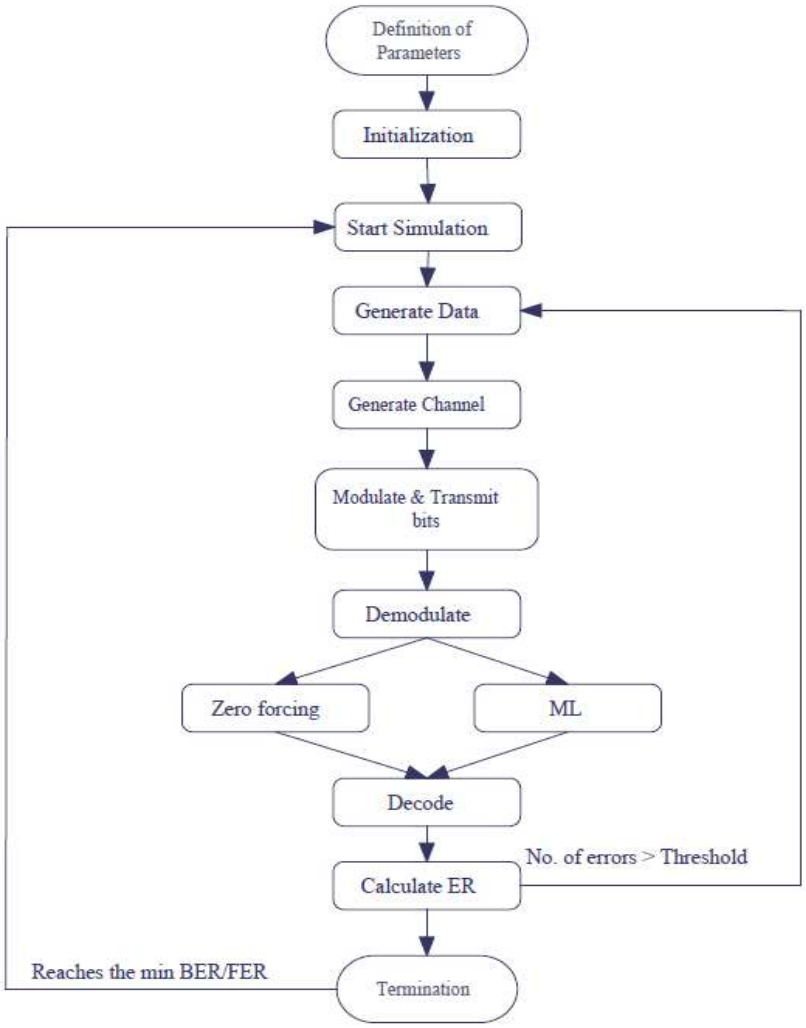
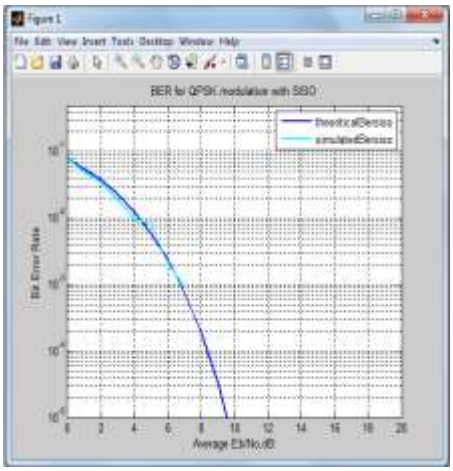
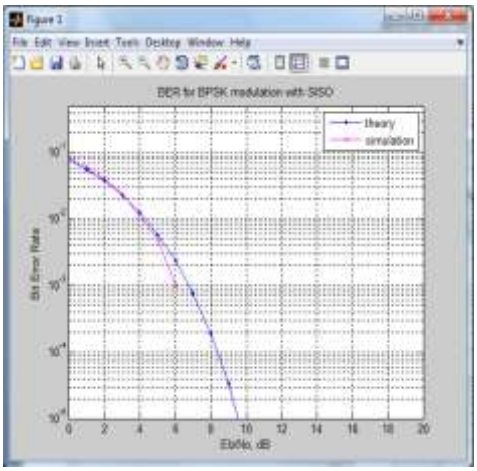


Fig. 1. Flowchart of general MIMO structure

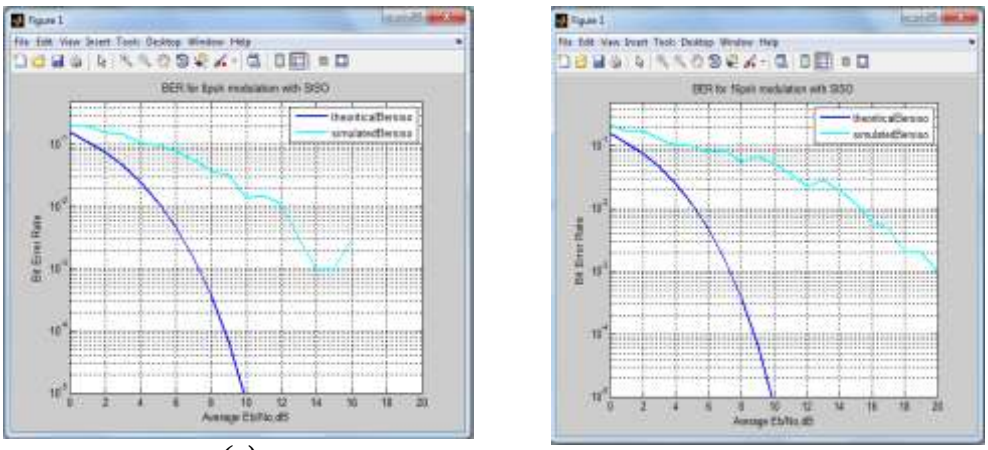
The bit errors are counted by comparing the output bit stream from the input stream transmitted. Further, the graphs are plotted between bit error rate and signal to noise ratios (dB), the graphs show the variation of theoretical BER and simulated BER with signal to noise ratio (dB). The comparison of the BER of different modulation schemes for SISO Channel using MATLAB is as shown in Fig. 2. The input parameters are: Number of symbols = 1000, ebno= 0:1:20 dB.



(a)



(b)



(c) (d)

Fig. 2. Performance analysis of SISO (a) BPSK (b) QPSK (c) 8 PSK (d) 16 PSK

III. Performance Analysis for Different m-ary Schemes for MIMO Channels

The V- BLAST detection technique is used for the MIMO system. The algorithm includes three steps: Ordering, Interference cancellation, Interference nulling. Symbols are detected one by one. The purpose of the ordering step is to decide which transmitted symbol to detect at each stage of the decoding. The symbol with highest SNR is the best pick in this step. The goal of the interference cancelation is to remove the interference from the already detected symbols in decoding the next symbol. Finally, interference nulling finds the best estimate of a symbol from the updated equations. This step is called interference nulling since it can be considered as removing the interference effects of undetected symbols from the one that is being decoded. We use the first Zero-Forcing detector to detect the first data stream x1, decode it and then subtract this decoded stream from the received vector. Assuming the first stream is successfully decoded, and then the second Zero-Forcing detector only needs to deal with streams x_2……, x_{Nt} as interference, since x1 has been correctly subtracted off. This process is continued until the last Zero-Forcing detector does not have to deal with any interference from the other data streams. We assume subtraction is successful in all preceding stages. This is called the successive interference cancellation zero forcing detecting technique used at the receiver as shown in Fig. 3.The zero forcing equalization technique is used at the receiver. The received symbols is given by (1):

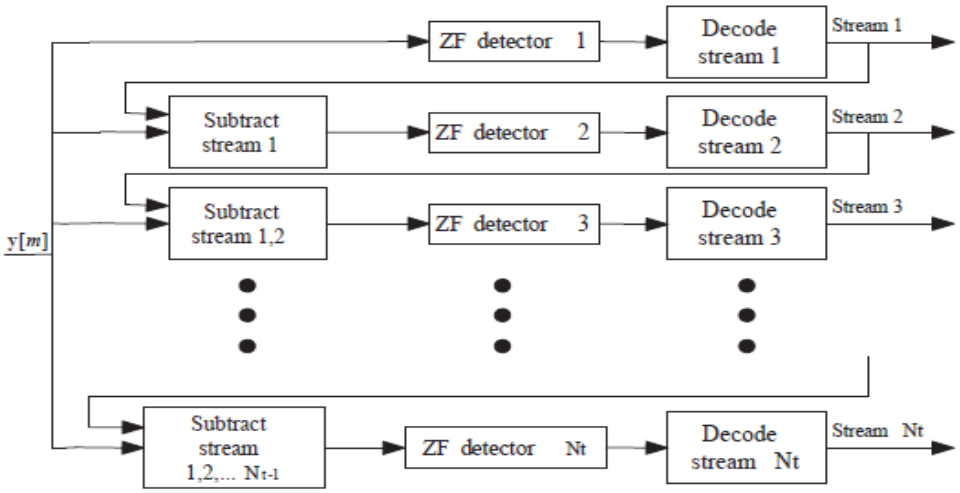
$$y = Hx + n \quad \ldots. (1)$$

Where: y = Received symbols, H = channel matrix, x = transmitted symbol, and n = noise

Now, to solve for x, we need to calculate a matrix W satisfying the equation WH = I. The Zero Forcing (ZF) linear detector for meeting this constraint is given by (2):

$$W = (H^H H)^{-1} H^H \quad \ldots. (2)$$

Where: H^H is the conjugate matrix of H



The comparison of the BER of different modulation schemes for MIMO channel using MATLAB is done. The theoretical BER is calculated for the two different receivers separately and finally the output from two receivers is combined as one simulated BER is also compared as in Fig. 4:

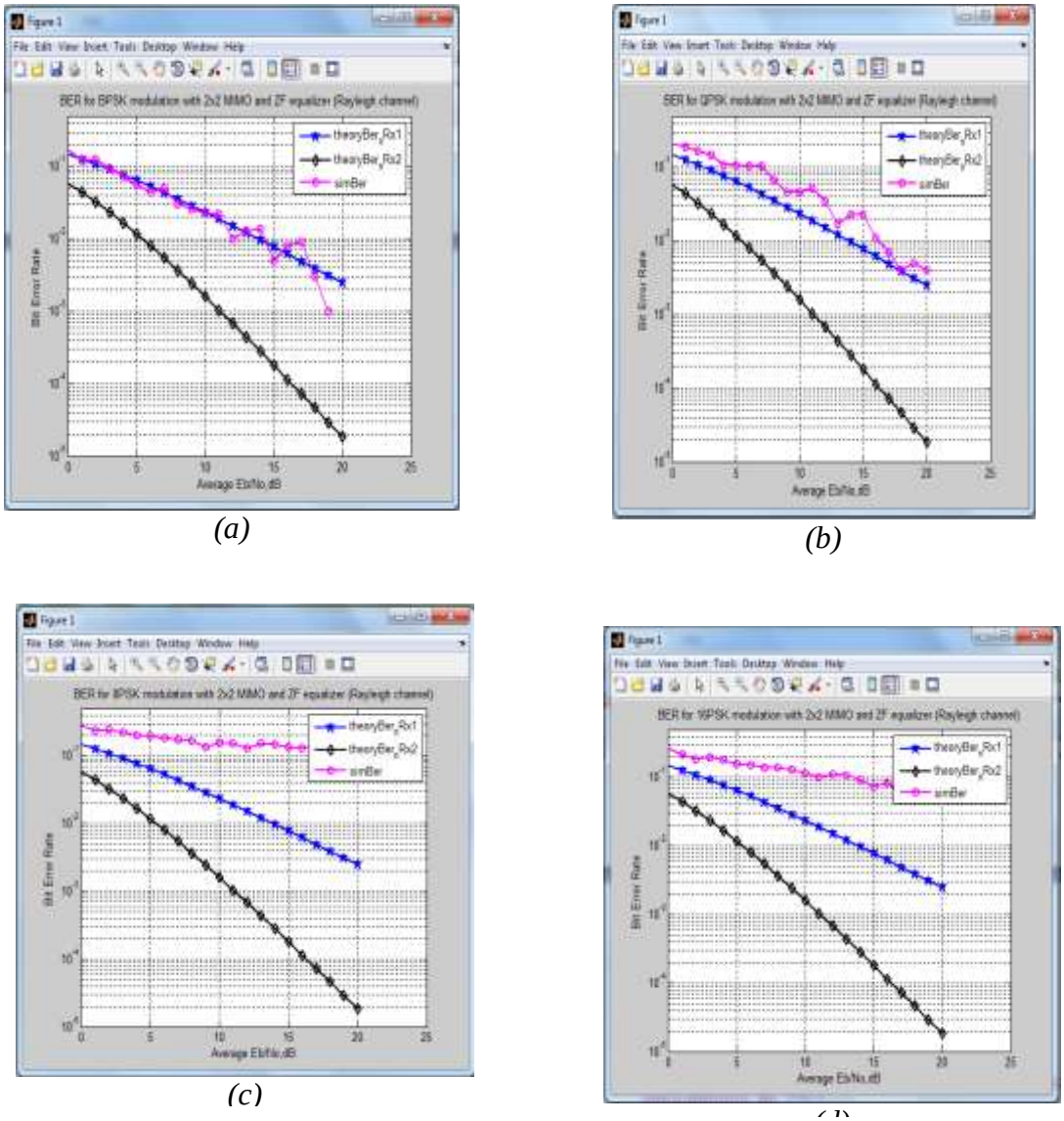


Fig. 4. Performance analysis of MIMO (a) BPSK (b) QPSK (c) 8 PSK (d) 16 PSK

IV. Comparison of Different m-ary Modulation Scheme for V-Blast MIMO and SISO

A GUI code is written on MATLAB, the input parameters to be supplied are as following: No. of transmitted symbols is "N" in the program, No. of transmitting antennas is "nTx = 2", No. of receiving antennas is "nRx = 2", EbNo_ratio_dB is signal to noise ratio, after entering the required input variables as specified, tick the modulation scheme to be used. The GUI window on MATLAB is as shown in Fig.5. The modulation schemes are: BPSK, QPSK, 16PSK, 8PSK, after inserting the input parameters the comparison of theoretical BER of two receivers of MIMO and single receiver of SISO system is compared with the simulated BER of MIMO and SISO case separately as in Fig. 6.

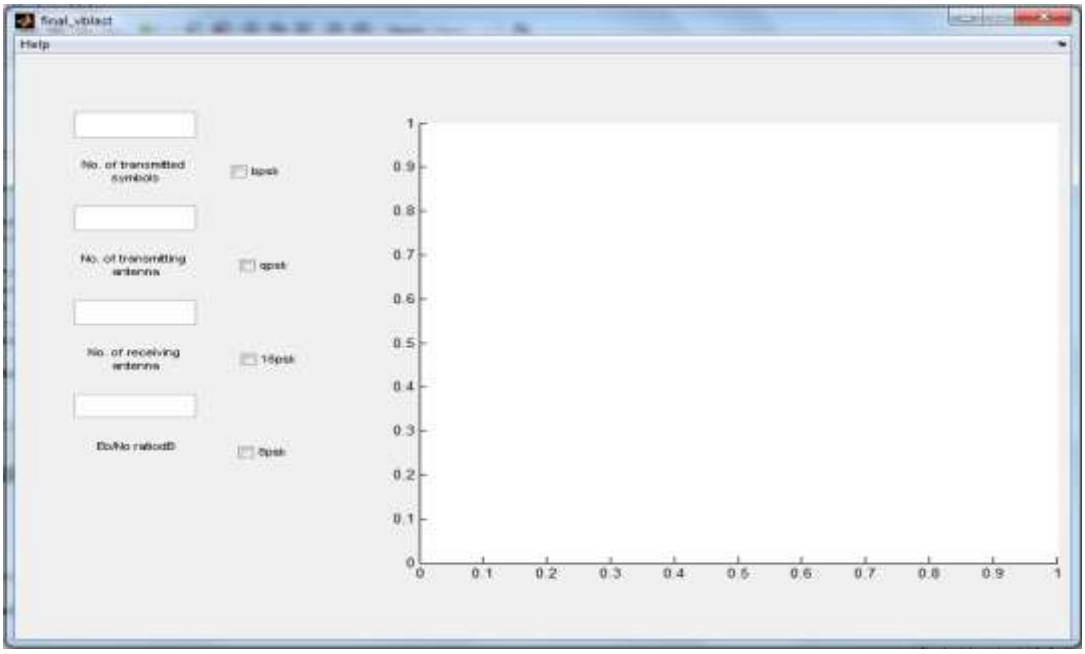
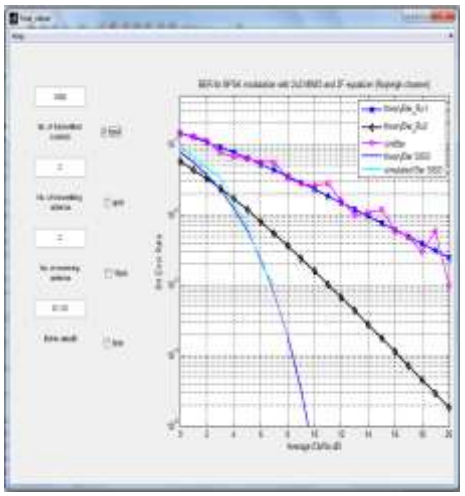
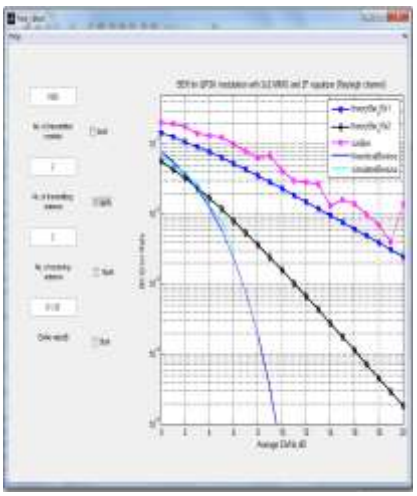


Fig. 5. MATLAB GUI Window



(a)



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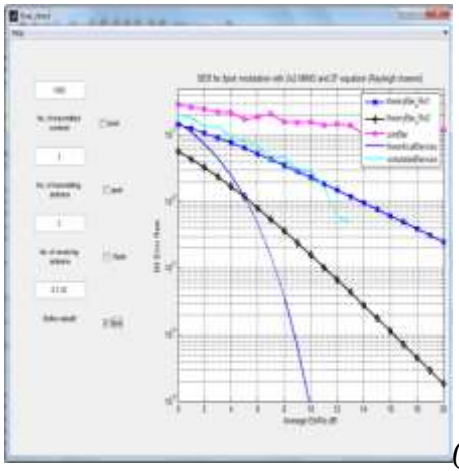
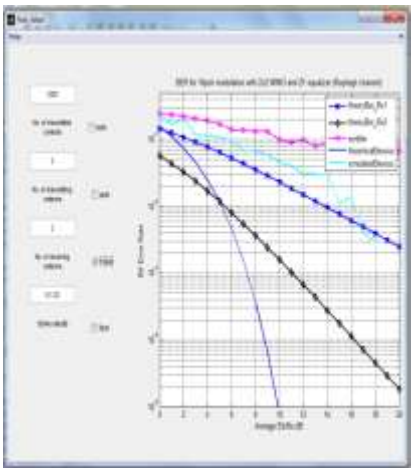


(c)



(d)

Fig. 6. Comparison analysis (a) BPSK (b) QPSK (c) 8 PSK (d) 16 PSK

V. Conclusions

We have studied the behavior of channel over various modulation schemes in SISO and MIMO channel for SISO and MIMO, performance of BPSK is better than other modulation schemes because of low BER. Bit Error Rate of all schemes decreases with increase in SNR. Probability of BER increases as M increases. Bandwidth requirement decreases as the M increases, thus decreasing the symbol rate. The selection of the Modulation scheme depends on the available bandwidth and the maximum data rate required. The bit error rate is least for BPSK modulation but as we know the data rate is least in BPSK modulation so higher order modulation techniques are used and also the bandwidth decreases for higher values of M.

References

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