IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 3 Issue 8, August 2016
ISSN (Online) 2348 – 7968 | Impact Factor (2015) - 4.332
www.ijiset.com

High Pass FIR filter Design and Performance Analysis using Rectangular and Blackman Window Techniques.

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ABSTRACT

A Digital Signal Processing is a main branch of electronics. 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. telecommunication, image processing, speech processing, medical diagnostic instrumentation and signal filtering etc. Signal filtering is the most important application of DSP. In this process we can remove all the unwanted background noise and interference. In this paper we are concentrating on High Pass FIR filter design by using Rectangular and Blackman window techniques. By the comparative analysis of both the window technique we conclude that, the Rectangular window technique shows more ripples in stop band region whereas in Blackman window more unwanted frequency components are present.

KEYWORDS: *DSP, Digital Filter, FIR filter, High Pass Filter, Blackman, Rectangular, MATLAB.*

1. INTRODUCTION

Signals play a major role in our life. In general, a signal can be function of time, distance, position, temperature, pressure, etc, and it represents some variable of interest associated with a system. For example, in an electrical system the associated signals are electric current and voltage. In a mechanical system, the associated signal may be force, speed, torque etc. In addition to these, some examples of signals that we encounter in our daily life are speech, music, pictures and video signals. A signal can be represented in a number of ways. Most of the signals that we come across are generated naturally. However, there are some signals that are generated synthetically. In general, a signal carries information, and the objective processing is to extract this information.

Signal processing is a method of extracting information from the signal which in turn depends on the type of signal and the nature of information it carries. Thus signal processing is concerned with signals in mathematical terms and extracting the information by carrying out the algorithmic operations in the signal. Mathematically, a signal can be represented in terms of basic function in the domain of the original independent variable or it can be represented in terms of basic functions in a transform domain. Similarly, the information contained in the signal can also be extracted either in the original domain or in the transform domain [5].

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 [6].

2. WINDOWING TECHNIQUE

The FIR filter design process using window functions can be enumerated as:
1) Define filter specifications.
2) Specify a window function according to the filter specifications.
3) Compute the filter order required for a given set of specifications.
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 or increasing it according to needs, and after this process the steps 4, 5 and 6 are iterated as many times as needed [6].

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

1.1 Rectangular Window Technique.
1.2 Blackman window Technique.

2.1 RECTANGULAR WINDOW

The rectangular window (sometimes 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:

Other windows are designed to moderate these sudden changes, which reduces scalloping loss and improves dynamic range.

The rectangular window is the 1st order *B*-spine window as well as the 0th power cosine window [4].

$$W_R(n) = \begin{Bmatrix} 1 \; for|n| \le \frac{M-1}{2} \\ 0 \, , otherwise \end{Bmatrix} \text{ .... (1)}$$

2.2 BLACKMAN WINDOW

Blackman windows are defined as:

By common convention, the unqualified term *Blackman window* refers to $\alpha = 0.16$, as this most closely approximates the "exact Blackman", with

$a_0 = {}^{7938}/_{18608} \approx 0.42659,$

$a_1 = {}^{9240}/_{18608} \approx 0.49656,$

and $a_2 = {}^{1430}/_{18608} \approx 0.076849.$

These exact values place zeros at the third and fourth side lobes [4].

$$W(n) = a_0 - a_1 \cos\left(\frac{2n\pi}{N-1}\right) + a_2 \cos\left(\frac{4n\pi}{N-1}\right) \text{ .... (2)}$$

Where;

$a_0 = \frac{1-\alpha}{2}$

$a_1 = \frac{1}{2}$

$a_2 = \frac{\alpha}{2}$

3. DESIGN SIMULATION

Table 2.1 Filter parameters and value

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

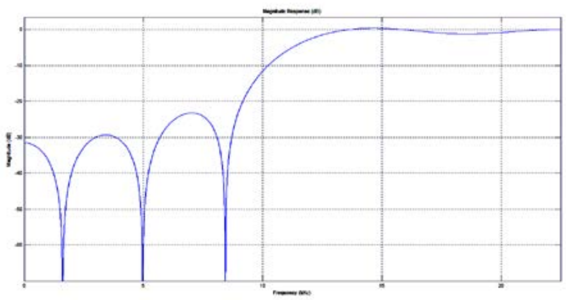

Fig 2.1 Magnitude Response of Rectangular Window Technique.

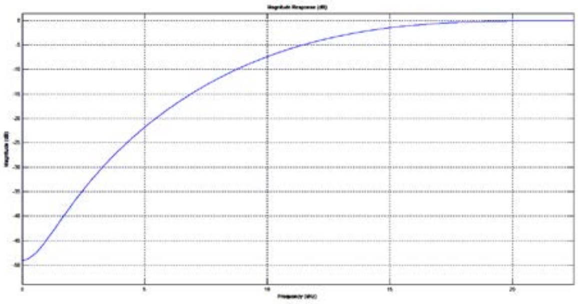

Fig 2.2 Magnitude Response of Blackman Window Technique.

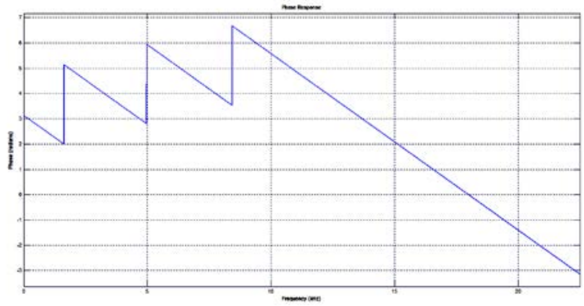

Fig 2.3 Phase Response of Rectangular Window Technique.

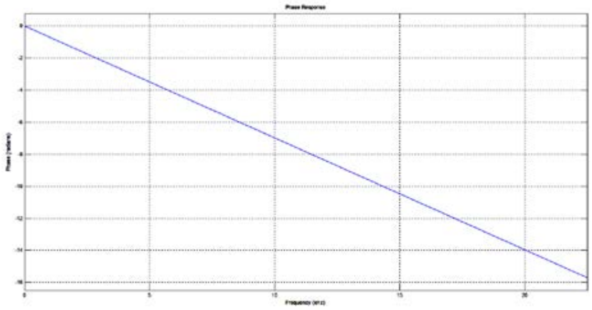

Fig 2.4 Phase Response of Blackman Window Technique.

Numerator:
-0.056707419461577778
0.018535388677854942
0.097615956928657099
-0.018682707406005587
-0.29754025840292009
0.48703119558461982
-0.29754025840292009
-0.018682707406005587
0.097615956928657099
0.018535388677854942
-0.056707419461577778

Fig 2.5 Filter Coefficients for Rectangular Window Technique.

Numerator:
0
0.00079663491657285044
0.020946554582522651
-0.010179380275083864
-0.27006210169688377
0.5205343964882998
-0.27006210169688377
-0.010179380275083864
0.020946554582522651
0.00079663491657285044
0

Fig 2.6 Filter Coefficients for Blackman Window Technique

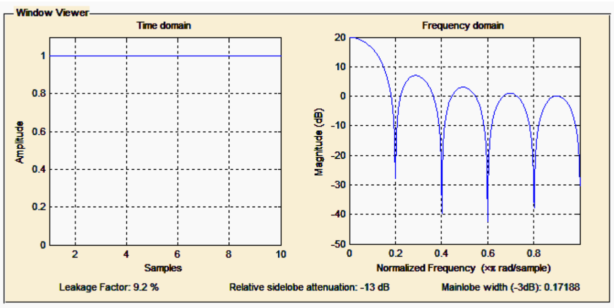

Fig 2.7 Time Domain & Frequency Domain of Rectangular Window

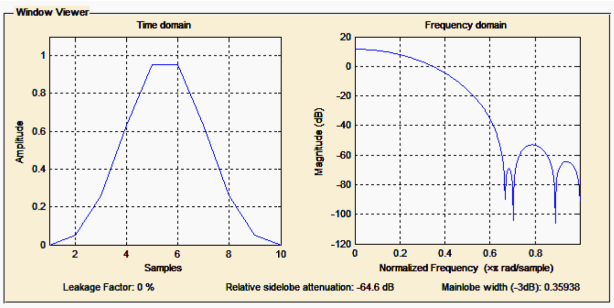

Fig 2.8 Time Domain & Frequency Domain of Blackman Window.

4. COMPARITIVE ANALYSIS

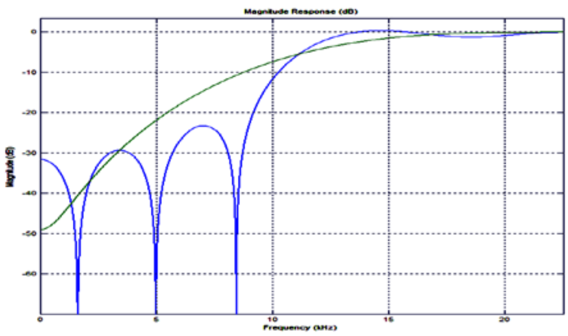

Fig 2.9 Magnitude Comparison of Rectangular & Blackman Window Technique.

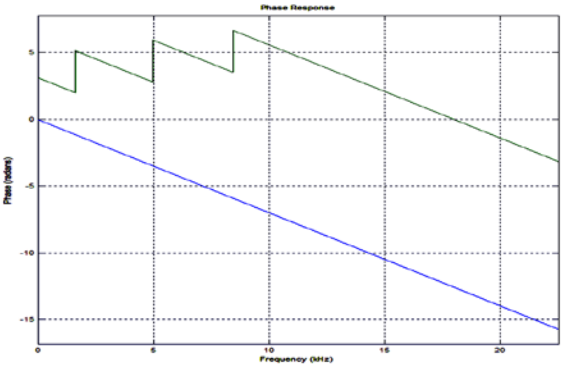

Fig 1.10 Phase Comparison of Rectangular & Blackman Window Technique.

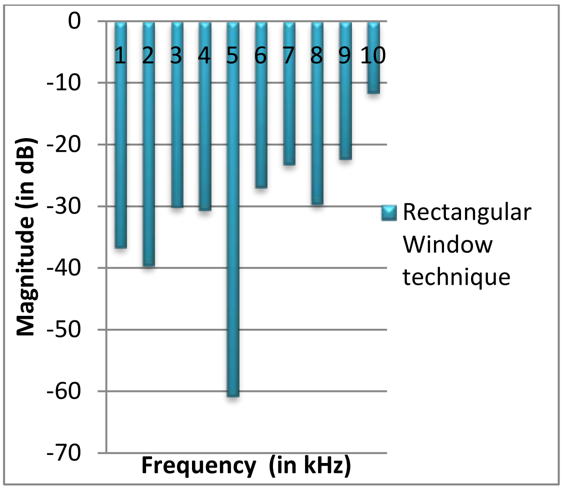

Chart 2.1 Magnitude and Frequency plot of Rectangular Window Technique.

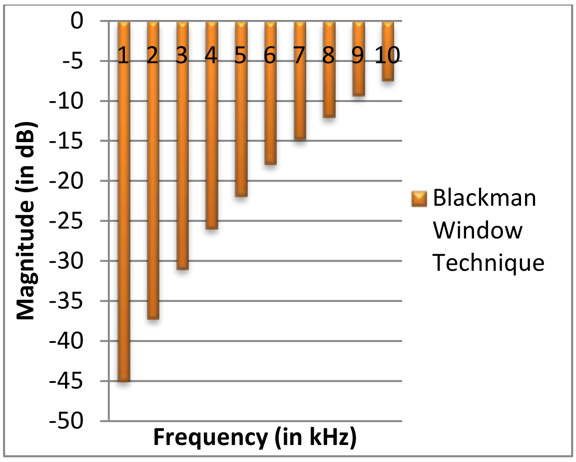

Chart 2.2 Magnitude and Frequency plot of Blackman Window Technique.

5. RESULT

Table 2.2 Simulation results from MATLAB.

Window technique	Relative side lobe attenuation	Main lobe width (-3dB)	Leakage factor
Rectangular window	-13dB	0.17188	9.2%
Blackman window	-64.6dB	0.3593	0%

Table 2.3 Magnitude and Frequency results of Rectangular and Blackman Window Technique.

Frequency (kHz)	Magnitude (dB)	
	Rectangular window	Blackman window
1	-36.6272	-44.9849
2	-39.5808	-37.1962
3	-30.0932	-30.9627
4	-30.6461	-25.9337
5	-60.7771	-21.8686
6	-26.9317	-17.8654
7	-23.2130	-14.7760
8	-29.6147	-12.0065
9	-22.3262	-9.3021
10	-11.5882	-7.4133

From MATLAB simulation result of Rectangular and Blackman 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 and Blackman 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=45000Hz and f_c=10800Hz.

The Rectangular window technique shows more ripples in stop band region whereas in Blackman window more unwanted frequency components are present.

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