Analyze the Performance Optimization of FIR Filter Using Neural Network Algorithms

Alok Pandey[1] Santosh Sharma[2]
Department of Electronics, Maharana Pratap College of Technology Gwalior, India
[1]alokp29@gmail.com
[2]santos_gwl@yahoo.co.in

Abstract-: **This paper presents the different design methods and techniques to optimize the FIR digital filters with the help of neural network. In this paper equiripple and Least squares design techniques are used to design the FIR digital filter. This paper describes the two different neural network algorithms for finding out the best validation performance on the basis of order and cutoff frequency. In this paper using FDA tool to design digital FIR filters of different order, and neural network tool box to compare different filters. The feed-forward algorithm provides the best validation performance as compared to cascade forward in case of Equiripple filter design. While in Least squares method cascade forward provides best validation performance as compared to feed-forward.**

Keywords- **FDA tool, FIR filters, High pass filter, ANN tool, MATLAB software.**

I. INTRODUCTION

Digital filters are exists in two types: Infinite impulse response(IIR) and Finite impulse response(FIR) the main problem occur with FIR filter is of high order implementation if conditional requirements are applied at design level. In addition to IIR filters having small group delay as compared to FIR filters. FIR filters have constant group delay over the baseband. A number of techniques are exists for designing of digital filters. For an effective and modified design of digital filter there are two methods available, equiripple and least squares filter design. Equiripple filter has equal ripples stop band and pass band, it means the distortion in signal happens at the pass band edge because of presence of large ripple is ignored in equiripple filter design. But it has large transition band, hence limiting the pass band area. While in Least squares design, transition band area is smaller than equiripple design, thus the pass band area is more. But in this design ripples are not equal and spike exists at the edge of pass band causes signal distortion.

The Filter Design and Analysis Tool (FDA Tool) is basically used to show graphical user interface for designing and analyzing filters quickly [1], [2]. FDA Tool allows you to design digital FIR filters with different design techniques by adjusting filter specifications [3]-[5], and importing filters from MATLAB.

II. METHODOLOGY

In this proposed work we are designing a high pass FIR filter using different orders of Least squares and Equiripple filter design techniques with the help of FDA tool in MATLAB. Firstly the data contains order and cutoff frequencies are imported in MATLAB window then this data is to train on Artificial Neural Network (NN tool) by using cascade forward back propagation feed forward back propagation algorithm. In this research work the result of different order filter which shows that main width lobe increases and the cutoff frequency decreases as order increases [6] as shown in table 1.Data shown in table 1 is implemented on NN tool. In this paper the other parameters selected are considered as:

Sampling frequency- 1000 HZ
Pass band frequency-160 HZ
Stop band frequency-260 HZ
Density factor-20
Pass band ripple- 1db
Stop band ripple-40db

The Cutoff frequency can be calculated by formula

$$\omega_c = \frac{\omega_p + \omega_s}{2} \quad (1)$$

III. DIGITAL FIR FILTER

A finite impulse response (FIR) filter is a type of filter structure such that it can be accomplished with almost any type of digital frequency responses. FIR filters can be realized by combination of delays connected in series, multipliers, adders and transfer functions to manage the desired output of filter [7].

FIR filters are those digital filters which are having impulse response of finite duration, because in this signal settles to minimum in finite duration. In particular to convert an "ideal" impulse response of finite duration, such as sine or cosine function to a finite impulse response filter design, that is called the window method [8]. The ideal high pass filter is one that permits through all frequency components of a signal above a designated cutoff frequency and rejects all frequency components of a signal below. The FIR filter also

known as non recursive digital filter as they do not have the feed-back even though recursive algorithm can be used for FIR filter realization [9].

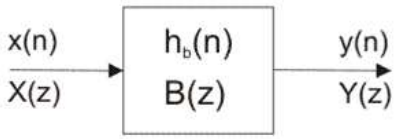
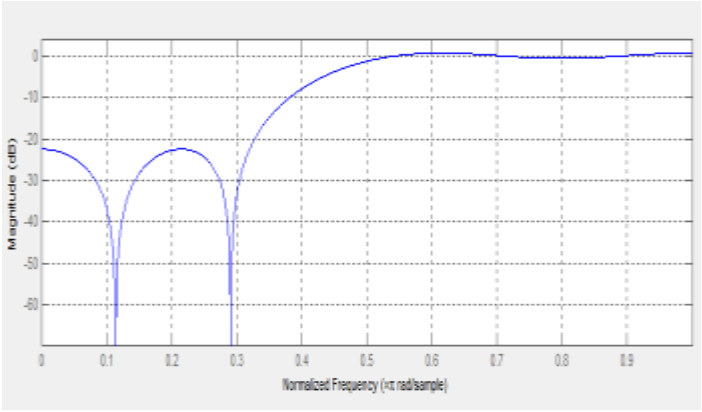


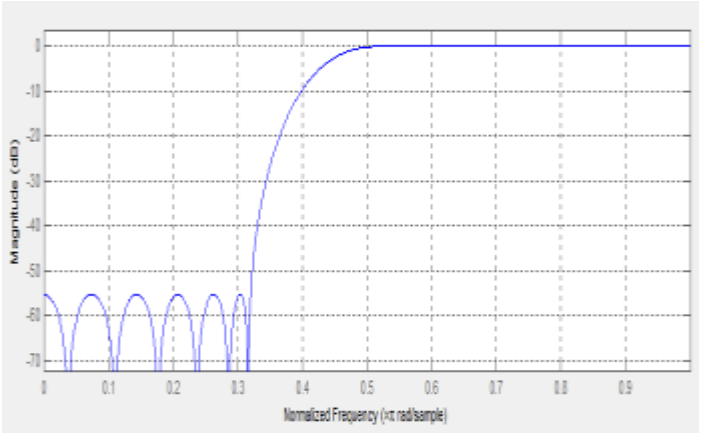
Fig 1 FIR Filter

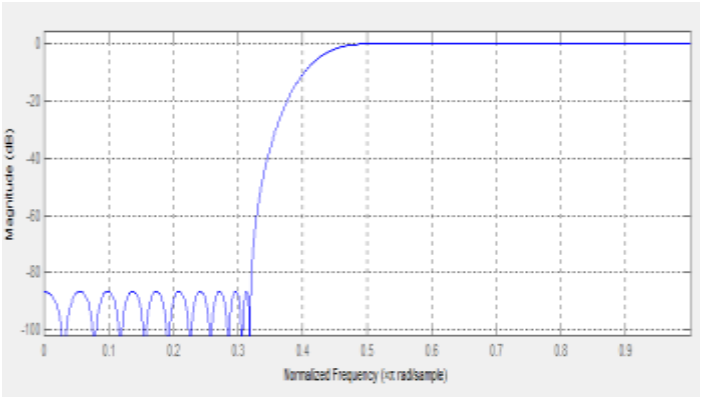
Where h(n) is the impulse response of ideal filter.

A. EQUIRIPPLE:

We analyze the filter using Equiripple filter design technique with the help of FDA tool in MATLAB and the frequency response of the filter is given in figure 2 respectively with order 10, 30, 50 & 70 [10].







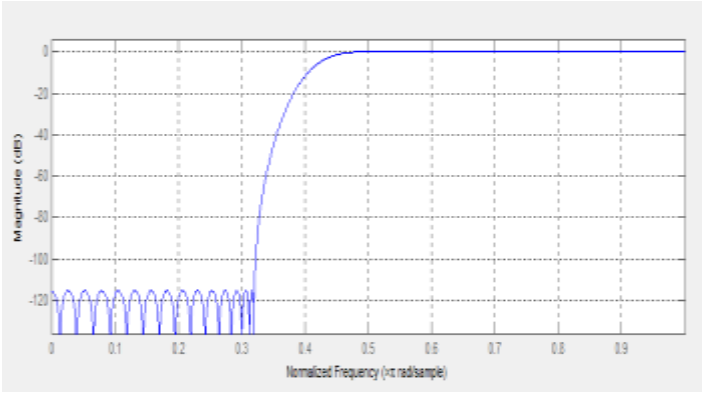
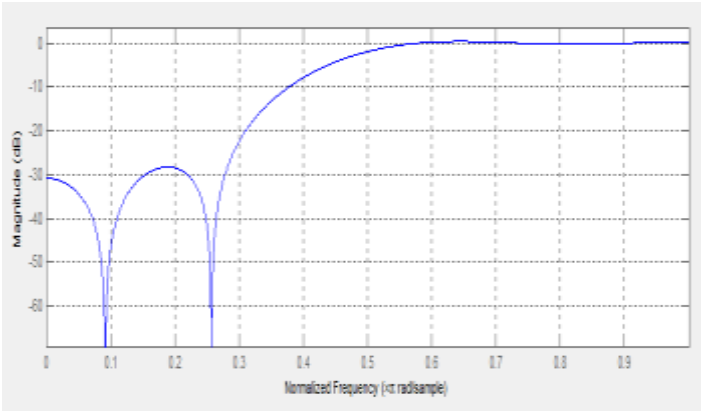


Fig 2 Equiriple filter with order 10, 30, 50 & 70

B. LEAST SQUARES:

We analyze the filter using Least squares filter design technique with the help of FDA tool in MATLAB and the frequency response of the filter is given in figure 2 respectively with order 10, 30, 50 & 70 [11].



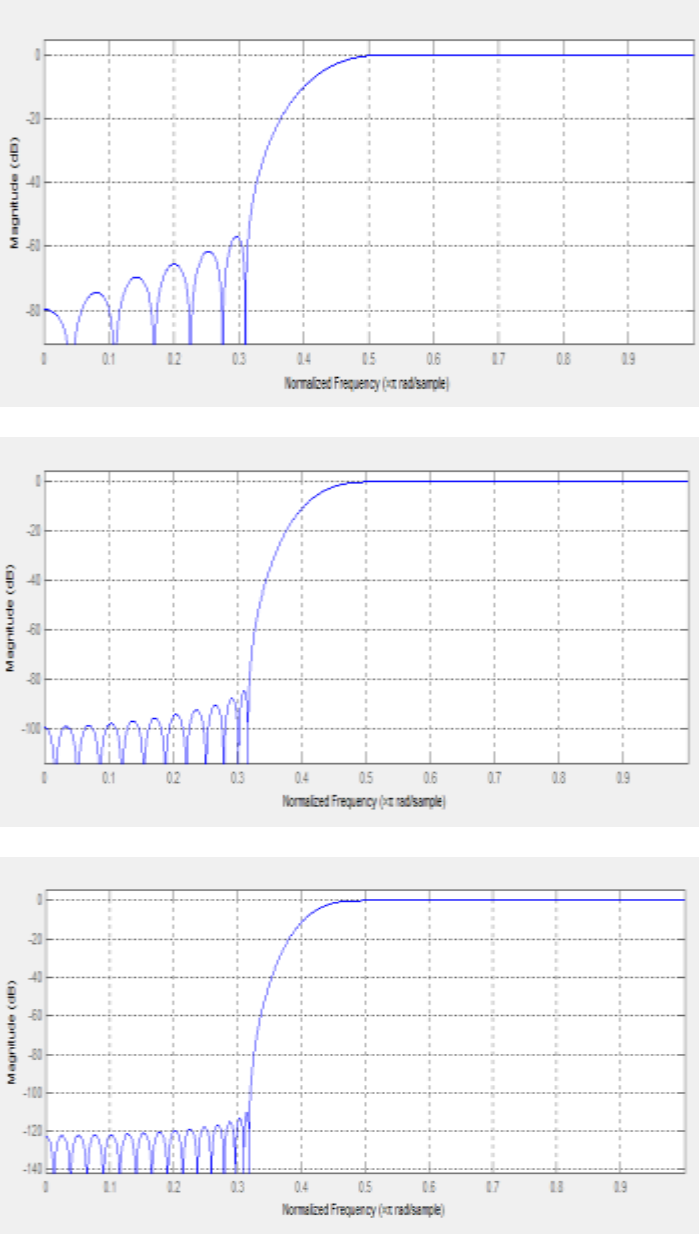


Fig 3 Least square filter with order 10, 30, 50 & 70

IV. NEURAL NETWORK

The fig obtained with the help of feed-forward and cascade forward neural network are respectively shown below. The best validation performance for cutoff frequency of Equiripple High pass FIR filter [12] is shown in fig.

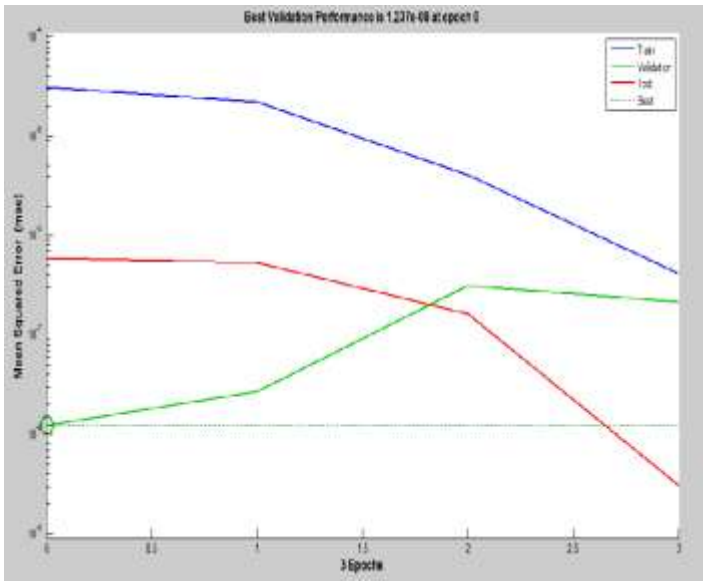


Fig 4 Validation point using Feed- forward network of Equiripple filter

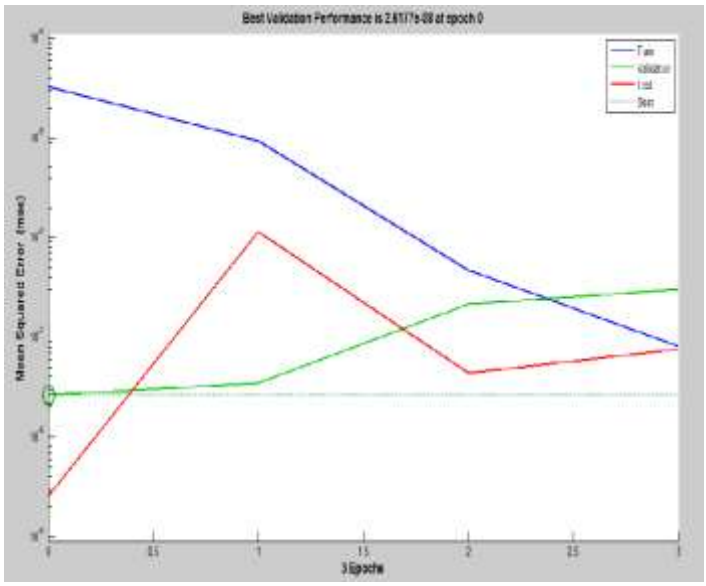


Fig 5 Validation point using cascade forward network of Equiripple filter

The fig obtained with the help of feed-forward and cascade forward neural network are respectively shown below. The best validation performance for cutoff frequency of Least squares High pass FIR filter is shown in fig .

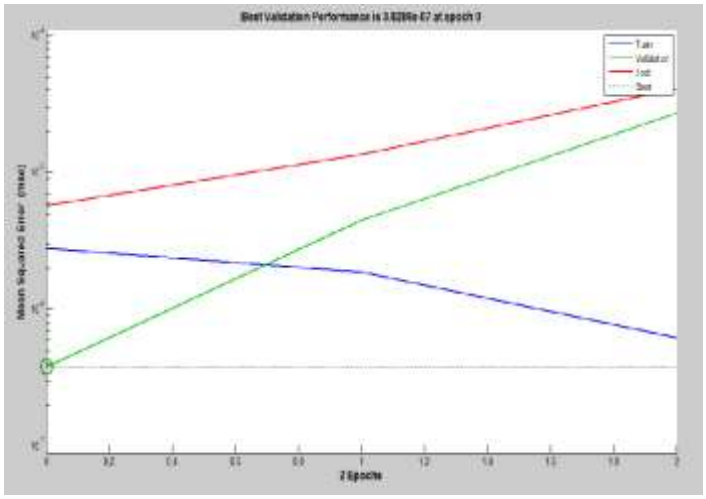


Fig 6 Validation point using feed forward network of Least square filter

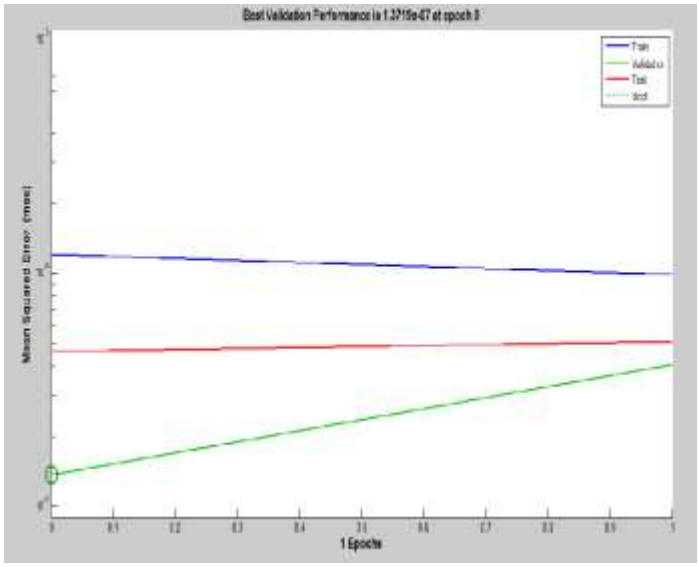


Fig 7 Validation point using cascade forward network of Least Square filter

Table 1(a)
(Comparison of different FIR filter)

s.no	Order	Cutoff freq(Hz)	Main width lobe (db)	No of side lobe
1	10	0.46459	57.22	2
2	20	0.45019	61.42	4
3	30	0.44470	68.02	6
4	40	0.44091	82.47	8
5	50	0.43908	92.23	10
6	60	0.43688	104.89	13
7	70	0.43591	117.73	15

(a) Equiripple filter cutoff frequency with order 10-70

Table 1(b)

s.no	order	Cutoff freq.	Main lobe width	No of side lobe
1	10	0.4726	60.32	2
2	20	0.4565	61.98	4
3	30	0.4473	70.07	6
4	40	0.4438	79.31	9
5	50	0.4398	93.18	11
6	60	0.4371	100.14	13
7	70	0.4350	117.37	15

(b) Least squares filter cutoff frequency with order 10-70

Table 2
(Best validation based on order, cutoff frequency and Algorithms)

Filter design technique	Best validation	Algorithm
Equiripple	1.237e-08	Feed-forward back prop.
Least square	1.37196e-07	Cascade forward back prop.

Best validation performance of Equiripple and Least squares Filters using CFBP and FFBP algorithms respectively, based on cutoff frequency.

V. CONCLUSION

In this paper comparison of Different filters design techniques and calculate the best validation point which is shown in table 2 with the help of Artificial NN tool has been done. After training with Neural Network result shows that Best validation performance of Equiripple and Least squares Filter, based on cutoff frequency using two algorithms. Table 1 shows different no. of orders with their respective cutoff frequencies. In comparison of both the techniques it results that the best validation performance comes in case of Equiripple filter design using feed-forward algorithm. While in Least squares method cascade forward provides best validation performance as compared to feed-forward.

VI. REFERENCES

[1] Design and Analysis of Low Pass FIR & IIR Filter and Find Optimum Result Using Neural Network [Global Journal of Researches in Engineering].

[2] Sara Moein, "FIR Cutoff Frequency Calculating for ECG Signal Noise Removing Using Artificial Neural Network" Verlag Berlin Heidelberg,pp.124-131(2010).

[3] Sanjit K. Mitra, "Digital Signal Processing: AComputer-Based Approach", Second Edition, McGrawHillScience/Engineering/Math,2001,pp.446-472.

[4] S.Salivahanan,"DigitalSignal Processing",McGraw-Hill, 2000, pp. 735-749.

[5] B. A. Shenoi, "Introduction to SignalProcessing and Filter Design", Wiley Interscience, 2006,pp-273-285.

[6] Andreas Antoniou, "Digital Signal Processing:Signal System and Filter", McGraw-Hill, 2006, pp-434-453. 5.

[7] Satish Kumar, "Neural Networks: A ClassroomApproach", McGraw-Hill, 2004, pp-227-230. 6.

[4] S.Salivahanan,"DigitalSignal Processing",McGraw-Hill, 2000, pp. 735-749.

[5] B. A. Shenoi, "Introduction to SignalProcessing and Filter Design", Wiley Interscience, 2006,pp-273-285.

[8] Ying-Wen Bai, "The Combination of Kaiser Window and Moving Average for the Low-Pass Filtering of the Remote ECG Signal", IEEE 2004.

[9] MATLAB-09

[10] saramaki T.,Mitra s.k., finite impulse response filter Design, handbook for digital signal processing,New York: wiley-interscience:1993.

[11] communication system: RP SINGH,SD sapre Page 468-469.

[12] Mahesh S. Chavan, R.A.Agarwala, M.D.Uplane, 'Use of Kaiser Window For ECG processing', Proceedings of the 5th WSEAS Int. Conf. on Signal Processing, Robotics and Automation, Madrid, Spain, February 15-17, 2006 (pp285-289).

