VIDEO TRANSMISSION IN V-BLAST ENCODED MIMO MC-CDMA WIRELESS SYSTEM: PERFORMANCE STUDY

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ABSTRACT

In this paper, the bit error rate (BER) performance study on video transmission in a V-BLAST encoded 2×2 MIMO MC-CDMA wireless communication system has been made. The system deploys two channel encoding schemes (1/2-rated Convolution and CRC) under four digital modulations (BPSK, DPSK, QPSK and QAM) and zero forcing (ZF) channel detection method. It is apparent that the BPSK modulation outperforms as compared to DPSK, QPSK and QAM modulation schemes in V-BLAST based MIMO MC-CDMA communication system under AWGN channel. The 16QAM digital modulation shows worst performance in video transmission as compared to other low order digital modulations. It is obvious from the present MATLAB based simulation study that the V-BLAST encoded 2×2 MIMO MC-CDMA wireless system with the deployment of ZF signal detection and ½-rated Convolution and CRC channel coding schemes shows superior performance using BPSK digital modulation in video transmission.

KEYWORDS

MIMO,V-Blast, MC-CDMA, ZF, BER, Signal to Noise Ratio (SNR), Video Transmission

1. INTRODUCTION

With the fast development in wireless communication techniques along with mobile internet and multimedia services, the demand for high data rate transmission is increased significantly. The reliable transmission of data through wireless channels offer great challenge including fading, interference and multipath propagation [1,2].

As the demand for multi-user communication such as cellular systems is increasing, it is required to have multiple access capability to transmit multiple signals simultaneously through the channel. In recent years, a new transmission technique called Multicarrier - Code Division Multiple Access (MC-CDMA) [3,4] which is the combination of Code - Division Multiple-Access (CDMA) [5] and Orthogonal Frequency Division Multiplexing (OFDM) has become most promising data transmission scheme in wireless communications. This multicarrier transmission scheme has received great attention because these combined systems possess many desirable properties for high data rate and efficient data transmission over wireless channels. The major advantage of the multicarrier technique is that it needs a lower symbol rate as compared to other transmission techniques. With a multicarrier CDMA system, for N carriers, the whole

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bandwidth of the system is divided into N sub-bands hence the symbol rate for each subcarrier can be made low.

MC-CDMA technique combines the capabilities of both OFDM and CDMA schemes to provide a communication system which has the advantages of both. This combined scheme has become attractive for broadband communications due to the parallel transmission nature of OFDM technique and has the ability to provide larger capacity and flexibility of resource allocation due to advanced allocation technique of CDMA. Another important property of MC-CDMA is that it is bandwidth efficient [6] due to the use of OFDM. In OFDM, the modulation or demodulation can be performed easily by using IFFT or FFT algorithms respectively [7]. MC-CDMA is a suitable candidate for the downlink of a cellular system because of having high spectral efficiency. The main advantages of the MC-CDMA system are that improve the reliability and performance of wireless radio links and the signal offered to the receiver contains not only a direct line-of-sight radio wave, but also a large number of reflected radio waves [8].

Multiple-input multiple-output, or MIMO, is a radio communications technology or RF technology, is used by Wi-Fi, LTE; Long Term Evolution, and many other radio, wireless and RF technologies to provide increased link capacity and spectral efficiency combined with improved link reliability using what were previously seen as interference paths [9]. Such technologies incorporate different types of multi-antenna techniques such as Alamouti space-time coding for transmit diversity, Eigen beam forming spatial multiplexing, BLAST spatial multiplexing architectures, Conventional beam and null forming and Conventional receive diversity. Under BLAST spatial multiplexing(SM) architectures, three Bell Laboratory layered space-time (BLAST) SM techniques have been known as Vertical BLAST (V-BLAST), Horizontal BLAST (H-BLAST) and Diagonal BLAST (D-BLAST) [10,11]. The study in [12] investigates the performance of D-BLAST architecture with 4 x 4 antenna configuration for a LDPC encoded MC-CDMA wireless communication system on secure color image transmission. The aim of this paper is to investigate the bit error rate (BER) performance of V-BLAST architecture with 2 x 2 antenna configuration for MC-CDMA wireless communication system with the employment of 1-2-rated convolution and CRC channel coding and Zero Forcing (ZF) signal detection schemes under different digital modulation techniques (BPSK, DPSK, QPSK, and 16QAM) on video transmission.

The paper is organized as follows. Section 2 presents a literature review of related works. Description of system model is given in Section 3. Section 4 provides the simulation results and discussion. Finally Section 5 concludes the work.

2. Related Works

Performance of encrypted color image transmission in a D-BLAST Aided LDPC encoded MC-CDMA wireless communication system is studied in Ref. [12]. The authors concluded that the implementation of QAM digital modulation technique with deployment of MMSE-SIC channel equalization technique provides satisfactory result as compared with MMSE, ZF, and ZF-SIC for such a LDPC encoded MC-CDMA system. Naznin *et al*. [13] shown that the implementation of MMSE-SIC signal detection scheme with utilization of 4QAM digital modulation schemes ratifies the robustness of LDPC encoded and MP-WFRFT based physical layer security scheme implemented MIMO wireless communication system in retrieving color image transmitted over noisy and Rayleigh fading channels.

Authors in [2] analyzed the performance of the image transmission through MC-CDMA system where they concluded that the MC-CDMA image transmission system having chaotic interleaving with LMMSE equalization transmits image efficiently as compared to system having helical interleaving with LMMSE. Kushwah *et al*. [14] investigated the performance of MIMO MC-CDMA system in Rayleigh fading environment in QPSK, 8PSK, 8QAM, 16QAM, 32QAM and 64QAM modulation technique. They showed that the performance of MIMO MC-CDMA using QPSK modulation technique outperforms other modulation techniques with very low probability of error and high gain.

An Extensive Survey on MIMO Technology using V-BLAST detection technique is presented in [15]. The performance of a MIMO MC-CDMA wireless communication system with the implementation of spatial domain noise reduction techniques and MMSE signal detection for transmitting and retrieving of color image signal is studied in [16]. They concluded that with MMSE signal detection, Median Filter outperforms than that of Order Statistic Filter.

The performance analysis of uplink MIMO MC-CDMA systems based on linear zero-forcing V-BLAST algorithm is presented in [17]. The authors shown that the MIMO MC-CDMA system based on linear ZF V-BLAST algorithm is capable of achieving better BER performance than that of the conventional MC-CDMA system by reducing the number of transmit antennas or increasing the number of receive antennas.

A comprehensive performance study was made on a V-BLAST encoded MIMO MC-CDMA wireless communication system on encrypted synthetically generated binary data transmission using Minimum Mean Square Error (MMSE) and Zero- Forcing (ZF) Linear channel equalization schemes [18]. They noticed that the ZF with ½-rated Convolution coding scheme is superior as compared to MMSE with CRC coding scheme for BPSK digital modulation. Author in [19] studied the performance of 4×4 MIMO MCCDMA system on video signal transmission with implementation of various digital Signal processing techniques and shown that MMSE signal detection scheme shows quite satisfactory performance.

3. SYSTEM MODEL

The simulated model of a multi-user 2 x 2 Vertical Bell Labs Layered Space-Time (V-BLAST) spatially multiplexed encoded MC-CDMA Wireless Communication System is depicted in Fig. 1. A video signal is captured for 5 second. In such a communication system, first a captured video is converted into particular number of image frames (in this case 141). Each of the frames are encrypted two times using Vigenere Cipher and RSA cryptographic algorithm Encryption Scheme.

The doubly encrypted data are converted into binary bits and channel encoded using ½-rated Convolutional encoding and CRC scheme. To minimize the burst errors the encrypted data are interleaved. Interleaving are used for Combating bursts of errors. Different types of digital Modulation scheme are used such as, Binary phase shift keying(BPSK), Quadrature phase shift keying (QPSK), Differential phase shift keying(DPSK) and Quadrature Amplitude Modulation (QAM) to modulate the interleaved bits and spatially multiplexed using V- BLAST scheme to produce four independent data streams [19]. The number of digitally modulated symbols is increased in coping section (as the processing gain of the Walsh Hadamard codes is eight) and subsequently multiplied with Walsh Hadamard codes. The digitally modulated symbols of the Walsh-Hadamard coded are fed into the Vertical Bell Labs Layered Space-Time (V-BLAST) encoder.

In the encoding portion, a single complex signal stream is multiplexed in space over multiple antennas. The output of the Vertical Bell Labs Layered Space-Time (V-BLAST) encoder fed into the four serial to parallel converter, Each data stream are serial to parallel converted .The output of the serial to parallel converter generate a complex data symbol which are fed into each of the OFDM modulator with 1024 subcarrier which perform IFFT on each of the OFDM system are followed by a parallel to serial conversion. To mitigate the effects of inter-symbol interference (ISI) caused by channel time spread, each block of IFFT coefficients is typically preceded by a cyclic prefix. The modulated complex symbols are parallel to serial converted and transmitted.

In receiving section, all the transmitted signals are detected with zero forcing (ZF) linear signal detection scheme and the detected signals are subsequently sent up to the serial to parallel(S/P) converter and fed into OFDM demodulator which performs FFT operation on each OFDM block. The FFT operated OFDM blocked signal are processed with cyclic prefix removing scheme and are undergone from parallel to serial conversion and are fed into Vertical Bell Labs Layered Space-Time (V-BLAST) decoder. Its output is multiplied with Walsh Hadamard codes. The multiplexed data are digitally demodulated, de-ciphered, de-interleaved, channel decoded and decrypted to recover the transmitted image frames.

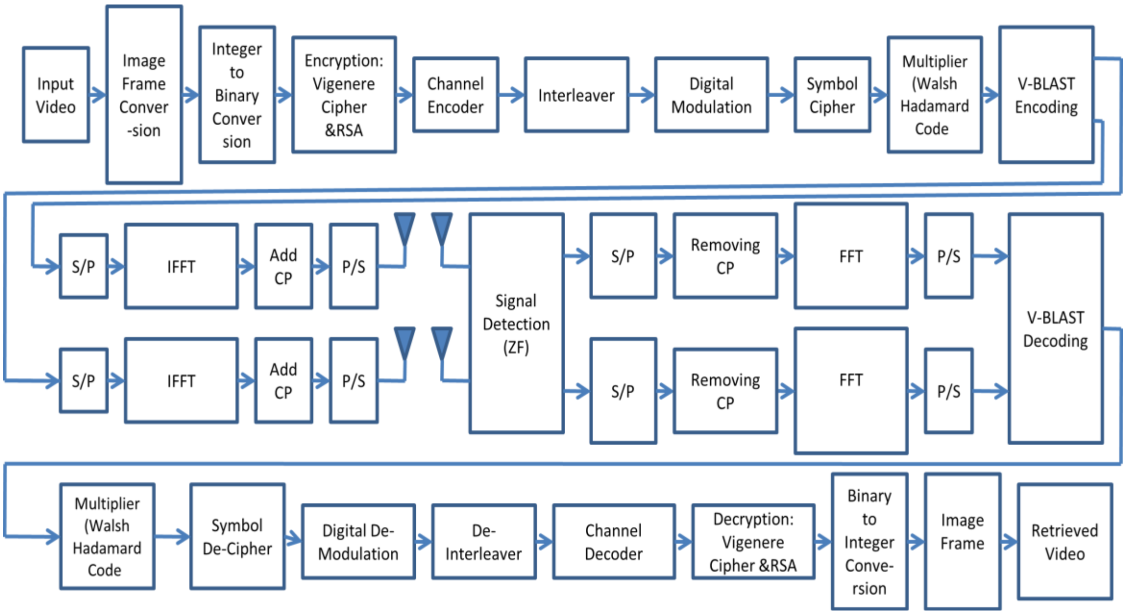

Figure 1. Block diagram of a V-Blast encoded MIMO MC-CDMA wireless Communication system model.

4. RESULT AND DISCUSSION

This section presents all the results obtained by the computer simulation for a 2×2 V-BLAST encoded MIMO MCCDMA system with the implementation of different digital modulation schemes under Convolution and CRC channel coding with the Zero-Forcing (ZF) signal detection scheme for video signal transmission. The simulation is performed on Matlab platform following the theoretical approach of a wireless communication system, taking into account the following simulation parameters as shown in Table 1.

The system's performance results are expressed in terms of the bit error rate (BER) as a function of signal to noise ratio (SNR) and are presented in graphical form for the selected image frame numbers of 1, 31, 71, 101 and 141 in Figures 2 to 6, respectively. These graphs show a comparison of the performance of different low order digital modulation schemes (BPSK, DPSK, QPSK and 10QAM) which are employed in simulated communication system for video data transmission.

Figure 2 shows the BER performance of 2×2 V-BLAST MIMO MCCDMA system for 1st image frame with BPSK, DPSK, QPSK and 16QAM digital modulation scheme under Convolution and CRC channel coding with Zero-Forcing (ZF) signal detection scheme. It is obvious that the system outperforms in BPSK and shows worst performance in 16-QAM modulation. The difference in BER values is very clear in lower SNR regions; the BER values decreases with increasing SNR and vice-versa. For BPSK and 16-QAM modulation, the BER values in Fig. 1 are 0.1931 and 0.4641, respectively for a SNR value of 3 dB which implied the simulated V-BLAST MIMO-MCCDMA wireless communication system achieves improved performance gain of 11.91 dB with the employment of BPSK modulated.

Table1. Summary of the simulated model parameters.

Parameter	**Value**
Data Type	Video Signal
Video size	5,372,219 bytes
Number of Inage frames	141
Channel Coding	½-rated Convolution and CRC
Modulation	BPSK, DPSK, QPSK, 16QAM
Cryptographic algorithm	Vigenere Cipher and RSA
Antenna configuration	2× 2
Channel	AWGN
Signal to noise ratio, SNR	0 to 10 dB
Spreading Code	Walsh Hadamard
Signal detection	ZF

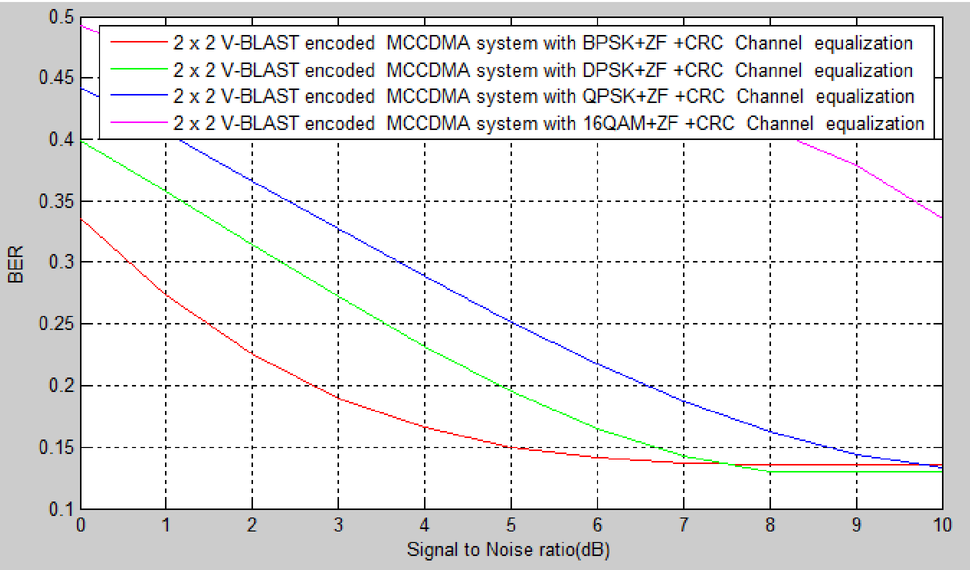

Fig. 2 BER performance of 2×2 MIMO MCCDMA system for 1st image frame with implementation of different digital modulation scheme under Convolution and CRC channel coding with ZF signal detection scheme.

The BER performance of 2×2 V-BLAST MIMO MCCDMA system for 31st image frame with BPSK, DPSK, QPSK and 16QAM digital modulation scheme under Convolution and CRC channel coding with ZF signal detection scheme is shown in Fig. 3. It shows that the BPSK-modulated system achieves a performance gain of 12.09 dB at an SNR value of 3 dB; the BER values for BPSK and 16QAM are found to be 0.1850 and 0.4712, respectively. The lowest order BPSK modulated system shows best performance in video signal transmission as compared to other modulations under consideration.

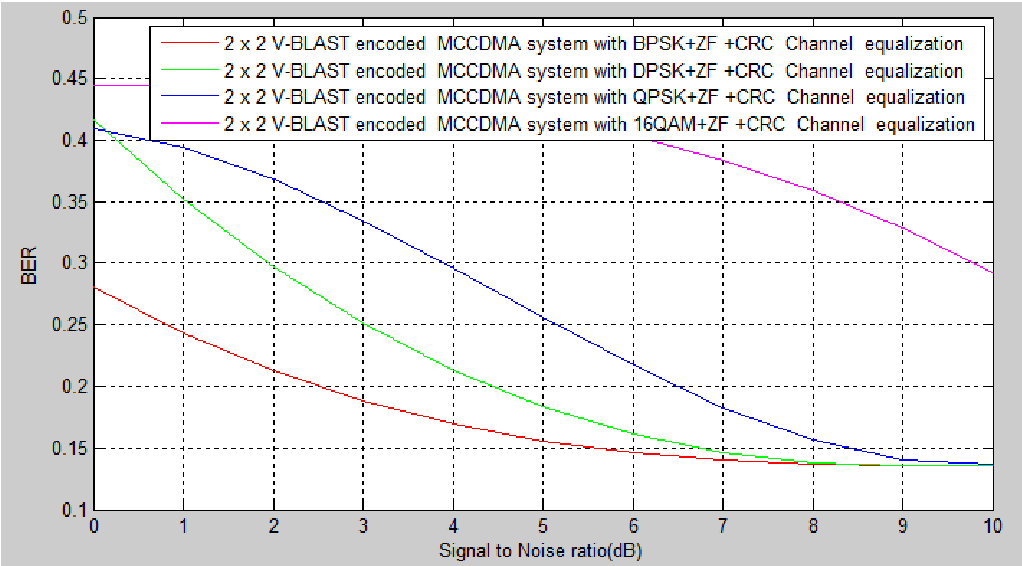

Fig. 3 BER performance of 2×2 MIMO MCCDMA system for 31st image frame with implementation of different digital modulation scheme under Convolution and CRC channel coding with ZF signal detection scheme.

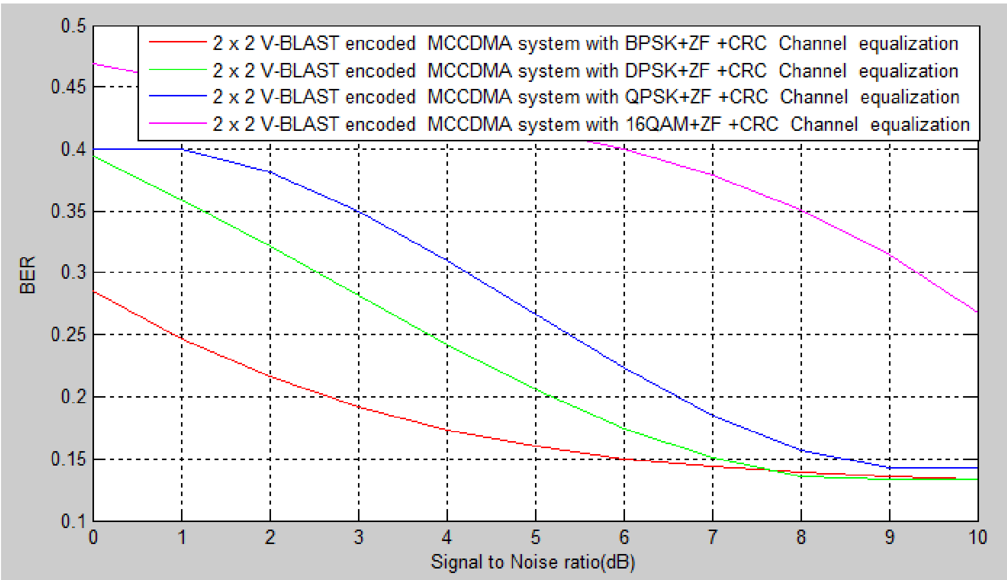

Fig. 4 BER performance of 2×2 MIMO MCCDMA system for 71st image frame with implementation of different digital modulation scheme under Convolution and CRC channel coding with ZF signal detection scheme.

A similar performance result (as for the 1st and 31st frames) is obtained for the 71st image frame as shown in Fig. 4. It shows that the BER values for a SNR value of 3 dB are 0.1979 and 0.4508 for BPSK and 16QAM digital modulations, respectively which implies that the system achieves a performance gain of 11.80 dB with BPSK modulation in video data transmission.

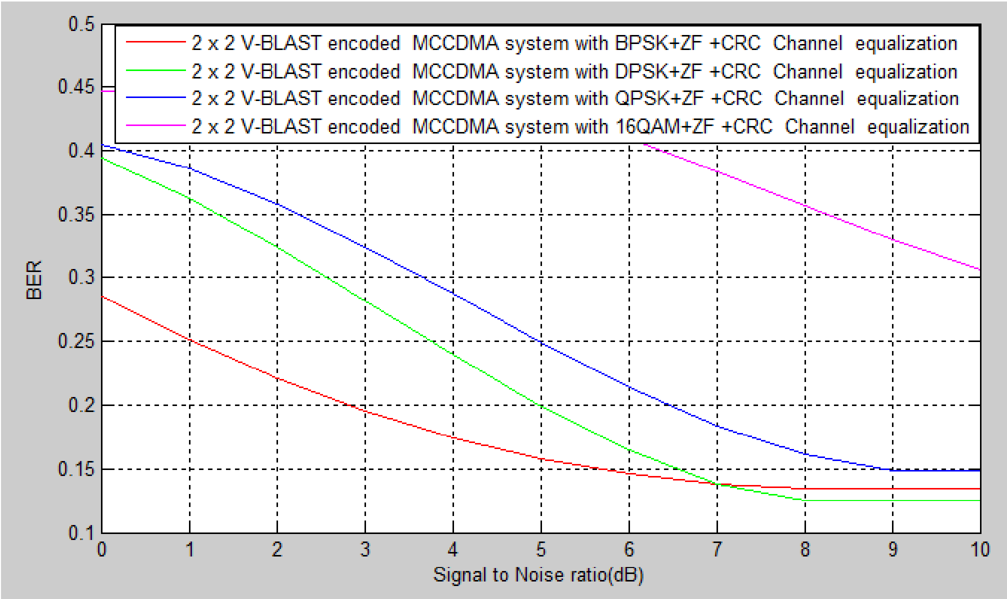

Fig. 5 BER performance of 2×2 MIMO MCCDMA system for 101st image frame with implementation of different digital modulation scheme under Convolution and CRC channel coding with ZF signal detection scheme.

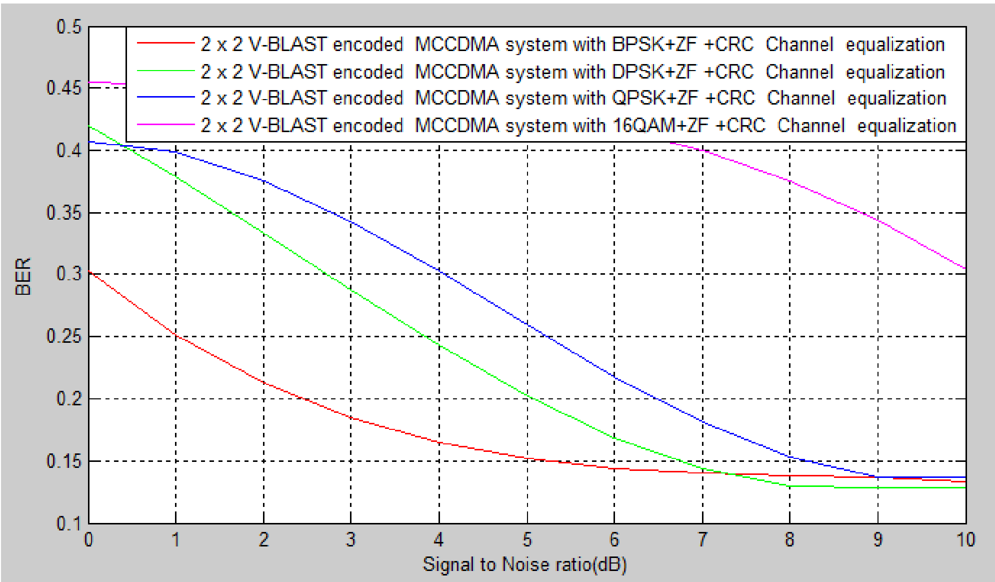

Fig. 6 BER performance of 2×2 MIMO MCCDMA system for 141st image frame with implementation of different digital modulation scheme under Convolution and CRC channel coding with ZF signal detection scheme.

Figure 5 shows the BER performance result of 2×2 V-BLAST MIMO MCCDMA system for 101st image frame with different digital modulation schemes. It is seen that the system outperforms in BPSK and shows worst performance in 16QAM modulation. The BER values decreases with increasing SNR and vice-versa. For BPSK and 16QAM modulation, the BER values are 0.1931 and 0.4641, respectively for a 3 dB SNR value which indicates that the system achieves a performance gain of 11.99 dB with BPSK modulation.

The BER dependence of for the 2×2 V-BLAST MIMO MCCDMA system for the 141st image frame is shown in Fig. 6. It is observed that for the SNR value of 3 dB, the system's performance attains gain of 11.89 dB, 10.25 dB, 9.55 dB and 8.11 dB with BPSK, DPSK, QPSK and 16QAM modulation schemes, respectively which indicate that the BPSK modulated V-BLAST MIMO MCCDMA system shows best performance in video data transmission.

From the above comparative analysis of the BER performance results under BPSK, DPSK, QPSK and 16QAM modulation, it is clear that the implementation of BPSK digital modulation scheme with the deployment of convolution and CRC channel encoding and the ZF signal detection scheme in V-BLAST MIMO MCCDMA wireless communication system provides satisfactory results in video data transmission.

The BER values of the V-BLAST MIMO MCCDMA system at a fixed SNR of 3dB for different modulation schemes at the selected image frames of the video signal are summarized in Table 2. It is evident that the BER values for the BPSK modulated system is lowest while that of the 16QAM modulation is highest for each of the image frames. These simulation results show that the BPSK modulated V-BLAST MIMO MCCDMA system with the employment of convolution and CRC channel encoding and ZR signal detection technique outperforms in video data transmission while the 16QAM modulated system shows worst performance.

Table 2. BER values at SNR of 3dB for BPSK, DPSK, QPSK and 16 QAM modulations at selected frame numbers of the transmitted video signal.

	BER Values for different modulations			
Frame Number	**BPSK**	**DPSK**	**QPSK**	**16QAM**
1	0.1931	0.2763	0.3354	0.4641
11	0.1929	0.2895	0.3366	0.4404
21	0.1779	0.2569	0.3283	0.4497
31	0.185	0.2798	0.33	0.4712
41	0.1943	0.2545	0.34	0.449
51	0.1975	0.282	0.3266	0.4501
61	0.2002	0.2743	0.3497	0.4375
71	0.1979	0.2831	0.3445	0.4508
81	0.1912	0.2818	0.3164	0.4158
91	0.1889	0.2726	0.3608	0.4435
101	0.1897	0.2784	0.3299	0.4501
121	0.1941	0.2762	0.3434	0.4683
131	0.1969	0.2743	0.3409	0.447
141	0.194	0.2831	0.3328	0.4634

5. CONCLUSIONS

In this paper, the performance of V-BLAST encoded 2×2 MIMO MC-CDMA wireless communication system has been investigated based on their bit error rates and signal-to-noise ratio on video transmission with the employment of ½-rated convolution and CRC channel coding and ZF signal detection scheme under BPSK, DPSK, QPSK and 16-QAM digital modulation schemes. The MTALAB based simulation results shown that the BPSK modulation outperforms while the 16QAM shows worst performance as compared to other modulations in video signal transmission over the system. It can be concluded that the deployment of BPSK digital modulation technique with the ZF signal detection scheme and ½ rated convolution and CRC channel encoding in V-Blast encoded 2×2 MIMO MC-CDMA system provides satisfactory performance in retrieving transmitted video signal over AWGN channel.

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