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Frequency Domain Equalization With Mapping Of Data Onto Subcarrier Pairs In MIMO OFDM Antenna Diversity

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***Abstract*— This paper investigates the performance of multi-antenna SC-FDE under cyclic-delay diversity (CDD) and Alamouti signaling. Our analysis fully characterizes the diversity, showing that it depends not only on the antenna configuration and channel memory, but also on data block length and data transmission rate. Below a certain rate threshold, full diversity is available to both CDD and Altamonte signaling, while at higher rates their diversity diminishes, albeit not quite in the same way. Our analysis shows that at high rates the CDD diversity degenerates to the diversity of the SISO SC-FDE, while Alamouti signaling provides twice the diversity of SISO SC-FDE. OFDM is the modulation method chosen for many high-speed digital communication systems. This is despite OFDM having a number of well-known disadvantages that include extreme sensitivity to frequency offset, large out-of-band power, and high peak-to-mean power ratio. A consequence of that is that OFDM is not a very good solution for one to one communications with several users on a shared channels, because of the problem of frequency allocation.**

***Index Terms*— Alamout's STBC, Cyclic Delay Diversity, Cyclic Prefix, MIMO Technogy, MMSE,OFDM, Single-carrier.**

I. INTRODUCTION

Single-carrier (SC) block transmission with cyclic prefix (CP) is a method with several advantages that has been incorporated into standards. One of the often-quoted advantages of OFDM is that by using a cyclic prefix it can be made insensitive to multipath transmission. However this is at the cost of some loss in bandwidth efficiency One technique which has the potential to solve many of the problems of OFDM is Polynomial Cancellation Coding (PCC). One common transmit diversity technique used for single carrier and multicarrier systems is antenna delay diversity, which can take the form of time delay, cyclic delay and phase delay . Among them, cyclic delay diversity (CDD) is more widely adopted for single carrier and multicarrier applications as CDD can be applied to any number of transmit antennas without any rate loss or change.

II. FREQUENCY DOMAIN EQUALIZATION USING OPTIMAL MMSE ALGORITHM

A. In this the frequency domain equalization at the receiver is done using the optimal minimum mean square error (MMSE). The Optimal MMSE channel estimation for multiple-input multiple-output orthogonal frequency division multiplexing (MIMO-OFDM) systems is investigated. We first propose an time, and frequency domains to estimate the channel frequency response. By the principle of maximum entropy, we then design an efficient robust MMSE channel estimation algorithm, which does not need to know spatial and time correlations and has a complexity.

B. Correlation of Optimal MMSE algorithm with OFDM antenna diversity:

We implement the transmit diversity to provide diversity benefit to a receiver in a Rayleigh fading environment. With transmit diversity; multiple antennas transmit delayed versions of a signal to create frequency-selective fading at a single antenna at the receiver.

C. Orthogonality

In a transmission system, we want the occupied bandwidth on the channel to be as small as possible. For that, in a multicarrier system, we try to set a minimum frequency space between carriers without having intercarrier interference (ICI). The minimum space is reached when carriers are orthogonal to each other, signal from each can have a small overlap on the other without causing interference. That's what is meant by the « O » (Orthogonal) of OFDM. We'll see further that the inverse fourier transform has that orthogonality property

III. SINGLE-CARRIER (SC) BLOCK TRANSMISSION WITH CYCLIC PREFIX (CP)

OFDM is derived from the fact that the digital data is sent using single carrier (SC) to many carriers, each of a different frequency and these carriers are orthogonal to each other, hence Orthogonal Frequency Division Multiplexing . The frequency spacing of the carriers is chosen in such a way that the modulated carriers are orthogonal and do not interfere with one another. To use MATLAB to simulate a multi path (frequency selective fading) channel for a given number of Multi Paths. We will explain and use the FIR filter model of a Frequency Selecting Fading Channel.

IV. OFDM

OFDM is the modulation method chosen for many high-speed digital communication systems. This is despite

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OFDM having a number of well-known disadvantages that include extreme sensitivity to frequency offset, large out-of-band power, and high peak-to-mean power ratio. One of the often-quoted advantages of OFDM is that by using a cyclic prefix it can be made insensitive to multipath transmission. However this is at the cost of some loss in bandwidth efficiency. One technique which has the potential to solve many of the problems of OFDM is Polynomial Cancellation Coding (PCC). In PCC-OFDM the data to be transmitted is mapped onto weighted groups of subcarriers rather than individual subcarriers.

V. BLOCK DIGRAM OF OFDM

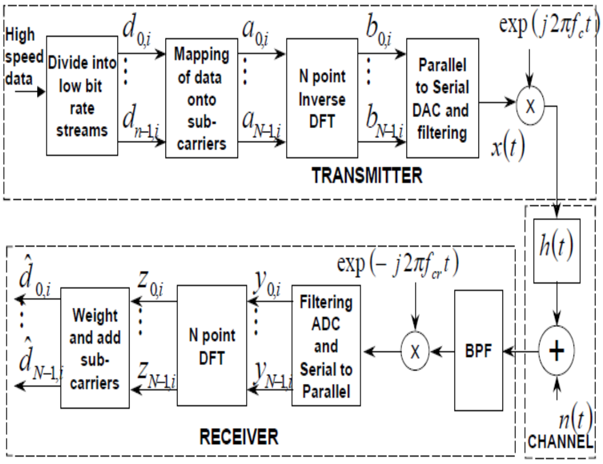

Figure1-Block Diagram of OFDM

A. *Bandwidth:*

Occupied bandwidth is of course directly related to the data rate to transmit. However, the question is , what is the minimum bandwidth to take in order to obtain enough diversity and avoid the loss off all the signal in frequency selective fading environments. On the other hand much bandwidth means also much transmitting power. There is a tradeoff between bandwidth and transmitted power. That optimal bandwidth is found by channel simulations and field test trials. In DAB, for example, a bandwidth of 1,5 Mhz is a good compromise for the type of propagation conditions that apply. The wider the bandwidth, the more probably that the system overcome the correlation bandwidth of the channel. Problem to overcome: Short delay echoes are the main problems to overcome, and as these are always present there is no hard bound.

B. *Number of Sub-carriers:*

We have seen that the greater the number of carriers, the greater the symbol period on each carrier and so lees equalization is needed and the greater the diversity offered by the system. However, with differential modulation, it is important that the channel not vary too much during one symbol period. This is not the case when the receiver is moving because of dopler effect and short term fading. Then a great number of carrier will limit the moving speed. This is another tradeoff of OFDM.

C. *Guard interval:*

One way to avoid Inter-symbol interference is to set a small gap equal to the duration of delay spread between the symbols. So, each symbol does not affect the next one. We'll also see later that this interval plays an important role in the implementation

D. *Modulation*

The modulation scheme used on each carrier depends on the BER needs. In DAB, QPSK is used but for higher order systems 16, 64 or 256 QAM is used.

VI. OFDM MIMO ANTENNA DIVERSITY SCHEME WITH DIFFERENT DIVERSITY PARAMETERS

Future wireless communications systems need a high quality of service coupled with high data rate transmission for multimedia services. Achieving this goal in the hostile wireless environment with its limited spectrum has several challenges and implies the necessity of a communication system that is able to increase the channel capacity and overcome the difficulties of the wireless transmission environment with reasonable system complexity. Two of the most enabling technologies for the next generation of wireless systems are orthogonal frequency division multiplexing (OFDM) and multiple-input multiple output (MIMO) systems. MIMO systems have been originally designed for known flat fading channels. In this research, some novel MIMO-OFDM schemes for broadband wireless applications are developed and presented. The objective of the proposed schemes is to enhance the performance of OFDM systems over multipath fading channels by using antenna diversity techniques, and also to make MIMO systems applicable to frequency selective multipath fading channels. For the performance evaluation, both bit error rate (BER) and channel capacity analysis are considered. The channel capacity of MIMO-OFDM systems is analytically evaluated and it is shown that the channel capacity of the these systems can be dramatically increased as a function of the number of antennas. The BER performance of the MIMO-OFDM systems is analytically evaluated. New closed-form expressions for the BER performance of the MIMO-OFDM systems over frequency selective fading channels are derived. On the other hand, the growing popularity of both MIMO and OFDM systems creates the need for adaptive modulation to integrate temporal, spatial and spectral components together.

TABLE I
PROPOSED PARAMETERS OF OFDMA

S.N O.	**PROPOSED PARAMETERS OF OFDMA**		
	Parameter	**Symbol**	**Range**
1	Bandwidth	B	101.25 MHz
2	Number of Sub-carriers	Nc	512
3	FFt length	NFFT	1024
4	Guard interval length	Ngi	226
5	Modulation	M	QAM

VII. OFDM SIGNAL PROCESSING

A general block diagram of an OFDM transceiver is shown in figure 1. In the transmitter path, binary input data is encoded by a rate 1/2 convolutional encoder. The rate may be increased to 2/3 or 3/4 by pucturing the coded output bits. After interleaving, the binary values are converted into QAM values. To facilitate coherent reception, 4 pilot values are added to each 48 data values, so a total of 52 QAM values is reached per OFDM symbol, which are modulated onto 52 subcarriers by applying the Inverse Fast Fourier Transform (IFFT). To make the system robust to multipath propagation, a cyclic prefix is added. Further, windowing is applied to get a narrower output spectrum. After this step, the digital output signals can be converted to analog signals, which are then upconverted to the 5 GHz band, amplified and transmitted through an antenna.Other Recommendations

VIII. TRANSMIT DIVERSITY

Alamouti's STBC: Alamouti published his technique on transmit diversity. Historically, Alamouti's scheme was the first STBC .The simplicity and structure of the Alamouti STBC has placed the scheme in both the W-CDMA and CDMA-2000 standards. The Alamouti STBC scheme uses two transmit antennas and Nr receive antennas and can accomplish a maximum diversity order of 2Nr . Moreover, the Alamouti scheme has full rate (i.e. a rate of 1) since it transmits 2 symbols every 2 time intervals.

At a time t, the symbol s1 and symbol s2 are transmitted from antenna 1 and antenna 2 respectively. Assuming that each symbol has duration T, then at time t + T, the symbols –S2* and S1* , where (.)* denotes the complex conjugate, are transmitted from antenna 1 and antenna 2 respectively

$$\mathcal{G}_2 = \begin{pmatrix} s_1 & s_2 \\ -s_2^* & s_1^* \end{pmatrix}$$

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$$r_1^{(1)} = r_1(t) = h_{1,1}s_1 + h_{1,2}s_2 + n_1^{(1)}$$
$$r_1^{(2)} = r_1(t+T) = -h_{1,1}s_2^* + h_{1,2}s_1^* + n_1^{(2)}$$

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$$\tilde{s}_1 = h_{1,1}^* r_1^{(1)} + h_{1,2} r_1^{*(2)}$$
$$\tilde{s}_2 = h_{1,2}^* r_1^{(1)} + h_{1,1} r_1^{*(2)}$$

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IX. CYCLIC DELAY DIVERSITY

One common transmit diversity technique used for single carrier and multicarrier systems is antenna delay diversity, which can take the form of time delay, cyclic delay and phase delay . Among them, cyclic delay diversity (CDD) is more widely adopted for single carrier and multicarrier applications as CDD can be applied to any number of transmit antennas without any rate loss or change in the receiver structure . In this section we show that linear MMSE receivers can achieve the maximal spatio-temporal diversity provided that the equalizer and the cyclic delay taps are properly designed.

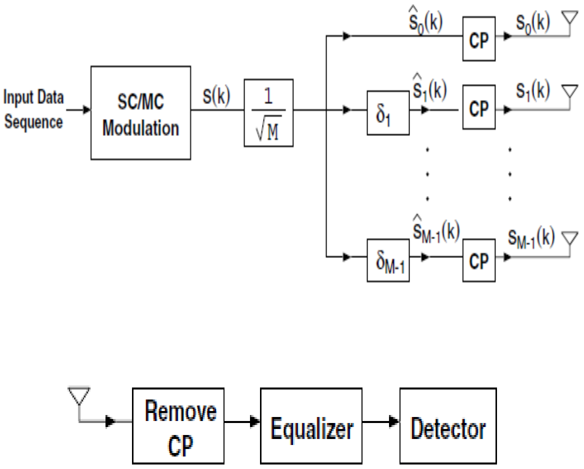

FIg-2 MISO system with transmitter sided CDD scheme

In vector form, the received signal can be written as

$$\mathbf{y} = \sum_{i=0}^{M-1} \sqrt{\rho}\,\mathbf{H}_i\, \hat{\mathbf{s}}_i + \mathbf{n}$$

where **H**i is an L×L circulant channel matrix whose first row is [hi,0, . . . , hi,vi , 0, . . . , 0], ˆ**s**i is the L × 1 transmitted data block (without the CP) from transmit antenna i. CDD converts the MISO channel into a SISO channel with increased channel selectivity. The model can be written as

$$\mathrm{y} = \sqrt{\rho}\,\mathrm{H}_{\mathrm{cir}}\,\mathrm{s} + \mathrm{n} = \sqrt{\rho}\,\mathrm{Q}^H \Lambda \mathrm{Q}\,\mathrm{s} + \mathrm{n}$$

where **H**cir is L×L circulant matrix, **s** is the L×1 modulated symbols , **Q** is the L × L normalized DFT matrix, and Λ is a diagonal matrix whose diagonal entries are the DFT point of the first row of **H**cir which are given by

$$\hat{h}(l) \triangleq \frac{1}{\sqrt{M}} \sum_{i=0}^{M-1} h_i(l-\delta_i)_{\mathrm{mod}\ L}.$$

X. MIMO TECHNOLOGY:

Multiple-Input Multiple-Output (MIMO) technology is a wireless technology that uses multiple transmitters and receivers to transfer more data at the same time. MIMO technology takes advantage of a radio-wave phenomenon called multipath where transmitted information bounces off walls, ceilings, and other objects, reaching the receiving antenna multiple times via different angles and at slightly different times. Multicarrier transmission or modulation uses multiple subcarrier signals at different frequencies, sending parallel bits on multiple subcarriers. Therefore data rate will be improved in multicarrier schemes. There are two main types of Multicarrier Transmission schemes such as OFDM (Orthogonal Frequency Division Multiplexing) and FMT (Filtered Multi-Tone).

MIMO technology leverages multipath behavior by using multiple, “smart” transmitters and receivers with an added “spatial” dimension to dramatically increase performance and range. MIMO allows multiple antennas to send and receive multiple spatial streams at the same time.

MIMO makes antennas work smarter by enabling them to combine data streams arriving from different paths and at different times to effectively increase receiver signal-capturing power. Smart antennas use spatial diversity technology, which puts surplus antennas to good use. If there are more antennas than spatial streams, the additional antennas can add receiver diversity and increase range.

The performance of the MMSE I/Q imbalance compensator can be improved by exploiting the characteristics of the OFDM signal. In the OFDM receiver, all the signal components in the subcarrier frequency are available by taking the DFT of the received signal. Since a_{-m} can be recovered in the OFDM receiver, it can be used as the reference instead of d_{-m} in the proposed I/Q imbalance compensator. The block diagram of the proposed I/Q compensator is depicted in Fig. 5, where the interference signal a_{-m}^* is obtained by the decision-directed method.

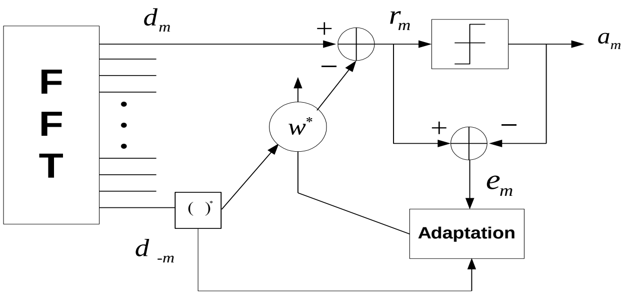

Fig. 3. MMSE I/Q imbalance compensator in the zero-IF OFDM receiver

To evaluate the performance of the proposed I/Q imbalance compensator, the proposed scheme is applied to an wireless LAN IEEE 802.11a OFDM transceiver scheme that comprises 64 subcarriers each of which employs 256-QAM signaling. The proposed compensator is trained first using known 50 preamble symbols and then using a decision-directed mode. The performance is verified by computer simulation in an AWGN channel when the initial value of θ is 10 degrees and G is 1.0 dB. To verify the tracking performance, we assume that θ and G are slowly time- varying (e.g., the value are changed in 1% during 1000-symbol time-interval).

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