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IMPLEMENTATION AND COMPARISON OF WAVELET TRANSFORM AND FOURIER TRANSFORM IN WI-MAX OFDM SYSTEM

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Abstract - WIMAX wireless communication is based on ofdm technology which enables going towards 4G Based on IEEE 802.16d-2004. But the reliability of ofdm is limited with the problems of time varying nature of the channel. This can reduced by adding cyclic prefix or guard interval between each block of data symbols. This guard interval minimizes the spectral efficiency in ofdm system. Recently, it was proved that discrete wavelet transform in ofdm system will reduce the isi Inter carrier interference, which is produced by loss of ortho-gonality between carriers and also provides more spectrum efficiency. It is found that proposed wavelet design achieves much lower bit error rates, Increases signal to noise power ratio (SNR), and can be used as an alternative to the Conventional OFDM WIMAX. The proposed OFDM system was modeled tested, and its Performance was found under different International Telecommunications Union (ITU Channel models.

***Keywords**: WIMAX, SFF SDR, OFDM, RS, Coding, AWGN, DWT, FFT.*

I. INTRODUCTION

The Wi-max is the standard harmonic for wide variety of Broadband wireless access (BWA) technologies. In the present paper we compare the performance with the schemes of the Fourier and wavelet transforms. The simulated packet error rate (PER) and the throughput results are shown for Wi-max technique. The expected throughput for each technique is computed as a function of base station terminal separation distance.

The Fourier transform Orthogonal Frequency Division Multiplexing (OFDM) has the complex based exponential function and it is replaced by the wavelets to reduce the level interference. It is founded that the Haar based wavelet transform is used for reducing the inter symbol interference and inter carrier interference which will occur due to the loss of orthogonality between the carriers [1, 2, 3]. The simulation results are shown that BER performance of the OFDM system with different orthogonal bases like Fourier based OFDM and Wavelet based OFDM. The simulation results are found a great deal of channel dependence with the performance of Fourier and wavelet filters

The main aim of using the wavelet based OFDM WIMAX is the superior spectral properties of the Wavelet filters over the Fourier filters [4]. Further performance gains are made by looking at the alternative orthogonal basis function and found a better transform than the Fourier transform. In this paper further performance using the DWT OFDM in Wi-max technology is executed and compared with the FFT OFDM in the different international Union (ITU) channel modes. This paper analysis the Discrete Wavelet Transform Orthogonal Frequency Division Multiplexing (DWT-OFDM) based on the WIMAX. It is organized as follows: Section 2 describes the proposed system model for DWT OFDM based on WIMAX. Section 3 presents the SFF SDR development platform and section 4 presents the simulation results and section 5 describes the conclusion.

II. PROPOSED SYSTEM MODEL FOR DWT OFDM BASED ON WIMAX

From the figure shown below the system is divided in to 3 main sections. They are

- Transmitter
- Channel
- Receiver

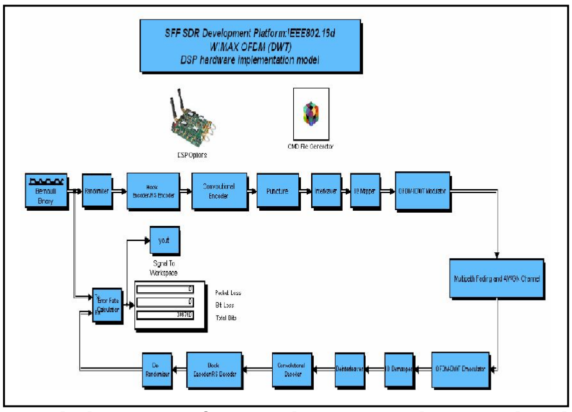

Fig: Block Diagram of Proposed IEEE802.16d WIMAX based DWT-OFDM

The data is generated from random source of information to the receiver section through channel. The generated data consists of series of ones and zeros. The transmission is done on block wise with forward error correction (FEC) and the size of data that is generated is depended on the size of the block. The generated data is converted in to lower rate sequence through series and parallel conversion and then randomized. The randomized data is encoded and it consists of concatenation of outer reed Solomon (RS) code. The implemented RS encoder is derived from the systematic RS code using the field generator and the inner convolution code. That is the data is first pass in block format through the RS encoder and then pass through the convolution encoder[5]. Finally interleaving is done by a two stage permutation.

➢ To avoid the mapping of the adjacent coded bits on the adjacent sub carriers

➢ It insures the adjacent coded bits that are mapped alternately on to more or less significant bits of the constellation, so it avoids the low reliable bits.

The pilot sub carrier's frame will be inserted and sent according to the information frame. These pilot sub carriers are used for estimating the channel which is used to compensate the channel effects on the signal. Symbol mapping is the method used for mapping the bits to form the symbol. The 16 QAM modulation scheme is used with half of code with gray coding in the constellation map. In some case the symbol is normalized so the average power is unity irrespective of modulation technique used. In the modulation the data is converted to the corresponding value of M-ary constellation which is complex word i.e. it has real component and imaginary component.

The band width $B = \left(\frac{1}{Ts}\right)$is divided in to equally spaced N sub carriers at frequencies $(k\Delta f)$, $where\ k = 0,1,2..,N-1\ \ with\ \Delta f = \frac{B}{N}$ and Ts is the sampling interval.

In the transmitter section the information bits are grouped and mapped in to the complex symbols which have real and imaginary parts. In this project constellation with QAM is the modulation technique used to map the bits to symbols. To modulate the spread data symbols to orthogonal carriers N point inverse Wavelet Transform (IDWT) is used with conventional OFDM. In the IDWT zeros are inserted in some bins in order to make the transmitted spectrum compact and to reduce the adjacent carrier's interference. The zeros that are added to the sub carriers will limit the bandwidth of the system, and the system without zeros pad has a spectrum which is spread in frequency. The total number of bits in OFDM symbol is equal to $\log^2 M{*}Nc$ [where Nc is the sub set of total sub carriers (Nt)]. Orthogonality between the carriers is destroyed when the transmitted signal is passed to the dispersive channel. When the orthogonality between carriers is destroyed then the inverse transformation at the receiver cannot recover the data that is transmitted perfectly. The interference is occurred in the symbol when the energy from one sub channel is transferred or leaked to the other sub channel. But the above problem is solved by introducing the cyclic prefix (CP). The cyclic prefix consists of the v samples from the original K samples that to be transmitted, and it is prefixed to the transmitted symbol. The length v is calculated as the channel's impulse response and it is used to minimize the Inter symbol interference (ISI). If the impulse response channel length is less than or equal to the v, then cyclic prefix is sufficient to completely eliminate Inter Symbol Interference and Inter Carrier Interfernce (ICI).

The efficiency of the transceiver is reduced by a factor of $\frac{k}{k+v}$. It is desirable to calculate v as small or to take K as a large as possible. If the number of the sub channels is sufficiently large, then the channel power spectral density can be assumed virtually flat with in the sub channel. The size of the sub channel is required to approximate the optimum performance of the channel transfer function. The optimum performance depends on how the channel transfer function varies with the frequency [6]. After 16 QAM the data is converted to serial to parallel and applied the Inverse Discrete wavelet Transform (IDWT) after that the data is converted from parallel to serial and these data is fed to the channel. WIMAX model of the receiver performs the same operation as the transmitter but is completely reverse to the transmitter i.e. the data is converted to serial to parallel and Discrete Wavelet Transform (DWT) is applied to the output of the channel. It also includes the operations for compensation and synchronization for the destructive channel. After that the transformed output is modulated and finally produces the received signal.

III. SFF SDR DEVELOPMENT PLATFORMS

The SFF SDR development platform consists of mainly 3 distinct hardware modules.

1. Digital processing module
2. Data conversion module
3. RF module

The above three modules offer the flexible development capabilities.

Fig: SFF SDR Development Platform

The Digital processing module is used for Virtex-4 FGPA and DM 6446 SoC which are used for necessary performance for implementing the custom IP and the acceleration function with varying from one protocol to another protocol which supports the same hard ware.

The Data conversion module is equipped with the dual channel analog to digital and digital to analog converter The RF module covers different types of frequency ranges in both transmission and reception by allowing it to support a wide range of applications [7].

3.1 System performance analysis and optimization to achieve

The two companies Math works and Texas Instruments both together are used for Mat-Lab or Simulink development of a DSP development tool. The Object modules are designed to their own needs and the programming system is implemented through the RTW (Real time Work Shop) and S-function with the TLC (Target Language compiler). The function of the system design is directly converted to the DSP programming language when it is completed.

3.2 System integration and implementation of Workflow

The overall WIMAX PHY physical layer system is opened in the simulink interface and Matlab is used to communicate the internal function of RTW and TLC. Here we need to build a finished system in to a module according with the code of each block. The over all work flow is shown in the below figure. The figure describes the system that is build based on the simulink IEEE 802.16d Wireless MAN-OFDM PHY standard modules. The first step is the configuration by simulink of the parameters interface and development for connecting node configuration. The information is set to leave the bulk form of a fixed number of patterns and the Real Time Workshop development module is used to and replaced by the C language.

In the mean while the Target Language Complier file, SDR development module and the simulink system development are scheduled for DSP link module by an external module. The configuration of IEEE 802.16d wireless OFDM is achieved with the DSP option Block, simulink is used to develop interfaces connecting node and development platform. The use of compiler option and DSP option block are to optimize the system.

In the SFF SDR development platform of the DSP configuration is classified in to 3 types of memories.

- LIDRAM (8KB)
- L2RAM (64KB)
- SDRAM (8MB)

From the above 3 memories LIDRAM and L2RAM are used for internal memory and SDRAM is used for external memory.

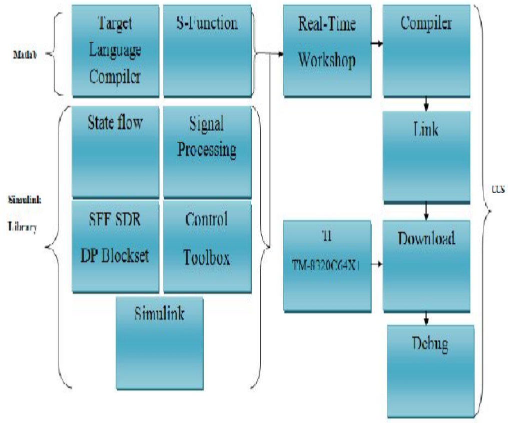

Fig: System Work Flow diagram

Due to the retention of internal memory the speeds become quicker, and if the information is placed in the internal memory system the speeds and executive would enhance the performance.

1.3 Target Language Compiler (TLC)

TLC is a Mat-lab Program and it uses as the syntax. Developers that are using the Real Time Workshop (RTW) tool can use the TLC for creating the self designed syntax language code by adding to executive after the RTW is generated. The usage of S function in the input and output of the set is to design its own system for c programming and creates the simulink objects in the box to use; anyway the RTW is used for producing the C language program. It will not check by performing the actions or debugging code in to the editor. The design of the TLC and the features are shown below

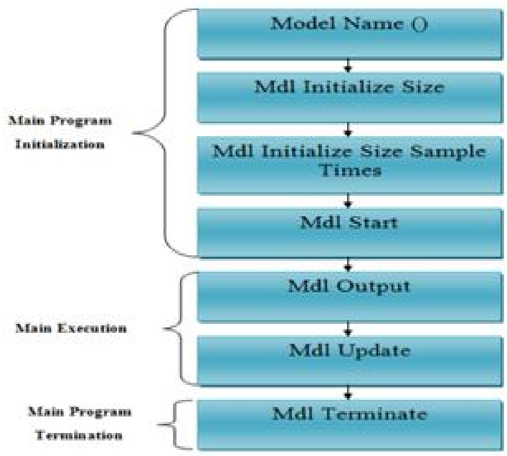

Fig: Target Language Compiler (TLC) structure

IV. SIMULATION RESULTS

The simulation results are proposed on DWT OFDM with WIMAX and comparing with the FFT OFDM system and the BER performance of the OFDM system is considered with the AWGN channel.

4.1 Performance with AWGN channel

The results are for the proposed DWT OFDM and it gives the BER performance of the DWT OFDM in AWGN channel. The figure clearly shows the DWT OFDM is better than the FFT OFDM. So we can conclude that the orthogonal base of the Wavelets is more significant than the orthogonal base of the Fourier transform.

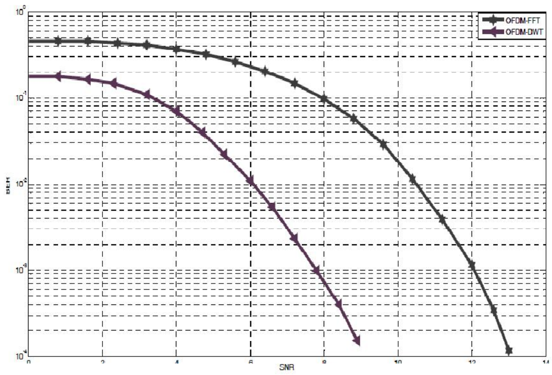

Fig: BER performance of OFDM with DWT and FFT for AWGN channel

4.2 Pedestrian channel A

In Pedestrian situation we have considering two different situations: Moving and Stationary Person. The results are shown in below figure.

In the stationary case we can seen that BER is and the SNR for DWT-OFDM is about 13.2 dB and for FFT-OFDM the SNR is about 17.5 dB.

In the moving case is seen that BER= and the SNR for DWT-OFDM is about 16.2 dB and for FFT-OFDM the SNR is about 21.8 dB

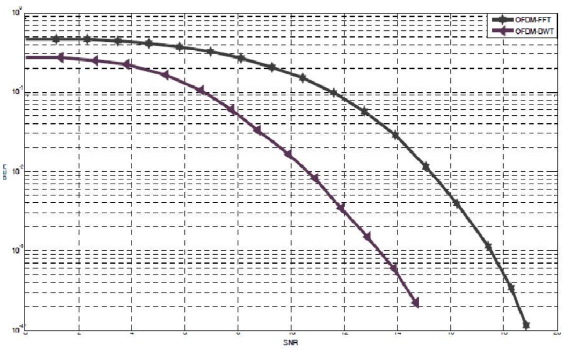

Fig: BER performance of DWT -OFDM in AWGN & Multipath for stationary Pedestrian Channel

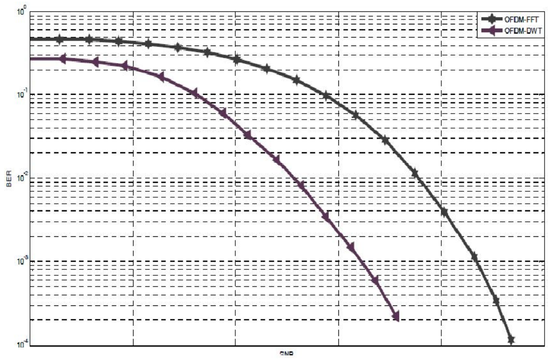

Fig: BER performance of DWT OFDM in AWGN & Multipath for moving Pedestrian Channel

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 Math-Works. The SFF SCA Development Platform optional package allows SCA waveform development and implementation. The key contribution of this paper was the implementation of the IEEE 802.16d PHY layer based the DWT-OFDM structure was proposed simulate and tested. Simulations provided proved that proposed design achieves much lower bit error rates and better performance than FFT-OFDM assuming reasonable choice of the bases function and method of computations. Proposed DWT-OFDM systems is robust for multi-path channels and does not require cyclically prefixed guard interval, which means that it obtains higher spectral efficiency than conventional OFDM and it can be used at high transmission rates. From obtained results it can be concluded, that SNR can be successfully increased sing proposed wavelet designed method and using a desired wavelet bases function. Therefore this structure can be considered as an alternative to the conventional OFDM.

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