SUGGESTED A ONE VARIABLE WINDOW FOR IMPROVE IN SIDE LOBE REDUCTION IN FIR FILTER

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ABSTRACT—A new feature is recommended, within the design construct of finite impulse reaction filter out we decide its highest -lobe width, ripple ratio and side-lobe fall off ratio with the aid of the help of different window . the suggestible window is a mixture of Lanczos, blackmain and kaiser window .The window is suggestible as moving the value of r, the window can be suggestible consequently, From MATLAB simulation outcomes, it is experiential that the suggested window delivers improved highest lobe width, ripple ratio and SLRR than Gaussian window.

KEYWORD— FIR filter, Gaussian window, Hamming window Highest-lobe width, Kaiser window, , Ripple ratio, Side-lobe fall-off ratio.

1. INTRODUCTION

A filter is a frequency selective device. Digital filters show a lot of applications in speech processing, noise suppression [1] and image enhancement etc. FIR filters are highly preferable if no phase distortion is required. Various researchers across the globe have proposed a various approaches for FIR filter design which provides a closed form solutions. Windowing is a truncation of the IIR filter impulse response [9]. Truncation of the desire response $\boldsymbol{h_d}$[n] is equivalent to product of the $\boldsymbol{h_d}$ [n] by a rectangular window w[n].

$$h[n] = h_d[n]\, w[n]$$

we can change the value of adjustable window by changing the one or more variable parameter[1],[2]. Designed of various filter can be done using window function [2]. Several windows have been suggested for better spectral specifications than commonly used windows [3]. Digital filter can be used to improve the quality of a signal. Digital filters are used in wide variety of applications like signal processing, telecommunication, control systems and many more. FIR and IIR are basically the two kind of digital filter used for filtering purpose. Desire response of digital FIR filters is fixed in interval with linear phase characteristics and is always stable. On the other hand, IIR filters have unlimited duration impulse response and may be unstable sometimes. Because of the linear phase response and stability FIR has great benefits over IIR [9][10].

Right here are three desired specifications for any window feature. They must have smaller highest-lobe width, high ripple-ratio (in negative sense) and high side-lobe roll-off ratio. However, these necessities are contradictory [1[,[6]. A For a fixed period, a window having higher side lobes has smaller primary-lobes width and smaller ripple ratio and vice versa [4]. Gaussian, Kaiser and Hamming window are commonly used adjustable window functions [6], [7]. Kaiser window has higher computational complexity because of inclusion of Bessel abilities [8].

Author proposed a brand new dynamic window characteristic which reveals better overall performance compared to the various generally acknowledged window features i.e. By adjusting the value of its adjusting parameter r, desired specification for the digital filter can be achieved. The suggested window suggests better spectral traits with some window with a very small compromisation of one of the spectral characteristics.

II. CHARACTERISTIC OF WINDOW FUNCTION

A general characteristic of a window in frequency domain is given as:

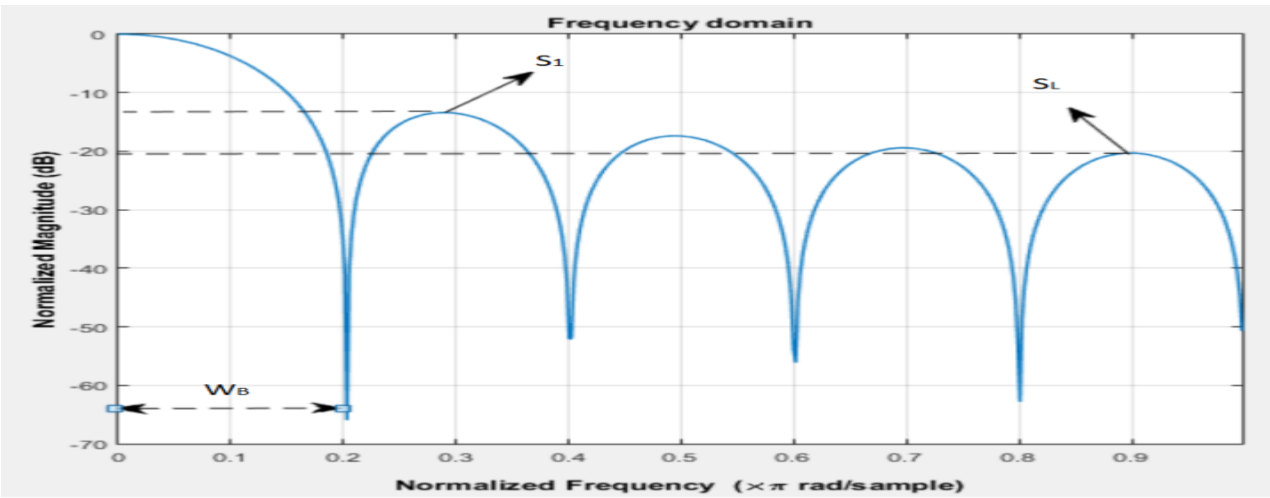


Fig 1. A general normalized window characteristics

RIPPLE RATIO

Ripple ratio given as the ratio of highest side lobe amplitude and Highest lobe amplitude of frequency characteristic of a signal. For side-lobe rejection ripple ratio should be high.

Ripple ratio=Highest side lobe amplitude in(dB)-Highest lobe amplitude in(dB)=s1

SIDE-LOBE FALL-OFF RATIO

In a frequency response ratio of Highest-side lobe amplitude value to smallest side lobe amplitude value known as the side-lobe fall-off ratio. To prevent aliasing problem side-lobe fall off ratio should be high.

Side-lobe fall-off ratio (SLRR)= Highest side-lobe amplitude (in dB)-Smallest side-lobe amplitude (in dB)=s1-sL .

HIGHEST-LOBE WIDTH

Highest-lobe width(HLW)=Width of the Highest-lobe$\times 2\pi$

III. SUGGESTED WINDOW FUNCTION

The suggested window function is the mixture of blackmain , Lanczos Window functions, kaiser window provided in (1),(2) and (3)respectively.

$$w_1[n] = 0.54 - 0.46\cos\left(\frac{2\pi n}{N-1}\right) \quad (1)$$

$$w_2[n] = sinc^L\left(\frac{2\text{n}}{\text{N}} - 1\right) \quad (2)$$

$$w_3[n] = \frac{I_0\left(\pi\alpha\sqrt{1-\left(\frac{2n}{N-1}\right)^2}\right)}{I_0(\pi\alpha)} \quad \text{for } 0 \le n \le N-1 \quad (3)$$

The value of the variable L in (2) is fixed at 3 has the function $w_2[n]$ has been described in (4).

$$w_2[n] = sinc^3\left(\frac{2\text{n}}{\text{N}} - 1\right) \quad (4)$$

Where N is the length of FIR filter required.

The suggested window functions given by equation (5)..

W[n]= $\lfloor \sin(w_2[\text{n}])\, w_1[\text{n}] \sinh(w_3[n]) \rfloor^{r1}$

Where ‘r’ is the spectral control parameter.

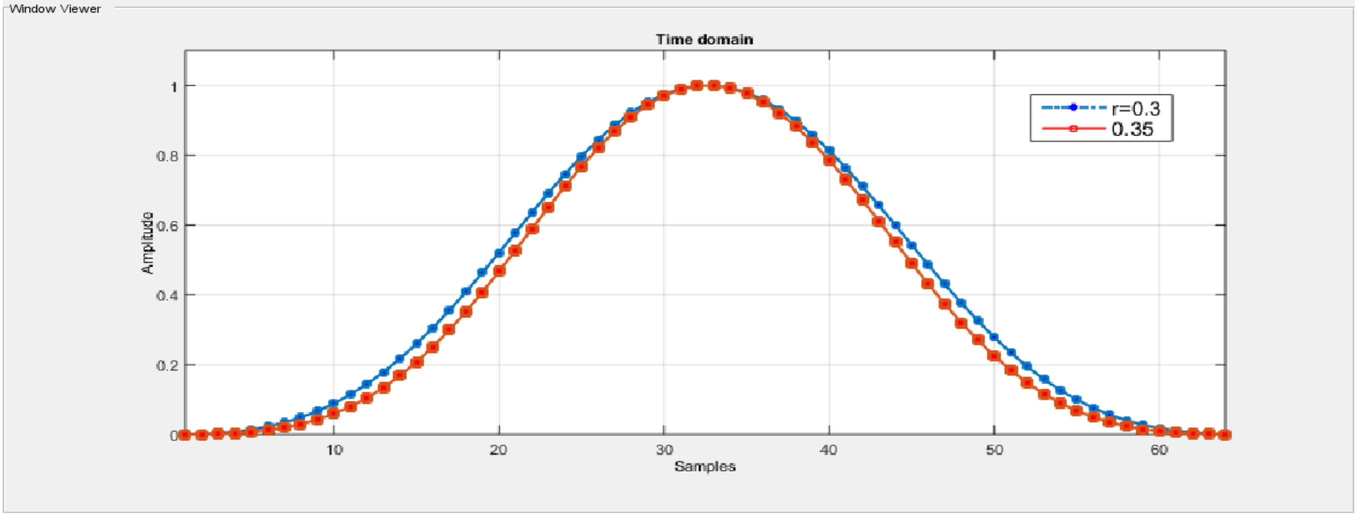


Fig.2: Time domain behavior of suggested window for specific expense of ‘r’

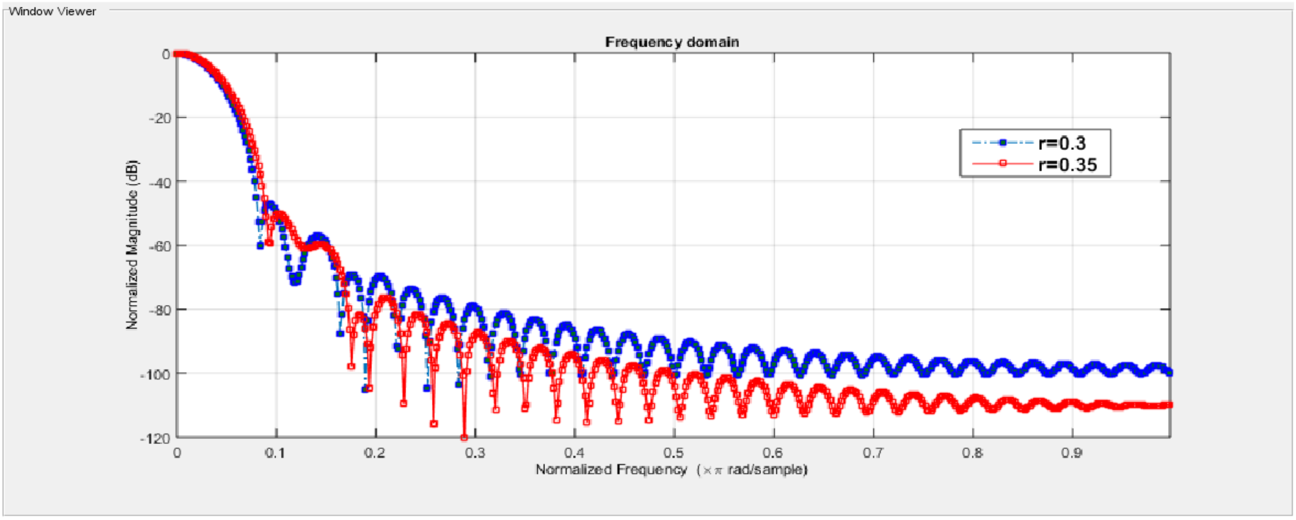


Fig.3 Frequency domain response of the suggested window for specific expense of ‘r’

Fig. 2 and Fig.3 present such suggested window width reduces in time domain while increasing ‘r’. The reduction of window width in time domain causes higher main-lobe width in frequency domain [7].

Table 1 and Fig. 3 indicates that increasing ‘r’ increases the RR ,SLRR and MLW smaller.

Table1: Frequency domain charactristic of suggested window for specific ‘r’

Factor‘r‘	**HLW**	**RR(dB)**	**SLRR**
r=0.3	0.082 x 2π	-46.84	48.15
r=0.35	0.091 x 2π	-50.8	56.35

IV. PERFORMANCE STUDY

Comparison of the suggested window with the empirical available window function is presented in this section

GAUSSIAN WINDOW

The function is defined as Gaussian window

$$w[n] = exp\left(-0.5\left(\frac{\alpha n}{\frac{N}{2}}\right)^2\right)$$

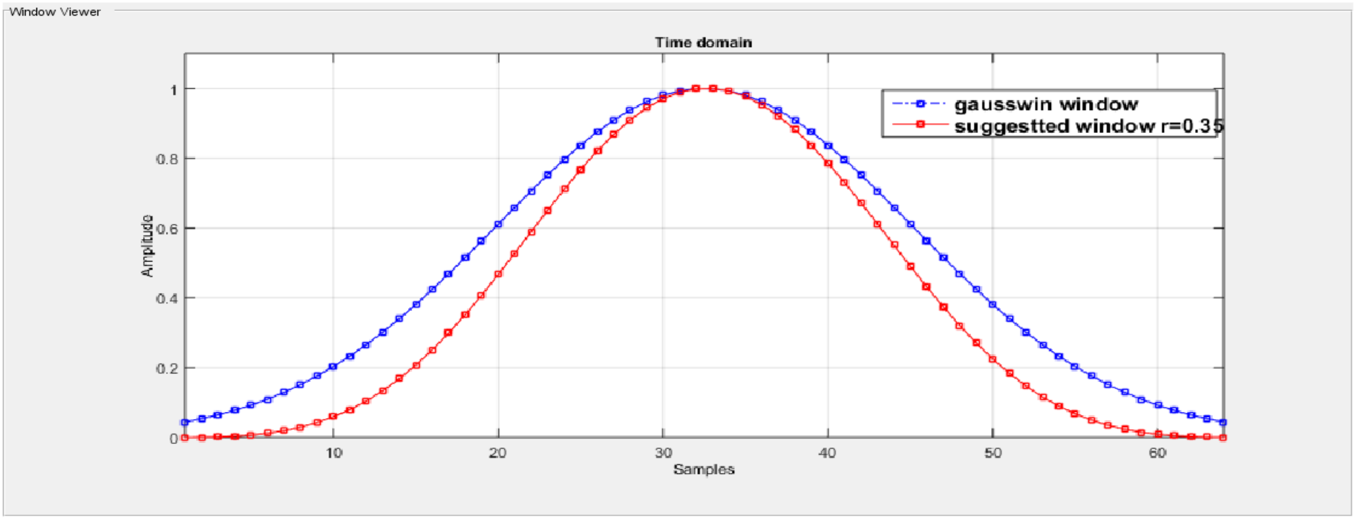


Fig4:Gaussian window evaluation with suggested window in time domain

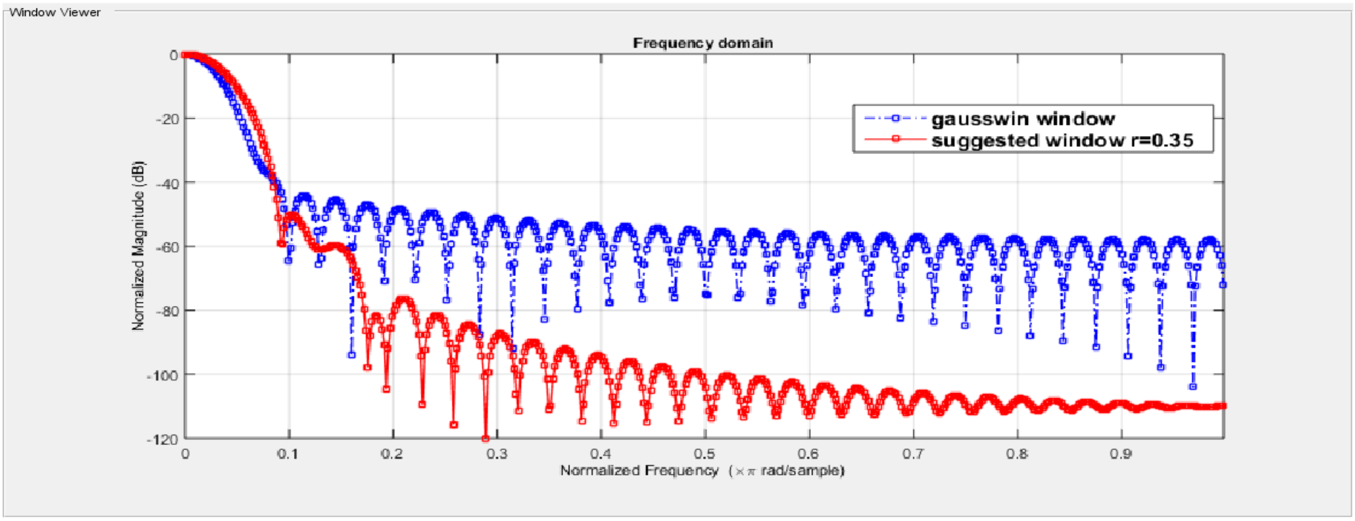


Fig. 5: Gaussian window evaluation with suggested window in frequency domain

Fig. 5 and Table II shows that suggested window r=0.35 gives smaller main-lobe width, smaller ripple-ratio compared to Gaussian window . Even for r=0.35 the suggested window gives better frequency domain characteristics as compared to Gaussian window.

Table2: Frequency domain charactristics comparison of suggested window with gaussian window.

Window function	HLW	RR(dB)	SLRL (dB)
Gausswin∝ = 2.5	0.101 8 x2π	-43.29	13.90
Proposed window r=0.35	0.091 x 2π	-50.8	56.35

KAISER WINDOW

The function is define as Kaiser window

$$w[n] = \frac{I_0\left(\pi\alpha\sqrt{1-\left(\frac{2n}{N-1}\right)^2}\right)}{I_0(\pi\alpha)} \quad \text{for } 0 \le n \le N-1$$

where I_0 is the zero-th order modified Bessel function of the first kind.

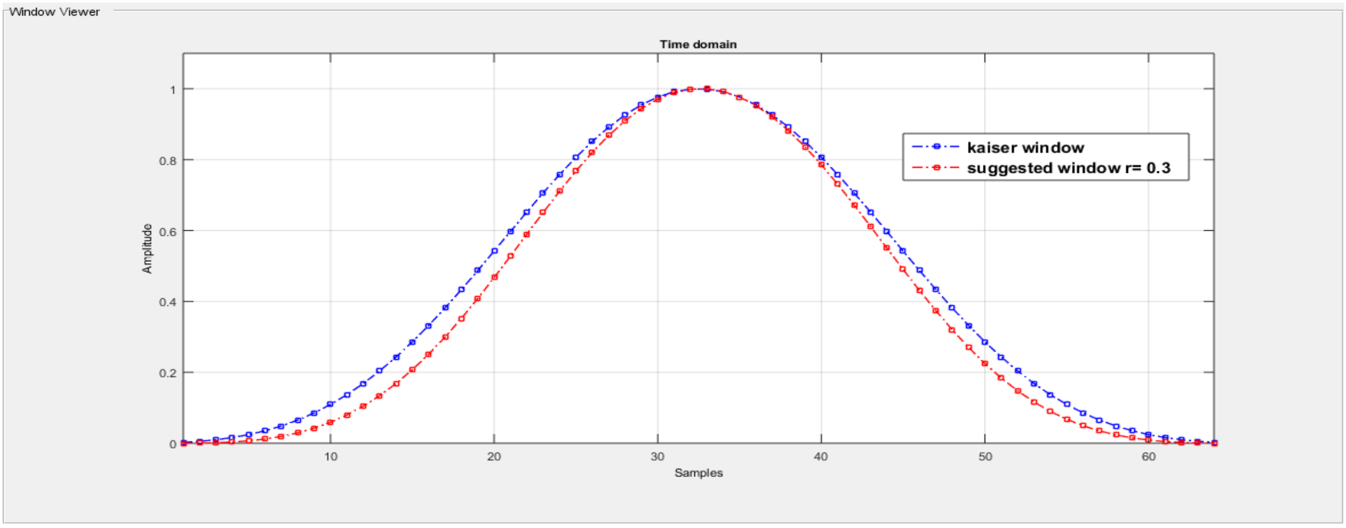


Fig.6: Kaiser window evaluation with suggested window in time domain

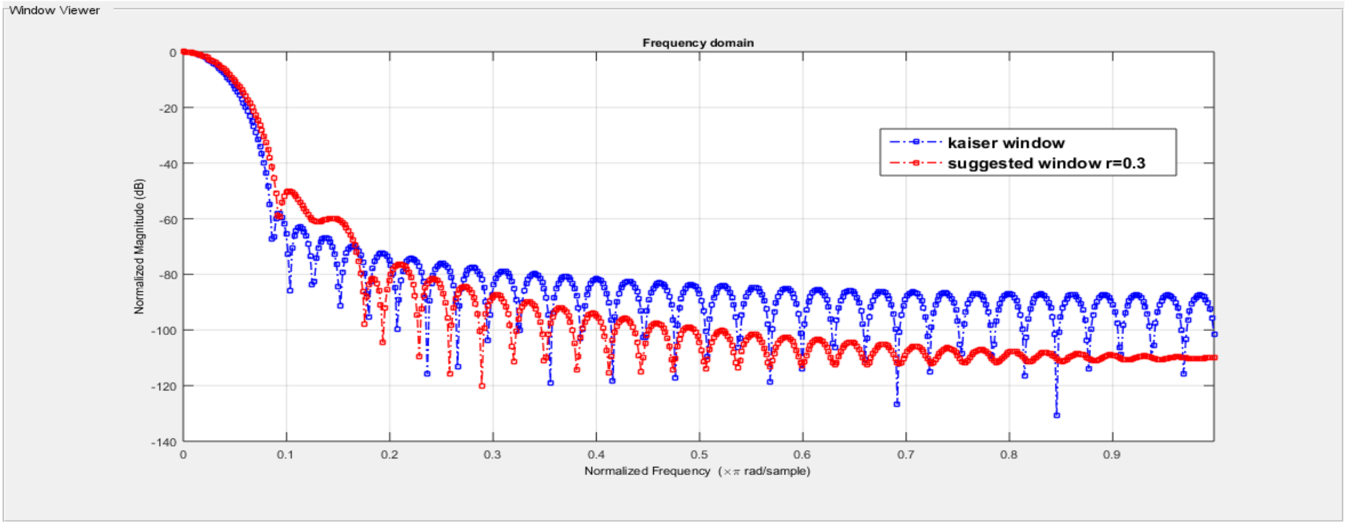


Fig. 7: Kaiser window evaluation with suggested window in frequency domain.

Fig. 7 and Table III indicates that suggested window r=0.35 gives smaller MLW and higher SLRR compared to Kaiser window as desired. But the ripple ratio of suggested window is higher.

Table3: Frequency domain charactristics evaluation of suggested window with kaiser window.

Window function	HLW	RR(dB)	SLRR(dB)
Kaiser$\propto = 9$	$0.0957 x 2\pi$	-65.95	31.90
Proposed window r=0.35	$0.091 x 2\pi$	-50.8	56.35

HAMMING WINDOW

The function is define as hamming Window

$$w[n] = 0.54 - 0.46 \cos\left(\frac{2\pi n}{N-1}\right)$$

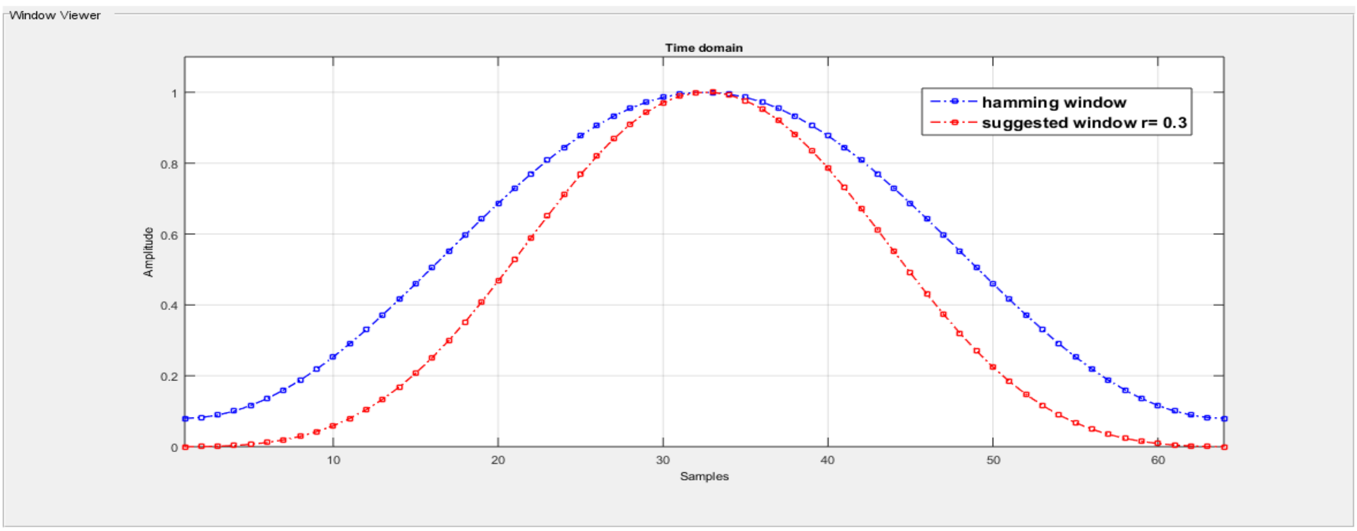


Fig. 7: Hamming window evaluation with suggested window in frequency domain.

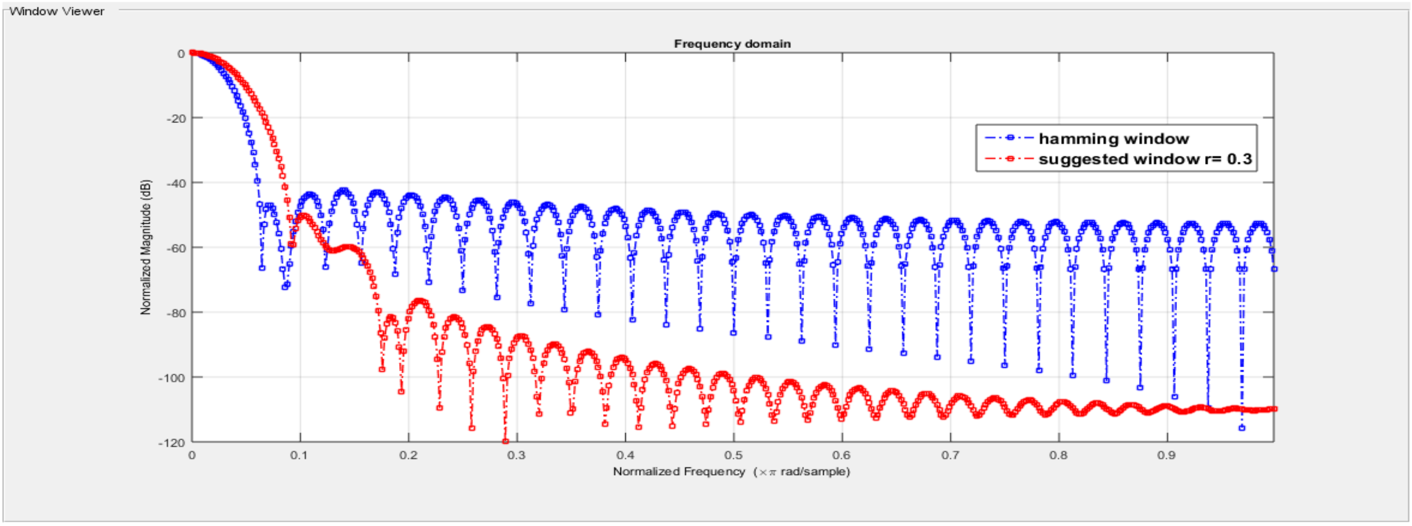


Fig. 9: hamming window evaluation with suggestted window in frequency domain.

Table4: Frequency domain charactristics comparison of suggested window with hamming window.

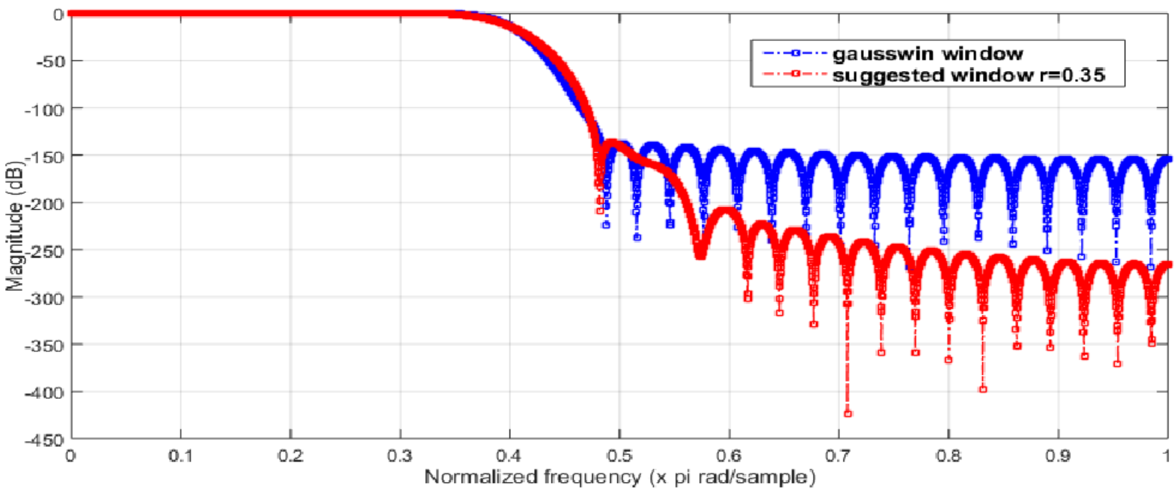
Window function	**HLW**	**RR(dB)**	**SLRR (dB)**
Hamming	0.0644 x 2π	-42.82	9.77
Proposed widow r=0.35	0.091 x 2π	-50.5	56.35

Fig. 9 and Table Iv indicates that suggested window r=0.35 gives smaller ripple ratio and higher SLRR compared to hamming window as desired. But the highest-lobe width of suggested window is higher.

V. SPECTRAL ANALYSIS OF FILTERS

In this section, the suggested window designed by FIR low pass filter will be compared with the low-pass filter designed using Gaussian window function [11].

Fig. 10 shows that the filter designed by the proposed window exhibits better ripple ratio and better side-lobe roll-off ratio than the filter designed by Gaussian Window.



VI. CONCLUSION

The suggested window function can adjust the spectral characteristics i.e. Ripple ratio, Highest-Lobe Width, and Side-Lobe fall- off ratio by using parameters 'r'. It shows better performance than Gaussian window in all desired specifications. The proposed window has better MLW and RR than Kaiser Window but with a very small compromisation of SLRR. The comparative study with Hamming window shows that suggested window provides better MLW and SLRR with a small compromisation of MLW. Finally to show that proposed window gives far better performance than Gaussian window function.

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