



Design and Realization of Digital Filter

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Abstract: The FIR filter is widely used in digital communication and Digital signal processing systems. This paper presents an analysis of the principle of the FIR filter, and selects the proper window function to cut off impulse response, then presents the designing process with the help of tool in fdatool for obtaining the unit impulse response sequence. This paper introduces basic realization of FIR digital filters, and the design methods based on MATLAB. After the selection of desired parameters simulation of a FIR band-pass filter by means of window function method, the results prove that various performance of the designed FIR filter. The designed method and process is very efficient. The result shows that the FIR filter is accurate, stable, and reliable.

Index Terms - FIR digital filter; DSP program; fdatool; window function; MATLAB Simulation

I. INTRODUCTION

Digital filters are used in a wide variety of signal processing applications, such as spectrum analysis, digital image processing, and pattern recognition. Digital filters eliminate a number of problems associated with their classical analog counterparts and thus are preferably used in place of analog filters. Digital filters belong to the class of discrete-time LTI (linear time invariant) systems, which are characterized by the properties of causality, reusability, and stability. They can be characterized in the time domain by their unit-impulse response, and in the transform domain by their transfer function. Obviously, the unit-impulse response sequence of a causal LTI system could be of either finite or infinite duration and this property determines their classification into either finite impulse response (FIR) or infinite impulse response (IIR) system. [1]

Digital filter is the basis of digital signal processing, used to signal filtration, detection and parametric estimation etc. With the development of the technology of information, the technology of digital signal processing in the fields such as communication, voice, image, automatic control, radar, military, aviation, spaceflight etc. has been widely used. Because of digital signal of the communicated system often mixed with all kinds of complicated composition, digital filters perform a virtual role in signal processing and reduction. This function of digital filters is to carry out operational handling for input the digital code of dispersed signal, in order to reach the purpose that changes signal frequency spectra. Digital filters have multiple classifications. According to the frequency characteristics can be divided into: high-pass, low pass, band-pass, and band-stop. According to the time domain of digital filter impulse response characteristics can be divided into: finite impulse response-FIR, infinite impulse response IIR. Impulse response $h(n)$ of FIR filter is finite sequence limited, while impulse response $h(n)$ of IIR filter is infinite subsequence. Compared with IIR filter, the realization of FIR is non-recursive.

II. DESIGN OF FIR DIGITAL FILTERS BASED ON MATLAB TOOLBOX OF MATLAB

Signal processing provides various window functions, designing functions of filter and realizable functions of filter. The method of Window function is the most commonly used method which design FIR digital filter. It has very important function in the design of FIR digital filters, properly choose window function, can improve the performance of design of the digital filter, or under meeting the require of design circumstances reducing the order of FIR digital filters. Commonly, there are the five types of used window functions in engineering that is boxcar, Hanning, Hamming, Blackman, and Kaiser. Performance comparison of all sorts of window functions can be seen in Table 1. During the design process of FIR filters, it can choose window function of suitable by the requirements.

TABLE 1 PERFORMANCE COMPARISON OF ALL SORTS OF WINDOW FUNCTIONS

Window	Performance index of window Side lobe peak value /dB
Blackman	-51.8
Hamming	-42.6
Hanning	-31.5
Kaiser	-13.6

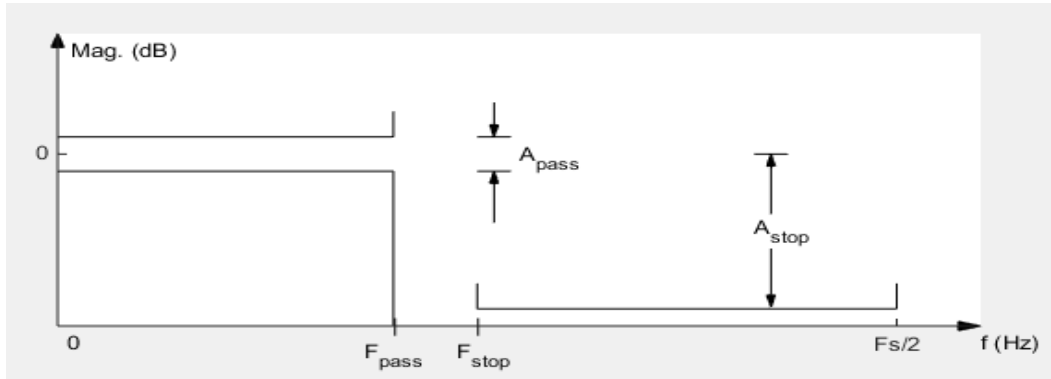
III. DIGITAL FILTER SPECIFICATION

Setting the Sampling Frequency: - The sampling Frequency control is used to specify the sampling frequency. The sampling frequency entered should match the sampling frequency that was used to generate the FIR filter coefficients.

Pass Band Ripple: - The Pass Band Ripple control is used to specify the Pass band ripple: deviation from maximum gain (dB) in the pass band and filter order and coefficient calculation.

Stop Band Ripple: - The Stop Band Ripple control is used to specify Stop band attenuation: deviation from 0 gains (dB) in the stop band: filter order and coefficient calculation.

FIR Filter Methods control: - A full suite of design methods is available for finite impulse response (FIR). These methods support the rapid design and evaluation of low pass, high pass, band pass, and band stop, filters such as equiripple , lest squares and Kaiser window.



Interface Design based on FDATool

Parameters requirements:

Filter order number $N = 100$,

Sampling frequency $f_s=1000\text{Hz}$,

$F_{\text{pass}}=300\text{Hz}$

$F_{\text{stop}}=350\text{Hz}$

$A_{\text{pass}}=0.2\text{ dB}$

$A_{\text{stop}}=60\text{ dB}$

IV. RESULTS AND DISCUSSION

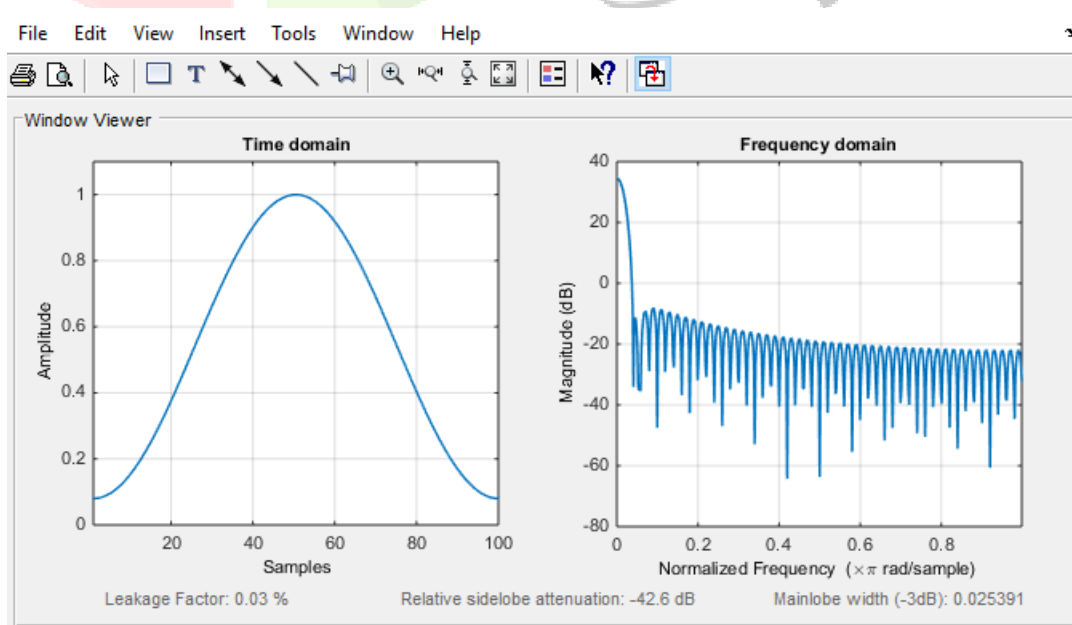


Fig.1 Response of low pass FIR filter designed using Hamming window function.

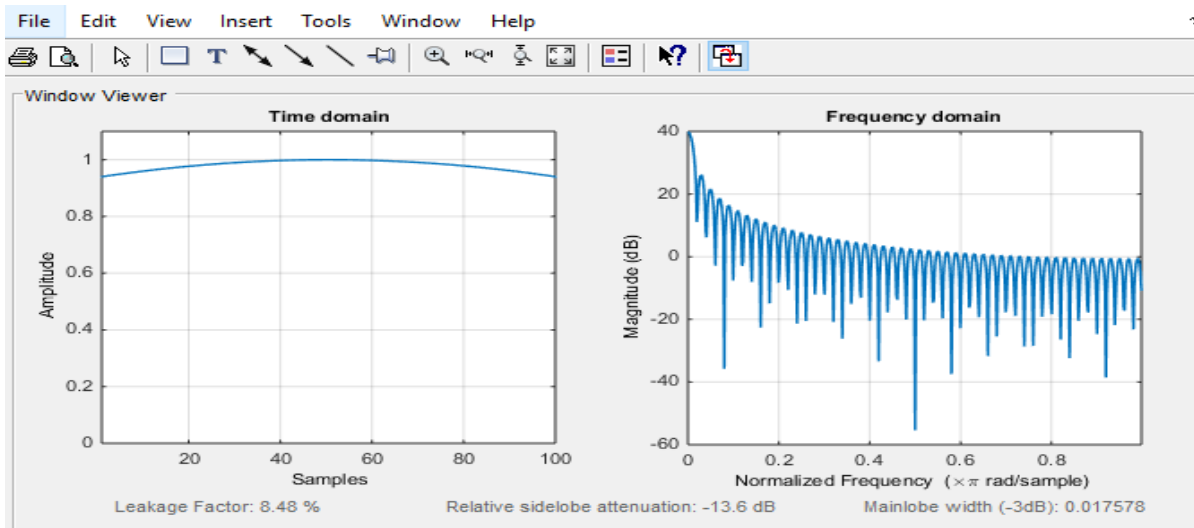


Fig.2 Response of low pass FIR filter designed using Kaiser window function.]

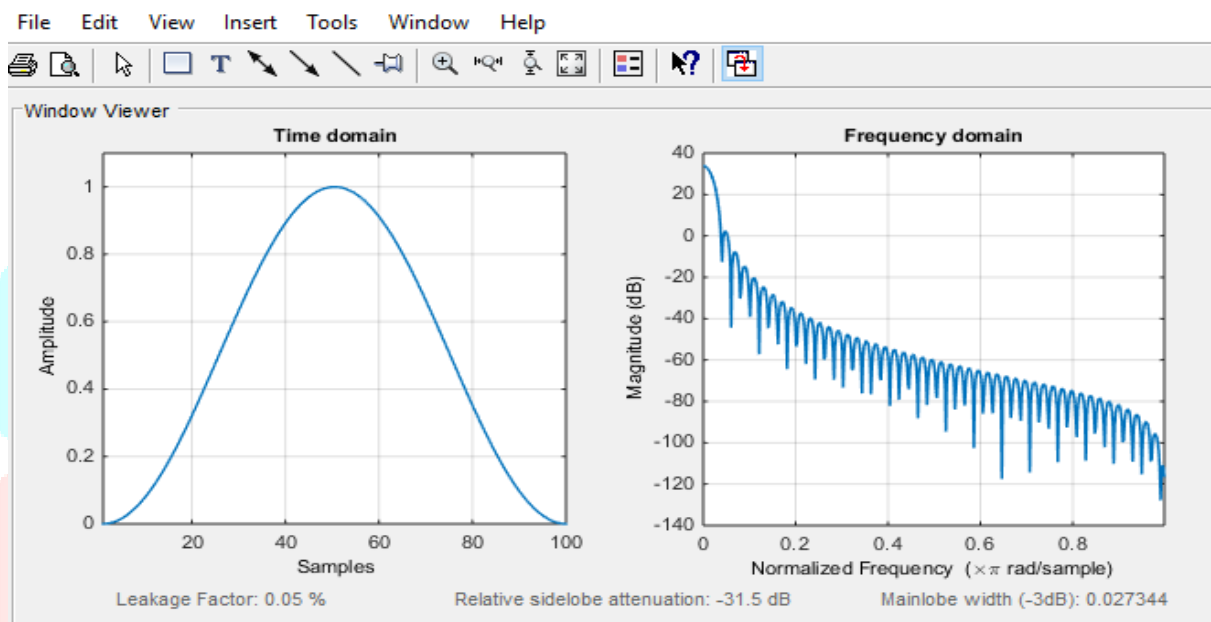


Fig. 3 Response of low pass FIR filter designed using Hanning window function.

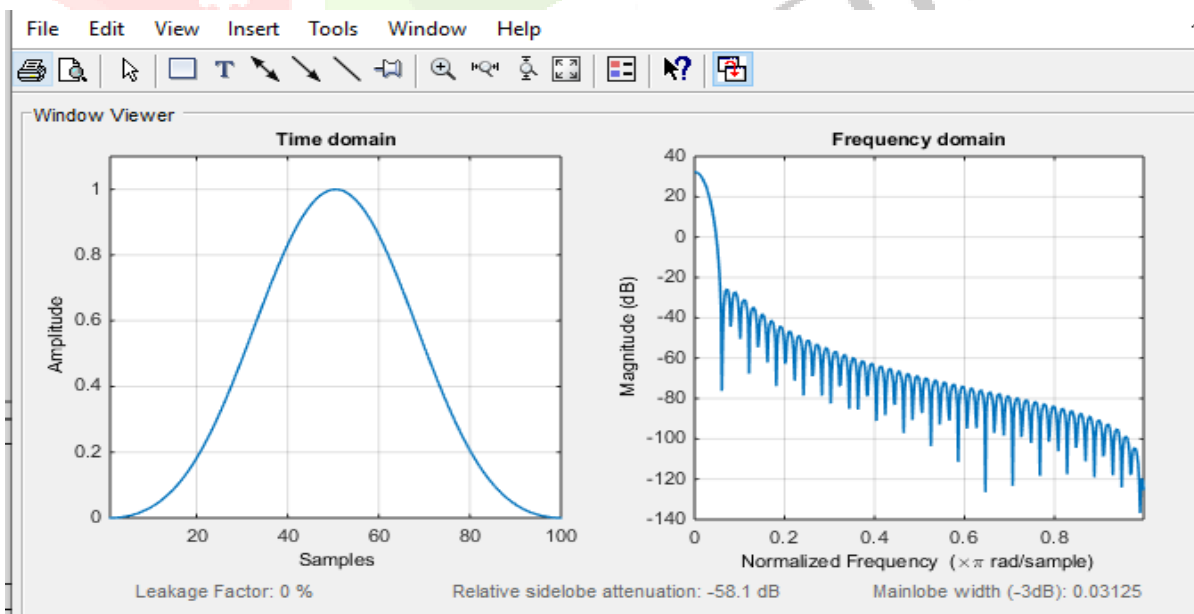
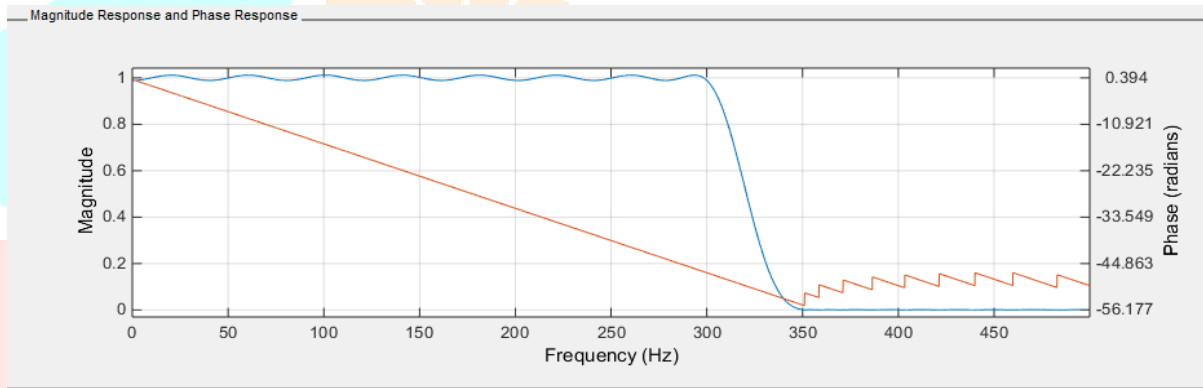
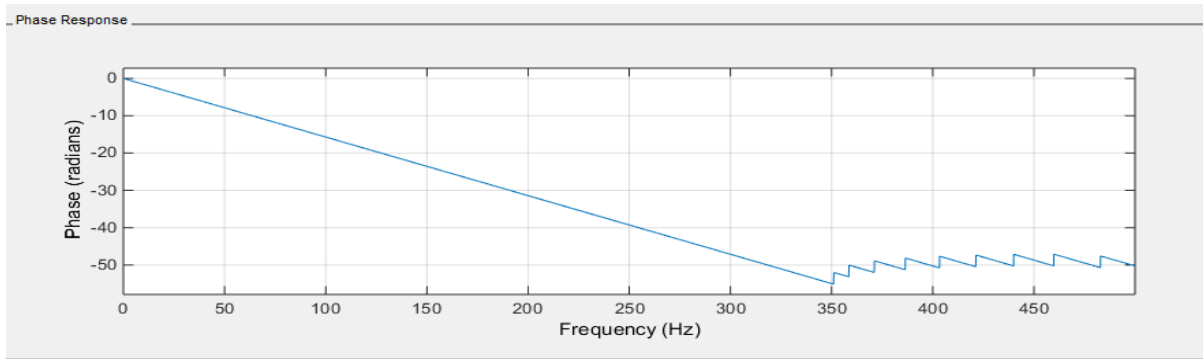
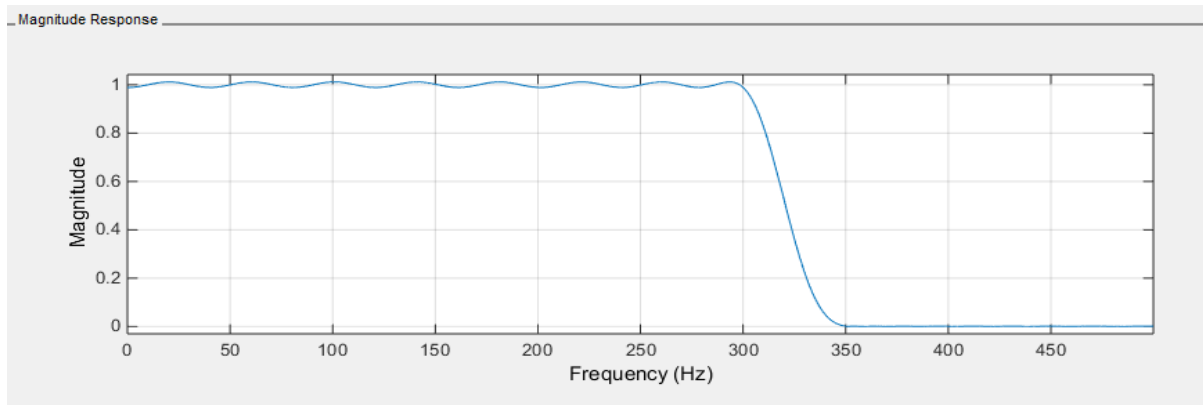


Fig.4 Response of low pass FIR filter designed using Blackman window function.



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Discrete-Time FIR Filter (real)
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Filter Structure : Direct-Form FIR
Filter Length   : 51
Stable          : Yes
Linear Phase    : Yes (Type 1)

Implementation Cost
Number of Multipliers : 51
Number of Adders      : 50
Number of States      : 50
Multiplications per Input Sample : 51
Additions per Input Sample : 50
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Value of all co-efficient:

1x51 double																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	-0.0035	-0.0042	0.0027	0.0011	-0.0046	0.0030	0.0035	-0.0077	0.0028	0.0076	-0.0112	7.9694e-04	0.0142	-0.0151	-0.0040	0.0242
2																
3																
4																

1x51 double																
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	-0.0187	-0.0142	0.0404	-0.0217	-0.0369	0.0748	-0.0237	-0.1229	0.2864	0.6422	0.2864	-0.1229	-0.0237	0.0748	-0.0369	-0.0217
2																
3																

1x51 double																
	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1	0.0404	-0.0142	-0.0187	0.0242	-0.0040	-0.0151	0.0142	7.9694e-04	-0.0112	0.0076	0.0028	-0.0077	0.0035	0.0030	-0.0046	0.0011
2																
3																

49	50	51	52
0.0027	-0.0042	-0.0035	

V. CONCLUSION : FIR digital filter through the example of the design and analysis, in MATLAB environment, based on MATLAB Signal Processing Toolbox design of digital filters can be convenient, fast and correctly designed to meet the strict linear phase. Because of its strict linear phase, the FIR filter is widely applied in the digital signal processing system, but the traditional design of FIR is very complicated. The FIR filter, saving a lot of programming time, improving the efficiency of programming, and parameter changes is also very convenient. Digital Filter designed using MATLAB in the digital communications systems and signal processing of the computer field, have broad application prospects.

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