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IMPLEMENT A NEW WINDOW FUNCTION AND DESIGN FIR FILTERS BY USING THIS NEW WINDOW

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Abstract: ***Abstract--*** **In this paper a new window function is implemented based on Blackman window function. Tthis window provides higher side lobe attenuation comparison to Hamming window, Hanning window and Blackman window. The width of the main-lobe is slightly greater than Hamming window function and Hanning window function, but slightly less than Blackman window function. In this paper FIR filters are design by using this new window function.**

Keywords: Blackman window, FIR filter, Hamming window,
Hanning window, Lowpass filter,
MATLAB , New window.

I. Introduction

Filter is a device or process that removes some unwanted component from a signal. Filters are widely employed in signal processing and communication systems in applications such as noise reduction, channel equalization, radar, biomedical signal processing, audio processing, video processing and analysis of economic and financial data. Digital filters are two types: i) Finite Impulse Response (FIR) and ii) Infinite Impulse Response (IIR) filters.
Finite impulse response (FIR) filter is a filter whose impulse response is of finite duration, because it settles to zero in finite time. This is in contrast to infinite impulse response (IIR) filters, which may have internal feedback and may continue to respond indefinitely.

FIR filters offer the following advantages over the IIR filters:
i. They can have an exact linear phase.
ii. They are always stable.
iii. The design methods are generally linear.
iv. They can be realized efficiently in hardware.
v. The filter start-up transients have finite duration. [1]

1. Fir Filter design

To design a filter means to select the coefficients such that the system has specific characteristics. The required characteristics are stated in filter specifications. Most of the time filter specifications refer to the frequency response of the filter. There are essentially three well-known methods for FIR filter design namely:

(a) The window method
(b) The frequency sampling technique
(c) Optimal filter design methods [2]

1.1. Window design method

The window design method is first designs an ideal IIR filter and then truncates the infinite impulse response by multiplying it with a finite length window function. The result is a finite-impulse response filter whose frequency response is modified from that of the IIR filter. Multiplying the infinite impulse by the window function in the time domain results in the frequency response of the IIR being convolved with the frequency response of the window function.[3]
Some of the windows commonly used are as follows:

1.1.1. Hanning window : The Hanning window is a raised cosine window . The hanning window is defined as

$$w(n)=\begin{cases} 0.5-0.5\cos\frac{2\pi n}{M-1}, & \text{for } n=0 \text{ to } M-1 \\ 0, & \text{elsewhere} \end{cases} \quad \textbf{....(1)}$$

The Hanning window is represented in Fig.1

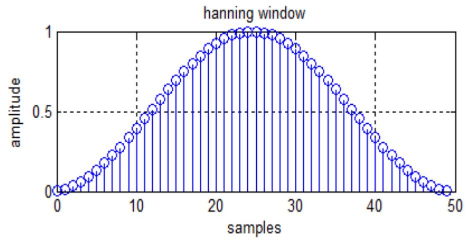

Fig.1- Hanning window shape

The magnitude response of Hanning window is represented in Fig.2

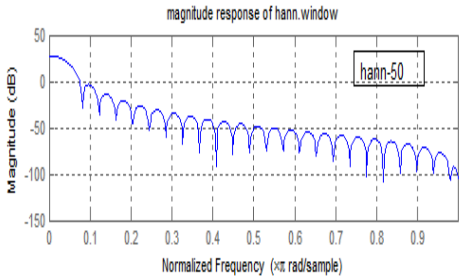

Fig.2- Magnitude response of hanning window

1.1.2. Hamming window: The hamming window is also a raised cosine window. The hamming window is defined as

$$w(n) = \begin{cases} 0.54 - 0.46cos\frac{2\pi n}{M-1} & , \text{ for } n = 0 \text{ to } M-1 \\ 0 , & \text{elsewhere} \end{cases} \quad \textbf{....(2)}$$

The Hamming window is represented in Fig.3

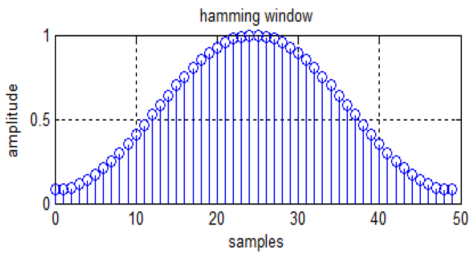

Fig.3- Hamming window shape

The magnitude response of Hamming window is represented in Fig.4

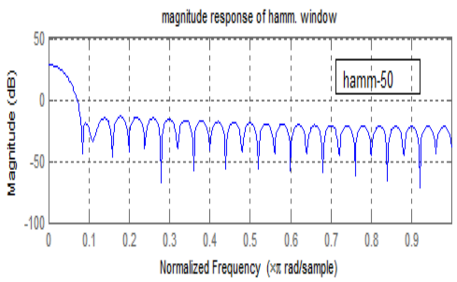

Fig.4- Magnitude response of hamming window

1.1.3. Blackman window: The Blackman window is defined as

$$w(n) = \begin{cases} 0.42 - 0.5cos\frac{2\pi n}{M-1} + 0.08cos\frac{4\pi n}{M-1} & , \text{ for } n = 0 \text{ to } M-1 \\ 0 , & \text{elsewhere} \end{cases}$$

...(3)

The Blackman window is represented in Fig.5

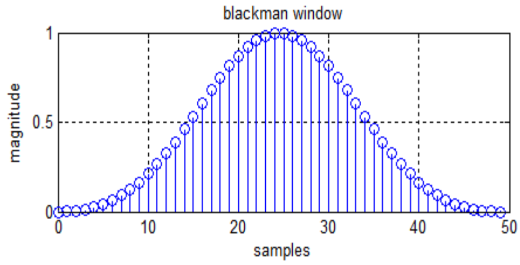

Fig.5- Blackman window shape

The magnitude response of Blackman window is represented in Fig.6

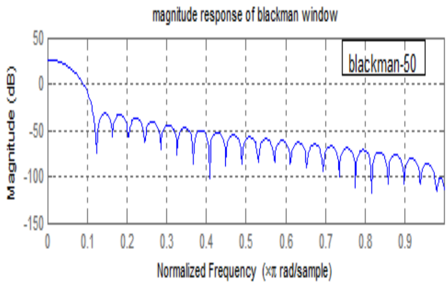

Fig.6- Magnitude response of Blackman window

1.1.4. New window: The New window is defined as

$$w(n) = \begin{cases} 0.591 - 0.664cos\frac{2\pi n}{M-1} + 0.0885cos\frac{4\pi n}{M-1} & , \text{ for } n = 0 \text{ to } M-1 \\ 0 , & \text{elsewhere} \end{cases}$$

.... (4)

The New window is represented in Fig.7

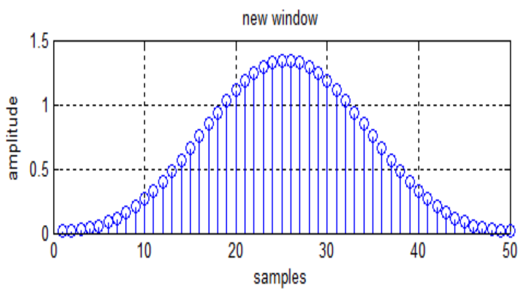

Fig7- New window shape

The magnitude response of New window is represented in Fig.8

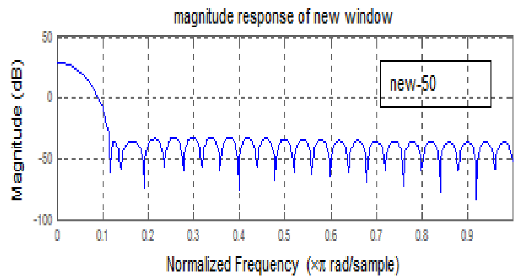

Fig8- Magnitude response of New window

1. COMPARE BETWEEN NEW WINDOW & OTHER WINDOWS

In this section, performance of the new window with several commonly used windows is compared which is shown in Fig.9 and Fig10.

Different windows are represented in Fig9

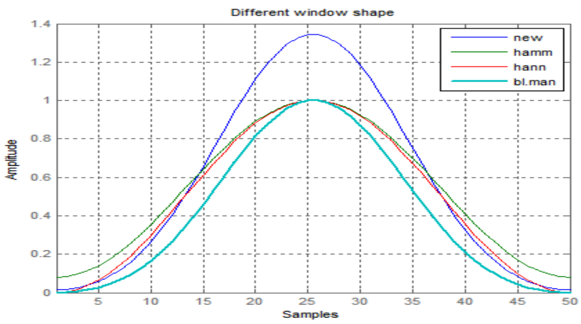

Fig.9- Different window shapes

Magnitude response of different windows are represented in Fig.10

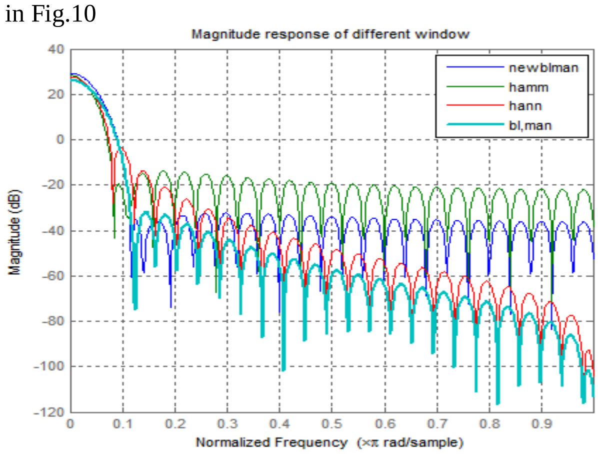

Fig.10- Magnitude response of different windows

According to Fig.9 and Fig.10 the specification of different window sequence is given in Table1.

Table-1

Window technique	**Order of the filter**	**Width of main lobe**	**No. of side lobes**	**Relative side lobe attenuation (dB)**	**Maxi - mum Amplitude of Window**	**Mini-mum Ampli-tude of Window**
Hanning window	50	0.058594	23	-31.5	0.99897	0
Hamm - ing window	50	0.050781	23	-42.3	0.999	0.08
Black -man window	50	0.066406	22	-58.1	0.998315	0
New window	50	0.0625	22	-61.5	1.341409	0.0155

3. DESIGN OF FIR FITERS BY USING NEW WINDOW:

The new window function w(n), as in equation (4) is used to compute the frequency response of various types of FIR filter i.e. low pass, high pass, band pass and band stop.

Low pass filter:

The frequency response of a low pass FIR filter using w(n) is represented in Fig. 11. The order of the filter is taken 50.

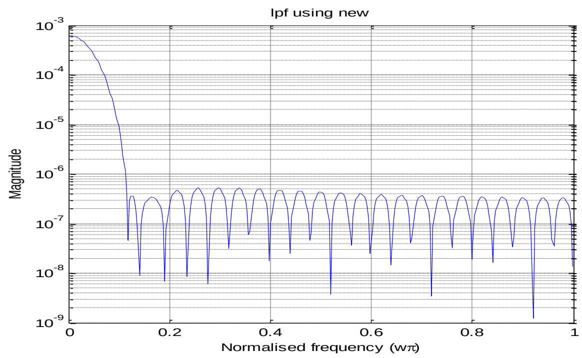

Fig.11- Magnitude response of lpf using New window

From the Fig.11the specifications are given in Table.2

Table-2

Cut-off frequency	Minimum stop-band attenuation (dB)	Maximum Stop-band attenuation (dB)
0.5	2.7×10^{-7}	0.5×10^{-9}

High pass filter:

The frequency response of a high pass FIR filter using w(n) is represented in Fig. 12. The order of the filter is taken 50.

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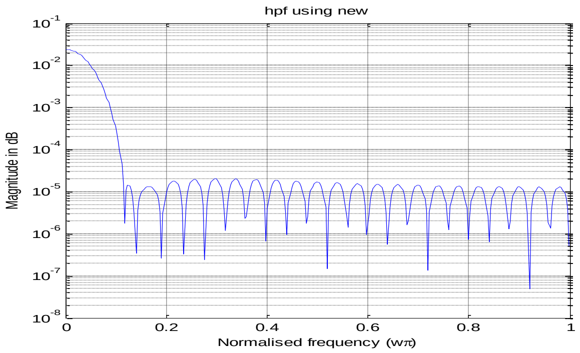

Fig.12- Magnitude response of hpf using New window

From the Fig.12 the specifications are given in Table.3

Table-3

Cut-off frequency	Minimum stop band attenuation (dB)	Maximum stop band attenuation (dB)
0.5	0.5×10^{-5}	4×10^{-8}

Band pass filter:

The frequency response of a band pass FIR filter using w(n) is represented in Fig.13. The order of the filter is taken 50.

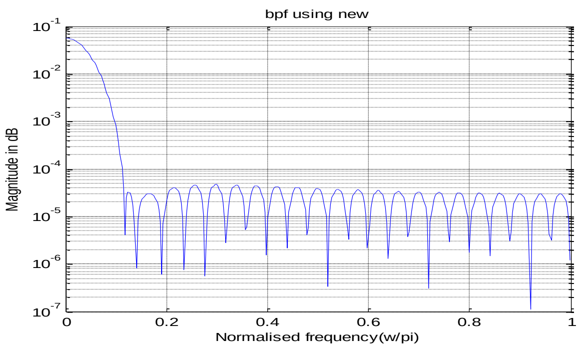

Fig.13- Magnitude response of bpf using New window

From the Fig.13the specifications are given in Table.4

Table.4

Cut-off frequency	Minimum Stop-band attenuation (dB)	Maximum stop-band attenuation(dB)
0.5	2.4×10^{-5}	0.2×10^{-7}

Band stop filter:

The frequency response of a band stop FIR filter using w(n) is represented in Fig.14. The order of the filter is taken 50.

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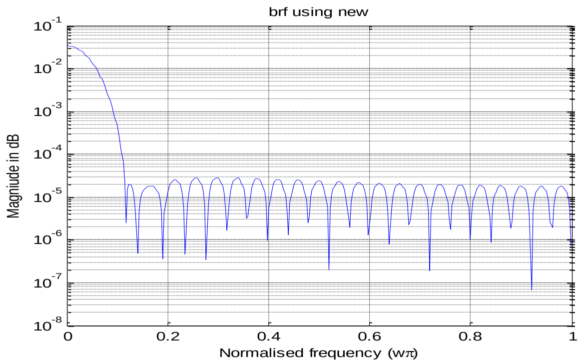

Fig.14- Magnitude response of brf using New window

From the Fig.14the specifications are given in Table.5

Table-5

Lower Cut-off frequency (wc1)	Upper Cut-off frequency (wc2)	Minimum Stop-band attenuation (dB)	Maximum stop-band attenuation (dB)
0.25	0.75	10^{-5}	7×10^{-8}

5. CONCLUSIONS:

In new window, the main lobe width is 0.0625 for filter order 50 which means this window has less transition width and introduces more ripple. Digital filter can play a major role in speech signal processing applications such as, speech filtering, speech enhancement, noise reduction and automatic speech recognition.

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