DMWTCS BASED STBC-MC-DS-CDMA in Fast-Fading Multipath Channel

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Abstract**—***Wireless digital communications is rapidly expanding resulting in a demand for systems that are reliable and have a high spectral efficiency, to fulfill these demands, the Multicarrier modulation scheme, often called Orthogonal Frequency Division Multiplexing (OFDM), has drawn a lot of attention. On the other hand (CDMA) techniques have been considered to be a candidate to support multimedia services in mobile radio communications. In this work, STBC-OFDM block have been studied extensively, and proposed a new structure for STBC-OFDM that based on Multifilters called Multiwavelets using Critically-Sampled (DMWTCS), it has two or more lowpass and highpass filters, the purpose of this multiplicity is to achieve more BER performance than the conventional STBC-OFDM using FFT and DWT. The proposed STBC-OFDM systems have been examined in different channel models AWGN, flat fading and selective fading. After a study made to the STBC-OFDM systems and evaluated their BER performances with channels models. Several structures of STBC-MC-DS-CDMA systems will be studied, these structures based on FFT, DWT and DMWTCS. The simulation results are presented for a simulated AWGN, Flat fading and Selective fading channels****.***

Index Terms —OFDM, DWT, DMWTCS, STBC, MC-DS-CDMA

1. INTRODUCTION

In [1], a comparison was made to the performance of the different STBC-OFDM systems that based on FFT, Wavelet and Multiwavelet. The results showed that the DMWTCS STBC-OFDM is better than the other OFDM systems in different channel models namely AWGN, flat fading and selective fading channels. Due to the current trend of personal wireless communication, there are growing needs for both higher data rate transmission and multiple accesses. To fulfill these demands, a new scheme communication system which combines wireless digital modulation and multiple access is proposed, that combines the principle of CDMA with OFDM which allows one to use the available spectrum in an efficient way and retain the many advantages of CDMA system. This combination of OFDM-CDMA is a useful technique for 4G communication systems where it needs variable data rates as well as provides reliable communication systems.

The different STBC-MC-DS-CDMA systems will be studied that based on FFT, wavelet and Multiwavelets and its performance in different channel models AWGN, flat fading and selective fading will be discussed.

2. STBC-MC-DS-CDMA SYSTEM DESIGN

Code Division Multiple Access (CDMA) is a multiplexing technique where a number of users simultaneously and asynchrounsly access a channel by modulating and spread their information-bearing signals with preassigned signature sequences.

Recently, CDMA techniques have been considered to be a candidate to support multimedia services in mobile radio communications. Because its own capabilities to provide higher capacity over conventional access techniques such as time division multiple access TDMA and Frequency division multiple access FDMA, and combat the hostile channel frequency selectivity.

On the other hand, the Multicarrier modulation scheme OFDM, has drawn a lot of attention in the field of radio communications, this is mainly because of the need to transmit high data rate in a mobile environment which makes a highly hostile radio channel. To combat the problem, the OFDM seems to be the solution.

Recent studies have combined the principle of CDMA with OFDM which allows one to use the available spectrum in an efficient way and retain the many advantages of a CDMA system. If the number and spacing between the subcarriers are chosen appropriately, it will provide frequency diversity. This combination of OFDM-CDMA is a useful technique for 4G systems where it need variable data rates as well as provides reliable communication systems.

A MC-DS-CDMA system basically applies the OFDM type of transmission to a DS-CDMA signal. In conventional DS-CDMA each user symbol is transmitted in the form of sequential chips, each of which is narrow in time and hence wide in bandwidth. In contrast to this, in MC-DS-CDMA due to the FFT transform along with OFDM the chips are longer in time duration and hence narrow in bandwidth. The multiple chips for a data symbol are not sequential but instead transmitted in parallel over many subcarriers. An interesting feature of MC-DS-CDMA is that the modulation and demodulation can be easily implemented using simple FFT and IFFT operators.

Multicarrier CDMA schemes can be broadly categorized into two groups. The first type spreads the original data stream using a spreading code and then modulates different carriers with each chip, spreading the chips in the frequency domain. This is usually referred to as

MC-CDMA and is the technique of interest. The second type spreads the serial to parallel converted streams using a spreading code and then modulates different carriers with each data stream, spreading in the time domain.

Again two schemes are reported in this spreading in time domain approach based on the subcarriers frequency separation. If we denote the bit duration as Tb and the chip duration as T_c, then the subcarriers spacing in one system is $1/T_c$ and the other is $1/T_b$. The former is called the Multicarrier DS-CDMA (MC-DS-CDMA) and the latter is called the Multi-tone CDMA (MT-CDMA).

In [7] the author has shown that MC-CDMA outperforms MC-DS-CDMA and MT-CDMA in terms of downlink BER performance. MC-CDMA is thus an attractive technique for the downlink.

3. PROPOSED SYSTEM FOR DMWTCS BASED STBC-MC-DS-CDMA

The block diagrams of the proposed systems for MC-DS-CDMA are depicted in Figure (1) and (2).These Figures illustrates a typical STBC-MC-DS-CDMA system used for Multicarrier modulation using one or two receivers.

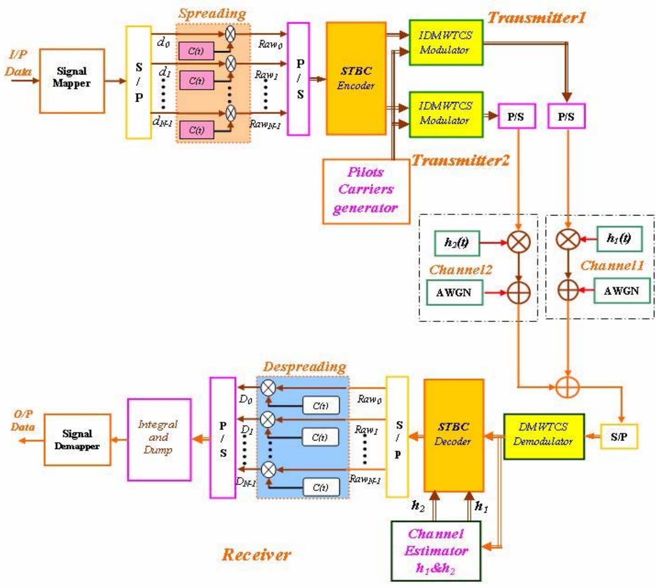

Figure 1: Block Diagram of the proposed STBC-MC-DS-CDMA System Based on DMWTCS

In the conceptual block diagram of a MC-DS-CDMA suppose the data packet d_n are a stream of serial data to be transmitted using this scheme of modulation. d_n are generated at a rate R_s. Each data packet convert the data streams from serial to parallel form to construct a one dimensional vector contains the data symbols to be transmitted as shown:

$$d = (d_o\ d_1\ d_2 \ldots\ldots\ldots\ d_{L-1})^T \qquad (1)$$

where, L is the packet length and refers to the code length. Each serial-to-parallel converted data symbols are DS-SS modulated using a user specific spreading code. As a result each data symbol becomes a vector with L bits. So, a matrix D of size L by L is obtained. Then each column of the matrix D converts to serial data using parallel-to-serial converter. The same procedure illustrated in [4] will be use with each converted serial data.

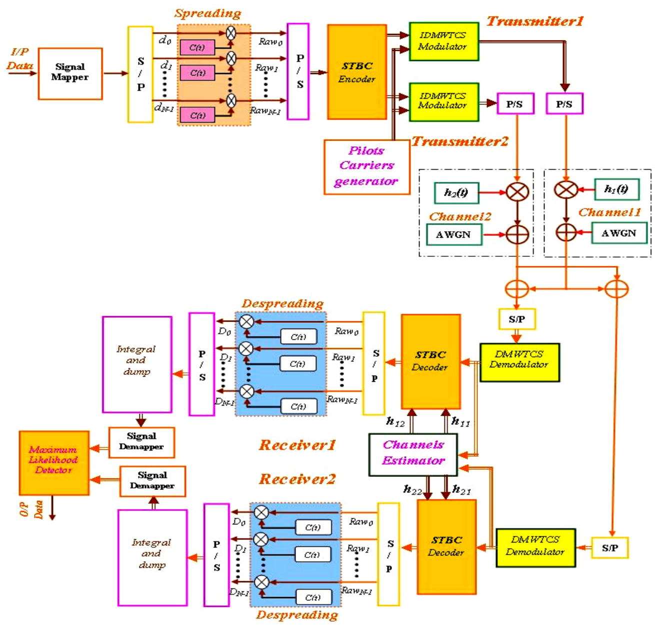

Figure 2: Block Diagram of the proposed STBC-MC-DS-CDMA System Based on DMWTCS with two receivers.

The proposed STBC-OFDM based on DMWTCS will be used from STBC encoder through out Generation and insertion of Pilot Carriers and The OFDM Modulator using IDMWTCS and the addition of the cyclic prefix, and Sequences Insertion and Parallel to Serial Converter for each transmitter and then The Channel Effect for each transmitted sequence , then S/P and sequence separation for each additive received sequences in each receiver antenna in the receiver part ,after this step each sequence discarded the cyclic prefix and inter to OFDM Demodulator that use the DMWTCS . After the sub-carrier demodulation the zeros pad is removed for each sequence and the training sequence will be used to estimate the channel transfer function $h_1(t)$ and $h_2(t)$ using equation of G2 for each received sequence .The data sequence will be inter to the STBC Decoder that expressed in [4, 5, and 10].After this step each vector collected using the S/P converter to reconstruct the received matrix D_R whose dimension is $L \times L$, after all the matrix of the spread data is despreaded using same spreading user code sequence that used in transmitter ,then integral and dump each raw of the resultant matrix then pass to the signal demapper used to get the output data for single receiver if used more receiver the outputs of signals demapper will pass to Maximum Likelihood Detector to get Maximum Likelihood symbol data for the output data.

4. SIMULATION RESULTS OF THE PROPOSED STBC-MC-DS-CDMA SYSTEMS

In this section the simulation of the proposed STBC-MC-DS-CDMA Systems in MATLAB V_7 are achieved. And the BER performance of the STBC-MC-DS-CDMA Systems considered in different channel models, the AWGN channel, the flat fading channel, and the selective fading channel [13]. Table (1) shows the parameters of the system that are used in the simulation; the bandwidth used was 10MHz.

Table 1: Simulation Parameters

Modulation Types	BPSK
Spreading Code	Gold
Number of sub-carriers	64
Number of DMWT points	64
Channel model	AWGN
	Flat fading+AWGN
	Frequency selective fading+AWGN

4.1 Performance of STBC-MC-DS-CDMA Systems in AWGN channel

In this section, the channel is modeled as Additive White Gaussian Noise for wide range of SNR from 0dB to 40dB. Simulation result of the proposed STBC-MC-DS-CDMA Systems is calculated as shown in Figure (3) which gives the BER performance of STBC-MC-DS-CDMA Systems in AWGN channel. It is shown clearly that the STBC-MC-DS-CDMA Based on DMWTCS is much better than the two other STBC-MC-DS-CDMA systems Based on FFT and DWT. This is a reflection to the fact that the orthogonal bases of the Multiwavelets is much significant than the orthogonal bases used in STBC-MC-DS-CDMA FFT and DWT.

For BER 10^{-4} the STBC-MC-DS-CDMA Based on DMWTCS have SNR=2, for 2Rx and 4.5dB for 1Rx while in FFT base STBC-MC-DS-CDMA SNR=17dB for 2Rx and 19dB for 1Rx, therefore the gain of Multiwavelet based STBC-MC-DS-CDMA to FFT based STBC-MC-DS-CDMA is about 15dB.For Wavelet based STBC-MC-DS-CDMA the BER=10^{-4} is found in SNR=3dB for 2Rx and 6dB for 1Rx, and it is also a significant, and the gain achieved by using Wavelet based MC-CDMA is about 14dB in proportion to FFT based STBC-MC-DS-CDMA. It's found the STBC-MC-DS-CDMA when combined with STBC-OFDM, the BER performance of the system is better than just using the STBC-OFDM only. Because this type spreads the original data stream using a spreading code and then modulates different carriers with each chip.

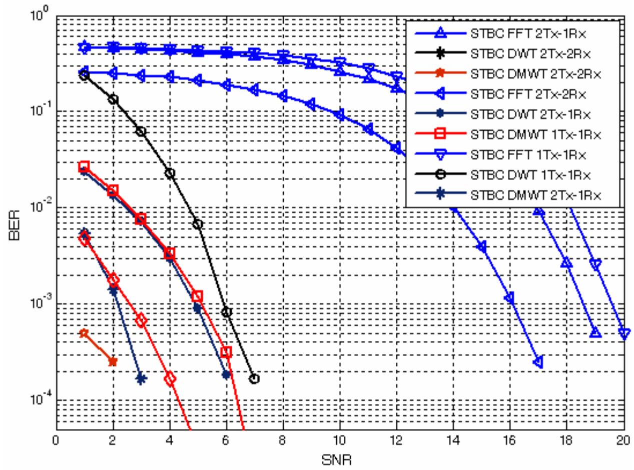

Figure 3: BER performance of STBC-MC-DS-CDMA System in AWGN channel

4.2 Performance of STBC-MC-DS-CDMA in Flat Fading Channel

In this type of channel, the signal affected by the flat fading with addition to AWGN; in this case all the frequency components in the signal will be effect by a constant attenuation and linear phase distortion of the channel, which has been chosen to have a Rayleigh's distribution. A Doppler frequency of 10Hz is used in this simulation. From Figure (4) it can be seen that for BER=10^{-4} the SNR required for STBC-MC-DS-CDMA Based on DMWTCS is about 7dB for 2Rx and 10dB for 1Rx, while in STBC-MC-DS-CDMA Based on DWT the SNR about 9dB for 2Rx and 13dB for 1Rx and for STBC-MC-DS-CDMA Based on FFT have 18dB for 2Rx and 25dB for 1Rx, therefore a gain of 2dB for the DMWT against DWT. As shown in Figure (4), it was found that the STBC DMWTCS-MC-DS-CDMA is outperform significantly other than the two systems for this channel model.

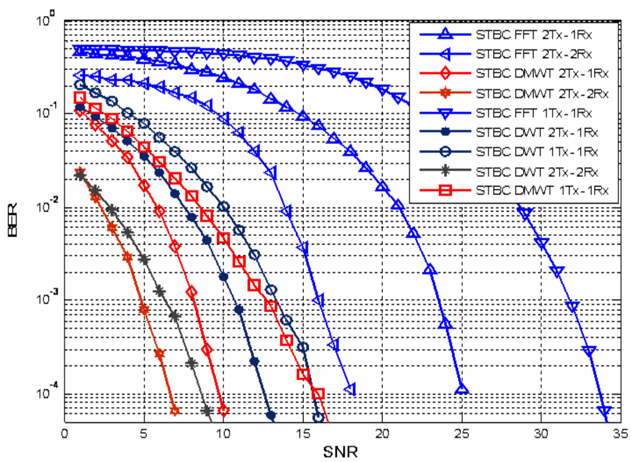

Figure 4: The BER performance of STBC-MC-DS-CDMA in Flat Fading Channel at Max. Doppler Shift=10Hz.

An alternative Doppler Shifts are used, the values taken is 100Hz, 500Hz and the BER vs. SNR are given in the two Figures (5) and (6) below.

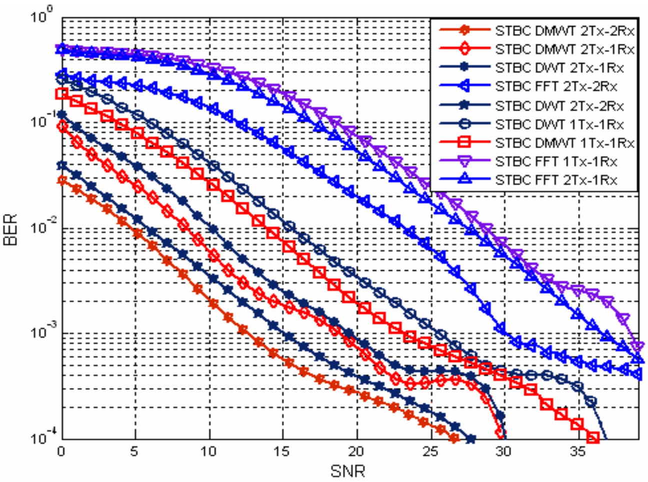

Figure 5: BER performance of modified STBC-MC-DS-CDMA in Flat Fading Channel at Max. Doppler Shift=100Hz.

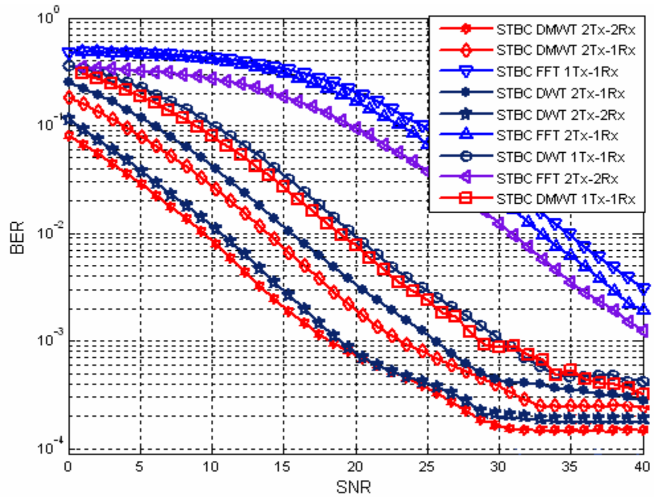

Figure 6: The BER performance of STBC-MC-DS-CDMA in Flat Fading Channel at Max. Doppler Shift=500Hz.

4.3 Performance of STBC-MC-DS-CDMA in Selective Fading Channel

In this section, the channel model is assumed to be selective fading channel, where the parameters of the channel in this case corresponding to multipaths where two paths are chosen the LOS and second path the LOS path have Average Path Gain equals 0dB and Path Delay of 0 sample, where the second path have Average Path Gain -8dB and path Delay one sample as shown in Figure (7). It is shown clearly in Figure (7), that BER performance of STBC-MC-DS-CDMA Based on DMWTCS is better than the two systems which are STBC-MC-DS-CDMA Based on DWT and STBC-MC-DS-CDMA Based on FFT. The STBC-MC-DS-CDMA Based on DMWTCS has BER performance 10^{-4} at SNR 6dB for 2Rx and 10.5dB for 1Rx and the STBC-MC-DS-CDMA Based on FFT have the same BER performance at 25dB for 2Rx and 30dB for 1Rx and STBC-MC-DS-CDMA based on DWT have 8.5dB for 2Rx and 15dB for 1Rx

The BER STBC-MC-DS-CDMA Based on DMWTCS, DWT and FFT as shown in [2, 9] and Figures (9) and (10) for Maximum Doppler Shift parameter 100Hz and 500Hz will become constant after a certain SNR. For this case it was constant to 10^{-2} after SNR 25 dB for 1Rx and $(2*10^{-3})$ for 2Rx for DWT and $5*10^{-3}$ after SNR 25dB to 1Rx and 10^{-3}.to 2Rx for DMWTCS. From this results it can be concluded that the STBC-MC-DS-CDMA Based on DMWTCS is most significant than the other systems based of STBC DWT and STBC FFT in the different channels that have been assumed. From Doppler Shift parameter tests, the STBC-MC-DS-CDMA based on Multiwavelet is performing better than the conventional STBC-MC-DS-CDMA based on FFT and DWT.

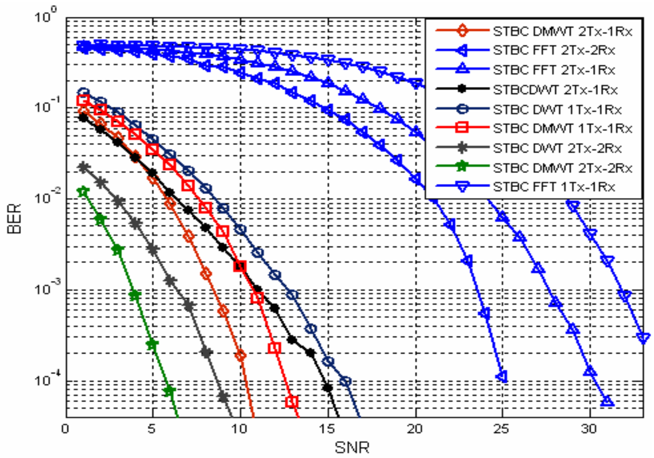

Figure 7: The BER performance of STBC-MC-DS-CDMA in Selective Fading Channel at Max Doppler Shift=10Hz.

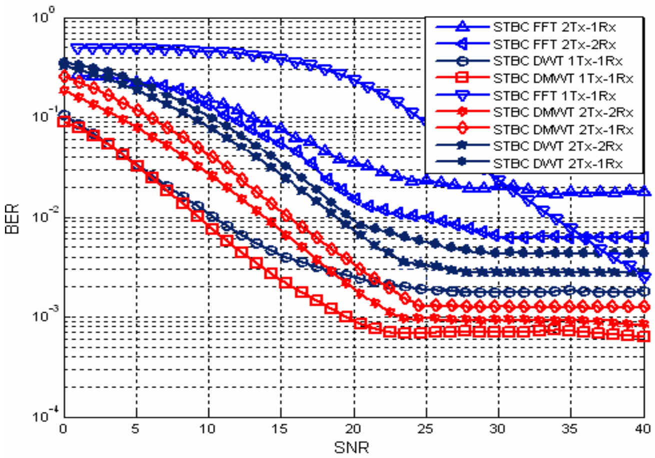

Figure 8: The BER performance of STBC-MC-DS-CDMA in Selective Fading Channel at Max Doppler Shift=100Hz.

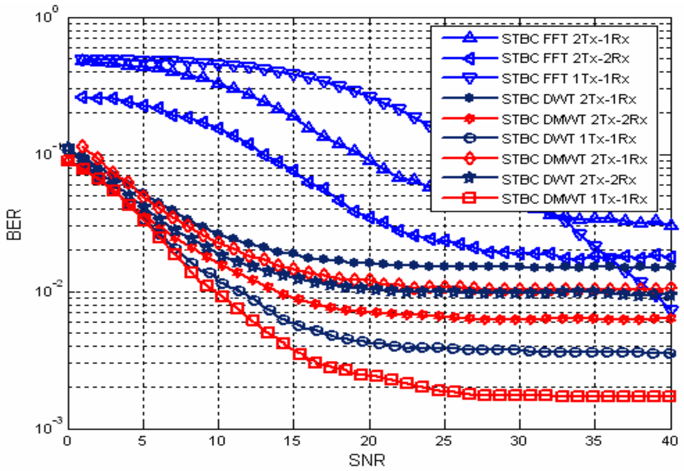

Figure 9: The BER performance of STBC-MC-DS-CDMA in Selective Fading Channel at Max Doppler Shift=500Hz.

From this results it can be concluded that the STBC-MC-DS-CDMA Based on DMWTCS is most significant than the other systems based of STBC DWT and STBC FFT in the different channels that have been assumed. From Doppler Shift parameter tests, the STBC-MC-DS-CDMA based on Multiwavelet is performing better than the conventional STBC-MC-DS-CDMA based on FFT and DWT.

5. CONCLUSION

In this paper, we investigate the improved performance of the combined MC-DS-CDMA system using STBC schemes with multiple transmit antennas, DWT and DMWTCS The performance comparisons of bit error probability for the conventional MC-DS-CDMA, STBC MC-DS-CDMA, DWT STBC MC-DS-CDMA and DMWTCS STBC MC-DS-CDMA has been presented. Simulation results were provided to demonstrate that significant gains can be achieved by introducing some combination technique (e.g. DMWTCS, DWT) and using two transmit antennas with very little decoding complexity. Therefore, the STBC MC-DS-CDMA, DWT STBC MC-DS-CDMA and DMWTCS STBC MC-DS-CDMA are a feasible way to reach the next generation of wireless communication for large data rates and applications.

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