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Investigation of QR-RLS based Channel Estimation Techniques for MIMO-OFDM Systems

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Abstract— Use of multiple antennas at the transmitter and receiver ends called as MIMO has become a very popular technique for improvement of data rates required by the current and future wireless networks. OFDM combined with MIMO is very attractive air interface in mobile and wireless communication scenario. Less complex and reliable channel estimation and detection techniques are required to take advantages offered by MIMO. In this thesis, channel estimation and detection techniques for MIMO and MIMO-OFDM system are studied. In MIMO-OFDM system, the received OFDM symbols can be processed in time domain or frequency domain. The numbers of channel estimation methods for OFDM and MIMO-OFDM system are studied. This research work has implemented a combined time and frequency domain approach to channel estimation for MIMO-OFDM.

Keywords:- MIMO-OFDM System, Channel Estimation Technique, Bit Error Rate, Mean Square Error

I. INTRODUCTION

The anytime, anywhere connectivity with fast transfer of data has become an essential feature of the state of the art communication system. Higher data rates are possible with the help of multiple antennas at the transmitter and receiver ends. Simple transmit diversity technique and Space-Time Block Codes (STBC) for Multiple Input Multiple Output (MIMO) systems was proposed by Alamouti [1]. Since then MIMO has been an active area of research. The number of transmitter-receiver concepts has been introduced in literature, an excellent overview of which can be found in [2]. The MIMO technology is now being part of next generation communication networks. Orthogonal Frequency Division Multiplexing (OFDM) is used to combat multipath fading in wireless transmission. Hence, MIMO-OFDM technology is employed in Wireless LAN (IEEE 802.11n). MIMO techniques introduced in WiMAX networks based on IEEE 802.16e [3] and Long Term Evolution (LTE) [4] are essential components for supporting higher data rates with reliability on wireless links. In LTE, there were four transmit antennas in downlink. LTE-Advanced have eight transmit antennas in downlink and four in the uplink, providing spectral efficiencies of 30 b/s/Hz in uplink and 15 b/s/Hz in downlink. WiMAX standard also uses MIMO both in uplink and downlink. The previous generation of Wi-Fi (IEEE WLAN Standard 802.11n) was designed for peak data rates of 600 Mbps with 4X4 MIMO-OFDM. The latest generation Wi-Fi ((IEEE WLAN Standard 802.11ac) can deliver data rates in Gbps. Thus, MIMO along with OFDM will remain the most popular air interface for wireless communication in near future. MIMO systems can be categorized as spatial diversity, spatial multiplexing and beamforming systems [5]. A combinations of these techniques have also emerged which are called as hybrid systems [6]. In spatial multiplexing techniques, information is de-multiplexed and independently transmitted over multiple antennas. Transmission of multiple information simultaneously results in an increase in the data rate, i.e. multiplexing gain is achieved, but the diversity gain is reduced because of higher error rate. Spatial decent variety strategies transmit a similar data over various reception apparatuses enhancing the mistake rate, however the information rate is influenced. In beamforming system, the radio wire bar is guided the specific wanted way with the goal that the flag to-commotion proportion (SNR) is enhanced at the recipient. The decent variety multiplexing tradeoff is examined in [7]. This exploration work is kept to spatial decent variety and spatial multiplexing MIMO and MIMO-OFDM frameworks.

The system's ability to achieve MIMO capacity depends on channel state information. Accurately estimating MIMO channel is much more challenging than SISO channel [8]. There is a number of channel estimation schemes suggested in the literature. Reference gives a detailed survey of the channel estimation schemes.

These schemes can be categorized as Training based (TBCE), Blind (BCE) and Semi-Blind (SBCE). Training based schemes are capable of accurately estimating a MIMO channel, provided a large training overhead is made available. Hence, there is considerable reduction in system throughput. The least-square (LS) and minimum-mean-square-error (MMSE) techniques are widely used for channel estimation when training symbols are available. The LS method is simpler than the MMSE, but the performance of MMSE scheme is better. MMSE method, however, requires knowledge of second order channel statistics. Blind methods do not require the training overhead. However, these methods not only impose high complexity and slow convergence, but also suffer from unavoidable estimation and decision ambiguities. Semi-blind methods offer attractive, practical means of implementing MIMO systems. Semi-blind channel estimation schemes, use a very few training symbols to provide the initial MIMO channel estimation and make use of blind information to improve further the estimation. Some SBCE schemes also exchange the information between the channel estimator and the data detector iteratively, which are termed as joint channel estimation and data detection [9]. This research work has proposed a new approach to semi-blind channel estimation which is an improvement over the SBCE of [10].

II. MIMO SYSTEM

In wireless communication environment, the main challenge is to combat multipath fading. Multipath is a phenomenon that occurs due to the arrival of the transmitted signal through different paths. The signal arrives at the receiver through different angles, with different time delays and different frequency shifts. As a result, the signal power at the receiver fluctuate giving rise to fading [6]. Apart from fading, constraints such as low power and limited bandwidth make the communication system designer's task of increasing data rate and reliability more challenging. MIMO technology can be used effectively to meet these requirements by taking advantage of multipath.

The Single Input Single Output (SISO) communication system consists of a single transmits and receive antenna. The capacity of a SISO system is given by Shannon's capacity equation [7] as,

$$C = \log_2(1 + SNR)\, bits/\sec/Hz \qquad (1)$$

The multi-antenna systems can offer an advantage in terms of array gain, diversity gain, and multiplexing gain.

Array Gain

The coherent combining of wireless signals at the receiver end results in increase in SNR. This increase in SNR is called array gain. The coherent combining can be achieved through spatial processing at transmitter or receiver or both the locations.

Diversity Gain

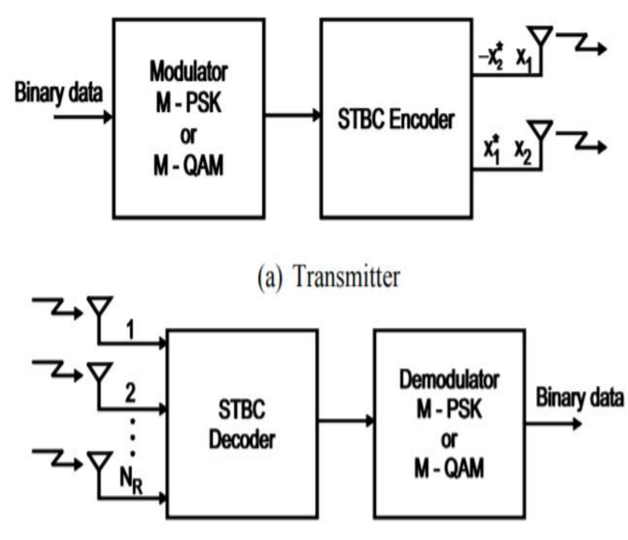
Diversity gain can be achieved by providing multiple independent copies of the signal in space, time or frequency. When multiple copies of the signal are available at the receiver, the probability of receiving at least one copy correctly increases. Thus, the diversity gain is an improvement in link reliability.

Multiplexing Gain

The multiplexing gain is an increase in data rate without any additional power or bandwidth. This gain can be achieved by transmitting multiple independent data streams.

III. SPACE TIME BLOCK CODE

The space-time block codes have become popular because of their simplicity. These codes started appearing in literature after the revolutionary work by Alamouti [1] who designed the code for two transmit antennas. These codes were extended for more than two transmit antennas using orthogonal design [2] [3] and are known as space-time block codes (STBC). However, Alamouti codes are the only known full diversity and full data rate codes for two transmit antennas whereas for more than two transmit antennas the codes are either full diversity or full data rate codes.



(b) Receiver

Figure 1: A MIMO communication system with STBC Code

IV. PROPOSED METHODOLOGY

The MIMO-OFDM device modified into applied with the useful resource of MATLAB/SIMULINK. The execution device is binary facts this is modulated the use of QAM and mapped into the constellation elements. The virtual modulation scheme will transmit the records in parallel by means of manner of assigning symbols to every sub channel and the modulation scheme will determine the phase mapping of sub-channels thru a complex I-Q mapping vector show in figure 2. The complicated parallel facts stream must be converted into an analogue signal this is suitable to the transmission channel. The complicated parallel facts stream has to be transformed into an analogue sign that is suitable to the transmission channel. It is performed to the cyclic prefix add to the baseband modulation signal because the baseband signal is not overlap. After than the signal is splitter the two or more part according to the requirement.

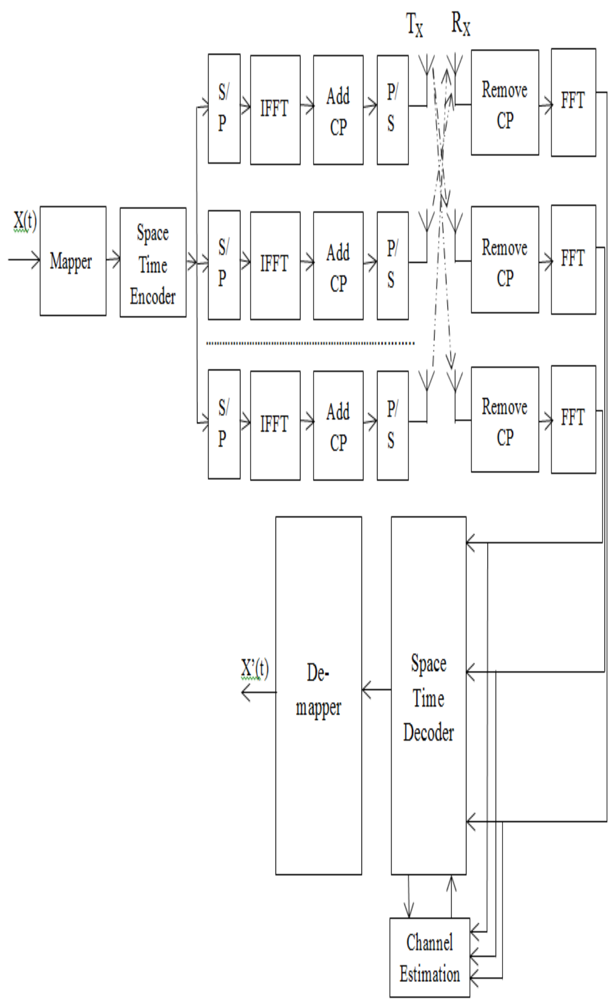


Figure 2: MIMO-OFDM System Models with Channel Estimation Technique

V. Simulation Result

In simulations it is assumed that the system is perfectly synchronized. Different values of SNR are taken and the performance is checked.

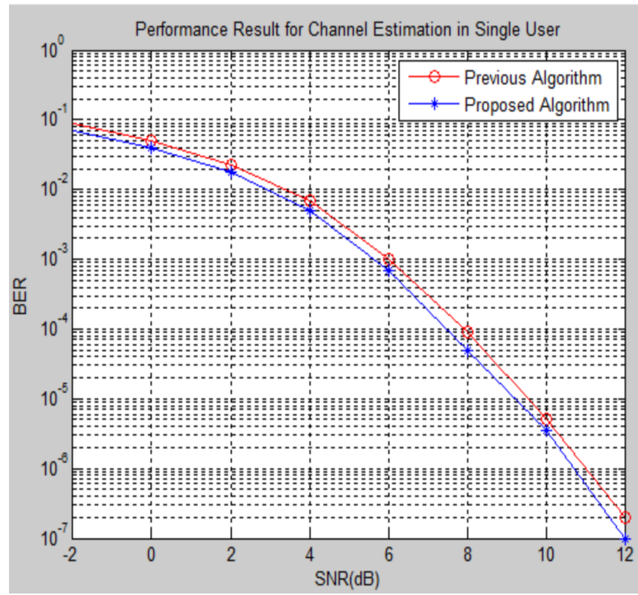


Figure 3: Performance BER for Single User

Table I: Comparison of BER in Different Channel Estimation Technique for Single user System

SNR	Previous Technique [1]	Proposed Technique
	IDMA based Channel Estimation Technique	QR-RLS based Channel Estimation Technique
-2	0.09	0.07
0	0.05	0.04
2	0.022	0.018
4	0.007	0.005
6	0.001	0.0007
8	0.0009	0.000049
10	0.000005	0.0000035
12	0.0000002	0.0000001

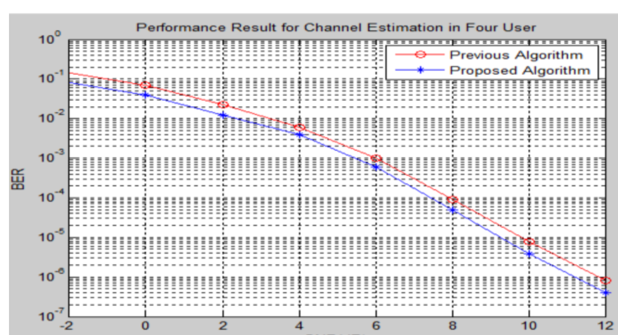


Figure 4: Performance BER for 2×2 MIMO-OFDM Systems

Table II: Comparison of BER in Different Channel Estimation Technique for Four user System

SNR	Previous Technique [1]	Proposed Technique
	IDMA based Channel Estimation Technique	QR-RLS based Channel Estimation Technique
-2	0.14	0.08
0	0.07	0.04
2	0.022	0.012
4	0.006	0.004
6	0.001	0.0006
8	0.0009	0.000049
10	0.000008	0.0000038
12	0.0000008	0.0000004

VI. CONCLUSION

In this paper channel estimation techniques for MIMO and MIMO-OFDM based systems are investigated. The channel estimation techniques are studied through simulations using MATLAB. New improved techniques are proposed, and their performance is evaluated and compared with existing techniques. For spatial diversity MIMO systems, detection is simple. From analysis of the results, it is found that the proposed adaptive channel estimation for MIMO-OFDM system using QR-RLS algorithm gives 0.002 mean square error for 32 dB SNR and 0.0000001 bit per unit of time bit error rate for 13 dB SNR as compared with previous adaptive channel estimation technique.

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