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Optimal Design of High-Pass FIR Filter by Blackman, Rectangular and Tringular Window Techniques

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ABSTRACT: The aim of our paper is to design FIR filter using Blackman window and Rectangular window Techniques of order 10. In this paper The analysis of magnitude and phase response of proposed FIR High-pass filter are performed using MATLAB simulation. The result window technique provides better result in term of magnitude and phase response of High-pass FIR filter.

KEYWORDS: DSP, FIR, HIgh-Pass Fir Digital Filter, Rectangular Window and Blackman Window

I. INTRODUCTION

A signal carries information, and the objective of signal processing is to extract useful information carried by the signal. The method of information extraction depends on the type of signal and the nature of the information being carried by the signal [1].Digital Signal Processing (DSP) is an important field of study that has come about due to advances in Communication theory, digital computer technology, and consumer devices.There is always a driving need to make thing better and DSP provides many techniques for doing this. For example, people enjoy music and to download new songs. However, with slow Internet connection speeds (typically 56 kilobits per second for a dial-up modem), downloading a song could take hours. WithMP3 compression software, though, the size of the song is reduced by as much as 90%, and can be downloaded in a matter of minutes. The MP3 version of the song is not the same as the original, but is a “good enough” approximation that most users cannot distinguish from the original.[2].

II. APPLICATIONS OF DSP IN AREA-WISE ARE AS FOLLOWING

1) Telecommunication- Echo cancellation in telephone networks, equalization, telephone dialing application, modems, line repeaters, channel multiplexing, data encryption, video conferencing, cellular phone and FAX.
2) Military- Radar signal processing, sonar signal processing, navigation, secure communications and missile guidance..
3) Consumer electronics- Digital Audio/TV, electronic music synthesizer, educational toys, FM stereo application and sound recording applications.
4) Image processing- Image representation, image compression, image enhancement, image restoration and image analysis compression, image enhancement, image restoration and image analysis.
5) Speech processing- Speech analysis methods are used in automatic speech recognition, speaker verification and speaker identification.
6) Medicine-Medical diagnostic instrumentation such as computerized tomography (CT), X-ray scanning, Patientmonitoring and X-ray storage/enhancement.
7) Signal filtering-Removing of unwanted background noise, removal of interference, separation of frequency bands and shaping of the signal spectrum. [3].

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III. FIR FILTER DESINING

FIR filters are filters having a transfer function of a polynomial in *z*- and is an all-zero filter in the sense that the zeroes in the *z*-plane determine the frequency response magnitude characteristic. The *z* transform of a *N*-point FIR filter is given by

$$\mathbf{H}\,(\mathbf{z}) = \sum_{n=0}^{N-1} h(n) Z^{-n} \text{ .... (1)}$$

FIR filters are particularly useful for applications where exact linear phase response is required.The FIR filter is generally .implemented in a non-recursive way which guarantees a s

FIR filter design essentially consists of two parts

(i) approximation problem

(ii) realization problem

The approximation stage takes the specification and gives a transfer function through four steps. They are as follows:

(i) A desired or ideal response is chosen, usually in the frequency domain.

(ii) An allowed class of filters is chosen (e.g. the length *N* for a FIR filters).

(iii) A measure of the quality of approximation is chosen.

(iv) A method or algorithm is selected to find the best filter transfer function.

The realization part deals with choosing the structure to implement the transfer function which may be in the form of circuit diagram or in the form of a program.[4][5],

There are essentially three well-known methods for FIR filter design namely:

(1) The window method

(2) The frequency sampling technique

(3) Optimal filter design methods [6][7][8].

IV.WINDOW TECHINIQUES

The desired frequency response of any digital filter is periodic in frequency and can be expanded in a fourier series, i.e.

$$\mathbf{H_d(e^{j\omega})} = \sum_{n=-\infty}^{\infty} \mathbf{h_d}\,(\mathbf{n})\,\mathbf{e}^{-j\omega} \text{ ....(2)}$$

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

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 equation for designing a digital filter. First, the impulse response is of infinite duration and second, the filter is non-causal and unrealizable. No finite amount of delay can make the impulse response realizable Hence the filter resulting from a Fourier series representation. Of H()is an unrealizable IIR filter

A. BLACKMAN WINDOW

The Blackman window is defined as

$$Wb(n) = \begin{Bmatrix} 0.42 + 0.5\cos\left(\frac{2\pi n}{M}\right) + 0.08\cos\left(\frac{4\pi n}{M}\right), for|n| \le \frac{M}{2} \\ 0, \qquad for|n| > \frac{M}{2} \end{Bmatrix} \text{..................(3)}$$

B. RECTANGULAR WINDOW FUNCTION

The weighting function for the rectangular window is given by

$$WR(n) = \begin{cases} 1 for|n| \le \frac{m-1}{2} \\ 0, otherwise \end{cases} \text{................(4)}$$

C. TRINGULAR WINDOW FUNCTION

The standard triangular window is defined as

$$w_t(n) = \begin{cases} \frac{-2|n|}{M+2} & , for|n| \le \frac{M}{2} \\ 0, & for|n| > \frac{M}{2} \end{cases} \text{.................. (5)}$$

V. SIMULATION

Table 1: Parameter Specification

Parameter	Values
SamplingFrequency(Fs)	48000Hz
Cut off Frequency(Fc)	10800Hz
Order(N)	10

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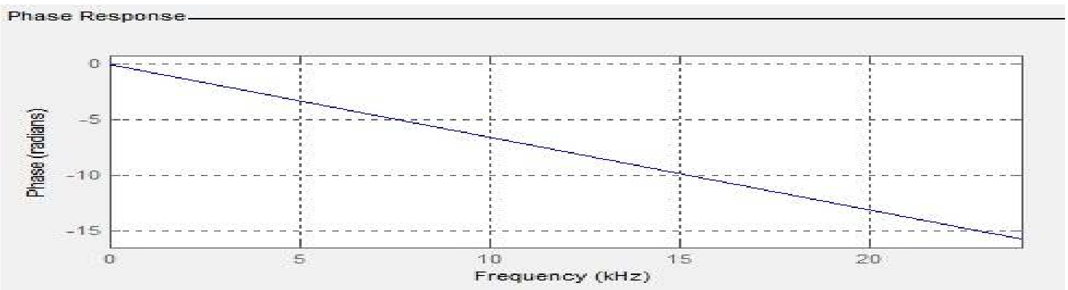
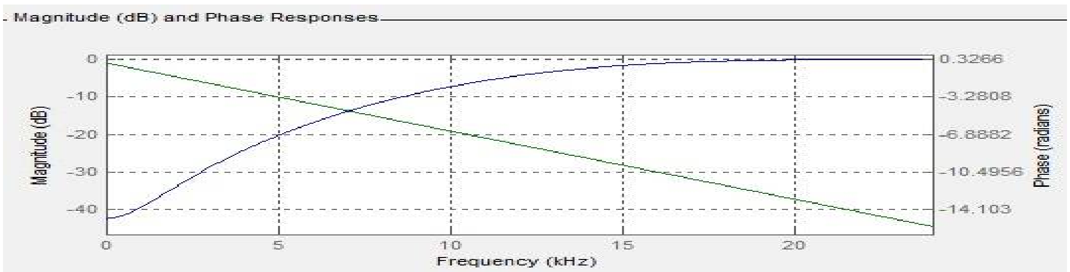
Table2: Filter coefficients of Rectangular , Blackman and tringular Window Technique

Filter Coefficient h(n)	**Window Techniques**		
	Rectangular	**Blackman**	**tringular**
h(0)=h(10)	-0.04187	0	-0.00781
h(1) =h(9)	0.04351	0.00188	0.01624
h(2)= h(8)	0.08794	0.01898	0.04923
h(3)= h(7)	-0.04575	0.02508	-0.03415
h(4)= h(6)	-0.29247	0.26708	-0.27289
h(5)	0.51166	0.55019	0.57288



Figure(1); Phase respose of Blackman window technique



Figure(2); Magnitute and Phase respose Blackman window technique

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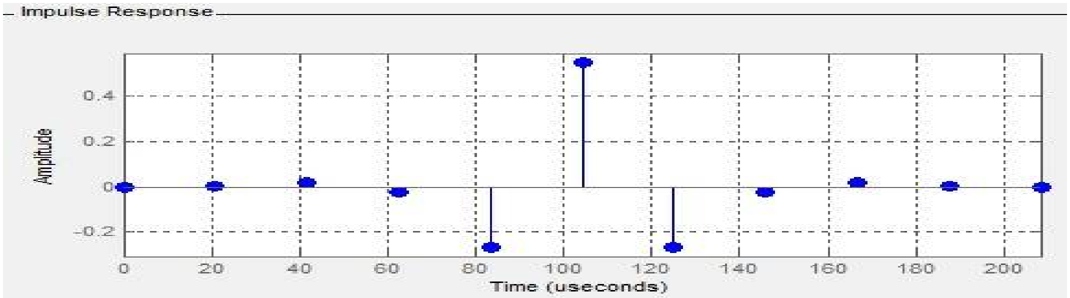
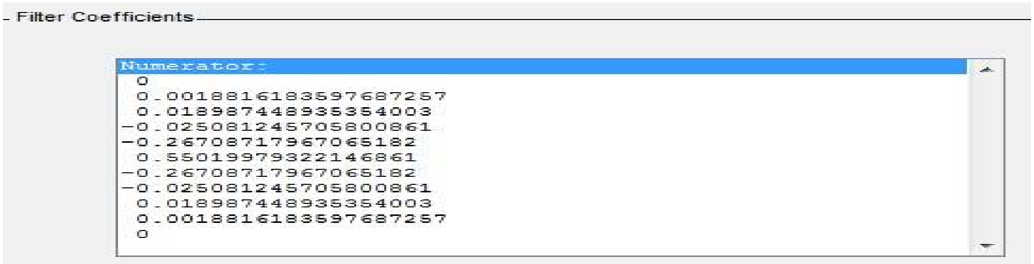
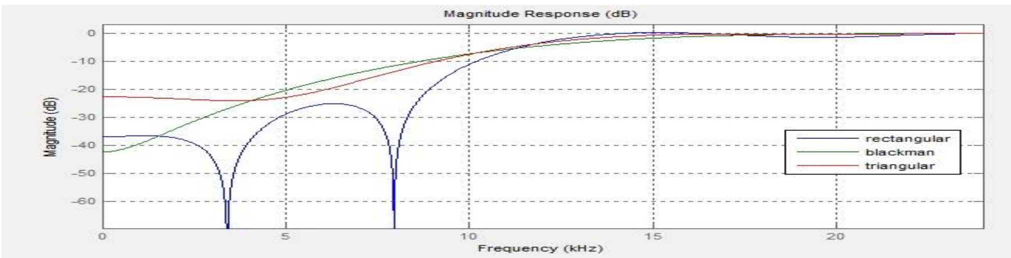


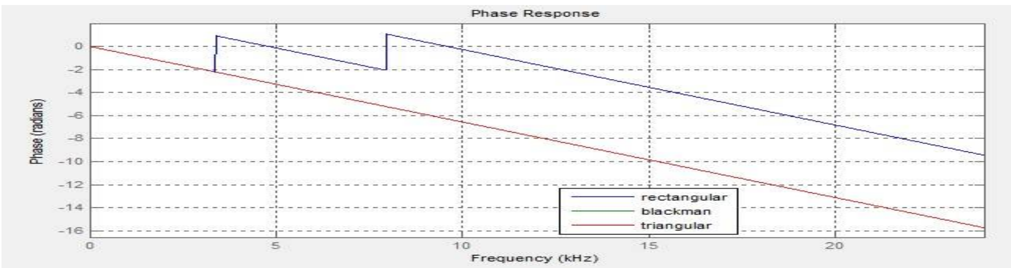
Figure(3);Impulse response of Blackman Window technique



Figure(4);Filter coefficient of Blackman window technique



Figure(5); Magnitute response of Blackman ,Rectangular and Tringular window technique



Figure(6);Phase response of Blackman,Rectangular and triangular window technique

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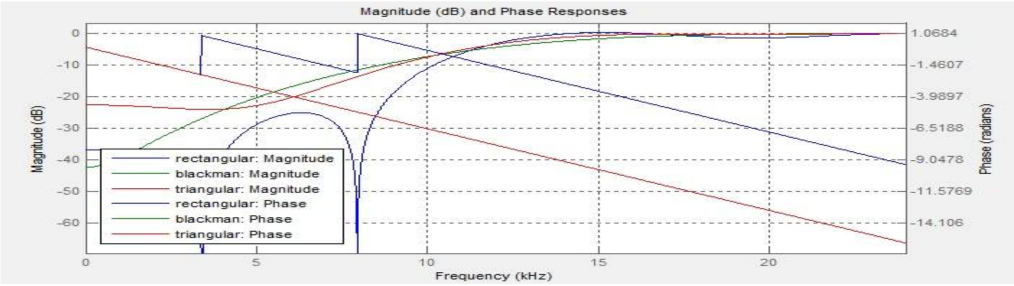
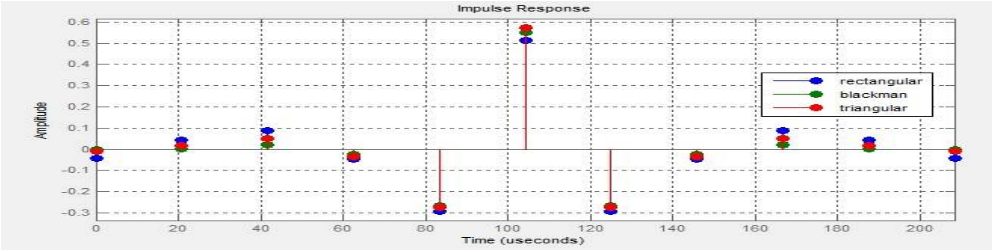
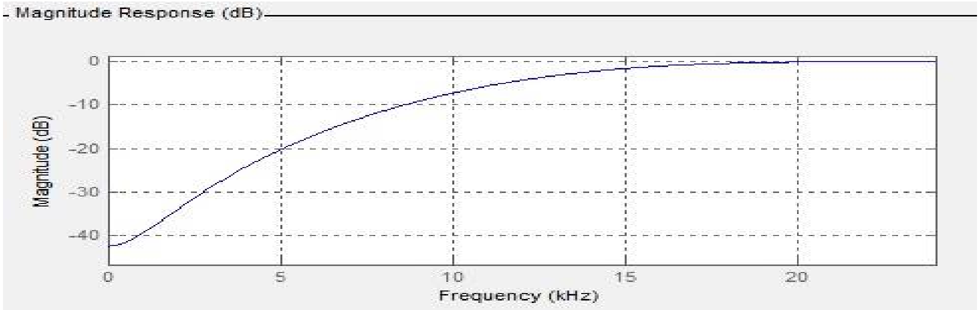


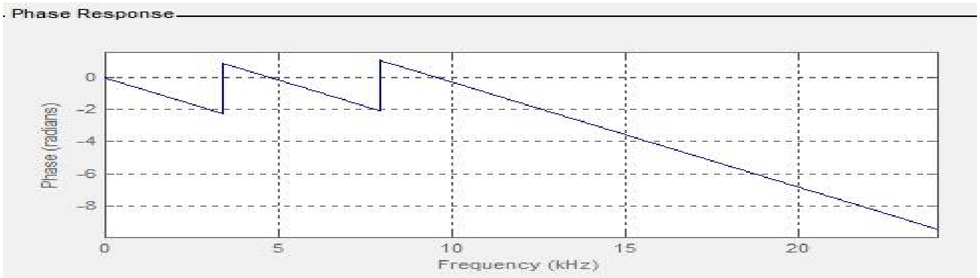
Figure(7); Magnitute and Phase response of Blackman ,Rectangular and Triangular window technique



Figure(8); Impulse response of Blackman ,Rectangular and Tringular window technique



Figure(9);Magnitute response of rectangular window technique



Figure(10); Phase response of rectangular window technique

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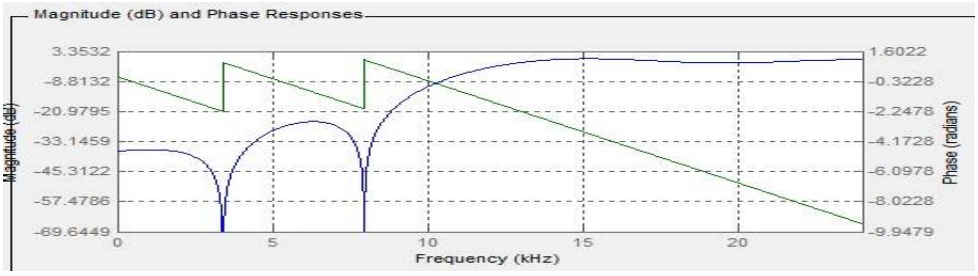
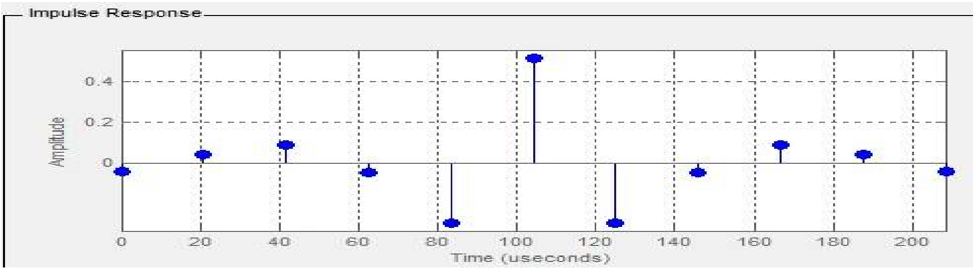
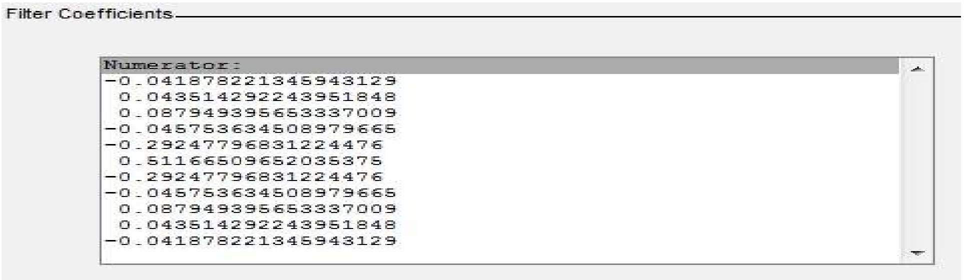


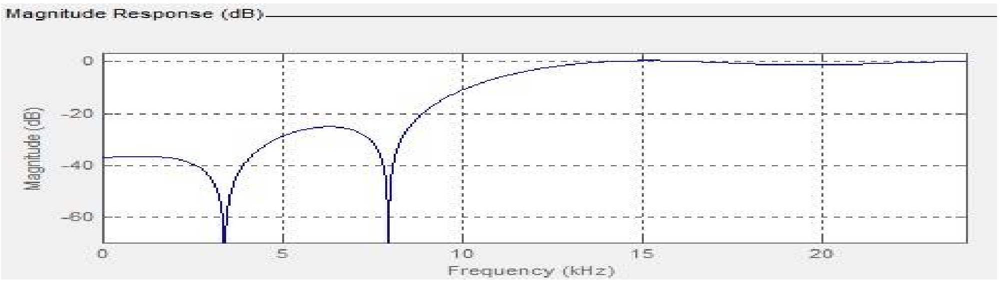
Figure(11); Magnitute and Phase response of rectangular window technique



Figure(12); Impulse response of rectangular window technique



Figure(13); Filter coefficient of rectangular window technique



Figure(14); Magnitute response of rectangular window technique

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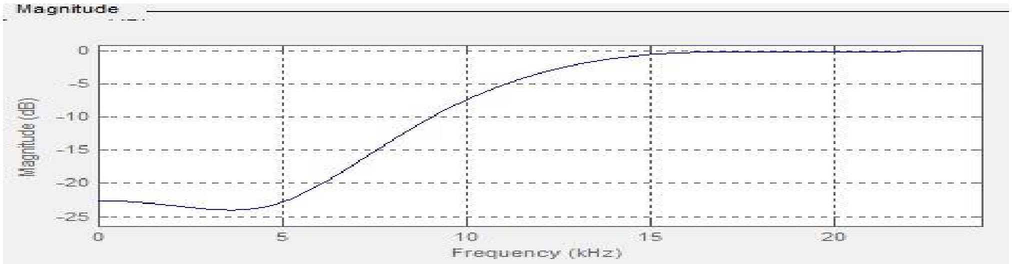
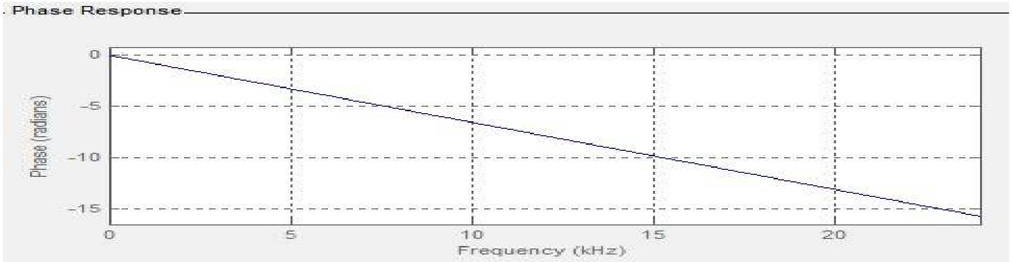
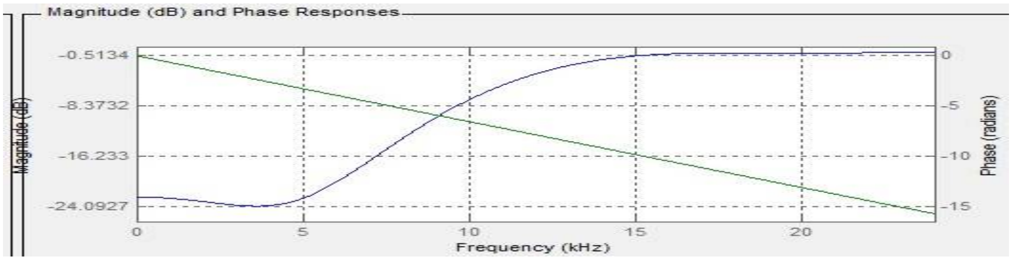


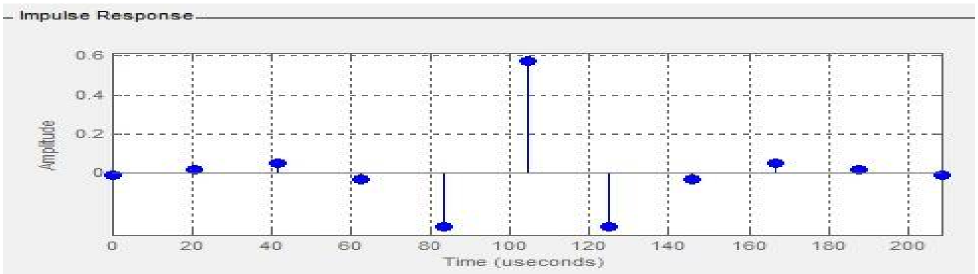
Figure(15);Magnitute response of triangular window technique



Figure(16); Phase response of triangular window technique



Figure(17);Magnitute and Phase response of triangular window technique



Figure(18); Impulse response of triangular window technique

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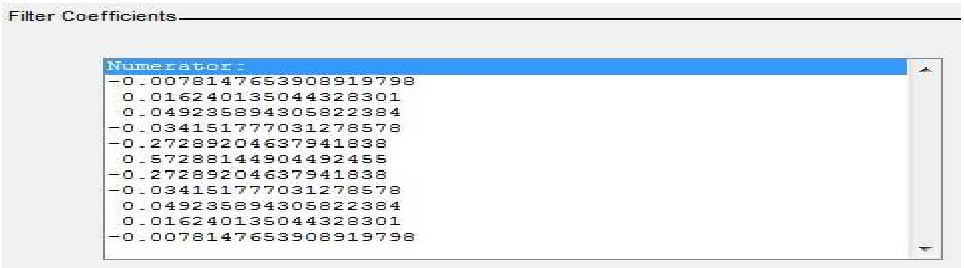

Figure(19); Filter coefficient of triangular window technique

VI. RESULT

Table (3) simulation Result in MATLAB

Window technique	**Leakage Factor**	**Relative sidelobe atteanuation**	**Mainlobe width (dB)**
Blackman	0.1	-64.6Bb	0.35938
Rectangular	9.2	-13dB	0.17188
Tringular	0.17	-28.2dB	0.25

VII. CONCLUSIONS

In this paper FIR high pass filter has been designed and simulated using Blackman ,Tringular and Rectangular Window technique. It has been compared leakage factor ,mainlobe width and relative sidelobe attenuation of the three window from the simulated result. Rectangular window mainlobe width is increase and decreases the amplitude of sidelobes that is increases the attenuation. Rectangular Window main lobe width (-3dB) is 0.17188 at sampling frequency 48000 Hz,cut off frequency 10800 Hz and order 10 Rectangular window has greater mainlobe width and less leakage factor in comparison of Blackman window and Tringular window.

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