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Synthesis of OFDM System on FPGA

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Abstract: OFDM is a multicarrier communication system and it is extensively used because of its immunity to frequency selective fading channels. The aim of this project is to design and implement an OFDM system on FPGA. The system is design using VHDL which is a high level synthesis tool. The design of OFDM system is realize on FPGA kit. FPGA implementation has a advantage to modify the changes and improve the system performance which rebuts a OFDM system which reduces the bit error rate and also reduces the LUT's in the VHDL code.

Keywords: Orthogonal frequency division multiplexing (OFDM) ,Field programmable gate array (FPGA), Intercarrier interference (ICI), Inter symbol interference (ISI).

I. INTRODUCTION

In recent digital communications, the reliability and efficiency of data transmission is the most concerning issue for communication channels. These days the wireless communication has included around two third of world population, which is almost linearly relational to development both in technical field with expansion in consumer stipulate. Wireless communication a quick rising innovation fascinated the users as well as the growing enormous businessperson, research followers and enthusiastic design engineers all around the world. As the demand of extraordinary quality service in next generation wireless communication systems, a high performance of data transmission needs an increase of spectrum efficiency and an development of error performance in wireless communication systems.

High data rate wireless communication has enhanced by a factor of minimum four while transferring from one generation to next generation. This technology is based on OFDM. Orthogonal Frequency Division Multiplexing is a multicarrier modulation technique that has advanced into a widespread scheme for wideband digital communication because of its proficiency to manage with severe channel conditions deprived of complex equalization filters.

OFDM works up to expectations by means of separating the radio waves into numerous smaller sub-signals and afterward transmit at the same time at distinctive frequencies to the recipient. OFD0M is a broadband multicarrier balance system that offers predominant execution and advantages over more established, supplementary customary single-bearer balance techniques on the grounds that it is a greater fit with today's high velocity information fundamentals and process in the UHF and microwave range. The main advantages of OFDM are its multipath delay spread resistance and operative spectral utilization by authorizing covering in the frequency domain. The channel execution may be extremely fluctuating over the subcarriers and fluctuates from symbol to symbol. In the event that the same transformed transmission plan is consumed for all OFDM subcarriers, the error possibility decreased slowly by growing SNR. In this manner, if there should be an occurrence of frequency selective fading the error probability diminishes gradually with expanding normal sign to noise ratio (SNR). Adaptive modulation scheme is used to evaluate the channel or link performance and power output in the RF link. By analyzing the channel condition and calculating the parameters channel bandwidth, modulation, antenna size, link configuration, diversity schemes, transmission power and more it becomes easy to take decision for better communication.

II. OFDM

OFDM technology is generally used in lots of high data-reception communication systems,such as digital audio broadcasting (DAB), power line communications (PLC), and satellite communication systems. In broadband wireless communication, the delay spread produced by channel multi-path fading will usually introduce serious ISI to the receiver.

Orthogonal Frequency Division Multiplexing or OFDM is a modulation format that is being used for many of the latest wireless and telecommunications standards. OFDM has been accepted in the Wi-Fi arena where the standards like 802.11a, 802.11ac, 802.11n and additional. It has also been selected for the cellular telecommunications standard LTE / LTE-A, and in adding to this it has been adopted by other standards such as WiMAX and many more. Orthogonal frequency division multiplexing has also been adopted for a number of broadcast standards from DAB Digital Radio to the Digital Video Broadcast standards. It has correspondingly accepted for other broadcast systems as well including Digital Radio Mondiale used for the extended medium and short wave bands. Though OFDM, orthogonal frequency division multiplexing is more complex than previous forms of signal format, it provides some different advantages in terms of data transmission, especially where high data rates are required along with relatively wide bandwidths.

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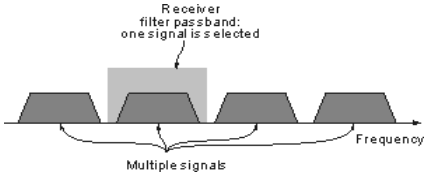

Fig.1Traditional view of receiving signals carrying modulation

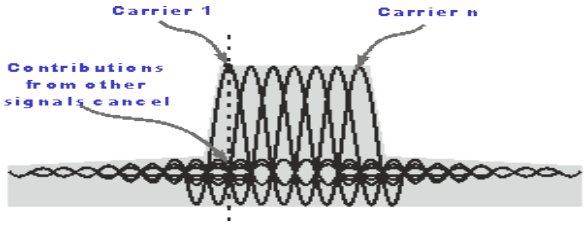

Fig.2 OFDM Spectrum

To respond the ISI, the high-efficiency OFDM modulations first breaches the high-rate data stream into a number of parallel sub-streams and modulates them into different orthogonal sub-carriers and thus slower the symbol rate, and then add a Cyclic Prefix (CP) to the head of each symbol to condense the influence of neighbouring symbol interference.

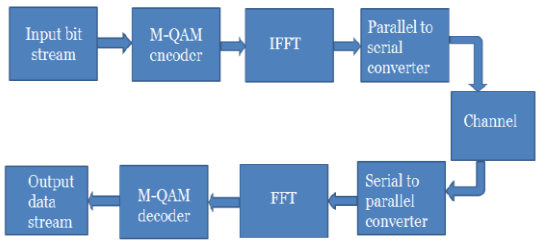

Fig.3 OFDM Structure

OFDM is a exceptional form of multicarrier modulation, where a single data stream is transmitted over a number of lower rate subcarriers. It should be declared that OFDM can be seen as either amodulation technique or a multiplexing technique.One of themain reasons of using OFDM is to increase the healthiness against frequency selective fading and narrowband interference.

In a single carrier system, a single disappear or interferer can cause the entire link to flop, but in a multicarrier system, only a small percentage of subcarriers will be affected. OFDM is computationally efficient using FFT technique to implement themodulation and demodulation functions, less sensitive to sample timing offsets than single carrier systems are, anddelivers good protection against co-channel interference and impulsive parasitic noise.

III. OFDM TRANSMITTER

The figure 2 shows the basic building block which plays an important role to made OFDM transmitter as shown below.

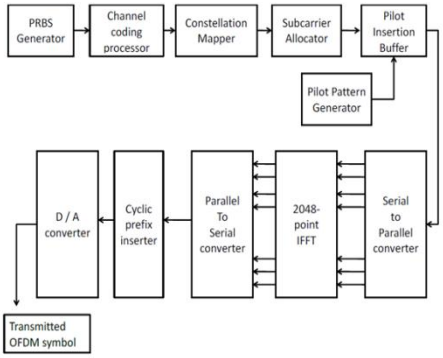

Fig.4 Block Diagram of OFDM Transmitter

A) PRBS Generator
The MAC layer provides an data which is to be transmitted by the transmitter in the PHY layer, pseudo random bit generator is used to create a serial random binary data, these binary data models the raw binary data which is to be transmitted or the data provided by the MAC layer .The serial binary data provided by the PRBS generator is feed to the transmitter.

B) Channel Coding Processor
The objective of channel coding is to map the incoming data signal into the channel input in such a way that the effect of channel noise is minimized and to provide mechanism of self-correcting errors at receiver without giving request to transmitter to retransmit the data. That is, the combine d role of channel coder and decoder is to provide reliable communication over noisy channel.

Fig.5 Block diagram of Channel Coding Processor

As shown in figure 3 the channel coder consist of scrambler, forward error correction and bit interleaver. Scrambler is used to eliminates long stream of 1`s and 0`s in the incoming data. Forward error correction is used for self-correcting errors at the receiver by adding redundant bit. Bit interleaver is used for eliminating unusual bits.

C) Data Modulation
There are four modulation scheme used in transmitter in that three modulation schemes, 16-OAM and 64-QAM are used for data modulation and BPSK is used for pilot modulation. Which modulation scheme has to be used on a particular data burst is depending on the channel condition, it will be informed to the transmitter by the MAC layer by modulation index. The output of the bit interleaver is entered serially to the constellation mapper. The input data to thecanstellation mapper is first distributed into groups of number of coded bits per carrier.

IV. SYNTHESIS AND SIMULATION RESULTS

Synthesis and simulation results are shown below in stepwise.

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A) PRBS Generator

The RTL view and simulation results for PRBS generator is shown in fig.6 and 7.

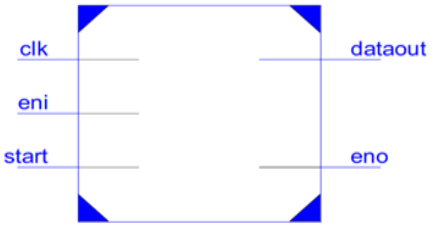

Fig.6RTL View of PRBS Generator

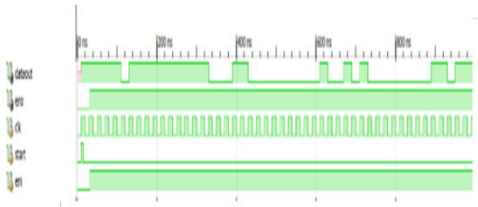

Fig.7 Simulation Result of PRBS Generator

B) Channel Coder

The RTL view and simulation results for Channel Coder are shown in fig.8 and 9.

Fig.8RTL View of Channel Coder

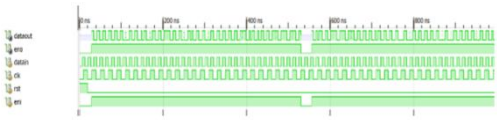

Fig.9 Simulation Result of Channel Coder

C) Constellation Mapper

The RTL view and simulation results for Constellation Mapper is shown in fig.10 and 11.

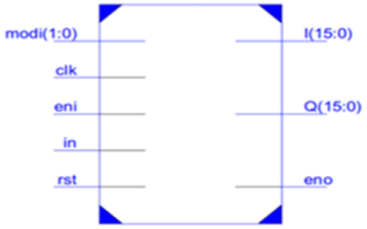

Fig.10RTL View of Constellation Mapper

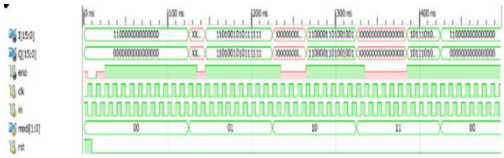

Fig.11 Simulation Result of Constellation Mapper

D) Pilot Generator

The RTL view and simulation results for Pilot generator are shown in fig.12 and 13.

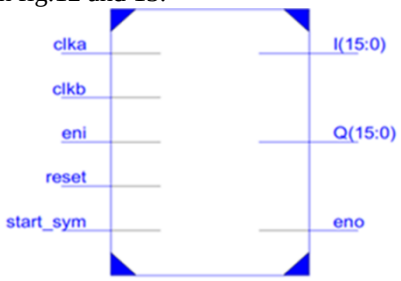

Fig.12RTL View of Pilot Generator

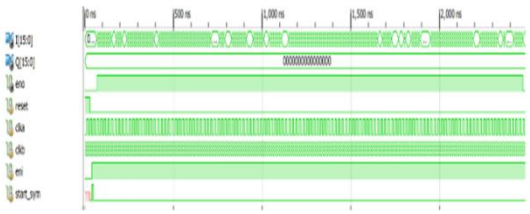

Fig.13 Simulation Result of Pilot Generator

V. CONCLUSION

OFDM is widely regarded as the key air interface technology for broadband wireless systems. Due to the inherent nature of the technology, OFDM signals an exhibit hardware requirement that challenges the designers. The diverse hardware requirements including processing speed, flexibility, integration and time-to-market necessitate an FPGA based implementation platform. This work presents the complete implementation of OFDM system and FPGA synthesis results of all of the major blocks in the OFDM system. Programming is done by VHDL in Xilinx ISE13.2i software.This subsequently builds the speed of transmission of information. OFDM systems are vigorous against inter symbol interference (ISI) and fading created by multipath engendering.

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