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OFDM-STBC Based Transceiver for WiMAX 802.16e

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ABSTRACT: The development of 802.16 standards for Broadband Wireless Access technologies(BWA) was motivated by the rapidly growing need for high-speed, ubiquitous and cost-effective access. The limitations of conventional Broadband wireless access have been overcome with the scalable features of WiMAX.WiMAX is Worldwide Interoperability for Microwave Access (WiMAX)[5].It is one of the wireless communication technologies, especially Broadband Wireless Access (BWA) which uses OFDM and MIMO systems in order to provide high data rates, minimization of bandwidth and fading effects. Orthogonal Frequency Division Multiplexing (OFDM) is one of the best digital modulation schemes, where signal is divided into number of narrow band channels to obtain spectral efficiency and minimizing the Inter Symbol Interference (ISI)[2].In this paper we have reviewed the communication system of OFDM-STBC based transceiver for WiMAX 802.16e standard.

KEYWORDS: WiMAX, OFDM, MIMO, FFT/IFFT,STBC.

I. INTRODUCTION

The bit error rate (BER),the data rate and bandwidth are parameters that are considered to produce a reliable wireless communication system in modern communication services.Many systems have been proposed for this and OFDM combined with MIMO has gained much attention for solving these problems.OFDM technique was first developed in 1960s and nowadays OFDM has developed into a popular scheme for wideband digital communication, used in applications such as digital television and digital audio broadcasting(DAB),digital video broadcasting(DVB),DSL Internet access, wireless networks, powerline networks, and 4G mobile communications[1].

Multiple Input Multiple Output Orthogonal Frequency Division Multiplexing (MIMO-OFDM) techniques have been recently considered in the panorama of ongoing and future multimedia mobile communications due to their robustness to frequency-selective fading and their flexibility in handling multiple data rates. Nowadays, MIMO-OFDM techniques present some well-promising applications in wireless standards like IEEE 802.11n, E-UTRAN Long Term Evolution (LTE), and IEEE 802.16x (WiMax) [1]. In the literature different Space-Time (ST) processing techniques have been proposed in order to fully exploit the potentialities of MIMO systems.Space-Time Coding is one of the most popular technique in which the time dimension is complemented with the spatial dimension inherent to the use of multiple spatially-distributed antennas[2].Most commonly used ST coding schemes are ST-trellis codes and ST block codes (STBC)[7].A well-known example of conceptually simple, computationally efficient and mathematically elegant STBC scheme has been proposed by Alamouti in 1998.He originally employed 2 transmit and 1 receive antenna in flat fading channel. Substantially, Alamouti's coding is an orthogonal ST block code where two successive symbols are encoded in an orthogonal 2x2 matrix[5].

Basic communication system using OFDM consists of a mapping/de-mapping (PSK or QAM), serial to parallel, parallel to serial converter and a FFT / IFFT processor. In this paper we have reviewed how it has been added to the system by implementing STBC MIMO 2x2 which is intended to support the WiMAX 802.16e standard. STBC system is used to increase the data rate and bandwidth efficiency[11].The work consist of the mapping/de-mapping symbol, serial to parallel, parallel to serial, encoder/decoder STBC. The main contents of this paper is organized as follows:-Section II presents a description of the WiMAX 802.16e standard, OFDM fundamentals and STBC. At section

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III is brief description of the system design,comparison of various approaches related to OFDM in section IV and conclusion at section V.

II. RELATED WORK

In [3] authors have presented design and implementation of OFDM with 512 subcarriers and 2x2 STBC MIMO transceiver for WiMAX 802.16e standard. The design consists of (Space Time Block Code) STBC, Fast Fourier Transform (FFT / IFFT) for subcarrier division, mapping and de-mapping symbols, and system integration using high level design tool based on VHSIC Hardware Description Language (VHDL) on FPGA.In [4] authors have described performance study of adaptive modulation and various coding schemes in WiMAX OFDM-based system.In [7] authors have presented design of MIMO-OFDM system for Wireless Broadband Communications and have analysed its BER performance.In [8] authors have presented a comprehensive analysis about BER and SNR for various scenarios which include different channels, different modulation techniques and carrier frequency offsets.In [9] authors have presented MIMO-OFDM techniques which are used to increase the performance efficiency by having multiple transmit and receive antenna for the Rayleigh channel. The reference model SISO, MISO, MIMO(2X2) are esigned and simulated in MATLAB. The evaluation of Bit Error Rate (BER) and Signal to Noise Ratio (SNR) performance of the MIMO-OFDM technique combined with Alamouti Space Time Block Codes (STBC) based on 16 QAM over Rayleigh Channels are carried out.In [10] authors have presented a new Non-Linear precoding method to the acclimatization for the Worldwide Interoperability for fixedMicrowave Access (WiMAX) baseband, in the physical layer performance of multi-antenna techniques.The proposed Non-Linear Precoding Tomlinson-Harashima Precoding (THP) in WiMAX baseband consider a new way to further reduce the level of interference and signals achieved much lower bit error rates and increase spectral efficiency.

III. WIMAX, OFDM & STBC OVERVIEW

A.WiMAX 802.16e STANDARD

WiMAX is Worldwide Interoperability for Microwave Access.It is one of the wireless communication technologies,especially Broadband Wireless Access(BWA) that provide high data rate communication services in high mobility conditions. The system is released by the Institute of Electrical and Electronics Engineering (IEEE).,IEEE has released the 802.16 standard for the first time.Then in 2004,with some improvements in the previous system it become 802.16a standard which is called fixed WiMAX. In December 2005, the IEEE group completed and approved IFEEE 802.16e-2005, which is improvement of the previous standard that added mobility support and 802.16e standard then called as mobile WiMAX. WiMAX (also known as IEEE 802.16) is a wireless digital communication system that is intended for wireless "metropolitan area networks" (WMAN). It can provide broadband wireless access (BWA) up to 30 miles (50 km) for fixed stations, and 3 - 10 miles (5 – 15 km) for mobile stations. Some of the added features of 802.16e were: Enhanced mobility and portability capabilities, improved increased system gain and improved handovers for portable and mobile access.This paper is based on mobile WiMAX (IEEE 802.16e) which it is predicted to be widely used by the user since it is more flexible and provides high mobility. Standard parameters for mobile WiMAX that are used in this are FFT point, modulator/demodulator QPSK and STBC 2x2 for support of 2 antennas system.

TABLE 1:WiMAX 802.16e STANDARD

PARAMETRES	**802.16e**
Completed	2005
Spectrum	<6GHz
Channel Conditions	Non line-of-sight-Service
Bit Rate	Upto 15Mbps in 20MHZ channel bandwidth
Modulation	Scalable OFDMA, QPSK, 16QAM and 64 QAM
Mobility	Nomadic/mobile
Channel Bandwidths	1.75-20MHZ

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B.OFDM Fundamentals

OFDM is orthogonal frequency division multiplexing.It is being adopted in several number of wireless standards due to its spectrum efficiency and a various number of advantages.It is an efficient bandwidth signaling scheme for wideband digital communications.One important difference between OFDM and FDM is that in the OFDM spectrum ,individual carriers mutually overlaps.OFDM carriers exhibit orthogonality property based on a symbol interval if their spacing in frequency is at the reciprocal of the symbol interval,which can be accomplished by utilizing DFT(Discrete Fourier Transform)[1].

In this,a large number of closely spaced orthogonal sub-carrier signals are used to carry data on several parallel data streams or channels.OFDM is a special form of multicarrier modulation (MCM), where a single data stream is transmitted over a number of lower rate subcarriers which are orthogonal between subcarriers. This orthogonal effect can make overlapping among subcarriers without inter-carrier interference (ICI). OFDM system employs the IFFT and FFT for making orthogonal frequency [11]. OFDM provides a large number of advantages like its immunity to selective fading,it makes efficient use of the spectrum,it is resilient to interference, intersymbol interference(ISI) and narrow band effects,also it has much simpler channel equalization.Its implementation is efficient using fast fourier transform(FFT).Also in this unlike conventional FDM,there is no requirement of tuned sub-channel receiver filters.Transceiver block of OFDM is shown in Fig. 1.

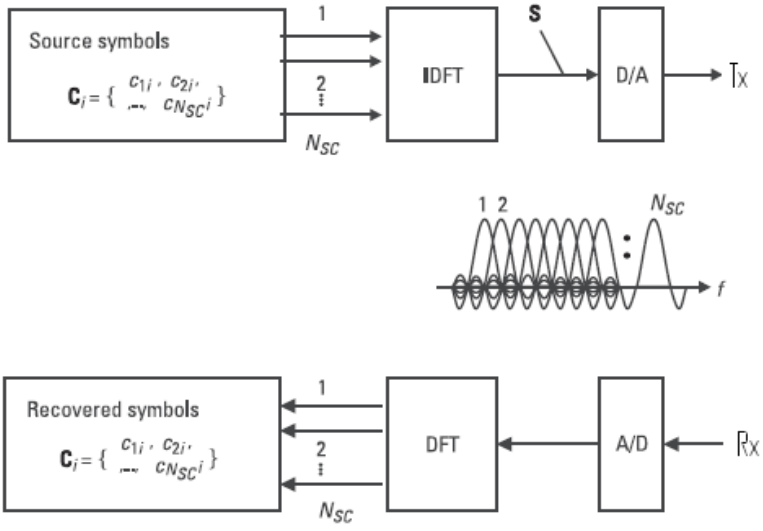

Fig. 1. Tranceiver block diagram for the OFDM [3]

C. STBC Alamouti Fundamentals

STBC is Space Time Block Code.It is a technique used in wireless communications to transmit multiple copies of a data stream across a number of antennas and to exploit the various received versions of the data to improve the reliability of data-transfer.STBC combines all the copies of the received signal in an optimal way to extract as much information from each of them as possible.It uses both temporal and spatial diversity and in this way it enables significant gains to be made.In this,the data stream is encoded in blocks prior to transmission.These data blocks are then distributed among multiple antennas and data is also spaced across time. The combination of STBC and OFDM provides double orthogonality to the transmitting signal and improves security during transmission of data.[3].An STBC is usually represented by a matrix.Each row represents a time slot and each column represents one antenna's transmissions over time.

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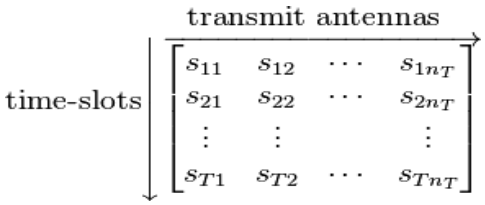

Fig.2 STBC Code Matrix[3]

Here, $s_{ij}$is the modulated symbol to be transmitted in time slot $i$from antenna j. There are to be Ttime slots and $n_T$transmit antennas as well as $n_R$receive antennas. This block is usually considered to be of 'length' T. Alamouti invented the simplest of all the STBCs in 1998, although he did not coin the term "space–time block code" himself. It was designed for a two-transmit antenna system.In this paper,we have discussed the scheme which uses two transmit antennas and two receive antennas. In this the encoding is done in space and time (space–time coding). The encoding, however, may also be done in space and frequency. Instead of two adjacent symbol periods, two adjacent carriers may be used (space–frequency coding).

IV. SYSTEM DESIGN

The stages of implementation of OFDM-STBC transceiver for WiMAX 802.16e standard consists of:- firstly to design transceiver block system, then to design and simulate OFDM-STBC system for WiMAX using MATLAB.In this,the design has been divided into two subsystems: At the transmitter side: QPSK for symbol mapping, STBC encoder, IFFT. The receiver consists of an FFT, STBC decoder and the QPSK slicer.

Following functions have been performed to implement this communication system:-

A. SIGNAL GENERATOR:- Input data are generated bit stream by data generator which value is repeated every 16 bits.

B. QPSK Mapping/De-Mapping :-Data bits from the signal generator will be formed into complex data (real & imaginary) symbols based on QPSK modulation scheme and multiplied by a constant modulation *k* = 0707.

QPSK De-mapping- In the symbol representation used a sign bit on the MSB, bit '1' indicates data bit = 1 and bit '0' indicates data bit = 0. So with this method is simple way to get information bits. This method is called a hard decision.

C. STBC :-STBC encoder uses two transmit antennas and two receive antennas based on Alamouti scheme.

D. IFFT/FFT:-In this,IFFT(Inverse Fast Fourier Transform) and FFT(Fast Fourier Transform) are used for implementation of OFDM-STBC in MATLAB.

V. COMPARISON OF VARIOUS PREVIOUS WORKS RELATED TO OFDM

In previous years,various communication systems based on OFDM(Orthogonal Frequency Division Multiplexing) has been developed in digital communication.We have taken some papers from the literature for review and analysis.In some approaches,MIMO-OFDM is used where distortion induced by high power amplification(HPA) subsequently affects SNR and BER.Also MIMO system adds to complexity of environment.Further in another approach,MIMO-

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OFDM is used for multiple antennas where BER is significantly reduced.In some other approaches,STBC Coding is used with OFDM which gives better BER performance.Following table gives comparison of these approaches.

TABLE 2.COMPARISON OF VARIOUS OFDM SYSTEMS

S.No.	Technique Used	Year of Publica-tion	Tool Used	Performance Analysis of BER vs SNR
1	MIMO-OFDM System for Modulation scheme of QAM & BPSK	2014	Communication Toolbox in MATLAB Version 7.14 2002	BER and SNR estimation pose a complex challenge due to multitude of reasons and complex iterations between different componenets of OFDM.
2.	MIMO-OFDM for Multiple Antennas	2014	MATLAB	BER is significantly reduced in MIMO-OFDM system as compared to MISO-OFDM and SISO-OFDM.
3.	Fixed WiMAX OSTBC-OFDM Transceiver based Wavelet Signals by Non-Linear Precoding using SDR Platform	2013	MATLAB	In this proposed design archives much lower BER and it can be used at high transmission rates.
4.	STBC-OFDM WiMAX System using Graphics Processing Unit (GPU)	2014	MATLAB	In this,GPU system is used to reduce the computational time when large data has to be processed.With GPU,performance of BER is better.
5.	OFDM-STBC based Tranceiver for WiMAX 802.16e	2014	MATLAB	In this,BER vs SNR performance is enhanced.

VI. CONCLUSION

In most of the day to day applications,the portable and battery operated devices are getting integrated.As OFDM is being playing a chief role in these devices has to be updated and evolved continuously. This offers researchers ample opportunities and challenges alike in improving the performance of the OFDM systems.In this paper we have reviewed the communication system of OFDM with STBC Coding for WiMAX 802.16e standard in MATLAB.OFDM is being adopted in several wireless standards like 4G and others due to its spectrum efficiency and a large number of advantages.In this OFDM is implemented using Space Time Block Coding(STBC) 2X2 for WiMAX 802.16e.STBC is used because of its high data rate and bandwidth efficiency.This communication system gives an enhanced system performance and efficient BER vs SNR performance. Also we have concluded that despite of its several advantages,OFDM also suffers from a severe disadvantage of high PAPR(peak-to-average-power-ratio).However this can be overcome by using an another technique say,SC-FDMA(single carrier frequency division multiple access).

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