

Design Technique of High-pass Filter using different window

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Abstract

In the field of signal processing and communication, digital filter plays pivotal role. Digital FIR filter designed by different window techniques perform better for reducing noise from signal. In this paper, we design high-pass filter by using various window methods such as Hanning, Hamming, Blackman, Kaiser. This paper also provides comparative study of highpass filters using above window. It has been seen that Kaiser window is better with respect to Hanning, Hamming, Blackman window.

Keywords: Blackman window, FIR filter, Hamming window, Hanning window, Kaiser window, Lowpass filter, MATLAB

I. Introduction

In different areas digital filter design techniques are widely used. In the digital filter, the input and output signals are digital or discrete time sequence. Digital filters are categorized in two parts as finite impulse response (FIR) and infinite impulse response (IIR). According to the frequency characteristics digital filter can be divided-lowpass, highpass, bandpass, and bandstop. Filtering can be applied to perform applications such as noise reduction, frequency boosting, digital audio equalizing, and digital crossover, among others.

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.
- v. They can be realized efficiently in hardware.
- vi. The filter start-up transients have finite duration.

1. Fir Filter design

To design a filter means to select the coefficients such that the system has specific characteristics. The required characteristics are stated in filter specifications. Most of the time filter specifications refer to the frequency response of the filter. There are essentially three well-known methods for FIR filter design namely:

- (a) The window method
- (b) The frequency sampling technique

(c) Optimal filter design methods ^[2]

1.1. Window design method

The window design method is first designs an ideal IIR filter and then truncates the infinite impulse response by multiplying it with a finite length window function. The result is a finite-impulse response filter whose frequency response is modified from that of the IIR filter. Multiplying the infinite impulse by the window function in the time domain results in the frequency response of the IIR being convolved with the frequency response of the window function.^[3]

Some of the windows commonly used are as follows:

1.1.1. Hanning window : The Hanning window is a raised cosine window . The hanning window is defined as

$$w(n) = \begin{cases} 0.5 - 0.5 \cos \frac{2\pi n}{M-1} & , \text{ for } n = 0 \text{ to } M-1 \\ 0, & \text{ elsewhere} \end{cases} \dots(1)$$

1.1.2. Hamming window: The hamming window is also a raised cosine window. The hamming window is defined as

$$w(n) = \begin{cases} 0.54 - 0.46 \cos \frac{2\pi n}{M-1} & , \text{ for } n = 0 \text{ to } M-1 \\ 0, & \text{ elsewhere} \end{cases} \dots(2)$$

1.1.3. Blackman window: The Blackman window is defined as

$$w(n) = \begin{cases} 0.42 - 0.5\cos\frac{2\pi n}{M-1} + 0.08\cos\frac{4\pi n}{M-1}, & \text{for } n = 0 \text{ to } M-1 \\ 0, & \text{elsewhere} \end{cases}$$

...(3)

1.1.4. Kaiser window: The Kaiser window with parameter β is defined as [2]

$$w(n) = \begin{cases} \frac{I_0^2\left(\beta\sqrt{1-\left(\frac{n-M/2}{M/2}\right)^2}\right)}{I_0^2(\beta)}, & \text{for } n = 0 \text{ to } M-1 \\ 0, & \text{elsewhere} \end{cases}$$

..... (4)

2. Design Technique of High pass FIR filter using Various Window Function:

2.1 Filter Specifications:

Table.1 Filter specification

Parameters	Values
Filter Type	High pass
Design method	FIR windows ($\beta=0.37$ for Kaiser window only)
Filter order	20,30
Sampling frequency	48000HZ
Cut-off frequency	10800HZ

3. Result and simulation

3.1. Haanning window:

From the table.1, we analyzed the high-pass filter using Hanning window in MATLAB and the response of the filter is given in fig.1 & fig.2 respectively at the order 20 & 30.

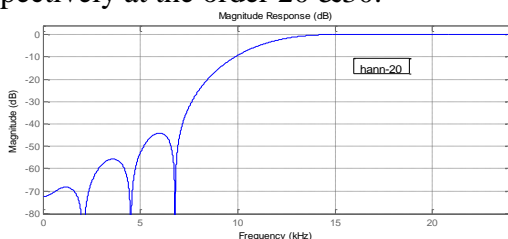


Fig.1a Magnitude response of HPF using Hanning window of order20

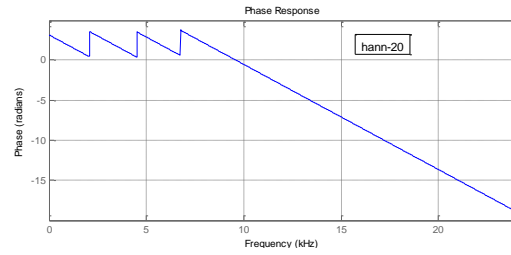


Fig.1b Phase response of HPF using Hanning window of order20

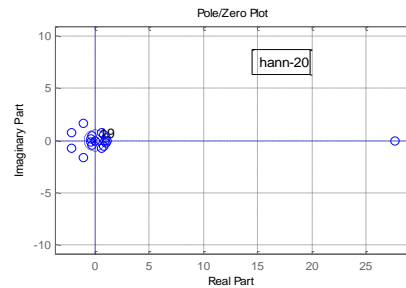


Fig.1c Pole/Zero plot of HPF using Hanning window of order20

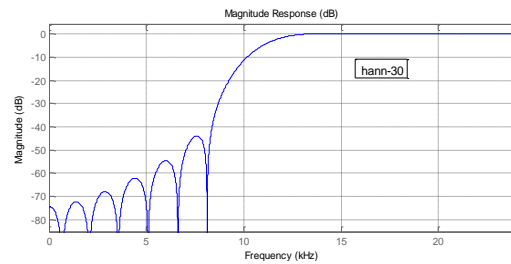


Fig.2a Magnitude response of HPF using Hanning window of order30

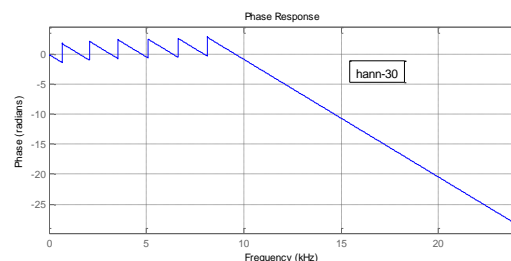


Fig.2b Phase response of HPF using Hanning window of order30

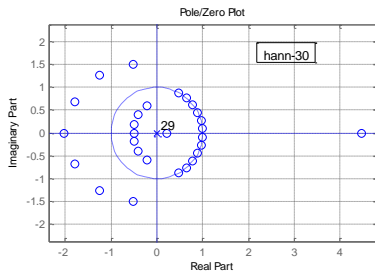


Fig.2c Pole/Zero plot of HPF using Hanning window of order 30

3.2. Hamming window:

From the table.1, we analyzed the high-pass filter using Hamming window in MATLAB and the response of the filter is given in fig.1 &fig.2 respectively at the order 20 &30.

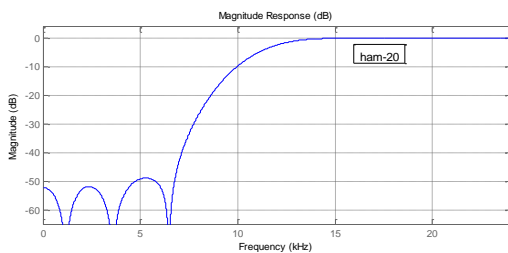


Fig.3a Magnitude response of HPF using Hamming window of order 20

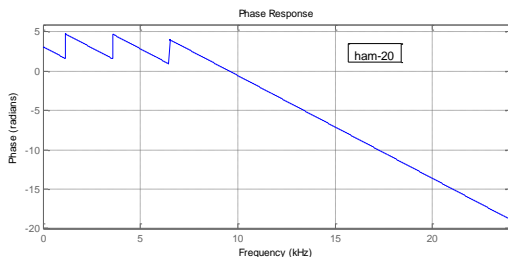


Fig.3b Phase response of HPF using Hamming window of order 20

Fig.3c Pole/Zero plot of HPF using Hamming window of order 20

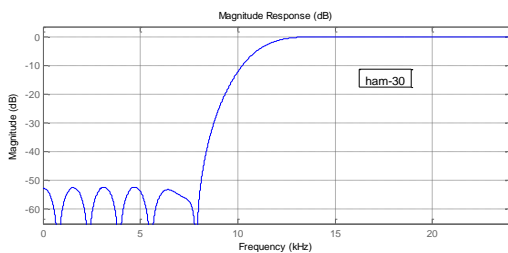


Fig.4a Magnitude response of HPF using Hamming window of order 30

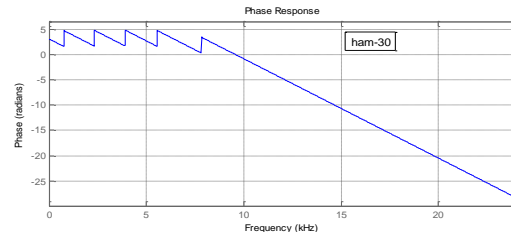


Fig.4b Phase response of HPF using Hamming window of order 30

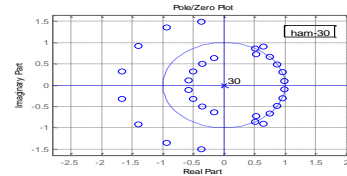


Fig.4c Pole/Zero plot of HPF using Hamming window of order 30

3.3. Blackman window:

From the table.1, we analyzed the high-pass filter using Blackman window in MATLAB and the response of the filter is given in fig.1 &fig.2 respectively at the order 20 &30.

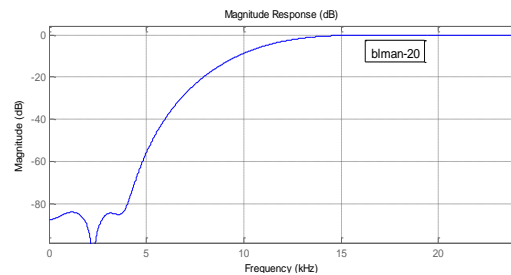


Fig.5a Magnitude response of HPF using Blackman window of order 20

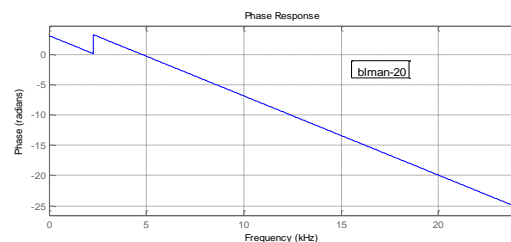


Fig.5b Phase response of HPF using Blackman window of order 20

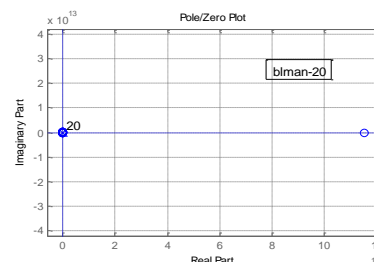


Fig.5c Pole/Zero plot of HPF using Blackman window of order 20

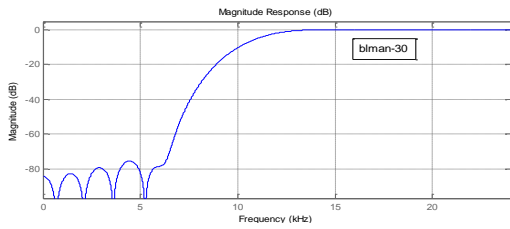


Fig.6a Magnitude response of HPF using Blackman window of order30

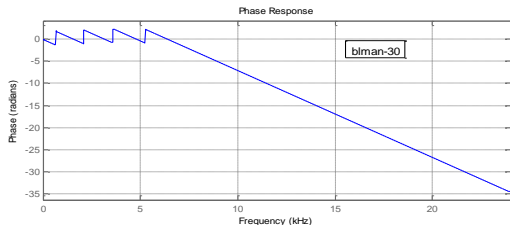


Fig.6b Phase response of HPF using Blackman window of order30

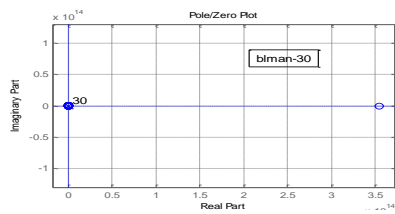


Fig.6c Pole/Zero plot of HPF using Blackman window of order30

3.4. Kaiser window:

From the table.1, we analyzed the high-pass filter using Kaiser window in MATLAB and the response of the filter is given in fig.1 &fig.2 respectively at the order 20 &30.

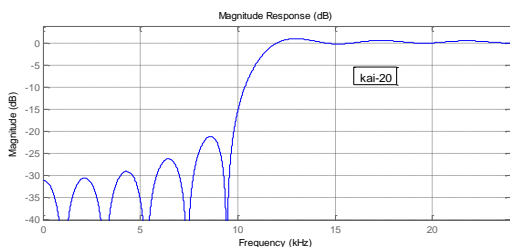


Fig.7a Magnitude response of HPF using Kaiser window of order20

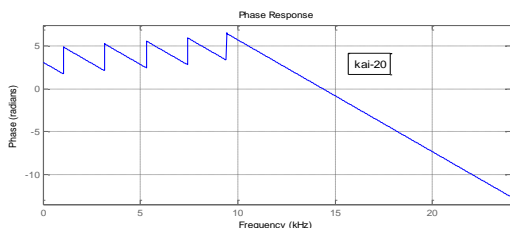


Fig.7b Phase response of HPF using Kaiser window of order20

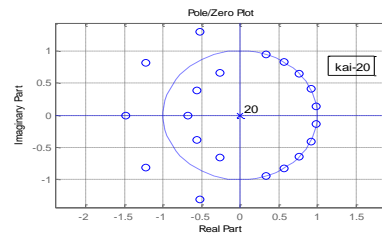


Fig.7c Pole/Zero plot of HPF using Kaiser window of order20

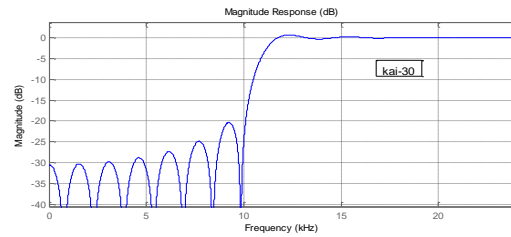


Fig.8a Magnitude response of HPF using Kaiser window of order30

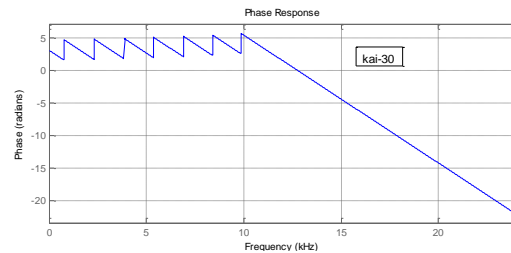


Fig.8b Phase response of HPF using Kaiser window of order30

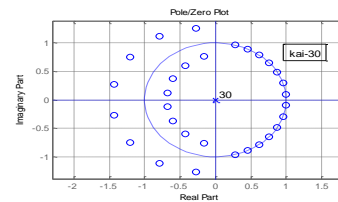


Fig.8c Pole/Zero plot of HPF using Kaiser window of order30

Table.2 Comparison between various window:

Window technique	Order of the filter	Width of main lobe	No. of side lobes	Relative side lobe attenuation (dB)
Hanning window	30	0.09375	6	-31.5
	20	0.14844	3	-31.5
Hamming window	30	0.085938	5	-41.7
	20	0.13281	3	-40.4
Blackman	30	0.10938	4	-58.1

n window	20	0.17188	2	-58.3
Kaiser window	30	0.054688	7	-13.5
	20	0.085938	5	-13.4



MANIRA KHATUN: She achieved her B.Tech (2007) and M.Tech (2010) degrees in Electronics & Communication Engineering under West Bengal University of Technology. She has seven years seven months teaching experience in Electronics and Communication related subjects. She is presently serving as an Assistant Professor, Department of Electronics and Communication Engineering at Mallabhum Institute of Technology, Bishnupur, Bankura, West Bengal, India.

From the table 2 we can see that as the order of the FIR filter increases the number of the side lobes also increases and width of the main lobe is decreased, that it is tending to sharp cut off that is the width of the main lobe decreased. If the width of the main lobe reduces then the number of the side lobes gets increased. So there should be a compromise between attenuation of side lobes and width of main lobe. On comparing all methods, the Blackman has the smallest side lobes at any order but the width of the main lobe is increased. In the Kaiser window for the lower order the width of the major lobe is less than the other windows. The Kaiser window gives best result. Therefore it is most commonly used window for FIR filter design.

5. Conclusions:

Digital filter plays a very important role in different digital signal processing applications. In Kaiser window, the main lobe width is 0.054688 for filter order 30 which means this window has less transition width and introduces more ripple. Digital filter can play a major role in speech signal processing applications such as, speech filtering, speech enhancement, noise reduction and automatic speech recognition.

References

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