Designing a Low- Pass Fir Digital Filter By Using Bartlett Hanning and Blackman Harris Window Technique

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ABSTRACT

In this paper, we have designed the low pass fir digital filter using Bartlett Hanning & Blackman Harris Window Techniques of order 10. The design of frequency-selective filters, the desired filter characteristics is specified in the frequency domain in terms of the desired magnitude and phase response of the filter. In the filter design process, we determine the coefficients of a casual FIR filter by using MATLAB simulation.

Keywords – *DSP, Digital Filter, Low Pass Filter, FIR, Bartlett Hanning Window and Blackman Harris Window.*

1. INTRODUCTION

Digital Signal Processing (DSP) is an area of science and engineering that has developed rapidly over the past 40 years [2]. It is said that the origin of DSP techniques can be traced to the seventeenth century when finite difference methods numerical integration methods, and numerical interpolation methods were developed to solve physical problems involving continuous variables and functions [1]. This rapid development is a result of the significant advances in digital computer technology and integrated-circuit fabrication [2].

DSP techniques used in a variety of areas which include speech, radar, sonar, image, etc. These techniques are applied in spectral analysis, channel vocoders, homomorphism processing systems, speech synthesizers, linear prediction system, analyzing the signals in radar tracking etc [1].

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 Finite Impulse response (FIR) filter can be used to design a linear phase digital filter which is convenient for image processing and data transmission applications [9]. As compare to IIR filter, the FIR filter is a non-recursive (without feedback) structure, finite precision mathematical error is very small, while IIR filter is recursive (with feedback) structure and parasitic oscillation may occur because of IIR filter. FIR filter gives better amplitude and linear phase characteristics and also avoid the drift, noise and distortion as compare to IIR filters [10]. The FIR filters are broadly used in various fields, such as long distance communication, image processing applications etc [9].

The main reasons for such wide applications are due to numerous advantages of DSP techniques are as following-

1. Digital signals are easily stored on magnetic media (tap or disk) without deterioration or loss of signal fidelity beyond that introduced in the A/D conversion.

2. Accuracy considerations also play an important role in determining the form of the signal processor [2].

3. Storage of digital data is very easy. A signal can be stored on various storage media such as magnetic tapes, disks and optical disks without any loss. On the other hand, stored analog signals deteriorate rapidly as time progresses and cannot be recovered in their original [1].

Disadvantages of DSP- Though the advantages are many, there are some drawbacks associated with processing a signal in the digital domain.

1. However, such high sampling frequencies are not used since the resolution of the A/D converter decreases with an increase in the speed of the converter.
2. Digital processing needs 'pre' and 'post' processing devices like analog-to-digital and digital-to-analog converters and associated reconstruction filters. T his increases the complexity of the digital system.
3. Moreover, active devices are less reliable than passive components[1].

Application of DSP-

1. Instrumentation and control spectrum analysis, position and rate control, noise reduction, data compression, digital filter, PLL, function generator, servo control, robot control and process control.
2. Seismology DSP techniques are employed in geographical exploration for oil and gas, detection of underground nuclear explosion and earthquake monitoring.
3. Digital signal processing techniques are widely used in the biomedical field to facilitate the monitoring, diagnosis and analysis of abnormalities in the body its important areas of application are –
   (a) Removal of artifacts.
   (b) Electrocardiogram (ECG).
   (c) Electroencephalogram (EEG).
   (d) Phonocardiogram (PCG).
   (e) Speech processing [1].

2. FIR FILTER DESIGN USING WINDOW TECHNIQUES

In the design of FIR filters using any window technique, the order can be calculated using the formula given by

$$N = \frac{-20log(\sqrt{\delta p \delta s}) - 13}{14.6(fs - fp)/Fs}$$

where, δp is the passband ripple, δs is the stopband ripple, f_p is the frequency, f_s is the stop band frequency and F_x is the sampling frequency.

2.1 BARTLETT HANNING WINDOW FUNCTION

The window function of Bartlett Hanning window is expressed by

$$w(n) = a0 - a1\left|\frac{n}{N-1} - \frac{1}{2}\right| - a2\cos\left(\frac{2\pi n}{N-1}\right)$$

2.2 BLACKMAN HARRIS WINDOW FUNCTION

The equation for the symmetric 4-term Blackman-harris window of length N is

$$w(n) = a0 - a1\cos\left(\frac{2\pi n}{N-1}\right) + a2\cos\left(\frac{4\pi n}{N-1}\right) - a3\cos\left(\frac{6\pi n}{N-1}\right) \quad 0 \leq n \leq N-1$$

The equation for the periodic 4-term Blackman-harris window of length N is

$$w(n) = a0 - a1\cos + a2\cos\left(\frac{4\pi n}{N}\right) - a3\cos\left(\frac{6\pi n}{N}\right) \quad 0 \leq n \leq N-1$$

The periodic window is N-periodic. The following table lists the coefficients:

Coefficient	Value
a0	0.35875
a1	0.48829
a2	0.14128
a3	0.01168

3. SIMULATION AND RESULT

Table 1: Parameter Specification

PARAMETER	VALUES
Sampling Frequency(F_s)	48000
Cut off Frequency(F_c)	10800
Order(N)	10

Table 2: Filter Magnitude of Bartlett Hanning and Blackman Harris

S .N.	Frequency	Window Techniques	
		Bartlett Hanning	Blackman Harris
1.	0.1 π	11.78784	9.49142
2.	0.2 π	7.783002	7.44910
3.	0.3 π	0.311631	3.96915
4.	0.4 π	-16.1766	-1.34491
5.	0.5 π	-21.71704	-8.23040
6.	0.6 π	-59.98652	-17.86716
7.	0.7 π	-24.38517	-30.89744
8.	0.8 π	-35.41817	-50.53611
9.	0.9 π	-32.38386	-93.56658

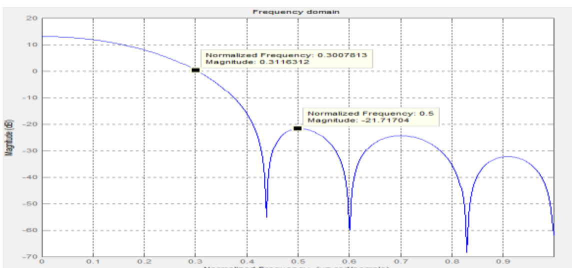

Fig. 1 Magnitude response of Bartlett Hanning Window Technique

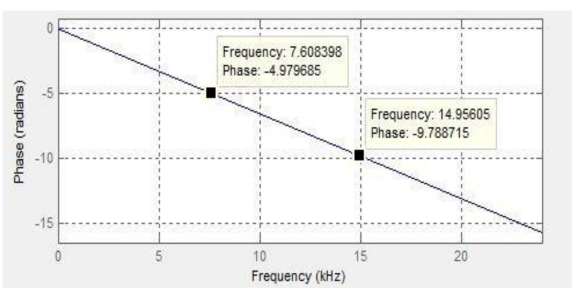

Fig. 2 Phase response of Bartlett Hanning Window Technique

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Numerator:
 0
-0.0057141467374695444
-0.034346188249966873
 0.031962439103326329
 0.28013032793224818
 0.45593513590372381
 0.28013032793224818
 0.031962439103326329
-0.034346188249966859
-0.0057141467374695444
 0
```

Fig. 3 Filter coefficient of Bartlett Hanning Window Technique

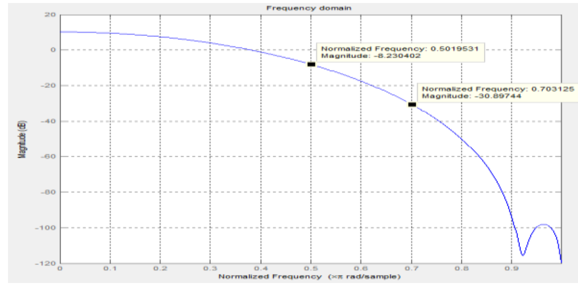

Fig.4 Magnitude response of Blackman Harris Window Technique

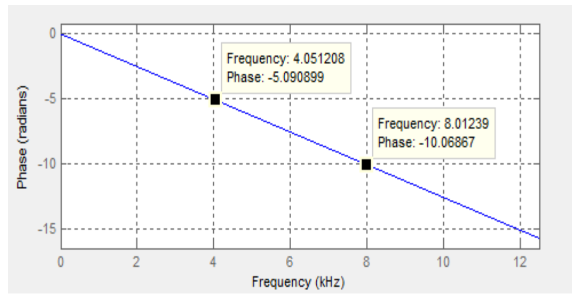

Fig. 5 Phase response of Blackman Harris Window Technique

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Numerator:
 0.0000027942585915432229
-0.00053143919370153699
-0.010075013629768275
 0.019634472724500283
 0.25819611419344796
 0.46554614329386007
 0.25819611419344801
 0.01963447272450029
-0.010075013629768276
-0.0005314391937015371
 0.0000027942585915432229
```

Fig. 6 Filter coefficient of Blackman Harris Window Technique

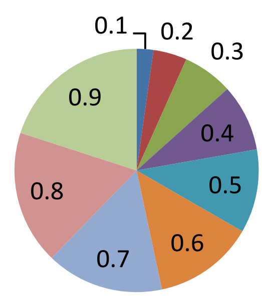

Fig. 7 Magnitude and Frequency plot of Bartlett Hanning Window Technique.

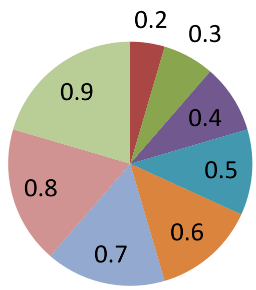

Fig. 8 Magnitude and Frequency plot of Blackman Harris Window Technique

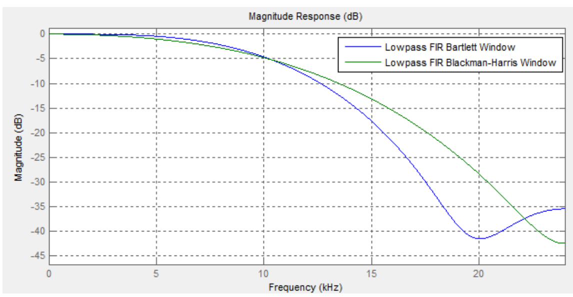

Fig. 9 Magnitude response of Bartlett Hanning and Blackman Harris Window Technique

4. CONCLUSIONS

In this research paper Low pass FIR Filter has been designed by using Bartlett Hanning and Blackman Harris Window Technique. We observe by analysis that Blackman Harris Window Technique has better magnitude response than Bartlett Hanning Window Technique.

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