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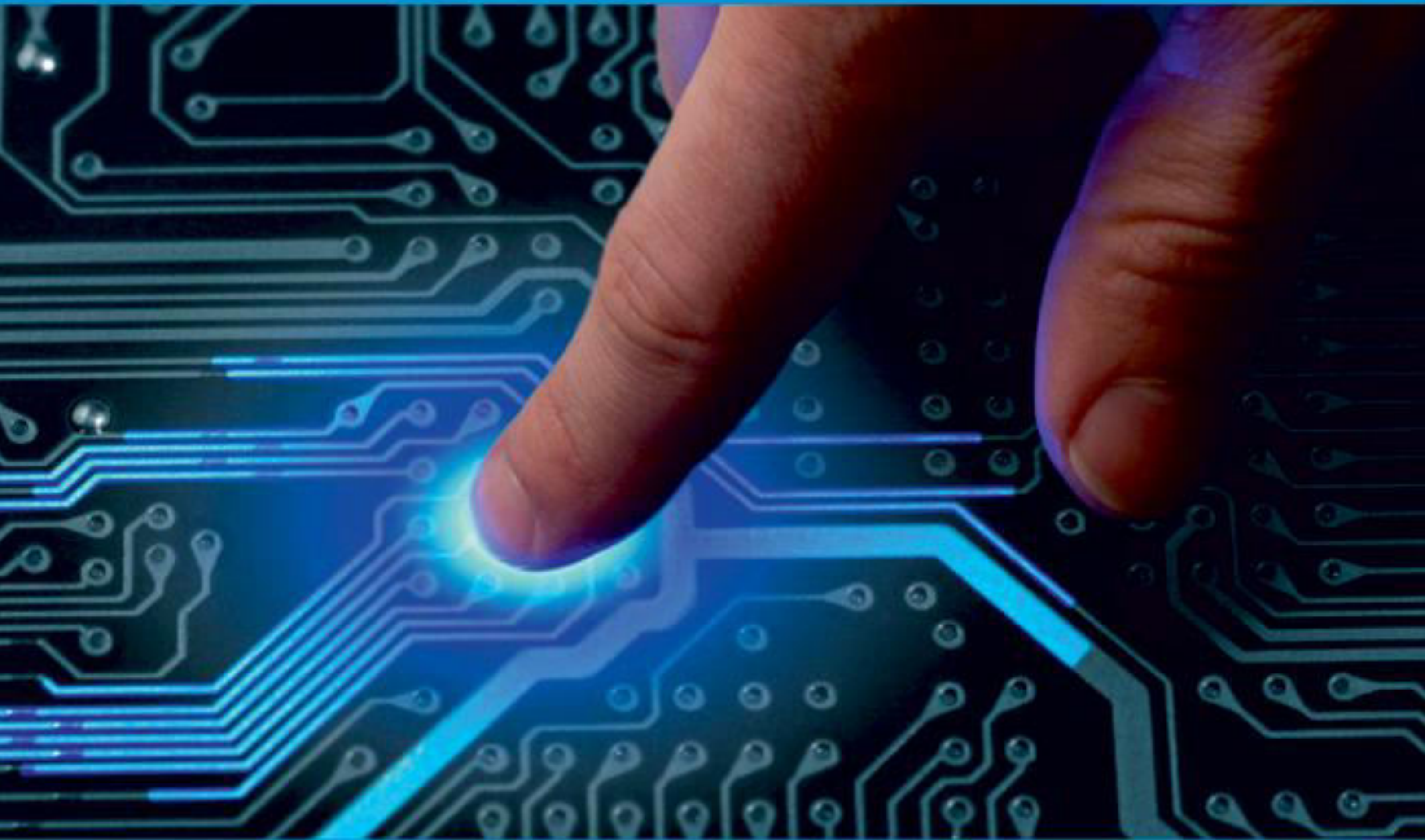

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MIMO-OFDM with Alamouti Space-Time Coding

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ABSTRACT: This paper refers to MIMO-OFDM (multiple input multiple output orthogonal frequency-division multiplexing) system studies in the fourth-generation mobile communication. We have designed two schemes, one is two transmit antennas and one receive antenna, and the other is two transmit and two receive antennas. In this system we use MPSK modulation, Alamouti space-time coding, RS coding in channel transmission. We analyse the system's error performance by simulation, and prove the design is feasible. The system not only provides highly frequency spectral efficiency but also has better error performance. The research is a promising approach used in the future communication and has tremendous potential.

KEYWORDS: MIMO, OFDM, Space-Time Coding.

I. INTRODUCTION

MIMO (multiple input multiple output) has the capacity of producing independent parallel channels and transmitting multi-path data stream, and meets the demands for high-data rate wireless transmission. OFDM (orthogonal frequency-division multiplexing) greatly reduces the influence of multi- path fading by transforming frequency-selective fading channels to flat fading channels in frequency domain. We can produce what has been called a MIMO-OFDM system with employing multiple transmit and receive antennas in an orthogonal frequency division multiplexing communication system. This system can provide highly frequency spectral efficiency and is a promising approach with tremendous potential. Using MATLAB simulation, we find that 2T2R (two transmit and two receive antennas) system has better error performance than 2T1R system. Moreover, the system performance can be greatly enhanced through the use of RS coding. When SNR (Signal to Noise Ratio) achieves 25dB, the system with 2T2R adopting QPSK modulation in frequency-selective fading channels can obtain a BER below 10^{-4} and this corresponds with our assumption in theory. In section 2 Alamouti space-time coding is given in brief. In section 3, an overview of MIMO-OFDM is presented and the results that were obtained by simulation are illustrated. Finally, conclusions are given in section 4.

II. ALAMOUTI SPACE-TIME CODING.

The Alamouti Space-Time coding for two-branch transmit diversity scheme is done as shown in table I, where Tx0 is transmit antenna 0, Tx1is transmit antenna 1[2].

Antenna **Time**	t	$t+T$
Tx0	s_0	[illegible]
Tx1	s_1	s_0^*

TABLE I.THE ENCODING AND TRANSMISSION SEQUENCE FOR THE TWO TRANSMIT ANTENNAS SCHEME

Here we adopt multilevel modulation. First, we modulate m ($m=\log_2 M$) bits as a group, the channel encoder will get two modulated signals s_0 , s_1 as a group each time when encoding and map the two signals into the transmit antennas according to the following encoding matrix:

$$S = \begin{pmatrix} s_0 & -s_1^* \\ s_1 & s_0^* \end{pmatrix} \qquad (1)$$

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The outputs of the encoder are transmitted by the two transmit antennas during two continuous periods. During the first period signals s_0 ! s_1 are transmitted at the same time by antenna zero and antenna one respectively while during the second period signal $-s_1^*$ is transmitted by antenna 0 and s^* by antenna 1, where s^* is the conjugate complex number of s.

We can express transmit sequences from antennas 1 and 2 as follows:

$$s^0 = \left(s_0 \quad -s_1^*\right)$$

$$s^1 = \left(s_1 \quad s_0^*\right) \qquad (2)$$

$$s^0 \bullet s^1 = s_0 s_1^* - s_1^* s_0 = 0$$

(3)

Now we can find that the inner product of s^0 and s^1 is zero, that is to say, the two transmit sequences are orthogonal.

Maximum likelihood decoding is used in this system, and the decision rule of MPSK modulation scheme is [2]:

$$\hat{x}_1 = \arg\min_{\hat{x}_1 \in S} d^2(\tilde{x}_1, \hat{x}_1)$$

$$\hat{x}_2 = \arg\min_{\hat{x}_2 \in S} d^2(\tilde{x}_2, \hat{x}_2) \qquad (4)$$

III. MIMO-OFDM SYSTEM

Space-time coding plays an important role in MIMO system, and can greatly enhance channel capacity and data transmit rate in wireless communication system. Simultaneously it can achieve optimum tradeoff between spectral efficiency and power dissipation of the system [3].

OFDM modulation can be used to transform the frequency- selective channel into a set of parallel frequency flat sub-channels, providing high spectrum efficiency and greatly eliminating ISI (inter-symbol interference). In addition, a multicarrier system can be efficiently implemented in discrete time using an IFFT (inverse fast Fourier transform) to act as a modulator and an FFT (fast Fourier transform) to act as a demodulator, so it is not very complex. Because OFDM allows sub-carriers frequency spectrum to overlap each other partly, it has high spectrum efficiency and it is considered to be an efficient modulation [4].

In real environment, most wireless channels are frequency- selective fading ones and it will make space-time coding be very complicated. However, as the above said, OFDM can transform the frequency-selective channel into a set of parallel frequency flat sub-channels that can reduce the complexity of space-time coding. MIMO-OFDM system will make full use of its own characteristics to further enhance the system's total performance [5].

The transmitter and receiver blocks diagram of 2T1R MIMO-OFDM system is shown in Fig. 1. At transmitter, Source bit streams is encoded, passed via STBC and then mapped to their corresponding symbols with two outputs. Each symbol via a serial to parallel (S/P) converter becomes parallel data and then IFFT is performed, i.e., employing OFDM modulation in each sub-carrier. Next time domain symbols are parallel to serial (P/S) converted and then add cyclic prefix (CP) in order to mitigate or eliminate ISI and ICI (inter-carrier interference). At last, the amplified modulated signals are transmitted. With contrary to the transmitter through a complex channel matrix, at receiver, we can obtain useful signals by removing CP, via P/S converter, and then the serial data is decoded in space-time decoder and channel

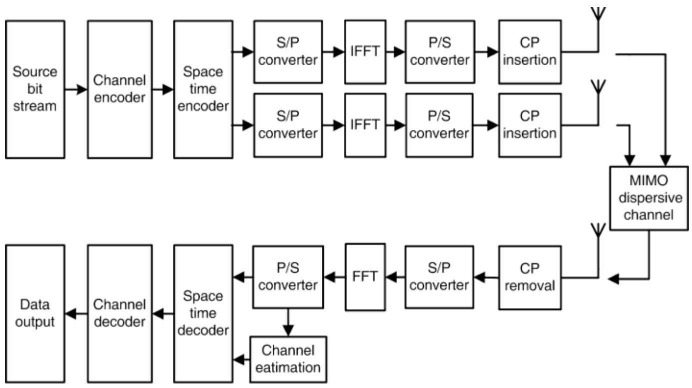

Figure 1. The transmitter and receiver blocks diagram of 2T1R MIMO- OFDM system

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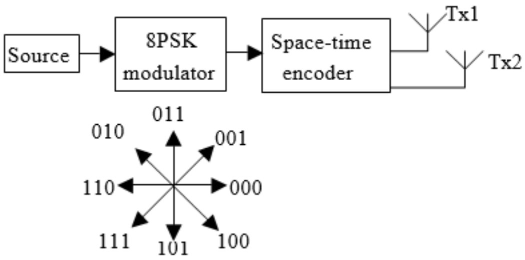

Constellation diagram with grey code

Figure 2. The block diagram of the 8PSK-Alamouti Space-Time Coding

decoder to get the output data. Through decoding the random error and burst error can be corrected and finally we get the output data. The receiver block diagram of M receive antennas MIMO-OFDM system is similar to one receive antenna system except with more receiver antennas. Based on the scheme of MPSK modulation and Alamouti space-time coding, the MIMO-OFDM system is simulated by MATLAB. We start from the simulations of 2T1R and 2T2R in the ideal fading channels and use 8PSK modulation with RS (7, 3) coding.

In the 8PSK Alamouti space-time modulator as shown in Fig. 2, each three bits information is mapped into a symbol in the constellation. Then with two contiguous signals as a group, the symbols are encoded in the Alamouti space-time encoder and form a matrix of 2x2. For example, the information source generates bit stream of 011110, so the 011 is mapped into signal j, and 110 is mapped into signal –1. Then [j, –1] is encoded with Alamouti space-time encoder, so we can get a matrix:

$$S = \begin{pmatrix} j & 1 \\ -1 & -j \end{pmatrix} \qquad (5)$$

The outputs of encoder are transmitted by two antennas during two consecutive transmission periods. During the first period, j and –1 is transmitted by antenna 1 and 2 separately at the same time. While in the second period, 1 is transmitted by antenna 1 and –j by antenna 2. Here sequences transmitted by antenna 1 and 2.

$$\begin{aligned} s^0 &= \begin{pmatrix} j & 1 \end{pmatrix} \\ s^1 &= \begin{pmatrix} -1 & -j \end{pmatrix} \end{aligned} \qquad (6)$$

We use the grey code in the MPSK modulation because of its lower error rate and relatively simple circuit [6].

In all cases in this paper, we assume that all fading is independent between transmit and receive antennas and the fading parameters are known to the receiver perfectly but unknown to the transmitter. From the result of simulation shown in Fig. 3, we can see that in the scheme of 8PSK Alamouti, the 2T2R system performs better in BER than the 2T1R system obviously. When the SNR reaches 23dB, the BER of 2T2R 8PSK system drops to below 10^{-4}. The result is preferable when RS coding is used in this system achieving 10^{-4} or even smaller when SNR is only 17dB.

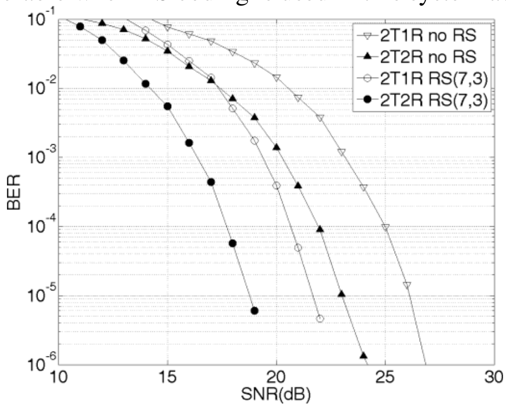

Figure 3. BER performance of the MIMO-OFDM systems with 8PSK.

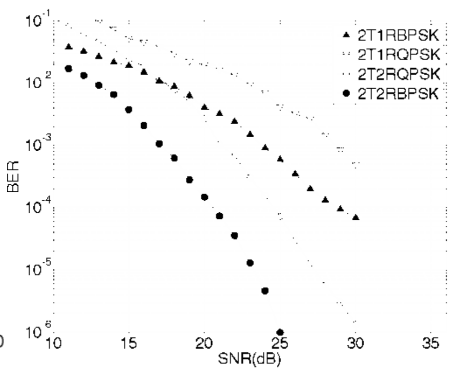

Figure 4. BER performance of the MIMO-OFDM systems

The system is simulated in frequency-selective fading channel using BPSK and QPSK modulation. From Fig. 4 it can be seen that BER performance of BPSK system is better than QPSK. We can infer that the BER performance of 8PSK scheme is worse than the MIMO-OFDM system using BPSK and QPSK modulation, however the 8PSK scheme has

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the highest data rate. When SNR achieves 25 dB, the scheme of 2T2R modulated by QPSK has better error performance and BER drops to 10^{4-} or even smaller.

IV. CONCLUSION

In this paper, the MIMO-OFDM technique is studied for the fourth-generation wireless communication system using MPSK modulation and Alamouti space-time coding. By simulation we get the results of the BER performance of different schemes. The study showed that MIMO-OFDM with space-time coding can provide high data rate transmission without increasing transmit power and expanding bandwidth. MIMO-OFDM technique is a promising approach to solve the problem that how we should efficiently use space resources and has a bright future.

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