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VLSI Implementation of Wavelet Decomposition using QRS Complex Multiplier

Shekhar Kumar[1], Dr. Amrita Pahadia[2], Prof. Suresh. S. Gawande[3]
M. Tech. Scholar, Department of Electronics and Communication, Bhabha Engineering Research Institute, Bhopal[1]
Guide, Department of Electronics and Communication, Bhabha Engineering Research Institute, Bhopal[2]
Co-Guide, Department of Electronics and Communication, Bhabha Engineering Research Institute, Bhopal[3]

Abstract: The discrete wavelet transform (DWT) has established itself as an efficient method for processing a signal. Due to many useful characteristics like adaptive time-frequency window, efficient computational complexity, and low aliasing distortion, DWT is widely utilized in the applications such as real-time signal and image processing. DWT generally demands a lot of computation, and many of its applications are productive when operating in real-time. The plans vary with approbation to the competition and gear essential, the memory reacquired to provision the data picture, and widely appealing coefficients. The guideline focus of this investigation striving is to decide capable VLSI structures, for the gear use of the 9/7 and 5/3 DWT, using quality rating system (QRS) complex multiplier (CM) and improving the speed and hardware complicities of existing plans.

Index Terms – 1_D DWT, 2_D DWT, CM

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]. 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. 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 [2]. 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. 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 [3]. The development of very large scale integration (VLSI) technology has facilitated the designers to develop a low-power, cost-effective, and high-performance system on chip. The characteristics of the VLSI system are, they offer a substantial amount of concurrency, and the power dissipation within a small area is high. The global communication demands enormous amount of power [4]. Thus a high degree of parallel and pipeline processing is important for realization of a high-performance system for real-time operation. Therefore, discrete wavelet transform (DWT) is presently implemented in VLSI to fulfill the prerequisite of real-time processing.

II. CM

Structure of N×N CM is representing in fig. 1. R_r & R_i is first I/P, I_r & I_i is second I/P and O_r & O_i is O/P of CM. r and I represent by real and imaginary number.

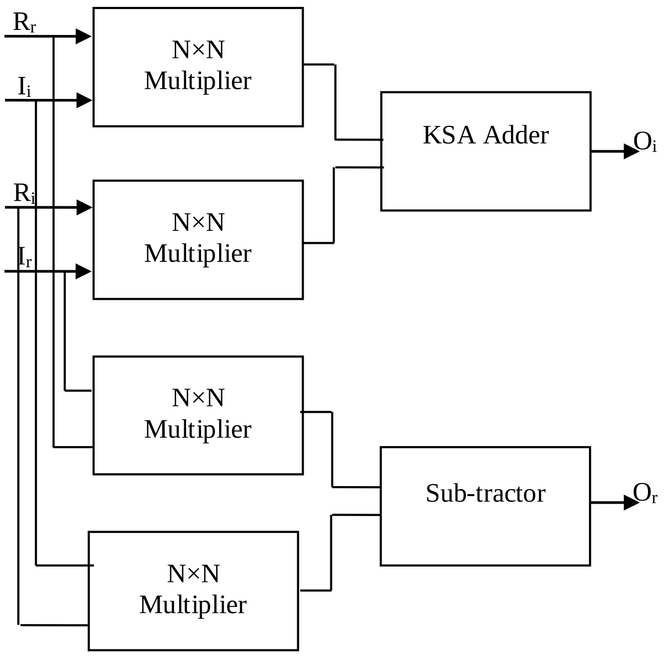

Fig. 1: Structure of N×N CM

CM is consists of four N×N multiplier and one KSA and sub-tractor. N is representing by number of bits. CM is the important role of the different types of field i.e. wireless and speech processing.

$$R = R_r + jR_i$$

$$I = I_r + jI_i$$

R multiplier I then

$$O = R \times I$$

$$O = R_r \times I_r - R_i \times I_i + j(R_r \times I_i + R_i \times I_r)$$

$$O_r = R_r \times I_r - R_i \times I_i$$

$$O_i = R_r \times I_i + R_i \times I_r$$

III. DWT

The resolution analysis limit and time-gradation district properties of the DWT has set up it as stunning resource for different applications, for instance, signal examination, picture pressure and numerical assessment, as communicated by Mallat. It is driven different exploration social occasions to make counts and gear models to execute the DWT.

In the standard convolution method for DWT, several Finite Impulse Response (FIR) aqueducts are applied in equal, to decide high_pass and low_pass aqueduct coefficients. Mallat's monolith estimation can be recycled to addresses the wavelet coefficients of an illustration in a couple of spatial headings. The plans are by and large crumbled, and can be completely requested into consecutive and equal structures as discussed [7]. The designing discussed executes aqueduct bank structure capably, using digit consecutive pipelining. This building structures the explanation behind the gear execution of sub band rot, using the conversational DWT for JPEG 2000. An accustomed plan in whichever DWT break down the information picture is showed up underneath in Fig. 2.

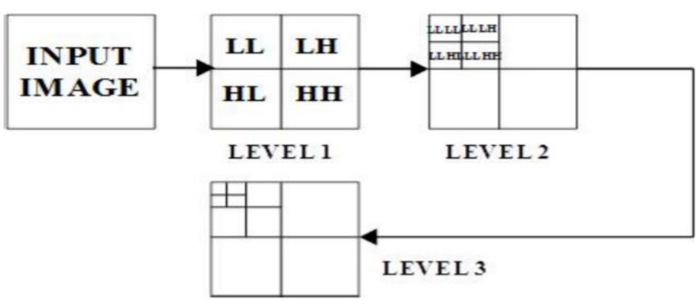

Fig. 2: 3-level DWT of an image

Each crumbling level showed up in Fig. 2 incorporates two stages arrange performs level isolating, and stage 2 operate vertical permeate. In the primary level rot, the breadths of the data picture are N by N size and dissociate four standby federate L_L, H_H, L_H and H_L. L is imitate by Low and H is imitate by high frequency. Four standby federate are N/2 by N/2 size. L_L standby federate more dossier compared to other standby federate by virtue of L standby federate is boilerplate value of pixel and H standby federate is difference value of pixel. H_H standby federate is fewer dossiers. Derived the all standby federate is below:

$$x_{LL}^{J}(n_1,n_2)=\sum_{i_1=0}^{K-1}\sum_{i_2=0}^{K-1}h(i_1)h(i_2)x_{LL}^{J-1}(2n_1-i_1)(2n_2-i_2)$$

$$x_{LH}^{J}(n_1,n_2)=\sum_{i_1=0}^{K-1}\sum_{i_2=0}^{K-1}h(i_1)g(i_2)x_{LL}^{J-1}(2n_1-i_1)(2n_2-i_2)$$

$$x_{HL}^{J}(n_1,n_2)=\sum_{i_1=0}^{K-1}\sum_{i_2=0}^{K-1}g(i_1)h(i_2)x_{LL}^{J-1}(2n_1-i_1)(2n_2-i_2)$$

$$x_{HH}^{J}(n_1,n_2)=\sum_{i_1=0}^{K-1}\sum_{i_2=0}^{K-1}g(i_1)g(i_2)x_{LL}^{J-1}(2n_1-i_1)(2n_2-i_2)$$

Position of X_{LL} is 2-D data picture, J is boilerplate by decompose, h & g is boilerplate by low and high pass distill coefficient.
Explanatory and iterative reproduction calculations are the two philosophies in PC tomography for the examination of picture quality. Explanatory model is one in which it endeavors to locate the immediate answer for the picture remaking from the obscure projections. Investigative calculation is constrained to fragmented projections and scanty in see. In iterative reproduction, Image gauge is dynamically refreshed towards an improved arrangement. To help the iterative picture reproduction calculation, numerous methodologies have been introduced in writing. Among these techniques, the projection based strategy is an proficient and a twisting less method.

IV. **PROPSOED METHODOLOGY**

In the DWT, the bi-balanced wavelets are realized by using the lifting strategy. The spatial territory and lifting system is used to create the lifting strategy. In the lifting plan, three guideline steps are generally played out that are, split, anticipate and update. The information picture tests x(n) are apportioned concerning the odd and even models in the split square. The channel is required for the odd and even guides to keep from the bothersome hailing. Lifting plan is performed by based kind of the channel.
Scaling step is used to find the low pass sub-gatherings of the odd and even tests. Channel utilization is changed into the growth cross sections in the lifting plan.
The image pressure is performed successfully by using the lifting plan, and the gear uses are significantly diminished by using the channels.
Inward item calculation can be communicated by complex multiplier. The DWT detailing utilizing convolution plot given in can be communicated by internal item, where the 1-D DWT definition surrendered (1) – (2) can't be communicated by inward item.
In spite of the fact that, convolution DWT requests number juggling assets than DWT, tortuousness DWT is speculate to ensnare the benefits of CM-based plan. CM definition of tortuousness based DWT utilizing 5/3 and 9/7 biological channel is introduced here.
As per (5) and (6), the 5/3 wavelet channel calculation in tortuousness structure is communicated as

$$Y_L=\sum_{i=0}^{4}h(i)X_n(i)$$

$$Y_H=\sum_{i=0}^{2}g(i)X_n(i)$$

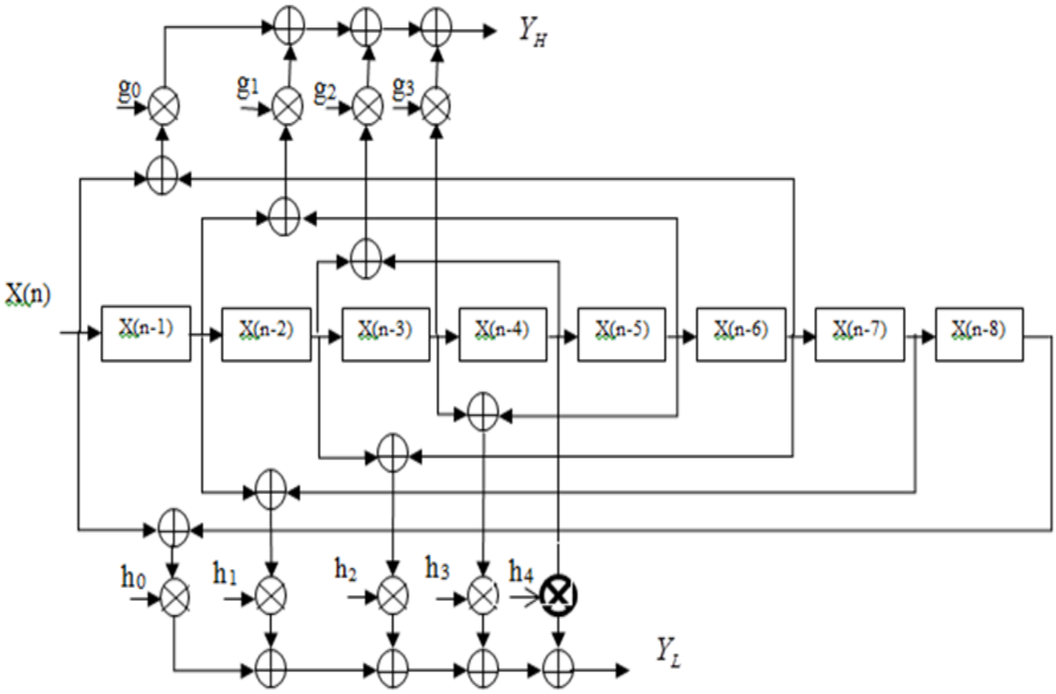

Fig. 3: Multiplier Based 9/7 Coefficient based 1-D DWT

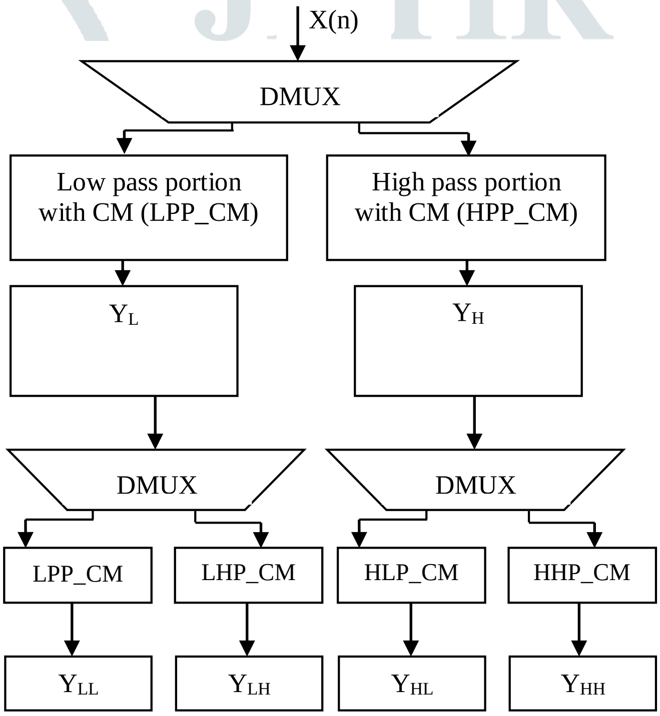

Fig. 4: 5/3 & 9/7 2-D DWT using CM Technique

Position of h(i) & g(i) is boilerplate by low and high pass distill 5/3 coefficient. Position of Y_L & Y_H is boilerplate by low and high pass distill O/P. Position I is varies between 0 to 4 for low distill and 0 to 2 for high distill.

V. SIMULATION RESULTS

CM based 5/3 & 9/7 2_D DWT is design Xilinx software with 14.2i version. Xilinx is work on two steps i.e. primary and secondary design. Primary design is defined on the I/O part of the systems and secondary part is defined the relation between I/O part. 5/3 1-D DWT are represents primary and secondary design in fig. 5 & fig. 6.

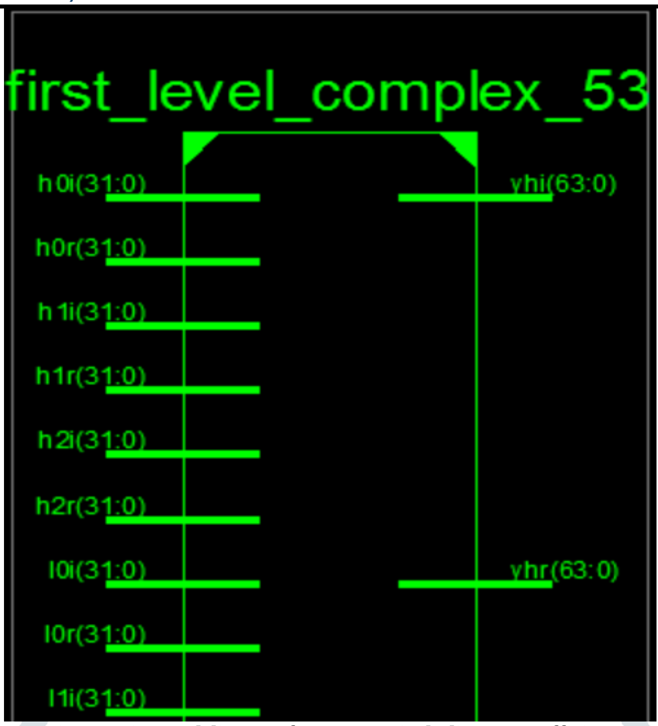

Fig. 5: Primary delineate of 1_D DWT including 5/3 coefficient

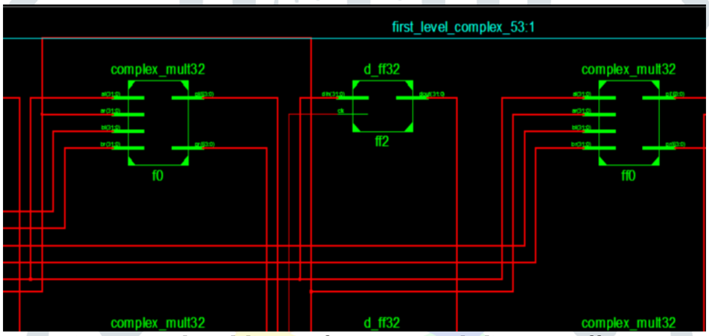

Fig. 6: Secondary delineate of 1_D DWT including 5/3 coefficient

9/7 1-D DWT are represents primary and secondary design in fig. 7 & fig. 8.

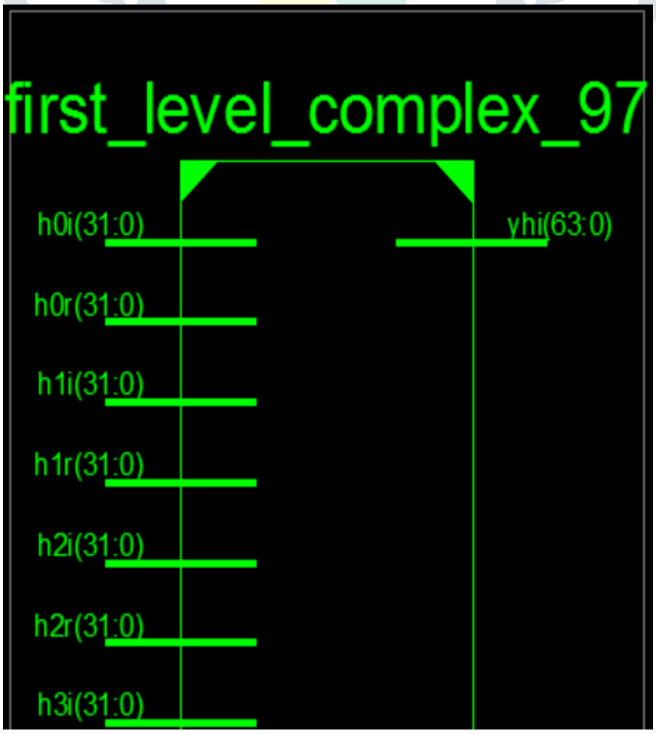

Fig. 7: Primary delineate of 1_D DWT including 9/7 coefficient

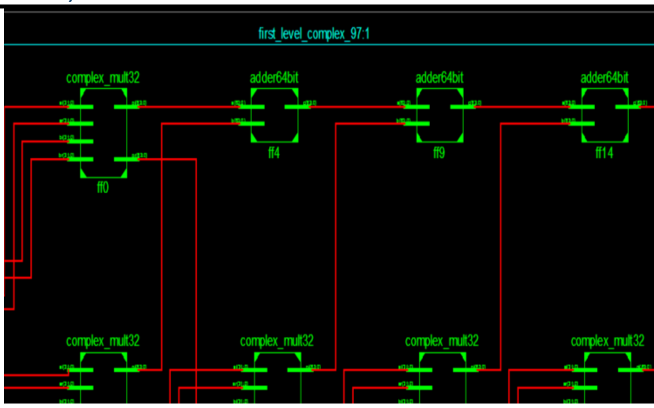

Fig. 8: Secondary delineate of 1_D DWT including 9/7 coefficient

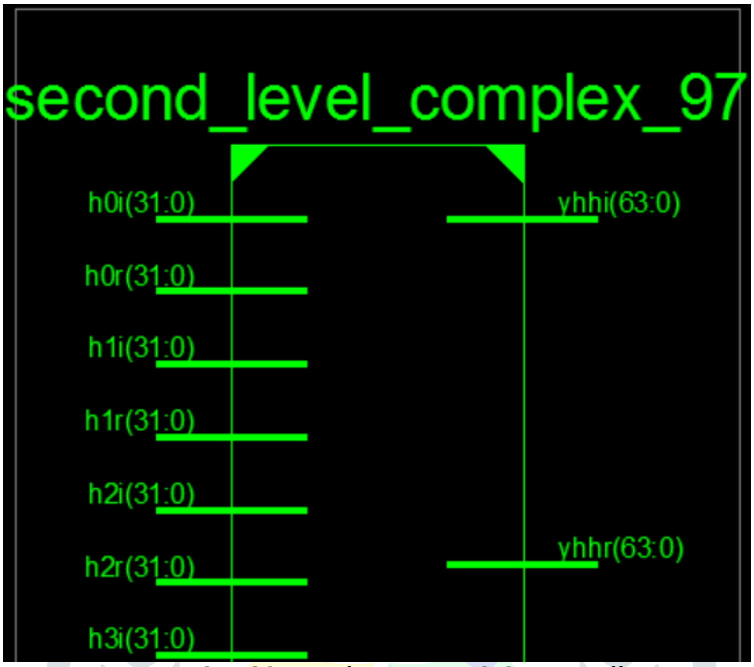

Fig. 9: Secondary delineate of 2_D DWT including 9/7 coefficient

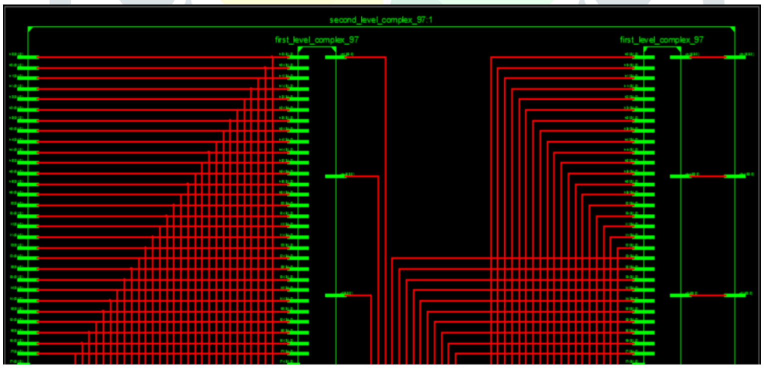

Fig. 10: Secondary delineate of 2_D DWT including 9/7 coefficient

Table 1: Comparison Result

Parameter	**2-D DWT**	
	Previous Design	Proposed Design
Number of Slice	830	768
Number of Slice Flip Flop	378	324
Number of LUTS	1347	899
Maximum Combinational Path Delay	9.95 ns	7.847 ns

VI. **CONCLUSION**

Currently, the VLSI signal processing community has taken a lot of interest in the wavelet transform based applications, for e.g., the compression technique based on the DWT is adopted in the JPEG-2000 and MPEG (Moving Picture Experts Group) standard. The DWT algorithms have become a standard tool for processing of signals and images in several areas in research and industry.

The 1-D DWT architecture for the 9/7 filter with two-input/ two-output uses twelve arithmetic resources, and twenty-two registers for its operation and the high-speed structure utilizes twenty-four arithmetic resources, and forty-four registers to store the intermediate data. The one-level 2-D DWT structure is proposed for the 9/7 and 5/3 filters with a throughput rate of two and four.

It is concluded that the CM based 2_D DWT provide best result compared to previous year. The compared result is based on delay, adder, frequency and net power.

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