OFDM Baseband Modulation Technology based on Verilog

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ABSTRACT-In order to improve the transmission velocity in multipath fading wireless channel, the high speed OFDM technology receives increasing attentions in mobile communication. The growth of mobile communications and wireless Internet access has produced a strong demand for advanced wireless techniques. The challenges for wireless communication designs come from the detrimental characteristics of wireless environments, such as multipath fading, Doppler effect, co-channel interference, and intentional jamming in military communications. In this OFDM base band modulation consists of from scrambler, encoder, Serial to Parallel converter, inter leaver and Sub carrier modulation (mapping). Sub carrier modulation mostly uses three modes that are BPSK (Binary phase shift keying), QPSK and QAM, QAM-4, QAM-6. Interleave is to disperse lost information to decrease error bit rate, in other words, when user information bits are lost among transmission process. Experimental results indicate that setup time corresponding to transmission velocity and steady time is approximately doubled as setup time, that is, not only achieving the high speed transmission, but also supplying adequate modulation time.

Keywords – OFDM; VERILOG; Baseband Modulation;

I. INTRODUCTION

OFDM requires very accurate frequency synchronization between the receiver and the transmitter; with frequency deviation the sub-carriers will no longer be orthogonal, causing inter-carrier Orthogonal frequency division multiplexing (OFDM) is a method of encoding digital data on multiple carrier frequencies. OFDM has developed into a popular scheme for wideband digital communication, whether wireless or over copper wires, used in applications such as digital television and audio broadcasting, DSL broadband internet access, wireless networks, and 4G mobile communications. Interference (ICI). Frequency offsets are typically caused by mismatched transmitter and receiver oscillators, or by Doppler shift due to movement. While Doppler shift alone may be compensated for by the receiver, the situation is worsened when combined with

multipath, as reflections will appear at various frequency offsets, which is much harder to correct. This effect typically worsens as speed increases, and is an important factor limiting the use of OFDM in high –speed vehicles. Several techniques for ICI suppression are suggested, but they may increase the receiver complexity.

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Wireless internet access has produced a strong demand for advanced Wireless techniques. The challenges for wireless communication designs come from the detrimental Characteristics of wireless environments, such as multipath fading, Doppler Effect, co-channel interference, and intentional jamming in military communications. The objective of this paper is to provide an approach to solve the problem of transmission velocity of multipath fading by means of orthogonal frequency division multiplexing.

OFDM is a special form of multicarrier modulation, which was originally used in high frequency military radio. An efficient way to implement OFDM by means of a discrete Fourier transform (DFT) was found by Weinstein in 1971. The computational complexity could be further reduced by a fast Fourier transform (FFT). However, OFDM was not popular at that time because the implementation of large size FFTs was still too expensive. Recent advances in VLSI technologies have enabled cheap and fast implementation of FFTs and IFFTs. In the 1980s, Cimini first investigated the use of OFDM for mobile communications. Since then, OFDM has become popular. In the 1990s, OFDM was adopted in the standards of digital audio broadcasting (DAB), digital video broadcasting (DVB), asymmetric digital subscriber line (ADSL), and IEEE802.11a. OFDM is also considered in the new fixed broadband wireless access system specifications.

II. IMPLEMENTATION OF OFDM-QAM 64 BIT DATA PROCESSOR

In OFDM, the sub-carrier frequencies are chosen so that the sub-carriers are orthogonal to each other, meaning that cross-talk between the sub-channels is eliminated and inter-carrier guard bands are not required. This greatly simplifies the design of both the transmitter and the receiver; unlike conventional FDM, a separate filter for each sub-channel is not required.

The orthogonally requires that the sub-carrier spacing is $\Delta f = \frac{k}{T_U}$ Hertz, where TU seconds is the useful symbol duration (the receiver side window size), and k is a positive integer, typically equal to 1. Therefore, with N sub-carriers, the total pass band bandwidth will be $B \approx N \cdot \Delta f$ (Hz).

The orthogonally also allows high spectral efficiency, with a total symbol rate near the Nyquist rate for the equivalent baseband signal (i.e. near half the Nyquist rate for the double-side band physical pass band signal). Almost the whole available frequency band can be utilized. OFDM generally has a nearly 'white' spectrum, giving it benign electromagnetic interference properties with respect to other co-channel users.

OFDM requires very accurate frequency synchronization between the receiver and the transmitter; with frequency deviation the sub-carriers will no longer be orthogonal, causing inter-carrier interference (ICI) (i.e., cross-talk between the sub-carriers). Frequency offsets are typically caused by mismatched transmitter and receiver oscillators, or by Doppler shift due to movement. While Doppler shift alone may be compensated for by the receiver, the situation is worsened when combined with multipath, as reflections will appear at various frequency offsets, which is much harder to correct. This effect typically worsens as speed increases,[1] and is an important factor limiting the use of OFDM in high-speed vehicles. Several techniques for ICI suppression are suggested, but they may increase the receiver complexity.

A. ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING (OFDM)

Orthogonal Frequency-Division Multiplexing (OFDM) is used as the underlying technology in 802.11g and 802.11a. OFDM is a form of Frequency-Division Multiplexing (FDM); normally, FDM uses multiple frequency channels to carry the information of different users. OFDM uses multicarrier communications, but only between one pair of users that is, a single transmitter and a single receiver.

Multicarrier communications splits a signal into multiple signals and modulates each of the signals over its own frequency carrier, and then combines multiple frequency carriers through FDM. OFDM uses an approach whereby the carriers are totally independent of (orthogonal to) each other. Note that the total bandwidth consumed with OFDM is the same as with single carrier systems even though multiple carriers are used—because the original signal is split into multiple signals. OFDM is more effective at handling narrowband interference and problems related to multipath fading, simplifying the building of receiver systems.

Orthogonal Frequency-Division Multiple Access (OFDMA) superimposes the multiple-access mechanism on OFDM channels, so that multiple users can be supported through subsets of the subcarriers assigned to different users. Note that 802.16-2004 ("Fixed" WiMAX) uses OFDM, whereas 802.16e-2005 ("Mobile" WiMAX) uses OFDMA.

Recently, OFDM systems have become popular for providing high data rate multimedia services over several multi-path channels (Hanzo et al 2001, Prasad and Van Nee 2000). For data services, the offered peak bit rate is very important in determining the overall system performance, because of the highly burst nature of internet traffic. The GPRS, EDGE and WCDMA systems support transmission rates up to 144 – 384 kb/s in macro-cellular environments. To achieve rates in the megabits-per-second range for all environments using the 5 MHz spectrum is challenging for both the physical layer as well as for the radio resource management design. Single carrier TDMA solutions are limited in supportable transmission bit rate by equalizer complexity. Low spreading gain or inter-code interference at high bit rates limits CDMA solutions.

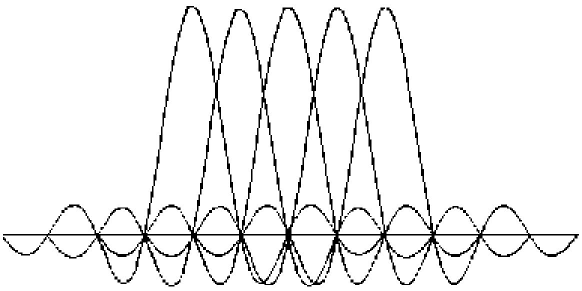


Fig: 2.1Frequencies with overlapping spectrum

In OFDM, high rate data streams are split into a number of lower rate streams that are transmitted simultaneously over a number of sub-carriers. Hence, OFDM is a multi-carrier technique wherein data bits are encoded to multiple sub-carriers. Unlike single carrier systems, all the frequencies are sent simultaneously in time. Transmission of high data rate signals using conventional single carrier techniques suffer in terms of achievable bit rates even with interference suppression and space-time processing along with equalization. OFDM systems offer low complexity solutions. Since the symbol duration increases for the lower rate parallel sub-carriers. The use of OFDM with sufficiently long symbol periods of 100 – 200 μs for packet data transmission supports a high bit rate in time delay spread environments with performance that improves with increasing delay spread up to a point of extreme dispersion. Inter-symbol interference is eliminated almost completely by introducing a guard time in every OFDM symbol. The effect is shown in Figure 1.3 which shows the overlapping spectra of individual sub-carriers. At the maximum of each sub-carrier spectrum, all other sub-carrier spectra are zero. As an OFDM sub-carrier essentially calculates the spectrum values at these points that correspond to the maxima of individual sub-carriers.

In the OFDM scheme, data is transmitted in parallel through several sub-carriers. OFDM offers flexibility in multiple access by suitably dividing the sub-carriers among several u In an OFDM system, a very high rate data stream is divided into multiple parallel low rate data streams. Each smaller data stream is then mapped to individual data sub-carrier and modulated using some sorts of PSK (Phase Shift Keying) or QAM (Quadrature Amplitude Modulation). i.e. BPSK, QPSK, 16-QAM, 64-QAM

III. OFDM-QAM 64 BIT DATA PROCESSOR

In this paper we are using QAM-64 modulation technique for implementation of the OFDM data processor. Quadrature amplitude modulation (QAM) is both an analog and a digital modulation scheme. It conveys two analog message signals, or two digital bit streams, by changing (modulating) the amplitudes of two carrier waves, using the amplitude-shift keying (ASK) digital modulation scheme or amplitude modulation (AM) analog modulation scheme. The two carrier waves, usually sinusoids, are out of phase with each other by 90° and are thus called quadrature carriers or quadrature components hence the name of the scheme. The modulated waves are summed, and the resulting waveform is a combination of both phase-shift keying (PSK) and amplitude-shift keying (ASK), or (in the analog case) of phase modulation (PM) and amplitude modulation. In the digital QAM case, a finite number of at least two phases and at least two amplitudes are used.

This research presents an FPGA technique to gain approach in the problem of OFDM system implementation. The proposed design is synthesized by using high-level design tools .The design flow is optimized for fast prototype, which is implemented on the latest generation of FPGA chips. Such an FPGA implementation has the added advantage to modify for changes and improved system performance. The total needed area for the transmitter is taken into account. The total power of OFDM system is 105mw. The proposed design is suitable for low power portable wireless communication in order to obtain long battery life.

The over all System Architecture will be designed using HDL language and simulation, synthesis and implementation (Translation, Mapping, Placing and Routing) will be done using various FPGA based EDA Tools(). Finally the proposed system architecture performance (speed, area, power and throughput) will be compared with already exiting system implementations.

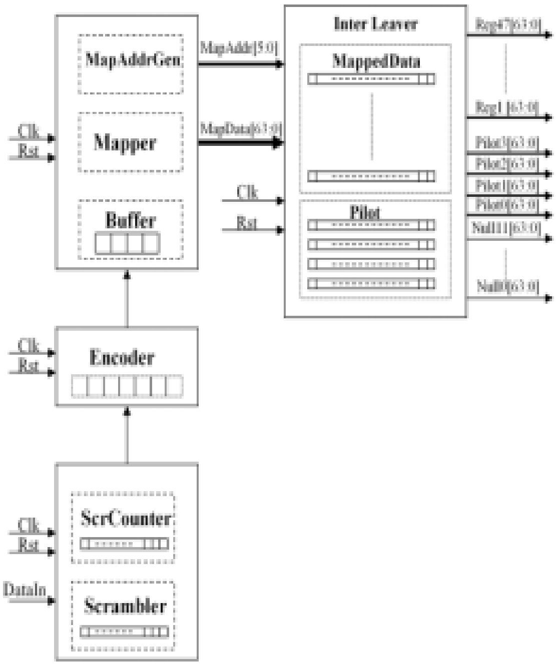


Fig. 3.1: OFDM-QAM64 bit data processor

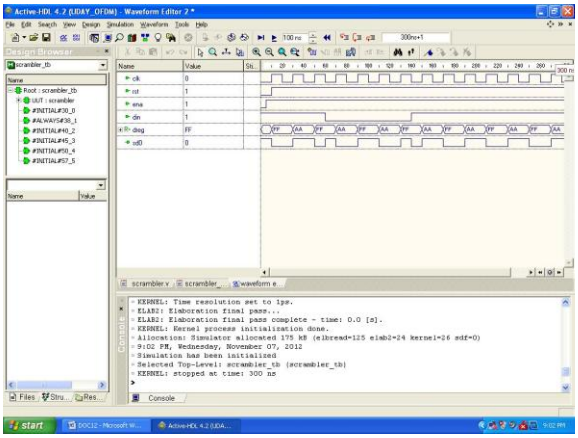
IV. SIMULATION RESULTS

This chapter explains the top level overview of the environment and simulation results. The following is the sequence of operations followed to verify the design. VERILOG code is written for every module in OFDM-QAM64 bit data processor, Simulation of these modules is done in Active HDL.

Test benches are written to give a required input to each block and check the outputs for their correctness. The simulation of each module is shown for OFDM-QAM64 bit data processor and also for top module of OFDM-QAM64 bit data processor.

a. SCRAMBLER

When rst=o, for every rising edge of the clock scrambler perform some XOR operations by using LFSR and Counter



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KERNEL: Time resolution set to 1ps.
ELAB2: Elaboration final pass...
ELAB2: Elaboration final pass complete - time: 0.0 [s].
KERNEL: Kernel process initialization done.
Allocation: Simulator allocated 175 kB (elbread=125 elab2=24 kernel=26 sdf=0)
9:02 PM, Wednesday, November 07, 2012
Simulation has been initialized
Selected Top-Level: scrambler_tb (scrambler_tb)
KERNEL: stopped at time: 300 ns
>
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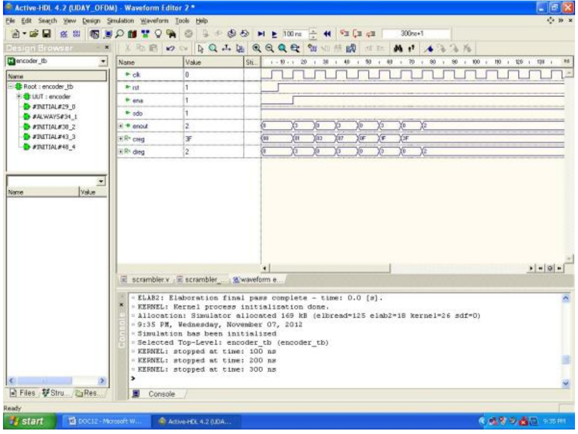
Fig. 4.1: **Simulation results for Time sequence of scrambler**

b. ENCODER:

Encoder modulates data which is coming from the Scrambler. when rst=0, for every rising edge of the clock encoder performs XOR and shifting operations.



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ELAB2: Elaboration final pass complete - time: 0.0 [s].
KERNEL: Kernel process initialization done.
Allocation: Simulator allocated 169 kB (elbread=125 elab2=18 kernel=26 sdf=0)
9:35 PM, Wednesday, November 07, 2012
Simulation has been initialized
Selected Top-Level: encoder_tb (encoder_tb)
KERNEL: stopped at time: 100 ns
KERNEL: stopped at time: 200 ns
KERNEL: stopped at time: 300 ns
>
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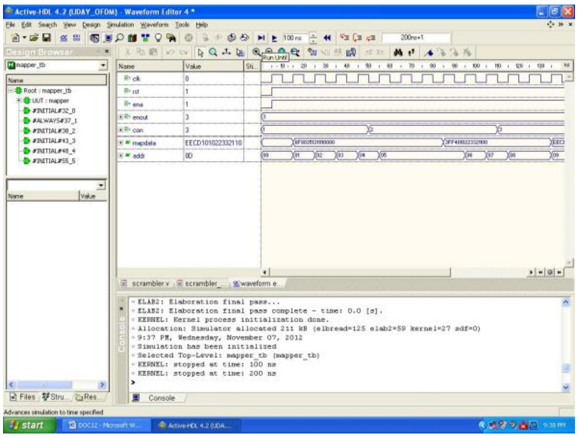
Fig 4.2: **Simulation results for Time sequence of Encoder**

c. MAPPER

Mapper is used to generate the address for data.it maps useful data and remaining data will be kept a side. Here we are using QAM 6 bit modulation technique. Finally we get mapped data and mapped address. When rst=0 then for every rising edge of the clock, 2bits of data is converted into 64 bit data by the mapper and it also generates address for the 64 bits.



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ELAB2: Elaboration final pass...
ELAB2: Elaboration final pass complete - time: 0.0 [s].
KERNEL: Kernel process initialization done.
Allocation: Simulator allocated 211 kB (elbread=125 elab2=59 kernel=27 sdf=0)
9:37 PM, Wednesday, November 07, 2012
Simulation has been initialized
Selected Top-Level: mapper_tb (mapper_tb)
KERNEL: stopped at time: 100 ns
KERNEL: stopped at time: 200 ns
>
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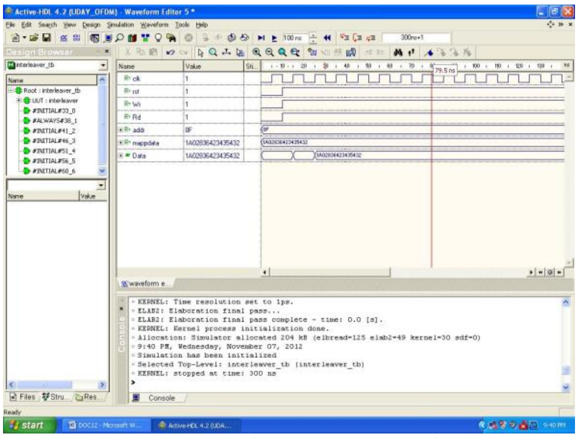
Fig 4.3: **Simulation results for Time sequence of mapper**

d. INTERLEAVER

Register block is also called as Interleaver. It acts as a memory storage device. Register block used here stores the 64 bit data which is coming from a mapper, by using the 64 registers present in it stores the 64bit data and corresponding address of the data.When rst=0, then for every rising edge of the clock the data from the mapper is loaded into this register block. Finally we get 64 bit data.



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KERNEL: Time resolution set to 1ps.
ELAB2: Elaboration final pass...
ELAB2: Elaboration final pass complete - time: 0.0 [s].
KERNEL: Kernel process initialization done.
Allocation: Simulator allocated 204 kB (elbread=125 elab2=49 kernel=30 sdf=0)
9:40 PM, Wednesday, November 07, 2012
Simulation has been initialized
Selected Top-Level: interleaver_tb (interleaver_tb)
KERNEL: stopped at time: 300 ns
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Fig 4.3: Simulation results for Time sequence of interleave

V. CONCLUSION

OFDM has various advantages over the previous generation's access techniques. In OFDM, interference's within the cell are averaged by using allocation with cyclic permutations. OFDM enables orthogonally in the uplink by synchronizing users in time and frequency, multi path mitigation without using Equalizers and training sequences, enables Single Frequency Network coverage, where coverage problem exists and gives excellent coverage, spatial diversity by using antenna diversity at the Base Station and possible at the Subscriber Unit. OFDM also enables adaptive modulation for every user, making the 4G backward compatible with 2.5G and 3G wireless mobile systems. OFDM offers Frequency diversity by spreading the carriers all over the used spectrum, time diversity by optional interleaving of carrier groups in time. OFDM also enables the usage of Indoor Omni Directional antennas for the users. In OFDMA systems the medium access control layer complexity is same as that of TDMA system

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