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Implementation of Orthogonal Frequency Division Multiplexing based on Discrete Wavelet Transforms in FPGA

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Abstract— This study describes the development of a Field Programmable Gate Array (FPGA)-based Orthogonal Frequency Division Multiplexing (WOFDM) transceiver (FPGA).Utilizing VHDL and XILINX ISE, a Wavelet transform-based Orthogonal Frequency Division Multiplexing (WOFDM) Transceiver Model is created. In order to test a wavelet transform-based orthogonal frequency division multiplexing (WOFDM) transceiver utilising Modelsim, random data was created using a linear-feedback shift register (LFSR).

Keywords: ***Wavelet transform, Orthogonal Frequency Division Multiplexing, VLSI, VHDL, FPGA, and LFSR***

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I. INTRODUCTION

OFDM is based on the idea of orthogonality. Orthogonality means that it creates orthogonal sub-carriers, avoiding cross-channel contact and eliminating the need for inter-carrier guard bands [1]. The Fast Fourier Transform technique is used in practise to create and detect OFDM signals [2]. Orthogonal frequency division multiplexing is more complicated than Fast Fourier Transformation (FFT) since it requires specialised hardware [3]. Existing wireless communication methods are based on Fourier transform mathematical concepts.The Fourier transform decomposes a signal into elementary waveforms called sines and cosines. The basic functions of the wavelet transform are time compact, but the Fourier sine and cosine functions are not [4].Wavelet transform basis functions are temporal and frequency localized and provide varied resolutions [5].Wavelet basis functions provide adaptability and flexibility that can be adjusted to meet the needs of wireless communication systems. More frequency resources are required in future wireless communication networks for improved communication. Wavelet transform-based systems can manage the interference between adjacent subcarriers in a variety of ways [6] [7].

II. IMPLEMENTATION OF DISCRETE WAVELET TRANSFORM (DWT) OFDM SYSTEM

TRANSFORMS (DWT) OFDM system was modeled with VHDL and built with FPGA. Below is a short description of the model.

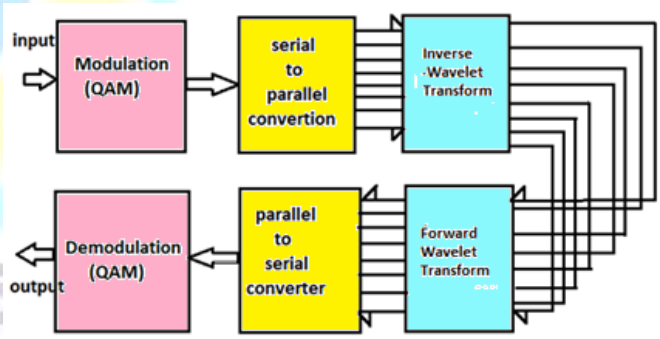

Figure 1 DISCRETE WAVELET

The configuration for a DWT OFDM transmitter and receiver is shown in Fig. 1. A lossless and reversible transform is the discrete wavelet transform. The forward and inverse wavelets transform equations are listed below.

A. Forward Discrete Wavelet transform

$$y(2n+1) = x(2n+1) - \left\lfloor \frac{x(2n) + x(2n+2)}{2} \right\rfloor \quad (1)$$

$$y(2n) = x(2n) + \left\lfloor \frac{y(2n-1) + y(2n+1) + 2}{4} \right\rfloor \quad (2)$$

B. Inverse Discrete Wavelet Transform:

$$x(2n) = y(2n) - \left\lfloor \frac{y(2n-1) + y(2n+1) + 2}{4} \right\rfloor \quad (3)$$

$$x(2n+1) = y(2n+1) + \left\lfloor \frac{x(2n) + x(2n+2)}{2} \right\rfloor \quad (4)$$

Figures 2 and 3 show the VLSI architecture of the wavelet transform.

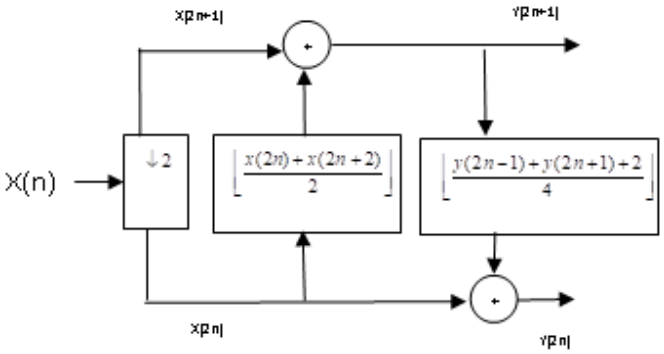

Fig. 2 Architecture of Discrete wavelet transforms

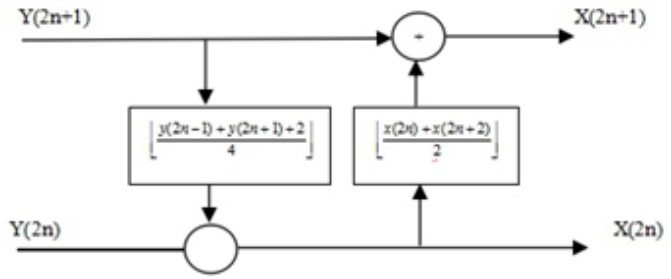

Fig. 3 Architecture of Inverse Discrete wavelet transforms

III. RESULT ANALYSIS

The Wavelet transform-based Orthogonal Frequency Division Multiplexing (WOFDM) transceiver model is created and implemented in VHDL using XILINX ISE. To test a wavelet transform-based orthogonal frequency division multiplexing (WOFDM) transceiver, random data was generated using a linear-feedback shift register (LFSR). MODELSIM is used to do test simulations. Table 1 shows the resource summary utilised to implement the discrete wavelet transform-based OFDM using FPGA and Xilinx ISE.

The development and implementation of a Wavelet transform-based Orthogonal Frequency Division Multiplexing (WOFDM) Transceiver model utilizing VHDL and XILINX ISE is completely described. In order to test a wavelet transform-based orthogonal frequency division multiplexing (WOFDM) transceiver, random data was generated with the help of a linear-feedback shift register (LFSR). MODELSIM is the platform on which test simulations are run. Table 1 displays a resource summary that was utilized in the process of implementing discrete wavelet transform-based OFDM using FPGA and Xilinx ISE.

Table1: FPGA Device (Kintex) utilization summary

SL.No.	Slice Logic Utilization	
1	Number of Slice LUTs	72453 out of 712000
2	Number of DSP48E1s:	40 out of 3360

Timing Summary: Maximum delay: 29.116ns

IV. CONCLUSIONS

In this research, an OFDM (WOFDM) transmitter and receiver based on discrete wavelet transforms is presented and implemented utilizing FPGA. On the transmitter side, there are three blocks: modulation, serial to parallel, and IDWT. On the receiver side, the DWT, parallel to serial converter, and demodulation blocks are implemented. These blocks have been tested with XILINX ISE and Modalism.

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