Department of Electronic and Telecommunication Engineering University of Moratuwa, Sri Lanka

EN2063 — SIGNALS AND SYSTEMS



Digital Filter Design

Semester 03: Project

Submitted by

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Specifications

Index Number: 200087A (200ABC.)

A = 0, B = 8, C = 7

 $D = 7 \bmod 4 = 3$

Parameters

Maximum passband ripple = 0.1 dB

Minimum stopband attenuation = 58 dB

Lower passband edge = 1100 rad/s

Upper passband edge = 1600 rad/s

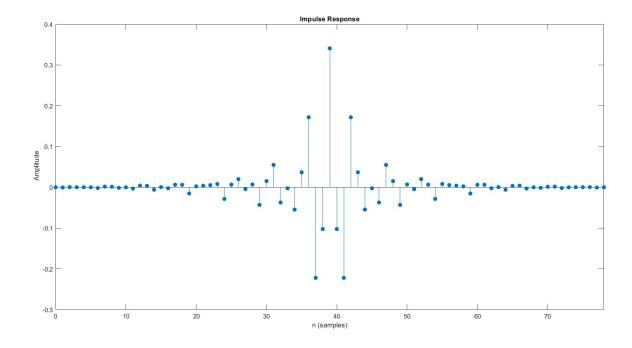
Lower stopband edge = 800 rad/s

Upper stopband edge = 1800 rad/s

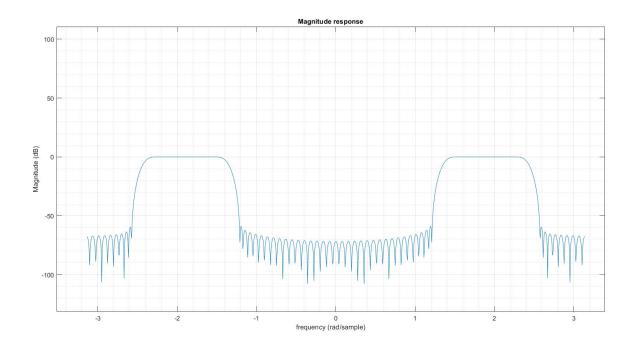
Sampling frequency = 4400 rad/s

1 FIR Bandpass Digital Filter

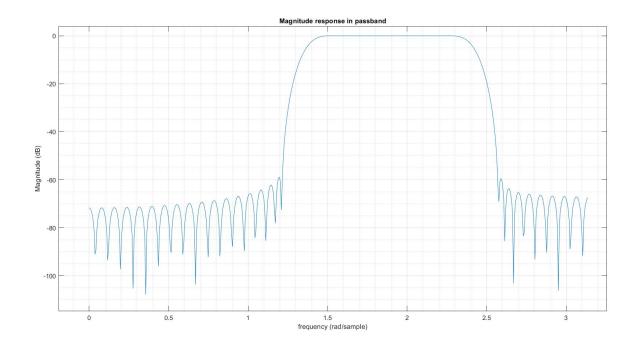
1.1 Impulse Response



1.2 Magnitude Response of the Digital Filter



${\bf 1.3}\quad {\bf Magnitude\ Response\ in\ the\ Passband}$



2 IIR Bandpass Filter

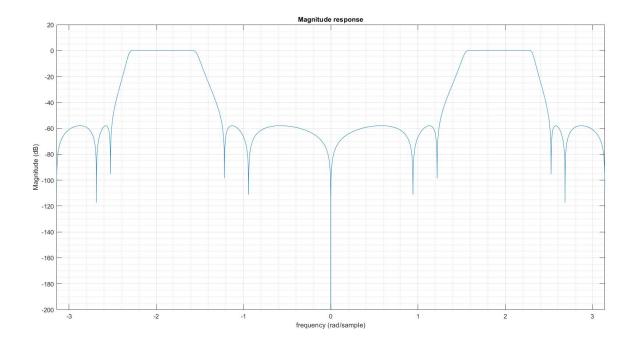
D = 3

 ${\bf Approximation\ Method:\ Elliptic}$

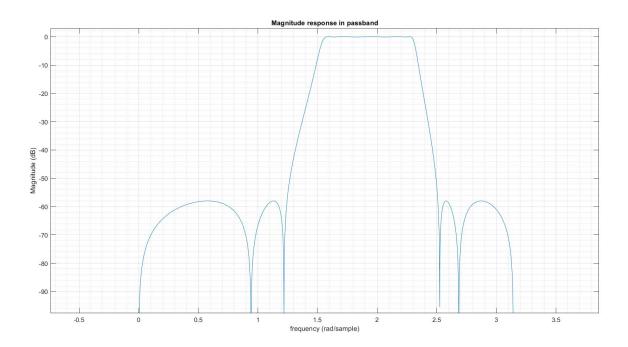
2.1 Coefficients of the Trasfer Function

k	Zeroes	Poles
0	0.007480014	1
1	0.011662351	3.070331905
2	0.002568812	7.078414662
3	0.003252407	10.79920825
4	0.012882167	13.72339129
5	-8.53E-14	13.223374
6	-0.012882167	10.79919059
7	-0.003252407	6.664838984
8	-0.002568812	3.422578911
9	-0.011662351	1.144285098
10	-0.007480014	0.293204173

2.2 Magnitude Response of the Digital Filter



${\bf 2.3}\quad {\bf Magnitude\ Response\ in\ the\ Passband}$



3 Comparision of FIR and IIR

FIR Filter	IIR Filter
Order of the filter $= N = 78$	Order of the filter $= N = 10$
Number of adders required $= 78$	Number of adders required = $2*10 = 20$
Number of multipliers required = $78+1 = 79$	Number of multipliers required = $2*10+1 = 21$
Group delay = $78/2 = 39$	Group delay = $10/2 = 5$

4 Appendices

FIR Filter.m

```
Editor - FIR_Filter.m

FIR_Filter.m × | IIR.m × | ellip.m × | ellipord.m × | bilinear.m × +

1 - fsamp = 4400/(2*pi);
2 - fcuts = [800/(2*pi) 1100//--
                                                                    🕤 🗙 🔏 Variables - pd
          fcuts = [800/(2*pi) 1100/(2*pi) 1600/(2*pi) 1800/(2*pi)];
         mags = [0 1 0];
   3 -
          devs = [10^{-58/20}] 10^{(0.1/20)} 10^{(-58/20)};
    5 -
          [n,Wn,beta,ftype] = kaiserord(fcuts,mags,devs,fsamp);
    6 -
          n = n + rem(n, 2)
    7 -
          hh = fir1(n, Wn, ftype, kaiser(n+1, beta), 'noscale');
    8
           %impz(hh,1)
   9 -
           [H,W] = freqz(hh,1);
          Hdb=20*log10(abs(H));
   10 -
   11 -
          figure;
   12 -
          plot([flip(-w); w], [flip(Hdb); Hdb])
   13 -
           xlabel('frequency (rad/sample)')
  14 -
          ylabel('Magnitude (dB)')
   15 -
          title('Magnitude response')
   16 -
          ax = gca;
   17 -
           ax.YLim = [-200 20];
   18 -
          ax.XLim = [-pi pi];
   19 -
          grid on;
  20 -
          grid minor;
   21 -
          figure;
  22 -
          plot(w, Hdb);
  23 -
          xlabel('frequency (rad/sample)')
  24 -
          ylabel('Magnitude (dB)')
  25 -
          title('Magnitude response in passband')
  26 -
          ax = gca;
  27 -
          ax.YLim = [-0.2 \ 0.2];
  28 -
           ax.XLim = [1100*T 1600*T];
  29 -
           grid on;
   30 -
           grid minor;
  31
```

IIR Filter.m

```
Editor - IIR.m

FIR_Filter.m × IIR.m × ellip.m × ellipord.m × bilinear.m × +

T=2*pi/4400;

2 - Wp=2*tan([1100 16001*m/0) //
                                                                🕞 🗙 🌠 Variables - pd
   3 -
         Ws=2*tan([800 1800]*T/2)/T;
   4 -
          [N,W] = ellipord(Wp, Ws , 0.1, 58,"s")
    5 -
          [num,den] = ellip(N,0.1,58,W,"bandpass","s");
          [zd,pd]=bilinear(num,den,1/T);
   6 -
   7
          %freqz([zd,zp])
   8 -
          [H,w]=freqz(zd,pd);
   9 -
          Hdb=20*log10(abs(H));
  10 -
         figure;
   11 -
         plot([flip(-w); w], [flip(Hdb); Hdb])
  12 -
         xlabel('frequency (rad/sample)')
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```