IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

IJARSCT
Impact Factor: 7.301

Volume 3, Issue 1, April 2023

Performance Improvement of MIMO-OFDM System using V-Blast and STBC Technique

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Abstract: *MIMO-OFDM is a key technology for next-generation wireless communications (3GPP-LTE, Mobile WiMAX, IMT-Advanced) as well as wireless LAN (IEEE 802.11a, IEEE 802.11n), wireless PAN (MB-OFDM), and broadcasting (DAB, DVB, DMB). In MIMO-OFDM Wireless Communications with MATLAB. In this paper 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, V-BLAST

I. INTRODUCTION

Orthogonal frequency-division multiplexing (OFDM) is a digital communication technique and 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), LTE, fifth-generation (5G) 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. This sampled digital signal enables the discrete Fourier spectrum to exist only for discrete frequencies. Each OFDM carrier matches to at least one of the discrete Fourier spectrum component.

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. 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].Multiple antennas can be used at the transmitter and receiver, an arrangement called a multiple-input multiple- output (MIMO) system. A MIMO system takes advantage of the spatial diversity that is obtained by spatially separated antennas in a dense multipath scattering environment. MIMO systems may be implemented in a number of different ways to obtain either a diversity gain to combat signal fading or to obtain a capacity gain. Simulation results are obtained using Matlab2020A.

II. METHODOLOGY

2.1 Orthogonal Frequency Division Multiplexing (OFDM)

A. OFDM Concepts

OFDM is a special case of multi-carrier modulation.Orthogonal Frequency Division Multiplexing (OFDM) is a popular modulation scheme that is used in wireless LANstandards like 802.11a, g, HIPERLAN/2 and in the Digital Video Broadcasting standard (DVBT).The merits of this technique that make it a preferred choice over other modulation techniques are;1) It has high spectral efficiency.2) Easy implementation of FFT.3) Low receiver complexity.4) Its robustness for high-data rate transmission over multipath fading channel.5) Its high flexibility for link adaptation are few advantages to list. But every coin has two sides and same principle apply to this technique too.

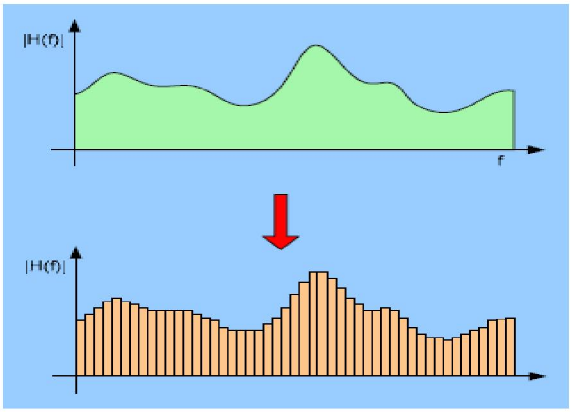

Figure 1 Sub-channel Distorted Differently

Different Sub-channels are distorted differently as shown in Figure. 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,

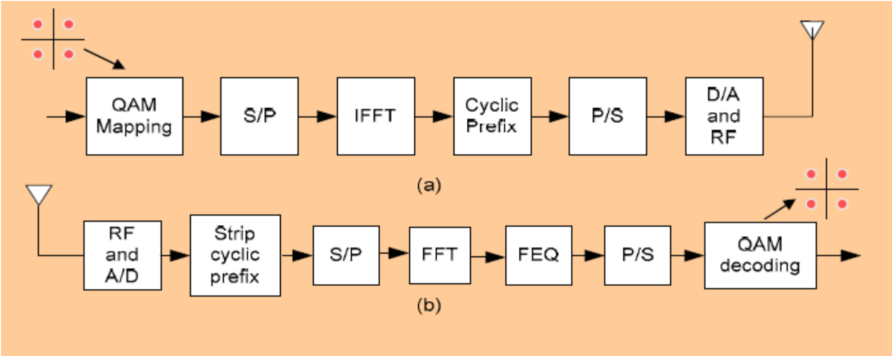

Figure 2 Block diagram of OFDM

The block diagram of an OFDM multiplexing modem, including the transmitter and the receiver. 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. An OFDM modulator can be implemented as an IDFT on a block of information symbols followed by an (ADC)converter Moreover, the approach enables the receiver to use fast signal processing transforms such as a FFT for OFDM implementation.

III. MIMO (MULTIPLE INPUT MULTIPLE OUTPUT)

3.1 MIMO Basics

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

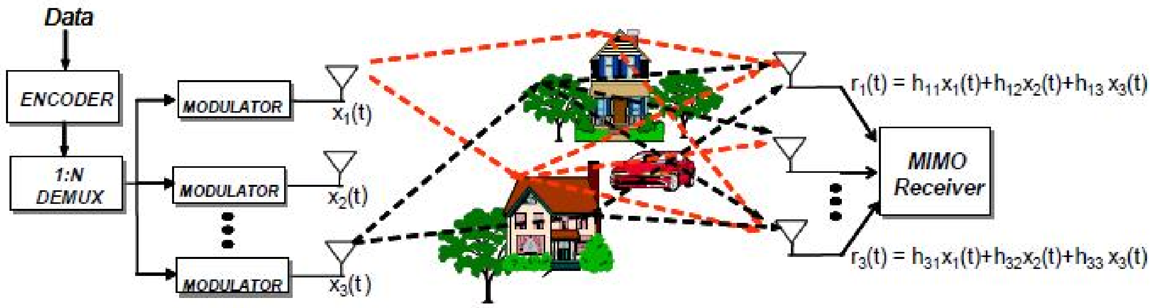

Figure 3 MIMO System

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 Outputs (MIMO)

They transmit independent data (say *x1, x2,..,xN*) on different T_x antennas simultaneously and in the same frequency band At the receiver, a MIMO decoder users M≥N antennas. Assuming N receive antennas, representing the signal received by each antenna as *rj*wehave:

$$
\begin{aligned}
r_1 &= h_{11}x_1 + h_{12}x_2 + \cdots + h_{1N}x_N \\
r_2 &= h_{21}x_1 + h_{22}x_2 + \cdots + h_{2N}x_N \\
&\vdots \\
r_N &= h_{N1}x_1 + h_{N2}x_2 + \cdots + h_{NN}x_N
\end{aligned}
$$

From the above set of equations, in making their way from the transmitter to the receiver, the independent signals {x1, x2, xN} are all combined. Traditionally this "combination" has been treated as interference. To recover the transmitted datastream *{xi}* from the *{rj}* we must estimate the individual channel weights *hij*, construct the channel matrix ***H***.

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. As a result, the receiver sees thesuperposition of multiple copies of the transmitted signal, each traversing a different path. Communication through these channels can be difficult Special techniques may be required to achieve unexceptional performance.

3.2.1 Rayleigh fading Rayleigh fading is a statistical model for the effect of a propagation environment on a radio signal, such as that used by wireless devices. Rayleigh fading is most applicable when there is no dominant propagation along a line of sight between the transmitter and receiver.

3.2.2 Rician fading 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. It occurs when one of the paths, typically a line of sight signal or some strong reflection signals, is much stronger than the others.

IV. 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. 1 shows a typical MIMO-OFDM implementation.

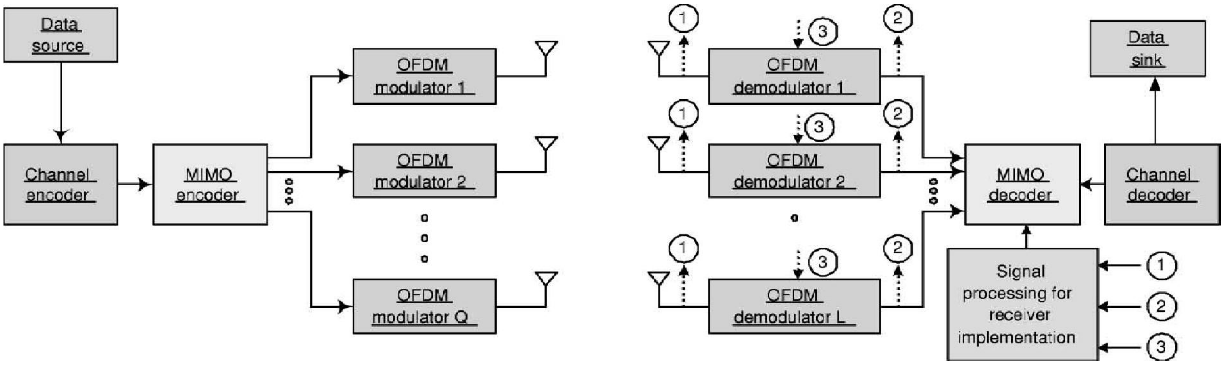

Figure 4 Atypical MIMO-OFDM implementation.

Let $\mathbf{X} = \{X_0, X_1, \ldots, X_{N-1}\}$ denote the length-N data symbol block. The IDFT of the date block $\mathbf{X}$ yields the time domain sequence $\mathbf{x} = \{x_0, x_1, \ldots, x_{N-1}\}$, i.e.,

$$x_n = \text{IFFT}_N\{X_k\}(n). \qquad (1)$$

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, Where,the OFDM complex envelope is obtained by passing the sequencethrough a pair of ADCs with sample rate s,and the analog and signals are

$$x_n^g = x_{(n)_N},\ n = -G, \ldots, -1, 0, 1, \ldots, N-1 \qquad (2)$$

upconverted to an RF carrier frequency. 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.

V. MIMO V-BLAST System Model

Although various implementation architectures for Multiple-Input Multiple -Output (MIMO) systems have been introduced since the BLAST (Bell Laboratories layered Space-Time) system was proposed in and, a variation of such system, V-BLAST still emerges as a promising architecture due to lower receiver complexity and higher data rates in the case of large number of antennas. This report considers a V-BLAST system with N transmit and $M = N$ receive antennas.

5.1 V-BLAST Processing and CCI cancellation

Theoretically, ML detection would be optimal for VBLAST detection. However, it's too complex toimplement. For example, in the case of 6 transmit antennas and 4-QAM modulation, a total of 46= 4096 comparisons would have to be made for each transmittedsymbol. Therefore, V-BLAST performs a non-lineardetection that extracts data streams by a ZF (or MMSE)filter w (k) with ordered successive interference cancellation (OSIC). A low-complexity sub-optimal algorithm for ZF VBLASTdetection consists of four recursive stepsdescribe as follows:

1. Ordering: Determine the optimal detectionordercorresponds to choosing **w**kithe row of **w**(k) withminimum Euclidian norm. **w**(k) is referred to as nullingmatri x and **w**kias nulling vector.
2. Nulling: Use the nulling vector **w**kito null out allthe"weaker" signals and obtain the "strongest" (highSNR) transmitted signalyki= **w**kiT**r.**
3. Slicing: The estimated value of the strongest transmit signal is detected by slicing to the nearest valuein the signal constellation **A**.âki= arg {min ||a –yki||2}.
4. Canceling: Since the strongest transmit signal hasbeen detected (assume âki=aki), its effect should be cancelled from the received signal vector to reduce thedetection complexity for remaining transmit Iteration: I= i+ 1, and return to step 1 (i = 1, …M-1).

The proposed system is a single-TDMA stream scheme (for multiuser operation) capable tohandle 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 MIMOOFDM 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. The indoor environment is the ideal rich-scattering environment necessary by the V-BLAST processing to get CCIcancellation at the receiver. V-BLAST algorithm with OSIC processing implements a non-linear detection techniquebased on Zero Forcing (ZF) or MMSE filtering combined with symbol cancellation to improve the performance.

5.2 Transmitter

The transmitter figure, has an array of *N*-antennas and performs a MIMO vertical encoding (VE).

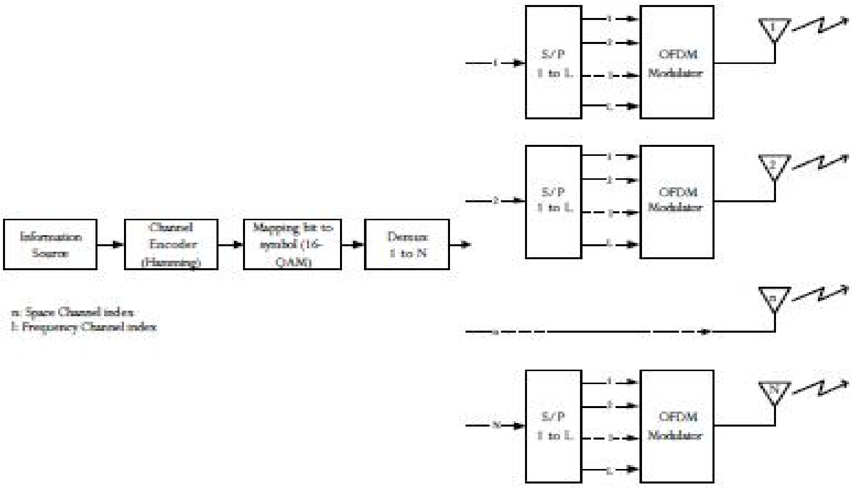

Figure 3 MIMO OFDM Transmitter

The first step is the encoding of the bit stream from the information source (TDMA frame for multiuser operation). The coded bits are then mapped to some symbols. It has been established that OFDM is a spectrally efficient modulation technique, thus spectral efficiency depends mainly on the bandwidth of the symbol, *Bs*.M-QAM is the most spectrally efficient system and it is most often used in OFDM systems. Once the encoded bits are mapped to symbols, the symbol frame is passed through a demultiplexer (1? *N*) Representing the space encoding. 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 OFDM 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 subcarrier, at the output we get a time-domain OFDM symbol that corresponds to the input symbols in the frequency domain. Once we have the OFDM symbol, a cyclic extension is performed.

5.3 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* ³ *N*). 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,

$$r_{m,l} = \sum_{n=1}^{N} h_{m,n,l} \cdot C_{n,l} + \eta_{m,l}, \quad \text{with } l = 1, \ldots, L,$$

where *hm,n,l* is the flat fading coefficient representing the channel from the transmit antenna *n* to the receive antenna *m* at frequency *l*, and *hm,l* are independent samples of a Gaussian random variable with PSD *N0* representing noise. The *M* outputs for the frequency *l* are the inputs to a V-BLAST signal processor *l*. 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 inclued) and the symbols are de-mapped and decoded to destination.

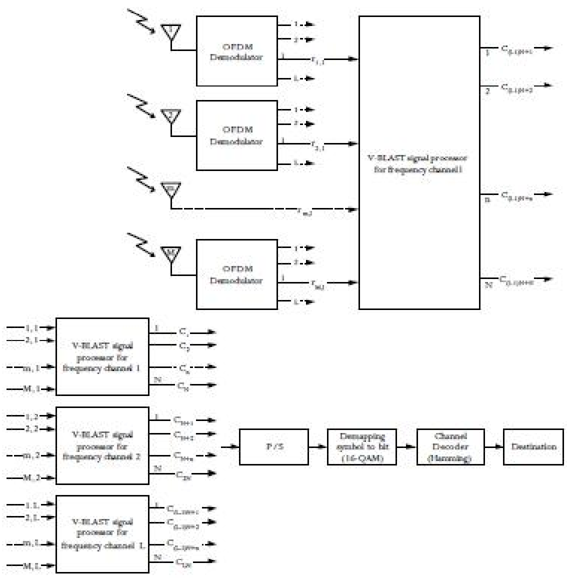

Figure 4. MIMO OFDM Receiver

VI. RESULTS AND DISCUSSION

6.1 Simulation Results

All the coding are implemented in MATLAB. The proposed method was subjected to various experiments in order to check its accuracy and feasibility. MIMO using V-BLAST method are implemented using BPSK modulation.

Here, 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

Figure 5. Main screen

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ISSN (Online) 2581-9429

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Volume 3, Issue 1, April 2023

Impact Factor: 7.301

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

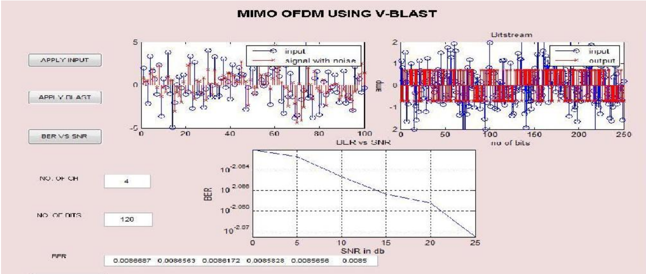

Figure 6.2×2 MIMO V-BLAST MMSE equalizer for 4 channel and 128 bits

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

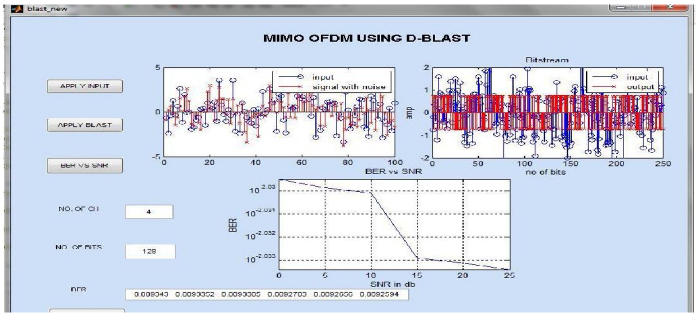

Figure 7. 2×2 MIMO V-BLAST MMSE equalizer for 4 channel and 128 bits

6.4 Comparison of V-BLAST and D-BLAST method

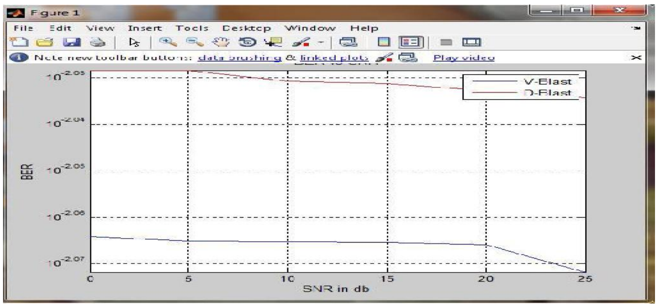

Figure 8.2×2 MMSE equalizer with V-BLAST and D –BLAST

VII. CONCLUSION

This project 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 noorthogonal transmitted signals and received co-channel signals are separated by de-correlation (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.We can see from result that V-BLAST technique is better than STBC 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. Thus we have obtained better bit error rate using V-BLAST technique as compared to all other techniques

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