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Implementation of Equalization & Channel Estimation for OFDM & CDMA

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Abstract— **In this paper three systems are joined together in order to mitigate distortion effect caused by multipath fading. Those systems are; space time block coding (STBC), code division multiple access (CDMA), and orthogonal frequency division multiplexing (OFDM). The proposed STBC OFDM-CDMA system has been simulated in the presence of frequency selective fast multipath fading channel which is considered the worst form of channel fading. Therefore, system performance depends mainly on channel equalization technique applied at the receiver. In this paper, a comparison among three channel equalization schemes was introduced, those schemes are; phase equalizer (PE), maximal ratio (MR), and minimum mean square error equalizer (MMSE). Those equalization schemes have been compared under various system conditions and using different modulation techniques. The main problem of OFDM system is the relative high peakto- average power ratio (PAR). Therefore, three techniques for reducing the PAR have been applied into the proposed STBC OFDM-CDMA transmitter. Channel coding is essential for any wireless communication system especially in the presence of this bad fading form. This is coming from its ability of error detection and correction at the receiver. Two types of channel coding, Hamming and convolutional coding, have been introduced into the proposed system in order to enhance its performance.**

Index Terms— **Orthogonal Frequency Division Multiplexing (OFDM), Code Division Multiple Access (CDMA), Space Time Block Coding (STBC), and Peak- to- Average Power Ratio (PAR)**

I. INTRODUCTION

Multi-path channel fading is the main enemy for any wireless communications system. Therefore, for any novel approach applied at any wireless communication system, its efficiency is measured according to its ability of mitigating the distortion caused by fading. The worst fading types is frequency – selective fast fading type since it results in two forms of distortion. First it causes time dispersion to the transmitted symbols resulting in inter symbol interference (ISI). The second effect is the distortion in the spectrum of the transmitted signal.

In the proposed system, two systems have been joined together to mitigate distortion appears in both time and frequency domains. Those two systems are OFDM and DS-CDMA systems. DSCDMA. mechanism can convert fast fading into slow fading channel where, the symbol duration is divided into much smaller chip duration after spreading [5]. This chip duration will be smaller than coherence time of the channel of course resulting in slow fading form. OFDM system will convert frequency selective fading into flat fading. Where instead of modulating all data symbols using the same carrier and over one frequency band, each symbol (or a group of symbols) modulates different carriers so that the total band is divided into smaller adjacent non-interfered subbands. Therefore, the resultant sub-bands will be of smaller width than channel coherence bandwidth resulting in frequency nonselective (or flat) fading form.

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II. SYSTEM MODEL

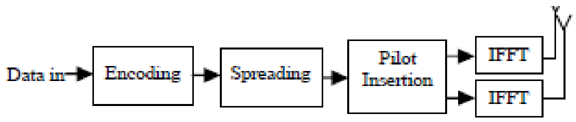

Figure 1: Simple Model of MIMO MC-CDMA Transmitter

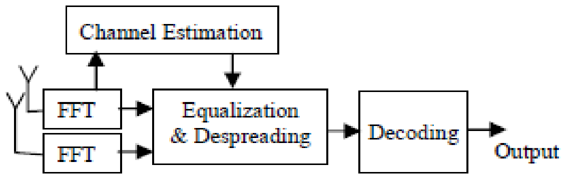

Figure 2: Simple Model of MIMO MC-CDMA Receiver

Figures 1 and 2 show the simple model of MIMO MC-CDMA transmitter and receiver respectively. The transmitter of MIMO MC-CDMA consists of BPSK/QPSK modulator, Direct sequence spreader and OFDM modulator. In these schemes the pilot sequence are very important for the performance.

After modulating, the data stream is multiplied by a spreading sequence. The length of this spreading code is usually identical to the number of SC. The pilot signals are multiplexed to the data streams, after OFDM modulation the signals are transmitted through multiple antennas.

The received signal is demodulated using Fast Fourier transform (FFT). After OFDM demodulation the user data symbols and pilot symbols are recovered by despreading with corresponding spreading codes. The required transfer function for channel estimation and equalization is recovered from pilot sequence. Finally the original data stream is recovered by dividing the received signal by channel response.

At the receiver end, the demodulator process the channel equalized waveform and reduces each waveform to a scalar (or) a vector that represents an estimation of the transmitted data symbol. The detector, which follows the demodulator, decides whether the transmitted bit is a 0 or 1.

III. OPTIMIZATION BASED APPROACHES

To increase the diversity of the system the multidimensional MIMO channel can be exploited. Generally, there are three categories of MIMO techniques. The first aims to improve the power efficiency by maximizing spatial diversity. Such

techniques include delay diversity, space–time block codes (STBC) and space–time trellis codes (STTC) [7].
Diversity is generally considered lower risk and a well knownexample is space time codes [8] [9].Space time coding is a promising technique to improve the efficiency and good performance of MIMO-OFDM system. Orthogonal Space Time Block Code (O-STBC) is an important class of space time codes due to its ability to provide optimal transmit diversity by requiring only simple linear processing at the receiver.But to achieve full rate transmission while retaining much of the orthogonallybenefits .QO-STBC has been proposed, and also QO-STBC can achieve higher code rates than O-STBC. Using space time coding, for OFDM system with transmit diversity; two or more different signals are transmitted from different antennas simultaneously. On the other hand, spatial multiplexing divides the incoming data into multiple sub-streams and transmits each on a different antenna. Spatial multiplexing is thus more exciting than spatial diversity from a high data rate point of view, but there is a fundamental tradeoff between them [10]. It can easily adapt to severe channel conditions without the need for complex channel equalization algorithms being employed. With OFDM, we can easily mitigate the ISI because low data rates are carried by each carrier. OFDM involves the transmission of data on multiple frequencies for the duration of a symbol. By using multiple carriers, communication is maintained should one or more carriers be affected by either narrow-band or multi-path interference. A key aspect of OFDM is that the individual carriers overlap to improve spectral efficiency. Normally, overlapping signals would interfere with each other. However, through special signal processing, the carriers in an OFDM waveform are spaced in such a manner that they do not interfere with one another – i.e., they are orthogonal to each other so that there is no cross-interference and hence no signal loss. The key benefits of OFDM include increased spectral efficiency and high resistance to multi-path interference and frequency selective fading. Using OFDM and coding across the frequency band can mitigate narrow-band interference. Indeed, coding and OFDM exhibit a spreading gain similar to spread-spectrum techniques.

IV. APPROACH TOWARDS EQUALIZATION

In mobile communications systems, data transmission at high bit rates is essential for many services such as video, high quality audio and mobile integrated service digital network. When the data is transmitted at high bit rates, over mobile radio channels, the channel impulse response can extend over many symbol periods, which leads to Inter-symbol interference (ISI). Orthogonal Frequency Division Multiplexing (OFDM) is one of the promising technology to mitigate the ISI. In an OFDM signal the bandwidth is divided into many narrow sub-channels which are transmitted in parallel. Each sub-channel is typically chosen narrow enough to eliminate the effect of delay spread. By combining OFDM with CDMA dispersive fading limitations of the cellular mobile radio environment can be overcome and the effects of co-channel interference can be reduced. In this paper, the performances of equalization techniques by considering 2 transmit 2 receive antenna case (resulting in a 2×2 MIMO channel). Assume that the channel is a flat fading Rayleigh multipath channel and the modulation is BPSK.

Based on those assumptions such as perfect synchronization and block fading, we end up with a compact and simple signal model for both the single antenna OFDM and MIMO-OFDM systems. In training based channel estimation algorithms, training symbols or pilot tones that are known to the receiver, are multiplexed along with the data stream for channel estimation. The idea behind these methods is to exploit knowledge of transmitted pilot symbols at the receiver to estimate the channel. For a block fading channel, where the channel is constant over a few OFDM symbols, the pilots are transmitted on all subcarriers in periodic intervals of OFDM blocks. This type of pilot arrangement, depicted in Fig. 3(a), is called the block type arrangement. For a fast fading channel, where the channel changes between adjacent OFDM symbols, the pilots are transmitted at all times but with an even spacing on the subcarriers, representing a comb type pilot placement, Fig. 3(b)

1) ***The channel estimates from the pilot subcarriers are interpolated to estimate the channel at the data subcarriers.***

The work to be done in later stages is to perform the Channel estimation based on comb-type pilot arrangement is achieved by giving the channel estimation methods at the pilot frequencies and the interpolation of the channel at data frequencies. This study can also be used to efficiently estimate the channel in both OFDM systems given certain knowledge about the channel statistics in future. Also,the MMSE estimator assumes a priori knowledge of noise variance and channel covariance and discussed Space Time Block coding and maximum likelihood decoding in the MIMO OFDM system to enhance its performance further. Wecan also observe the advantage of diversity in MIMO systemresults less BER than SISO system. It can also compares the performance of MMSE with LS, and is observed that the former is more resistant to the noise in terms of the channel estimation

V. SIMULATION RESULT

The vectors X1 and X2 are modulated using the inverse fast Fourier transform (IFFT) and after adding a cyclic prefix as a guard time interval, two modulated blocks Xg1 and Xg2are generated and are then transmitted by the first and second transmit antennas respectively. Assuming that the guard time interval is more than the expected largest delay spread of a multipath channel. The received signal will be the convolution of the channel and the transmitted signal. Assuming that the channel is static during an OFDM block, at the receiver side after removing the cyclic prefix, the FFT output as the demodulated received signal can be expressed as in the above equation [W1, W2……WNT] denotes AWGN and Hm,n is the (single-input single-output) channel gain between the mth receive and nth transmit antenna pair. The nth column of **H** is often referred to as the spatial signature of the nth transmit antenna across the receive antenna array.Knowing the channel information at the receiver, Maximum Likelihood (ML) detection can be used for decoding of received signals for two antenna transmission system, which can be drawn as

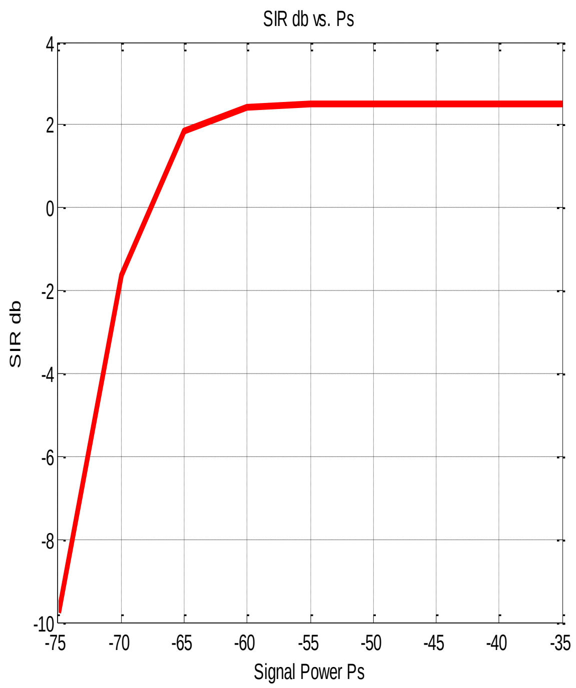

Fig 3. SIR db vs. Ps

Here we can see that the plot is in between the signal power (Ps) vs. signal to interference ratio (SIR). If we increase the signal power (Ps) then signal to interference ratio (SIR db) will be increase. We found the curve for alpha = 0.8 and consider 10 number of user.

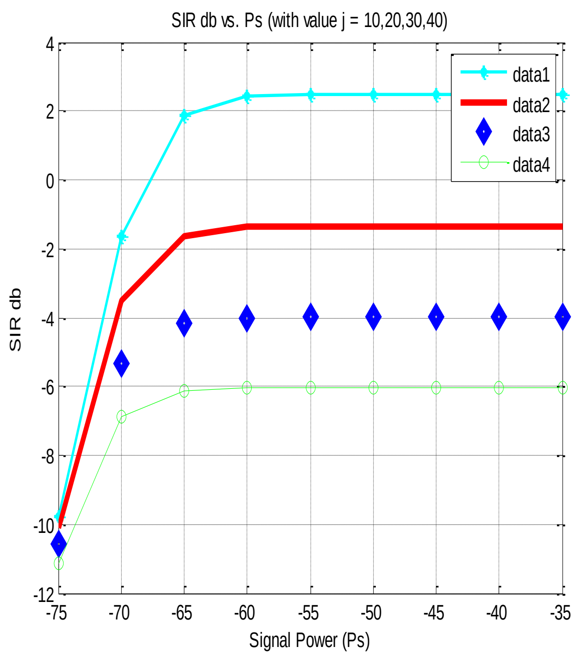

Fig.4 SIR db vs. Ps (with value j)

Here we can see that the plot between signal power (Ps) vs. signal to interference ratio in db (SIR db). If we increase the signal power (Ps) then SIR db will be increase. Here alpha is fixed at 0.8. For different sets of number of user (j) we have got different curves. j = 10, 20, 30, 40.

VI. CONCLUSION AND FUTURE RESULTS

In my work, I have compared channel estimation based on both block-type pilot and comb-type arrangements in both SISO and MIMO OFDM based systems

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REFERENCES

[1] Ramjee Prasad, *"OFDM for wireless communications systems"* Artech House, Inc. Publications.

[2] Ezio Biglieri, Robert Calderbank, Robert Calderbank, Anthony Constantinides, Andrea Goldsmith, Arogyaswami Paulraj, H. Vincent Poor, *"MIMO wireless communications"* Cambridge Press.

[3] A. Petropulu, R. Zhang, and R. Lin, "Blind OFDM Channel Estimation Through Simple Linear Pre-Coding" *IEEE Transactions on Wireless Communications, vol. 3, no.2, March 2004, pp. 647-655.*

[4] Osvaldo Simeone, Yeheskel Bar-Ness, Umberto Spagnolini, "Pilot-Based Channel Estimation for OFDM Systems by Tracking the Delay-Subspace",

[5] R. Corvaja and A. García Armada, "Effect of multipath and antenna diversity in MIMOOFDM systems with imperfect channel estimation and phase noise compensation",*Elsevier Physical Commun.*, Vol. 1, No. 4, Dec. 2008, pp. 288-297.

[6] S. Bittner, E. Zimmermann and G. Fettweis, "Iterative phase noise mitigation in MIMOOFDM systems with pilot aided channel Estimation", in *Proc. IEEE VTC 2007 Fall*, Sep. 2007, pp. 1087-1091.

[7] P. Liu, S. Songping, and Y. Bar-Ness, "A phase noise mitigation scheme for MIMO WLANs with spatially correlated and imperfectly estimated channels", *IEEE Commun. Lett.*, Vol. 10, No. 3, Mar. 2006, pp. 141-143

[8] Xianhua Dai, Han Zhang and Dong Li, "Linearly time-Varying Channel Estimation for MIMO/OFDM Systems Using Superimposed Training", IEEE *Trans. on Commun*., Vol. 58, No. 2, Feb. 2010, pp. 681-693.

[9] Benjamin R. Hamilton, Xiaoli Ma, John E. Kleider and Robert J. Baxley, "OFDM Pilot Design for Channel Estimation with Null Edge Subcarriers", *IEEE Trans. on wireless commun.*, Vol. 10, No. 10, Oct. 2011, pp. 3145-3150.

[10] Francesco Montorsi and Giorgio Matteo Vitetta, "On the Performance Limits of Pilot-Based Estimation of Band limited Frequency-Selective Communication Channels", *IEEE Trans. On Commun*., Vol. 59, No. 11, pp. 2964-2969, Nov. 2011.

[11] Barbara M. Masini *and* Andrea Conti, "Combined Partial Equalization for MCCDMA Wireless Systems", *IEEE Commun. Lett.*, Vol. 13, No. 12, Nov. 2011, pp. 884-886.

[12] Flavio Zabini, Barbara M. Masini and Andrea Conti, "Partial equalization for MCCDMA systems in non-ideally estimated correlated fading", *IEEE Trans. Veh. Technol*, Vol. 59, No. 8, Oct. 2010, pp. 3818-3830.