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A Comparative Performance Analysis of High Pass Filter Using Bartlett Hanning And Blackman Harris Windows

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ABSTRACT

In this paper, high pass filter has been designed and simulated using Bartlett Hanning and Blackman Harris window techniques. We represent the role of filter in our daily life. As a result good digital filter performance is important and hence to design a digital finite impulse response (FIR) filters satisfying all the required condition. Here the performance analyses of Bartlett Hanning and Blackman Harris window have been compared in time and frequency domain using MATLAB simulation. Comparing simulation result of different window, we found Blackman Harris window with best performance as Bartlett Hanning window. The Blackman Harris window is a more elaborate version of the sinusoid approach used by the Hanning window .it is observed that the Blackman Harris window gives better responses as Bartlett Hanning window.

Keywords: - DSP, Digital filter, FIR, High pass filter, Bartlett Hanning, Blackman Harris.

1. INTRODUCTION

Digital filters play an important role in digital signal processing applications. A digital filter is a mathematical algorithm implemented in hardware / software that operates on a digital input to produce a digital output [1]. In signal processing, a filter is a device or process that removes from the unwanted component of the signal. Digital filter are classified into two categories and they are the Finite Impulse Response (FIR) filter and Infinite Impulse Response (IIR) filter [2]. In the FIR system, the impulse response is of finite duration, this number of nonzero terms. On the other hand, the IIR system has an infinite number of nonzero terms [3]. There are mainly three methods used for FIR filter design:

- FIR filters design using windows.
- FIR filter design using frequency sampling method.
- Optimal or Minimax FIR filter design [4].

2. FIR FILTER

The response of the FIR filter depends only on the present and past input samples. These are some forms of FIR filter .They are given below [5]:

1. High pass filter,
2. Low pass filter,
3. Band pass filter,
4. Band stop filter and
5. All pass filter.

2.1 HIGH PASS FILTER

High pass filter because frequency above $\omega = 1/\tau$ tend to be passed with little attenuation or phase shift while those ω tend to be attenuated. The phase shift is positive while for the low pass will be negative.

FIR filter has following advantages over IIR filters

1. FIR filter has finite impulse response where as IIR has infinite impulse.
2. FIR filter is linear phase and can easily controlled whereas IIR filter has no particular phase and difficult to control.
3. FIR filter consist of only zeros but IIR filter has both zeros and poles.
4. The design methods are generally linear.
5. They are always stable.

MATLAB software is used to generate the simulation results. The benefit of using this software is that it enables us to use various tools to make the work easier. MATLAB is a very strong scientific computing and graphics software system which can be accurately mathematical filter design and therefore, the realization of MATLAB program is simple.

The features of an FIR filter are enumerated below:

1. It is an all zeros filter.
2. It is non-recursive in nature.
3. It does not use feedback.
4. The complexity in implementing is low
5. It requires higher order of filter for similar specification

3. WINDOW TECHINIQUES

Window Technique implicates a function called window Function. It is also known as Tapering Function. This report deals with some of the techniques used to design FIR filters. In the beginning the windowing method and the frequency sampling method are discussed in details with their merits and demerits [6]. The desired frequency of digital filter is periodic in frequency and can be expanded in a Fourier series, *i.e.*,

$$H_d(e^{j\omega}) = \sum_{n=-\infty}^{\infty} h_d(n)e^{-j\omega} \text{ ………………………(1)}$$

Where, $h(n) = \frac{1}{2\pi}\int_0^{2\pi} H(e^{j\omega})\, e^{j\omega n} d\omega$ …………….(2)

The Fourier coefficient of the series h(n) are identical to the impulse response of a digital filter. There are two difficulties with the implementation of above equation for designing digital filter First the impulse response is of infinite duration and second, the filter is non-causal and unrealizable. No finite amount of delay can make the impulse response realizable. Hence the filter resulting from a Fourier series representation of $H_d(e^{j\omega})$ is an unrealizable IIR filter.

The windows used in this paper to design the FIR are:

1. Bartlett Hanning window and
2. Blackman Harris window.

The digital filters are classified either as finite duration pulse response (FIR) and infinite duration of (IIR). It`s **z** transform of FIR filter is given by,

$$H(z) \triangleq \sum_{n=-\infty}^{\infty} h_n z^{-n} = \sum_{n=0}^{M} b_n z^{-n} \text{ ………… (3)}$$

Where, $M = N-1$

3.1 BARTLETT HANNING WINDOW FUNCTION

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

$$W_{bart}(n) = \begin{Bmatrix} 1+n, -\frac{M-1}{2} < n < 1 \\ 1-n, 1 < n < \frac{M-1}{2} \end{Bmatrix} \text{……(4)}$$

Where, n = number of samples
M = total number of sample point.

The Hanning window has a shape similar to that of half a cycle of cosine wave. The following equation defines the Hanning window.

$$W(n) = 0.5 - 0.5\cos\frac{2\pi n}{N}\,(c) \quad \text{……..……..(5)}$$

Where, N is length of the window and w is the window value.

The Bartlett Hanning window is useful for analyzing transients longer then time duration of window and for general-purpose applications.

3.2 BLACKMAN HARRIS WINDOW

Blackman Harris window is a higher order generalized cosine window. The Blackman Harris windows form a family of three and term window. The variation on the coefficient allows a compromise between main-lobe width and side- lobe level. The Blackman–Harris window has one degree of freedom which is used to minimize the level of side-lobes, and the other is used for the maximization of the roll-off rate. It defines the three-term Blackman Harris window as the one which uses both degrees of freedom to minimize side-lobe level.

$$\mathbf{W(n) = a_0+a_1+a_2\cos\frac{4\pi n}{N-1}\ for\ -\frac{N-1}{2} \le N \le \frac{N-1}{2}} \ldots\mathbf{(6)}$$

Where $a_{0,}a_{1,}a_2$ are constants.

$$\mathbf{A_0=\frac{1-\alpha}{2},\ a_1=\frac{1}{2}\ ,\ a_2=\frac{\propto}{2}}$$

The Blackman Harris Window is a modified version of Exact Blackman Window. The following above equations define the Blackman Harris window. It is useful for single tone measurement. The Blackman Harris window has a wider main lobe and a lower minimum side lobe level then the exact Blackman window. Harris use of windows for harmonic analysis.

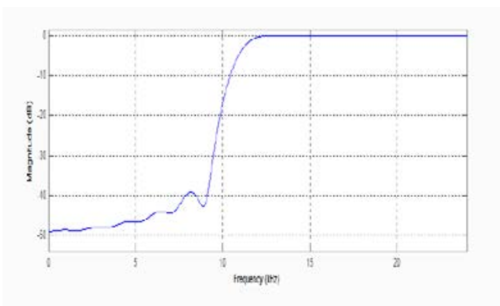

Fig.1 Magnitude Response of Bartlett Hanning Window Technique

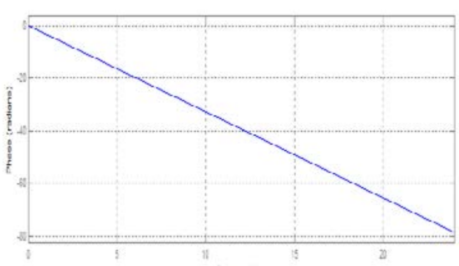

Fig.2 Phase Response of Bartlett Hanning Window Technique

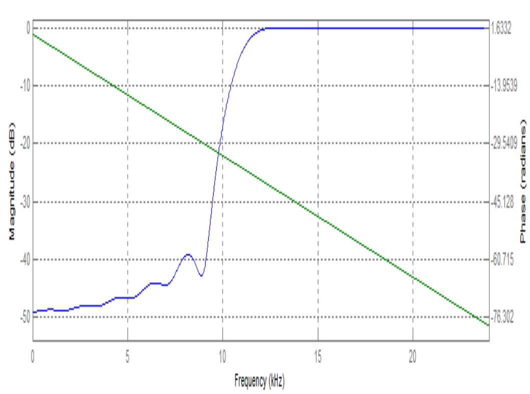

Fig.3 Magnitude [dB] and Phase response of Bartlett Hanning Window Technique

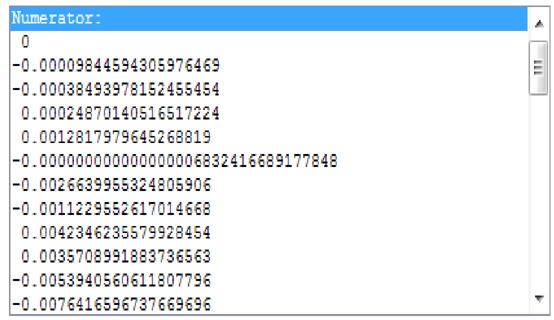

Fig. 4 Filter coefficient on Bartlett Hanning Window Technique

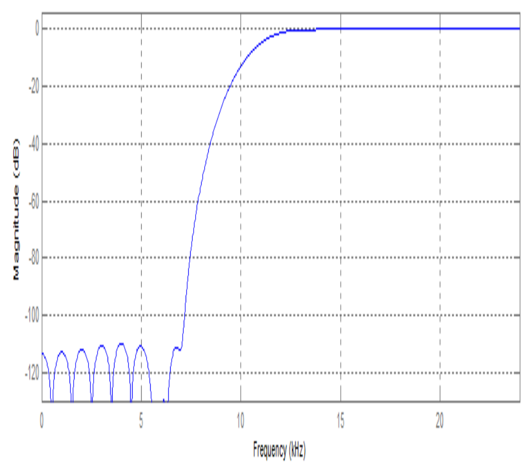

Fig. 5 Magnitude Response of Blackman Harris Window Technique

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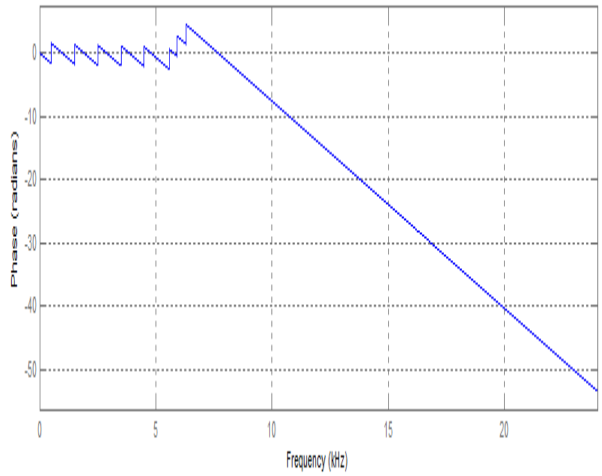

Fig. 6 Phase Response of Blackman Harris Window Technique

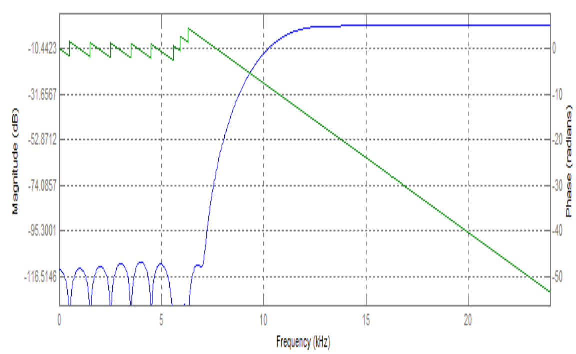

Fig. 7 Magnitude [dB] and Phase Response of Blackman Harris window technique

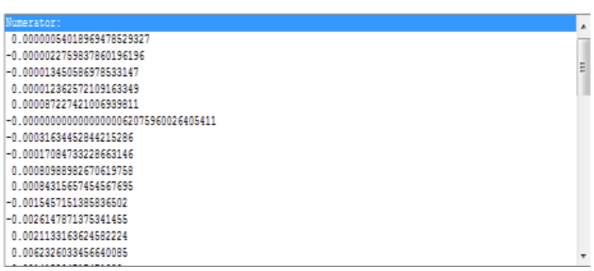

Fig.8 Filter co-efficient of Blackman Harris Window Technique

3. SIMULATION AND RESULT

Table 1. Parameter Specification

Parameter	Values
Sampling frequency (f_s)	48000Hz
Cut off Frequency (f_c)	10800Hz
Order (N)	50

Table 2. Filter co-efficient of Bartlett Hanning and Blackman Harris window Techniques

Bartlett- Hanning		Blackman-Harris	
Frequency (kHz)	**Magnitude (dB)**	**Frequency (kHz)**	**Magnitude (dB)**
1	**-48.692**	**1**	**-112.95**
2	**-48.636**	**2**	**-111.99**
3	**-48.061**	**3**	**-110.01**
4	**-47.326**	**4**	**-109.700**
5	**-44.730**	**5**	**-110.910**
6	**-46.7052**	**6**	**0**
7	**-44.443**	**7**	**-111.587**
8	**-39.551**	**8**	**-54.31**
9	**-42.106**	**9**	**-27.813**
10	**-16.885**	**10**	**-12.949**

4. CONCLUSIONS

In this paper, high pass filter has been designed and simulated using Bartlett – Hanning and Blackman – Harris Window Techniques. By analysis of performance of proposed FIR filter we conclude that Blackman – Harris Window Technique shows better than Bartlett – Hanning Window Technique. The performance of Bartlett – Hanning and Blackman – Harris Window has been mainly compared considering their magnitude and phase response using MATLAB simulation. Comparing simulation results of different window, this paper has found Blackman-Harris Window with best performance among them which is also expected from the theory. In all cases, it has been found Blackman-Harris Window showing superiority in performance and demonstrating best functionality among these Bartlett-Hanning Windows which is also expected.

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