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A New Hamming window Design for Improving Width of Lobes for Noise Removal

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Abstract

Digital filters are used in communication systems. The Digital filter performance is important as a good result. Design of FIR (finite impulse response) filter satisfy demand condition is required. Maximum side lobe is minimized by Hamming window. The new window has a main lobe width approximately same as Hamming window. The new window has a wider main lobe width in proposed window. Digital Signal processing two main applications of windows is: Finite impulse response (FIR) and Fast Fourier transforms (FFT) from infinite impulse response (IIR) filters. Windows and FFT (Fast Fourier transform) analysis, both are decrease side lobes. So this effect is called 'Leakage Effect.

Keywords: FIR Filters, Modified Hamming window, New Window, proposed window, Hamming window, Simulink, MATLAB.

Introduction

The DSP (digital signal processing) is fundamental filter of signal. Mathematical operation performed by digital filter as reduced signal of separate time.Digital filter are two types : i. IIR filters, ii. FIR filters, iii. IIR filters have infinite impulse is called IIR filter. IIR filter is feedback (recursive) filters. FIR filter has a finite impulse response is called FIR filters. FIR filters have no feedback.

Finite impulse response provide linear phase, stable, no feedback. Described of finite impulse response given following formula[1]: $Y(n) = \sum_{k=0}^{N-1}\{h(k).x(n-k)\}$ (1)

Where: $x(n)$ is the input signal and $h(n)$ is the impulse response of finite impulse response (FIR) system.

FIR filter design is most easy method is window method. This window is a truncated infinte to finite impulse response. This is the main advantage of window method. The window method is easy to understand, operation is simple.

Hamming, rectangular, Hanning and Kaiser windows are most popular widely used. The Rectangular window gives high ripples in stop band and pass band. The side lobe amplitude is found by ripple amplitude. Rectangular window has a main lobe width is narrower. Hamming window function provides FIR filter design for smaller main lobe width.

New Window: A new window is defined as

$$w(n) = \begin{cases} 0.591 - 0.664\cos\frac{2\pi n}{M-1} + 0.885\cos\frac{4\pi n}{M-1}, for\ n = 0\ to\ M-1 \\ 0, \quad elsewhere \end{cases} \quad (2)$$

Modification to hamming window is side lobe peak is reduced. Hamming window and Blackman window are special family called raised cosine windows.

For hamming window ($W_H[n]$), k=1, a0=0.54, a1=0.46, that is only the first two terms are non zero

$$w(n) = \sum_{i=0}^{k} (-1)^i a_i \cos\left(\frac{2\pi n}{M}\right), 0\leq n \leq M, \quad (3)$$

For hamming window ($W_H[n]$), k=1, a0=0.54, a1=0.46, that is only the first two terms are non zero

$$W_H[n] = 0.54-0.46\cos(2\pi n/M), 0\leq n \leq M \quad (4)$$

Result: When filter order M is increased then main-Lobe width is increases and side –Lobe width decreases of different types of signals[2].

Proposed Window: The proposed window function is represented as.

$$w(n)=0.58--0.66\cos\frac{2\pi n}{N-1}+0.088\cos\frac{4\pi n}{N-1}, \text{ for n=0 to N-1} \quad (5)$$

FIR Filters Design Methods

Different methods of FIR filter design. The common methods are[3]: i. Windowing method, ii. Frequency Sampling method, iii. Fourier series method, iv. Optimal Filter Design Method

Window Method[4]: Windows has desired frequency response in any digital filter is periodic in frequency can be expressed in Fourier series. The window is a truncated infinite impulse response to finite impulse response. Hamming window main lobe width is approximately 8π /M. Hamming window has following equation:

$$w(n) = \{\alpha - (1-\alpha)\cos\left(\frac{2\pi n}{M-1}\right), 0 \le n \le M-1; \qquad (6)$$

Where: α =0.54.

Frequency sampling Method: Frequency sampling the continuous frequency response H_d (w) at N points essentially gives us the N-point DFT of h_d (2pnk/N). Thus, by using the IDFT formula, the filter coefficients can be calculated using the following formula[5]:

$$\text{h (n)}=\frac{1}{N}\sum_{n=0}^{N-1}(H(k)e(\frac{j2\pi n}{N})\ \text{K} \qquad (7)$$

The frequency sampling method is providing feedback realization for FIR filters.

Fourier Series Methood: Fourier series method the desired frequency response specification H_d (w) and corresponding unit sample response h_d (n) is determined using the following relation[6]

$$h_d\ \text{(n)}=\frac{1}{2\pi}\int_{-\pi}^{\pi} H_d(e^{jw})\ \text{exp (jwn)dw} \qquad (8)$$

$$\text{Where: } H_d(e^{jw})=\sum_{n=-\infty}^{n=+\infty}(hd(n)e^{-jwn}) \qquad (9)$$

The $h_d(n)$ unit sampled response. Filter show oscillations in both band known as Gibb's oscillations because truncations of Fourier series is the main reason.

Optimal filter design Method: The optimal filter design method uses easing programs and more efficient. This method is used in industry. Frequency sampling method error reduces by optimal filter design. The optimal filter design method used for minimizing error. Determine of filter coefficients is more complex by optimal filter design method.

Filter design and implementation have five steps: i. Filter Specifications. ii. Coefficient Calculations. iii. Structure Selection. iv. Simulation. v. Implementation

Simulations Results

Simulation results are found in New window, modified Hamming window and proposed window Hamming window.

Figures and interpretation details are given in simulation results.

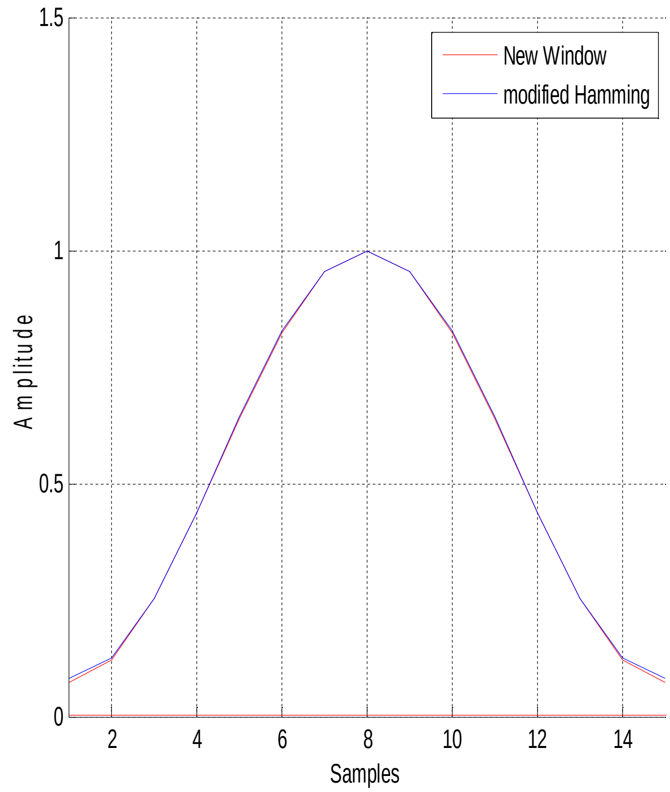

Figure-1
Amplitude response of the Modified Hamming window and new window

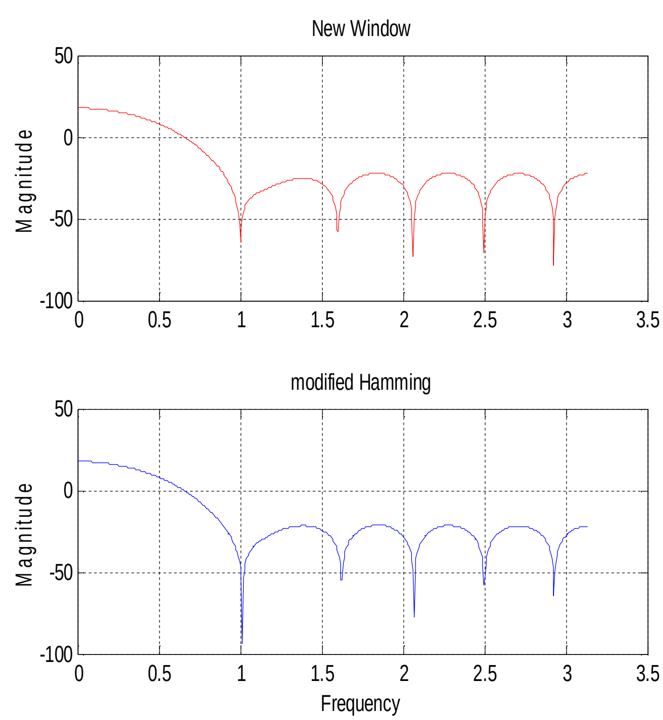

Figure-2
Frequency Magnitude response of modified Hamming window and New window

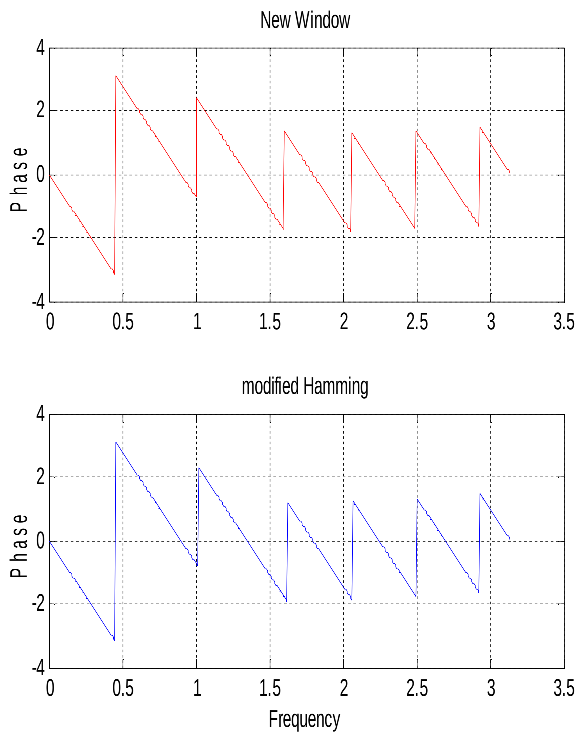

Figure-3
Frequency-Phase response of Modified Hamming and New window

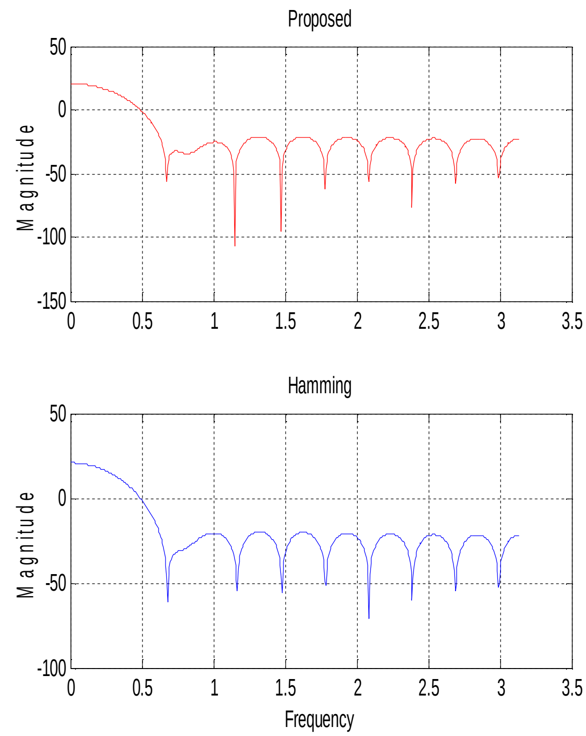

Figure-5
Frequency Magnitude response of Hamming window and Proposed window

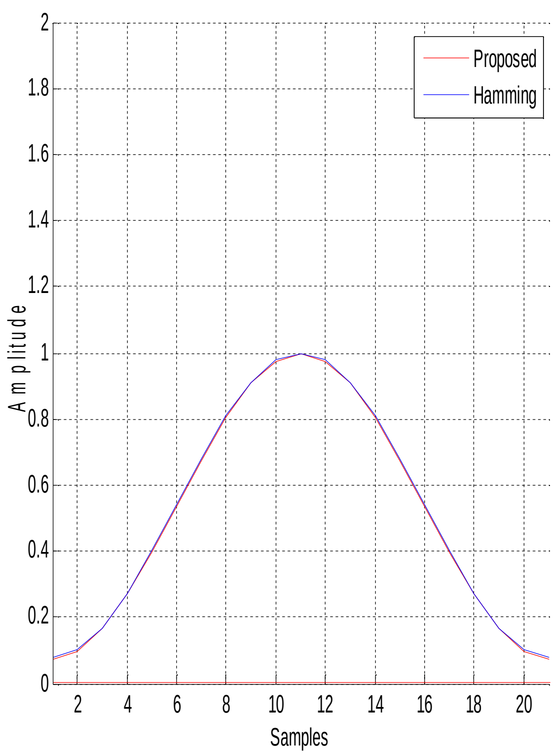

Figure-4
Time Amplitude response of Hamming window and proposed window

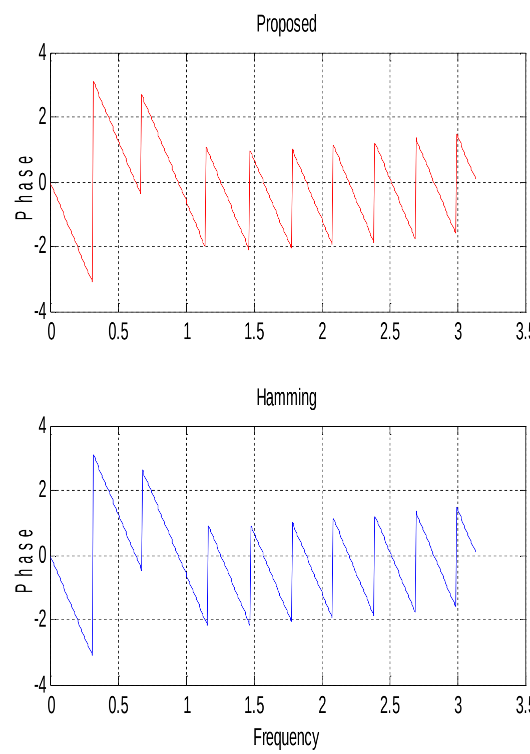

Figure-6
Frequency-Phase response of Hamming and Proposed window

Interpretation of Above Result: New window gives the same response as modified hamming window Figure-1. Amplitude of the modified hamming window and the new window is equal to 1. New window and modified hamming window filter order is 14.

In Figure-2 new window and modified hamming window have magnitude response is -25 dB. Modified hamming window and new window both has a wider main lobe width. Main lobe width is 0.1875 in the modified hamming window and new window. Relative side lobe attenuation in hamming window and new window is -38.5 dB. Leakage factor of modified hamming window is 0.04%.

In Figure-3 frequency –phase response of hamming window and new window is same[8]. When frequency in increases in hamming window and new window then phase response in decreases.

In Figure-4 amplitude of hamming window and proposed window is equal to 1. Proposed window and hamming window less main lobe width in comparison of new window.

In Figure-5 proposed window and hamming window have magnitude response is -25 dB. Hamming window and proposed window both have less main lobe width is 0.13281 in comparison of the new window[9].

In Figure-6 frequency –phase response of hamming window and proposed window is same. When frequency in increases in hamming window and proposed window, then phase response is decreased.

Applications: A hamming and proposed window used in reducing noise. The main applications are speech processing, filter of noise. A hamming window has a wider main lobe width in comparison of the proposed window[10].

Discussions: New window and modified hamming window has wider main lobe width in comparison of proposed window. New window and modified window are providing wider main lobe width than proposed window hamming window[11].

Conclusion

Modified hamming window function is very simple operation. This window is provides more flexible in DSP applications. New window has main lobe width approximately same as modified hamming window. New window has wider main lobe width than proposed window.

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