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Designing A Low Pass Fir Digital Filter By Using Rectangular Window and Blackman Window Technique

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Abstract: digital filter plays an important role in today's field of communication. Without digital filter we cannot think about proper communication because noise occurs in channel. For removing of noise we use various type of digital filter. In this paper, we design of fir filter using two window techniques i.e., rectangular window and blackman window and the comparison of the result obtained. The fir filter is design using the windows matlab and the results are being explained for each window separately and the result for comparing both the windows is also shown.
Keywords: low pass filter, fir filter, rectangular window, blackman window.

I. INTRODUCTION

Digital signal processing(DSP) is the process of analyzing and modifying a signal to optimize or improve its efficiency or performance. It involves applying various mathematical and computational algorithms to analog and digital signal to produce a signal that's of higher quality than the original signal[1]. In signal processing technique a filter is a component which eliminates unwanted elements of the signal and extracts the desired parts of the signal by filtering the original signal. Filter structure are classified into two types:[2]

A. IIR Filter

The Infinite Impulse Response filters have an impulse response function which is non zero over an infinite length of time.[2]

B. Fir Filter

The Finite Impulse Response filters have finite impulse response function which has finite length of time. The output of filters simply the convolution of impulse function and the input signal.[2]

C. Advantages of Fir Filter Over IIR Filter

1) Simple to design, delay the input (linear phase) without altering the phase.
2) Calculations are simple and need single instruction for looping.
3) They are always stable.
4) They can realize efficiently in hardware.[3]

II. IMPULSE RESPONSE

In the signal processing, the impulse response or impulse response function of a dynamic system is its output when presented with a brief input signal, called impulse. More generally, an impulse response refers to the reaction of any dynamic system in response to some external change.[4]

III. FREQUENCY RESPONSE

Frequency response is the quantitative measure of the output spectrum of a system or device in response to a stimulus, and is used to characterize the dynamic of the system. It is measure of magnitude and phase as a function of output as a function of frequency, in comparison to input.[4]

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IV. WINDOW METOD

The desired frequency response of any digital filter is Periodic in frequency(fourier series), i.e.
$H_d(e^{jw})=\sum_{n=-\infty}^{\infty} h_d\,(n)e^{-jw}$

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

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 equations for designing a digital filter. First, the impulse response is of infinite duration. And second, the filter is non-causal and unrealizable.

The infinite duration response can be converted to a finite duration impulse response by truncating the infinite series at n=±N. But, this result in undesirable oscillation in pass band and stop band of the digital filter. These undesirable oscillations can be reduced by using a set of time-limited weighting functions, $w(n)$, referred to as window functions, to modify the Fourier coefficients.[5]

A. Rectangular Window Function

The rectangular window (sometime known as the boxcar or Dirichlet window) is the simplest window, equivalent to replacing all but N values of a data sequence by zeros, making it appear as though the waveform suddenly turns on and off; ω(n)=1

$$\omega_R = \begin{cases} 1\ for\ |n| \le \frac{M-1}{2} \\ 0,\ otherwise \end{cases}$$

The rectangular window is the 1st order B-spline window as well as the 0th power cosine window.[6]

B. Blackman Window Function

The following equation defines the Blackman window of length N.
Where,
$h(n)=\frac{1}{2\pi}\int_0^{2\pi} H(e^{jw})e^{jw}dw$

$$\omega(n) = 0.42 - 0.5cos\frac{2\pi n}{N-1} + 0.08cos\frac{4\pi n}{N-1},$$

$0 \le n \le M-1$Where M is N/2 for N even and (N+1)/2 for N odd. In the symmetric case, the second half of the Blackman window M ≤ n ≤ N-1 is obtained by flipping the first half around the midpoint when using a Blackman window FIR filter design. The periodic Blackman window is constructed by extending the desired window length by one sample to N+1.[7]

V. RESULTS AND SIMULATIONS

Table Parameter specification

Parameter	Values
Sampling frequency	48000Hz
Cut off frequency	10800Hz
Order	10

A. Simulated Result Of Rectangular Window

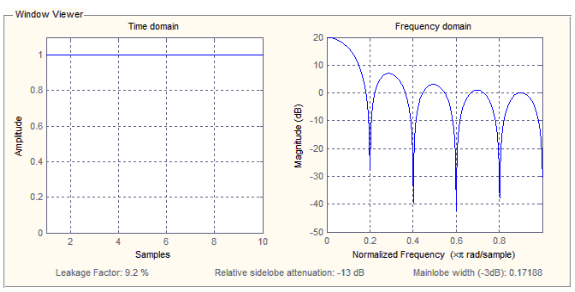

Figure 1. Time and Frequency domain of Rectangular window

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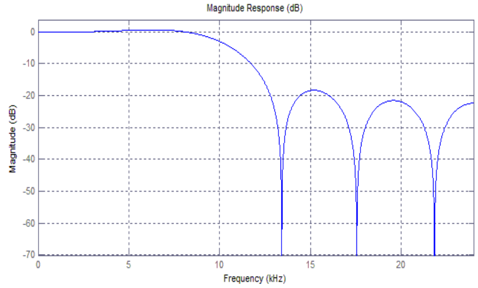

Figure 2. Magnitude response of rectangular wind**ow**

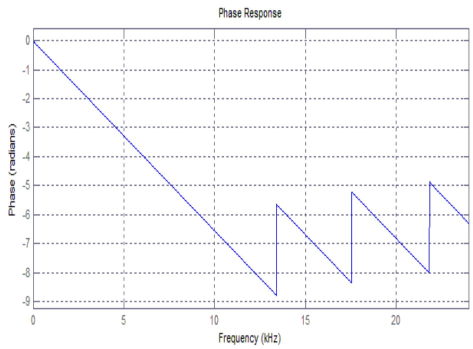

Figure 3. Phase response of rectangular window

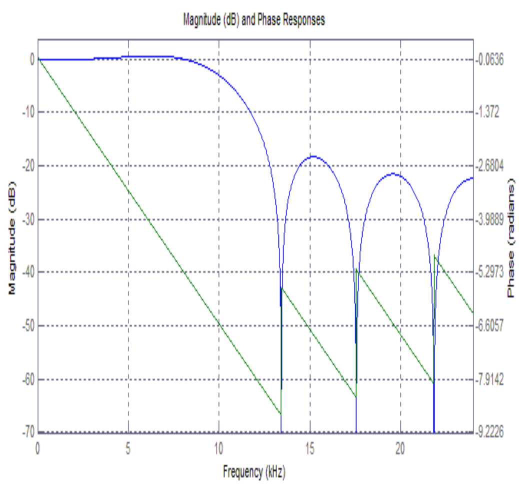

Figure 4. Magnitude and phase response of Rectangular window

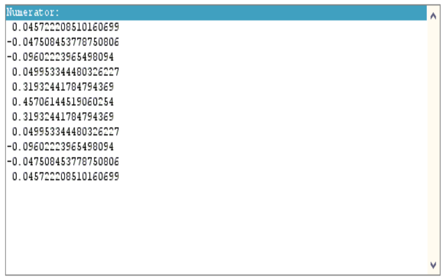
Numerator:
0.04572208510160699
-0.04750845377875080 6
-0.0960223965498094
0.04995334448032622 7
0.3193244178479436 9
0.4570614451906025 4
0.3193244178479436 9
0.04995334448032622 7
-0.0960223965498094
-0.04750845377875080 6
0.04572208510160699

Figure 5. Filter coefficients of Rectangular window

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B. Simulated Result Of Blackman Window

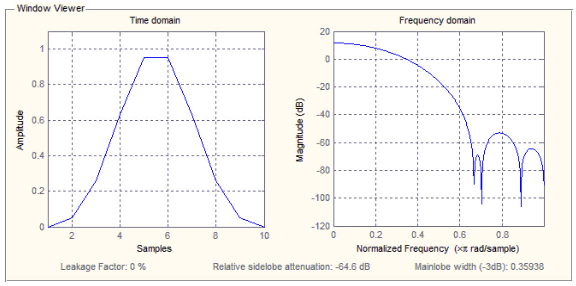

Figure 6.Time and frequency domain of Blackman window

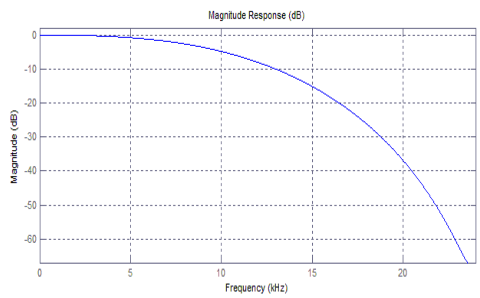

Figure 7.Magnitude response of Blackman window

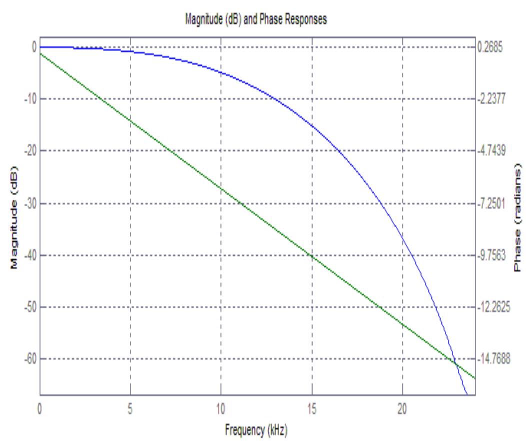

Figure 8.Phase response of Blackman window

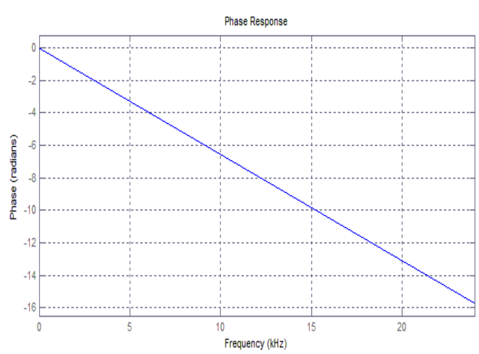

Figure 9.Magnitude and phase response of Blackman

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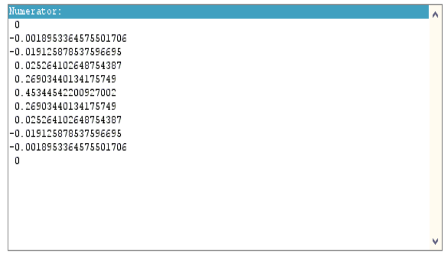

Figure 10.Filter coefficients of Blackman window

C. Comparative Analysis

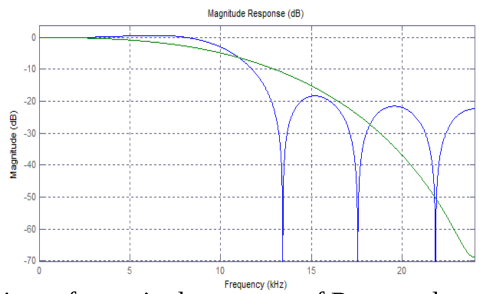

Figure 11.Comparison of magnitude response of Rectangular and Blackman window

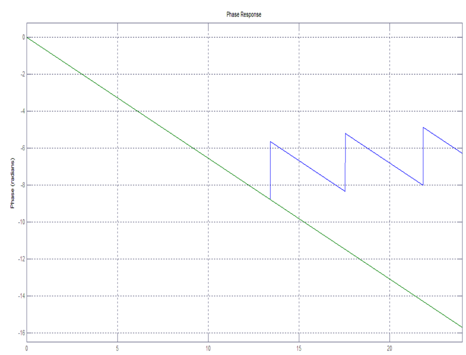

Figure 12.Comparison of phase response of Rectangular and Blackman window

Table simulated result in MATLAB

Window technique	Relative side lobe attenuation	Main lobe width (-3dB)
Rectangular	-13dB	0.17188
Blackman	-64.6dB	0.35938

Table magnitude and frequency result of Rectangular and Blackman window

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Frequency (KHz)	Magnitude in dB	
	Rectangular	Blackman
5.01	.4647712	-.8114994
10.01	-2.957171	-4.838237
15.01	-18.39469	-15.10109
18.25195	-27.2345	-27.2345
20.04492	-21.9559	-36.75962

VI. CONCLUSION

In this paper, an FIR low pass filter is designed by using Rectangular and Blackman window technique. In general Blackman window can be considered as a stable window as it provides with good attenuation and a better transition from pass band to stop at cut-off frequency than Rectangular window. The Blackman window has better frequency response and also has low leakage factor (0%) but unfortunately Blackman has slower roll-off. The Blackman should be our first choice, a slow roll-off is easier to handle than poor stop band attenuation.

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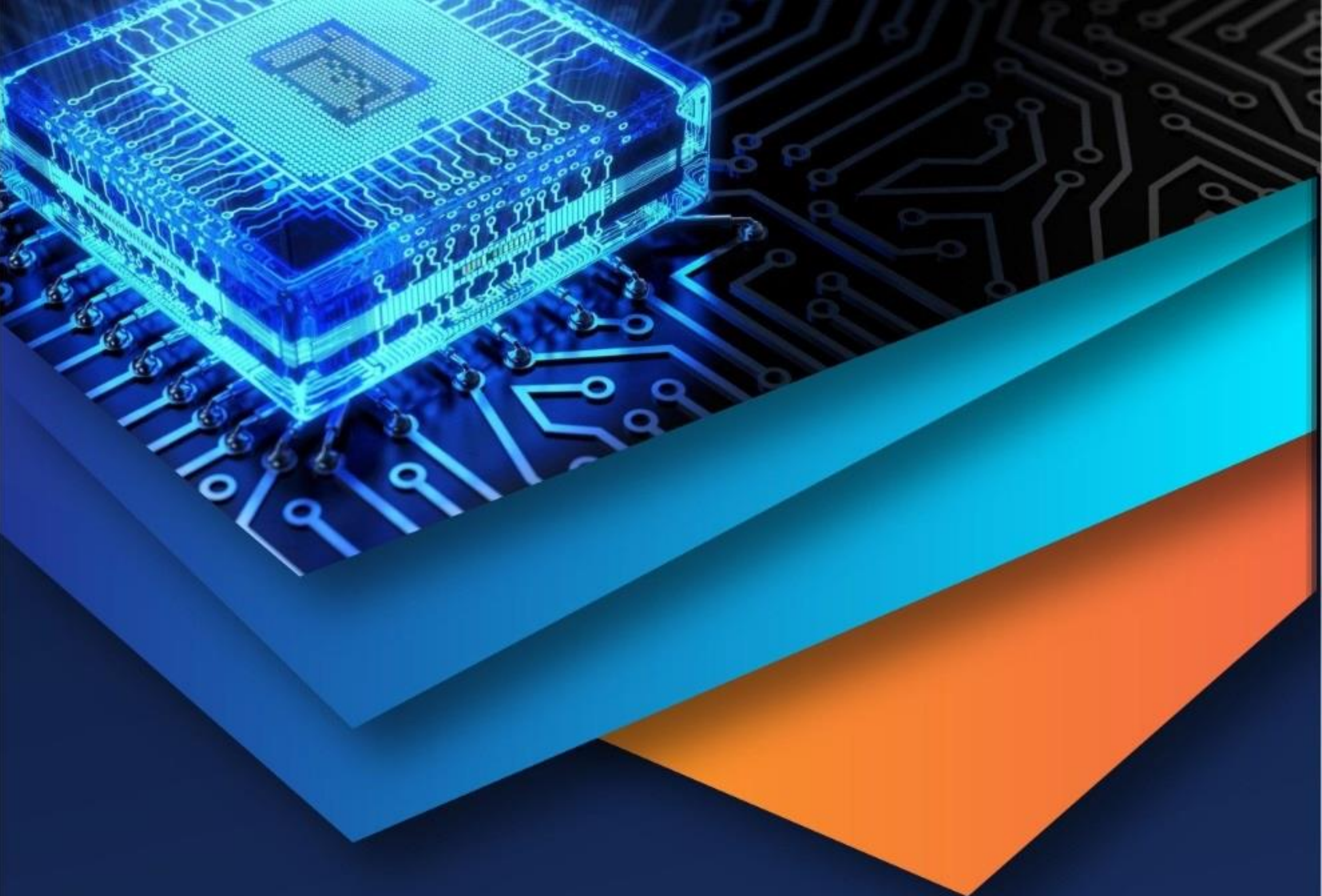

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