Design and Improvement the Performance of LTE Transceiver based OFDM Wavelet Signals and Turbo Coder

Aassia Mohammad Ali Jassim Al-a'Assam

Abstract-LTE, a term of Long Term Evolution, marketed as 4G LTE, is a standard for wireless communication of high-speed data for mobile phones and data terminals. It is based on the GSM/EDGE and UMTS/HSPA network technologies, increasing the capacity and speed using a different radio interface together with core network improvements. In this paper a new technique based on the Discrete Wavelet Transform (DWT) for implementing the OFDM in LTE is proposed. The proposed scheme is tested in different SUI channels. The results explain that the proposed system overcome the conventional method based on the Fast Fourier transform (FFT) and give lower BER compared with the conventional method based on FFT.

Keywords: Turbo Coder, LTE, 3GPP, OFDM, FFT, DWT, SUI.

I. INTRODUCTION

Mobile communications have experienced dramatic advances over the last two decades. The technologies are rapidly moving toward the convergence of the communications, computing and consumer‟s platforms and bridged the services across fixed and wireless networks. Mobile broadband is becoming a reality, as the internet generation grows accustomed to having broadband access wherever they go, and not just at home or in the office. Out of the estimated 1.8 billion people who will have broadband by 2012, some two-thirds will be mobile broadband consumers and the majority of these will be served by HSPA (High Speed Packet Access) and LTE (Long Term Evolution) [1]. LTE is a jointly collaborated project with 3GPP. The main motto of this project is to improve the Universal Mobile Telecommunications System (UMTS).The main reason behind the name LTE is that the scientists are trying to establish a mobile broad band highway that will be support the future demand of mobile users like efficiency improvement, service enhancement, lowering cost and better integration with other standard [2]. In December 1998, Third Generation partnership project established. The members of 3GPP project are ARIB/TTC (Japan), China communication standard association, Telecommunications industry association (North America) and telecommunication technology associate (South Korea) [3]. 3GPP responded on IMT-Advanced requirements with a set of additional technology components specified in 3GPP Release 10, also known as LTE-Advanced [4].

Manuscript published on 30 June 2014.
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In October 2010 LTE-Advanced (LTE-A) successfully completed the evaluation process in ITU-R complying with or exceeding the IMT-Advanced requirements and thus became an acknowledged 4G technology. The LTE technology offers a number of distinct advantages over other wireless technologies. These advantages include increased performance attributes, such as high peak data rates, high spectral efficiency, very low latency, support of variable bandwidth, simple protocol architecture, compatibility and interworking with earlier 3GPP releases, interworking with other systems, e.g., cdma2000, FDD and TDD within a single radio access technology, efficient multicast broadcast and greater efficiencies in using the wireless spectrum [5]. The data rate of 100Mbps in downlink and 50Mbps in uplink are expected for 20MHz channel [6-8].To overcome the effect of multi path fading problem available in UMTS, LTE uses Orthogonal Frequency Division Multiplexing (OFDM) for the downlink - that is, from the base station to the terminal to transmit the data over many narrow band careers of 180 KHz each instead of spreading one signal over the complete 5MHz career bandwidth ie. OFDM uses a large number of narrow sub-carriers for multi-carrier transmission to carry data. Orthogonal frequency-division multiplexing (OFDM), is a frequency-division multiplexing (FDM) scheme used as a digital multi-carrier modulation method [9]. OFDM meets the LTE requirement for spectrum flexibility and enables cost-efficient solutions for very wide carriers with high peak rates. The basic LTE downlink physical resource can be seen as a time-frequency grid .The OFDM symbols are grouped into resource blocks [10]. The resource blocks have a total size of 180kHz in the frequency domain and 0.5ms in the time domain. Each 1ms Transmission Time Interval (TTI) consists of two slots (T slot). Each user is allocated a number of so-called resource blocks in the time. Frequency grid. The more resource blocks a user gets, and the higher the modulation used in the resource elements, the higher the bit-rate. Which resource blocks and how many the user gets at a given point in time depend on advanced scheduling mechanisms in the frequency and time dimensions [11]. The scheduling mechanisms in LTE are similar to those used in HSPA, and enable optimal performance for different services in different radio environments. Many advantages of OFDM The primary advantage of OFDM over single-carrier schemes is its ability to cope with severe channel conditions (for example, attenuation of high frequencies in a long copper wire, narrowband interference and frequency-selective fading due to multipath) without complex equalization filters [12].

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Channel equalization is simplified because OFDM may be viewed as using many slowly-modulated narrowband signals rather than one rapidly-modulated wideband signal. The low symbol rate makes the use of a guard interval between symbols affordable, making it possible to eliminate inter symbol interference (ISI). This mechanism also facilitates the design of single frequency networks (SFNs), where several adjacent transmitters send the same signal simultaneously at the same frequency, as the signals from multiple distant transmitters may be combined constructively, rather than interfering as would typically occur in a traditional single-carrier system [13]. The drawbacks of OFDM, inter-symbol interference (ISI) and ICI, which are caused by the loss in orthogonality between the carriers. The Fourier based OFDM uses the complex exponential bases functions and it's replaced by orthonormal wavelets in order to reduce the level of interference. It is found that the Haar-based orthonormal wavelets are capable of reducing the ISI and ICI, which are caused by the loss in orthogonality between the carriers [14]. In this work will used OFDM-DWT in LTE Transceiver to overcome the conventional method based on the Fast Fourier transform (FFT) and give lower BER compared with the system based on FFT.

II. PROPOSED MODIFIED MODEL

The Block diagram in Fig (1) represents the whole system model for Proposed Modified LTE Transceiver Design

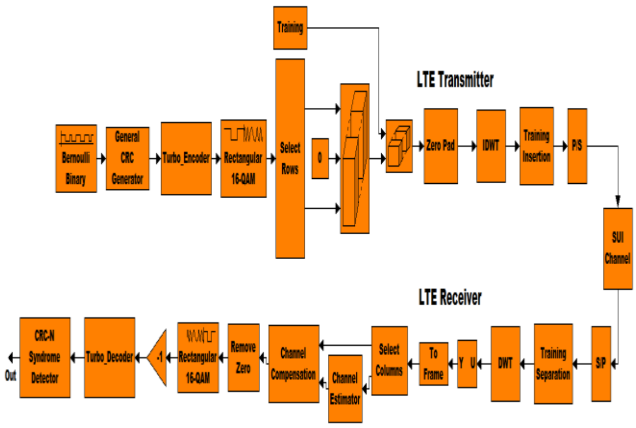

Fig .1.Block Diagram of Proposed Modified LTE Transceiver Design

In this section the system models that have been used in the LTE simulator will be presented. The used system model is outlined in Figure 1 In transmitter side the digital random data set is generated uniformly. CRC Insertion: A 24-bits CRC is calculated and appended at the end of every transport block. CRC allows receiver to detect residual errors from the decoded transport block. The block diagram for CRC insertion is shown in Figure 1. The current 3G systems use turbo coding scheme, but due to the high peak data rates supported by LTE [15], it becomes imperative to know if this same turbo coding scheme can scale to high data rates while maintaining reasonable decoding complexity. It is currently debated that turbo coding has a particular drawback that it is not amenable to parallel implementations which limit the achievable decoding speeds. The underlying reason behind this issue is the contention for memory resources among parallel processors which occurs as a result of the turbo code internal interleaver [16]. On the other hand, it is argued that turbo codes can also employ parallel implementations if turbo internal interleavers can be made contention-free. These blocks of digital data set have been paralleled and mapped into complex data blocks using 16-QAM modulation technique. Every complex data block referred to a symbol of data is attached to an individual sub-carrier. The Inverse Fast Fourier Transform (IDWT) is used in order to generate the time version of transmitted signal. The time domain signals corresponding to all subcarriers are orthogonal to each other. However, the frequency spectrum overlaps. After this, the data converted from the parallel to the serial form are fed to the SUI channels more information about SUI channels in [17]. The receiver performs the same operations as the transmitter, but in a reverse order. In addition, wavelet OFDM includes operations for synchronization and compensation for the destructive SUI channels.

III. SIMULATION RESULTS OF THE PROPOSED DESIGN

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

Table (1) LTE Physical Parameters

Transmission Bandwidth	**2.5 MHz**
Sub-frame duration	**0.5ms**
Sub-carrier spacing	**15KHz**
Sampling Frequency	**3.84MHz**
DWT Size	**256**
Modulation type	**16QAM**
Channel coding	**Turbo**
Channel type	**SUI Channel**
Channel estimation	**Perfect**
Receiver decoder type	**Softsphere detection (SSD)**
Number of iterations	**1000**

In this part the simulation of the proposed DWT-OFDM system LTE Transceiver Design and comparing with FFT-OFDM system is achieved, beside the BER performance of the OFDM system considered in Six SUI channels models

3.1 Performance of Proposed Model in SUI-1 Channel

In this scenario, the results obtained were encouraging. With OFDM-DWT and OFDM-FFT it can be seen that for BER=10^{-3} the SNR is required for OFDM-DWT is about 5.6 dB while in OFDM-FFT the SNR is required is about 13.13 dB .From Figure 2 it is found that the DWT-OFDM outperforms significantly other system for this channel model.

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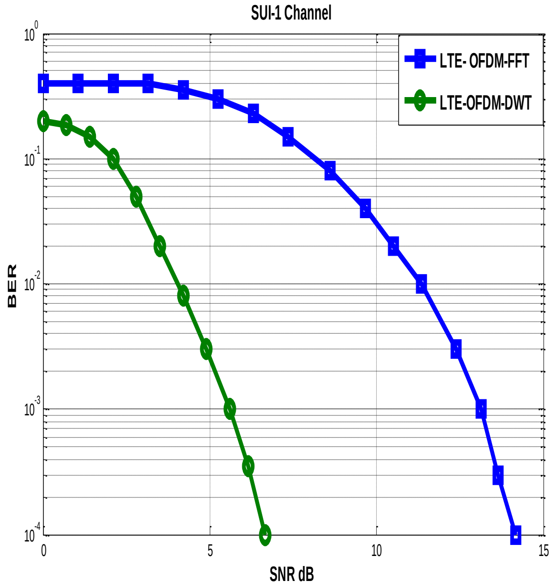

Fig .2. BER Performance of LTE Transceiver based OFDM DWT in SUI-1 Channel

3.2 Performance of Proposed Model in SUI-2 Channel

In this simulation profile some influential results were obtained. With OFDM-DWT and OFDM-FFT it can be seen that for BER=10^{-3} the SNR required for OFDM-DWT is about 7.8 dB while in OFDM-FFT the SNR required is about 17.5 dB. From Figure 3 it is found that the DWT-OFDM outperforms significantly other system for this channel model.

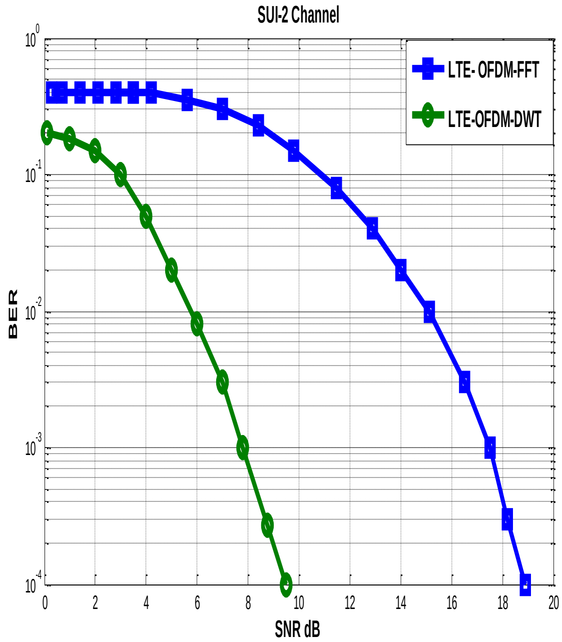

Fig .3. BER Performance of LTE Transceiver based OFDM DWT in SUI-2 Channel

3.3 Performance of Proposed Model in SUI-3 Channel

In the SUI-3 channel, the results are depicted in Figure 4 it can be seen that for BER=10^{-3} the SNR required for DWT-OFDM is about 11.7 dB, while in FFT-OFDM the SNR about 22.5 dB. From Figure 4 it is found that the DWT-OFDM outperforms significantly than FFT-OFDM systems for this channel model.

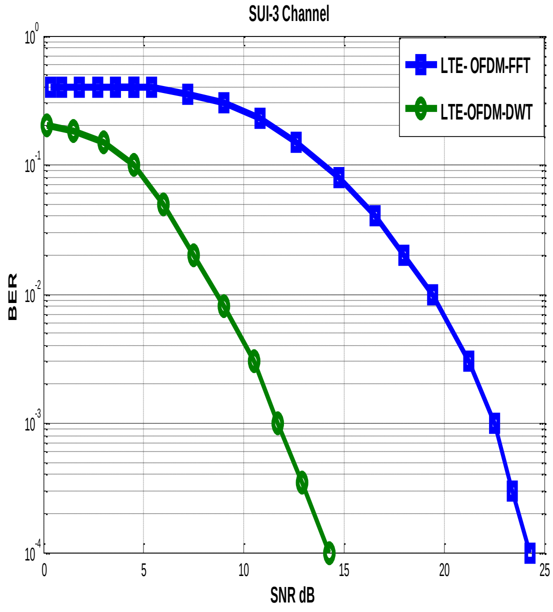

Fig .4. BER performance of LTE Transceiver based OFDM DWT in SUI-3 Channel

3.4 Performance of Proposed Model in SUI-4 Channel

Using similar methodology as in the previous section, simulations for SUI-4 channel The result depicted in Figure 5 it can be seen that for BER=10^{-3} the SNR required for DWT-OFDM is about 15.6 dB, while in FFT-OFDM the SNR about 27.5 dB. Also from Figure 5 it is found that the DWT-OFDM outperforms significantly than FFT-OFDM systems for this channel model.

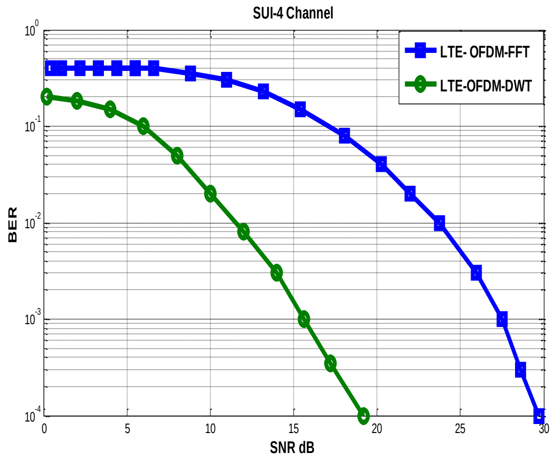

Fig. 5. BER performance of LTE Transceiver based OFDM DWT in SUI-4 Channel

3.5 Performance of Proposed Model in SUI-5 Channel

In this model, the results obtained were encouraging. With OFDM- DWT and OFDM-FFT it can be seen that for BER=$10^{-3}$the SNR required for OFDM DWT is about 19.5 dB while in OFDM-FFT the SNR about 32.5 dB. From Figure 6, it is found that the DWT-OFDM best significantly other system for this channel model.

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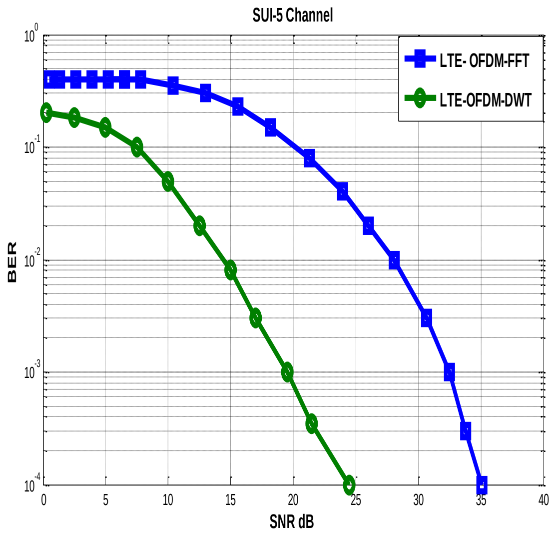

Fig .6. BER performance of LTE Transceiver based OFDM DWT in SUI-5 Channel

3.6 Performance of Proposed Model in SUI-6 Channel

In this state, the results obtained were hopeful. With OFDM-DWT and OFDM-FFT it can be seen that for BER=10^{-3} the SNR required for OFDM DWT is about 24.8 dB while in OFDM- FFT the SNR is about 37.75 dB. From Figure 7 it is found that the DWT-OFDM better significantly other system for this channel model

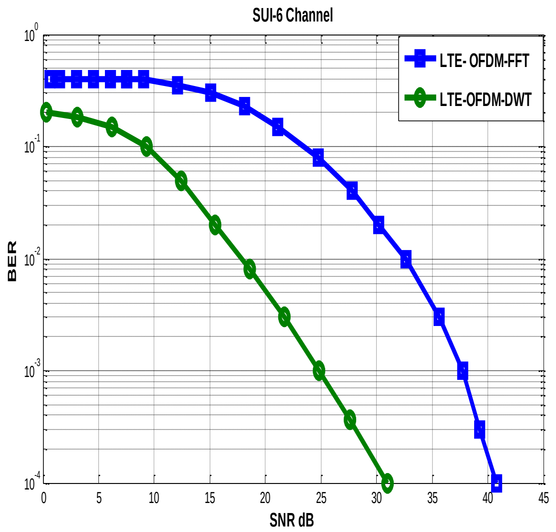

Fig .7 BER performance of LTE Transceiver based OFDM DWT in SUI-6 Channel

Table (2) Comparison between results

Channel for BER= 10^{-3}	SUI- 1 dB	SUI-2 dB	SUI-3 dB	SUI-4 dB	SUI-5 dB	SUI-6 dB
LTE OFDM- FFT	13.13	17.5	22.5	27.5	32.5	37.75
LTE OFDM- DWT	5.6	7.8	11.7	15.6	19.5	24.8

In this section the simulation of the proposed LTE Transceiver system in MATLAB version 13 are achieved, and the BER performance of the OFDM system considered in different SUI channel models, the, SUI-1, SUI-2, SUI-3,-SUI4, SUI-5 and SUI-6 .The simulation results shown in Table (2) in the all cases the LTE Transceiver based OFDM-DWT is better than the conventional structure.

IV. CONCLUSION

It can be concluded that the proposed LTE Transceiver structure achieves much lower bit error rates assuming reasonable choice of the bases function and method of computation. In SUI channels the wavelet based OFDM outperform the other OFDM based Fourier systems. Therefore, this structure can be considered as an alternative to the conventional structure. It can be concluded from the results obtained, that S/N measure can be successfully increased using the proposed wavelet designed method within a desired wavelet basis function. Thus wavelet based OFDM outperforms the conventional one.

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