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Channel Matrix Pre-Computation For Mimo Ofdm Systems In High Mobility Fading Channels

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Abstract---*A novel technique to enhance the robustness of space–frequency block coded (SFBC) orthogonal frequency-division multiplexing (OFDM) systems. The proposed system shapes the channel matrix of a frequency-selective fading channel into a piecewise flat--fading over each block of two adjacent subcarriers. Analytical and simulation results show that the proposed scheme substantially outperforms the conventional SFBC in frequency-selective fading channels, which assumes that the channel parameters are equal over the duration of the codeword. Moreover, we demonstrate that the proposed system offers a superior performance in fast time-varying channels where the interference that results from the channel variations acts only as an additive noise. In addition to its superior performance, the proposed system has low computational complexity, because it is based on the short-block-length Walsh–Hadamard transform `Walsh–Hadamard transforms (WHTs) has required A modified SFBC decoder to resolve the frequency selectivity problem has been implemented in existing system. The main drawback of this technique is that it requires accurate knowledge of the channel response difference across adjacent subcarriers. In an embedded Alamouti (EA) SFBC-OFDM system is designed to reduce the impact of the inter carrier interference (ICI) caused by the channel variations by separating the Alamouti code words by B subcarriers and using a three-tap frequency-domain equalizer (FDE) reduce the BER degradation.*

Keywords—Frequency selective channels, orthogonal frequency division multiplexing (OFDM), precoding, space frequency block coded (SFBC), space time block codes (STBCs).*

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I. INTRODUCTION

Recently, a worldwide convergence has occurred for the use of Orthogonal Division Frequency Multiplexing as an emerging technology for high data rates. In particular, the wireless local network systems such as WiMax, WiBro, WiFi etc., and the emerging fourth-generation (or the so-called 3.9G) mobile systems are all OFDM based systems. OFDM is a digital multi-carrier modulation scheme, which uses a large number of closely-spaced orthogonal sub-carriers that is particularly suitable for frequency-selective channels and high data rates. This technique transforms a frequency selective wide-band channel into a group of non-selective narrow-band channels, which makes its robust against large delay spreads by preserving orthogonality in the frequency domain. Moreover, the introduction of a so-called cyclic prefix at the transmitter reduces the complexity at receiver to FFT processing and one tap scalar equalizer at the receiver.The simplified equalization at receiver, however, requires knowledge of the channel over which the signal is transmitted. To facilitate the estimation of the channel in an OFDM system (such as WiMax, WiBro, WiFi, and 3.9/4G), known signals or pilots could be inserted in the transmitted OFDM symbol. Different methods can then be applied to estimate the channel using these known pilots. The focus of this project is to investigate performance of different channel estimators for an OFDM-based 3.9G system.

II. SYSTEM MODEL

The MIMO technique does not require any bandwidth expansions or any extra transmission power. Therefore, it provides a promising means to increase the spectral efficiency of a system. In his paper about the capacity of multi-antenna Gaussian channels, Telatar showed that given a wireless system employing Nt TX (transmit) antennas and Nr RX (receive) antennas, the maximum data rate at which error-free transmission over a fading channel is theoretically possible is proportional to the minimum of Nt and Nr (provided that the NtNr transmission paths between the TX and RX antennas are statistically independent). Hence huge throughput gains may be achieved by adopting Nt x Nr MIMO systems compared to conventional 1 £ 1 systems that use single antenna at both ends of the link with the same requirement of power and bandwidth. With multiple antennas, a new domain, namely, the spatial domain is explored, as opposed to the existing systems in which the time and frequency domain are utilized. The bottleneck problem of complexity for channel estimation in MIMO-OFDM systems has been studied by two different approaches. The first one shortens the sequence of training symbols to the length of the MIMO channel, as described in [50], leading to orthogonal structure for preamble design. Its drawback lies in the increase of the overhead due to the extra training OFDM blocks.

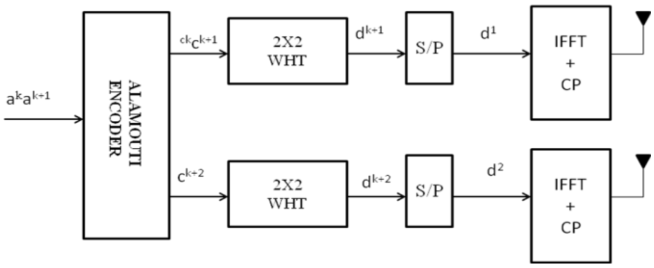

Fig 1. Block diagram of the proposed CMS system.

The block diagram of a MIMO-OFDM system is shown in Fig 1. Basically, the MIMO-OFDM transmitter has Nt parallel transmission paths which are very similar to the single antenna OFDM system, each branch performing serial-to-parallel conversion, pilot insertion, N-point IFFT and cyclic extension before the final TX signals are up-converted to RF and transmitted. It is worth noting that the channel encoder and the digital modulation, in some spatial multiplexing systems can also be done per branch, not necessarily implemented jointly over all the Nt branches. The receiver first must estimate and correct the possible symbol timing error and frequency offsets, e.g., by using some training symbols in the preamble as standardized. Subsequently, the CP is removed and N-point FFT is performed per receiver branch. In this thesis, the channel estimation algorithm we proposed is based on single carrier processing that implies MIMO detection has to be done per OFDM subcarrier.

Therefore, the received signals of subcarrier k are routed to the k^{th} MIMO detector to recover all the Nt data signals transmitted on that subcarrier. Next, the transmitted symbol per TX antenna is combined and outputted for the subsequent operations like digital demodulation and decoding. Finally all the input binary data are recovered with certain BER. Here we demonstrated that if each group of subcarriers in an OFDM system is precoded with a short unitary transform whose elements have equal magnitudes, then each subcarrier within the group will experience the same instantaneous signal-to-noise ratio (SNR). In this paper, we introduce an influential extension to McCloud’s work where we show that incorporating precoding after SFBC encoders results in each frequency response over each pair of precoded sub-carriers. Therefore, the frequency-selective channel is converted to a piecewise flat-fading channel. Consequently, CMS enforces the channel equality condition over each pair of subcarriers that form the SFBC block regardless of the original channel matrix.

A . Modulation

Traditionally, local communications was done over wires, as this presented a cost-effective way of ensuring a reliable transfer of information. For long-distance communications, transmission of information over radio waves was needed. Although this was convenient from a hardware standpoint, radio-waves transmission raised doubts over the corruption of the information and was often dependent on high-power transmitters to overcome weather conditions, large buildings, and interference from other source of electromagnetic.

Sometimes known as quaternary or quadriphase PSK, 4-PSK, or 4-QAM, QPSK uses four points on the constellation diagram, equispaced around a circle. With four phases, QPSK can encode two bits per symbol, shown in the diagram with Grey coding to minimize the BER — twice the rate of BPSK. Analysis shows that this may be used either to double the data rate compared to a BPSK system while maintaining the bandwidth of the signal or to maintain the data-rate of BPSK but halve the bandwidth needed.

III. SPACE TIME CODING FOR MIMO-OFDM

A **space–time code** (STC) is a method employed to improve the reliability of data transmission in wireless communication systems using multiple transmit antennas. STCs rely on transmitting multiple, redundant copies of a data stream to the receiver in the hope that at least some of them may survive the physical path between transmission and reception in a good enough state to allow reliable decoding. Space time codes may be split into two main types:

- **Space time trellis codes (STTCs) distribute** a trellis code over multiple antennas and multiple time-slots and provide both coding gain and diversity gain.
- **Space time block code (STBC)** act on a block of data at once (similarly to block codes) and provide only diversity gain, but are much less complex in implementation terms than STTCs.

The MIMO channel matrix H corresponding to nt transmit antennas and nr receive antennas can be represented by an nr × nt matrix: Given the receive matrix Y the ML-detector decides for the transmit matrix S with smallest Euclidian distance d2.The structure of the MIMO solution is very similar to that of a conventional wireless OFDM physical layer, except that the carrier frequency is changed based on the time-frequency code. In addition, other modifications have been made to reduce the area and size. Therefore, parallel architectures have been proposed in an effort to reduce power consumption as well as to relax timing constraints. Exploiting parallelism with -way parallel architecture enables to keep throughput constraint at -time's lower clock speeds, whereas it may increase the hardware resources by a factor.

$$\mathbf{H} = \begin{pmatrix} \mathbf{ht1,1\ ht1,2 \ldots ht1,nt} \\ \mathbf{ht2,1\ ht2,2 \ldots ht2,nt} \\ \ldots\ \ldots\ \ldots\ \ldots\ \ \ldots\ \ldots. \\ \mathbf{htnr,1\ htnr,2 \ldots htnr,nt} \end{pmatrix}$$

Where the ji-th element, denoted by ht j,i, is the fading gain coefficient for the path from transmit antenna i to receive antenna j. We assume perfect channel knowledge at the receiver side and the transmitter has no information about the channel available at the transmitter side.

IV. RESULTS AND DISCUSSION

1.Performance Analyzes Of STBC Over CMS Scheme

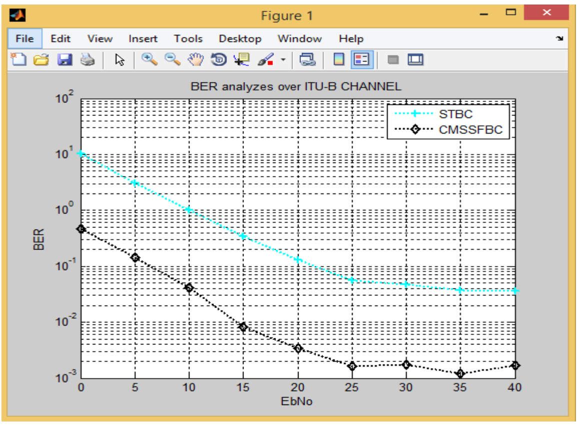

Fig 5.1 BER analyzes of STBC Vs CMS SFBC

When the channel length is larger than guard interval length (channel dispersion), that guard time interval will not produce considerable impact on interference caused by channel due to CMS robustness against selective fading .In this case channel dispersion cause worst case BER performance in entire SNR range for STBC.

2. Performance Analyzes Of STBC Over SFBC

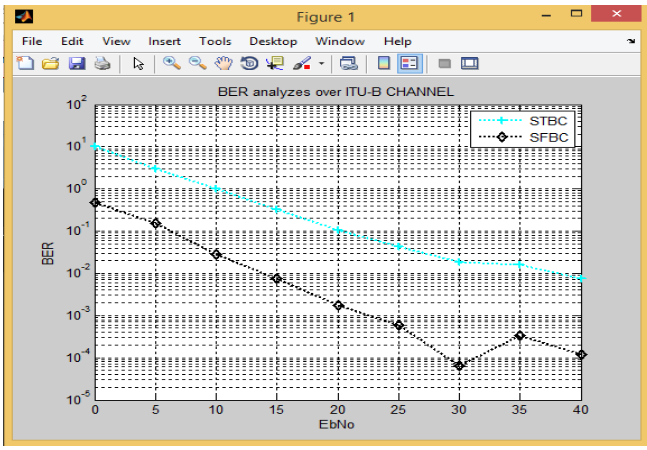

Fig 5.2 BER analyzes of STBC Vs SFBC

When the channel length is larger than guard interval length (channel dispersion), that guard time interval will produce considerable impact on interference caused by selective fading nature of channel. In this case channel dispersion cause worst case BER performance even in best case SNR range for SFBC.

3.Selective Fading Channel Response

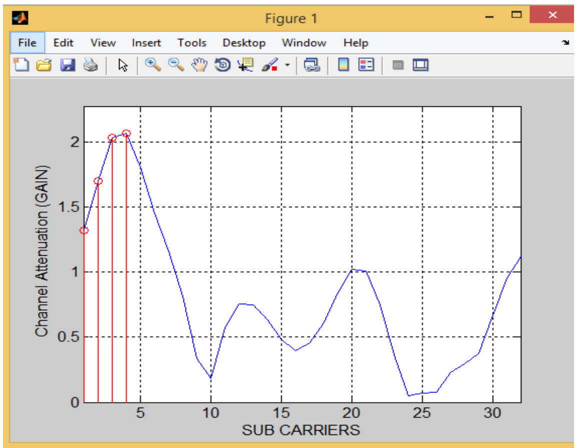

Fig 5.3 CHANNEL RESPOSNE

The sub carrier divided channel is used for transmitting the signal from the transmitter to receiver. These wireless broadband channels are modelled based on the number of paths, distance between the transmitter to receiver and environment. In frequency selective fading cases the number of multipath components and its attenuation level in each model is different.

4.Performance Analyzes Of CMS Over Guard Length

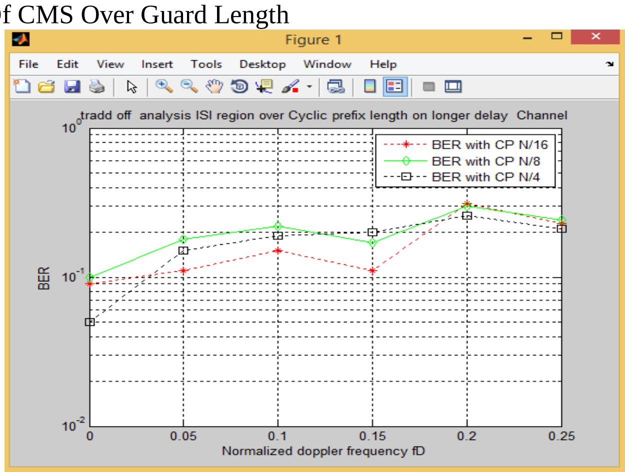

Fig 5.4 BER analyzes of CMS over various CP length

Here Doppler spreading is used where signal undergoes frequency dispersion leading to distortion. When the doppler spread is more the coherence time gets reduced (i.e) channel changes faster. In this case radio signals level changes according to mobility of either mobile terminal or surrounding environments.But here irrespective of guard interval length used system will give similar performance throughout the SNR range due its robust design.

5. Performance Analyzes Of Stbc Over Sfbc

Here the longer delay channel is considered where delay of each received signal becomes negligible but some will be at maximum. The delay spread will be high for highly dispersive channel. Under this selective fading nature without channel shaping method SFBC will give worst case performance as compared to STBC method.

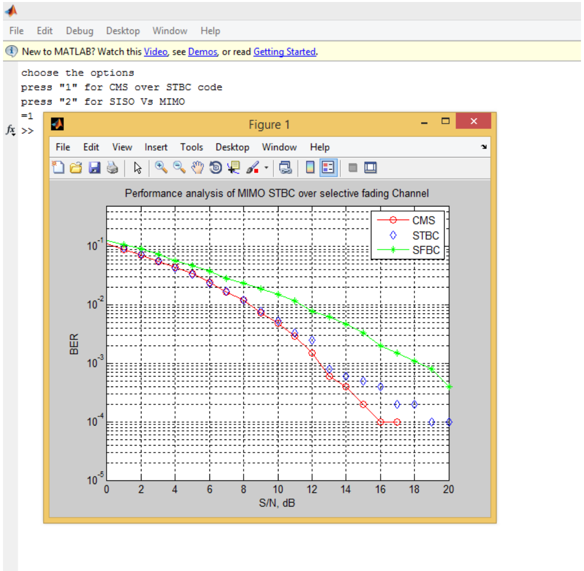

Fig 5.5 BER analyzes of STBC Vs SFBC

6. Performance Analyzes Of Mimo

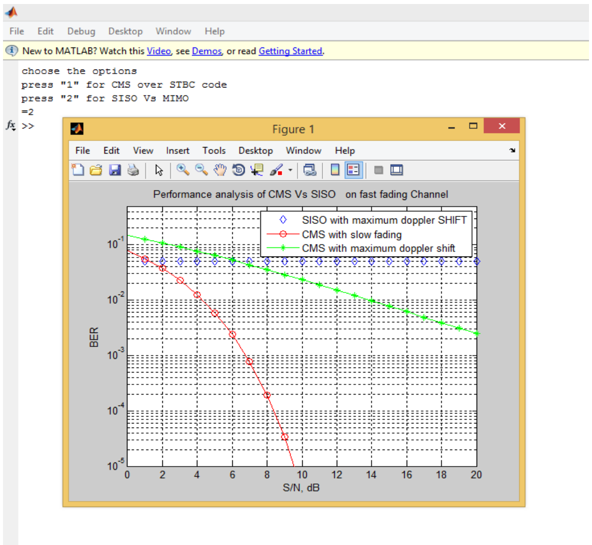

Fig 5.6 BER analyzes of SISO Vs MIMO

- From the figure we conclude that without MIMO based CMS approach for any modulation system will not give better QoS.
- Without diversity attainable QoS will be 0 even in the range of 20-25 SNR rate. But with diversity QoS is attained at SNR=8.

V. CONCLUSION

In this paper, we analyze performance of a channel matrix shaping strategy in space–frequency block coded (SFBC) orthogonal frequency-division multiplexing (OFDM) systems over double selective fading channel. First, we proved the efficiency of proposed SFBC over conventional approach and its robustness against fading. Then, we apply the Doppler Effect to prove the achievable rates and compare them with the theoretical values of a simulated transmission over severe fading channels with high mobility levels. And the CMS superior performance was evaluated over the other systems at low and high Doppler values with FEC coded OFDM.

VI. FUTURE WORK

This scheme can be extended to determine the most appropriate number of antennas to be used & to determine the most appropriate number of relay required to re-modulate the symbols by carefully considering their potential benefits and then assigning a specific modulation scheme for relaying the message. As a further benefit, Here MS with maximum possible mapping rate can be used for high throughput.. If we use ML detector for 64-QAM leads overall system complexity. By using suboptimal detectors number of constellation point are divided & detected separately using suboptimal detectors. The performance of the suboptimal detectors is very closeto ML performance.

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