Design and Analysis of Low Pass FIR & IIR Filter and Find Optimum Result Using Neural Network

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***Abstract*-This paper is only based on the computational analysis. First of all taking window method for designing low pass FIR filter and the window equation for the different window is coded in the Matlab and find out the result by changing filter order randomly 21 to 54 and find out there results the width of main lobe and number of side lobes 0.4330 to 0.7500 and 4 to 15 respectively. But our goal to find out the width of main lobe is 0.4000 and minimum sides lobes, and then using same parameters for IIR filter we design an IIR filter and then we compare the FIR and IIR filter to find the best result, so for this optimization all data is coded in the Matlab and then by the help of Neural Network we find out the best result after simulation.**

Index Terms-FIR filter, IIR filter, Neural Network.

I. INTRODUCTION

Digital filter design techniques are widely used in different areas. The digital filters consist of software and hardware. The input and output signals in the digital filter is digital or discrete time sequence. Basically, digital filters are linear time invariant (LTI) systems which are characterized by unit sample response these filters are highly flexible and portable and it has minimum/negligible interference noise and other effects. Digital filters are easier in storage, maintenance and reduced failure time. The digital filters are classified in two categories as FIR (Finite impulse response) filter and IIR (Infinite impulse response) filter. The FIR filters have greater flexibility to control the shape of their magnitude response over the IIR filters [1-2].As there is much software for the designing of the digital filters but we are using the Matlab due to reason that the MATLAB is a high-performance language for technical computing integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation [3].

II. FILTER SPECIFICATIONS

For the designing of the low pass filter we choosepassband cutoff frequency 150 Hz and stop band frequency 250 Hz. It is safe to choose passband ripple of 1 dB and the minimum stopband attenuation of 40 dB.

Table.1 Filter specifications

Parameters	Value
$F_{passband}$	150 Hz
$F_{stopband}$	250Hz
$\alpha_{passband}$	1dB
$\alpha_{stopband}$	40dB
$F_{sampling}$	1000Hz

As we have

$$\alpha p = -20\log(1-\delta p)dB \qquad (1)$$

$$\alpha s = -20\log(\delta s)dB \qquad (2)$$

So we have

The Pass band ripple is given by:

$$rp = 1 - 10^{-\alpha p/20} = 0.1087 \qquad (3)$$

The Stop band ripple is given by:

$$rs = 10^{-\alpha s/20} = 0.01 \qquad (4)$$

$$wp = 2\pi * \frac{fp}{f} = 0.3\pi \qquad (5)$$

$$ws = 2\pi * \frac{fs}{f} = 0.5\pi \qquad (6)$$

$$wc = \frac{(wp+ws)}{2} = 0.4\pi \qquad (7)$$

III. FIR FILTER DESIGN

1) *Hamming Window*

We analysis the filter using Hamming window or fixed widow by coding in the Matlab and the response of the filter is given in figure 1, 2&3 respectively at the order 21,36& 54.

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2) *Blackman Window*

We analysis the filter using Blackman window by coding in the Matlab and the response of the filter is given in figure 4,5 and 6 respectively at the order 21,36 and 54.

3) *Kaiser Window*

We analysis the filter using adaptive window or Kaiser window By coding in the Matlab and the response of the filter is given in figure 7,8 and 9 respectively at the order 21,36 and 54.

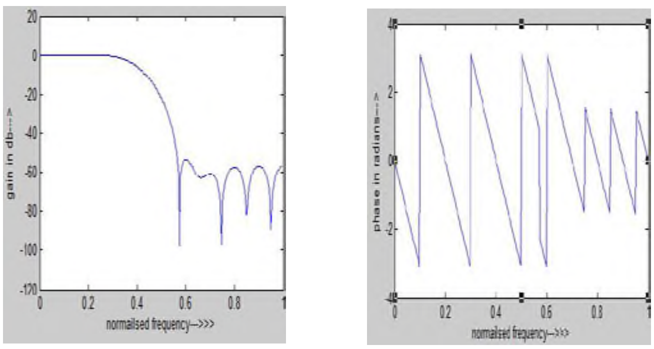


Figure.1 FIR Hamming window (n=21)

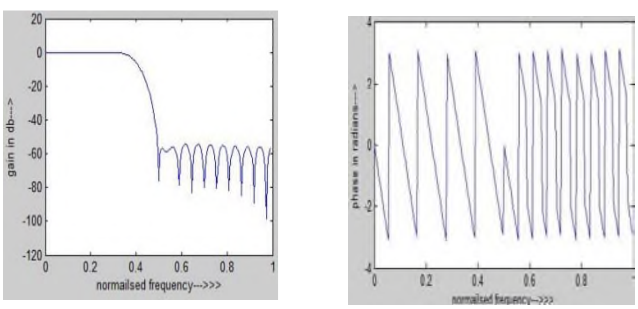


Figure.2 FIR Hamming window (n=36)

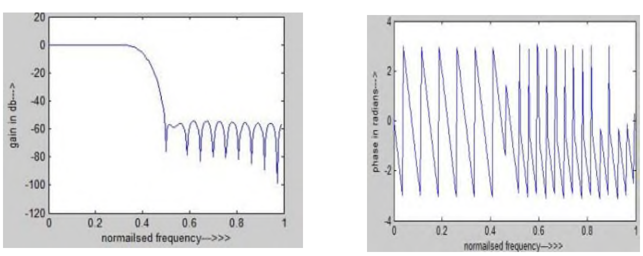


Figure.4FIR Blackman window (n=21)

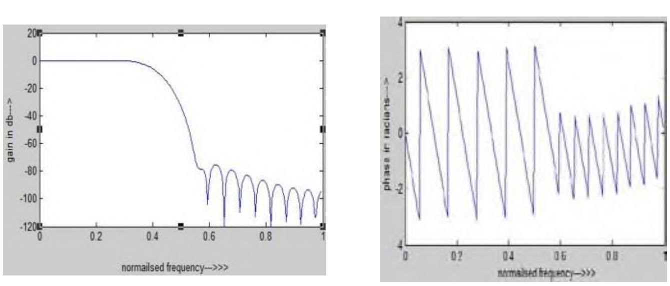


Figure.5 FIR Blackman window (n=36)

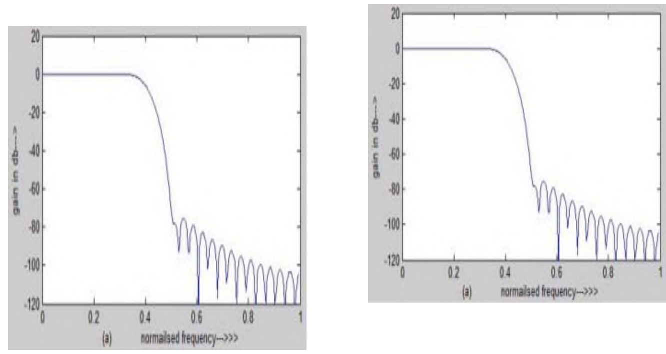


Figure.6FIR Blackman window (n=54)

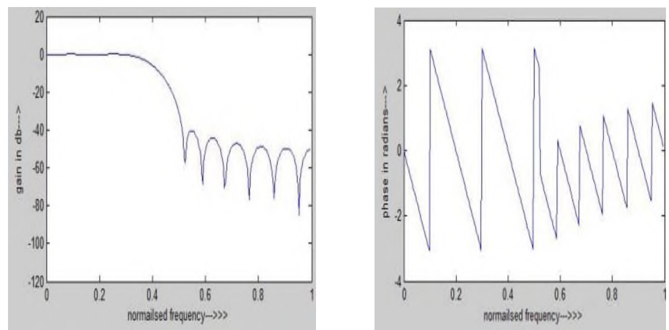


Figure.7FIR Kaiser Window (n=21)

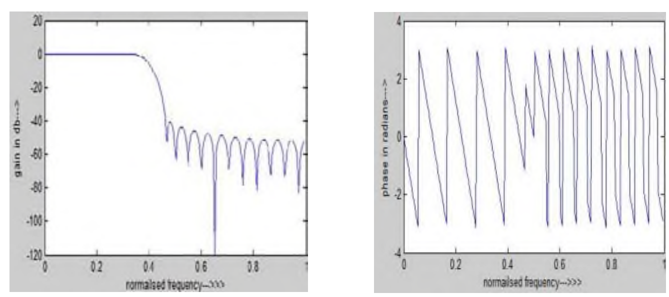


Figure.8FIR Kaiser Window (n=36)

IV. IIR FILTER DESIGN

We use three different approaches for the designing of the IIR filter. First we estimate the order of the filter, and then we design the filter by the help of the Matlab functions provided in Matlab Signal Processing toolbox.

1) *Elliptic*

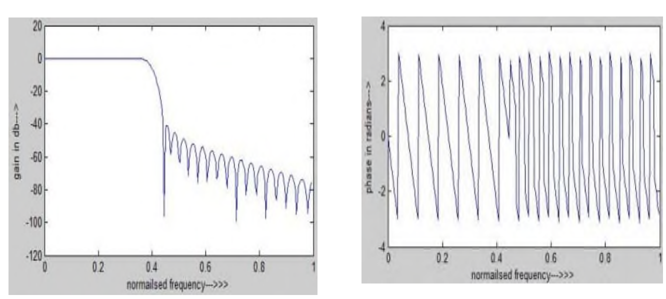


Figure.9 FIR Kaiser Window (n=

We design the elliptic filter on taking order (n = 4).The corresponding response is shown in the figure 10.

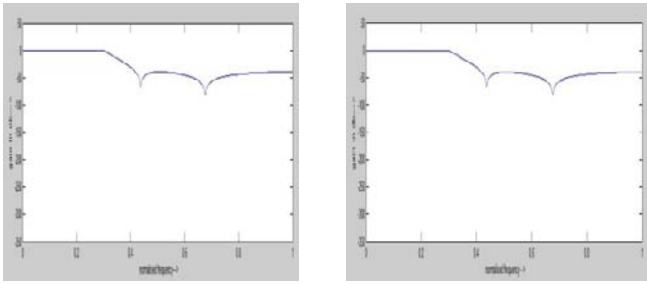


Figure.10 IIR Elliptic (n=4)

2) *Chebyshev*

We design the chebyshev filter on taking order (n = 5).The corresponding response is shown in the figure 11.

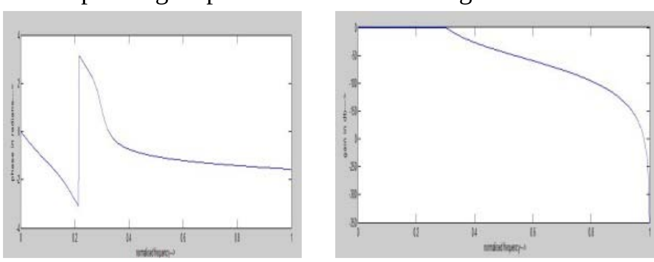


Figure.11IIR Chebyshev (n=5)

3) *Butterworth*

We design the Butterworth filter on taking order (n = 8).The corresponding response is shown in the figure 12.

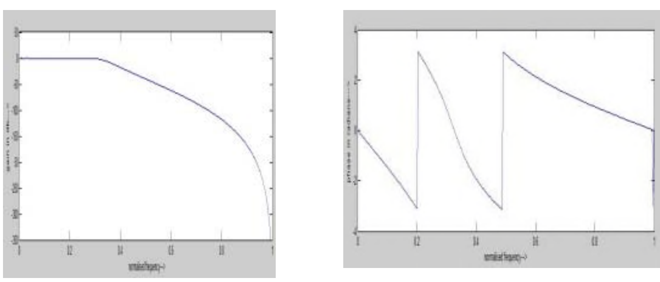


Figure.12IIR Butterworth (n=8)

VII. RESULT

1) *Fir Filter*

Table.2 Comparison between different window techniques

Window technique	Order of the filter	Width of main lobe	No. of side lobes
Hamming Window	21	0.5703	4
	36	0.5000	9
	54	0.4648	14
Blackman Window	21	0.7500	3
	36	0.5938	7
	54	0.5273	13
Kaiser Window	21	0.5195	5
	36	0.4687	10
	54	0.4330	15

We can see that as the order of the FIR filter increases the number of the side lobes also increased and width of the main lobe decrease that it is tending to sharp cut off that is the width of the main lobe decreased. If we want to reduce the width of the main lobe then the number of the side lobes gets increased. So there should we a compromise between attenuation of side lobes and width of main lobe. The Blackman has the smallest side lobes compare to all methods at any order but the width of the main lobe is increased. As in the Kaiser window we can see that at the lower order the width of the major lobe is less than the other approaches and the number of the sides lobes are also less. The Kaiser window provides the flexibility to designer and it gives best result. Therefore it is most commonly used window for FIR filter design.

2) *Iir Filter*

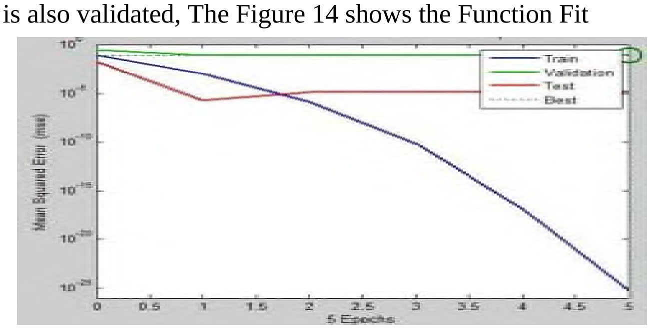
From Figure 10 to 12 we can say that for frequency response, the Butterworth and Chebyshev both the filter have flat response in the passband and it smoothly decreases in the stopband. Elliptic Filter has the ripples in both the passband and stopband, and it also provides us a narrow transition bandwidth.

3) *Comparison Between Fir And Iir Filter*

On comparing the FIR and IIR Filter for the same filter specifications, the IIR filter can achieve the requirement in much lower order, so it is more efficient .But when we want the filter to be linear phased, FIR filter is preferred because it automatically achieves linear phase. The gain response of IIR filter will keep decreasing in the stop band while most FIR will have ripples in stopband.

4) *Neural Network*

The plot obtained by the help of the neural network is shown below. The Figure 13 shows the best validation performance is 0.466 for the FIR filter and for the IIR filter is also validated, The Figure 14 shows the Function Fit



curve for the differentstates and Figure 15 shows the Regression plot.

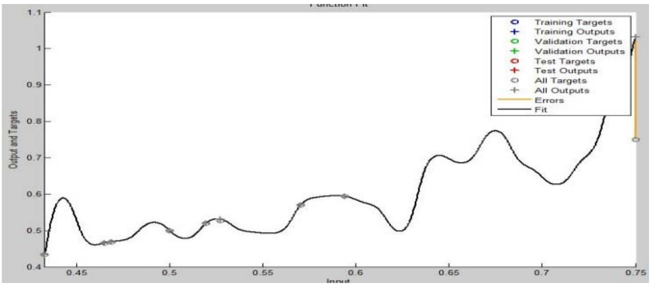


Figure.14 Function Fit graph

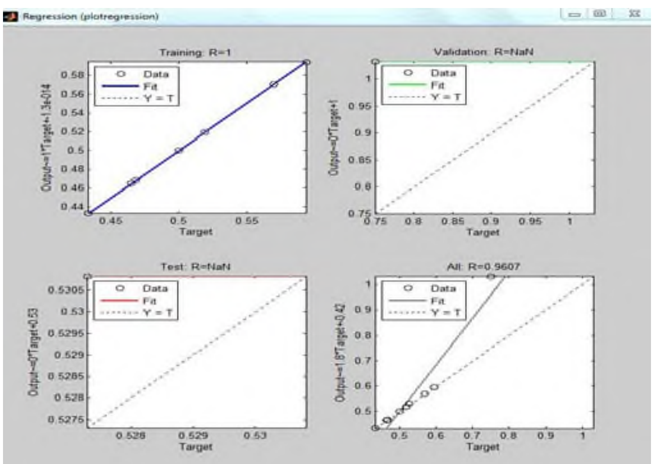


Figure.15 Regression plot

VI. CONCLUSION

We use the neural networks for verification of the coded value and find the best result. From both of the results we found that IIR filter can give best result in lower order. So by the help of the neural network we can say that the for designing the lower order digital filters IIR filter is best and for the linear phase response FIR filter is used.

VII. REFERENCES

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