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A New Interference Mitigation Technique of HiperLAN/2 Transceiver with Multiple Antennas

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Abstract
This paper investigates a new approach to the adaptation of the HiperLAN/2 transceiver with multiple antennas based multiwavelet, replaced DFT-OFDM by multiwavelets OFDM on HiperLAN/2 physical layer .The new transceiver proposed achieved, further reduce the level of interference and increase spectral efficiency than conventional HiperLAN/2 Transceiver. In MATLAB/ Simulink modeling simulation proved that the performance of proposed HiperLAN/2 baseband transceiver has a significant degradation in the packet (PDU or PSDU) error rate (PER) compared to conventional HiperLAN/2 baseband transceiver due to the considerable channel models.
Keywords: HiperLAN/2, OFDM, DMWT, IDMWT, MIMO, PER, C/N.

1. Introduction

The European Telecommunication Institute (ETSI) High Performance Local Area Network Type2 (HiperLAN/2) is a system designed to give wireless access to the Internet and multimedia applications such as real time video, providing speeds up to 54 Mbps. Multiple antennas can be used at the transmitter and receiver, now widely termed a MIMO system. A MIMO system takes advantage of the spatial diversity obtained by spatially separated antennas in a dense multipath scattering environment. MIMO systems may be implemented in a number of different ways to obtain either a diversity gain to combat signal fading or to obtain a capacity gain. Generally, there are three categories of MIMO techniques. The first one aims to improve the power efficiency by maximizing spatial diversity. Such techniques include delay diversity, space-time block codes (STBC)(V. Tarokh, 1999) and space-time trellis codes (STTC)(V. Tarokh, 1998). The second type uses a layered approach to increase capacity (G.D. Golden, 1999). One popular example of such a system is the vertical-Bell Laboratories layered space-time (V-BLAST) architecture, where independent data signals are transmitted over antennas to increase the data rate, but full spatial diversity is usually not achieved. The third type exploits knowledge of the channel at the transmitter. It decomposes the channel matrix using singular value decomposition (SVD) and uses these decomposed unitary matrices as pre- and post-filters at the transmitter and receiver to achieve capacity gain (Jeongseok Ha, 2002). MIMO opens a new dimension, space, to offer the advantage of diversity, and therefore has been adopted in various standards. For instance, MIMO may be implemented in the high-speed downlink packet access (HSDPA) channel, which is a part of the Universal Mobile Telecommunications System (UMTS) standard. Preliminary efforts are also underway to define a MIMO overlay for the IEEE 802.11 standard for WLAN under the newly formed Wireless Next Generation (WNG) group .The implementations in practice of OFDM in HiperLAN/2 transceiver today have been done by using FFT and its inverse operation IFFT to represent data modulation and demodulation the concept of scalar wavelets has been exploited as wavelet modulation, multi –wavelet modulation and multi-scale modulation for multi rate transmissions(N. Erdol, 1995, G. W. Wornell and A. V. Oppenheim, 1992, William W. Jones, 1994, M. J. Manglani and A. E. Bell, 2001, J. N. Livingston and C. Tung, 1996, L. Atzori, 2002). Multi-wavelet is a new concept has been proposed in recent years. Multi-wavelets have several advantages compared to single wavelets. A single wavelet cannot possess all the properties of orthogonality, symmetry, short support, and vanishing moments at the same time, but a multi-wavelet can (M. Cotronei, 1998, V. Strela P. N. Heller. G. S m e . P. Tooiwala and C. Heil. L 1 1999),For all the priorities of multi-wavelet, a natural thought is applying it in OFDM. In (Abbas Hasan Kattoush a, 2009) a new OFDM system was being introduced, based on Multi-filters called Multi-wavelets. It has two or more low-pass and high-pass filters. The purpose of this multiplicity is to achieve more properties which cannot be combined in other transforms (Fourier and wavelet). A very important multi-wavelet filter is the GHM filter proposed by Geronimo, Hardian, and Massopust. The GHM basis offers a combination of orthogonality, symmetry, and compact support, which cannot be achieved by any scalar wavelet basis (Geronimo, 1994). The GHM will be used in the OFDM system for error-rate minimization in HiperLAN/2 Transceiver has not been considered yet. In this paper, the design of the OSTBC-OFDM systems based on DMWT, simulations results, and evaluation tests of these proposed systems are given. In the OSTBC-OFDM system, three types of the transform FFT and multi-wavelet transform (DMWT) were considered. The new proposed structures for the OSTBC-OFDM system based on DMWT are studied for HiperLAN/2 Transceiver, and for a range of modulation and coding rates. Based on a typical link-budget, the expected throughput for each scheme is computed as a function of the base station-terminal separation distance. The Fourier-based OFDM uses complex exponential bases functions, and was replaced with orthonormal wavelets to reduce the level of interference. It was found that Haar-based orthonormal wavelets were capable of reducing the ISI and ICI, which were caused by the loss in orthogonality between the carriers. In (M. J. Manglani and A. E. Bell, 2001) the simulation results showed the BER performance of OFDM system with different orthogonal bases (i.e., Fourier-based OFDM and wavelet-based OFDM). The simulations were found to have a great deal of channel dependence in the performance of wavelet and Fourier filters. The main motivation for using wavelet-based OFDM for HiperLAN/2 Transceiver is the superior spectral containment properties of wavelet filters over Fourier filters. It has been found that under certain channel conditions, Wavelet OFDM outperformed Fourier OFDM. However, under other channels, the situation is reversed (e.g., the selective fading channel). Further performance gains can be made by looking into alternative orthogonal basis functions and finding a better transform rather than Fourier and wavelet transform. The current implementations of HiperLAN/2 Transceiver OFDM were achieved using FFT and its inverse operation, IFFT, to represent data modulation and demodulation. In (Abbas Hasan Kattoush a, 2009), a new OFDM system was introduced based on multi-filters, called multi-wavelets. This new system has two or more low-pass and high-pass filters. The purpose of this multiplicity is to achieve more properties that other transforms (Fourier and wavelet) are unable to combine. The GHM basis offers a combination of orthogonality, symmetry, and compact support, which cannot be achieved on any scalar wavelet basis. The GHM is used in the OFDM system block (Abbas Hasan Kattoush a, 2009). In the multi-wavelet setting, GHM multi-scaling and multi-wavelet function coefficients are 2×2 matrices that must multiply vectors, instead of scalars during transformation step. This means that the multi-filter bank needs two input rows. The aim of preprocessing is to associate the given scalar input signal of length N to a sequence of length-2 vectors to start the analysis algorithm and reduce noise effects. In the one- dimensional signals, the implementation of the "repeated row" scheme is convenient and powerful. In this paper, further performance gains were made by looking into alternative orthogonal bases functions and finding a better transform than Fourier and wavelet transforms. We determined this transform to be a discrete multi-wavelets transform (DMWT). Multi-wavelets are very similar to wavelets but have some important differences. Wavelets may be described in the context of a multi-resolution analysis. It is possible to have more than one scaling (and wavelet) function. This is the idea behind multi-wavelets, which are a natural expansion of the wavelets. Multiwavelets are designed to be simultaneously symmetric, orthogonal, and have short supports with high approximation power, which cannot be achieved simultaneously for wavelet using only one scaling function. The trick is to increase the number of scaling functions to raise the approximation power to more than one scaling function. A new proposed OSTBC-OFDM HiperLAN/2, the DWTM-OFDM, which is based on a fast computation method for DMWT, is introduced in this paper. This paper is focused on performance evaluation of OSTBC HiperLAN/2 based wavelet signals. A physical layer improvement simulator of HiperLAN/2 was conceived in accordance with the standard defined by ETSI in (ETSI, 2001). This paper is structured as follows. In section 2 the simulation block diagram is described. Section 3 describes summarizes the results. Finally, Section 5 concludes the paper.

2. The Simulation Block Diagram

At first, a supplied a HiperLAN/2 physical layer model, from MathWorksTM in the MATLAB® & SIMULINK® R20013a software package, was modified and its performance measured. The new suggested transceivers for the OSTBC HiperLAN/2 physical layer model based multiwavelet signals in different channels will be studied in this paper. The block diagram in Figure 1 represents the whole system model for proposed design.

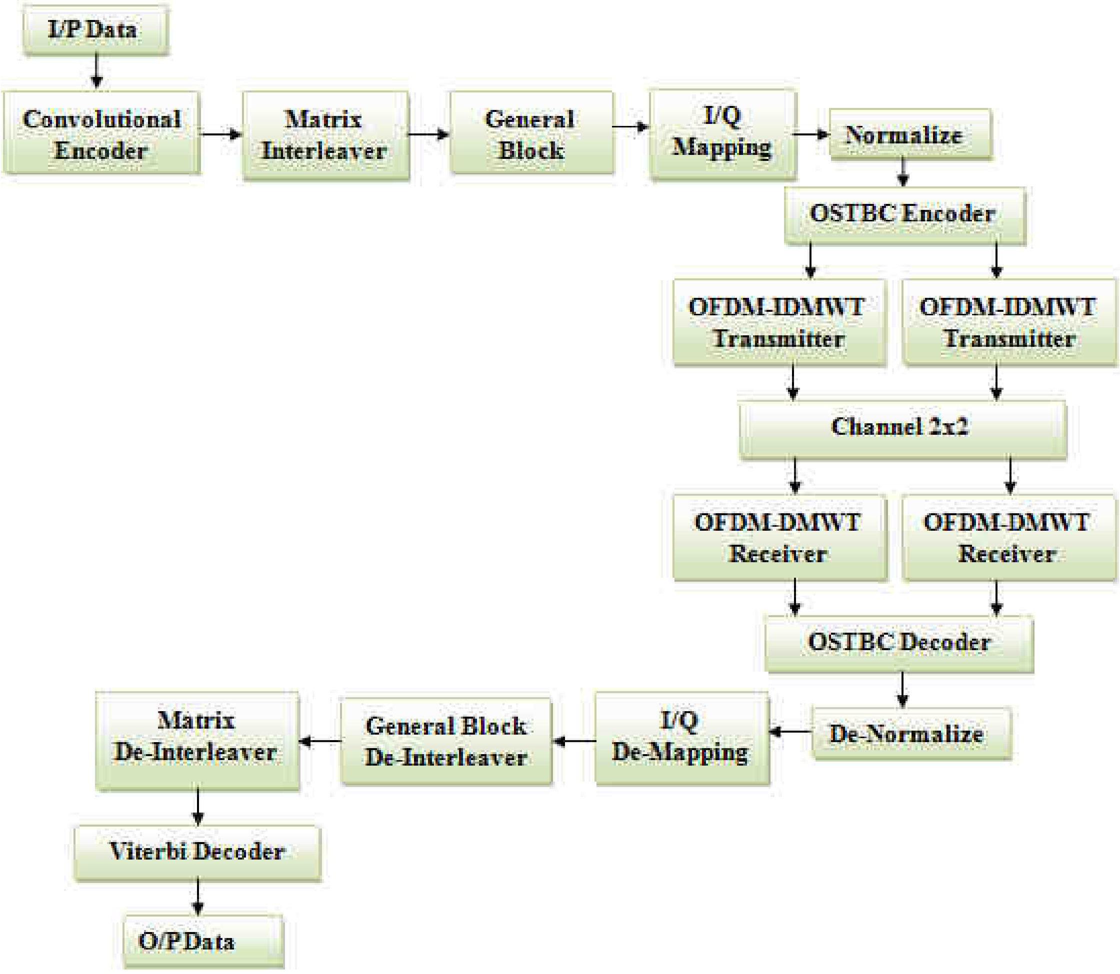

Figure 1. Simulation Block Diagram

The Block diagram in Figure 1 represents the whole system model for the HiperLAN/2 transceiver based multiwavelet transform signals system is used for multicarrier modulation. The HiperLAN/2 transceiver structure is divided into three main sections: transmitter, channel, and receiver: Data are generated from a random source and consist of a series of ones and zeros. Since 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 the data are encoded when the encoding process consists of a concatenation of a Convolutional Code (R.A.N. Ahmed and M. Berwick, 2005). This means that the first data pass in the Convolutional encoder. It is a flexible coding process due to 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). Finally, interleaving is conducted using a two-stage permutation. The first stage aims to avoid the mapping of adjacent coded bits on adjacent subcarriers, while the second ensures that adjacent coded bits are mapped alternately onto relatively significant bits of the constellation, thereby avoiding long runs of lowly reliable bits. The training frame (pilot subcarriers frame) is inserted and sent prior to the information frame. The pilot frame is used to create channel estimation to compensate for the channel effects on the signal. The coded bits are then mapped to form symbols. The modulation scheme used as shown in Table.1

Table 1. Mode-dependent parameters (Angela Doufexi, 2002)

Mode	Modulation	Coding Rate *R*	Nominal Bitrates (Mb/s)	Coded Bits per Subcarrier	Coded Bits per OFDM Symbol	Data Bits per OFDM Symbol
1	BPSK	1/2	6	1	48	24
2	BPSK	3/4	9	1	48	36
3	QPSK	1/2	12	2	96	48
4	QPSK	3/4	18	2	96	72
5	16-QAM	9/16	27	4	192	108
6	16QAM	3/4	36	4	192	144
7	64QAM	3/4	54	6	288	216

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 ($k\Delta f$),$k=0,1,2,...,N-1$ 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 Space-time block-coded code is transmitted from the two antennas simultaneously during the first symbol period (l=1) for each$k\epsilon\kappa$. During the second symbol period, (l=2) are transmitted from the two antennas for each $k\epsilon\kappa$. The set $\kappa \cong \kappa\{(N - N_c/2), \dots, (N + N_c/2) - 1\}$is the set of data-carrying sub-carrier indices, N_c and is the number of sub-carriers carrying data. N is the multicarrier size; consequently, the number of virtual carriers is N-N_c. We assume that half of the virtual carriers are on both ends of the spectral band [21]. Both the OFDM modulator and demodulator of the DMWT-based OFDM are shown in Figure 1. 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. To modulate spread data symbol on the orthogonal carriers, an N-point Inverse multi-wavelet Transform IDMWT is used, as in conventional OFDM. Zeros are inserted in some bins of the IDMWT 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_s) is used. Therefore, the number of bits in OFDM symbol is equal to log_2 (M)* N_c. Orthogonality between carriers is normally destroyed when the transmitted signal is passed through a dispersive channel. When this occurs, the inverse transformation at the receiver cannot recover the data that was transmitted perfectly. Energy from one sub-channel leaks into others, leading to interference. However, it is possible to rescue orthogonality by introducing a cyclic prefix (CP). This CP consists 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 less 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$\frac{K}{K+V}$; thus, it is desirable to make the v as small or K as large as possible. Therefore, the drawbacks of the CP are the loss of data throughput as precious bandwidth is wasted on repeated data. For this reason, finding another structure for OFDM to mitigate these drawbacks is necessary. If the number of sub-channels is sufficiently large, the channel power spectral density can be assumed virtually flat within each sub-channel. In these types 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 approximate optimum performance depends on how rapidly the channel transfer function varies with frequency. For procedure computation of DMWT and IDMWT, which is explained in detail in [], is used. After which, the data converted from parallel to serial are fed to the channel models. After this, the data converted from the parallel to the serial form are fed to different channel models. In this model a set of five channels was chosen to address three different terrain types that are typical of the continental US. The parameters for the model were selected based upon some statistical models. The tables below depict the parametric view of the five channels more information about channel models in Table.2

Table 2. Channel models (Angela Doufexi, 2002)

Name	RMS Delay Spread	Characteristic	Environment
A	50 ns	Rayleigh	Office NLOS
B	100 ns	Rayleigh	NLOS
C	150 ns	Rayleigh	NLOS
D	140 ns	Rayleigh	LOS
E	250 ns	Rayleigh	NLOS

The receiver performs the same operations as the transmitter, but in a reverse order. In addition, multiwavelet OFDM includes operations for synchronization and compensation for the destructive channels.

3. Simulation Results of the Proposed Design:

The PHY layer simulation results take the form of packet (PDU or PSDU) error rate (PER) vs. average C/N. In this part the simulation of the modified HiperLAN/2 transceiver based wavelet transform signals structure based OFDM-DWT and comparing with OFDM-FFT system is achieved, beside the BER performance of the modified OSTBC HiperLAN/2 transceiver structure considered in five channel models. Figures (2-8) presents the compressions performance results between OSTBC HiperLAN/2 transceiver based Fourier and wavelet transform signals for the different modes of OSTBC HiperLAN/2 vs. average C/N for channel model A. Channel model A is typical of large office environments with non-line of- sight (NLOS) propagation. Note that similar results have been observed elsewhere (H. Li, 2000) . It can be seen that the C/N requirement increases for modes 1, 3, 2, 4, 5, 6, and 7 correspondingly. The degradation in performance in mode 2 (BPSK 3/4) is due to the fact that the punctured Convolutional code does not cope well with the lack of frequency diversity in channel A. Errors due to large and deep fades in the frequency domain are difficult to correct using this code. Since mode

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2 is inferior to mode 3 in terms of both C/N condition and data rate, it is extra for operation in channel A or like conditions. A reasonable point of operation for packet services without delay restriction can lie in a PER of 10^{-3} percent (J. Khun-Jush et al, 1999, A. Doufexi et al, 2001). Performance comparison results between two structures in channel A for all modes found in Table 3.

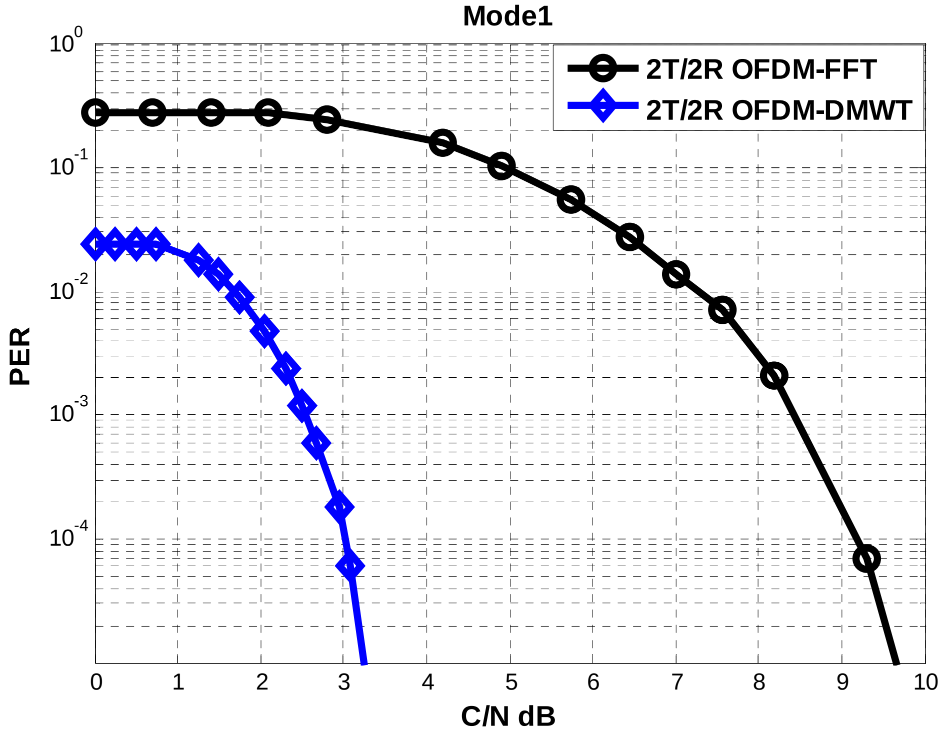

Figure 2. PER performance vs. mean C/N comparison between modified and conventional OSTBC HiperLAN/2 in channel A for mode 1

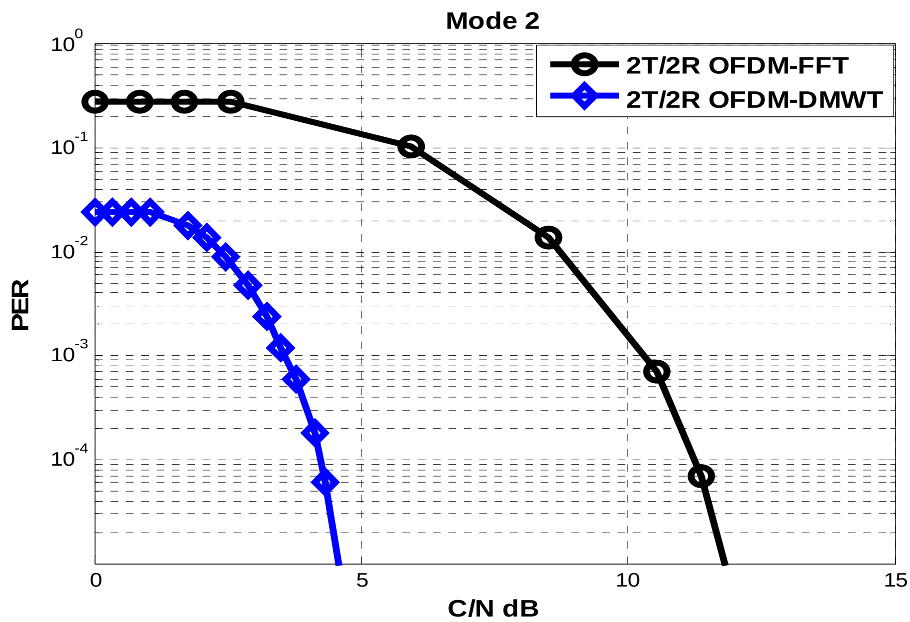

Figure 3. PER performance vs. mean C/N comparison between modified and conventional OSTBC HiperLAN/2 in channel A for mode 2

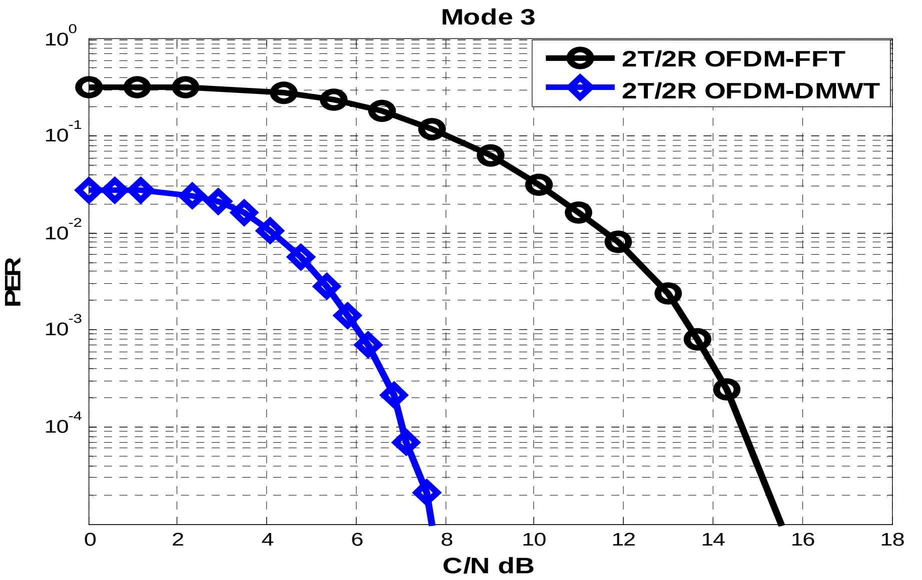

Figure 4. PER performance vs. mean C/N comparison between modified and conventional OSTBC HiperLAN/2 in channel A for mode 3

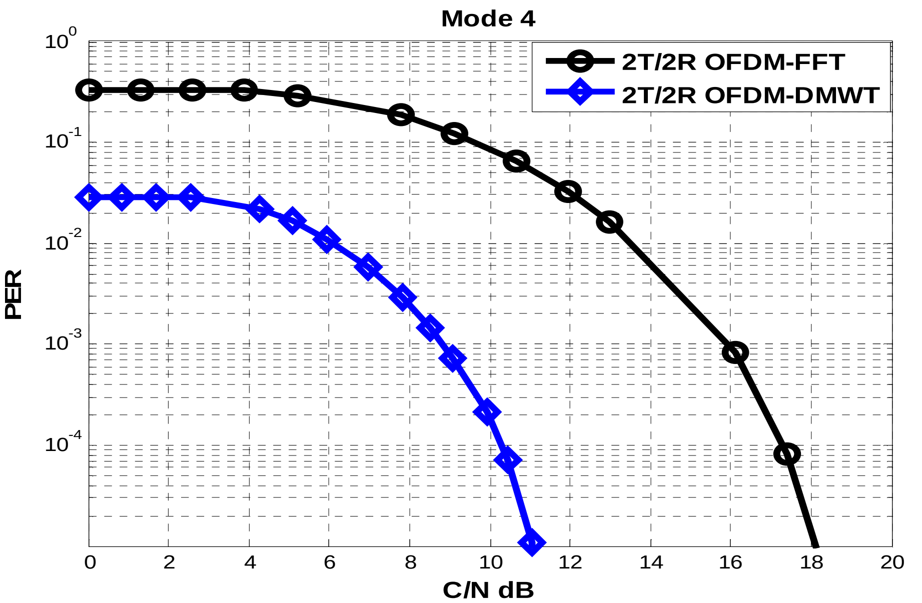

Figure 5. PER performance vs. mean C/N comparison between modified and conventional OSTBC HiperLAN/2 in channel A for mode 4

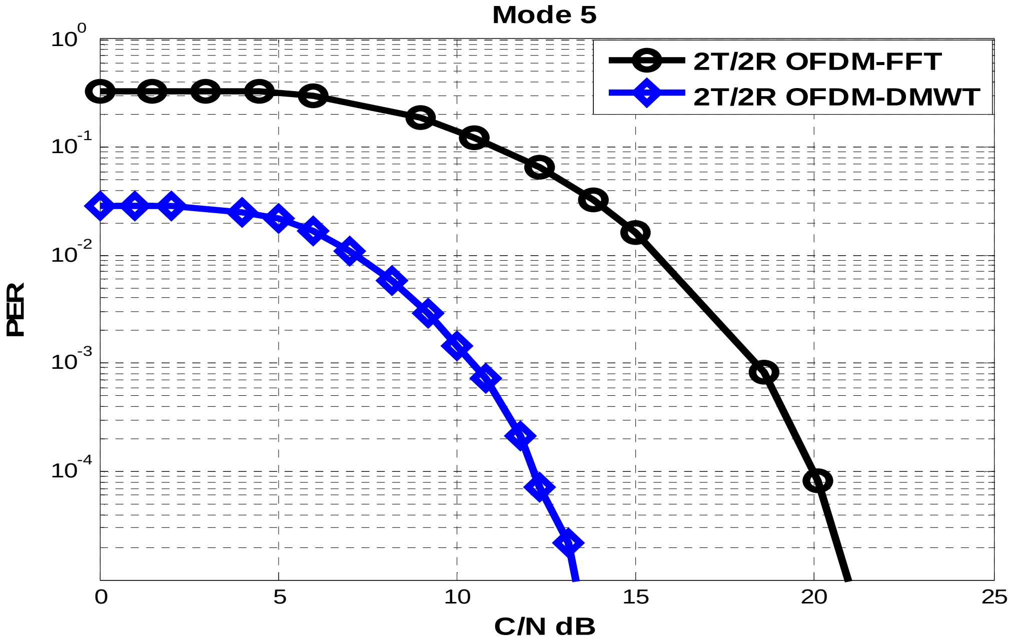

Figure 6. PER performance vs. mean C/N comparison between modified and conventional OSTBC HiperLAN/2 in channel A for mode 5

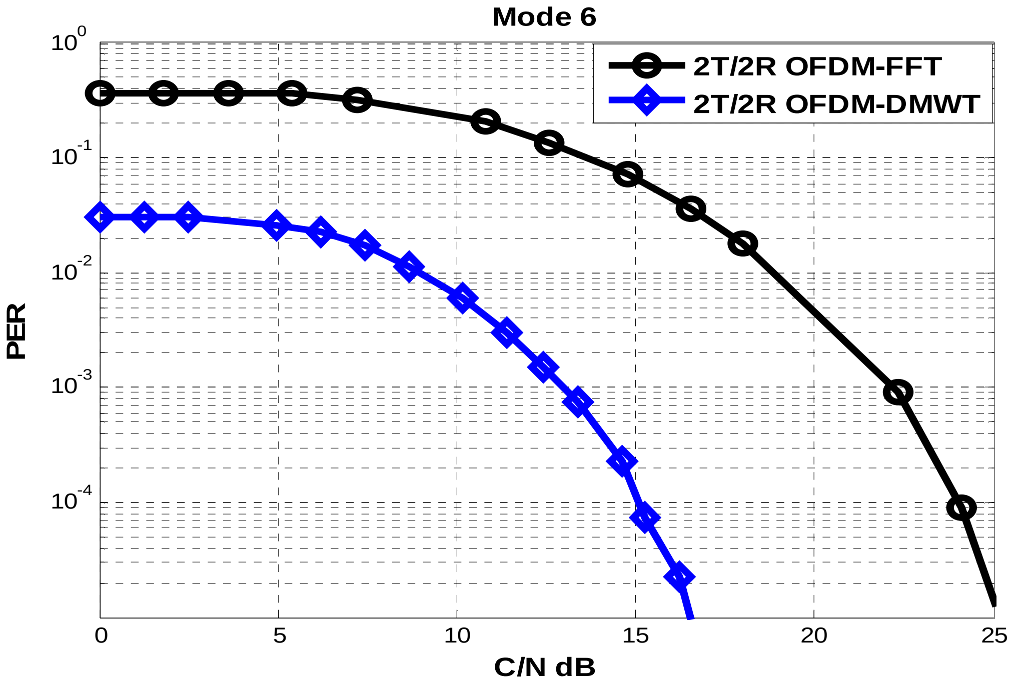

Figure 7. PER performance vs. mean C/N comparison between modified and conventional OSTBC HiperLAN/2 in channel A for mode 6

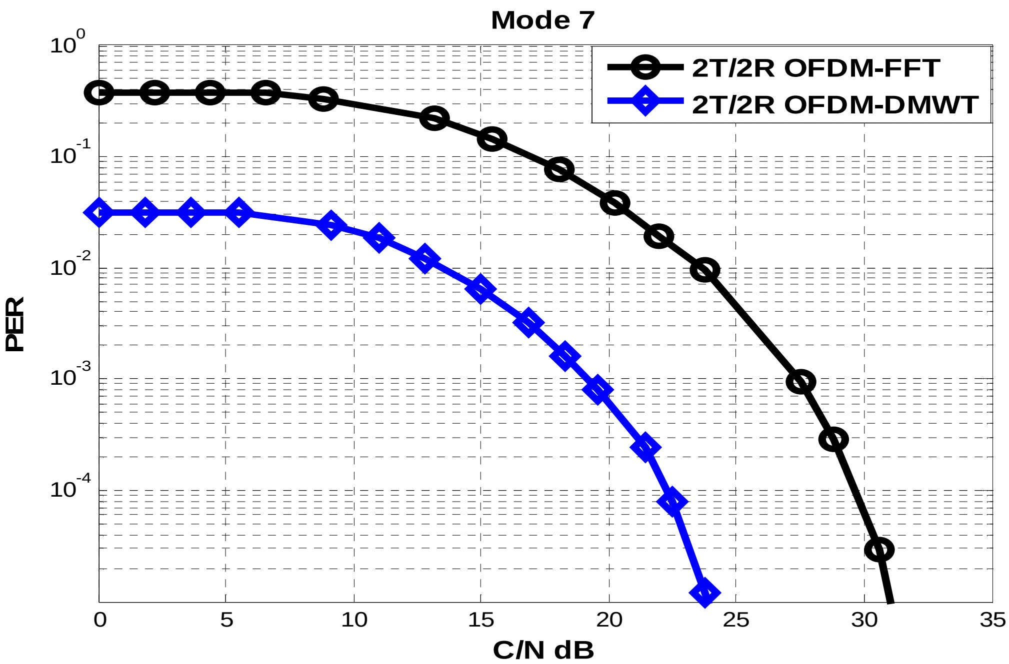

Figure 8. PER performance vs. mean C/N comparison between modified and conventional OSTBC HiperLAN/2 in channel A for mode 7

Table 3. PER Performance comparison between conventional OSTBC HiperLAN/2 and modified OSTBC HiperLAN/2 in channel A for all modes

Channel For PER=10^{-3}	Mode 1 dB	Mode 2 dB	Mode 3 dB	Mode 4 dB	Mode 5 dB	Mode 6 dB	Mode 7 dB
OSTBC 2T/2R HiperLAN/2 OFDM-FFT	8.4	10.5	13.8	16	18.2	22.4	27.5
OSTBC 2T/2R HiperLAN/2 OFDM-DMWT	2.5	3.5	6	8.8	10.2	13.2	19

Figures (9-13). Shows PER performance vs. mean C/N for mode 5 for all the specified channels for conventional HiperLAN/2. It can be seen that as the delay spread increases, the performance is improved in the Rayleigh channels until the delay spread becomes so large that ISI and ICI become limiting factors (as is the case for channel E). Channels B, C, and D have increasingly better performances than channel A due to the increased frequency diversity of the channels. As probable, channel D has somewhat better performance than channel C because it is modeled as a Rician channel. In channel E the excess channel delay is much larger than the guard interval. As a consequence, ISI cannot be completely eliminated.

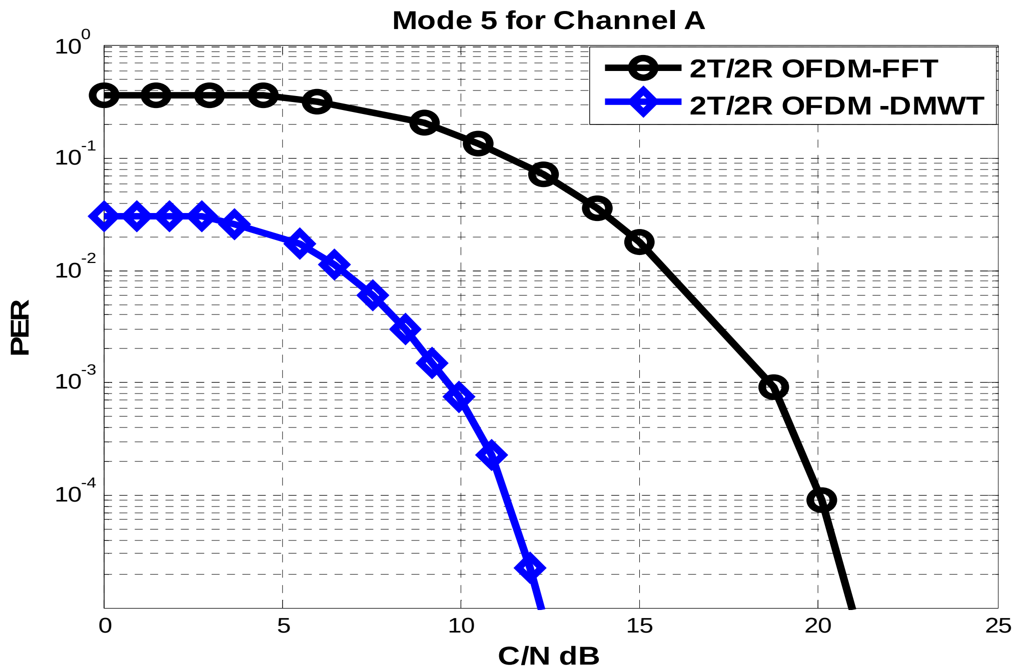

Figure 9. PER performance vs. mean C/N comparison between modified and conventional OSTBC HiperLAN/2 in mode 5 for channel A

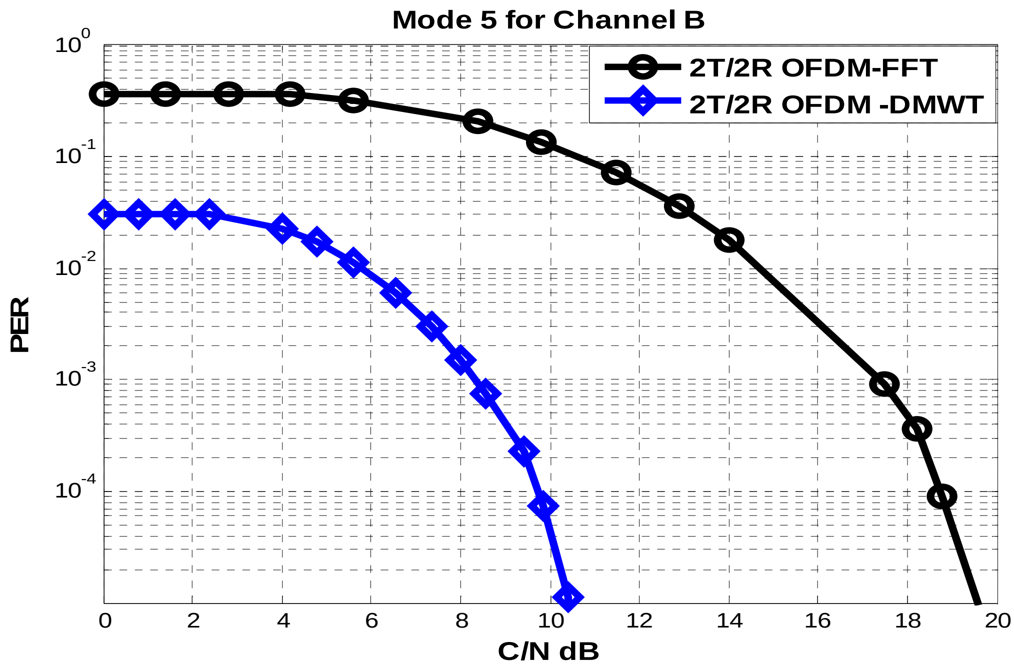

Figure 10. PER performance vs. mean C/N comparison between modified and conventional OSTBC HiperLAN/2 in mode 5 for channel B

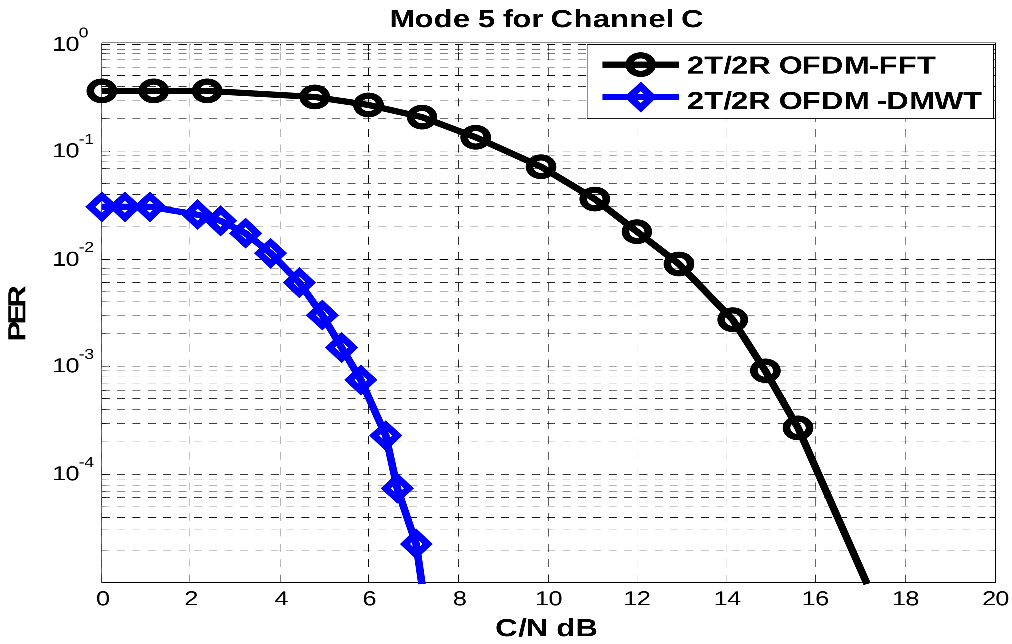

Figure 11. PER performance vs. mean C/N comparison between modified and conventional OSTBC HiperLAN/2 in mode 5 for channel C

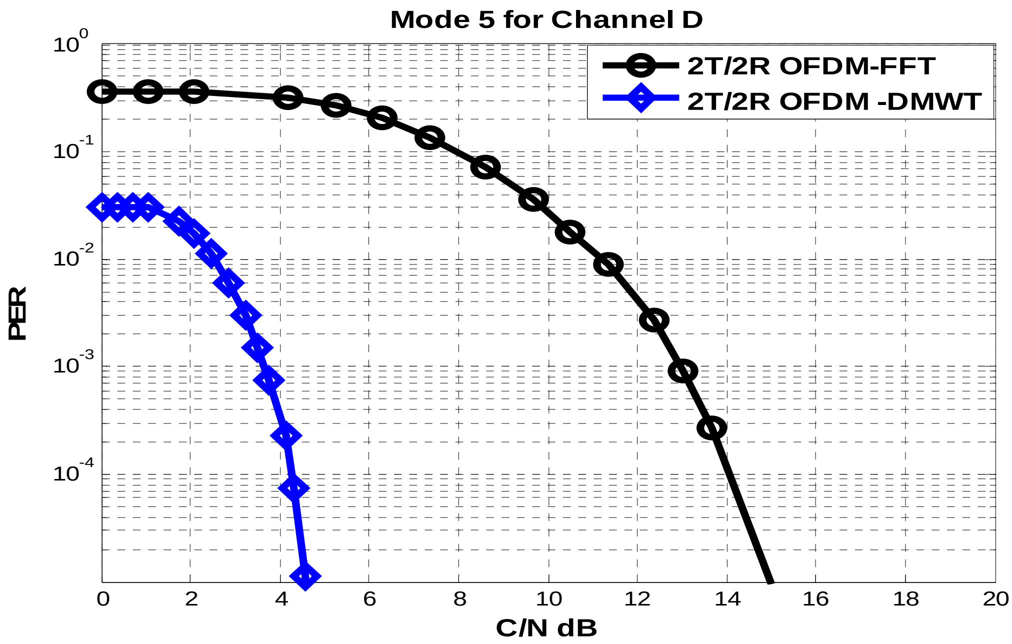

Figure 12. PER performance vs. mean C/N comparison between modified and conventional OSTBC HiperLAN/2 in mode 5 for channel D

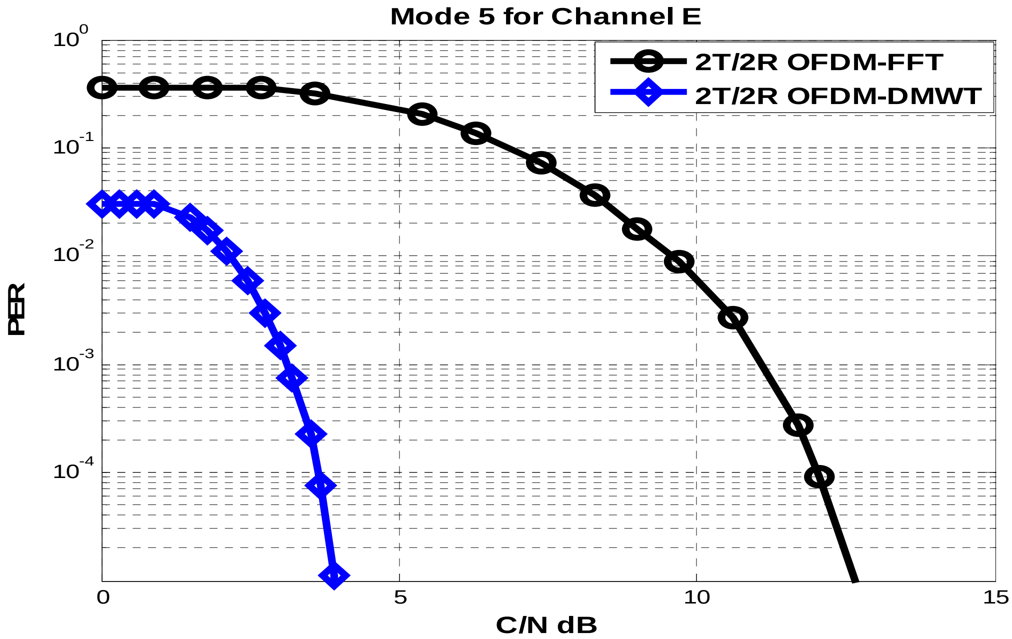

Figure 13. PER performance vs. mean C/N comparison between modified and conventional OSTBC HiperLAN/2 in mode 5 for channel E

Table 4. PER Performance comparison between conventional OSTBC HiperLAN/2 and modified OSTBC HiperLAN/ for mode 5 in all the specified channels

Channel For PER=10^{-3}	Channel A dB	Channel B dB	Channel C dB	Channel D dB	Channel E dB
OSTBC 2T/2R HiperLAN/2 OFDM-FFT	18.5	17.5	14.9	13	11.5
OSTBC 2T/2R HiperLAN/2 OFDM-DMWT	9.9	8.2	5.8	3.9	2.9

A number of significant results can be taken from Tables 3, 4; in this simulation, in most scenarios, OSTBC HiperLAN/2 based OFDM-DMWT system was better than the conventional OSTBC HiperLAN/2 based OFDM-FFT. The OSTBC HiperLAN/2 based OFDM-DMWT system proved its effectiveness in combating the multipath effect on the all channels.

4. Conclusion

This work has presented the performance evaluation in a OSTBC HiperLAN/2 physical layer model in simulated in different channel models is considered. By simulation we have concluded that the modes definition is efficient to provide high data rates in accordance with the link quality. And the use of OFDM-DMWT in OSTBC HIPERLAN/2 transceiver can be a new domain to be exploited representing an improvement in the performance. An important reason for the consideration of OFDM-DMWT is that these schemes are attractive to achieve much lower PER and better performance than OFDM-FFT. The proposed OFDM-DMWT system is robust for multipath channels and does not require cyclically prefixed guard interval, which means that it obtains higher spectral efficiency than conventional OFDM .A future upgraded of this work is the implementation over the OSTBC HiperLAN/2 physical layer model in order to make possible to evaluate good performance that this technique can offer.

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