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Review on FPGA based OFDM System Implementation using FFT

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ABSTRACT: Orthogonal Frequency Division Multiplexing (OFDM) is a multicarrier system which gives best usage of bandwidth at output and the system is unaffected by multipath effects. In this paper, the OFDM system is implemented using FFT/IFFT which is based on FPGA. The coding of the system is done in VHDL language and simulation can be done on XILINX ISE software.

KEYWORDS: Complex number multiplier, FFT, IFFT, butterfly structure, VHDL

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) is a master modulation method in this new period of communication world. In a conventional parallel data system, the total signal bandwidth can be divided into N non-overlapping frequency sub-channels. Each sub-channel is modulated with a separate symbol and then the N sub-channels are frequency multiplexed. To eliminate the inter-carrier interference (ICI), spectral overlap is avoided i.e. empty spectral region is provided, between two adjacent sub-channels. But this results in inadequate usage of the ready spectrum [1]. The concept was recommended in the mid-1960s, to handle with this wastefulness, through the advancement of frequency division multiplexing (FDM) with overlapping sub-channels. The sub-channels were ordered so that, the sidebands of the individual carriers overlap without inducing ICI. To accomplish this, the carriers must be mathematically orthogonal [2]. From this confinement the concept of Orthogonal Frequency Division Multiplexing (OFDM) was proposed. Block diagram of OFDM is shown in Fig.1.

A. QAM

Quadrature amplitude modulation (QAM) is an analog as well as a digital modulation strategy. By modulating the amplitudes of two carrier signals, it conveys two analog message signals, or two digital bit streams using the amplitude-shift keying (ASK) digital modulation technique or amplitude modulation (AM) analog modulation technique. The two carrier signals having same frequency and usually which are sinusoids, are out of phase with each other by 90° and are thus called quadrature carriers or components and therefore the name of the technique is Quadrature Amplitude Modulation (QAM) [3]. Summing the modulated signals results in the final waveform which is a combination of phase-shift keying (PSK) as well as amplitude-shift keying (ASK), or, in the analog technique, of phase modulation (PM) and amplitude modulation. At least two phases and at least two amplitudes of a finite number are used in the digital QAM technique. Using the QAM principle, PSK modulators are frequently made up of but are not advised as QAM since the amplitude of the modulated carrier signal is unvarying. QAM is used extensively as a modulation technique for digital telecommunication systems. Randomly high spectral efficiencies can be accomplished with QAM by setting a suitable constellation size, limited only by the noise level and linearity of the communications channel.

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B. SERIAL TO PARALLEL AND PARALLEL TO SERIAL CONVERTER

Serial to parallel converter is input block of OFDM transmitter and receiver and in this serial to parallel converter, input data is in serial form and it is converted to parallel form. One register 'temp' is taken for temporary holding of data and after n number of clock cycles, the value in 'temp' is allotted to the output register. Similarly, in parallel to serial converter, for every clock cycle, least significant bit (LSB) of input is allotted to output and this input number is right shifted by one place. In this way, we get LSB at output, for every clock cycle.

C. FFT

To calculate discrete Fourier transform there is an algorithm named as a fast Fourier transform (FFT). And because of a Fourier transform, conversion of time domain signal into frequency domain signal is possible. Thus FFT is used in a great extent in DSP method, also in applications of communication in greater extent. FFT is essential and widely used numerical algorithm [4]. In the field of digital signal processing as well as image processing FFT is one of the rudimentary operations. Use of FFT is necessary in most of the signal processing applications. There are efficient multiplication methods to minimize the partial product which is happened in conventional multiplication method therefore the FFT and inverse fast Fourier transform (IFFT) with efficient multiplication and with greater speed is used and important for Orthogonal Frequency Division Multiplexing (OFDM) Modulator and Demodulator. High speed and efficient multiplication is required in most of the applications. And therefore conventional multicarrier method are mostly selected, but this gives results in lower spectrum efficiency. Hence, the principles of OFDM are important. The speed enhancement is the useful contribution of the main processing blocks in OFDM system. FFT is used for demodulation and it is exactly opposite to IFFT.

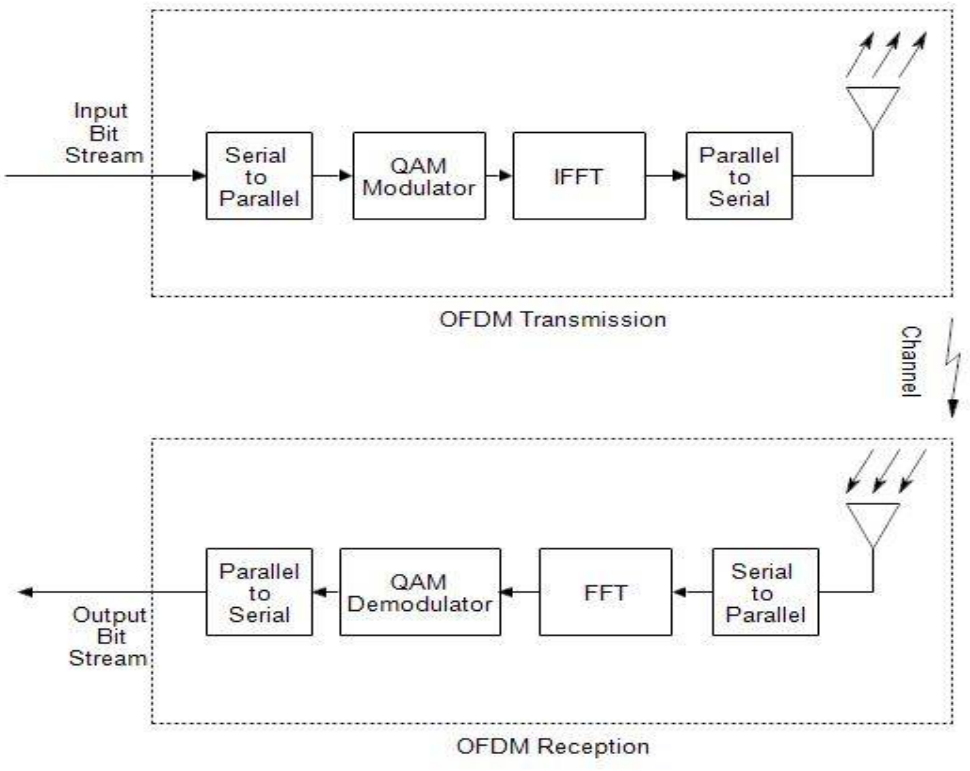

Fig. 1. Block Diagram of OFDM

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D. IFFT

IFFT is used for modulation purpose. The signals converted from time domain to frequency domain with using Fourier Transform and the signals are converted back from frequency domain to the time domain with using Inverse Fourier Transform. To examine the signals and create them to and from their frequency components the Fourier transform is an effective tool. If the discrete in time signal is sampled, to convert them to the discrete frequency form one uses the discrete Fourier transform and vice versa. Also to convert the discrete frequency form into the discrete time form the inverse discrete transform IDFT is used [5].One uses the fast Fourier transform algorithm FFT and IFFT, to decrease the mathematical operations used in the calculation of DFT and IDFT.By using OFDM as a multicarrier modulation technique in transmitters, the OFDM symbol is designed in the frequency domain by mapping the input bits on the I- and Q- components of the QAM symbols and then ordering them in a order with precise length according to the number of subcarriers in the OFDM symbol. That is by the mapping and ordering process, one designs the frequency components of the OFDM symbol. To transmit them, the signal should be represented in time domain. This is completed by the inverse fast Fourier transform IFFT.

II. LITERATURE REVIEW

An OFDM Transmitter Implementation paper using Cordic based Partially Reconfigurable IFFT Module by Arun Kumar K A describes in the advancement of modern-era wireless communication systems, reconfigurable technology plays a critical duty. OFDM is a method in which is wireless communication in practice and in this digital data is encoded in big number of closely separated orthogonal sub-carrier signals. The Baseband FPGA execution of an OFDM transmitter is also discussed in this paper. The module is executed using a method called partial reconfiguration so that someone can swap between distinct modulation techniques, coding techniques and number sub-carriers demanded in less time. In this execution the person which is using it can exchange between four OFDM transmitters in less than a minute without troubling the standard working of the module. In this PR based execution of OFDM Transmitter a greater area of the Modulator, coding and IFFT modules will be static and a lesser area will be dynamic. At the time of swapping only the dynamic area of the FPGA is reconfigured in less time which will decrease power and configuration time [6].

Mujtaba Afzal, Dayal Sati, HeenaChoudhary, Ashish Vats and RomikaChoudhary in the Design, Modelling and Implementation paper of Variable FFT Processor explained about the research which concentrates on the planning, Modeling and execution of inconsistent FFT Processor. In orthogonal frequency division multiplexing (OFDM) and OrthogonalFrequency-Division Multiple Access (OFDMA) techniques important block is Fast Fourier transform (FFT). Fromwired-communication to wireless-communication modems, Wi-Fi, IEEE802.16, Wi-MAX or 3GPP longterm evolution (LTE), digital subscriber lines (xDSL), process baseband data, OFDM is having large applications. Initially the design is constructedfor 8 point FFT and then it is used to execute variable FFT processor. The design is created with the support ofVHDL programming language and combined on Virtex-5 FPGA in Xilinx 14.2 software and functional simulation isdone in Modelsim software [7].

In FPGA Implementation of MIMO-OFDM Transceiver paper of K. Srinandhini and V. Vaithianathan, they explained Orthogonal Frequency Division Multiplexing (OFDM). FDM modulation is a guaranteed process for high data rate applications such as video streaming. This technique works efficiently for multipath frequency selective channels. Multiple Input and Multiple Output (MIMO) is a wireless technology which uses number of antennas at the transceiver terminals. Link throughput and network capacity it increases. The combination of both MIMO and OFDM gives a module that is robust against the frequency-selective fading which is due to sever multi-path scattering and narrowband interference. This judgment has accelerated the enhancement of System-onchip (SoC) platform to help the physical layer of these techniques. Field Programmable Gate Array (FPGA) execution of channel coder, decoder, interleaver and deinterleaver which is of MIMO-OFDM are explained in this paper. Convolutional encoder of code rate 112 is used because of its minimum complexity and Viterbi decoder is used for decoding. Interleaver and Deinterleaver is used to delete the burst error thus enhancing the performance [8].

In the paper of INTRODUCTION TO “THE HISTORY OF OFDM” author described about OFDM, orthogonal frequency-division multiplexing, which carries important duty in modern era of telecommunications, which is having scope from its part in DSL-modem technique to 802.11 Wi-Fi wireless methods. In next-generation mobile wireless systems or methods work underway plays the superiority of using OFDM methods as well. OFDM compounded with

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MIMO technology is awaited to givehuge enhancement in wireless transmission capacity. In the Communications Society and past Presidents, its author, Steve Weinstein, a leader was one of the innovators in the enhancement of OFDM techniques [9].

PawanVerma, Harpreet Kaur, Mandeepsingh and Balwinder Singh in the VHDL implementation paper which is of FFT/IFFT Blocks for OFDM describes that in lots of applications high-speed performance is needed. For this fact, formal multi-carrier methods are mostly used, but it gives output in the decreasing of spectrum efficiency. Therefore the principles of Orthogonal Frequency Division Multiplexing are needed in this type of applications. This paper gives the thorough knowledge of the enhancement of IFFT & FFT algorithms to be used in OFDM techniques depends on the IEEE 802.11a standard of WLAN. This system consists of separate OFDM transmitter & receiver. Basically, in the whole architecture of OFDM technique, all the mathematical use take place in these both blocks, i.e. IFFT & FFT blocks and remaining of the blocks modify the data from one form to other form. In this paper author has described in detail FFT and IFFT blocks in VHDL. The speed enhancement is the most important contribution of the main processing blocks in OFDM system [10].

In the Implementation of an IFFT for an Optical OFDM Transmitter with 12.1 Gbit/s paper Michael Bernhard, Joachim Speidel explained the plan of an inverse discrete Fourier transform (IDFT) for an optical orthogonal frequency division multiplexing (O-OFDM) transmitter for a bit rate of 12.1Gbit/s. On a Virtex 5 FX200T field programmable gate array (FPGA) the whole transmitter was enforced which is from Xilinx family. IDFT is the important unit of the transmitter and it requires to the highest signal processing hardware ways. Also inverse fast Fourier transform (IFFT) which is of 256-point radix-2 was designed [11].

In a Review on OFDM: Concept, Scope & its Applications paper Manushree Bhardwaj, ArunGangwar and DevendraSoni described about Orthogonal frequency division multiplexing (OFDM) which is a important case of multicarriertransmission and in which over a number of lower rate subcarriers the single Data Stream is transmitted. As the basis for a new 5-GHz standard purpose, a scope of data stream from 6 up to 54 Mbps to select OFDM is decided by the group of IEEE standardization in July 1998. To utilize the OFDM in packet-based communications this modern standard is the initial one. To achieve high throughput and good transmission quality the idea of parallel transmission of symbols is used in wireless communication. For parallel transmission the Orthogonal Frequency Division Multiplexing (OFDM) is one of the method. The concept of OFDM is to extend the total transmission bandwidth into a number of orthogonal subcarriers to transmit the symbols using these subcarriers in parallel. The idea of OFDM techniques, the duty of OFDM in this world, its advantages, disadvantages and application is discussed in this paper [12].

III. CONCLUSION AND FUTURE WORK

The 8 point FFT implementation in Orthogonal Frequency Division Multiplexing (OFDM) is proposed. In OFDM system, IFFT/FFT blocks are used to maintain orthogonalitybetween the successive channel sub-careers. Multi-carrier approach is used in regular frequency division multiplexing *i.e.* Guard bands are provided in between each channel, to avoid the interference. But in OFDM, overlapping carriers are used. For this purpose FFT and IFFT blocks are used. The conventional OFDM is implemented in FPGA. This project contributes the implementation of 8-point FFT using VHDL. The system is designed and simulated using XILINX ISE.

REFERENCES

1. Anurag Tiwari, SanketPhapal, DhirajKadam, Sivanantham S, Sivasankaran K, "FPGA Implementation of FFT Blocks for OFDM", IEEEOnline International Conference on Green Engineering and Technologies,pp.978-982, 2015.
2. Nilesh Chide, ShreyasDeshmukh, Prof.P.B.Borole, "Implementation of OFDM System using IFFT and FFT", International Journal of Engineering Research and Applications (IJERA), Vol.3, pp.2009-2013,2013.
3. E. Hari Krishna, K. Sivani, K. Ashoka Reddy, "Hardware Implementation of OFDM Transceiver using FPGA", IEEE International Conference on Computer and Computational Sciences (ICCCS), pp.3-7, 2015.
4. Shahid Abbas, Wagas Ali Khan, Talha Ali Khan, Saba Ahmmed, "OFDM based Transmitter Implementation Compliant IEEE Std 802.16d on FPGA", 17th Telecommunications forum TELFOR, pp.141-144, 2014.
5. Foisal Ahmed, Md. Liakot Ali, Mohammad Imam Hasan Bin Asad, "Design of a High speed OFDM Transmitter and Receiver", IEEE 8th International Conference on Electrical and Computer Engineering, pp.425-428, 2014.
6. Arun Kumar K A, "An OFDM Transmitter Implementation using Cordic based Partially Reconfigurable IFFT Module", IEEE3rd International Conference on Eco-friendly Computing and Communication Systems, pp.266-270,2014.

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ISSN (Print): 2320-9798

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7. Mujtaba Afzal, Dayal Sati, HeenaChoudhary, Ashish Vats, RomikaChoudhary, "Design, Modelling and Implementation of Variable FFT Processor", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5, pp.10774-10782, 2016.
8. K.Srinandhini and V.Vaithianathan, "FPGA Implementation of MIMO-OFDM Transceiver", IEEEInternational Conference on Communication and Signal Processing, pp.353-357, 2014.
9. Stephen B. Weinstein,"The History of Orthogonal Frequency Division Multiplexing", IEEE Communications Magazine, pp.28-35, 2009.
10. PawanVerma, Harpreet Kaur, Mandeep Singh, Balwinder Singh,"VHDL implementation of FFT/IFFT Blocks for OFDM",IEEE International Conference on Advances in Recent Technologies in Communication and Computing, pp.186-188,2009.
11. Michael Bernhard, Joachim Speidel," Implementation of an IFFT for an Optical OFDM Transmitter with 12.1 Gbit/s".
12. Manushree Bhardwaj, ArunGangwar, DevendraSoni,"A Review on OFDM: Concept, Scope & its Applications",Vol. 1, pp.07-11,2012.