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A NOVAL METHOD FOR DESIGNING FINITE IMPULSE RESPONSE FILTER USING COMPOSITE WINDOWING TECHNIQUE

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ABSTRACT

Digital filters are widely used in the world of the communication and computation. Designing a digital FIR filter that satisfies all the requirements is a challenging one. In this paper, a new composite windowing technique is proposed to design FIR low pass filter. Composite windowing technique is nothing but combination any two windows. A signal is taken with noise and filtered using Composite windowing technique based FIR filter. The filtered output is measured in terms of relative side lobe attenuation,main lobe width, leakage factor and finally SNR is calculated. The results of FIR filters design with composite windowing technique is compared with results of FIR filter design with individual windowing techniques.

***Keywords*: *Composite Windowing Technique, Leakage Factor, Main Lobe Width, Relative Side Lobe Attenuation& Snr*.**

I. INTRODUCTION

In signal processing, a **filter** is a device or process that removes from a signal some unwanted component or feature. Filtering is a class of signal processing, the defining feature of filters being the complete or partial suppression of some aspect of the signal[1]. Most often, this means removing some frequencies and not others in order to suppress interfering signals and reduce background noise. However, filters do not exclusively act in the frequency domain especially in the field of image processing many other targets for filtering exist. Correlations can be removed for certain frequency components and not for others without having to act in the frequency domain.

The pass band of the filter passes a band of desired frequencies without any distortion and stop band of the filter totally blocks band of unwanted frequencies. Accordingly, the digital filters are available as low pass filters, high pass filters, band pass filters and band reject filters. In this paper FIR low pass filter is considerd. Filters can be classified in several different groups, depending on what criteria are used for classification.

The two major types of filters are finite impulse response digital filters (FIR filters) and infinite impulse response digital filters (IIR)[1]. FIR filters are mostly used because of desired characteristics such as linear phase, high filter order (more complex circuits) and stability[2]. Here, the designing of FIR filter using composite window function takes place.

Individual windows are taken to reduce the ripples and to satisfy the condition stability. But, still ripples are present. So, to obtain better results composite windowing technique is proposed.

Composite window is a new concept which is obtained by the combination of two different windows with different mathematical operations[3]. There are two combinations of windows proposed in this paper.

(a). Blackman and Triangular.

(b). Hanning and Triangular.

The characteristics of FIR low pass filter[3], the windowing technique and the required equations for the composite windows are explained. The implementation of the filters was carried out using MATLAB tool.

The frequency response of FIR filter using composite window and individual windows are represented further[2]. Tabular forms for Relative side lobe attenuation, peak amplitude of side lobe, main lobe width and leakage factor are given in this paper for comparison.

II. PROPOSED METHOD

The composite window is a type of window formed due to combination of two different types of windows[4]. The combination of windows performed using addition, multiplication and averaging operations.

2.1. Triangular window:

$wt(n)=1-(2|n|)/(N-1)$ for $-(N-1)/2 \leq n \leq (N-1)/2$

$=0$ otherwise

2.2. Hanning window:

$wb(n)=0.5+0.5\cos(2*pi*n/N-1)$ for $-(N-1)/2 \leq n \leq (N-1)/2$

$=0$ otherwise

2.3. Blackman window:

$wb(n)=0.42+0.5\cos(2*pi*n/N-1)+0.08\cos(4*pi*n/N-1)$ for $-(N-1)/2 \leq n \leq (N-1)/2$

$=0$ otherwise

The composite window technique is used for improvisation of the signal response of the filter. A single windowing technique adds ripples to the signal[5]. But using this composite window, the ripples are decreased which tends to increase in accuracy.

This paper proposes two combinations.

2.4. Combination 1:

Composite window =Triangular window & Blackman window

2.5. Combination 2:

Composite window =Triangular window &Hanning window

Now these combinations are performed by using operations like addition, multiplication and averaging[5].

2.6. For combination 1:

2.6.1. Addition:

$wn(n)=wt(n)+wb(n)$

$=[1-(2|n|)/(N-1)]+[0.42+0.5\cos(2*pi*n/N-1)+0.08\cos(4*pi*n/N-1)]$

2.6.2. Multiplication:

wn(n)=wt(n)*wb(n)

= [1-(2|n|)/(N-1)]*[0.42+0.5cos(2*pi*n/N-1)+0.08cos(4*pi*n/N-1)]

2.6.3.Averaging:

wn(n)=[wt(n)+wb(n)]/2

={[1-(2|n|)/(N-1)]+[0.42+0.5cos(2*pi*n/N-1)+0.08cos(4*pi*n/N-1)]}/2

2.7. For combination 2:

2.7.1. Addition:

wn(n)=wt(n)+wh(n)

= [1-(2|n|)/(N-1)]+[0.5+0.5cos(2*pi*n/N-1)]

2.7.2. Multiplication:

wn(n)=wt(n)*wh(n)

= [1-(2|n|)/(N-1)]*[0.5+0.5cos(2*pi*n/N-1)]

2.7.3. Averaging:

wn(n)=[wt(n)+wh(n)]/2

={[1-(2|n|)/(N-1)]+[0.5+0.5cos(2*pi*n/N-1)]}/2

A signal which is noised is filtered using Composite windowing technique based FIR filter use above operations to obtain desired results. Finally, SNR(Signal to noise ratio) is calculated.

III. RESULTS

We obtain results by combining two individual windows to form a composite window. The main lobe width, relative side lobe attenuation, leakage factor and SNR is calculated[6]. The results of Individual windows are shown below

Individual window	Main lobe width(3db)	Relative sidelobe attenuation	Leakage factor	Signal to Noise ratio(SNR)
Rectangular	0.023438	-13.3db	9.37%	45.7336
Triangular	0.033203	-26.5db	0.29%	44.2373
Hanning	0.037109	-31.5db	0.05%	43.1819
Hamming	0.033203	-42.5db	0.04%	31.1755
Kaiser	0.023438	-13.6db	8.57%	-15.4254
Blackman	0.042969	-58.1db	0%	25.3933

TABLE 1: FIR low pass filter responses using individual windows

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3.1. FIR filter response using composite window

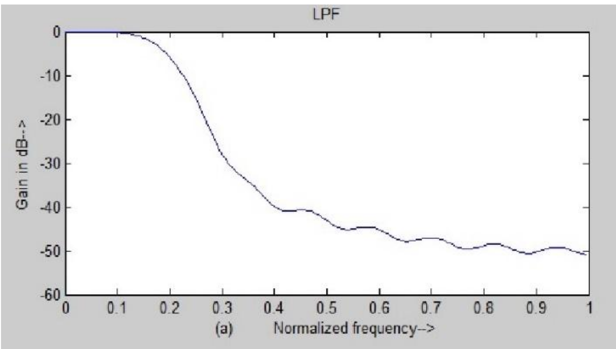

Fig.1.LPF response using composite window (Triangular & Blackman)

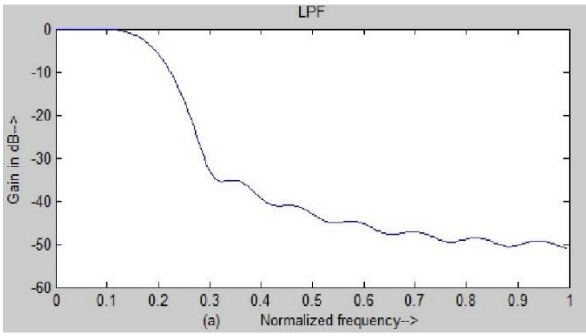

Fig.2. LPF response using composite window (Triangular & Hanning)

3.2. Time Domain and Frequency Domain responses of composite windows

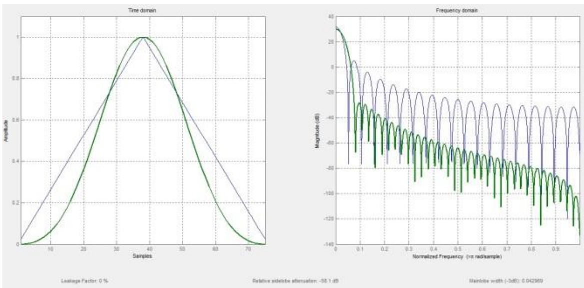

Fig.3.Composite window(triangular & blackman)

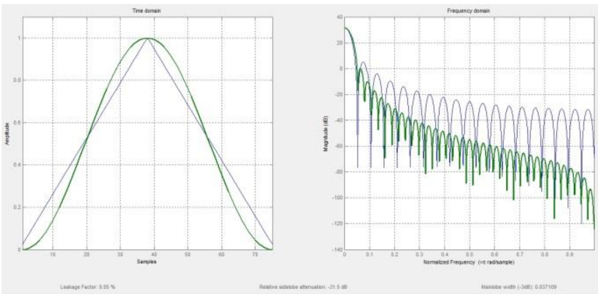

Fig.4.Composite window(triangular & hanning)

When a signal is taken with noise and filtered by using Composite windowing technique based FIR filter[6]. The filtered output is taken in terms of relative side lobe attenuation and peak amplitude of side lobes, main lobe width, leakage factor and finally SNR is calculated.

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The results are represented below

3.3. Signal added with noise is filtered using composite windows

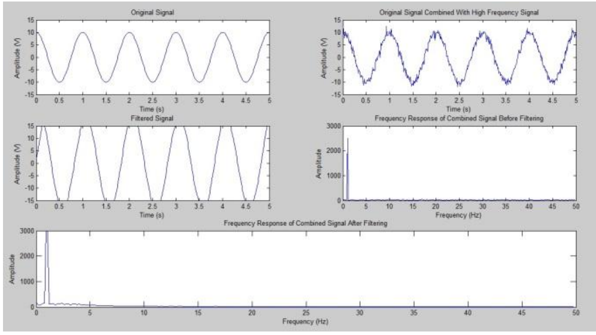

Fig.5.Composite window(Triangular & Blackman)

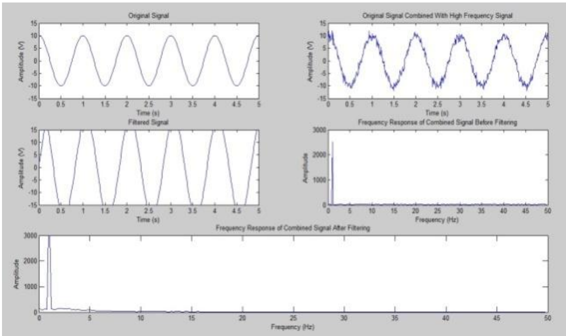

Fig.6.Composite window(Triangular & Hanning)

Individual Window	Main lobe width(3db)	Relative sidelobe attenuation	Leakage factor	Signal to Noise ratio(SNR)
Triangular	0.033203	-26.5db	0.29%	44.2373
Hanning	0.037109	-31.5db	0.05%	43.1819
Blackman	0.042969	-58.1db	0%	25.3933

TABLE 2: FIR low pass filter responses using selected individual windows

Composite window	Main lobe width(3db)	Relative sidelobe attenuation	Leakage factor	Signal to Noise ratio(SNR)
Triangular & Blackman	0.033203	-26.5db	0.29%	51.6345
Triangular & Hanning	0.037109	-31.5db	0.05%	57.7252

TABLE 3: FIR low pass filter responses using composite windows

IV. CONCLUSION

A Composite window based FIR filter is designed and the new composite windows are proposed with better results than individual windows. The relative side lobe attenuation, main lobe width, leakage factor and SNR is calculated. A better SNR is obtained using composite windowing technique than individual windowing technique.

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