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VLSI Implementation of High Speed DSP algorithms using Vedic Mathematics

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Abstract- **This paper is devoted for the design of various NxN multipliers, which uses Vedic Mathematics algorithms. For arithmetic multiplications, various Vedic multiplication techniques like Urdhva Tiryagbhyam, Nikhilam and Anurupye has been thoroughly analysed. It has been found that Urdhva Tiryagbhyam Sutra is most efficient Sutra (algorithm), giving minimum delay for multiplication of all types of numbers.Using Urdhva Tiryagbhyam, various NxN multipliers have been designed and using these multipliers, cube algorithm, linear convolution and single precision floating point multiplication have been designed. Logic verification of these designs has been done by using Modelsim 6.4a.Timing and power analysis has been done using QuartusII 9.0.**

Keywords-Vedic Mathematics, Urdhva Triyakbhyam Sutra,Nikhilam algorithm

I. INTRODUCTION

A.Vedic Mathematics

Vedic mathematics - a gift given to this world by the ancient sages of India. A system which is far simpler and more enjoyable than modern mathematics. The simplicity of Vedic Mathematics means that calculations can be carried out mentally though the methods can also be written down.There are many advantages in using a flexible, mental system. Pupils can invent their own methods, they are not limited to one method. This leads to more creative, interested and intelligent pupils. Vedic Mathematics refers to the technique of Calculations based on a set of 16 Sutras, or aphorisms, as algorithms and their upa-sutras or corollaries derived from these Sutras. Any mathematical problems (algebra, arithmetic, geometry or trigonometry) can be solved mentally with these sutras. Vedic Mathematics is more coherent than modern mathematics.Vedic Mathematics offers a fresh and highly efficient approach to mathematics covering a wide range - starts with elementary multiplication and concludes with a relatively advanced topic, the solution of non-linear partial differential equations. But the Vedic scheme is not simply a collection of rapid methods; it is a system, a unified approach. Vedic Mathematics extensively exploits the properties of numbers in every practical application.

II. VEDIC FORMULA

A.Vedic Sutras

The word 'Vedic' is derived from the word 'veda' which means the store-house of all knowledge. Vedic mathematics is mainly based on 16 Sutras (or aphorisms) dealing with various branches of mathematics like arithmetic,algebra, geometry etc.These Sutras along with their brief meanings are enlisted below alphabetically.

1) *(Anurupye) Shunyamanyat – If one is in ratio, the other is zero*
2) *Chalana-Kalanabyham – Differences and Similarities.*
3) *Ekadhikina Purvena – By one more than the previousone*
4) *Ekanyunena Purvena – By one less than the previous one*
5) *Gunakasamuchyah – The factors of the sum is equal to the sum of the factors*
6) *Gunitasamuchyah – The product of the sum is equal to the sum of the product*
7) *Nikhilam Navatashcaramam Dashatah – All from 9 and the last from 10*
8) *Paraavartya Yojayet – Transpose and adjust.*
9) *Puranapuranabyham – By the completion or noncompletion*
10) *Sankalana-vyavakalanabhyam – By addition and by subtraction*
11) *Shesanyankena Charamena – The remainders by the last digit*
12) *Shunyam Saamyasamuccaye – When the sum is thesame that sum is zero*
13) *Sopaantyadvayamantyam – The ultimate and twice*

14) *Urdhva-tiryakbyham – Vertically and crosswise*
15) *Vyashtisamanstih – Part and Whole*
16) *Yaavadunam – Whatever the extent of its deficiency*

III. PROPOSED TECHNIQUE

A.Urdhva Tiryagbhyam

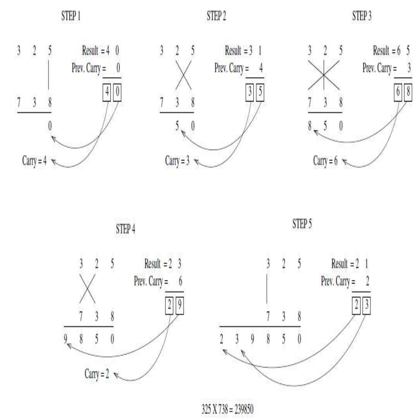

Figure 1. Method of Urdhva Tiryagbhyam

The basic sutras and upa sutras in the Vedic Mathematics helps to do almost all the numeric computations in easy and fast manner. The sutra which we employ in this project is Urdhva Tiryagbhyam (Multiplication).

B. Nikhilam Sutra

Nikhilam Sutra literally means “all from 9 and last from 10”. Although it is applicable to all cases of multiplication, it is more efficient when the numbers involved are large. It finds out the compliment of the large number from its nearest base to perform the multiplication operation on it, hence larger the original number, lesser the complexity of the multiplication. We first illustrate this Sutra by considering the multiplication of two decimal numbers (96 × 93) where the chosen base is 100 which is nearest to and greater than both these two number.

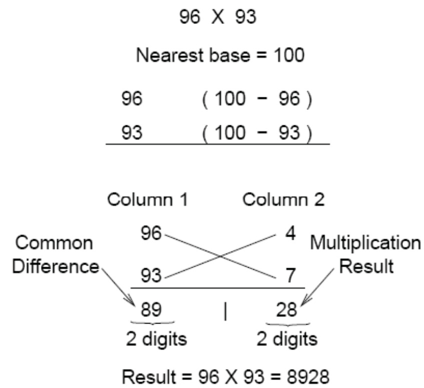

Figure 2. method of nikhilam sutra

As shown in Fig, we write the multiplier and the multiplicand in two rows followed by the differences of each of them from the chosen base, i.e., their compliments. We can now write two columns of numbers, one consisting of the numbers to be multiplied (Column 1) and the other consisting of their compliments (Column 2). The product also consists of two parts which are demarcated by a vertical line for the purpose of illustration. The right hand side (RHS) of the product can be obtained by simply multiplying the numbers of the Column 2 (7×4 = 28). The left hand side (LHS) of the product can be found by cross subtracting the second number of Column 2 from the first number of Column 1 or vice versa, i.e., 96 - 7 = 89 or 93 - 4 = 89. The final result is obtained by concatenating RHS and LHS (Answer = 8928).

IV. SINGLE PRECISION FLOATING POINT MULTIPLICATION

The single precision floating point algorithm is divided into three main parts corresponding to the three parts of the single precision format. The first part of the product which is the sign is determined by an exclusive OR function of the two input signs. The exponent of the product which is the second part is calculated by adding the two input exponents.The third part which is the significand of the product is determined by multiplying the two input significands each with a “1” concatenated to it.,as shown in Fig 3.

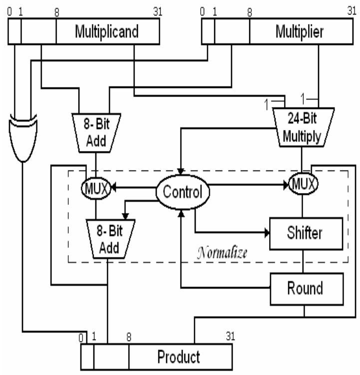

Figure 3: Single Precision Floating Point Multiplication Architecture.

V.VERIFICATION AND IMPLEMENTATION

Modelsim 6.4a has been used for simulation.Quartus II 9.0 has been used for timing and power analysis.

VI. RESULT

Thus,Vedic multiplication methods reduce the area and speed up the computation.It reduces the area by using less number of logic elements and speeds up the computation by using short-cut methods.Table 1.shows the results obtained.

TABLE 1. LOGIC ELEMENTS AND EXECUTION TIME FOR VARIOUS COMPUTATIONS

	Logic Elements Used	Execution Time
Vedic 4x4 Multiplier	26	11.994ns
Vedic 8x8 Multiplier	126	20.751ns
Vedic 16x16 Multiplier	546	20.952ns
Vedic 32x32 Multiplier	2266	29.587ns
Cube	52	12.845ns
Linear Convolution	2172	22.680ns
Single Precision Floating Point Multiplication	2007	20.438ns

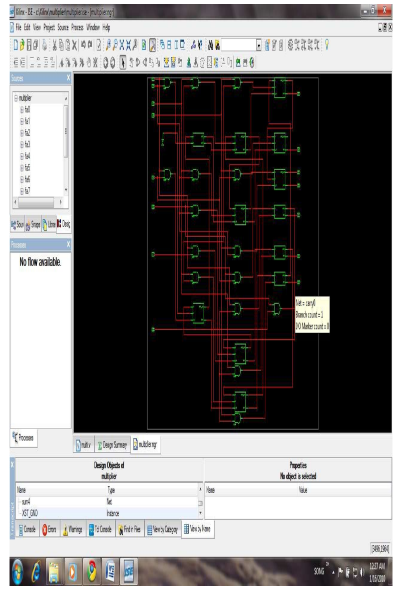

Figure 4. multiplication by normal method

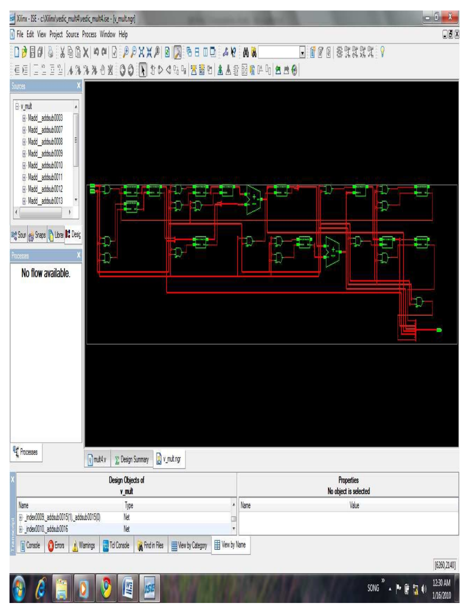

Figure 5. multiplication by vedic method

VII. CONCLUSION

Thus,Vedic multiplication methods use less logic elements and speed up the computations.And by using these multipliers,various algorithms shown in the table are designed

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