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# Image Compression Algorithms Using VHDL Techniques

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**ABSTRACT**
This paper presents an image, in its original form, contains huge amount of data which demands not only large amount of memory requirements for its storage but also causes inconvenient transmission over limited bandwidth channel. It is performed in steps such as image transformation, quantization and entropy coding. JPEG is one of the most used image compression standard which uses discrete cosine transform (DCT) and DWT transform the image from spatial to frequency domain. An image contains low visual information in its high frequencies for which heavy quantization can be done in order to reduce the size in the transformed representation. Entropy coding follows to further reduce the redundancy in the transformed and quantized image data. The proposed research work is focused on the efficient hardware implementation of transform based image compression algorithms by optimizing the architecture of the system. Distribute arithmetic (DA) is an efficient approach to implement digital signal processing algorithms. DA is realized by two different ways, one through storage of pre-computed values in RAMs and another without RAM requirements. RAM free DA is more efficient. The programming of VHDL is complex but it is feasible for digital processing directly.
***Keywords***: Discrete wavelet transform (DWT), DCT, image compression, VLSI design, testbench.

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## I. INTRODUCTION

An image clinched alongside its unique representational carries enormous sum about information. Thus, it obliges extensive measure for memory for stockpiling [1]. Image compression will be a paramount range for image transforming which effectively removes the outwardly inconsequential information [2–8]. Compressed pictures need aid sent again set data transfer capacity channel for exactly extra transforming to hearty (error free) transmission [9–12]. Transform based image compression calculation is a most preferred choice which consists of image transform (in non-overlapping blocks), quantization of transformed coefficients and entropy coding . The greater part favored decision which comprises for picture convert (in non-overlapping blocks), quantization for converted coefficients Also entropy coding [13]. Joint photographic master gathering (JPEG) may be An council that standardizes those picture squeezing algorithm [14]. Those 8x8 block-wise two-dimensional discrete cosimo the senior convert (2-D DCT) is utilized Similarly as orthogonal convert to JPEG picture squeezing [15]. Image compacted by this standard are utilized Comprehensively.

This calculation gives those client on pick between measure from claiming layering and personal satisfaction as for every those prerequisite of the picture in distinctive provisions. The variable measure about layering makes this calculation low recurrence suitableness to those transmission reason for existing as client might alter those spot rate of the transmission as stated by channel limit. JPEG will be settled calculation and it need some adaptability that camwood make consolidated undoubtedly without At whatever significant transforms in the essential structural characteristic. JPEG framework camwood make executed clinched alongside product and in addition done equipment. Programming result is not guaranteeing for the requisitions requiring secondary pace. Therefore, continuous-handling may be finished through those committed fittings [19,20]. To custom fittings implementation, building design assumes a basic part to choosing area, energy Furthermore throughput of the configuration. Building design optimizations prompt bring down computational units (adders, multipliers), diminished memory size for capacity from claiming Brief variables Also more diminutive interconnects. Building design explorations with minimize those region Also force utilization will be An issue for compact units running for battery. Low silicon territory diminishes those cosset of the machine [21,22] and low force utilization builds the battery lifetime (time between recharges to chargeable battery) which thus diminishes the weight of the battery and Generally speaking extent [23]. 2-D DCT may be an intricate calculation What's more obliges secondary computations. Further, resulting phases clinched alongside change based picture squeezing

oblige helter skelter memory stockpiling alongside math circuits. For convenient devices, Hosting picture squeezing framework (like JPEG layering in computerized Polaroid [24–27]), minimal effort design, that could make attained Toward lessening silicon region may be Exceedingly obliged [28–31]. Toward effectively outlining those fittings architecture, picture squeezing might be performed for minimal effort and low force plan. Target about this paper may be on configuration picture examination utilizing DWT technique.

## II. IMAGE COMPRESSION TECHNIQUE:

Image of a natural scene need infinite level of brilliance Furthermore color force varieties. A piece from intensity, they need aid constant capacity On two dimensional space. On methodology those picture for Different requisitions Eventually Tom's perusing advanced processors alongside its capacity over memory, image information acquired starting with electronic picture sensors (CCD or CMOS) clinched alongside advanced camera, scanner alternately At whatever comparative gadget need aid changed over under advanced structure Toward A/D converter. Testing Furthermore quantization steps are utilized [1]. Those infinite force level levels of the picture need not with standing ended up advanced Hosting limited levels. Spatial continuity, itself continuously sampled by those altered focuses available on the sensor, is changed over should discrete. Constant image indicator (natural scene), now, may be a two dimensional advanced function, spoke to Eventually Tom's perusing f(x, y), the place the extent about capacity f speaks to the power starting with "around limited levels from claiming intensities In any side of the point (x, y) in the space. Those coordinate (x, y) may be discrete Similarly as shown in fig. 2. 1.

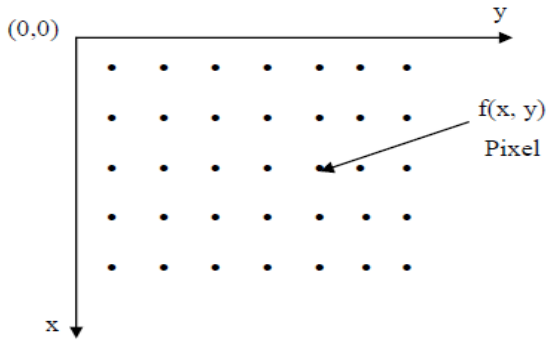



Fig.1. Representation of digital image in two dimensional spatial coordinate

In digital representation, the magnitude of intensity is represented by a fixed number of bits for the entire pixels. Classification of image on the basis of the number of bits used for representing each of its pixel value is as follows [72] (a) Bi-level image Each pixel will have one bit (binary) value, representing black and white. Textual information can be represented by the bi-level image. (b) Grayscale image This is a most common type of image used in many applications. A grayscale image represents the 2n shades of a gray, where n is the number of bits representing each pixel. The 8-bits (one byte) representation is most preferred and used for display in computer monitor and printing purpose as well. In 8-bit representation there are 256 shades of gray (or intensities) between black and white. (c) Continuous-tone image In a continuous-tone image there are many shades of a color (or gray). In other words, one pixel has many intensity levels such that nearby pixel intensity, though it differs by one unit intensity level, appears same to the eyes. Images obtained from the digital cameras and scanners are example of continuous-tone image. Color image is represented by 24-bits pixel value in three color component planes R (red), G (green) and B (blue) with 8-bits allocated for intensities of each color.

### 2.1 Image Compression Model

Image compression reduces the amount of data from the original image representation. There are two approaches to compress an image. These are: (a) Lossless compression (b) Lossy compression.

Fig.2.2 shows a general image compression model. Image data representation has redundancy (also called pixel correlation, interpixel redundancy or spatial redundancy), in the sense, a pixel value can be predicted by its neighborhood pixels [1, 76]. Decorrelation process removes the spatial redundancy and hence, facilitates compression. Some of the techniques used for this process are predictive coding, transform coding and subband coding [76]. Apart from the interpixel redundancy, there is statistical redundancy present in the data after de-correlation (not only image but any data possess statistical redundancy). This is removed by entropy encoding process where more probable symbol is assigned less number of bits and vice-versa (also called variable length encoding). Huffman coding and arithmetic coding are two important techniques used for entropy encoding of data. Although, arithmetic encoding gives slightly

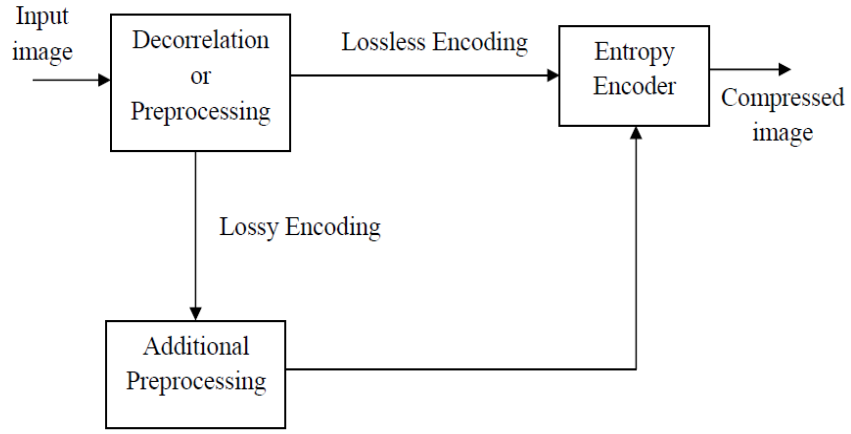



**Fig. A** generalized image compression model

More compression than the Huffman encoding, it is a more complex and computation intensive. Therefore, Huffman coding is preferred choice in hardware implementation of entropy coding. In case of lossless compression, images undergo entropy encoding directly after de-correlation, whereas lossy compression require additional preprocessing stage called quantization before it is encoded by entropy process. Quantization is irreversible process and it is the only lossy stage in image compression model.

**2.2 Transform based Image Coding**

Transform based image coding is most preferred and widely used lossy image compression (coding) method. Fig.2.3 shows the block diagram of transformed based image compression coding technique. The purpose of the transform is to remove interpixel redundancy (or de-correlate) from the original image representation. The image data is transformed to a new representation where average values of transformed data are smaller than the original form. This way the compression is achieved. The higher the correlation among the image pixels, the better is the compression ratio achieved. An image transform should have the following properties.

(a) Inverse transformation should exist
(b) De-correlate the original image data
(c) Clear separation of frequency

Inverse transformation is a pre-requisite requirement in any transform because transformed data should be re-constructed for image formation by inverse process (decompression). Orthogonal transform (like DCT, DHT, DWT, etc.) is used for this purpose. A de-correlation property makes the transformed data independent from each other. In lossy image compression, some coefficients are quantized to zero or altered to a new smaller value.

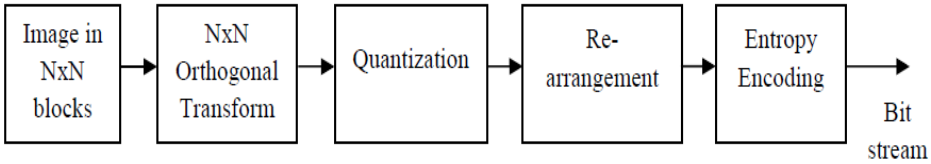



Fig. Transform based image compression model

## III. DISCRETE WAVELET TRANSFORM (DWT):

The wavelet change has been broadly utilized as a part of the utilization of image processing and a few different applications. Compression, signal analysis and signal processing have been a portion of the applications made practical in this field of study in the previous couple of decades. Despite the fact that a long way from finish, attempt to present couple of fundamental ideas of the DWT for the purpose of this dissertation. A discrete wavelet transform (DWT) is any wavelet transform for which the wavelets are discretely tested. Likewise with other wavelet transforms, a key advantage it has over Fourier transforms is temporal resolution. It captures both frequency and location information (location in time).

To comprehend the fundamental thought of the DWT concentrate on one dimensional signal. A signal is split into two parts, normally high frequencies and low frequencies [12]. The edge segments of the signal are largely limited into low frequencies. The edge segments of the signal are bigger in the high frequency part. The low frequency part is additionally part into two sections of high and low frequency(analysis). This procedure is proceeded until the signal has been altogether decomposed or stopped before by the user Besides, from the DWT coefficients, the original signal can be changed. The reconstruction process(synthesis) is known as the inverse DWT (IDWT). For some signals, the substance in low-frequency is the most critical part. It is that gives the signal its personality. The high-frequency components, on the other side, gives flavor or subtlety. Consider the human voice.

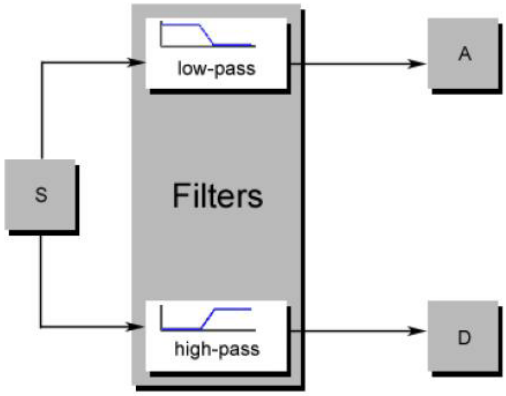



**Fig :** Filtering or decomposition process at its most basic level

The original signal, S, goes through two complementary filters and rises as two signals. Really do this operation on a real digital signal, finally entire with two fold the amount of data as began. Assume, for instance, that the original signal S involve 1000 samples of information. At that point the subsequent signals will have every 1000 samples, for a sum of 2000. These signals A and D are fascinating, however get 2000 esteems initially it was 1000. There exists a more pleasant approach to perform the decomposition using wavelets. By looking all the more deliberately at the computation, keep just a single point out of two in each of the two 2000-length samples to get the entire data. This is the concept of down sampling. Create two sequences called cA and cD.

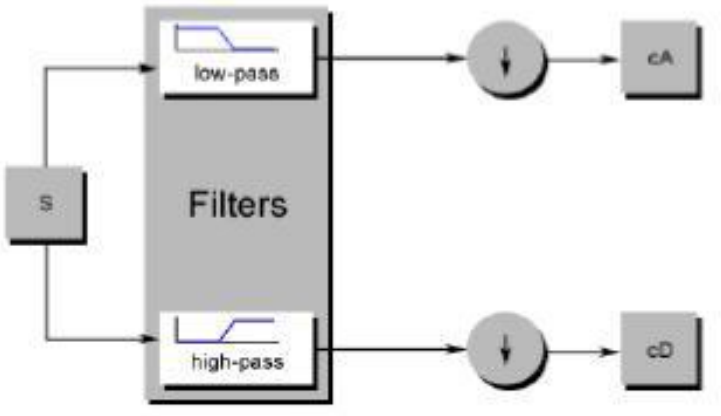



**Fig. 3.3:** Analysis with down sampling

The decomposition or analysis process with down sampling produces DWT coefficients. This sort of two-dimensional DWT prompts to a decomposition of approximation coefficients at level j in four components the approximation at level j +1, and subtle elements in three different orientations (horizontal, vertical, and diagonal).

## IV. SIMULATION RESULTS

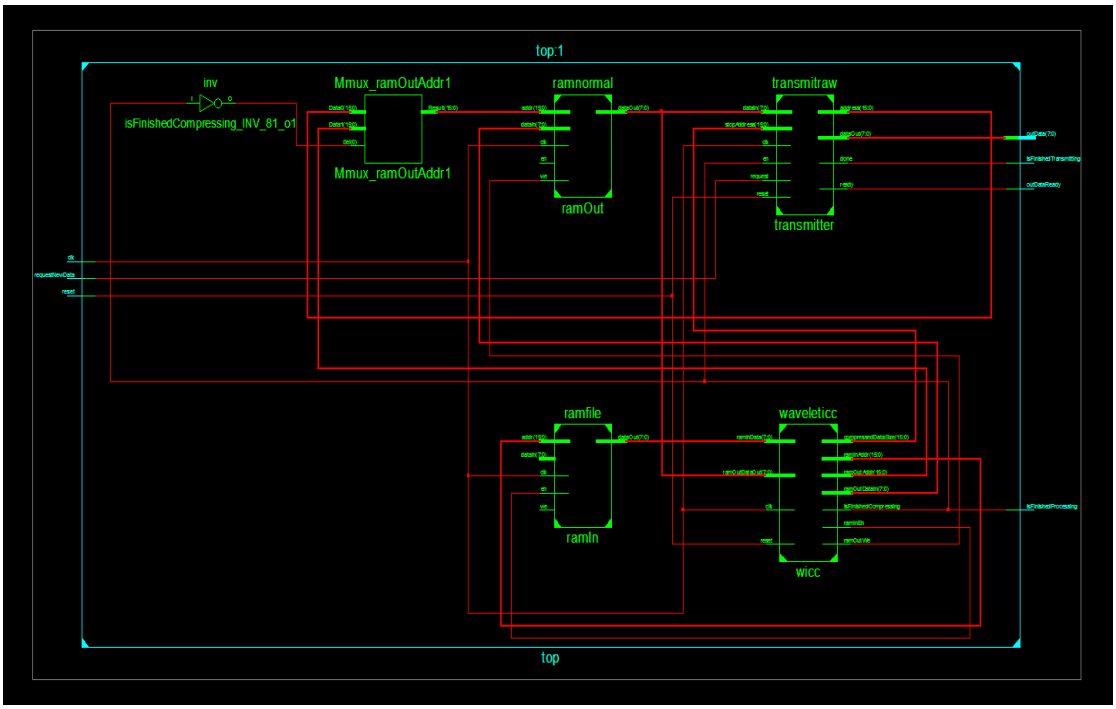
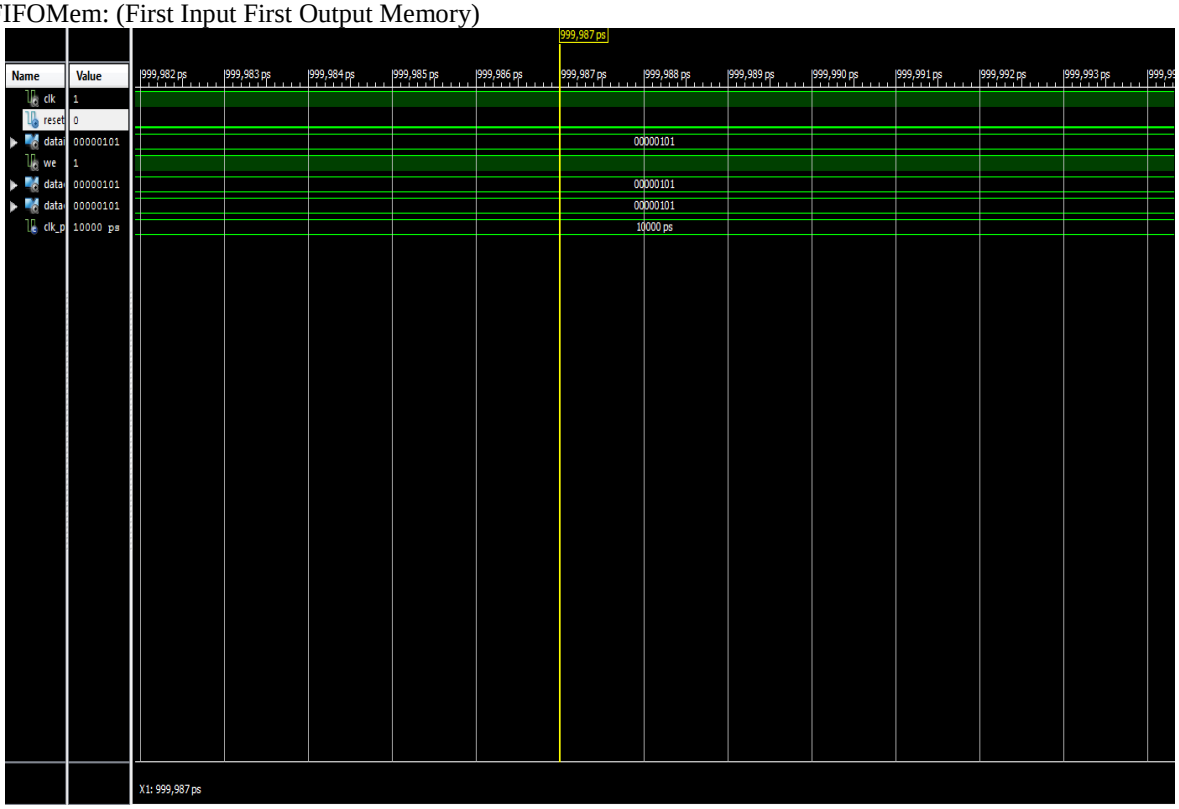
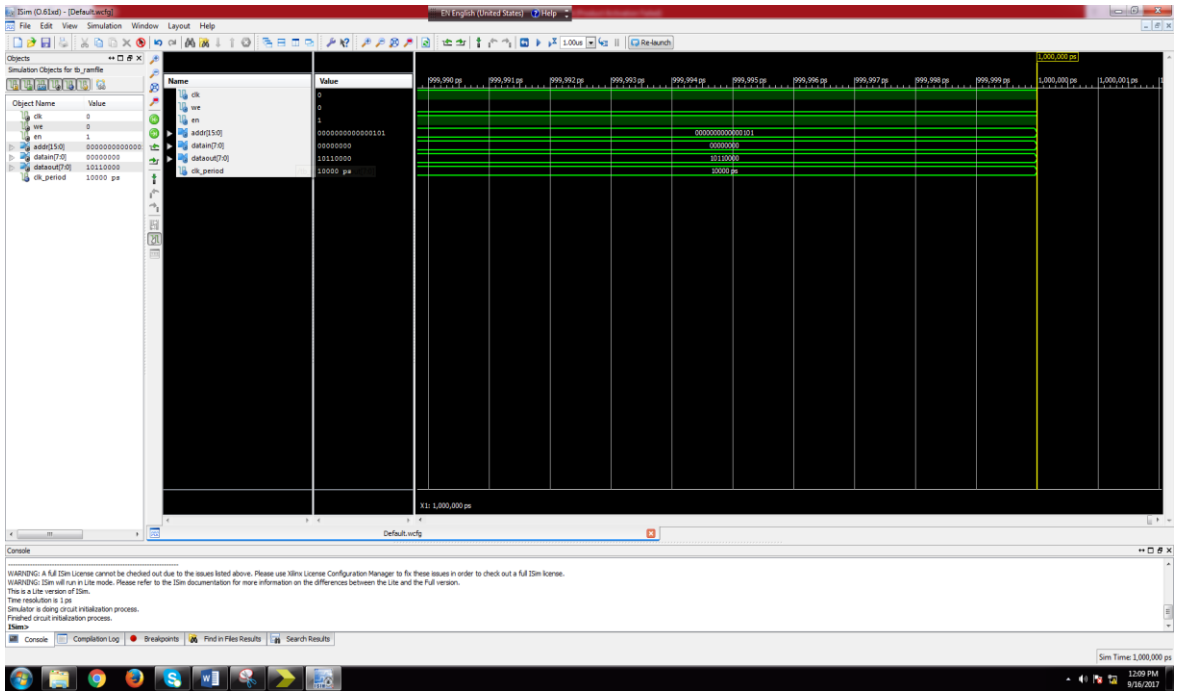



Fig. RTL Schematic View of Image compression using DWT technique

ModelSim Simulator Results:
FIFOMem: (First Input First Output Memory)



RAM File:



## V. CONCLUSION

This paper impliments those VLSI structural engineering about image compression configuration using VHDL. The conclusions starting with those research paper introduced regulate non-recursive calculation approach is the the vast majority suitableness outline to equipment usage At helter skelter picture nature may be obliged In low expense equipment. Those quantized What's more zig-zag requested coefficients gotten through thisnon-recursive structural engineering totally removes those intermediate phases similar to memory to storing quantization table Also DCT coefficients during diverse phases bringing about low expense picture squeezing building design. For the provisions requiring just DCT coefficients with helter skelter throughput, recommended proficient ram da built 1-D DCT meandering might a chance to be utilized which need low region and low control utilization over those accepted ram nothing da. Those altered quantization table suitableness to equipment rearrangements need those same. Execution As far as PSNR as default you quit offering on that one Gave by JPEG. However, it need no capacity prerequisite over memory and FSM based outline approach prompts memory diminishment over stockpiling from claiming DCT coefficients to zig-zag requesting What's more quantization. Those Huffman coding construction modeling need been actualized with those decreased memory for the stockpiling from claiming Huffman code tables Furthermore it encodes the coefficients bit-by-bit at each clock cycle bringing about efficient design .

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