



Magnitude and Phase Response of High Pass FIR filter using Rectangular, Hamming and Bartlett Window Techniques

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Abstract: A Digital Signal Processing is a main branch of electronics. In the digital control system, which is mixed in the input signal, has a great influence on the performance of the system. Therefore, processing of input signal has to be done to get useful signal. It is concerned with the representation by sequence of number or symbol and the processing of these signals. DSP have many more applications which are useful in our life i.e military processing of these signals. DSP have many more radar signal processing, sonar signal processing, navigation, instrument and control spectrum analysis etc. Signal filtering is the main application of DSP. In signal processing, a filter is a device or process that removes some unwanted components or features from a signal. In this we discuss about High Pass FIR filter using Rectangular, Hamming and Bartlett window techniques. By comparative analysis of these window techniques we conclude that Rectangular window technique is better in comparison with them techniques. In this technique the maximum wanted signals are present after cut off frequency.

Keywords: DSP, Digital Filter, FIR filter, Blackman, Rectangular, MATLAB.

1. INTRODUCTION

Digital signal processing is the technique employed for the mathematical manipulation of an information signal so as to modify or improve it. For this purpose filters are mainly used. Digital filters are used in numerous applications e.g. control system, system for audio and video processing and communication system. Digital filters can be applied to very low frequency signals, such as those occurring in biomedical and seismic applications very efficiently.[1]

Most signals we encounter are generated by natural means. However, a signal can also be generated synthetically or computer simulation. A signal carries information, and the objective of signal processing is to extract useful information carried by the signal. The method of information extractions depends on the type of signal and the nature of the information being carried by the signal. Thus, roughly speaking signal processing is concerned with the mathematical representation of the signal and the algorithmic carried out on it to extract the information present. The representation of the signal can be in terms of basic functions in the domain of the original independent variable(s), or it can be in terms of basis function in a transform domain. Likewise, the information extraction process may be carried out in the original domain of the signal or in transform domain [2].

There are two major types of digital filters are:

- 1) Infinite Impulse response (IIR) filters
- 2) Finite Impulse response (FIR) filters

Infinite Impulse Response (IIR) digital filter has the problems of phase non-linearity. Therefore it is a low

order filter which becomes highly unstable. Due to these factors, the FIR filter can be used to design a linear phase digital filter which is convenient for image processing and data transmission applications. The FIR filters are broadly used in various fields, such as long distance communication, image processing applications etc The system function of FIR filter is given below:

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

where, L is the length of the filter, and h[n] is the impulse response.[3]

2. WINDOW TECHNIQUE

The FIR filter design process using window function can be enumerated as

1. Define filter specification.
2. Specify a window function according to the filter specification.
3. Compute the filter order required for a given set of specification.
4. Compute the coefficients of the window function to be used.
5. Compute the coefficients the ideal filter according to the filter order.
6. Compute FIR filter coefficients in accordance the obtained window function and the coefficients of the ideal filter.



7. If the resulting filter has a very wide or a very narrow transition region, it is mandatory to change the filter order by decreasing it according to needs, and after this process the steps 4, 5 and 6 are iterated as many times as needs.[4]

In this paper the window techniques are used to design the FIR filter, which are

- 1.Rectangular
- 2.Hamming
- 3.Bartlett

3. WINDOWS AND THEIR EQUATIONS

Most digital signals are infinite, or sufficiently large that the data set cannot be manipulated as a whole. Sufficiently large signals are also difficult to analyze statically, because statistical calculation require all points to be available for analysis. In order to avoid these problems, engineers typically analyze small subsets of the total data, through a process called windowing. The window design method does not produce filters that are optimal (in the sense of meeting the design specifications in the most computationally efficient fashion), but the method is easy to understand and does produces filters that are reasonably good. Off all the hand design methods the window method is the most popular and effective[2]

Window can be categorized as fixed or adjustable window function. Fixed window such as rectangular, hanning, hamming, and blackman window have only one independent parameter window length which control the main-lobe width. Adjustable window have two or more independent parameters such as window length and one more additional parameters that can control the other window's characteristics [6,7]. The Kaiser window is a kind of two parameter window function. In a Kaiser window width of main lobe can be controlled by adjusting the length of the filter and side lobe level can be controlled by varying the other parameter. But the Kaiser window has the disadvantage of higher computational complexity due to the use of vessel function in the calculation of the window coefficient.

However the amplitude of side lobe and ripples in pass band is also increased. The function is

$$\omega(n) = \left\{ \alpha - (1 - \alpha) \cos\left(\frac{2\pi n}{M-1}\right), 0 \leq n \leq M-1 \right.$$

Otherwise the value of (n) is zero.

3.1. RECTANGULAR WINDOW

The rectangular window (sometimes known as the 32 **Tboxcar** **T0T0rT32T Dirichlet** (**0Twindow**) is the simplest window, equivalent to replacing all bu0T 0TN0T 0Tvalues of a data sequence by zeros, making it appear as though the waveform suddenly turns on and off: Other windows are designed to moderate these sudden changes, which reduces scalloping loss and improves dynamic

range. The rectangular window is the 1st order0T 0TB-spine window as well as the 0th power0T 0T32Tcosine window.[8]

$$W_R(n) = \begin{cases} 1 & \text{for } |n| \leq \frac{M-1}{2} \\ 0, & \text{otherwise} \end{cases}$$

3.2 Hamming Window

Hamming window has a bell-like shape. Its first and last samples are not zero. The window is optimized to minimize the maximum side lobe.[5]

$$W(n) = 0.54 - 0.46 \cos\left(\frac{2\pi n}{N-1}\right), 0 \leq n \leq N-1$$

$$= 0, \text{ otherwise}$$

3.3 Bartlett Window

The window function of a non-causal Bartlett window is expressed by

$$W_{Bar}(n) = \begin{cases} 1 + n, & -\frac{M-1}{2} < n < \frac{M-1}{2} \\ 1 - n, & \frac{M-1}{2} < n < \frac{M-1}{2} \end{cases}$$

3. DESIGN SIMULATION

Table 2.1 Filter parameters and value

PARAMETER	VALUE(Hz)
Sampling frequency(f_s)	45000
Cut off frequency(f_c)	10800

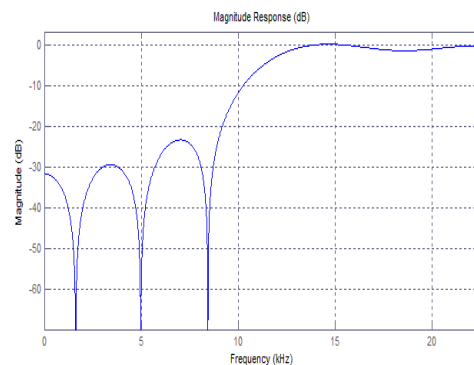


Fig.2.1 Magnitude response of Rectangular window Technique

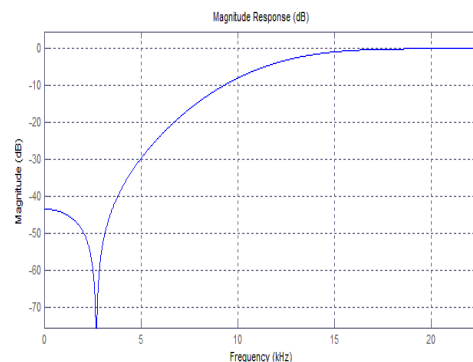


Fig.2.2 Magnitude Response of Hamming window Technique

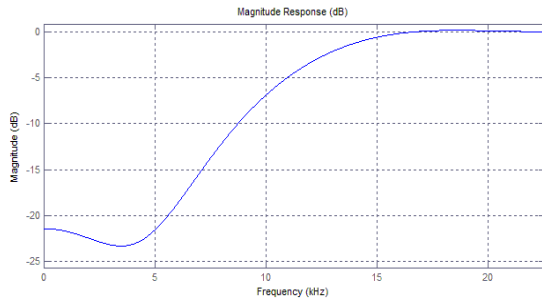


Fig 2.3 Magnitude Response of Bartlett Window Technique

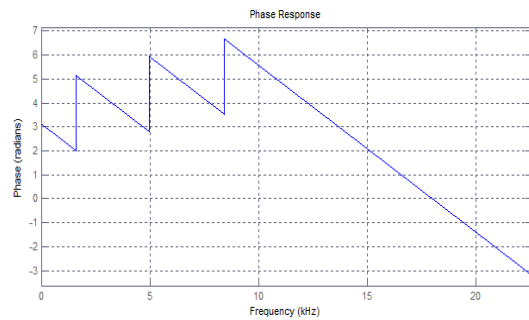


Fig 2.4 Phase Response of Rectangular Window Technique

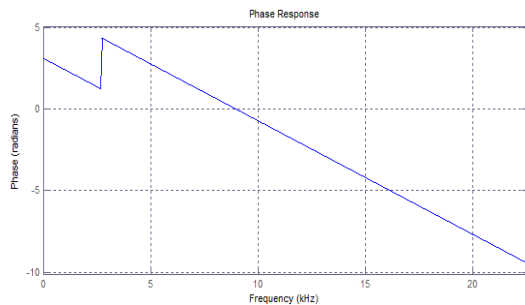


Fig 2.5 Phase Response of Hamming Window Technique

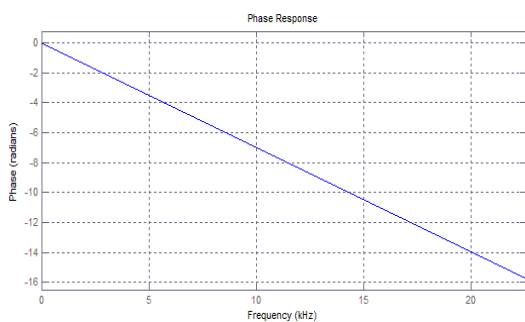


Fig 2.6 Phase Response of Bartlett Window Technique

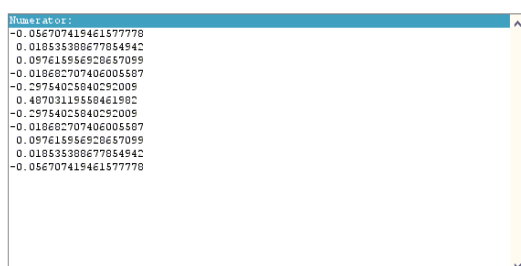


Fig 2.7 Filter Coefficient for Rectangular Window Technique

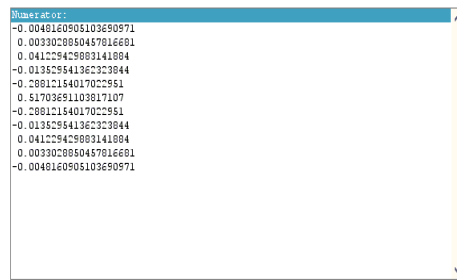


Fig 2.8 Filter Coefficient of Hamming Window Technique

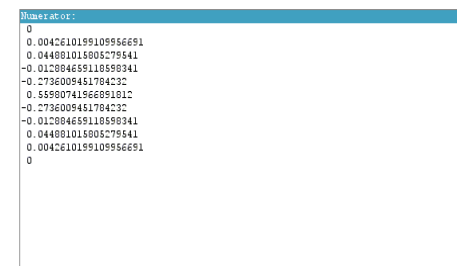


Fig 2.9 Filter Coefficient of Bartlett Window Technique

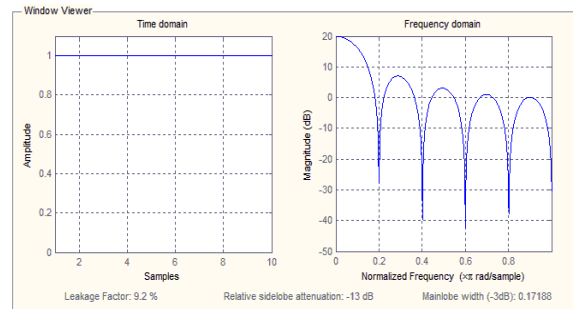


Fig 2.10 Time Domain and Frequency Domain of Rectangular Window

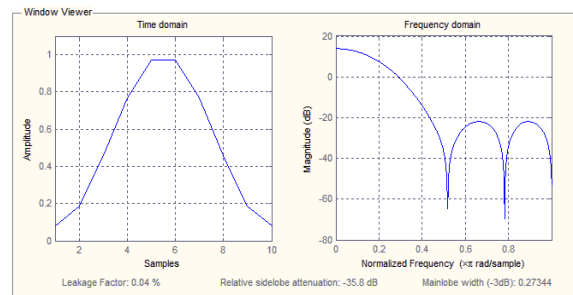


Fig 2.11 Time Domain and Frequency Domain of Hamming Window

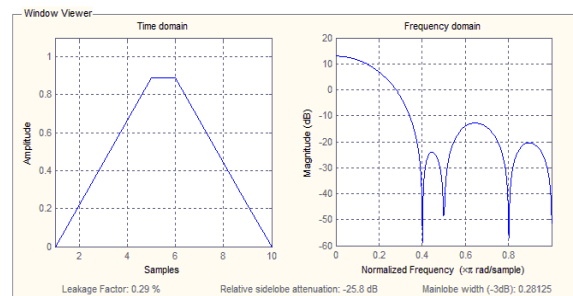


Fig 2.12 Time Domain and Frequency Domain of Bartlett Window



4. COMPARITIVE ANALYSIS

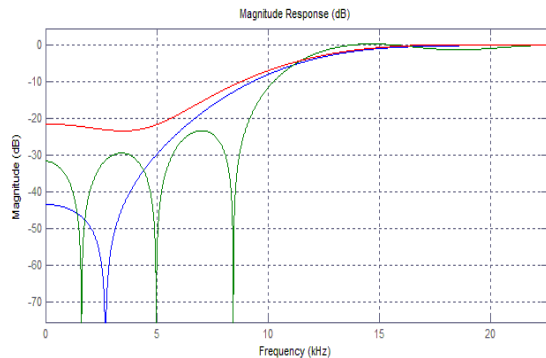


Fig 2.13 Magnitude Comparison of Rectangular, Hamming and Bartlett Window

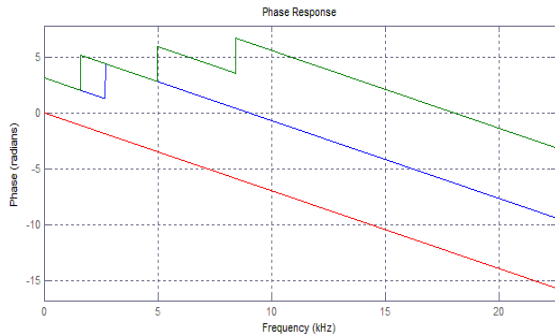


Fig 2.14 Phase Comparison of Rectangular, Hamming and Bartlett Window

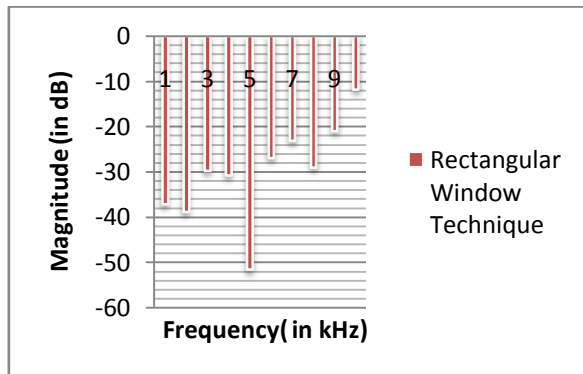


Chart 1.1 Magnitude and Frequency plot of Rectangular window

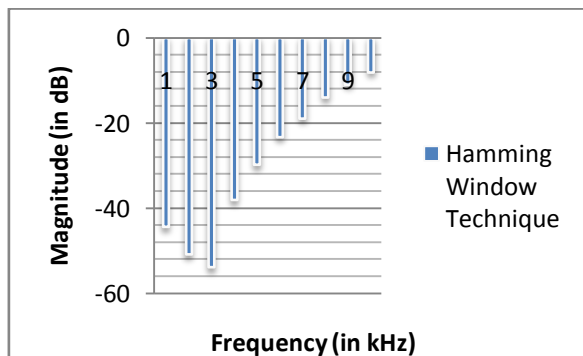


Chart 1.2 Magnitude and Frequency plot of Hamming window

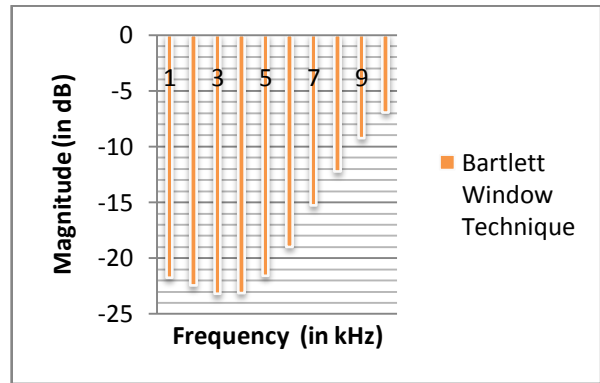


Chart 1.3 Magnitude and Frequency plot of Bartlett window

5. RESULT

Table 2.2 Simulation result from Matlab

Window Technique	Relative sidelobe attenuation	Mainlobe width (-3dB)	Leakage factor
Rectangular window	-13 dB	0.17188	9.2%
Hamming window	-25.8 dB	0.28125	0.29%
Bartlett window	-35.8 dB	0.27344	0.04%

Table 2.3 Magnitude and Frequency results of Rectangular, Hamming and Bartlett Window

Frequency (kHz)	Magnitude (dB)		
1	-37.1348	-44.3371	-21.7389
2	-38.8753	-50.7706	-22.4330
3	-29.7796	-53.7869	-23.1806
4	-30.7898	-37.9877	-23.0954
5	-51.6209	-29.7829	-21.5494
6	-26.9530	-23.2196	-18.9634
7	-23.2130	-18.8474	-15.2730
8	-29.0528	-13.9895	-12.2233
9	-21.0490	-10.8267	-09.2495
10	-11.8508	-8.0326	-06.9405

From MATLAB simulation result of Rectangular, Hamming and Bartlett window technique at sampling frequency (f_s) 45000 Hz and cut-off frequency (f_c) 10800 Hz.

6. CONCLUSION

In this research paper High pass FIR filter has been designed using MATLAB Rectangular, Hamming and Bartlett window technique. It concludes by comparative values of both magnitude and phase response of the filter using both the techniques at same frequency i.e.

$$f_s=45000\text{Hz and } f_c=10800\text{Hz}$$



In Rectangular windowing technique wanted signals are present in maximum after the cut-off frequency.

In Hamming windowing technique the unwanted signals are not present after the cut-off frequency, but this technique also cuts the wanted signals.

In Bartlett windowing technique wanted signals are present in maximum after the cut-off frequency but some unwanted signals are also present with the wanted signals too.

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BIOGRAPHIES



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