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Implementation and Analysis of Different Equalizers using SIC and V-Blast Architecture for MIMO systems

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Abstract—Wireless communication transfers the information between two points without connected electrically to each other. Wireless operations permits to user to communicate long range or at any range without wires. Wireless communication is reliable, robust and secure. This paper evaluates the performance of detectors using V-BLAST architecture for multiple-input multiple-output (MIMO) systems. To Review the performance, the implementation of the multiuser receivers like the ZF detector, the MMSE receiver and SIC Successive Interference Cancellation is required. The algorithms of these receivers combined with multiuser receivers to achieve high channel capacity. Simulation result shows that instead of using equal number of transmitter and receiver antennas, this will get better performance of BER with increased number of receiver antennas only compared to transmitters.

Keywords: *MIMO, V-Blast, BER, MMSE, ZF.*

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1. INTRODUCTION

Single antenna used both at transmitter and receiver sides in conventional wireless systems. In some cases, this gives rise to problems with multipath effects. The use of multiple antennas both at receiver and transmission ends about to eliminate the multipath wave propagation problems, these multiple antennas preferred for multiple signals transmission [2]. So use of multiple antennas for both ends means transmitter and receiving ends is called MIMO system and it is the one of the most significant technical breakthrough in modern wireless communication [3]. MIMO system is widely used because it increases data throughput significantly, link range without additional bandwidth and transmission power [6]. V-BLAST (Vertical-Bell Laboratories Layered Space-Time) is a detection algorithm used for MIMO systems is wireless communication architecture. V-BLAST uses linear detection techniques (such as ZF or MMSE) or non-linear methods. Desired signal selected turn by turn as sub streams and other are consider as interference. By linearly weighting the received signals nulling is obtained. On different antennas data rate is increased by transmitting independent. No channel knowledge required at transmitter in case of V-BLAST [7].

2. SYSTEM MODEL

Multiple antenna elements are equipped at transmitting and receiving ends. There are multiple receive antennas at the receiver and matrix channel through which transmission of stream is done. There are multiple receive antennas and decoders at receiving end which decodes the received signal called received signal vectors [2] [8].

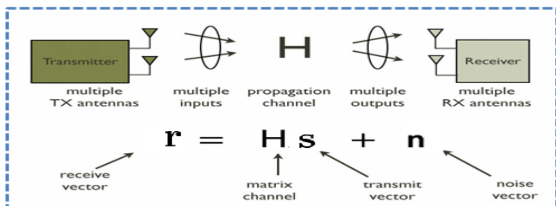

Fig 2. MIMO System Moldel

There are detail explains for denoted symbols:

- **R is received signal vector.**
- **H represented channel matrix**
- **S is transmitted signal vector.**
- **N is additive noise term.**

Let Q denote the covariance of x, then the capacity of the system described as below:

$$C = \log_2 [\det(\mathbf{I}_M + \mathbf{H}\,\mathbf{Q}\,\mathbf{H}^*)] \quad \text{b/s/Hz}$$ -----1

At the input distribution maximizing the mutual information is the Gaussian distribution. The form of equation gives rise to two practical keys. First, is the effect of **Q**. we can evaluate a maximum capacity gain due to feedback. The second concerns the effect of the **H** matrix [8]. we have a MIMO system with N transmitter antennas and the capacity is given by

$$C = \log_2 \left(1 + \frac{\rho}{N}\sum_{i=1}^{N}|h_i|^2\right) \quad \text{b/s/Hz}$$ -----2

Capacity has a logarithmic relationship with N. The use of diversity at both transmitter and receiver gives rise to a MIMO system. For N TX and M RX antennas, we have the now famous capacity equation:

$$C_{EP} = \log_2 \left[\det \left(\mathbf{I}_M + \frac{\rho}{N} \mathbf{H}\mathbf{H}^* \right) \right] \quad \text{b/s/Hz} \qquad \text{------3}$$

Where (*) means transpose-conjugate and is the channel matrix.

Minimum Mean Square Error (MMSE):

MMSE method is used to minimize the error between the estimated and transmitted symbols. MMSE suppresses both the interference as well as the noise components but the ZF receiver suppresses only the interference components [8]. So, in MMSE the error between the transmitted symbols and the estimated symbols at the receiver is minimized. Hence, MMSE performs better in the presence of noise. The MMSE receiver is given by

$$W = H^H H + ((1/SNR)I)^{-1} H^H$$

Where, **I** is the Identity matrix.

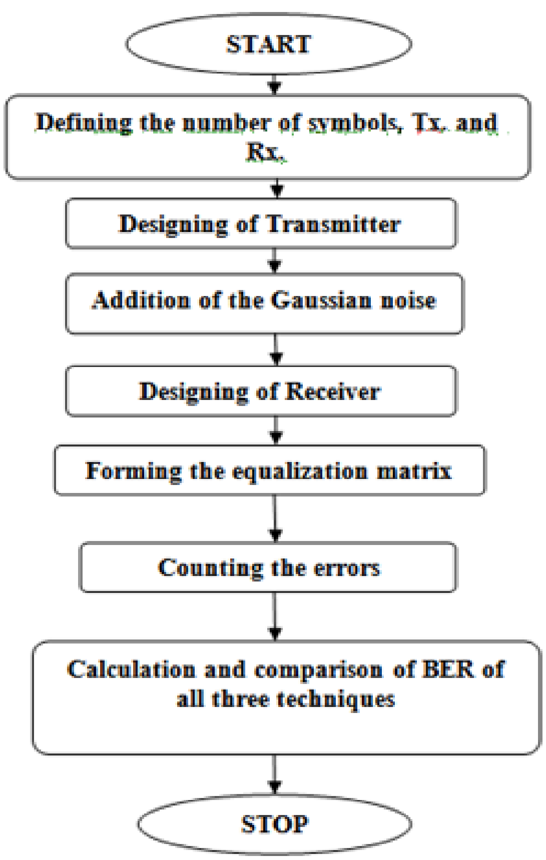

Fig 3.Flow chart of MMSE

Zero Forcing (ZF):

ZF is a linear and conventional MIMO detection technique. By inverting the channel with the weight of matrix the zero-forcing algorithm attempts to null out the interference from the channel matrix. Zero-forcing pre-coding is employing spatial multiplexing signal processing by which the multiple antenna transmitters can null interference signals. However accurate channel state information (CSI) is essential for their proper operation [8][9]. So with limited channel state information at the transmitter (CSIT) the performance of ZF-pre-coding decreases this depends upon the accuracy of CSIT [9]. To achieve the full multiplexing gain ZF-pre-coding requires the feedback with respect to signal-to-noise-ratio (SNR).

The ZF receiver is given by

$$W = (H^H H)^{-1} H^H$$

Where,

Superscript: **H** denotes hermitian transpose
W is the channel Pseudo- inverse
H is the channel matrix

SIC

Successive interference cancellation (SIC) is physical layer technique. Two or more signals receive concurrently is the ability of SIC, otherwise cause a collision in today's systems [9].SIC is applicable in such manner the stronger signal decoded by receiver firstly, subtract it from the combined signal and extract the weaker one from the residue [9][10]. Conventionally, only the strongest signal can be decoded and the other signals are treated as interference. However, SIC facilitates recovery of even the weaker signal. Regenerate the signal with the largest power and subtracted from the buffered received signal. Re-estimated the remaining signals and a new largest user are selected [9]. This process is continued until the maximum allowable number of cancellations is reached. All the user's signals are estimated during every iteration process .Steps for flow of SIC are given as follow:

1. Received 'K' number of user's signal.
2. The signals of the first stronger users (out of k) are chosen (with the help of initial stage of matched-filters) to perform SIC between them.
3. Reliable users are chosen, their signals reconstructed and subtracted (actually Subtracting estimates of interfering signals from the received signal.) from the buffered version of the received signal.

4. Remaining users are arranged according to their strength and one by one, Uses are detected and subtracted.

5. Again, a tradeoff must be made between the precision of the power ordering and the acceptable processing complexity.

6. Number of iterations to cancel out is directly proportional to the number of users.

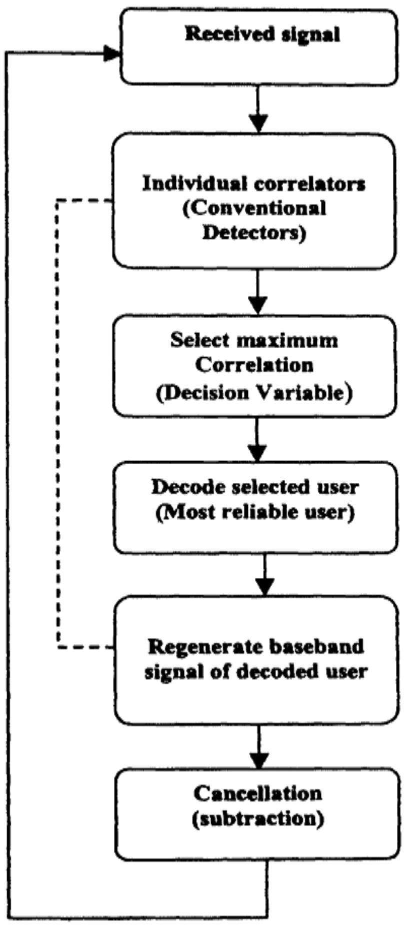

Fig 4.Flow chart of SIC

3. SIMULATION RESULT AND DISCUSSIONS

The simulation result for a V-BLAST MIMO system Using BPSK modulation in Rayleigh channel. Fig 4 shows the 2x2 MIMO systems with ZF and MMSE detector curves. Performance of MMSE shows better than ZF in terms of improvement in BER. This result is without using SIC.
In fig 5 the simulation results for a V-BLAST MIMO system Using BPSK modulation in Rayleigh channel. Fig 5 is comparative simulation result between MMSE and MMSE-SIC, Which shows improvement in performance using SIC with MMSE in terms of BER as increases in average SNR reduction in BER at large.

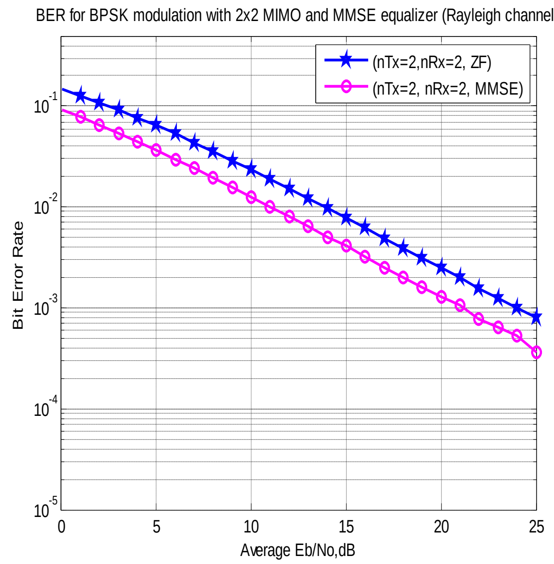

Fig5. Performance of BER for 2 transmitters and 2 receivers with ZF and MMSE

In fig 6 the simulation results for a V-BLAST MIMO system Using BPSK modulation in Rayleigh channel. Fig 6 is comparative analysis and simulation result between ZF and ZF-SIC, Which shows improvement in performance using SIC with ZF in terms of BER as increases in average SNR reduction in BER at large.

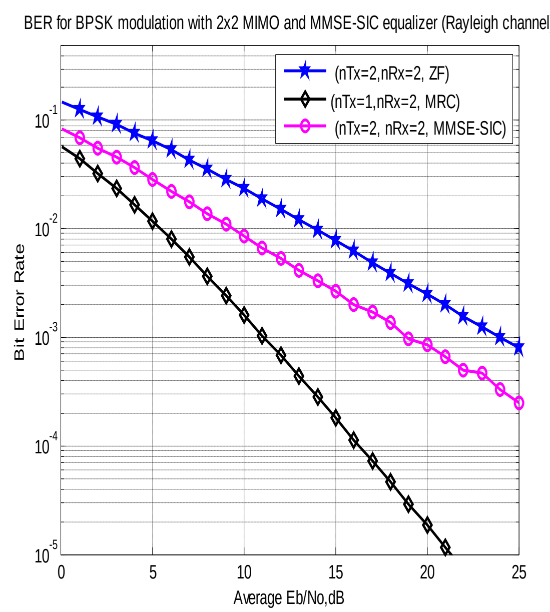

Fig 6.Performance of BER for 2 transmitters and 2 receivers with MMSE and MMSE-SIC

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From fig 6 it is clearer that conventional ZF detector having more BER than compare to ZF-SIC From the result it is clear that MMSE ZF scheme gives best results if using with SIC. So it is the improvement of BER and SNR of conventional detectors like MMSE and ZF if used with SIC detector.

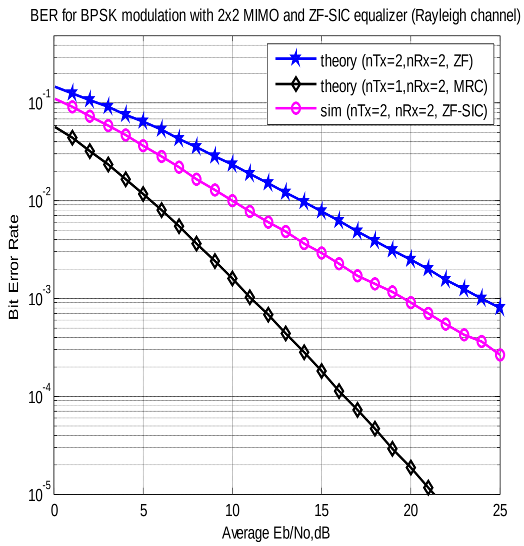

Fig 7.Performance of BER for 2 transmitters and 2 receivers with ZF and ZF-SIC

4. CONCLUSION

Due to the highly requirements in wireless services the widespread use of MIMO systems is expectable. Due to the heavy interference load interference suppression is required. So we Concluded from simulation results that the V-BLAST scheme for MIMO Systems at high SNR region present an asymptotic analysis. The ZF, MMSE using ZF-SIC and MMSE-SIC are analyzed with respect to their SNR and BER performances. Found that MMSE-SIC method is the best solution in detectors for BPSK in Rayleigh channel.

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