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Design of Digital FIR Filter for RADAR Application

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ABSTRACT: Digital FIR filtering is used to produce digital output by taking digital input. Digital filtering is one of the most powerful tools of digital Signal Processing. Due to advancement in VLSI technology and usage of Digital signal processors in RADAR application FIR filter plays important role. Digital filters are capable of performance specifications that would, at best, be extremely difficult, if not impossible, to achieve with an analog implementation. In addition, the characteristics of a digital filter can be easily changed under software control. This paper gives brief overview of the basic structure and hardware characteristics of the Finite Impulse Response (FIR) digital filter. FIR filter has been designed efficiently using DSP systems using Simulink, Mat lab, and Xilinx System Generator tool. Xilinx offers a variety of high quality state of the art products for DSP design. We will implement a digital filter using The Multiplier Accumulator (MAC) unit which is the basic element to implement a Digital filter on a FPGA.

KEYWORDS: Digital Signal Processing, Digital FIR filter, Mat lab Simulink , Xilinx system generator.

I. INTRODUCTION

A digital filter is a system which passes some desired signals more than others to reduce or enhance certain aspect of that signal. Signal carries information, and the objective of signal processing is to extract useful information carried by the signal. The method of information extraction depends on the type of signal and the nature of the information being carried by the signal. Filters are widely employed in signal processing and communication systems in applications such as noise reduction, channel Equalization, Radar, audio processing, video processing and analysis of economic and financial data. Digital Signal Processing (DSP) is an important field of study that has come about due to advances in Communication theory, digital computer technology, and consumer devices. There is always a driving need to make things better and DSP provides many techniques. The filter implementation simply performs a convolution of the time domain impulse response and the sampled signal [7]. The frequency domain impulse response is then transformed into a time domain impulse response that is the coefficients of the filter. Digital filters are two types: i) Finite Impulse Response (FIR) and ii) Infinite Impulse Response (IIR) filters. Finite impulse response (FIR) filter is a filter whose impulse response is of finite duration, because it settles to zero in finite time [1]. FIR filters also known as feed forward or non recursive, or traversal filters. In signal processing, a finite impulse response (FIR) filter is a filter whose impulse response (or response to any finite length input) is of finite duration, because it settles to zero in finite time. A Finite impulse response (FIR) filter is a filter structure that can be used to implement almost any sort of frequency response digitally. This is in contrast to infinite impulse response (IIR) filters, which may have internal feedback and may continue to respond indefinitely.

FIR filters offer the following advantages over the IIR filters:

- i. They can have an exact linear phase.
- ii. They are always stable.
- iii. The design methods are generally linear.
- iv. They can be realized efficiently in hardware.

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II. DIGITAL FILTERS AND APPLICATIONS

Digital filters are used in separation and restoration of signals. Signal separation is needed when the signal has been contaminated with interference and noise, while restoration of signal is used when a signal has been distorted in some way. All of those filters used in radar signal processing and mentioned earlier, i.e. Lowpass Filter (LPF), MF and MTI filters will be more reliable if they are implemented as digital filters. Digital filters are replacing analogue filters because of their reliability and their compatibility to Digital Signal Processing (DSP). They are available in two flavors, Finite Impulse Response (FIR) and Infinite Impulse Response (IIR) filters[7]. Although IIR filters are faster and have fewer components compared to FIR filters, they should be tested for stability per each design changes. On the other hand, FIR filter is stable by definition and has linear phase response and basic building block of many digital signal processing (DSP) systems. FIR Filters are used due to their stability and linear phase properties.

Digital filters in DSP Application as follows:

- 1) Military- Radar signal processing, sonar signal processing, navigation, secure communications and missile guidance.
- 2) Signal filtering-Removing of unwanted background noise, removal of interference, separation of frequency bands and shaping of the signal spectrum.
- 3) Ground-based radar is applied chiefly to the detection, location and tracking of aircraft of space targets.
- 4) Ship borne radar is used as a navigation aid and safety device to locate buoys, shorelines and other ships. It is also used to observe aircraft.
- 5) Space borne radar is used for the remote sensing of terrain and sea, and for rendezvous/docking.
- 6) Airborne radar is used to detect aircraft, ships and land vehicles. It is also used for mapping of terrain and avoidance of thunderstorms and terrain.
- 7) Telecommunication- Echo cancellation in telephone networks, equalization, telephone dialling application, modems, line repeaters, channel multiplexing, data encryption, video conferencing, cellular phone and FAX.
- 8) Consumer electronics- Digital Audio/TV, electronic music synthesizer, educational toys, FM stereo application and sound recording applications.
- 9) Image processing- Image representation, image compression, image enhancement, image restoration and image analysis compression, image enhancement, image restoration and image analysis.
- 10) Speech processing- Speech analysis methods are used in automatic speech recognition, speaker verification and speaker identification.
- 11) Medicine-Medical diagnostic instrumentation such as computerized tomography (CT), X-ray scanning and X-ray storage/enhancement.

III. DESIGN OF FIR FILTER

An FIR filter is usually implemented by using a series of delays, multipliers and adders to create the filter's output. The delays in operating on prior input samples. The coefficients used for multiplication, so that the output at time n is the summation of all the delayed samples multiplied by the appropriate coefficients. The processes selecting the filters length and coefficients is called as filter design[9]. The goal is to set those parameters such that certain desired stop band and pass band parameters will result from running the filter. Most engineers utilize a program such as MATLAB to do there filter design[8].

A Finite impulse response (FIR) filter is a filter structure that can be used to implement almost any sort of frequency response digitally. FIR filters are filters having a transfer function of a polynomial in z^{-1} and is an all-zero filter in the sense that the zeroes in the z -plane determine the frequency response magnitude characteristic. The z transform of a N -point FIR filter is given by

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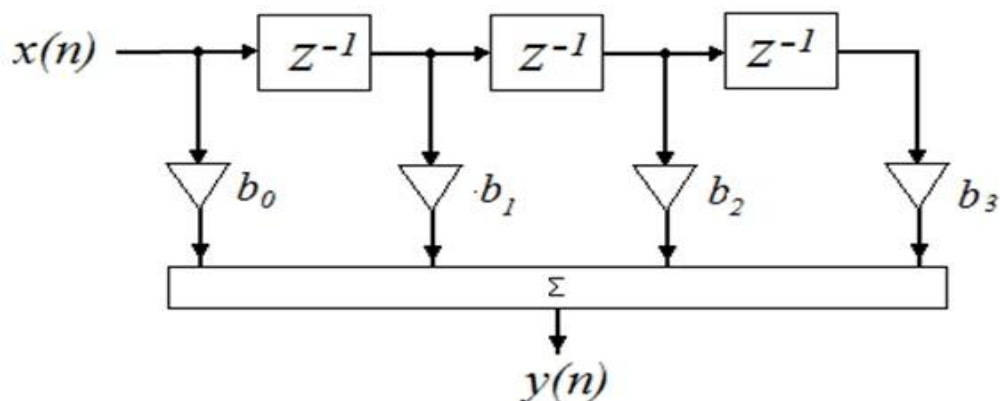


Fig 1. Block diagram of FIR filter

From Fig 1, we can notice that the current sample of the output signal of the FIR filter $y(n)$ is the sum of the current sample of the input signal $x(n)$ and previous samples multiplied by the filter coefficients b_k as follows.

$$Y[n] = \sum_{k=0}^{N-1} h(k)x(n-k) \dots 1.2 \quad k=0$$

where N is the number of taps or filter coefficients and $N-1$ is the filter order, which equals the number of delays marked Z^{-1} .

IV. MA LAB SIMULINK AND SYSTEM GENERATOR

MATLAB SIMULINK

The design options in MATLAB allow the user to either create a code for designing filters that calls built-in functions, or to design filters in tool, a graphical user interface. MATLAB provides all the information necessary for building a hardware replica of the filter designed in software [9].

FDA tool is used to design the filter required specification. Simulink is a data flow graphical programming language tool for modelling, simulating and analysing multidomain dynamic systems. Its primary interface is a graphical block diagramming tool and a customize set of block libraries. There are the customized block and libraries and solvers for modelling and simulating dynamic systems. It offers tight integration with the rest of MATLAB environment and can either drive MATLAB or be scripted from it. Simulink is widely used in control theory and digital signal processing for multidomain simulation and model-based design.

SYSTEM GENERATOR

The System Generator is high level tool for designing high performance DSP systems using FPGAs. The System generator tool enables us to integrate Xilinx with Simulink, it creates file. Xilinx block provides control of system and simulation parameters, and is used to invoke the code generator. Every Simulation model containing any element from the Xilinx Block set must contain at least one System Generator block.

Once a System Generator block is added to a model, it is possible to specify how code generation and simulation should be handled. Simulink is a software environment that runs under MATLAB. It provides a level of abstraction since it uses blocks to represent operations, so it is a block oriented design and the Xilinx block set is a library under Simulink [7].

FIR Filter and Simulate for FIR Filter using simulink and design characteristics and Configure the inputs and simulation parameters as specified and simulate the Filter in Simulink and verify the design functionality as shown in Fig 3. FDA tool is the important tool of MATLAB which is used to design the filter required specification and method for filter design. The FIR Filter is implemented using Mat lab simulink model and Xilinx System Generator for selected signal with noise for low and high frequency using FDA tool for Order of 6, Direct form FIR filter, type is of Low pass, method FIR least square as shown in the below figure 2.

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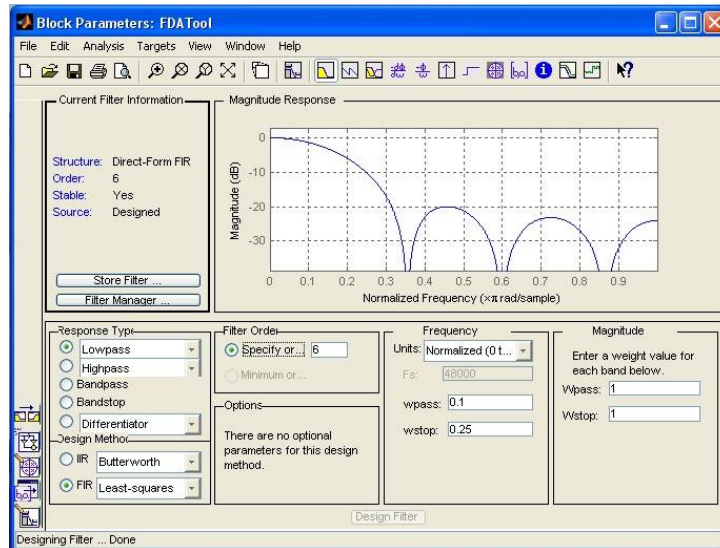


Fig 2 . Magnitude and Phase Response of 6 tap FIR filter

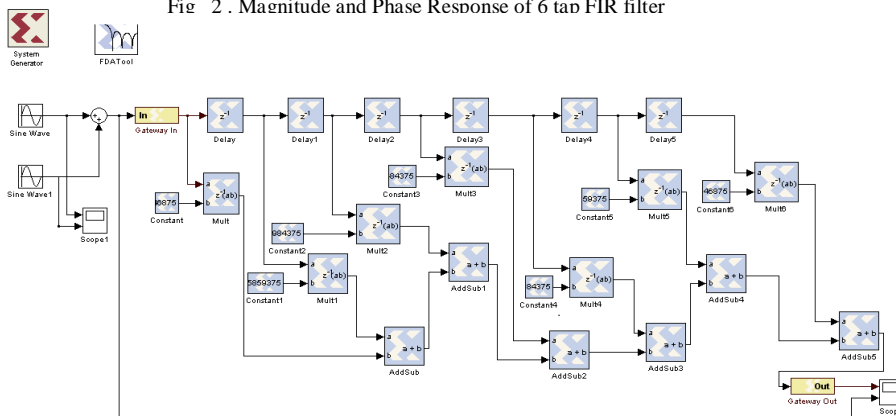


Fig 3 .The 6 Tap FIR filter design as shown above

Above Fig 2 Shows the magnitude and phase Response of 6 Tap low pass filter is obtained as per the specification and Fig 3 shows the 6 Tap direct form FIR filter designed with Low and High Frequency Sine waves given as input Implementing FIR Filter and Simulate for FIR Filter using simulink .

Design Characteristics are as follows :

- Separate multiplier and accumulator per filter coefficient
- Low Pass Filter of order 6
- Coefficients generated using the FDA Xilinx Tool
- Sampling frequency of 1kHz

Configure the inputs and simulation parameters as specified below. Next, simulate the Filter in Simulink and verify the design functionality.

- Two Sine inputs: low and high frequencies.
- 16 bit input: signed data (2's complement) binary point 13, and sampling period of 0.001 seconds.
- Multiplier Block latency of 1 and Full precision.
- Lowpass Type-I FIR filter of order 6.
- Simulation parameters: Stop time 0.5 seconds.

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V. EXPERIMENTAL RESULTS

The 6 tap FIR Filter is designed Configure the inputs and simulation parameters as specified and simulate the Filter in Simulink and verify the design functionality. We have got all the specifications. The sampled input signal and noise displayed on scope is shown below

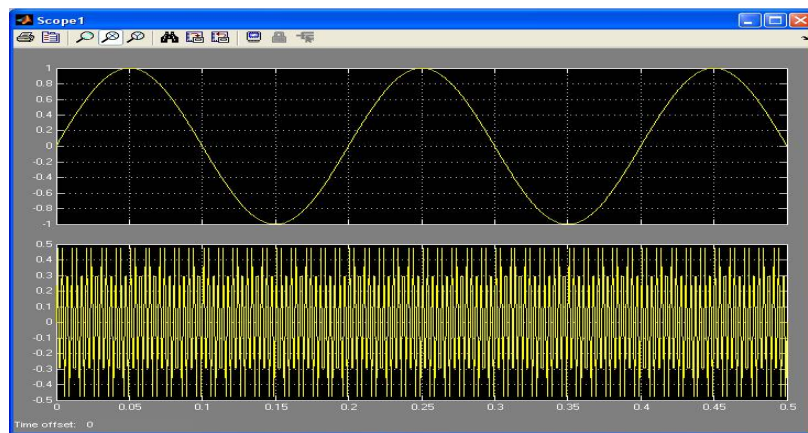


Fig 4 (a) Input signal with noise

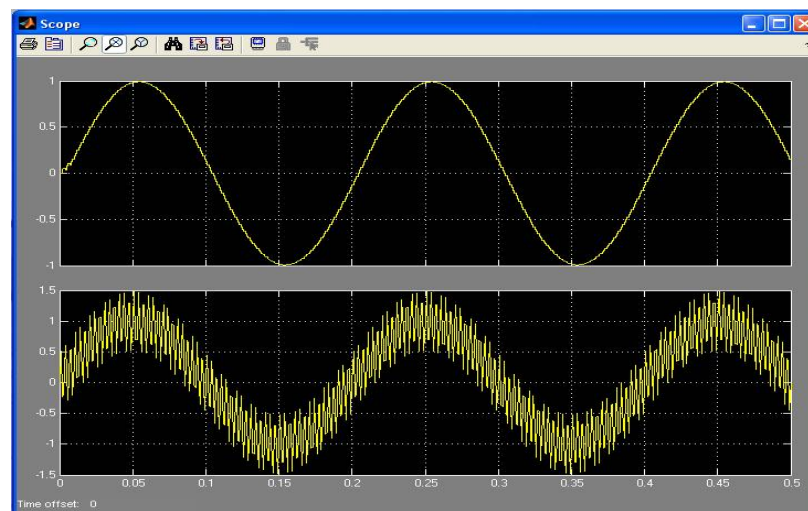


Fig 4 (b) Output signal without noise

Fig. 4 shows the sign wave given as Input signal with noise signal and Output signal without noise signal (a) Input signal (b) Output signal

VI. CONCLUSION

The analysis of magnitude and phase response are performed using System Generator under Simulink environment in MATLAB to design a FIR Digital Filter. FIR Low pass filter of 6th order using of multiple MAC's to implement design. Run the simulation with default settings and understand the output. The result provides better result in term of magnitude and phase response of Low pass FIR filter.

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REFERENCES

- [1] H. Yon and D. Anderson, "Hardware-Efficient Distributed Arithmetic Architecture for High-Order Digital Filters", in Proceedings of IEEE International Conference on Acoustics, Speech, and Signal Processing, 2005.
- [2] Shahnam Mirzaei, Anup Hosangadi, Ryan Kastner, FPGA Implementation of High Speed FIR Filters Using Add and Shift Method, IEEE ,2006.
- [3] Mark S.Manalo and Ashkan Ashrafi "Implementating Filters on FPGA" Department of Electrical and Computer Engineering University of Kansas Lawrence,KS 66045-2228
- [4] Anurag Aggarwal Astha Satija Tushar Nagpal, "FIR Filter Designing using Xilinx system generator" International Journal of Computer Application Volume 68,2013.
- [5] Suraj R.Gaikwad ,Snehal R.Gaikwad,Kunal N.Dekate, Design and implementation of FPGA based Low Power Digital FIR Filter" Journal of Electronics and Communication Engineering,Volume 4,2012.
- [6] A. Oppenheim and R. Schafer, "Digital Signal Processing, "Prentice-Hall, Inc., 2009.
- [7] Sanjit K. Mitra, " Digital Signal Processing : A Computer based approach" , McGraw Hill, 2006.
- [8] MathWorks,Simulink,<http://www.mathworks.com/products/simulink/>
- [9] Xilinx Inc., System generator for DSP : User Guide,Release 10.1,Snn Jose Clifornia,USA,Pp.1-40