Performance Analysis of Window Technique Based Band Reject FIR Filter

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ABSTRACT

The most important part of a Digital Signal Processing or DSP is a filter which passes the desired frequency components and rejects the unwanted signals as noise. So Digital filter play an important role in DSP based communication system. Digital filter has many advantages over the analog filter. FIR filter gives linear and stable performance as compare to IIR filter. In this paper Band reject filter is designed and analyzed using different window techniques. Blackman, Bartlett and Hamming windows are used for design simulation using Matlab. The performance of all the designs has been compared in terms of pass band ripples and roll off sharpness. The different filter orders of 16 and 36 is also used for design. It can be observed from the simulated results that Blackman window gives better roll off sharpness and Hamming window gives low pass band ripples. The result also shows that the performance of all the design is improved with increased filter order.

Keywords: *Band Reject filter, Bartlett window, Blackman window, Hamming window.*

I. INTRODUCTION

Digital signal processing is the processing of digital signals which consists a stream of numbers in binary form. DSP is based upon the fact that it is possible to build up a representation of the signal in a digital form [1]. This is done by sampling the voltage level at regular time intervals and converting the voltage level at that instant into a digital number proportional to the voltage. This process is performed by a circuit called an analogue to digital converter, A to D converter or ADC. In order that the ADC is presented with a steady voltage whilst it is taking its sample, a sample and hold circuit is used to sample the voltage just prior to the conversion. Once complete the sample and hold circuit is ready to update the voltage again ready for the next conversion. In this way a succession of samples is made.

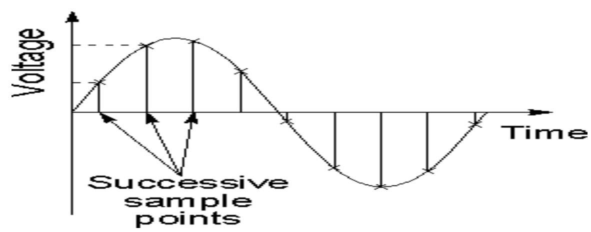

Fig.1 Waveform sampling for Digital Signal Processing.

Once in a digital format the real DSP is able to be undertaken. The digital signal processor performs complicated mathematical routines upon the representation of the signal. However to use the signal it then usually needs to be converted back into an analogue form where it can be amplified and passed into a loudspeaker or headphones. The circuit that performs this function is not surprisingly called a digital to analogue converter, [2] D to A converter or DAC.

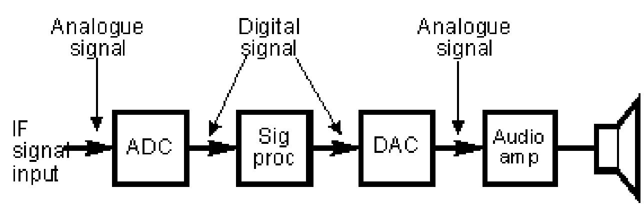

Fig.2 Digital Signal Processor block diagram.

Digital filters are used for two general purposes. One is separation of signals that have been combined and the other is restoration of signals that have been distorted in some way. Analog filters can be used for these same tasks however, digital filters can achieve far superior results.

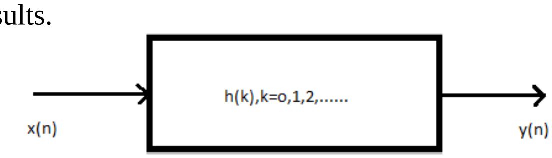

Fig.3 Digital Filter.

Where x(n) is input sequence, y(n) is output sequence and the impulse response of the filters can be represented by the sequence h(k). Mainly the digital filters are of two types. One is Finite Impulse Response or FIR filter and the other one is Infinite Impulse Response or IIR filter. Filters are also known as non recursive filters where IIR filters are recursive filters [1], [2]. IIR filters are difficult to control and have no particular phase, whereas FIR filters make a linear phase always possible. IIR can be unstable, whereas FIR is always stable. IIR when compared to FIR can have limited cycles, but FIR has no limited cycles. IIR is derived from analog, whereas FIR has no analog history. IIR filters make polyphase implementation possible, whereas FIR can always be made casual. The output response of FIR filter is given by the equation:

$$y(n) = \sum_{k=0}^{N-1} h(k)x(n-k) \tag{1}$$

The output response of IIR filter is given by the equation

$$y(n) = \sum_{k=0}^{\infty} h(k)x(n-k) \tag{2}$$

II. FIR DESIGN WINDOWS

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. This is in contrast to infinite impulse response (IIR) filters, which may have internal feedback and may continue to respond indefinitely, usually decaying.

Properties of FIR filters

FIR Filter can easily be designed to be "linear phase". Put simply, linear-phase filters delay the input signal but don't distort its phase. FIR filters are simple to implement. On most DSP microprocessors, the FIR calculation can be done by looping a single instruction. FIR filters are suited to Multirate application.

Types of FIR Filter

Lowpass filter, Highpass filter, BandPass filter, Band reject filter.

Designing of Band reject FIR Filter

Here our main emphasis is on Band rejected FIR filter. A band rejected filter is an electronic device or circuit that rejects signals between two specific frequencies to stop, but that discriminates against signals at other frequencies. The well known methods of design techniques for linear phase FIR Band reject filter are [2], [3], Fourier method, Window method, Frequency sampling method**.**

Window Techniques

The Window method is the most popular and effective method because this method is simple, convenient, fast and easy to understand. The main advantage of this design technique is that the impulse response coefficient can be obtained in closed form without the need for solving complex optimization problems [3]. The method is to make an ideal filter in the frequency domain, and then translate it into the discrete time domain. However this will give an infinite impulse response. To compensate for this, a window function is multiplied into the ideal impulse response.

Design Procedure

The basic design procedure is first decide the desired frequency response of the filter $H_d(e^{jw})$ then calculate the desired impulse response $h_d(n)$ by inverse fourier transform of $H_d(e^{jw})$, because $h_d(n)$ is infinitely long [4], we have to deal with it by window function to get to the unit impulse response h(n). Now it is written as

$$h(n) = w(n).\, h_d(n) \tag{3}$$

Where w(n) is the window function. Window techniques used for the designing of FIR Band Reject filter [4, 5] are Hamming Window, Hanning Window, Bartlett Window, Blackman Window etc.

Hamming Window	$w(n) = \alpha-\beta\cos(\frac{2\pi n}{N-1})$, α=0.54, β= 1-α=0.46
Hanning Window	$w(n) = 0.42-0.5\cos\frac{2\pi n}{N-1}+0.08\cos\frac{4\pi n}{N-1}$
Bartlett Window	$w(n) = 1-\frac{2(n-\frac{N-1}{2})}{N-1}$
Blackman Window	$w(n)= 0.42-0.5\cos\frac{2\pi n}{M-1}+0.08\cos\frac{4\pi n}{M-1}$

The frequency response of designed FIR filter is obtained by taking Fourier transform of h(n) [6].

$$H(ejw) = \sum_{n=0}^{N-1}(h(n)e^{-jnw}) \tag{4}$$

III. BAND REJECT FILTER DESIGN

The magnitude response of the Bandreject filter using Bartlett window, Blackman window and Hamming window is shown in Fig.4, Fig.5 and Fig.6 respectively for filter order N = 16, normalized cut-off frequencies ω_1

=0.976 rad/s, ω_2=1.53rad/s and sampling frequency Fs = 27khz.

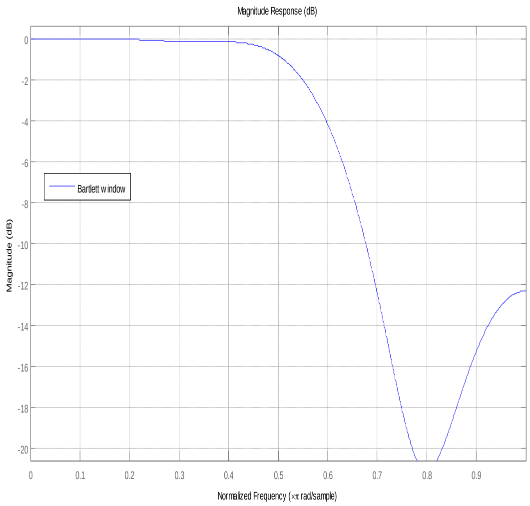

Fig.4 Bartlett window for N=16.

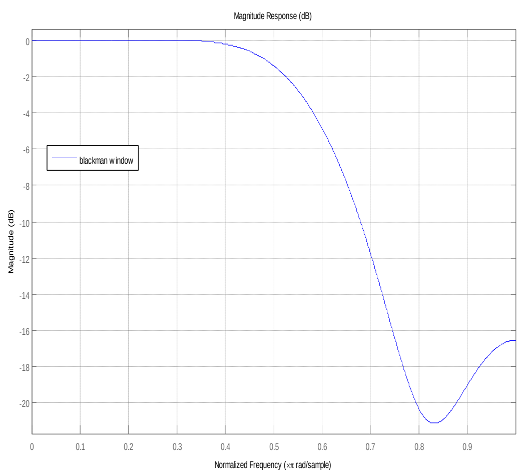

Fig.5 Blackman window for N=16.

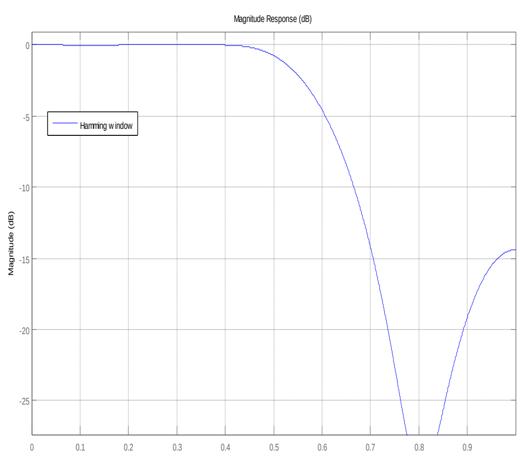

Fig.6 Hamming window for N=16.

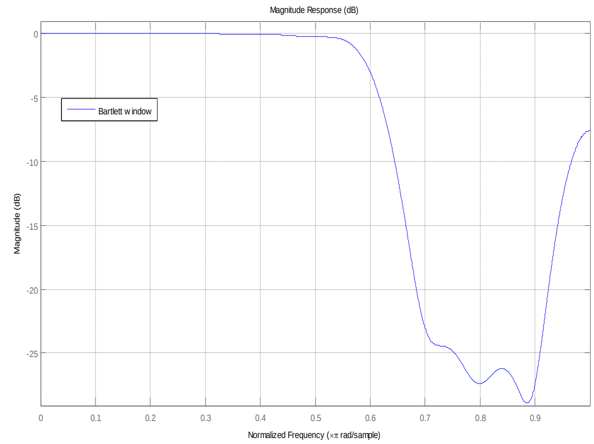

Fig.7 Bartlett window for N=36.

The magnitude response of the Bandreject filter using Bartlett window, Blackman window and Hamming window is shown in Fig. 4, Fig.5 and Fig.6 respectively for filter order 36 , normalized cut-off frequencies ω_1= .976 rad/s, ω_2=1.53rad/s and sampling frequency Fs=27khz.

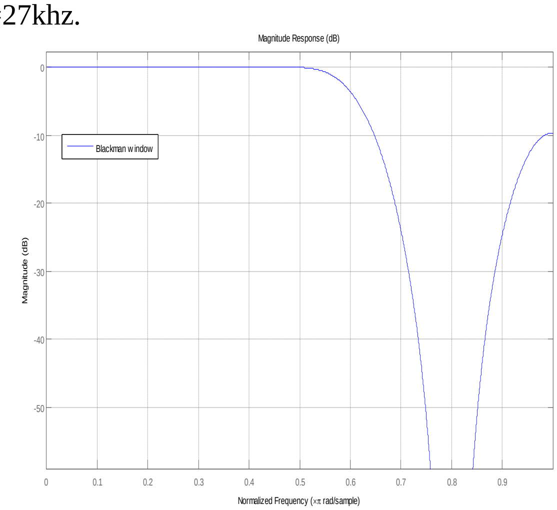

Fig.8 Blackman window for N=36.

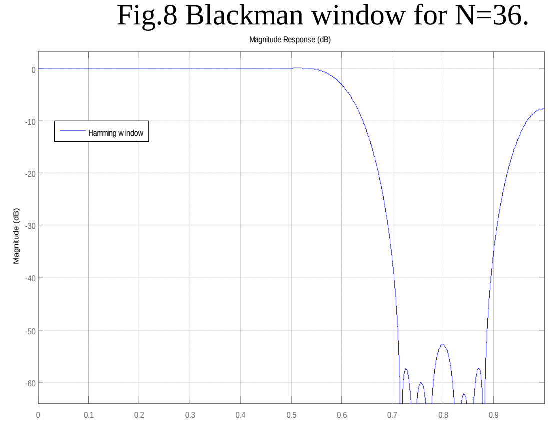

Fig.9 Hamming window for N=36.

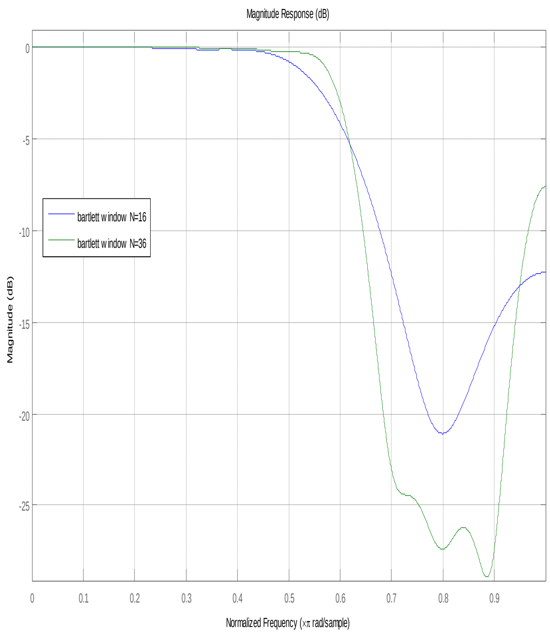

Fig.10 Bartlett window N=16, N=36.

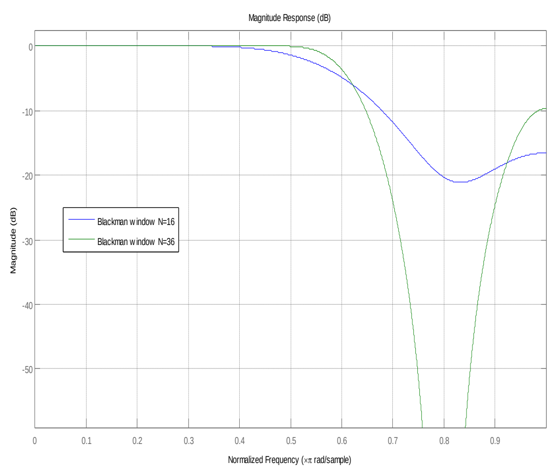

Fig.11 Blackman window for N=16, N=36.

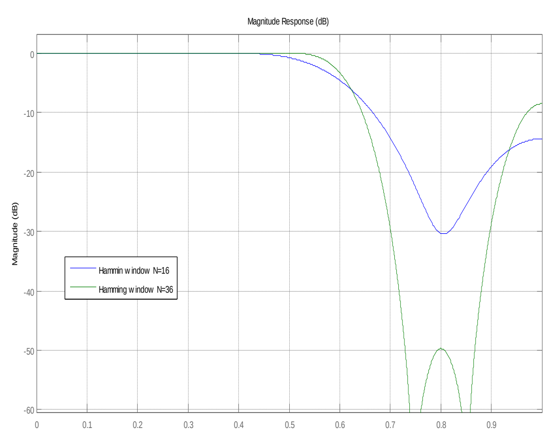

Fig.12 Hamming window for N=16 and N=36.

IV. RESULT ANALYSIS

Comparison of different window techniques in terms of filter parameters with changing the order is observed from the different magnitude response of the Band reject filter is shown in table.1.

Table1. Comparison of different Window Technique

Order	Window Technique	Transition Width (KHZ)	Roll off Sharpness (dB/KHZ)	Pass band Ripples (dB)
N=16	Bartlett	2.69	-6	0.01
	Blackman	4.47	-5.28	0.003
	Hamming	2.68	-10.37	-0.004
N=36	Bartlett	1.89	-48.25	-0.11
	Blackman	3.04	-31.6	-0.10
	Hamming	1.48	-94.25	-0.12

The magnitude responses of different design techniques for Band Reject FIR filter with normalized cut-off frequency normalized cut-off frequencies ω_1= .976 rad/s, ω_2=1.53rad/s and sampling frequency Fs = 27 kHz and filter order = 16 and 36, are illustrated in Fig.11 and Fig.12.

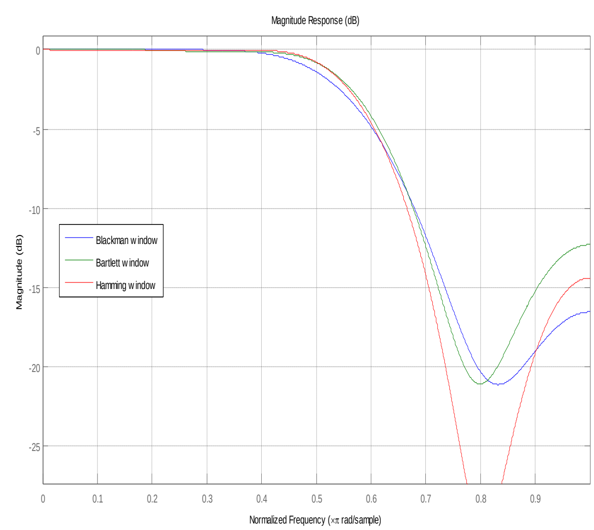

Fig.13 Blackman, Bartlett and Hamming window for N=16.

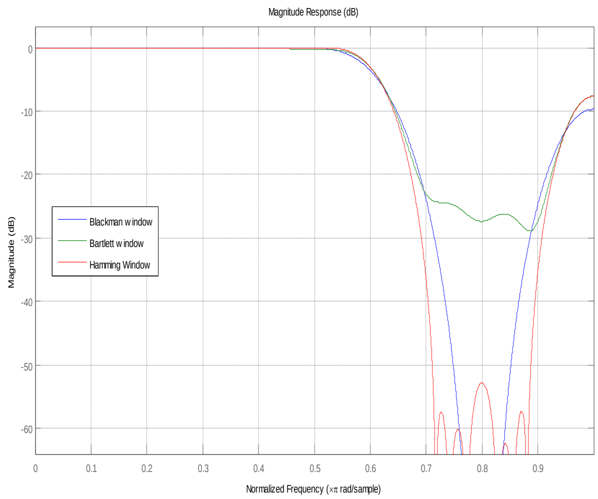

Fig.14 Blackman, Bartlett and Hamming window for N=36.

V. CONCLUSION

Band Reject FIR filter using Blackman window gives better roll off sharpness from pass band to stop band at the cut off frequencies ω_1 = .976 rad/s, ω_2=1.53rad/s but the magnitude frequency response in fig.13 and fig.14 clears that it has more pass band ripples. Hamming window has less pass band ripples comparing with the Blackman window and Bartlett window. It is also seen from result by increasing the order of the filter pass band ripples also increases.

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REFERENCES

[1] Dr. S.Palani, D. Kalaiyarasi, "Digital Signal Processing" First Edition Ane Books Pvt. Ltd, pp.1.1, 3.2, 4.28, 2010

[2] J.G.Proakis and D.G.Manolakis, "Digital Signal Processing Principles, Algorithms and Applications" Forth Edition Prentice-Hall, pp.5, 664-666, 2009.

[3] Saurabh Singh Rajput, Dr.S.S.Bhadauria "Implementation of FIR filter using efficient window function and its application in filtering a speech signal". International journal of Electrical, Electronics and Mechanical Controls. Volume 1 Issue 1, pp.1-8, 2012.

[4] Saurabh Singh Rajput, Dr. S.S. Bhadauria, "Comparison of Band-stop FIR Filter using Modified Hamming Window and Other Window functions and Its Application in Filtering a Mutitone Signal", International Journal of Computer Science & Engineering Technology, Volume 1, pp.325-328, 2012.

[5]Subhadeep Chakraborty Advantages of Blackman Window over "Hamming Window Method for designing FIR Filter". International Journal of Computer Science & Engineering Technology, Volume 4, pp.1181-1189, 2013.

[6] Smt.D.Swetha[1], Ms.K.Suneetha Krishna[2], Ms.A.Saritha[3] & Ms.V.Shamily[4]" Design of FIR BSF using modified hamming window". Journal of Information, Knowledge and Research in Electronics and Communication Engineering, Volume 2, pp.311-315, 2012.

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