MIMO-OFDM High Data Rate Wireless System Using V-BLAST Method

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Abstract

With increasing technology many new techniques are coming with which we can improve today’s available techniques for better future. In this topic we are trying to show new communication technique using multiple inputs and multiple outputs (MIMO). With MIMO we are using orthogonal frequency division multiplexing (OFDM) which is useful in sending large amount of data in single frequency band. MIMO can be used with high data rate and reduced distortion with V-BLAST technique. In MIMO communication system V-BLAST, D-BLAST and Alamouti methods are used to improving bit error rate and signal to noise ratio. So In this I am using V-BLAST and D-BLAST algorithms and develop code using BPSK modulation system. For V-BLAST processing algorithms and CCI cancellation has two types of equalizers zero forcing (ZF) and Minimum Mean Square Error (MMSE). For project we use MMSE equalizer using Rayleigh channel. We consider spatial multiplexing systems in correlated multiple-input multiple-output (MIMO) Rayleigh channels with equal power allocated to each transmit antenna.

Keywords: MIMO, OFDM, SNR, BER, Wireless.

1. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) has become a popular technique for transmission of signals over wireless channels. OFDM has been adopted in several wireless standards such as digital audio broadcasting (DAB), digital video broadcasting (DVB-T), the IEEE 802.11a [1] local area network (LAN) standard and the IEEE 802.16a [2] metropolitan area network (MAN) standard. OFDM is also being pursued for dedicated short-range communications (DSRC) for road side to vehicle communications and as a potential candidate for fourth-generation (4G) mobile wireless systems. Orthogonal frequency division multiplexing (OFDM) has become a popular technique for transmission of signals over wireless channels. OFDM has been adopted in several wireless standards such as digital audio broadcasting (DAB), digital video broadcasting (DVB-T), the IEEE 802.11a [1] local area network (LAN) standard and the IEEE 802.16a [2] metropolitan area network (MAN) standard. OFDM is also being pursued for dedicated short-range communications (DSRC) for road side to vehicle communications and as a potential candidate for fourth-generation (4G) mobile wireless systems. OFDM converts a frequency-selective channel into a parallel collection of frequency flat sub channels. The subcarriers have the minimum frequency separation required to maintain orthogonality of their corresponding time domain waveforms, yet the signal spectra corresponding to the different subcarriers overlap in frequency. Hence, the available bandwidth is used very efficiently. If knowledge of the channel is available at the transmitter, then the OFDM transmitter can adapt its signaling strategy to match the channel. Due to the fact that OFDM uses a large collection of narrowly spaced sub channels, these adaptive strategies can approach the ideal water pouring capacity of a frequency-selective channel. In practice this is achieved by using adaptive bit loading techniques, where different sized signal constellations are transmitted on the subcarriers.

OFDM is a block modulation scheme where a block of information symbols is transmitted in parallel on subcarriers. The time duration of an OFDM symbol is times larger than that of a single-carrier system. An OFDM modulator can be implemented as an inverse discrete Fourier transform (IDFT) on a block of information symbols followed by an analog-to-digital converter (ADC). To mitigate the effects of intersymbol interference (ISI) caused by channel time spread, each block of IDFT coefficients is typically preceded by a cyclic prefix (CP) or a guard interval consisting of samples, such that the length of the CP is at least equal to the channel length. Under this condition, a linear convolution of the transmitted sequence and the channel is converted to a circular convolution. As a result, the effects of the ISI are easily and completely eliminated. Moreover, the approach enables the receiver to use fast signal processing transforms such as a fast Fourier transform (FFT) for OFDM implementation [3]. Similar techniques can be employed in single-carrier systems as well, by preceding each transmitted data block of length by a CP of length , while using frequency-domain equalization at the receiver.

2. OFDM

Orthogonal Frequency Division Multiplexing (OFDM) is a popular modulation scheme that is used in wireless LAN standards like 802.11a, g, HIPERLAN/2 and in the Digital Video Broadcasting standard (DVBT). It is also used in the
ADSL standard, where it is referred to as Discrete Multitone modulation. OFDM modulation divides a broadband channel into many parallel sub channels. This makes it a very efficient scheme for transmission in multipath wireless channels. The use of an FFT/IFFT pair for modulation and demodulation make it computationally efficient as well. The transmitted signals arrive at the receiver after being reflected from many objects. Sometimes the reflected signals add up in phase and sometimes they add up out of phase causing a “fade”.

This causes the received signal strength to fluctuate constantly. Also, different sub channels are distorted differently as shown in Figure 1. An OFDM receiver has to sense the channel and correct these distortions on each of the sub channels before the transmitted data can be extracted. OFDM is effective in correcting such frequency selective distortions.

OFDM has many advantages over other transmission techniques. One such advantage is high spectral efficiency (measured in bits/sec/Hz). The “Orthogonal” part of the name refers to a precise mathematical relationship between the frequencies of the sub channels that make up the OFDM system. Each of the frequencies is an integer multiple of a fundamental frequency. This ensures that even though the sub channels overlap they do not interfere with each other. This results in high spectral efficiency. The use of IFFT and FFT for modulation and demodulation results in computationally efficient OFDM modems. The block diagram of an OFDM modulator and demodulator are shown in Figure 2.

The block diagram of an OFDM modem, including the transmitter and the receiver. The IFFT modulates a block of input QAM values onto a number of subcarriers. In the receiver, the subcarriers are demodulated by the FFT, which is the reverse operation of the IFFT. These two operations are almost identical. In fact, the IFFT can be made using an FFT by conjugating input and output of the FFT and dividing the output by the FFT size. This makes it possible to use the same hardware for both the transmitter and the receiver. Of course, this saving in complexity is only possible when the modem does not have to transmit and receive simultaneously, which is the case for the standard. OFDM converts a frequency-selective channel into a parallel collection of frequency flat sub channels. The subcarriers have the minimum frequency separation required to maintain orthogonality of their corresponding time domain waveforms, yet the signal spectra corresponding to the different subcarriers overlap in frequency. Hence, the available bandwidth is used very efficiently. If knowledge of the channel is available at the transmitter, then the OFDM transmitter can adapt its signaling strategy to match the channel. Due to the fact that OFDM uses a large collection of narrowly spaced sub channels, these adaptive strategies can approach the ideal water pouring capacity of a frequency-selective channel. In practice this is achieved by using adaptive bit loading techniques, where different sized signal constellations are transmitted on the subcarriers. OFDM is a block modulation scheme where a block of information symbols is transmitted in parallel on subcarriers. The time duration of an OFDM symbol is times larger than that of a single-carrier system. An OFDM modulator can be implemented as an inverse discrete Fourier transform (IDFT) on a block of information symbols followed by an analog-to-digital converter (ADC). To mitigate the effects of inter symbol interference (ISI) caused by channel time spread, each block of IDFT coefficients is typically preceded by a cyclic prefix (CP) or a guard interval consisting of samples, such that the length of the CP is at least equal to the channel length. Under this condition, a linear convolution of the transmitted sequence and the channel is converted to a circular convolution. As a result, the effects of the ISI are easily and completely eliminated. Moreover, the approach enables the receiver to use fast signal processing transforms such as a fast Fourier transform (FFT) for OFDM implementation [3].
Similar techniques can be employed in single-carrier systems as well, by preceding each transmitted data block of length by a CP of length, while using frequency-domain equalization at the receiver.

3. MIMO (Multiple input Multiple output)

3.1 MIMO Fundamentals

MIMO systems are found to be promising technique for high data rate in wireless communication systems. There are two types of MIMO systems. Space time coding (STC) and spatial multiplexing. We are using spatial multiplexing technique. Which requires MIMO antenna configuration. In spatial multiplexing, a high rate signal is split into multiple lower rate streams and each stream is transmitted from a different transmit antenna in the same frequency channel. If these signals arrive at the receiver antenna array with sufficiently different spatial signatures, the receiver can separate these streams into (almost) parallel channels. Spatial multiplexing is a very powerful technique for increasing channel capacity at higher signal-to-noise ratios (SNR). The maximum number of spatial streams is limited by the lesser of the number of antennas at the transmitter or receiver. Spatial multiplexing can be used with or without transmit channel knowledge. In a typical wireless communication environment, multiple propagation paths often exist from a transmitter to a receiver due to scattering by different objects. Signal copies following different paths can undergo different attenuation, distortions, delays and phase shifts. Constructive and destructive interference can occur at the receiver. The performance of a system (in terms of probability of error) can be severely degraded by fading. Basically MIMO is one of the multiple antenna technology and proven to be suited to fulfill large data rate requirement of modern wireless communication systems. Multiple antenna technologies are

- Single Input Single Output (SISO)
- Single Input Multiple Output (SIMO)
- Multiple Input Single Output (MISO)
- Multiple Input Multiple Output (MIMO).

Out of these first three have some limitations in terms of diversity and system reliability. The fourth one that is MIMO is having increased diversity gain and improved reliability as compared to other and suitable to fulfill high data rate requirement of modern digital communication systems.

When this Different Multiple Antenna Technologies having different gain with transmitting and receiving antennas. Bit stream b(t) is passing through transmitter then transmitter antenna transmit the signal and this signal is receive by receiver antenna and pass through decoded bit stream for output side.

3.2 MIMO Channel

Fading channel is a communication channel comprising fading. In wireless systems, Fading May either be due to multipath propagation, referred to as multipath induced fading. Due to shadowing from obstacles affecting the wave propagation, sometimes referred to as shadow fading. The presence of reflectors in the environment surrounding a transmitter and receiver create multiple paths that a transmitted signal can traverse. As a result, the receiver sees the superposition of multiple copies of the transmitted signal, each traversing a different path. Each signal copy will experience differences in attenuation, delay and phase shift while travelling from the source to the receiver. This can result in either constructive or destructive interference, amplifying or attenuating the signal power seen at the receiver. Strong destructive interference is frequently referred to as a deeply and may be result in temporary failure of communication due to a several drop in the channel signal-to-noise ratio. Mathematically, fading is usually modeled as a time-varying random change in the amplitude and phase of the transmitted signal. Channel fading is one of the degrading features of wireless communication system. Communication through these channels can be difficult. Special techniques may be required to achieve satisfactory performance

3.2.1 Rician fading

It is a stochastic model for radio propagation anomaly caused by partial cancellation of a radio signal by itself the signal arrives at the receiver by several different paths (hence exhibiting multipath interference) and at least one of the paths is changing (lengthening or shortening). Rician fading occurs when one of the paths, typically a line of sight signal is much stronger than the others. In Rician fading, the amplitude gain is characterized by a Rician distribution.

3.2.2 Rayleigh fading

It is the specialized model for stochastic fading when there is no line of sight signal, and is sometimes considered as a special case of the more generalized concept of Rician fading. In Rayleigh fading, the amplitude gain is characterized by a Rayleigh distribution. Rayleigh fading models assume that the magnitude of a signal that has passed through such a transmission medium (also called a communications channel) will vary randomly or fade according to a Rayleigh
distribution the radial component of the sum of two uncorrelated Gaussian random variables.

3.3 MIMO System

For multiplexing To take advantage of the additional throughput capability MIMO utilizes several sets of antennas. In many MIMO systems, just two are used, but there is no reason why further antennas cannot be employed and this increases the throughput. In any case for MIMO spatial multiplexing the number of receive antennas must be equal to or greater than the number of transmit antennas. To take advantage of the additional throughput offered, MIMO wireless systems utilize a matrix mathematical approach. Various schemes that employ multiple antennas at the transmitter and receiver are being considered to improve the range and performance of communication systems. By far the most promising multiple antenna technology today happens to be the so called multiple-input multiple-output (MIMO) system. Various schemes that employ multiple antennas at the transmitter and receiver are being considered to improve the range and performance of communication systems. By far the most promising multiple antenna technology today happens to be the so called multiple-input multiple-output (MIMO) system. MIMO systems employ multiple antennas at both the transmitter and receiver as shown in Figure 3.

They transmit independent data (say \(x_1, x_2, ..., x_N\)) on different transmit antennas simultaneously and in the same frequency band. At the receiver, a MIMO decoder uses \(M \geq N\) antennas. Assuming \(N\) receive antennas, and representing the signal received by each antenna as \(r_j\) we have,

\[
\begin{align*}
R_1 &= h_{11}x_1 + h_{12}x_2 + \ldots + h_{1N}x_N \\
R_2 &= h_{21}x_1 + h_{22}x_2 + \ldots + h_{2N}x_N \\
&\vdots \\
R_N &= h_{N1}x_1 + h_{N2}x_2 + \ldots + h_{NN}x_N
\end{align*}
\]

(1)

As can be seen from the above set of equations in making their way from the transmitter to the receiver, the independent signals \(\{x_1, x_2, ..., x_N\}\) are all combined. Traditionally this “combination” has been treated as interference. However, by treating the channel as a matrix, we can in fact recover the independent transmitted streams \(\{x_i\}\). To recover the transmitted data stream \(\{x_i\}\) from the \(\{r_j\}\) we must estimate the individual channel weights \(h_{ij}\), construct the channel matrix \(H\). Having estimated \(H\), multiplication of the vector \(r\) with the inverse of \(H\) produces the estimate of the transmitted vector \(x\). This is equivalent to solving a set of \(N\) linear equations in \(N\) unknowns. Because multiple data streams are transmitted in parallel from different antennas there is a linear increase in throughput with every pair of antennas added to the system. An important fact to note is that unlike traditional means of increasing throughput, MIMO systems do not increase bandwidth in order to increase throughput. They simply exploit the spatial dimension by increasing the number of unique spatial paths between the transmitter and receiver. However, to ensure that the channel matrix is invertible MIMO systems.

4. MIMO - OFDM System Model

A multicarrier system can be efficiently implemented in discrete time using an inverse FFT (IFFT) to act as a modulator and an FFT to act as a demodulator. The transmitted data are the “frequency” domain coefficients and the samples at the output of the IFFT stage are “time” domain samples of the transmitted waveform. Fig. shows a typical MIMO-OFDM implementation.
Let X={X0, X1, ..., XN-1} denote the length of N data symbol block. The IDFT of the data block X yields the time domain sequence X={x0x1, ..., xN-1} that is

\[ X_n = \text{IFFT}_N[X_k] \quad (n). \]  

(2)

To mitigate the effects of channel delay spread, a guard interval comprised of either a CP or suffix is appended to the sequence. In case of a CP, the transmitted sequence with guard interval is

\[ x_c(n) = x_{GN} \cdot n - G, \ldots, -1, 0, 1, ..., N-1 \]  

(3)

where is the guard interval length in samples, and is the residue of modulo. The OFDM complex envelope is obtained by passing the sequence through a pair of ADCs (to generate the real and imaginary components) with sample rate s, and the analog and signals are converted to an RF carrier frequency. To avoid ISI, the CP length must equal or exceed the length of the discrete-time channel impulse response. The time required to transmit one OFDM symbol is called the OFDM symbol time. The OFDM signal is transmitted over the pass band RF channel, received, and down converted to base band. Due to the CP, the discrete linear convolution of the transmitted sequence with the channel impulse response becomes a circular convolution. Hence, at the receiver the initial samples from each received block are removed, followed by an -point discrete Fourier transform (DFT) on the resulting sequence.

5. MIMO V-BLAST

Wireless communication system having different methods are used and to get improve the result in the form of higher data rate. So many techniques used in MIMO. V-BLAST, D-BLAST and Alamuti are the methods used in MIMO technology. V-BLAST means vertical-bell laboratories layered space time. This method depends on layered space time coding .V-BLAST is connected to receiver side of MIMO system. This is also known as receiver signal processing algorithm. V-BLAST is used to reduced the distortion due to interference from the channel as compared to other techniques V-BLAST is better than D-BLAST and Alamuti techniques in communication.

V-BLAST it first detects the most powerful signal or highest SNR and then it regenerated the received signal from the available channel. V-BLAST having higher spectral efficiency with high power and implementation complexity is low that’s why gets better result in this method. in this project we used V-BLAST method for getting better BER and SNR values as compared to other techniques. V-BLAST method depends on ZF (zero forcing) and minimum mean square error MMSE equalizer. V-BLAST techniques having low complexity then we use ZF VBLAST for recursive four steps ordering, nulling, slicing and cancelling. in this project used V-BLAST method for processing algorithm and CCI cancellation. The MIMO OFDM V-BLAST system operates in the 17 GHz unlicensed frequency band with an available bandwidth of 200 MHz (17.1–17.3 GHz) that is divided into four 50 MHz-width channels not simultaneously selectable. OFDM with L = 128 subcarriers (frequency sub channels) is designed for each of these 50 MHz wide channels. The indoor coverage ranges from 5 m for non line-of-sight to 20 m for line-of sight (LOS). The indoor environment is the ideal rich-10 scattering environment necessary by the V-BLAST processing to get CCI cancellation at the receiver. V-BLAST algorithm with OSIC processing implements a non-linear detection technique based on Zero Forcing (ZF) filtering combined with symbol cancellation to improve the performance.

5.1 V-BLAST Processing Algorithm and CCI cancellation

Theoretically ML detection would be optimal for V-BLAST detection. However, it’s too complex to implement. For example, in the case of 6 transmit antennas and 4-QAM modulation, a total of 4^6 = 4096 comparisons would have to be made for each transmitted symbol. Therefore, V-BLAST performs a non-linear detection that extracts data streams by a ZF or MMSE algorithm w(k) with ordered successive interference cancellation (OSIC). Co Channel Interference traditional approaches require nulling vector being orthogonal to N-I rows of H where as OSIC requires nulling vector being orthogonal to N-i undetected components per iteration i. there are two algorithms are use as follows Zero-Forcing (ZF) is the decor related receiver where H† is Moore-Penrose pseudo inverse of H

\[ w(k) = H^T = (H^*H)^{-1}H^* \]  

(4)

Minimum Mean-Square Error (MMSE) is the maximum SNR receiver

\[ w(k) = [H^*H^T + (M/N)I]^{-1}H^* \]  

(5)

Detection order depends on which subset of (M-i) rows wki should be constrained by since each component of the signal uses the same constellation the component with the smallest ki will dominate the error performance. At each symbol time, it first detects the "strongest" layer (in the sense of SNR and \( \text{Es/No} \) at the receiver branch) then cancels the effect of this strongest layer from each of the received signals and then proceeds to detect the "strongest" of the remaining layers. It is assumed that the receiver perfectly knows the channel matrix H, which can be accomplished by classical means of channel estimation, e.g. insertion of training bits in the transmitted TDMA frames. A low-complexity sub-optimal algorithm for ZF V-BLAST detection consists of four recursive steps described as follows:
Ordering
Determine the optimal detection order corresponds to choosing \( w_{ki} \) the row of \( w(k) \) with Minimum Euclidian norm. \( w(k) \) is referred to as nulling matrix and \( w_{ki} \) as nulling vector.

Nulling:
Use the nulling vector \( w_{ki} \) to null out all the “weaker” signals and obtain the strongest transmitted signal
\[
Y_{ki} = w_{ki}^T r
\]
Slicing:
The estimated value of the strongest transmit signal is detected by slicing to the nearest value in the signal constellation \( A \).
\[
\hat{a}_{ki} = \arg \{ \min \| a - y_{ki} \|_2 \}
\]
Canceling:
Since the strongest transmit signal has been detected (assume \( \hat{a}_{ki} = a_{ki} \)), its effect should be cancelled from the received signal vector to reduce the detection complexity for remaining transmit
\[
r^T r - \hat{a}_{ki} h_{ki}
\]
Iteration: \( i = i + 1 \), and return to step 1 (\( i = 1, \ldots, M-1 \)).

The system works in single-hop ad hoc networks and provides a wireless access for slowly moving users (about 1 m/s) in an indoor environment. The proposed system is a single-TDMA stream scheme (for multiuser operation) capable to handle rates ranging adaptively from 64 kbps to 100 Mbps after variable-rate adaptive modulation is implemented, according to the subcarrier SNR and target BER. In that sense, the system can implement different modulation schemes (BPSK, QPSK, 16-QAM, 64- QAM) and parallel convolution turbo code with rates 1/2, 2/3 and 3/4. The MIMO OFDM V-BLAST system operates in the 17 GHz unlicensed frequency band with an available bandwidth of 200 MHz (17.1–17.3 GHz) that is divided into four 50 MHz-width channels not simultaneously selectable. OFDM with is designed for each of these 50 MHz wide channels. The indoor coverage ranges from 5 m for non line-of-sight to 20 m for line-of-sight (LOS).

The indoor environment is the ideal rich-scattering environment necessary by the V-BLAST processing to get CCI cancellation at the receiver. V-BLAST algorithm with OSIC processing implements a non-linear detection technique based on Zero Forcing (ZF) or MMSE filtering combined with symbol cancellation to improve the performance. The idea is to look at the signals from all the receive antennas simultaneously first extracting the strongest sub-stream from the received signals. To proceeding with the remaining weaker signals, which are easier to recover once the strongest signals have been removed as a source of interference. Transmit space diversity techniques for V-BLAST receiver requires flat fading channel and Rayleigh channel.

5.2 MIMO V-BLAST Transmitter
The transmitter Figure has an array of N-antennas and performs a MIMO vertical encoding (VE). The first step is the encoding of the bit stream from the information source. The coded bits are then mapped to some symbols. It has been established that MIMO is a spectrally efficient modulation technique thus spectral efficiency depends mainly on the bandwidth of the symbol Bs. This depends on the modulation technique used to modulate the individual subcarriers channel. It is the mapping that corresponds to BPSK modulation technique which should minimize Bs. BPSK is the most spectrally efficient system and it is most often used in MIMO systems. The use of the IFFT does not pose a problem as it can take in both real and imaginary inputs of the BPSK symbol. Once the encoded bits are mapped to symbols, the symbol frame is passed through a demultiplexer, representing the space encoding. It maps symbols on the N space channels, which are sub streams of the original frame. Each symbol sub stream is then put through a serial-to-parallel (S/P) converter which takes \( L \) of these symbols as input and produces \( L \) parallel output symbols corresponding to the MIMO sub-band channels. These symbols are put through the IFFT and then transmitted by the antenna \( n (n = 1, 2, \ldots, N) \). Because each input to IFFT corresponds to a OFDM-MIMO subcarrier, at the output we get a time-domain OFDM symbol that corresponds to the input symbols in the frequency domain. In other words, the symbols constitute the frequency spectrum of the OFDM symbol. Once we have the OFDM symbol, a cyclic extension (with length depending on the channel) is
Performed. The final length of the extended OFDM signal will be the length of the original OFDM symbol plus the length of the channel response.

5.3 MIMO Receiver

After the channel, the cyclic extension is removed as it just contains the channel spread (assumed negligible in the simulation). Then the FFT is taken in each of the M receive antennas (V-BLAST requires $M > N$). Each antenna $m$ receives a different noisy superimposition of the faded versions of the $N$ transmitted signals shown Figure. If the transmit and receive antennas are sufficiently spatially separated, more than $l/2$ (at 17 GHz it is about 0.9 cm) and there is a sufficiently rich scattering propagation environment, the transmitted signals arriving at different receive antennas undergo uncorrelated fading. Moreover, if the channel state is perfectly known at the receiver, V-BLAST receiver is able to detect the $N$ transmitted sub streams. The output of the OFDM demodulator, at the receive antenna $m$, is a set of $L$ signals, one for each frequency sub channel, described by

$$h_{m,i} = f_{m,i} \cdot h_{m,i,0}, l, \cdot C_{m,i} + n_{m,i}$$

With $i = 1, \ldots, L$ (9)

where $h_{m,i,0}$ is the flat fading coefficient representing the channel from the transmit antenna $n$ to the receive antenna $m$ at frequency $l$, and $f_{m,i}$ are independent samples of a Gaussian random variable with power spectral density $N_0$ representing noise (where $N_0$ is the power spectral density of the noise at the receiver input). The $M$ outputs for the frequency $l$ are the inputs to a V-BLAST signal processor $l$. This sub-system is able to detect the $N$ different space channels once flat fading is assumed (true because OFDM). This processing is repeated for each of the $L$ sub-bands. The output of the $L$ different VBLAST signal processors is passed through a parallel-to-serial converter (with a multiplexer $N?1$ is included) and the symbols are de mapped and decoded to destination.

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**Figure 6** MIMO V-BLAST Transmitter architecture

**Figure 7** MIMO V-BLAST Receiver architecture
6. Simulation Result

All the coding have been implemented in MATLAB. The proposed method was subjected to various experiments in order to check its accuracy and feasibility. Multiple input multiple output (MIMO) using V-BLAST method are implemented using BPSK modulation. We used MATLAB version simulation software using GUI tools. The simulation flow we have taken source as random signal generated by communication tools in MATLAB. The simulation results for a V-BLAST and D-BLAST MIMO system using BPSK modulation in Rayleigh channel to added AWGN noise for shown in different graphs. This curve the no. of transmitters and receiver antenna is subsequently taking to see the effect on Bit Error Rate. The comparison curves, shows the BER is improving with the increase in number of receivers, and from the result it is clear that MMSE scheme gives best results in V-BLAST method as compared to D-BLAST method in BPSK modulation.

6.1 Main screen

![Main screen](image)

**Figure 8** Main screen

6.2 To apply V-BLAST 4 channels and 128 No. of bit

![MIMO V-BLAST MMSE equalizer](image)

**Figure 9** 2x2 MIMO V-BLAST MMSE equalizer for 4 channel and 128 bits

6.3 To apply D-BLAST 4 channels and 128 No. of bits

![MIMO D-BLAST MMSE equalizer](image)

**Figure 10** 2x2 MIMO V-BLAST MMSE equalizer for 4 channel and 128 bits

6.4 Comparison of V-BLAST and D-BLAST method

![MMSE equalizer with V-BLAST and D-BLAST](image)

**Figure 11** 2x2 MMSE equalizer with V-BLAST and D-BLAST
7. Conclusion
This topic has thoroughly analyzed the performance of the proposed MIMO OFDM V-BLAST system for different antenna configurations and propagation conditions. It has found that V-BLAST can get potentially higher spectral efficiency because no orthogonal transmitted signals and received co-channel signals are separated by decorrelation (processing algorithm) due to multipath. The report has shown that MIMO OFDM V-BLAST systems are capable of improving bit rate without increasing total transmit power or required bandwidth with V-BLAST processing at the receiver as an efficient CCI cancellation technique. Further research would describe the effect –under different array configurations and propagation conditions- of MMSE filtering in V-BLAST processing, Trellis encoding and Viterbi decoding, and variable-rate variable-power adaptive modulation schemes in the MIMO OFDM V-BLAST analyzed in this study.

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