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THE APPLICATION OF VEDIC MATHEMATICS FOR HIGH SPEED MULTIPLIER IN FIR FILTER DESIGN

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Abstract— The application of high speed multiplication plays vital role in the Digital Signal Processors. The method of implementation of High speed multiplier is of great concern. The modern multipliers process a drawback of speed in their multiplier design. The mode of multiplication operation takes more time as the the number of implicates increases. Thus designing a processor for High speed multiplication is of great concern. Finite Impulse Response filters normally called as a convolution filter includes a multiplier in it. Both FIR and IIR filters can be designed using the Vedic method. For the fast computation of signals Vedic Mathematics is used. Urdhwa Tiryagyam is one sutra among 16 sutras. It increase the speed compared to conventional method. The time comparison is done between Vedic method and conventional method in MATLAB Domain. The computation time taken by Vedic method is compared with the inbuilt function MATLAB. Later, the computation time is implemented by using Graphical User Interface (GUI).GUI is a tool in Matlab and it acts as a mode of interaction between the user and the system. The results show that the Urdhwa Tiryagbyam sutra reduces the execution time as compared to the inbuilt function of MATLAB.

Keywords— FIR, IIR, GUI, DSP, Urdhawa Tiryagyam, Vedic multiplier, Frequency sampling, FIR windows.

I.INTRODUCTION

Multipliers are basic building blocks of any processor design and normally we called as heart of DSPs. Modern multipliers speed of computation decreases as the inputs increase. There are many multipliers available today like Combinational multiplier, array multiplier, serial and parallel multiplier and many more. Thus building high speed multipliers for processor design is done using Vedic. In DSPs, Filtering is normally used and is applied to many applications like speech processing etc. Digital Signal Processing operations like convolution, Fast Fourier Transform, DFT calculation. Frequency sampling etc method is being used in many applications.

Filtering is a method which is used for removing unwanted signal frequencies by being sensitive to the wanted signal frequencies. Digital audio or video when it is transmitted through the communication channel, noisy is added to the original signal. So,at receiver side filtering is must in order to get original one. Basically, filters are Classified into 4 types depending upon the pass band and stopbands.FIR and IIR(Infinite Impulse Response Filter) are two types of filter designed in this paper. And computation time is compared (convolution and Urdhwa Tiryagbyam).Urdhwa Tiryagbyam is a method which reduces the computation time in processors. The method of computation of conventional and Vedic Urdhwa Tiryagbyam is same. In this paper, the computation time taken by both the methods are compared and implemented in GUI.

This paper is organized into VII parts. Part I spreads light over introduction, Part II explains about the ancient Vedic mathematics, III describes about FIR and IIR filter types and windows, IV shows the method of computation using Urdhwa Tiryagbyam method, V shows the Design Approach, VI proposed method, VII shows Results Analysis and VIII provides Conclusion and Future scope of the project.

II. VEDIC MATHEMATICS

Vedic mathematics is an ancient Indian mathematics discovered by ancient sages of India. It was rediscovered by Jagadguru shankaracharya Bharathi Krishna Teerthji maharaja (1884-1960) in the year 1965.Swaiji called the use of Vedic mathematics is as mental calculation. Vedic mathematics consists 16 sutras (formulae) and 16 Upa sutras (sub formulae), these sutras cannot be finding in Atharva Veda. These sutras were derived from Atharva Veda discovered by ancient sages of India. Vedic mathematics is a unique system of computation based on simple rules and basic principles. By using which we can able to solve complicated mathematical calculations within few seconds. These formulae proposed in Vedic math deals with many modern mathematical terms like arithmetic, trigonometry, geometry (plane or co-ordinate), calculus, factorization and many more mathematical terms. The Vedic methods builds simple rules based on natural principles and are derived from Atharva Veda. This field seems to be very interesting and gives us effective computation algorithm by using which we can solve mathematical equations of various branches in engineering such as computing. Image processing, Speech processing, Digital Signal Processing etc.

The word' vedic ' has been taken from the Sanskrit word 'veda', it means a bunch of knowledge or collection of all knowledge[1].Vedic mathematics is a logical tool and deals with several simple as well as complex mathematical operations. Because

of these marvelous, phenomenal characteristics, it has already crossed the boundaries of India and has became a leading research topic in foreign countries. Advantages of Vedic method is listed in brief below

1) Reduces the complexity of solving the equation
2) Allows a person to solve complex equation within 5 seconds
3) Avoids finger counting and scratch
4) Helps to solve equations 10-15 times faster.

As Vedic Math consists of 16 Sutras and 16 upa sutras and these are used to solve equations relating to any branch of engineering are enlisted below the brief description of each sutra alphabetically [1].

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 previous one.
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 last from 10.
8) Parvarya yojayet – Transpose and adjust.
9) Puranapuranabhyam – By the completion or no completion.
10) Sankalana- vyavakalanabhyam – By addition and by subtraction.
11) Shesanyankena Charamena – The remainders by the last digit.
12) Shunyam Saamyasamuccaye – When the sum is the same that sum is zero.
13) Sopaantyadvayamantyam – The ultimate and twice the penultimate.
14) Urdhava-tiryagbhyam – Vertically and crosswise.
15) Vyashtisamanstih – Part and Whole.
16) Yaavadunam – Whatever the extent of its deficiency.

The Sub Sutras are

1) Anurupyena
2) Shishyate Sheshsamjnah
3) Adyamadye Nantyamantyena
4) Kevalaih Saptakam Gunyat
5) Vestanam
6) Yavadunam Tavadunam
7) Yavadunam Tavadunikutya Vargankach Yojayet
8) Antyayordhshakepi
9) Antyatoreva
10) Samucchayagunitah
11) Lopanasthapanabhyam
12) Vilokanam
13) Gunitasamucchyah Samucchayagunitah.

Using these above enlisted sutras and upa sutras we can be able to solve complicated mathematical equations relating to any branch of engineering.

Vedic multiplier:

Multiplier with the use of Vedic multiplication is called as vedic multiplier. The method applied here is Urdhwa Tiryagyam method. A simple block diagram below shows the 8×8 multiplier.

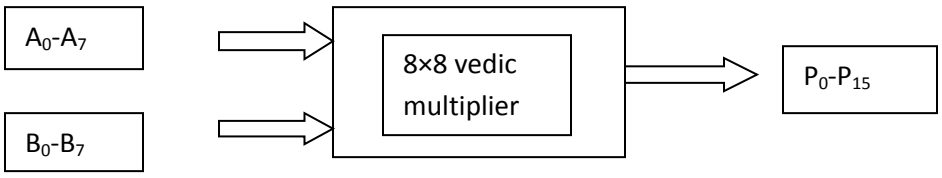
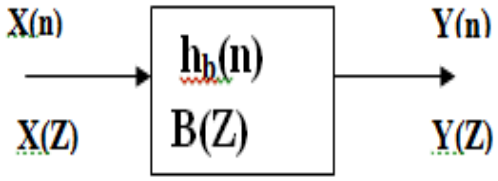


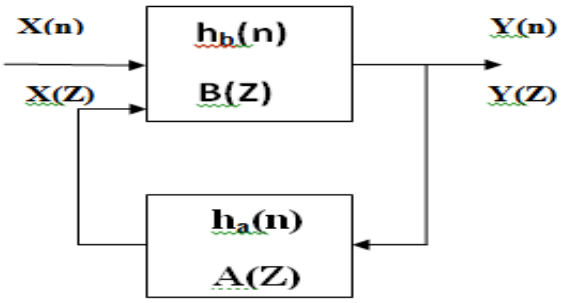
Figure 1.8×8 Vedic multiplier

III .FIR AND IIR FILTER DESIGN:

Finite impulse response filters are also called as convolution filter. These filters are used in the DSPs.IIR and FIR are types of digital filter.



(a)



(b)

Figure 2. (a)FIR filter and (b) IIR filter

FIR filter has finite impulse response and linear in nature. Whereas IIR are not linear in nature and phase linearity is not maintained. As shown in diagram (a) shows an FIR filter which does not have any feedback connection in the system design and (b) IIR filter has feed beck connection. Because of this system design FIR filters are more advantages than IIR in systems where phase linearity is maintained. There are many methods of designing both FIR and IIR filters. In this paper, an FIR filter design using window is shown. Windows like Hamming, Gaussian, Triangular, Rectangular, Kaiser, FIR filters are designed. In IIR Butterworth, Chebyshev Type-1 and Type-2 is shown in GUI.

IV.URDHWA TIRYAGBYAM

Urdhwa Tiryagbyam is one sutra among 16 sutras published by Swamiji Maharaja. This word is a Sanskrit word taken from 'veda', which means 'Vertical and Crosswise' [2].This sutra explains about a algorithm which can be applied to any cases of multiplication. Urdhwa Tiryangyam algorithm deals with the even numbered sequence and results in giving odd number of sequences. One more name given to this algorithm is Array multiplication. This method involves calculation of partial products with the concurrent operation of multiplication and addition. The multiplication operation which is used in FIR filter design is used by using Urdhwa Tiryagbyam method. This sutra can be applied to the generalization of N×N multiplication. The figure 3 shows the mode of multiplication for 8×8 bits.

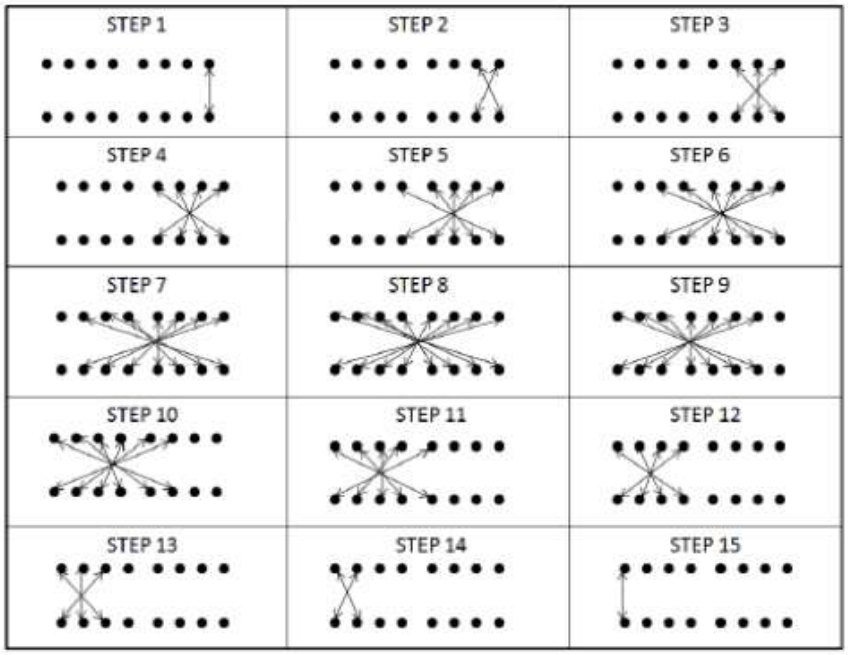


Figure 3.Urdhwa Tiryagbyam algorithm

V. FILTER DESIGN APPROACH

Using linear convolution operation the Direct form realization of FIR filter can be analyzed easily.FIR filter design approach is given below in figure 4.

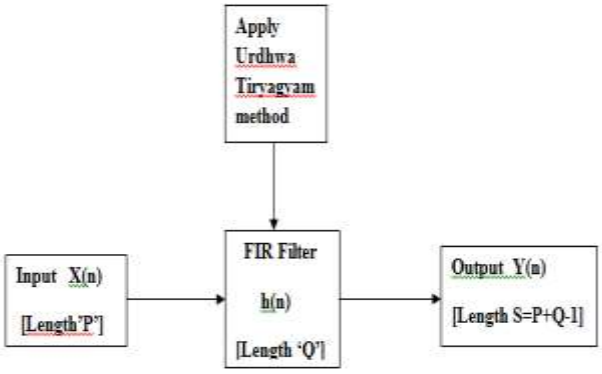


Figure 4 FIR filter

Let x(n)=Input sequence having length'P'

h(n)=Impulse response of filter having length 'Q'.

x(n)={0,1,2,3,…….,P-1}

h(n)={0,1,2,3,…….,Q-1}

The linear convolution of x(n) and h(n) produces the output sequence y(n).The length of y(n) is given by

$$L=P+Q-1 \quad (1)$$

If the number of sequence in x(n) and h(n) is less then by applying zero padding algorithm we made their sum equal to L.This means in order to get the exact output equal to L,we need to increase the length of x(n) by P points and length of h(n) by Q points.

In FIR filter,both the sequences x(n) and h(n) are finite length sequences and hence the resulting sequence would be finite length sequence.The convolution of x(n) and h(n) is given by

$$y(n) = \sum_{k=0}^{Q-1} h(k)x(n-k) \tag{2}$$

Figure 5 shows the diagram of direct form structure of FIR filter.The direct form structure based on the equation 2 is shown in figure5.By expanding that equation we get

$$y[n] = b_0x[n] + b_1x[n-1] + b_2x[n-2] + b_3x[n-3] \tag{3}$$

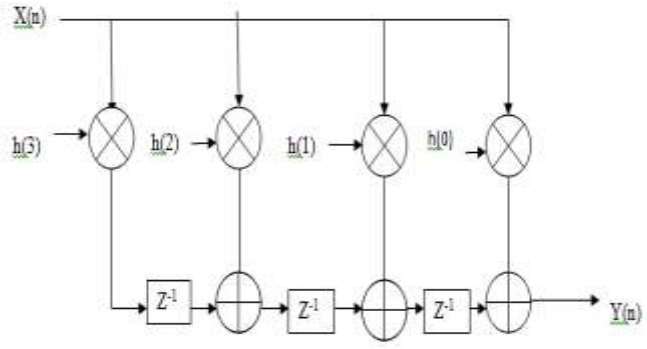


Figure 5. Direct form realization of FIR filter

The other name given to the direct form is the canonical structure since the order of the filter defines the number of delay elements. And the number of delay elements is equal to the order of the difference equation. Of a digital filter. This structure has 'Q-1' additions and 'Q' multiplications.

VI.PROPOSED METHOD

Output sequence y(n) of an FIR filter depends on the input sequence x(n) and impulse response h(n).The design methodology used in this paper is illustrated by figure 3.

Let us take a filter of order 4

Input sequence x(n)={x(0),x(1),x(2),x(3)}

Filter coefficient h(n)={h(0),h(1),h(2),h(3)}

The length of input sequence is x(n)=P=4

Therefore L=4+4+-1=7

By using Urdwa Tirygyam method,

y(0)=x(0)*h(0) (4)

y(1)=x(0)*h(1)+x(1)*h(0) (5)

y(2)=x(0)*h(2)+x(1)*h(1)+x(2)*h(0) (6)

y(3)=x(0)h(3)+x(1)*h(2)+x(2)h(1)+x(3)h(0) (7)

y(4)=x(1)h(3)+x(2)h(2)+x(3)h(1) (8)

y(5)=x(2)*h(3)+x(3)*h(2) (9)

y(6)=x(3)*h(3) (10)

VII. RESULT ANALYSIS

A Graphical User Interface (GUI), an inbuilt MATLAB function is used to show the computation time taken by both conventional and Vedic method is shown. A GUI builds the interaction between a user and the system, it helps the user to interact with the system through graphical icons.GUI is easy way to manipulate information and present data. The main aim of GUI is to increase the efficiency of computation and ease of use for the logical design of a stored program, Different technologies and devices uses GUI to provide a platform for the user to interact with the software for the tasks of producing information. In this paper, the computation using GUI is divided into 2 section. Section 1 explains deals with FIR filter and section 2 deals with IIR filter.

Section 1:FIR filter

For 36 order FIR filter with input as unit step signal

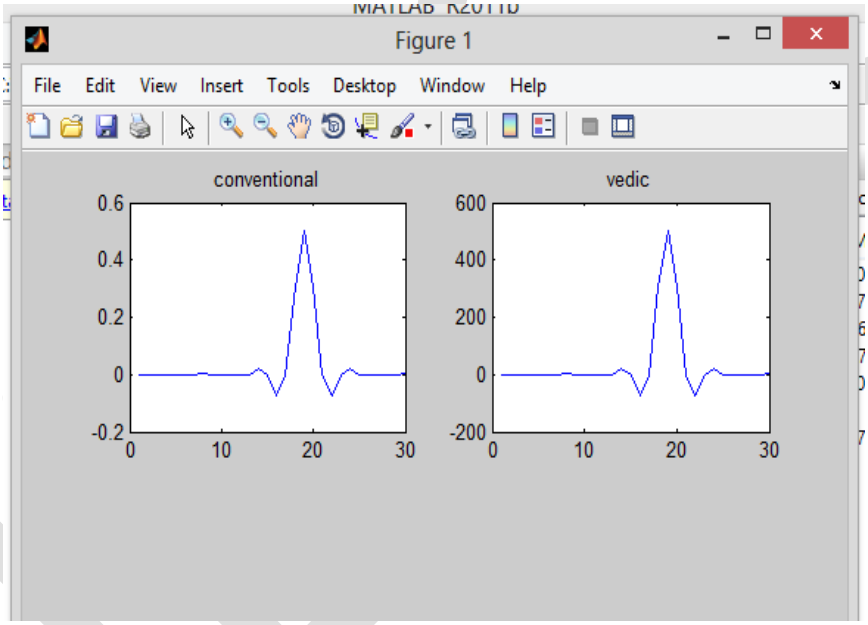


Figure 6.Output Response of FIR filter-36 order low pass Triangular window

Table 1.conventional versus Vedic time in LPF

S. No	FIR window	Vedic method	Conventional method
1	Flat top	2.057273s	0.045232s
2	Gaussian	0.371102s	0.0483s
3	Triangular	0.36913s	0.057355s
4	Kaiser	0.377437s	0.0483s
5	Hamming	0.836380s	0.0483s
6	Rectangular	3.587520s	0.045119s

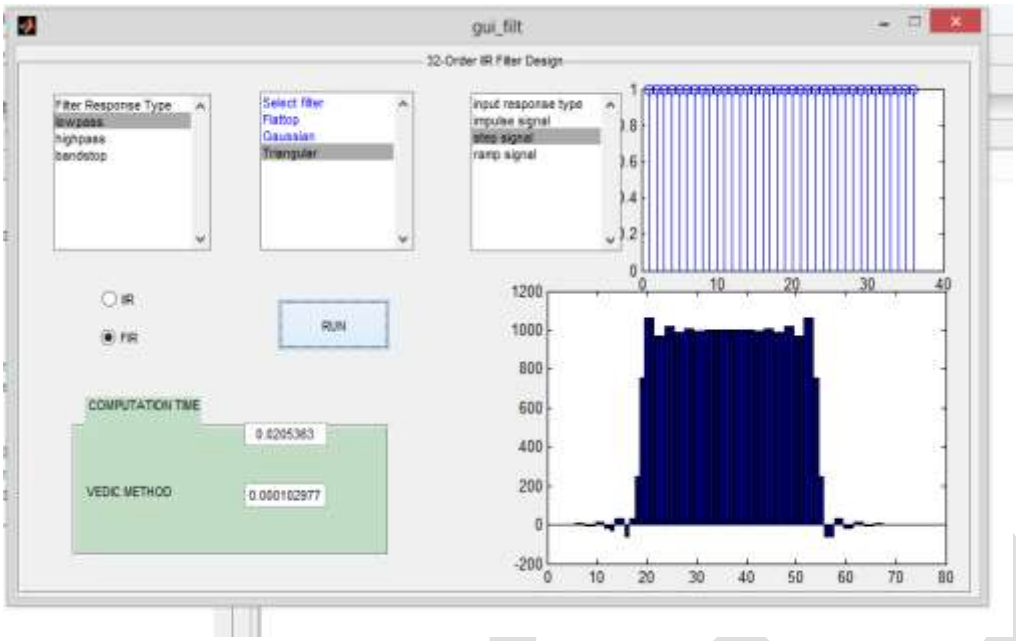


Figure 7.GUI for FIR filter for Triangular window

The above GUI is shown for FIR filter for Triangular window.The Y-axis shows the time consumed for the execution of sequences and the above graph in GUI shows the input and below one shows the Output of an FIR filter.

Section 2:IIR filter

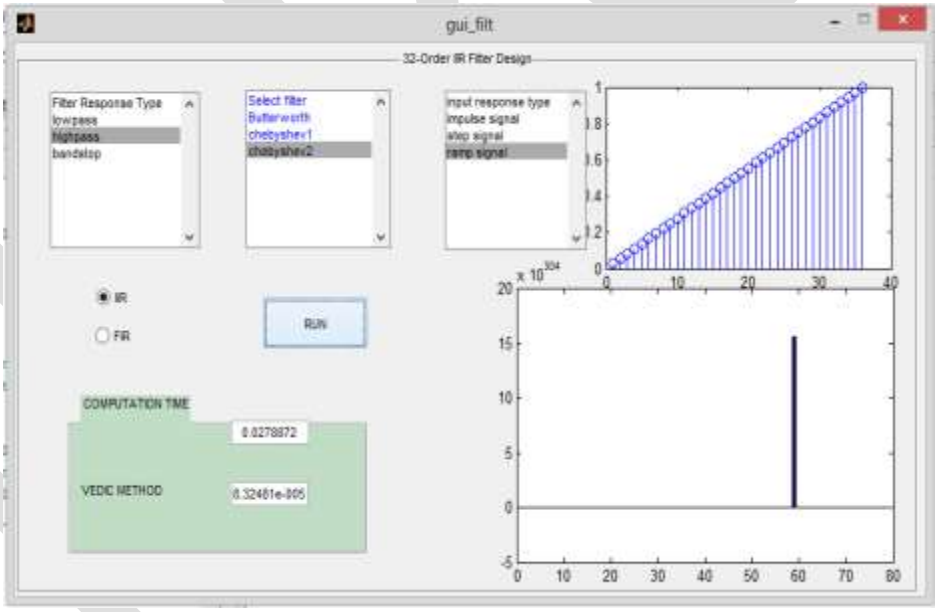


Figure 7 GUI filter for IIR Chebyshev filter Type-2

The above shown result for IIR filter is executed in the same way as for other butterworth,chebyshev filter type-1 filters for unit step,ramp,impulse etc.

VII.CONCLUSION

The implementation of IIR and FIR is done using Matlab. A window based FIR filter design is implemented by the use of Urdhwa Tiryakbyam multiplication Vedic sutra in Graphical user interface window. The computation time is calculated for Triangular, Rectangular, Hamming, Kaiser, Gaussian and flat top windows are calculated. By seeing the result we come to know that the execution time taken by Vedic method using Urdhwa Tiryakbyam is less compared to conventional method. These Vedic formulae are

much more efficient compared to conventional one. An IIR filter based on Vedic method computation is done and shown in GUI same like FIR for Butterworth, Chebyshev Type 1 and Chebyshev Type 2 filters. The computation time is compared for Frequency sampling method of design of filters. Thus FIR filter and IIR filter based on vedic method consuming less average execution time compared to inbuilt MATLAB function. This means the execution time taken by Urdhwa Tiryagbyam method is reduced.

Future works for filter design using Urdhwa Tiryagbyam method can be used to improve filtering technique used in Image processing, Stenography, Network security, for moving actions average like in finance business and in many more signal processing field. And also can be used for calculating Fast Fourier Transforms and Inverse fast Fourier Transforms (IFFT)..As a future scope the Vedic sutra can be applied to other filter design techniques like LMS (Least Mean Square), Frequency Domain sampling methods. And can be compared the execution time of Urdhwa Tiryakbyam method with other Vedic sutras like Nikhilam Navatashcaramam Dashatah etc.

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