Improvement of Fixed WiMAX OSTBC–OFDM Transceiver Based Wavelet Signals by Non-Linear Precoding Using SDR Platform

Mohammed Aboud Kadhim, Hamood Shehab Hamid, Nooraldeen Raaoof Hadi

Abstract*— *This paper inquire, a new Non-Linear precoding method to the acclimatization for the Worldwide Interoperability for fixed Microwave Access (WiMAX) baseband, in the physical layer performance of multi-antenna techniques, All cases are based on the IEEE 802.16d standard using orthogonal frequency division multiplexing (OFDM) based discrete wavelet transform (DWT) and 16-Quadrature amplitude modulation (QAM), ½ of coding rates and using SFF SDR development platform. The proposed Non-Linear Precoding Tomlinson-Harashima Precoding (THP) in WiMAX baseband consider a new way to further reduce the level of interference signals achieved much lower bit error rates and increase spectral efficiency. The proposed model was modeled-tested, and its performance was found to comply with International Telecommunications Union channel models (ITU) that have been elected for the wireless channel in the simulation process

Index Terms*— *THP, WIMAX, SFF SDR, OFDM, RS, Coding, OSTBC, IDWT, DWT.

I. INTRODUCTION

While using multiple antennas at a base station is feasible, a user's terminal is typically constrained by cost, size, and power such that adding multiple antennas is difficult. Since a base station does not have these same constraints, providing diversity using the base stations antennas during transmission is appealing. Transmit diversity is often characterized as open or closed loop. Open-loop transmit diversity does not require knowledge of the channel at the transmitter, while closed-loop diversity does. With open-loop transmit diversity, signals are sent from different transmit antennas, and because of this additional processing is required to achieve diversity and deal with the spatial interference introduced. The most popular processing scheme is space-time coding, where a code known at the receiver is applied at the transmitter. Of the many space-time codes studied, space-time block code (STBC) approaches are supported in WiMAX systems and easily implemented. (Space-time trellis codes can provide better performance but with much higher complexity.) In particular, the Alamouti code is an orthogonal STBC that is both easily implemented and provides optimal diversity order, but is limited to certain combinations of antenna numbers. WiMAX defines a capability with one or two transmit antennas and two receive antennas. Unlike MRC, STBC schemes provide diversity gain but not array gain.

Closed-loop transmit diversity takes advantage of channel information at the transmitter to make efficient use of the transmit antennas. There are two effective approaches for implementing closed-loop transmits diversity: linear diversity precoding and beamforming. Either approach provides array gain, although only beamforming specifically addresses interference. The IEEE 802.16-2004 standard is primarily intended for stationary transmission while IEEE 802.16e amendment is intended primarily for both stationary and mobile deployments. While there are multiple modulations defined in the IEEE 802.16 standards, in this paper, we examine Orthogonal Frequency Division Multiplexing (OFDM) because of OFDM's robustness to multipath propagation and its ease for utilizing multiple antenna techniques [1]. Furthermore, we focus on IEEE 802.16-2004 technology as it has already been ratified. IEEE 802.16-2004 currently supports several multiple antenna options including Space-Time Codes (STC), Multiple-Input Multiple-Output (MIMO) antenna systems and Adaptive Antenna Systems (AAS). In this paper, we focus on WiMAX systems based on the IEEE 802.16d-2004 standard [2].WiMAX technologies have recently made great advances. Personal communication devices now enable ubiquitous communications. The spectacular growth of data communication, voice and video service over Internet, justify great expectations for high data rates in radio communication systems. Current communication systems integrate various functions and applications, such high-rate data in a wireless local area network (WLAN), which is expected to provide its users with over 100 Mbps information rates. Since radio spectrum is limited, supporting such high data rates and overcoming the radio channel impairments presents challengs to the design of future high-speed radio communication systems. The performance improvement that results from the use of diversity in wireless communications is well known and often exploited. On channels affected by Rayleigh fading, the BER is known to decrease proportionally to SNR^{-d} where SNR designates the signal-to-noise ratio and d designates the system diversity obtained by transmitting the same symbol through d independently faded channels. Diversity is traditionally achieved by repeating the transmitted symbols in time, in frequency or using multiple antennas at the receiver. In the latter case, the diversity gain is compounded to the array gain, consisting of an increase in average receive SNR due to the coherent combination of received signals, which results in a reduction of the average noise power even in the absence of fading. Here, the situation is more complex, with a greater deal of flexibility in the design and potential advantages at the price of a larger system complexity. In fact, in addition to array gain and

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diversity gain, one can achieve spatial multiplexing gain, realized by transmitting independent information from the individual antennas, and interference reduction. The enormous values of the spatial multiplexing gain potentially achieved by MIMO techniques have had a major impact on the introduction of MIMO technology in wireless systems. Current trends in wireless system design focus on multiple-input multiple-output (MIMO) techniques to provide capacity (data rate) gains [3, 4], Transmit Diversity One of the WiMAX system profiles is the simple STC scheme proposed by Alamouti [4] for transmit diversity on the downlink. In the IEEE 802.16d-2004 specifications, Originally, Alamouti's transmit diversity was proposed to avoid the use of receive diversity and keep the subscriber stations simple. This technique is applied subcarrier by subcarrier. Closed-loop techniques to offer capacity gains or bit-error rate (BER) performance improvements [5, 6], and orthogonal frequency-division multiplexing (OFDM) to facilitate the utilization of these performance gains on frequency-selective channels [7, 8]. THP was invented independently by Tomlinson [9], and Harashima and Miyakawa [10] for equalization of dispersive SISO channels. It is a very efficient strategy to remove ISI in single-carrier systems. It enables the application of coded modulation in a seamless fashion and is able to come close to the channel capacity of the underlying channel [11]. Spatial separation in MIMO systems is tightly related to temporal equalization for SISO transmission over ISI channels. The TH precoder is then extended to MIMO channels to combat the interference between different spatial transmission layers [12, 13]. Wavelet transform is a tool for studying signals in the joint time-frequency domains. That is, it is capable of providing the time and frequency information simultaneously, hence giving a time-frequency representation of the signal [14]. Wavelets are known to have compact support (localization) both in time and frequency domain, and possess better orthogonality [14]. A promising application of wavelet transform is in the field of digital wireless multicarrier communication where they can be used to generate waveforms that are suitable for transmission over fading channels [15, 16, 17, 18, and 19]. With the ever increasing need for enhanced performance, communication systems can be designed for their optimum performance. The major advantage of wavelet based OFDM is its optimal performance over conventional OFDM. Wavelet bases therefore appear to be a more logical choice for building orthogonal waveform sets usable in communication. In this work we study orthogonal wavelet bases OFDM. Orthogonal wavelets are capable of reducing the power of inter symbol interference (ISI) and inter carrier interference (ICI) which are caused by loss of orthogonality between the carriers as a result of multipath propagation over the wireless fading channels. The work addresses performance of wavelet OFDM using different orthogonal wavelet basis families such as Haar, Daubechies, Symlets, Coiflets and Discrete Meyer over wireless channels and tries to investigate a suitable wavelet basis to Wavelet OFDM for its better performance. In previous my work Transmitter Diversity Tomlinson-Harashima Precoding (THP) OSTBC- OFDM-FFT for Fourier signals in WiMAX systems [20].The new proposed Transmitter Diversity Tomlinson- Harashima Precoding (THP) OSTBC-OFDM-DWT for wavelet signals in WiMAX systems are introduced in this work. The simulations results and evaluation tests of these proposed systems are given. The results of both systems in the International Telecommunications Union (ITU) channel models will be examined and compared.

II. PRPOSED MODEL

WiMAX IEEE 802.16d is a current trend in the development of high-data-rate wireless systems. Transmit precoding reacts to channel conditions to improve the system capacity or bit error rate (BER). OFDM is being widely adopted in several wireless standards because of its spectrum efficiency and other advantages. Recent integration TH precoding with multiple-antenna techniques promises a significant enhancement in the performance of OFDM system. In this section investigates a new approach to the adaptation of the WIMAX baseband for the physical layer performance of, multi-antenna techniques with TH precoding. THP was devised for equalization of dispersive SISO channels. It is a very efficient approach to remove ISI in single-carrier systems. It enables the application of coded modulation in a without seams fashion and is able to come close to the channel capacity of the underlying channel. Spatial separation in MIMO systems is strongly related to temporal equalization for SISO transmission over ISI channels. The TH precoder is then extended to MIMO channels to combat the interference between different spatial transmission layers .The Block diagram in Figure 1 represents the whole system model or signal chain at the base band. This figure illustrates a typical Transmitter Diversity Tomlinson-Harashima Precoding (THP) for WiMAX OSTBC-OFDM system used for multicarrier modulation. Data are generated from a random source, and consist of a series of ones and zeros. Since the transmission is conducted block-wise, when forward error correction (FEC) is applied, the size of the data generated depends on the block size used. These data are converted into lower rate sequences via serial to parallel conversion and convert to sample after that pass through the matlab function modulo arithmetic device and then randomize it to avoid a long run of zeros or ones. The result is ease in carrier recovery at the receiver. The randomized data are encoded when the encoding process consists of a concatenation of an outer Reed-Solomon (RS) code. The implemented RS encoder is derived from a systematic RS Code using field generator GF code (CC) as an FEC scheme. This means that the first data pass in block format through the RS encoder, and goes across the convolutional encoder. It is a flexible coding process caused by the puncturing of the signal, and allows different coding rates. The last part of the encoder is a process of interleaving to avoid long error bursts using tail biting CCs with different coding rates (puncturing of codes is provided in the standard) [2]. Finally, interleaving is conducted using a two-stage permutation; the first aims to avoid the mapping of adjacent coded bits on adjacent sub-carriers, while the second ensures that adjacent coded bits are mapped alternately onto relatively significant bits of the constellation, thus avoiding long runs of lowly reliable bits. The training frame (pilot sub-carriers frame) is inserted and sent prior to the information frame. This pilot frame is used to create channel estimation used to compensate for the channel effects on the signal. The coded bits are then mapped to form symbols. The modulation scheme used is 16-QAM coding rate (1/2) with gray coding in the constellation map.

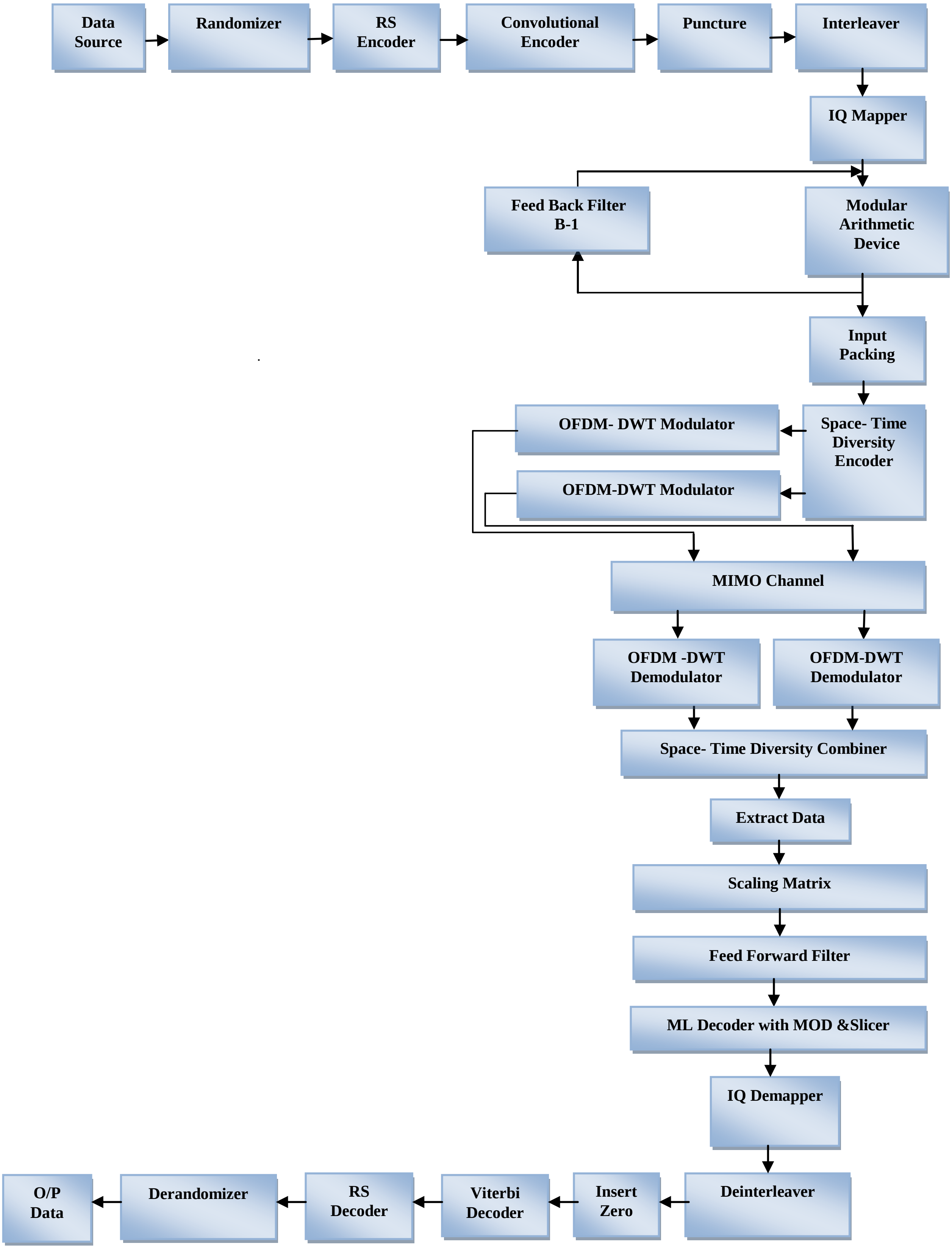

Fig.1. Transmitter Diversity Tomlinson-Harashima Precoding (THP) for WiMAX OSTBC- MIMO OFDM-DWT.

This process converts data to corresponding value of M-ary constellation, which is a complex word (i.e., with a real and an imaginary part). The bandwidth (B $=(1/T_s)$) is divided into N equally spaced subcarriers at frequencies ($k\Delta f$),$k=0,1,2,\ldots,N-1$ with $\Delta f=B/N$ and , T_s , the sampling interval. At the transmitter, information bits are grouped and mapped into complex symbols. In this system, (QAM) with constellation C_{QAM} is assumed for the symbol mapping. The training frame (pilot sub-carriers frame) are inserted and sent prior to the information frame. This pilot frame is used to create channel estimation, which is used to compensate for the channel effects on the signal the structures of the proposed improvement Diversity Tomlinson-Harashima Precoding (THP) for MIMO WiMAX OSTBC-OFDM-DWT is shown below in Figures 1. We consider an OFDM of WiMAX system with $\mathrm{M_T}$ transmits antennas and $\mathrm{M_R}$ receives antennas. Let $\mathrm{X_u}\,[\mathrm{n}]$ denote an M-ary QAM symbol on the nth subcarrier of WIMAX OFDM sent by the uth transmit antenna. The length-N input data vector can then be written as $\mathrm{X_u} = [\mathrm{X_u}(0)\mathrm{X_u}(1)\ldots\mathrm{X_u}(\mathrm{N}-1)]^{\mathrm{T}}$, where N is the number of OFDM subcarriers. In MIMO WiMAX OSTBC OFDM transmission, each of the $\mathrm{M_T}$ time-domain transmitted vectors is generated by taking an inverse DWT (IDWT) of an information vector:

$$\mathrm{X_u} = [\mathrm{X_u}(0)\mathrm{X_u}(1)\ldots\mathrm{X_u}(\mathrm{N}-1)]^{\mathrm{T}} = \mathrm{IDWT}\,\mathrm{X_u} \qquad (1)$$

Where transforms are the N × N IDWT matrix According to MIMO WiMAX OSTBC OFDM –DWT models. Zeros are inserted in some bins of the IDWT to compress the transmitted spectrum and reduce the adjacent carriers' interference. The added zeros to some sub-carriers limit the bandwidth of the system, while the system without the zeros pad has a spectrum that is spread in frequency. The last case is unacceptable in communication systems, since one limitation of communication systems is the width of bandwidth. The addition of zeros to some sub-carriers means not all the sub-carriers are used; only the subset (N_c) of total subcarriers (N_F) is used. Hence, the number of bits in OFDM symbol is equal to log_2 (M)* N_c. A cyclic prefix, which is longer than the expected maximum excess delay, is customarily inserted at the beginning of each time-domain OFDM symbol to prevent intersymbol interference. However, it is probable to rescue orthogonality by introducing a cyclic prefix (CP). This CP comprises of the final v samples of the original K samples to be transmitted, prefixed to the transmitted symbol. The length v is determined by the channel's impulse response and is chosen to minimize ISI. If the impulse response of the channel has a length of lesser than or equal to v, the CP is sufficient to eliminate ISI and ICI. The efficiency of the transceiver is reduced by a factor of$\frac{\mathrm{K}}{\mathrm{K+V}}$; thus, it is desirable to make the v as small or K as large as possible. If the number of sub-channels is enough large, the channel power spectral density can be assumed virtually flat within each sub-channel. In these kinds of channels, multicarrier modulation has long been known to be optimum when the number of sub-channels is large. The size of sub-channels required t about optimum performance depends on how rapidly the channel transfer function varies with frequency. As shown In Figure below The transmitter includes MIMO WiMAX OSTBC-OFDM-DWT transmitter, a modulo arithmetic feedback structure employing matrix $\mathrm{B[k]}$, and $\mathrm{M_T X M_T}$ feedback filter $\mathrm{B-I}$ with which the transmitted symbols $\mathrm{X[k]}$ are successively calculated for the data symbols $\mathrm{a[k]}$ drawn from the initial M-ary QAM signal constellation from MIMO WIMAX transmitter. The receiver structure consists from MIMO WiMAX transmitter, $\mathrm{M_T X M_T}$ scaling matrix G, $\mathrm{M_R X M_T}$ feed forward filter F, and a modular arithmetic device. The feedback matrix must strictly be upper triangular to enable data precoding in a recursive fashion. Given the data carrying symbols $\mathrm{a[k]}\epsilon\,\mathrm{A}$ (the M-ary constellation), where The $\mathrm{N}\times\mathrm{N}$ identity matrix is $\mathrm{I_N}$ the MXN all-zero matrix is 0_{MXN} . The mth row and nth column entry of A are demonstrate as $\mathrm{A(m,n)}$. The trace of A is given as $\mathrm{tr(A)} = \sum_{\mathrm{m}} \mathrm{A(m,n)}$. The $\Re(\mathrm{a})$ and $\Im(\mathrm{a})$ sign to the real and imaginary part of a complex number a. an M-ary quadrature amplitude modulation(QAM) square signal constellation is defined as $\mathrm{A} = \{\mathrm{a_1} + \mathrm{jaQ}|\,\mathrm{a_I}, \mathrm{a_Q}\epsilon \pm 1, \pm 3, \ldots, \pm(\sqrt{\mathrm{M}}-1)\}$. The transmitted symbols $\mathrm{X[k]}$ are successively calculated via the feedback filter as [21].

$$\mathrm{X[k]} = \mathrm{MOD}_{2\sqrt{\mathrm{M}}}\left\{\mathrm{a[k]} - \sum_{\mathrm{j=0}}^{\mathrm{k-1}} \mathrm{B(k,j)\,)X[j]}\right\}$$
$$= \mathrm{a[k]} + \mathrm{q[k]} - \sum_{\mathrm{j=0}}^{\mathrm{k-1}} \mathrm{B(k,j)\,)X[j]} \quad (2)$$

The initial signal constellation A is periodically expanded by the modulo arithmetic feedback structure at the transmitter. The modulo $2\sqrt{\mathrm{M}}$ operation can be considered as the signal-dependent addition $\mathrm{a[k]} + \mathrm{q[k]}$, where the real and imaginary parts of $\mathrm{q[k]}$ are the unique integer multiples of $2\sqrt{\mathrm{M}}$ for which $\Re = \{\mathrm{X[k]}\}\,\epsilon\,(-\sqrt{\mathrm{M}}, \sqrt{\mathrm{M}})$ and $\Im = \{\mathrm{X[k]}\}\,\epsilon\,(-\sqrt{\mathrm{M}}, \sqrt{\mathrm{M}})$ Thus, the power of the precoded transmitted signals is bounded. If $\mathrm{a[k]}$ is an i.i.d. sequence with variance $\mathrm{E_s}$ and uniformly distributed on A, then $\mathrm{X[k]}$ is also i.i.d. with variance $\left(\frac{\mathrm{M}}{\mathrm{M}} - 1\right)\mathrm{E_s}$ and uniformly distributed within bounds slightly larger than those of the initial constellation. The modulo operation employed at the transmitter is nonlinear and a slicer at the receiver uses the same modulo operation in detecting the points of the initial constellation A. In conventional THP for the system described, assuming that **G** is a G × G square matrix, the feed forward matrix is designed at the receiver by using a QR factorization of the overall channel matrix [13]

$$\mathrm{G} = \mathrm{D^H T} \qquad (3)$$

Where the feed forward matrix D is a unitary matrix, and $\mathrm{T} = [\mathrm{T(i,j)}]$ is an upper triangular matrix. Given the overall channel matrix G, the feedback matrix under the ZF criterion becomes $\mathrm{B} = \mathrm{PT}$,where the scaling matrix $\mathrm{P} = \mathrm{diag}[\mathrm{T}-1(1,1)\ldots\mathrm{T}-1(\mathrm{G},\mathrm{G})]$ keeps the average transmit power constant. THP involves modulo operation at both the transmitter and the receiver. The modulo $2\sqrt{\mathrm{M}}$ reduction at the transmitter, applied separately to the real and imaginary parts of the input, constrains the transmitted signals to within the range of $\Re = \{\mathrm{X[k]}\}\,\epsilon\,(-\sqrt{\mathrm{M}}, \sqrt{\mathrm{M}})$ and $\Im = \{\mathrm{X[k]}\}\,\epsilon\,(-\sqrt{\mathrm{M}}, \sqrt{\mathrm{M}})$. If the input sequence $\mathrm{a[k]}$ is a sequence of i.i.d. samples, the output of the modulo device is as well a sequence of i.i.d. random variables, and the real and imaginary parts are independent, i.e. At the receiver, a slicer, which applies the same modulo operation as that at the transmitter, is used. After discarding the modulo congruence and ML decoding, the unique estimates of the data symbols $\hat{\mathrm{a}}[\mathrm{k}]$ are obtained. The details of THP operation can be found in Reference [13]. We next consider the important special case of OSTBC, the

Alamouti code for 2 transmit antennas and multiple receive antennas. In the Alamouti code is used in space–time transmit diversity, we also generalize the proposed precoder design for an arbitrary number of transmit antennas. The Alamouti code can be described by a 2 × 2 code matrix $\mathrm{C} = \begin{bmatrix} c_1 & -c_2^* \\ c_2 & c_1^* \end{bmatrix}$ i.e., two symbols c_1 and c_2 and their conjugates are transmitted over two time slots. At the first time slot, the c_1 and c_2 are transmitted from the antenna 1 and 2, respectively; during the next symbol period, $-c_2^*$ is transmitted from the antenna 1, and c_1^* is from the antenna 2. Consequently, in Alamouti-coded OFDM with proposed THP, the output sequence of the feed forward filter can be given as $\begin{bmatrix} \widetilde{A}_1 & \widetilde{A}_3 \\ \widetilde{A}_2 & \widetilde{A}_4 \end{bmatrix} = \Psi \begin{bmatrix} A_1 & -A_2^* \\ A_2 & A_1^* \end{bmatrix} + n'$ where the 2N × 2N matrix $\Psi = \begin{bmatrix} \tilde{\imath}_N & 0 \\ 0 & \tilde{\imath}_N \end{bmatrix}$ $\tilde{\imath}_N$ is approximately an identity matrix [13 and 20]. The vectors $A_1 = [a_1(0) \cdots a_1(N-1)]^T$ and $A_2 = [a_1(0) \cdots a_1(N-1)]^T$ are transmitted over the first and second antenna at the first time Slot, respectively; and the $-A_2^*$ and A_1^* are transmitted in sequence in consecutive time slots. The received signal matrices can be represented as [13 and 21].

$$\begin{aligned} \widehat{A}_1 &= \widetilde{A}_1 + A_4^* = 2A_1 + n'_1 + n'^*_4 \\ \widehat{A}_2 &= \widetilde{A}_2 - \widetilde{A}_3^* = 2A_2 + n'_2 - n'^*_3 \end{aligned} \qquad (4)$$

In MIMO WiMAX OSTBC OFDM-DWT receiver, each of the M_R time-domain received vectors is generated by taking a DWT to the received signal matrices according to type of models, after that same procedure step in models mention in previous section according to the model type. The calculation of the filters in THP can be considered as performing a QR decomposition of the channel matrix. The computation of DWT and IDWT, the 256 point. After which, the data converted from parallel to serial are fed to the channel WiMAX THP MIMO fading channel model and the receiver perform the same operations as the transmitter, but in a reverse order. It further includes operations for synchronization and compensation for the destructive channel. All cases are based on the IEEE 802.16d standard using OSTBC-OFDM-DWT in simulink applied to the SFF SDR development platform. More details about the system performance analysis and optimization target of SFF SDR development platform in previous my work [20, 22and 23].

III. SFF SDR DEVELOPMENT PLATFORMS

The SFF SDR Development Platform is shown in Figure 2 consists of three distinct hardware modules that offer flexible development capabilities: the digital processing, data conversion, and RF module. The digital processing module uses a Virtex-4 FPGA and a DM6446 SoC to offer developers the necessary performance for implementing custom IP and acceleration functions with varying requirements from one protocol to another supported on the same hardware. The data conversion module is equipped with dual-channel analog-to-digital and digital-to-analog converters. The RF module covers a variety of frequency ranges in transmission and reception, allowing it to support a wide range of applications [24].

Fig .2. SFF SDR Development Platform[24]

IV. SIMULATION RESULTS OF PRPOSED SYSTEM

The reference model specifies a number of parameters that can be found in Table (1).

Table (1) System parameters

Number of sub-carriers	256
Number of DWT points	256
Modulation type	16-QAM
Coding rate	1/2
Channel bandwidth *B*	3.5MHz
Carrier frequency *fc*	2.3GHz
MIMO fading correlations	ρ_T=0.5 ,ρ_R=0.5
MIMO random phases	$\Phi_{1=}$1.8 , $\Phi_{2=}$2, $\Phi_{3=}$0.23 , $\Phi_{4=}$0.9
Ncpc	4
Ncbps	768
Number of data bits transmitted	10^6

In this section, the overall performance in terms of measured BER versus the link overall SNR is discussed for several user profiles and channel profiles. In this section the simulation comparing with the two types of the WiMAX IEEE802.16d baseband the Physical Layer performance in with THP for OSTBC – MIMO OFDM-DWT and open loop OSTBC-MIMO OFDM, on multi-core software defined radio platform is achieved, beside the BER performance of the system considered in different International Telecommunications Union (ITU) channel models.

A. Performance of AWGN channel:

In this section, the result of the simulation for the proposed with THP for OSTBC- MIMO OFDM- DWT system are shown The results obtained for this case are depicted in Figure 3 ,which gives the BER performance in AWGN channel. It is shown clearly that closed loop with THP for OSTBC–MIMO OFDM- DWT is much better than the open loop with non- precoding OSTBC-MIMO OFDM- DWT

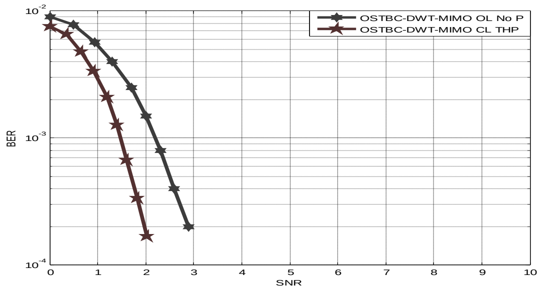

Fig .3. BER performance of WIMAX with THP OSTBC-MIMO DWT OFDM in AWGN channel model.

B. AWGN plus Multipath Channel Performance:

In this general channel scenario, all ITU profiles presented in [25]. In the next sections the relevant results are discussed

1) *Indoor Channel A:*

The indoor location user is a fixed subscriber, thus its Doppler spread is null. Profile A has shorter delay spread when compared to profile B. Profile A replicates rural macro-cellular surroundings in this scenario and the results obtained were encouraging. From Figure 4 it can be seen that for BER=10^{-3} the SNR required is approximately 3.4 dB with THP OSTBC-MIMO OFDM-DWT and 4.3 dB for non-precoding OSTBC-MIMO OFDM-DWT. Figure 4 clearly illustrates with THP OSTBC-MIMO OFDM- DWT significantly outperformed the other system for this channel model.

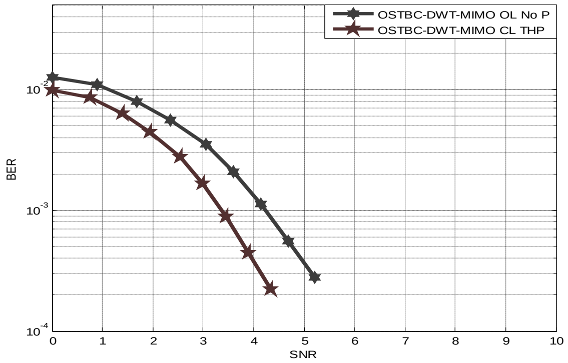

Fig 4. BER performance of WiMAX Closed loop with THP OSTBC-MIMO OFDM- DWT in AWGN plus Multipath Indoor Channel A

2) *Indoor Channel B:*

In this simulation profile some significant results were obtained. Recall that the profile of channel B has a bigger time delay spread than the profile of channel a, more than twice to be more quantitative. This factor plays a big role in the systems' performances. Observing Figure 5, It is clear from this Figure, that BER performance of closed loop with THP OSTBC-MIMO DWT OFDM is better than the open loop OSTBC-MIMO DWT OFDM systems which are closed loop with THP OSTBC-MIMO DWT OFDM and open loop non–precoding OSTBC-MIMO DWT OFDM performance of 10^{-3} approximately 6.5 dB and 7.45 dB respectively from these results it can be concluded that the closed loop with THP OSTBC-MIMO DWT OFDM is more significant than the open loop OSTBC-MIMO DWT OFDM in this channel that have been assumed.

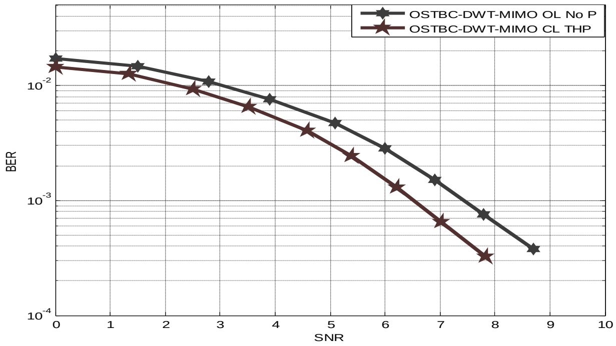

Fig 5 .BER performance of WiMAX Closed loop with THP OSTBC-MIMO DWT OFDM in AWGN plus Multipath Indoor Channel B

3) *Pedestrian Channel A:*

In the pedestrian profile, two different situations were considered: a moving and a stationary person. These results are depicted in Figure 6 and 7. Figure 6 represents the case of the stationary person. It can be seen that for BER=10^{-3} the SNR required for closed loop with THP OSTBC-MIMO DWT OFDM was approximately 6.9 dB also for the open loop OSTBC-MIMO DWT OFDM was approximately 7.8 dB. Figure 7 presents the case of a moving person. It can also be seen that for BER=10^{-3} the SNR required for closed loop with THP OSTBC-MIMO DWT OFDM is approximately 9 dB and for open loop OSTBC-MIMO DWT OFDM is approximately 10 dB. Figures 6 and 7 clearly illustrate that the closed loop with THP OSTBC-MIMO DWT OFDM significantly outperforms other system for this channel model.

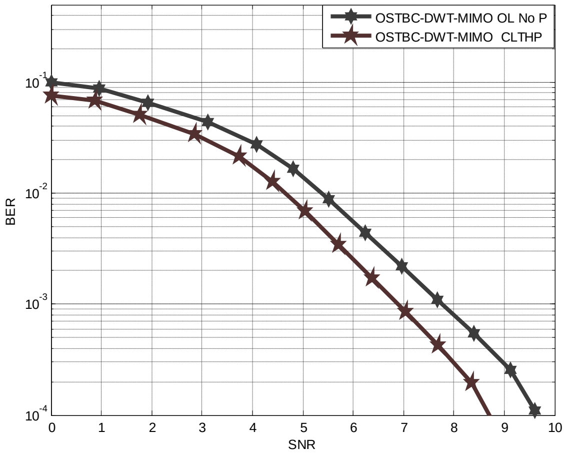

Fig.6. BER performance of WiMAX Closed loop with THP OSTBC-MIMO DWT OFDM in AWGN & Multipath stationary Pedestrian A channel

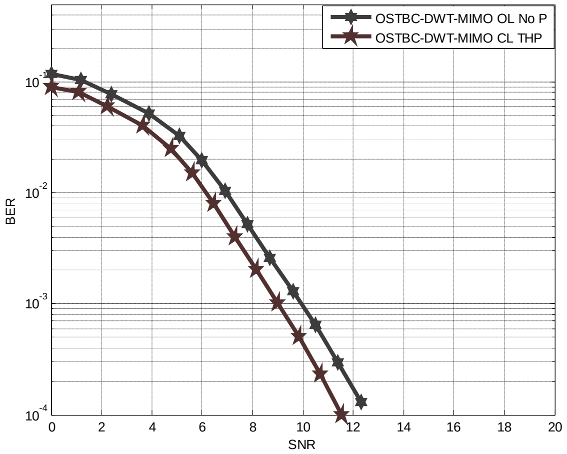

Fig .7. BER performance of WiMAX Closed loop with THP OSTBC-MIMO DWT OFDM in AWGN & Multipath Active Pedestrian A channel

4) *Pedestrian Channel B*

Using the same methodology as in the previous section, simulations for both active and stationary pedestrians were carried out. The results for the case of the stationary Pedestrian B channels are depicted in Figure 8, which shows that for BER=10^{-3}, the SNR required for Closed loop with THP OSTBC-MIMO DWT OFDM is approximately 14.2 dB, for open loop OSTBC-MIMO DWT OFDM is approximately 15.1 dB. The results for the case of the active pedestrians are depicted in Figure 9, It can be seen that for BER=10^{-3}, the SNR required for closed loop with THP OSTBC-MIMO DWT OFDM is approximately 21.9 dB, for open loop OSTBC-MIMO DWT OFDM is approximately 22.93 dB, Figures 8 and 9 clearly show that the closed loop with THP OSTBC-MIMO DWT OFDM significantly outperformed the other two systems for this channel model.

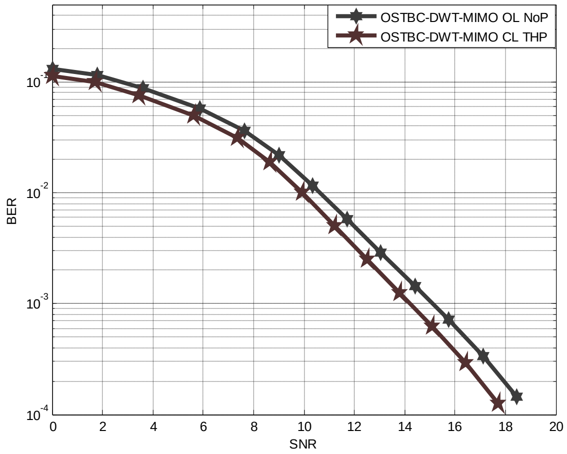

Fig .8.BER performance of WiMAX Closed loop with THP OSTBC-MIMO DWT OFDM in AWGN & Multipath stationary Pedestrian B channel.

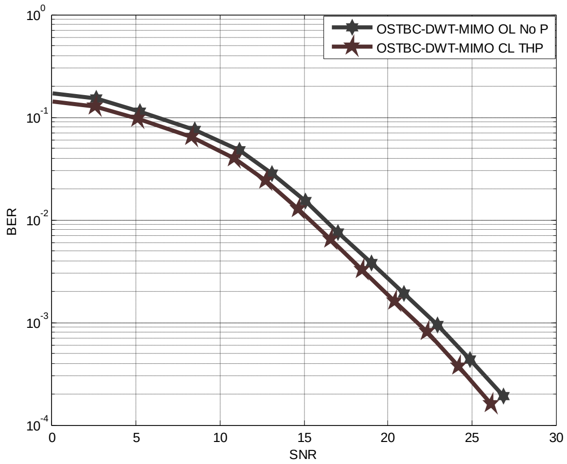

Fig .9 .BER performance of WiMAX Closed loop with THP OSTBC-MIMO DWT OFDM Performance in AWGN & Multipath Active Pedestrian B channel.

Table (2). BER with THP OSTBC-MIMO DWT OFDM and THP OSTBC-MIMO DWT OFDM comparison as a function of the SNR for model proposed in different ITU channels.

Channel For BER=10^{-3}	AWGN	Indoor Channel A	Indoor Channel B	Pedestrian Channel A		Pedestrian Channel B	
				AWGN & Multipath Stopped Pedestrian A	AWGN & Multipath Active Pedestrian A	AWGN & Multipath Stopped Pedestrian B	AWGN & Multipath Active Pedestrian B
NoP Open Lobe of OSTBC-MIMO DWT OFDM dB	2.2	4.3	7.45	7.8	10	15.1	22.93
THP Closed Lobe of OSTBC-MIMO DWT OFDM dB	1.5	3.4	6.5	6.9	9	14.2	21.9

A number of important results can be taken from Table (2); a used the THP enhances its performance of the system. In this simulation, in most scenarios, using THP for the DWT-OFDM system was better than the system without using THP. User-channel characteristics under which wireless communications is tested or used have important impact on the systems overall performance. In this work, using the IEEE802.16d standard, it became clear that channels with larger delay spread are a bigger challenge to any system. The THP for DWT-OFDM system proved its effectiveness in combating the multipath effect on the channels and achieves considerably lower bit error rate or bit error ratio (BER) and higher signal-to-noise power ratio than does not using.

V. CONCLUSION

The DSP of the SFF SDR Development Platform are completely integrated to the model based design flow, which integrates MATLAB, Simulink, and Real-Time Workshop from The MathWorks. The SFF SCA Development Platform optional package allows SCA waveform development and implementation. In this paper, the WiMAX Closed loop with THP OSTBC-MIMO DWT OFDM structure was proposed and tested. These tests were carried out to verify its successful operation and its possibility of implementation. It can be concluded that this structure achieves much lower bit error rates assuming reasonable choice of the bases function and method of computation. In AWGN, and other channels the Closed loop with THP OSTBC-MIMO DWT OFDM outperform than open loop OSTBC-MIMO DWT OFDM Therefore, this structure can be considered as an alternative to the conventional closed loop OSTBC-MIMO DWT OFDM. It can be concluded from the results obtained, that S/N measure can be successfully increased using the proposed THP OSTBC-MIMO DWT OFDM designed method. The key contribution of this paper was the implementation of the IEEE 802.16d PHY layer based the closed loop with THP OSTBC-MIMO DWT OFDM structure on The SFF SDR Development Platform, was proposed simulate and tested. Simulations provided proved that proposed design achieves much lower and it can be used at high transmission rates.

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