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Area Efficient LPF and HPF designing in DWT using MDA Technique and BK Adder

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Abstract: The DWT is expressed in a generalized form know as discrete wavelet transform which analyzes both the low and high sub bands with equal priority at every decomposition level. The DWT is a mathematical technique that provides a new method for signal processing. Due to various useful features like adaptive time-frequency window, lower aliasing distortion and efficient computational complexity, it is widely used in many signal and image processing applications. 2-D DWT is widely used in image and video compression. But flipping scheme introduces some design complexities in selected DWT structures. So in our proposed work, we have implemented BK adder and MDA technique that provides multiplier-less implementation and also will work for every bit. The proposed MDA and BK adder based 2-D DWT algorithm shows good performance as compared to previous algorithm. The proposed architecture for DWT implementation reduces the chip area, less computation time and also minimizes the maximum combinational path delay.

Index Terms – 2-D DWT, MDA, Low-pass Sub-band (LPSB), High-pass Sub-band (HPSB), VHDL Simulation

I. INTRODUCTION

In the field of engineering, digital signal processing techniques are selected according to the features present in the signal that is to be analyzed. The frequency and time-frequency based technique are the two major techniques used frequently for signal analysis. The frequency-based technique (FBT) is used to analyze a signal which is stationary, and for a non-stationary signal, time-frequency techniques (TFT) such as short time Fourier transform (STFT), wavelet transform, etc., are commonly used. The FBT provides energy information of the function in the frequency domain, but no details are obtained in the time domain. Whereas, the TFT extracts the transient features of a non-stationary signal such as the musical note or a vehicle noise and represent it in a time-frequency map for signal analysis [1, 2].

Over the years wavelet transform has emerged as a predominant tool for time-frequency decomposition of a signal. Wavelet is designed especially to study the non-stationary data, and due to its generality and accurate results, it has become useful in a number of areas. For a non-stationary signal, the frequency content at a particular point in time is different from the frequency content at another point, e.g., a sudden transient [3]. The Fourier transform is not able to specify accurately at what point in time the transient occurs because the Fourier bases are sinusoids that are infinite in extent and can give information only based on the entire duration of the signal. Hence, the Fourier bases are not able to localize the important events of the signal. On the contrary, wavelet has bases of finite duration, and this property enables it to identify and locate in time the important events in the signal which can be used to differentiate one signal from the other efficiently [4, 5].

Wavelet analysis allows researchers to isolate and manipulate the specific type of in formation hidden in the data, similar to the human ear picking the sound of the flute in a symphony. A diverse variety of wavelets can be used to analyze a signal, the type of wavelet to be used depends on the application. Wavelet is found in different branches from the signal analysis to the problems in engineering, physics, and mathematics. In the signal processing application, wavelet is mainly used in analyzing the non-stationary signals to provide the time-frequency information of an important transient [6]. In the bio-medical engineering, earth or ocean engineering the transient always carry a significant amount of information for the respective domain. The wavelet transform is found to be particularly useful for analyzing the signals that are considered to be aperiodic and noisy. The ability to analyze a signal distinctly both in time and frequency simultaneously has set wavelet transform apart from the STFT. Hence, wavelet transform is used to investigate a variety of physical phenomena such as climate change analysis, heart monitoring, seismic signal de-noising, astronomical image de-noising, video and image compression [7, 8].

II. DISCRETE WAVELET TRANSFORM

The history of DWT goes back to the year 1976 when a technique was invented by Croiser, Galand, and Esteban to decompose the discrete time signals. A similar kind of analysis on the speech signal was undertaken by Flanagan, Crochiere, and Weber in the same year. The technique was named as sub-band coding. In the year 1983, Burt defined a technique called the pyramidal coding similar to the sub-band coding also known as the multi-resolution analysis. The redundancy still existed in the pyramidal

coding scheme which could be eliminated. Vetterli and Le Gall improved the sub-band coding in the year 1989 by eliminating the redundancy in the pyramidal coding [9]. The DWT, when compared with the CWT is considerably easier to develop and implement. Although the CWT can be discretized and computed for DWT, the accurate discrete transform is not obtained. The information provided by this sampled version of the CWT is highly redundant. This redundant information on the contrary requires large amount of resources and computation time to analyze. Whereas, the DWT reduces the computation time and also extracts adequate useful information from the signal for analysis and synthesis. The DWT decomposes the input spectrum into two sub-bands, namely the high-pass subband and the low-pass sub-band. The input signal is filtered by a low-pass filter to obtain a low-pass sub-band, and filtering the input signal by a high-pass filter gives the high-pass sub-band [10]. The low-pass and high-pass filters are realized using a short length finite impulse response (FIR) filter. This pair of low-pass and high-pass filter form a quadrature mirror filter (QMF) for the perfect signal reconstruction. The computation of the DWT using lowpass and high-pass filters is performed either by the convolution scheme or lifting scheme [11].

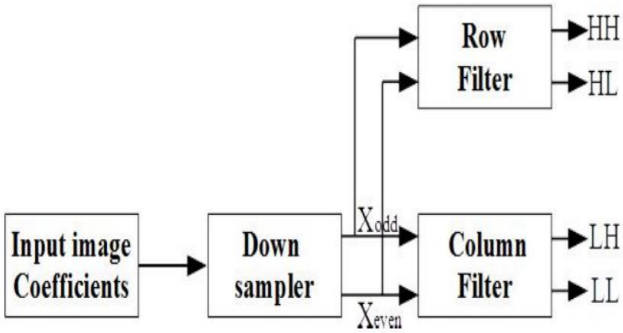

Figure 1: Two Level Diagram of Discrete Wavelet Transform

III. PROPOSED METHODOLOGY

In a digital system, particular attention is given to the performance of the system and cost. Effective performance is usually achieved at a higher cost. However, with a moderate increase in the hardware, better performance can be obtained. In the course of a computation, addition and multiplication are the fundamental operations that are performed frequently. The speed with which these operations are performed has a great impact on the overall performance of the digital system. Since the beginning of the digital computers, many fast algorithms for the basic arithmetic operations have been developed and implemented [12, 13].

There has been continuous research and development towards the newer algorithms. The main reason for the emerging algorithms is the rapid change in the technology used to implement these arithmetic operations. Besides the dependence on the technology used to implement the algorithm, it is the unique feature of the algorithm that affects the performance of the arithmetic operator [14].

In this stream graph, the double information is connected to the serial in serial out register. All whole numbers connected to the twofold frame in DWT design. Parallel information is relying upon the word length i.e. assume word length of the twofold info (3 down to 0) implies the information go is 0 to 15.

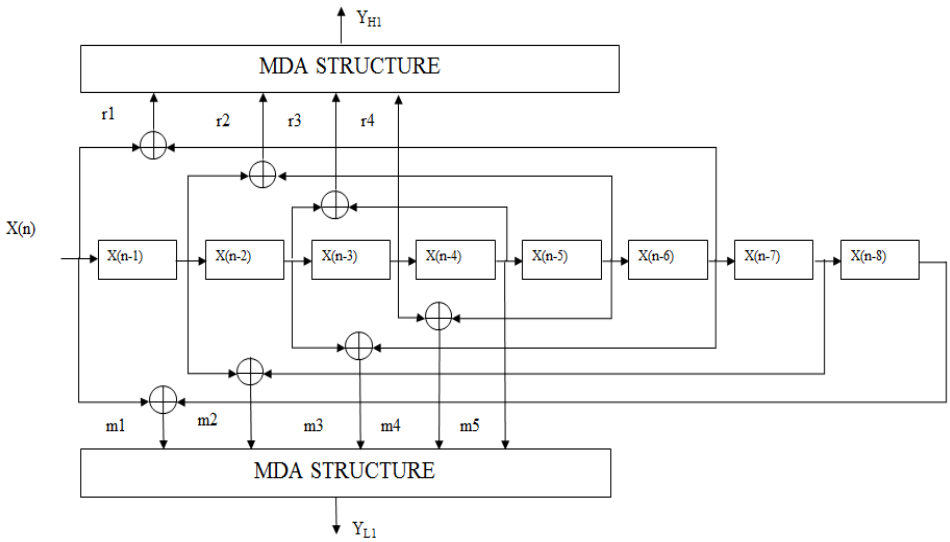

Figure 2: Block Diagram of 9/7 Wavelet Coefficient based Discrete Wavelet Transform

If takes the LPS coefficients h_0, h_1, h_2, h_3, and h_4 multiply by u_1, u_2, u_3, u_4 and u_5 then multiplier-less 1-D DWT LPS output is

$$Y_{LPS} = \begin{bmatrix} h_0 & h_1 & h_2 & h_3 & h_4 \end{bmatrix} \bullet \begin{bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \\ u_5 \end{bmatrix}$$

Where,

$u_1 = X(n) + X(n-8)$
$u_2 = X(n-1) + X(n-7)$
$u_3 = X(n-2) + X(n-6)$
$u_4 = X(n-3) + X(n-5)$
$u_5 = X(n-4)$

$$Y_{LPS} = \begin{bmatrix} 77 & 34 & -10 & -2 & 3 \end{bmatrix} \bullet \begin{bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \\ u_5 \end{bmatrix}$$

So,

$$Y_{LPS} = \begin{bmatrix} 01001101 & 00100010 & 11110110 & 11111110 & 00000011 \end{bmatrix} \bullet \begin{bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \\ u_5 \end{bmatrix}$$

All the LPS coefficient arranges down to up is below:

$$Y_H = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 \\ 0 & 1 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 & 0 \\ 1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 & 0 \end{bmatrix} \bullet \begin{bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \\ u_5 \end{bmatrix}$$

All rows pass through look up table and replace LPS coefficient to input

$$Y_H = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 \\ 0 & 1 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 & 0 \\ 1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 & 0 \end{bmatrix} \bullet \begin{bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \\ u_5 \end{bmatrix} = \begin{bmatrix} u_1 + u_5 \\ u_2 + u_3 + u_4 + u_5 \\ u_1 + u_3 + u_4 \\ u_1 + u_4 \\ u_3 + u_4 \\ u_2 + u_3 + u_4 \\ u_1 + u_3 + u_4 \\ u_3 + u_4 \end{bmatrix}$$

IV. BRENT KUNG ADDER

BK adders are efficient alternatives if the performance is important than the cost of implementation. However, the implementation cost can be reduced by the regularity of the design. The Ling adders are the variation of the BK adders. They achieve a significant hardware saving. The associated delays can be reduced by using a simple principle of the group generated carry signal. The new carry recurrence reduces the logic depth for the carry computation in the BK structures. Many recent works on the parallel prefix adder have presented the creation of Ling recurrence as the prefix computation to obtain a high-performance adder. The Ling adders in the prefix tree lead to the speed improvement than the existing high-performance fast adders.

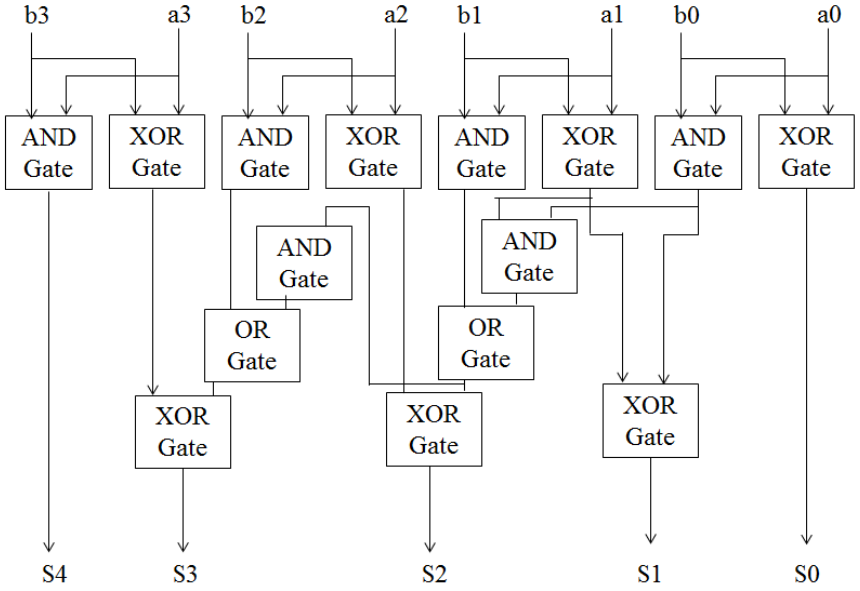

Figure 3: Block Diagram of Brent Kung Adder

V. SIMULATION RESULTS

Synthesis result of the 2-D DWT using MDA and BKA Technique is shown in this section.
In this section, it explains the view technology schematic (VTS), register transfer level (RTL) view, hardware utilization, synthesis utilization, VHDL test bench and comparison of 2-D DWT architecture for existing architecture. 2-D DWT architecture is consisted of shift registers, different bits of BK adder and multiplier-less MDA technique.

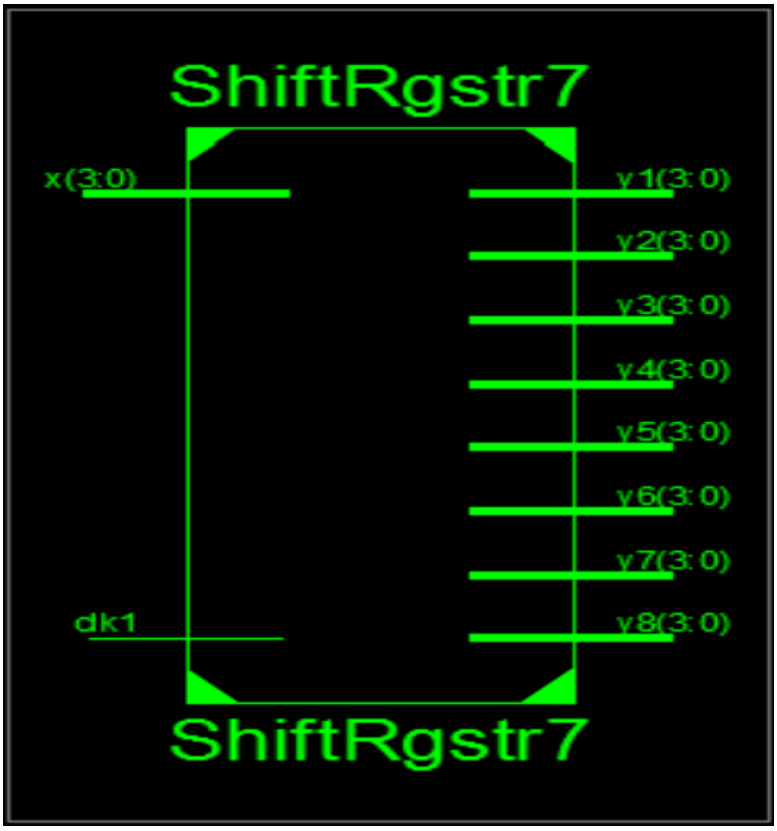

Figure 4: VTS for 4-bit SR

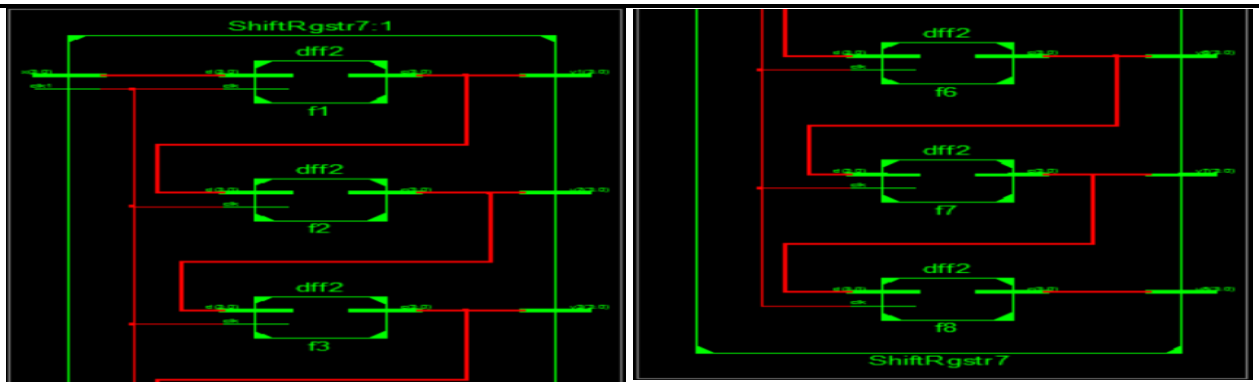

Figure 5: RTL for 4-bit SR

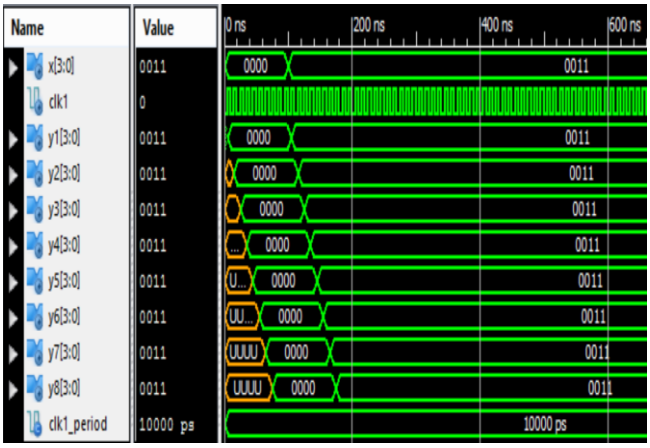

Figure 6: VHDL Test-bench in Shift Register

This figure 7 shows the RTL view of second level DWT. It has all the components of 2-D DWT. It contains all the shift registers, D-flip flops, BK adder. This RTL schematic depends on the view technology.

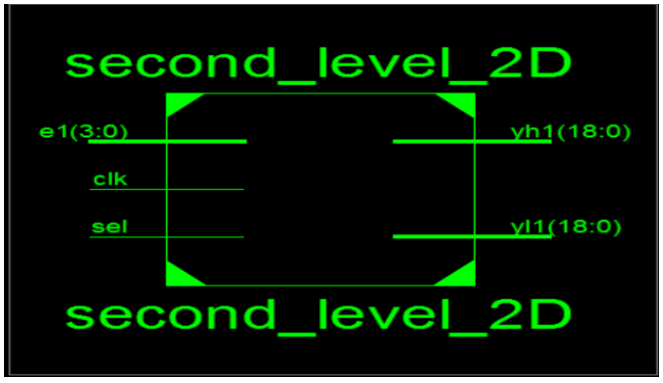

Figure 7: VTS for 2-D DWT

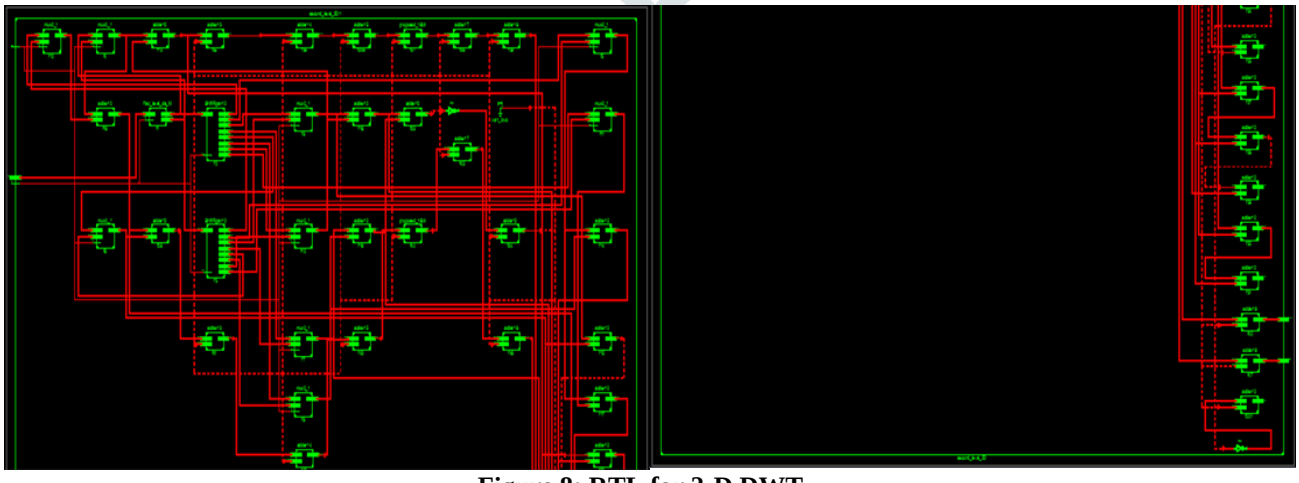

Figure 8: RTL for 2-D DWT

This figure 9 shows the waveform of the second level DWT. Here the input is given as '0011' and the output finally comes for both the filters. 'yh' is '1111101000000000000' for high pass filter output and 'yl' is '0000011000000000000' for low pass filter output.

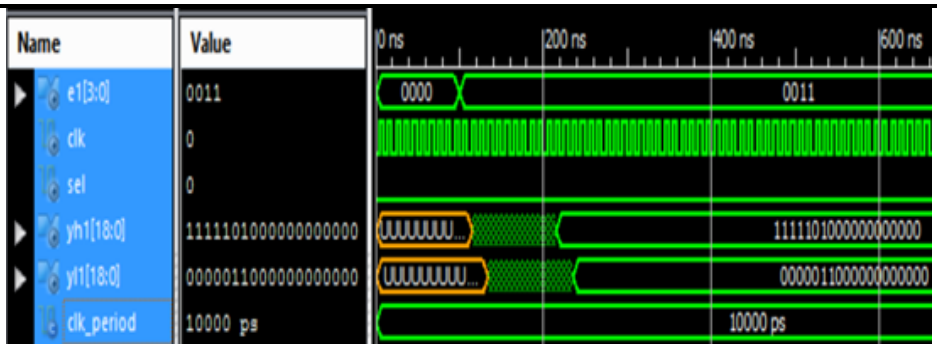

Figure 9: VHDL Test-bench in 2-D DWT

Table I: Hardware Utilization for 2-D DWT Architecture

Select Device	4vfx12sf363-12
Register	224
Flip Flop	224
XOR Gate	778
Memory	286452 Kilobytes
Real Time to XST	17.00 secs
CPU to XST	16.93 secs

VI. CONCLUSION

For this MDA technique is used which provides approach for multiplier less implementation. It contains adder, shift registers and free of multiplier. Finally we have designed the 1-D and 2-D DWT using BK adder and MDA technique which provide better efficiency and shows better results than the previous design. DWT has been an important technique of multimedia applications. This is not only the key algorithm of signal processing, but has also led to revolutions in image and video coding algorithms. There are many DWT architectures of flipping type, folded type and pipeline architecture for signal transform. Each structure has its own advantages and disadvantages. However, an efficient architecture design of DWT in JPEG 2000 is an important area of research to explore.

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