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“Implementation and Comparison of Low Pass FIR Filter on FPGA Using Different Techniques”

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Abstract: The paper introduces the basic structure and the principles of the finite impulse response digital filter, and gives an efficient FIR filter design on FPGA .Use MATLAB FDATool to determine filter coefficients and designed to constant coefficient FIR filter by VHDL,use of ISE 10.1 to simulate the performance of filter using two different techniques.

Keywords: FPGA, FDATool, FIR Filter

I INTRODUCTION

As the word indicates, a filter separates a desired signal from unwanted disturbances. For example, when we want to remove a disturbance such as noise from an audio signal, we design an appropriate filter that passes only the desired signal. Digital filters include infinite impulse response (IIR) digital filter and finite impulse response (FIR) digital filter. As the FIR system has a lot of good features, such as only zeros, the system stability, operation speed quickly, linear phase characteristics and design flexibility, so that FIR has been widely used in the digital audio, image processing, data transmission, biomedical and other areas. [1]FIR filter has a variety of ways to achieve, with the processing of modern electronic technology, taking use of field programmable gate array FPGA for digital signal processing technology has made rapid development, FPGA with high integration, high speed and reliability advantages, FIR filter implementation using FPGA is becoming a trend. This paper studies used Spartan-3 FPGA to achieve a FIR filter design method using different techniques. For designing a digital filter first step is to calculate the coefficients, which can be calculated by various methods such as windowing and frequency sampling method.[2]

II BASIC PRINCIPLE AND STRUCTURE OF THE FILTER

Set the unit impulse response $h(n)$ of finite unit impulse response filter as the sequence of length N , the transfer function usually has the following form[1]

$$H(z) = \sum_{n=0}^{N-1} h(n) \cdot z^{-n} \quad (1)$$

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Differential equation is described as

$$y(n) = \sum_{i=0}^{N-1} h(i)x(n-i) \quad (2)$$

As we can see from differential equation, FIR filter order is N-1, length N. System output depends on a function of input and has no direct relationship with the past output, it does not contain feedback branch. [1] If the FIR digital filter unit pulse response h(n) is real numbers, h(n) satisfies the odd symmetry or even symmetry, that is

$$h(n) = \begin{cases} h(N-1-n) & 0 \leq n \leq N-1, \text{ Even symmetry,} \\ -h(N-1-n) & 0 \leq n \leq N-1, \text{ Odd symmetry} \end{cases} \quad (3)$$

In this paper we have used an Odd symmetry, the structure used in paper is shown in Fig[1] [1]

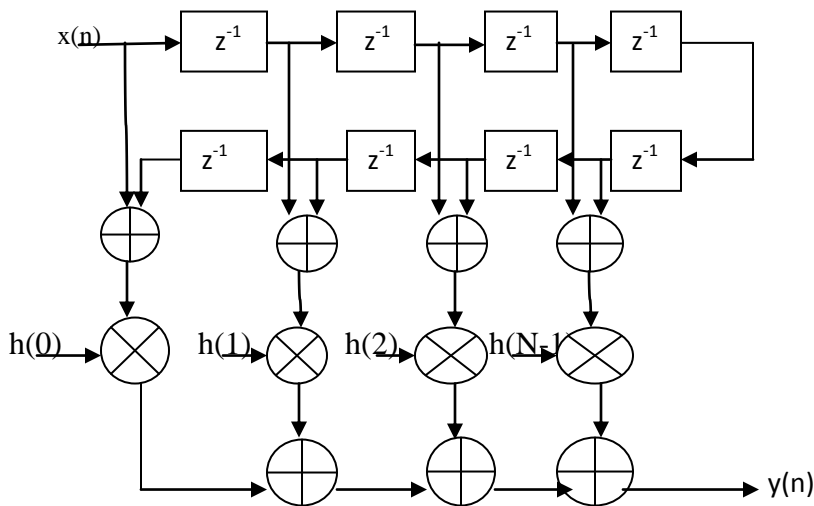


Fig -1 Odd numbers of Filters Tap

III FIR FILTER DESIGN

Design of Low Pass FIR Filter of 128 order ,the Filter specifications are sampling frequency fs= 4.8khz and cutoff frequency fc= 100hz, Response Type=Low Pass filter, width of data in=12 bits, Pass band attenuation= 3db.

- A) MATLAB implementation of Low Pass FIR filter using filter design techniques: Window function method and Frequency sampling method. The basic idea of window function is to have narrowest main lobe width and side lobes as small as possible, so use of Kaiser window for filter design. But theoretically calculations done in window method is more.[5] So another method use is Frequency sampling method in which less calculations are to be done theoretically .In this paper we compared the magnitude and phase response of both the techniques.

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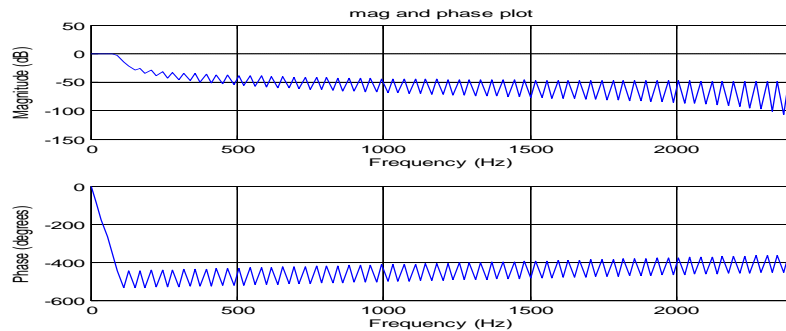


Fig-2 Plot of Window technique.

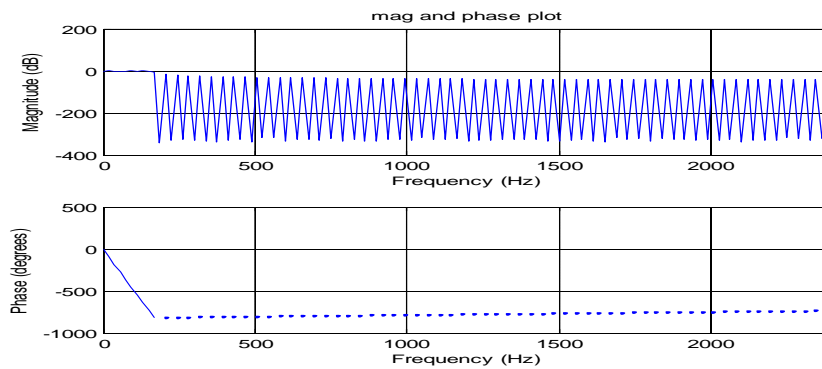


Fig 3 Plot of Frequency sampling technique

Comparison of window and frequency sampling techniques

Parameter	Window	Frequency sampling
Maximum Pass band Ripple	0.5 db	1.611db
Cutoff frequency At 3 db	92 Hz	165Hz
Stop band edge frequency	150 Hz	188Hz
Stop band Attenuation	26.24db	15.21 db

Table-1

From the above parameters we can conclude that Window method gives better result than Frequency sampling method.

B) Quantification and Extraction of the Coefficient: The unit impulse response $h(n)$ is gained through FDA Tool(Filter Design & Analysis Tool) which is a kind of tool in the software MATLAB. The format of the coefficient which is exported from Matlab is floating-point. In order to expediently deal with the coefficient

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by FPGA devices, there are two operations to be done: (1) converting the floating-point value into a fixed-point value that is called quantification. (2) converting fraction to integer.[2]

C) Achieve filter with VHDL language: VHDL has strong abstract description ability to support hardware design, verification, synthesis and testing. VHDL describes the same logic functions in multiple levels, such as it can describe the structure of the circuit composition in register level. In this paper ,for top level module structural modeling has used else for low level module the behavioral modeling has used.[1] By using MAC operation the FIR filter has designed. The structure describe in the Fig-1 which is odd symmetry linear phase, has described by using VHDL. Use of SPARTAN-3 FPGA has been done for downloading the code.

D) The hardware of Digital FIR filter:

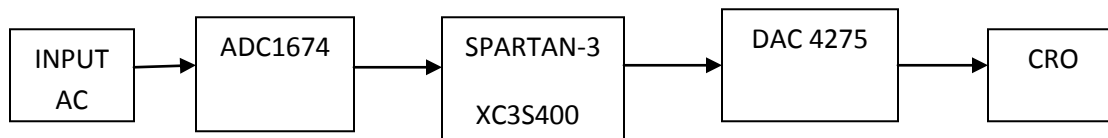


Fig 4 Basic block diagram

The signal is given to 12 bits ADC at sampling of 10 μ s ,the filter is stored in FPGA,use of SPARTAN-3,device is XC3S400,the digital output is given to serial DAC-4275,the output can be observe at CRO

IV RESULTS AND VERIFICATION

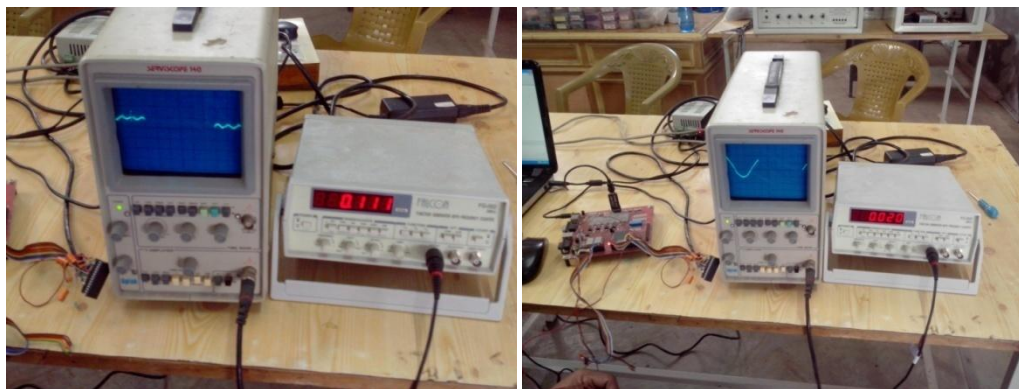


Fig 5 Wave Form by windowing method.

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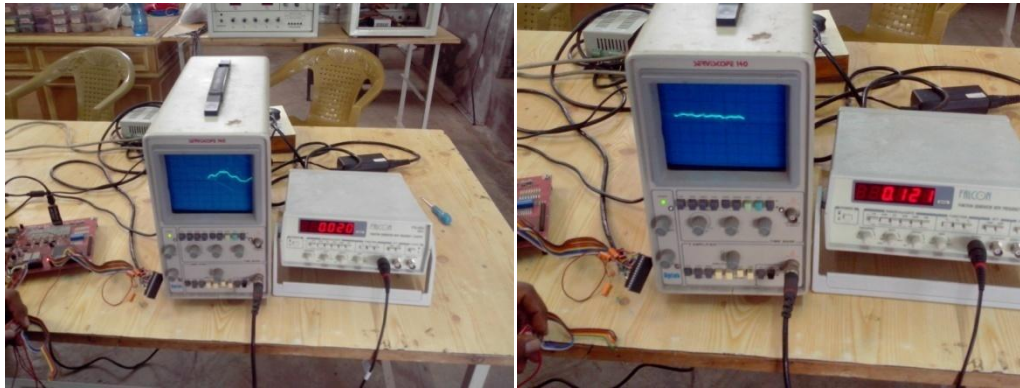


Fig 6 Wave Form by frequency sampling method.

With this analysis the cutoff frequency by windowing method is 111 hz. Where as cutoff frequency by frequency sampling method is 121 hz. The design is simulated and verified by ISE 10.1 Xilinx software and simulated by Modelsim Simulator. It is proved that the windowing method is better than the frequency sampling method for designing in FIR filter. The synthesis report is shown in Table 2.

Family	Device	Parameters	Windowing	Frequency sampling method
Spartan 3	XC3S400	No. of slices	1051 out of 3584	1403 out of 3584
		No. of flip flops	849 out of 7168	1192 out of 7168
		No. of 4 J/P	1429 out of 7168	1897 out of 7168

Table 2

V CONCLUSION

This paper mainly introduces the design and simulation of FIR filter, which is mainly based on FPGA, ISE 10.1 project navigator and Matlab. The use of these softwares significantly shortens the R&D periods. In this paper we have compared the two methods for finding the filter coefficients and hence come to the conclusion that windowing method gives better results than frequency sampling. In practical application, it is easier to achieve other types of filter design as long as you modify the parameters of the filter, including the width of the input data, the coefficient the and so on. The synthesis result is shown in Table 2 we find the windowing method uses less system sources.

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