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Performance Analysis & Implementation of different Modulation Techniques in Almouti MIMO Scheme with Rayleigh Channel

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***Abstract*— This paper presents performance comparison of various modulation techniques in almouti scheme with Rayleigh fading channel. In the comparison, the space time coding has been used. The performance comparison are made on the basis of symbol error rate(SER) performance matrices over Rayleigh fading channel with 16-PSK,QPSK,PAM,16-QAM,64-QAM modulation technique. The comparison results show that in Rayleigh fading the symbol error rate is least for QPSK modulation technique as compared to other three modulation techniques i.e. M- QAM ,PAM and 16-PSK.**

***Keywords*— MIMO, Modulation Techniques, SER,M-QAM,PAM,16-PSK,QPSK,64-QPSK**

I. Introduction

MIMO technology means multiple antennas at both ends of a communication system, i.e., at the transmit and receive side. This idea in a wireless communication link opens a new dimension in reliable communication and also improves the system performance substantially. The idea behind MIMO is that the transmit antennas at one end and the receive antennas at the other end are connected and combined in such a way that, the bit error rate (BER), or symbol error rate for each user is improved. The core idea in MIMO transmission is space-time signal processing in which signal processing with time in spatial dimension by using multiple, spatially distributed antennas at both link ends. Because of this enormous capacity increase, such systems gained a lot of interest in mobile communication.

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II. MIMO System Model

Wireless communication industry has recently turned to a strategy called Multiple- Input Multiple-Output (MIMO). MIMO is the single most important wireless technology as of today. MIMO is a technology evolution where both ends of the wireless link are equipped with antenna array (Figure 1).

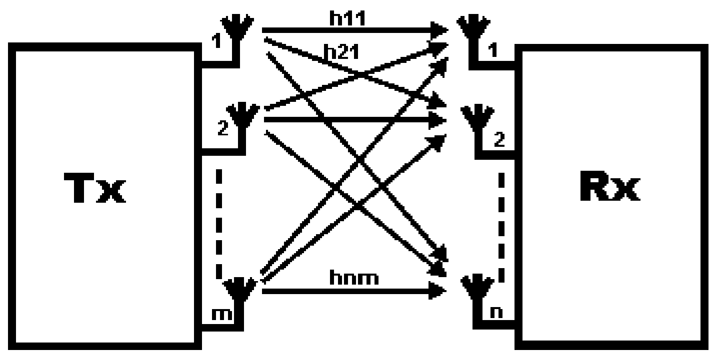

Figure 1: Block diagram of MIMO system

This can improve the quality (bit-error rate) and the data rate (bits per sec). Therefore, a superior quality of service (QoS) can be achieved, which revenues the wireless provider. Many space-time block codes for different number of transmit/receive antennas have been developed in order to achieve maximum diversity. MIMO takes advantage of multipath interference effect to increase the user and data capacity; it converts it into a positive feature by using the multiple transmitters and/or receivers to increase throughput and reliability. Usually, multiplexing would cause interference, but MIMO uses the additional pathways to transmit more information and then combines the signal at the receiving end; thus provides robustness against multipath fading. MIMO systems can be designed with the receiver knowing the channel state (coherent case) or not (not-coherent case)

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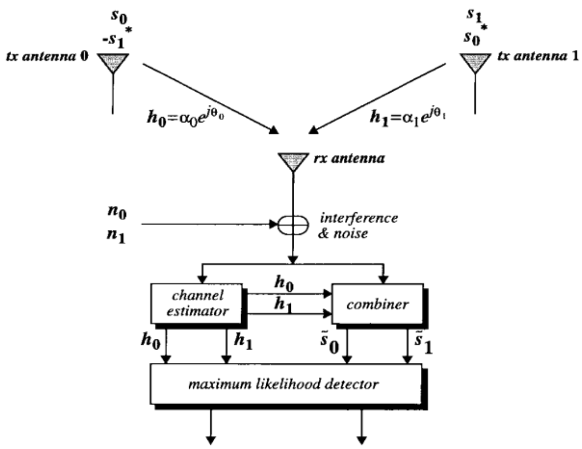

Figure 2: The new two-branch transmit diversity scheme with two receivers. Source [1]

Figure-2 shows the baseband representation of the new two branch transmit diversity scheme. The scheme uses two transmit antennas and one receive antenna and is called as Alamouti's code which is the first open-loop transmit diversity technique which provides full diversity with linear processing at the receiver complexity[1]. The new transmit diversity scheme can improve the error performance, data rate and capacity of wireless communications systems. The decreased sensitivity to fading may allow the use of higher level modulation schemes to increase the effective data rate, or smaller reuse factors in a multi cell environment to increase system capacity. The scheme may also be used to increase the range or the coverage area of wireless systems. In other words, the new scheme is effective in all of the applications where system capacity is limited by multipath fading and, hence, may be a simple and cost-effective way to address the market demands for quality and efficiency without a complete redesign of existing systems. Furthermore, the scheme seems to be a superb candidate for next-generation wireless systems as it effectively reduces the effect of fading at the remote units using multiple transmit antennas at the base stations. It may be defined by the following three functions

- The encoding and transmission sequence of information symbols at the transmitter;
- The combining scheme at the receiver;
- The decision rule for maximum likelihood detection.

III. The Encoding and Transmission Sequence

Each time we want to transmit one symbol, we make it twice. If we denote that s0 is the symbol sent from antenna 0 and s1 is the symbol sent from antenna 1 at a given time t, then, in the next symbol period (t+T) we transmit from antenna 0 the symbol -s1* and from antenna 1 the symbol s0*.

	Antenna 0	Antenna 1
t	s_0	s_1
$t+T$	$-s_1^*$	s_0^*

Figure 3: transmission sequence in two- branch transmit Alamouti scheme. Source [1]

It is also interesting to note that this space-time diversity can easily be exported to space-frequency diversity. It is only necessary to use two adjacent carriers in the same way we use two adjacent time periods.

One of the most important assumptions in this technique is that the channel will not vary in two consecutive symbol periods. With this, we can denote the channel 0 as h0 and channel 1 as h1. With the same notation and adding complex random variable n_x in order to express noise and interference, we obtain the following received signals:[1]

$$r_0 = r(t) = h_0 s_0 + h_1 s_1 + n_0$$

$$r_1 = r(t+T) = -h_0 s^*_1 + h_1 s^*_0 + n_1$$

Where r_0 and r_1 are the received signals at time t and (t+T) and n_0 and n_1 are complex random variables representing receiver noise and interference.

IV. Modulation Techniques

A modulation scheme is needed to transmit information over a communication channel. Among the various modulation methods are; amplitude modulation (data encoded by changing the amplitude of the signal), frequency modulation (data encoded by changing the frequency of the signal), and phase modulation (data encoded by changing the phase of the signal).The modulation methods chosen for this paper are: Quadrature phase shift keying (QPSK), M-ary phase shift keying (16PSK), M- Quadrature amplitude modulation (M-QAM).and Pulse amplitude modulation (PAM)

V. Simulation Result

Simulation results of SER for Rayleigh fading with different modulation technique

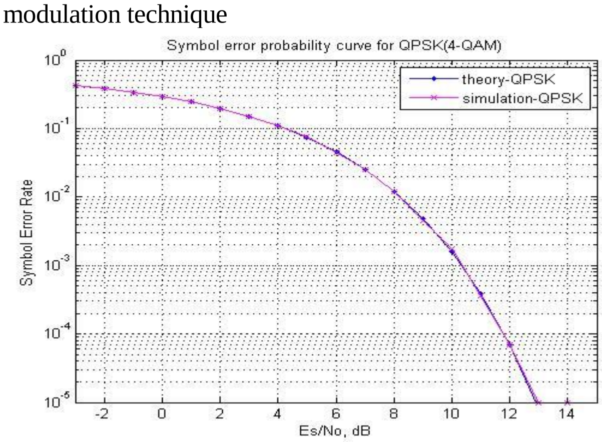

Figure 4: SER performance of QPSK for Rayleigh fading.

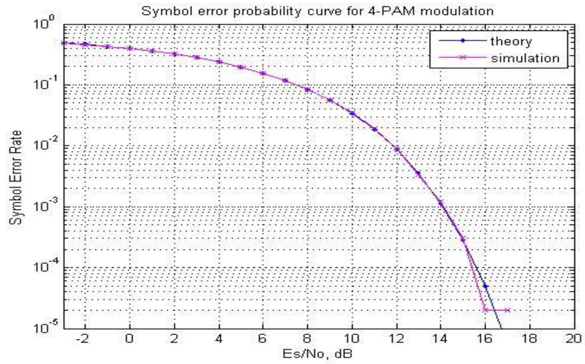

Figure 5: SER performance of 4-PAM for Rayleigh fading.

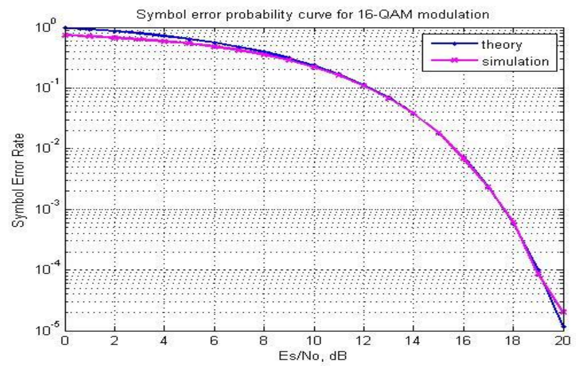

Figure 6: SER performance of 16-QAM for Rayleigh fading.

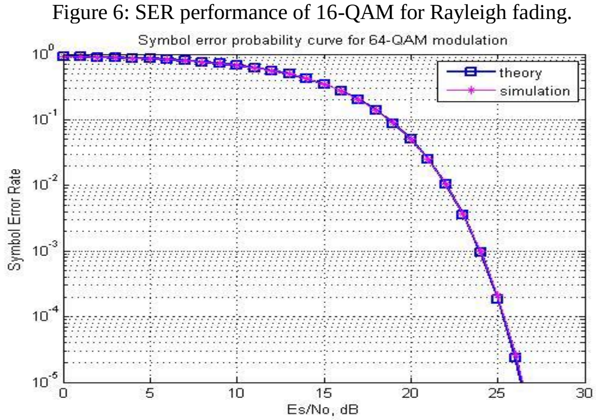

Figure 7: SER performance of 64-QAM for Rayleigh fading.

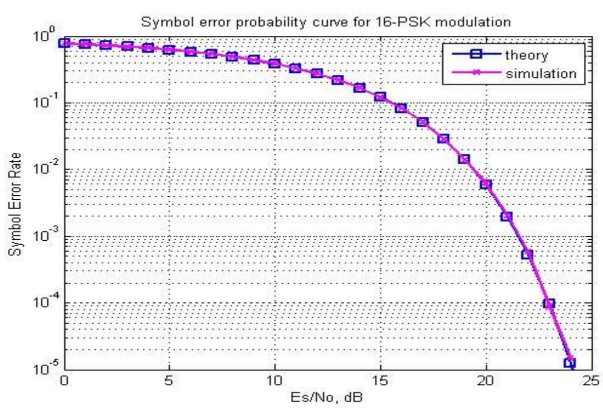

Figure 8: SER performance of 16-PSK for Rayleigh fading.

The Figure [4-8] shows that in case of RAYLEIGH fading the symbol error rate (SER) is least for QPSK modulation technique as compared to the other three modulation techniques i.e. 16-PSK, 16-QAM, 64-QAM, PAM. Hence the performance of the Quadrature phase shift keying is best when RAYLEIGH fading is present in 2:2 MIMO systems.

TABLE I
SER PERFORMANCE UNDER RAYLEIGH FADING CHANNEL AT 4DB, 6DB, 8DB

Modulation method (Symbol Error Rate)	4dB		6dB		8dB	
	SER (theory)	SER (Practical)	SER (theory)	SER (Practical)	SER (theory)	SER (Practical)
QPSK	0.1096	0.1095	0.0455	0.0450	0.0120	0.0118
PAM	0.2371	0.2365	0.1552	0.1551	0.0841	0.0856
16-QAM	0.3919	0.3536	0.2359	0.2201	0.1125	0.1088
64-QAM	0.8692	0.8693	0.8239	0.8234	0.7605	0.7613
16-PSK	0.6619	0.6605	0.5820	0.5818	0.4883	0.4894

VI. Conclusion

In this paper a comparative study of different modulation techniques with 2:2 MIMO systems under different Rayleigh fading environments is done. The figures 4-8 show that in case of RAYLEIGH fading channel the symbol error rate (SER) is least i.e. 0.0450 at 6dB for QPSK modulation technique as compared to the other three modulation techniques i.e. PAM, M-QAM, 16-PSK. Hence the performance of the Quadrature phase shift keying is bestwhen RAYLEIGH fading is present in 2:2MIMO system.

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