



Designing a Low- Pass FIR Digital Filter by using Rectangular, Hanning and Triangular Window Technique

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Abstract: Digital filter are widely used in the world of communication and computation. On the other hand, to design a Digital Finite Impulse Response (FIR) filter that satisfies all the required condition is challenging one. In this paper, design techniques of Low Pass filter using Rectangular, Hanning and Triangular Window Techniques of order (15) are presented. It shown that filter design by using Rectangular Window Technique is better as it provides better result in terms of magnitude, phase, impulse, step responses and pole-zero plot. The analysis of magnitude, phase, impulse, step response and pole-zero plot of proposed FIR Low Pass filter is performed using MATLAB Simulation.

Keywords: DSP, Digital filter, Low-Pass filter, FIR filter, Rectangular window, Hanning and Triangular Window Techniques.

1. INTRODUCTION

A digital filter is a system which passes some desired signals more than others to reduce or enhance certain aspects of that signal. It can be used to pass the signals according to the specified frequency pass-band and reject the other frequency than the pass-band specification.[1]

In the FIR system, the impulse response is of finite duration, this means that it has a finite number of nonzero terms. On the other hand, The IIR system has an infinite number of nonzero terms. This means its impulse response is of infinite duration. While implementation, FIR filter needs no feedback. FIR filter is not a recursive filter. Because of this reason, the structure of FIR filter is much more simpler than compared to the IIR filter [2] The structure of these algorithms uses a repetitive delay-and-add format that can be represented as "Direct Form-I Structure". The advantage of FIR filter over IIR filters are, FIR filter has linear phase and easily to control where as IIR filter has no particular phase and difficult to control. FIR filter is stable and depends only on input.[3] Digital filters have characteristics such as linear phase response. If we compare digital filter with analog.[4] Filter they are preferred in number of application like speech processing, image processing and data compression [5]

It is calculated by applying an impulse signal at the input. The values of $h(n)$ will determine the type of the filter e.g. low pass, high pass, band pass etc. the values of $h(n)$ are to be determine in the design process and N represents the order of the polynomial function.[6]

1.1 RECTANGULAR WINDOW FUNCTION

The rectangular window (sometimes known as the

OTwindow) is the simplest window, equivalent to replacing all but OTN OT values of a data sequence by zeros, making it appear as though the waveform suddenly turns on and off. The weighting function for the rectangular window is given by

$$WR(n) = \begin{cases} 1 & \text{for } |n| \leq \frac{M-1}{2} \\ 0 & \text{, otherwise (1)} \end{cases}$$

2. SIMULATION AND RESULT

Table 1: Parameter Specification

PARAMETER	VALUES
Sampling Frequency(Fs)	48000Hz
Cut off Frequency(Fc)	10800Hz
Order(N)	15

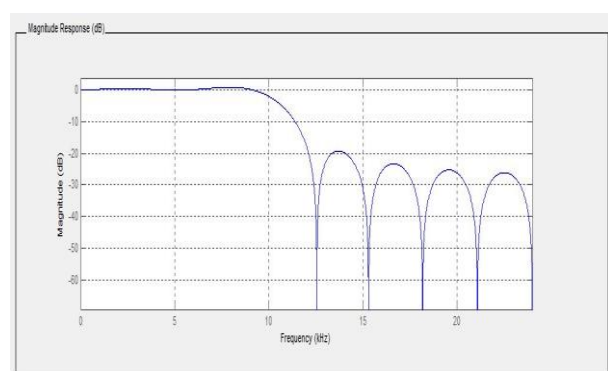


Fig 1: Magnitude response of Rectangular Window Technique

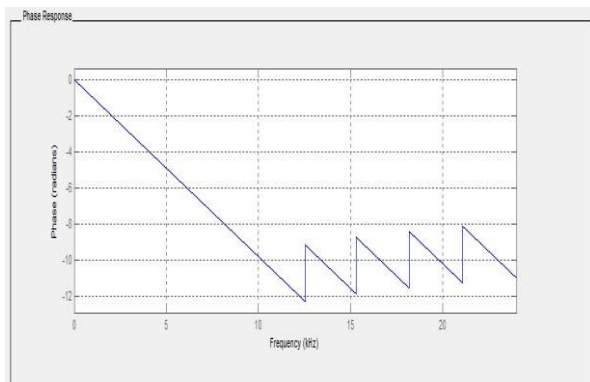


Fig2: Phase response of Rectangular Window Technique

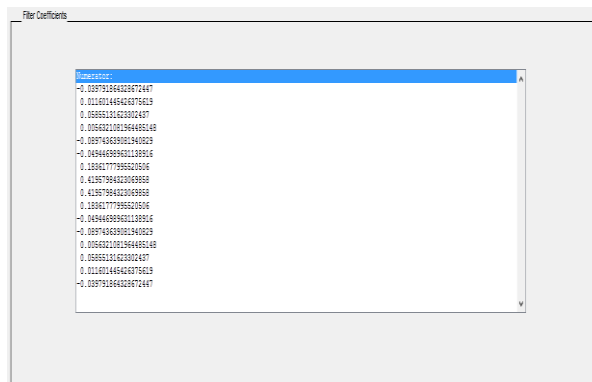


Fig6: Pole/Zero plot of Rectangular Window Technique

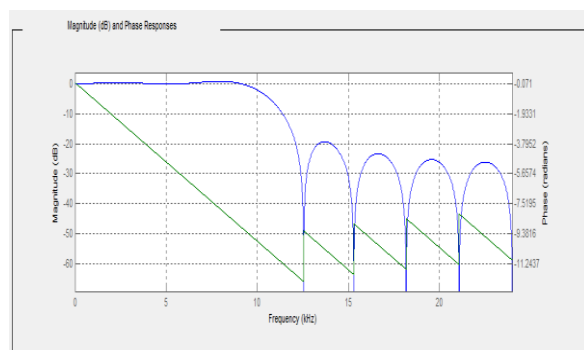


Fig 3: Magnitude and Phase Response rectangular window technique

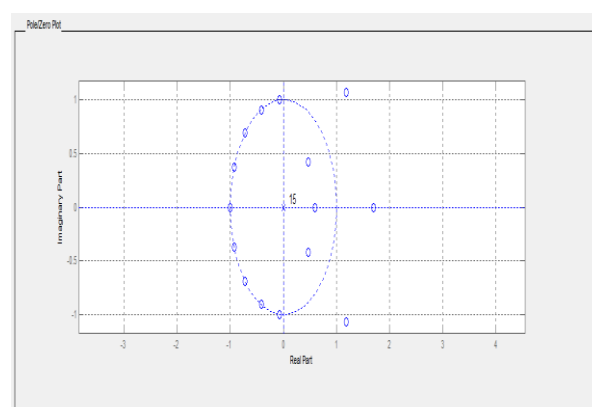


Fig 7: Filter coefficient of Rectangular Window Technique

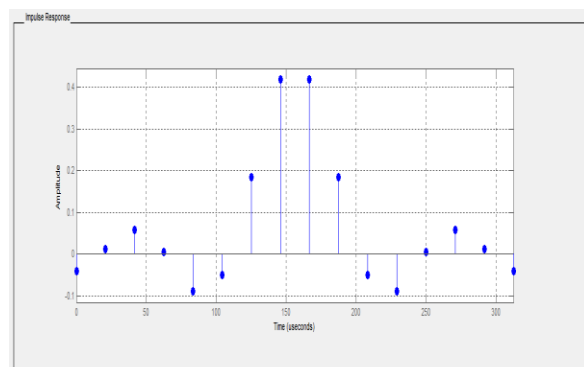


Fig 4: Impulse Response of rectangular Window technique

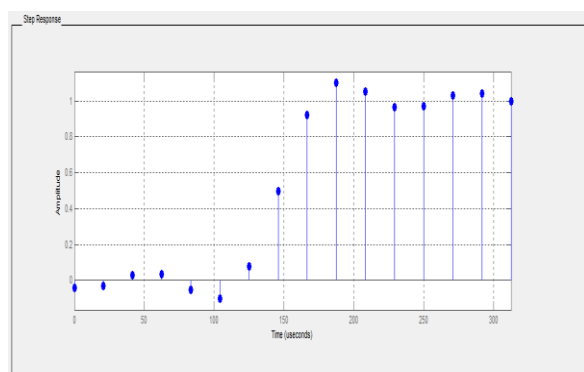


Fig5: Step Response of rectangular window Technique

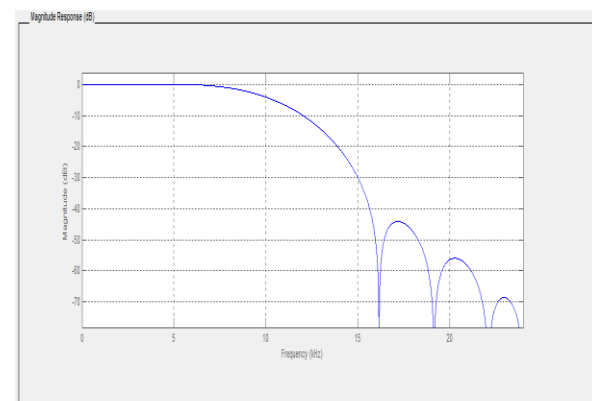


Fig 8: Magnitude response of Hanning Window Technique

2.1 HANNING WINDOW FUNCTION

The Hann window named after Julius von Hann and also known as the **Hanning** (for being similar in name and form to the Hamming window), **von Hann** and the **raised cosine window** is defined by (with hav for the haversine function):

$$W(n) = 0.5 \left(1 - \cos\left(\frac{2\pi n}{N-1}\right) \right) = \text{Hav}\left(\frac{2\pi n}{N-1}\right)$$

The ends of the cosine just touch zero, so the side-lobes roll off at about 18 dB per octave.

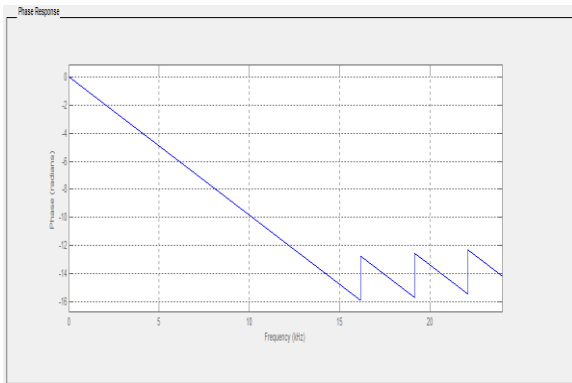


Fig 9: Phase response of Hanning Window Technique

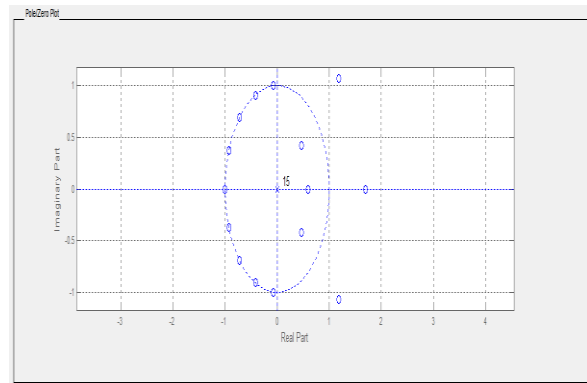


Fig13: Pole/Zero plot of hanning Window Technique

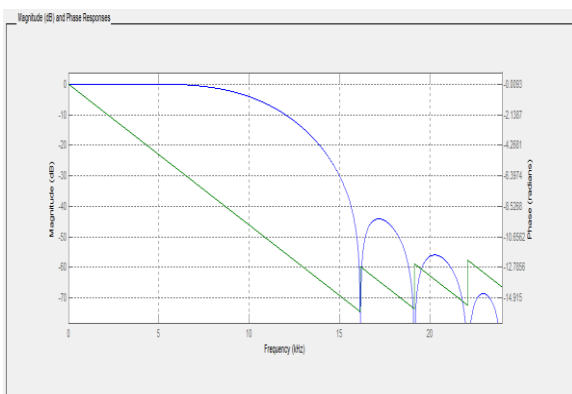


Fig 10: Magnitude and Phase Response Hanning window technique

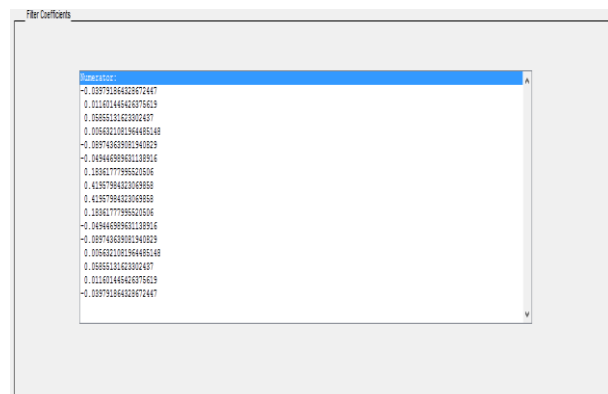


Fig 14: Filter coefficient of Rectangular Window Technique

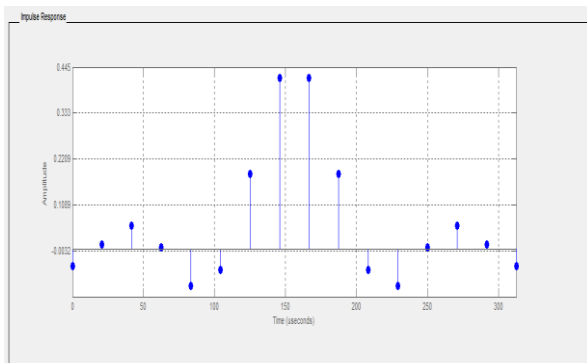


Fig 11: Impulse Response of hanning Window technique

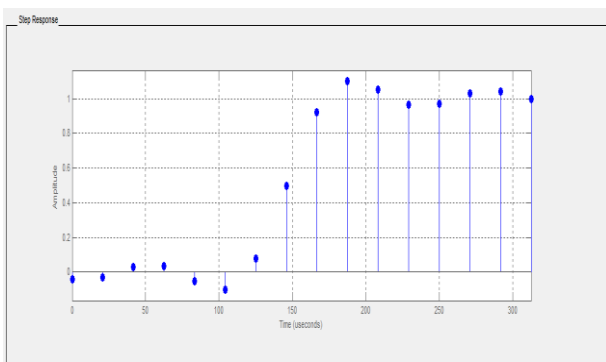


Fig 12: Step Response of hanning window Technique

2.2 TRIANGULAR WINDOW FUNCTION

The main problem associated with the rectangular Window is the presence of ripple near the band edges of the resulting filter, which are caused by the existence of sidelobes in the frequency response of the window. Such a problem is due to the inherent discontinuity of the rectangular window in the time domain. One way to reduce such a discontinuity is to employ a triangular shaped window, which will present only small discontinuities near its edges.

The standard triangular window is defined as

$$w_t(n) = \left\{ \frac{2|n|}{M} + 1, \text{ for } |n| \leq \frac{M}{2} \right\}$$

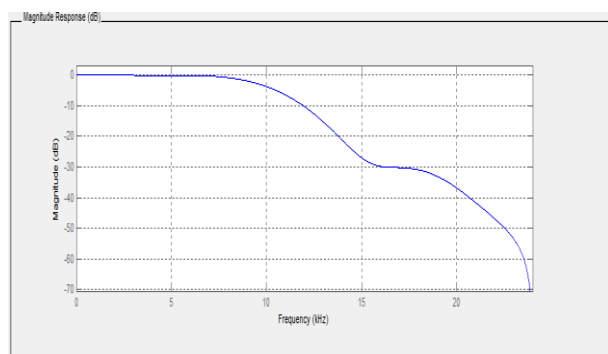


Fig15: Magnitude response of Triangular Window Technique

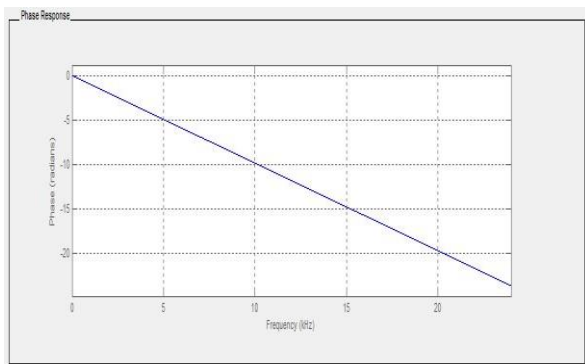


Fig 16: Phase response of Triangular Window Technique

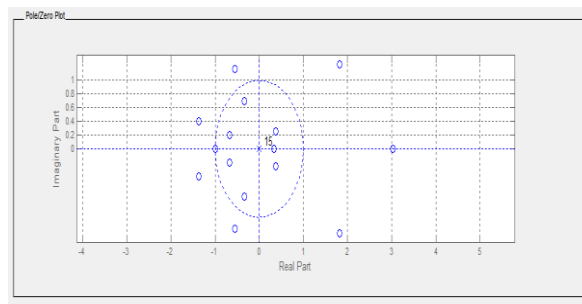


Fig20: Pole/Zero plot of Triangular Window Technique

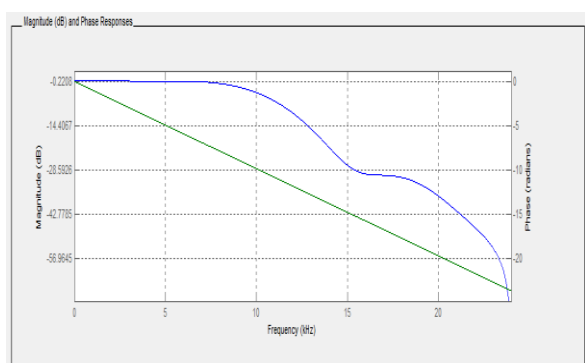


Fig 17: Magnitude and Phase Response of Triangular window technique

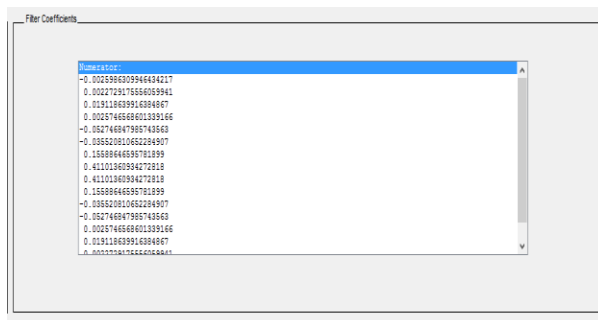


Fig 21: Filter coefficient of Triangular Window Technique

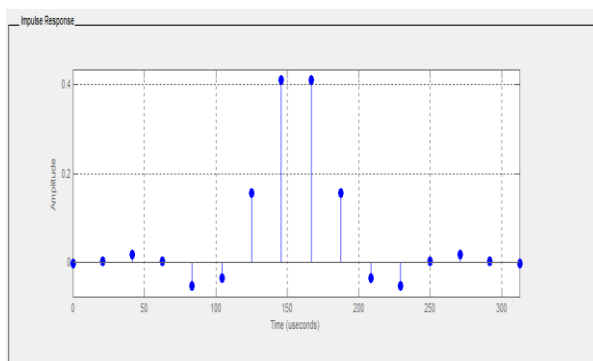


Fig 18: Impulse Response of Triangular Window technique

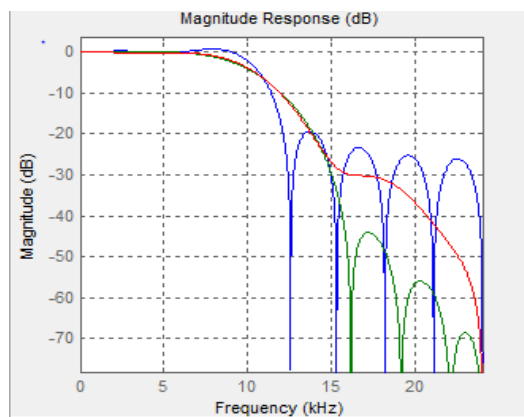


Fig 22: Magnitude comparison of rectangular, hanning And triangular window

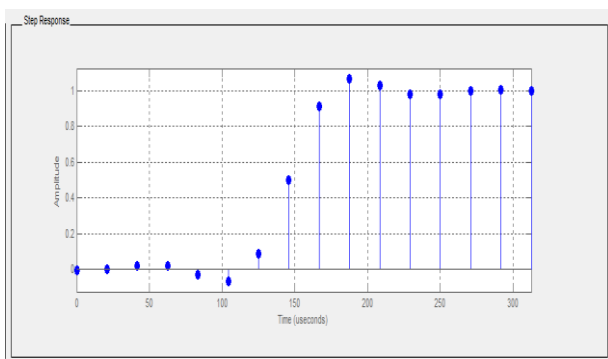


Fig 19: Step Response of Triangular window Technique

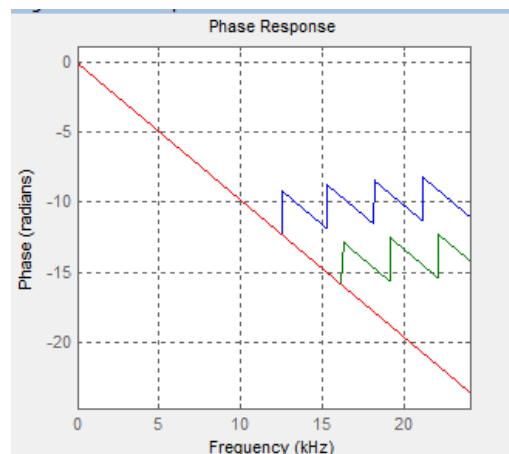


Fig 23: Phase comparison of rectangular, hanning And triangular window

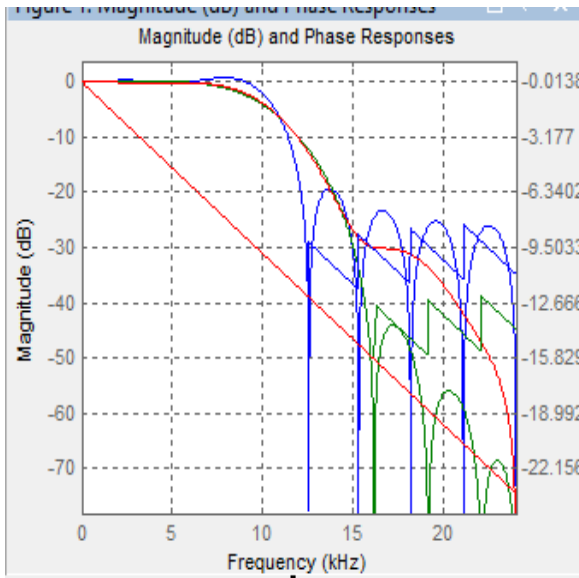


Fig 24: Magnitude and phase comparison rectangular, hanning and triangular window

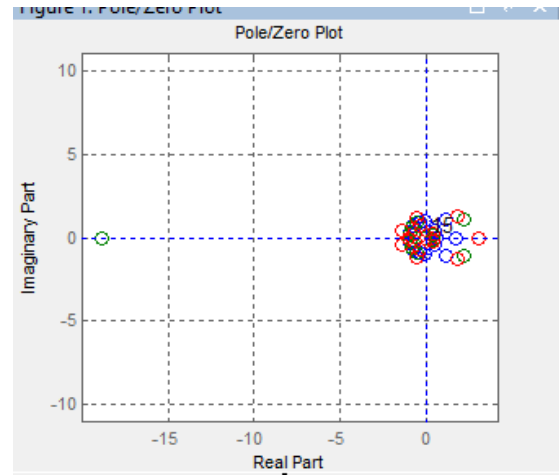


Fig 27: Pole zero plot comparison of rectangular, Hanning and triangular`

TABLE 2 Frequency and magnitude

Frequency	Rectangular	Hanning	Triangular
0.1π	0.136	0.002	-0.028
0.2π	0.282	0.014	-0.095
0.3π	0.220	0.043	-0.143
0.4π	-0.028	0.067	-0.155
0.5π	-0.160	0.030	-0.143
0.6π	0.312	-0.136	-0.186
0.7π	0.618	-0.521	-0.431
0.8π	0.710	-1.511	-1.603
0.9π	-0.395	-2.610	-2.133
Π	-2.605	-4.383	-4.769

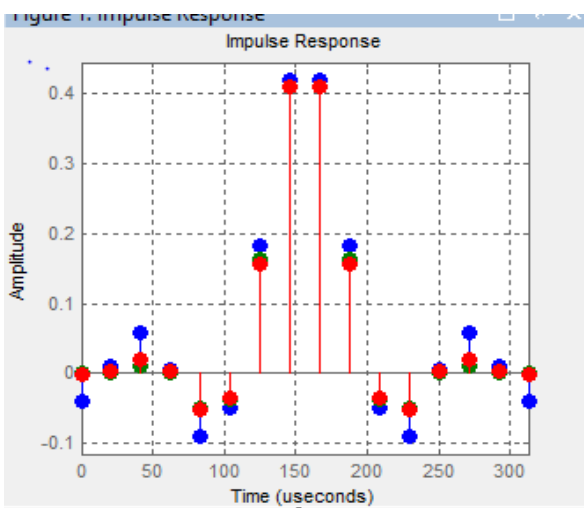


Fig25: Impulse comparison of rectangular, hanning and triangular window

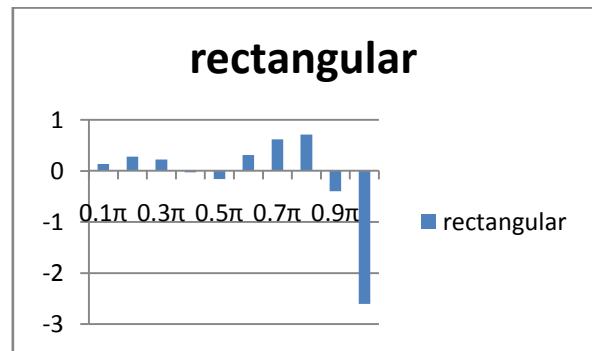


Fig28: Frequency and magnitude plot of rectangular window

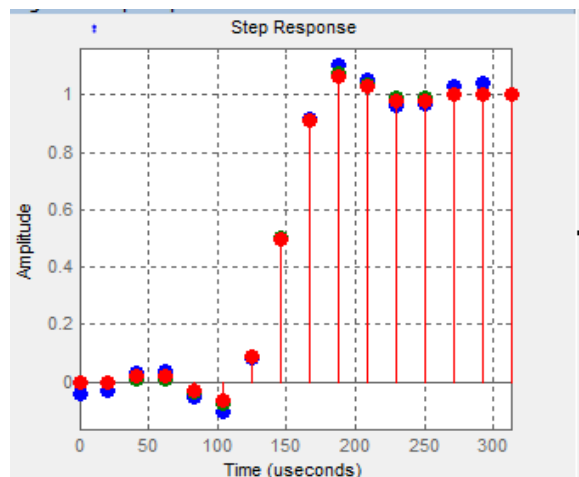


Fig.26: step comparison of rectangular, hanning and triangular

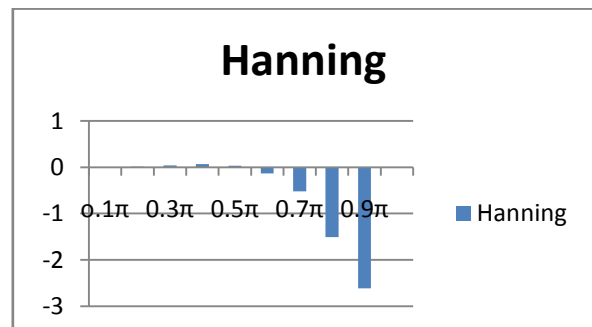


Fig 29: Frequency and magnitude plot of hanning window

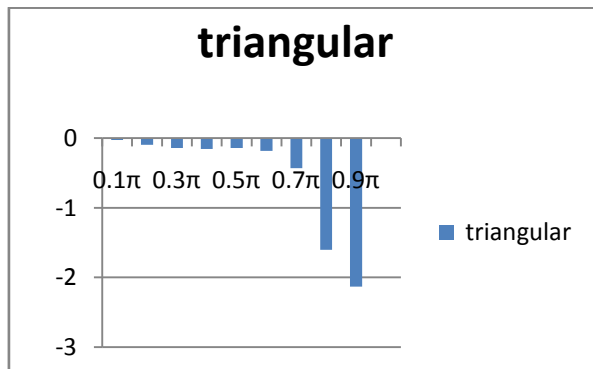


Fig 30: Frequency and magnitude plot of triangular window

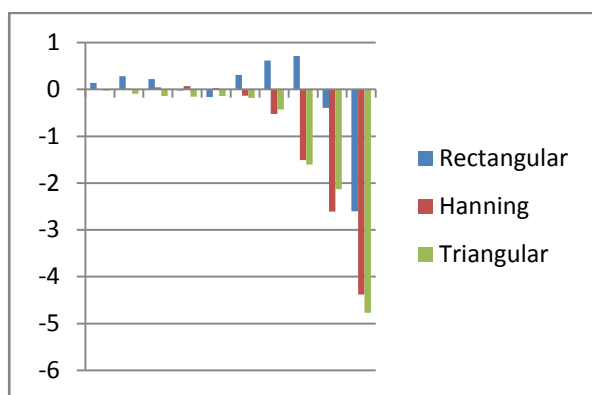


Fig 31: Magnitude and frequency plot of rectangular, hanning and triangular

3. CONCLUSION

In this research paper Low pass FIR filter has been designed using MATLAB Rectangular, Hanning and triangular 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. $f_{RcR}=45000\text{Hz}$ and $f_{RcR}=10800\text{Hz}$. present with the wanted signals too.

FILTER SPECIFICATION

Before a filter can be design, a set of filter specification must be define, For e.g suppose that we would like to design a low pass filter with a cut of frequency w_c .The frequency response of an ideal low pass filter with linear phase and a cut of frequency w_c is

$$H_d(e^{jw}) = \begin{cases} e^{-jw} & |w| \leq w_c \\ 0 & w_c \leq |w| \leq \pi \end{cases}$$

Which has a unit sample response

$$h_d(n) = \frac{\sin(n-a)w_c}{\pi(n-a)}$$

Because this filter is unrealizable (non causal and unstable) it is necessary to relax the ideal constraints on the frequency response and allow some deviation from the ideal response. The specification for a low pass filter will typically have the form.

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BIOGRAPHIES



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