EN 2063 Project 200029B
Report

A = 0, B = 2, C = 9

$\therefore$

Parameter	Value
Maximum passband ripple, $\tilde{A}_p$	0.1 dB
Minimum stopband attenuation, $\tilde{A}_a$	52 dB
Lower passband edge, Ω_{p_1}	1300 rad/s
Upper passband edge, Ω_{p_2}	1800 rad/s
Lower stopband edge, Ω_{s_1}	1000 rad/s
Upper stopband edge, Ω_{s_2}	2000 rad/s
Sampling frequency, Ω_{sm}	4800 rad/s

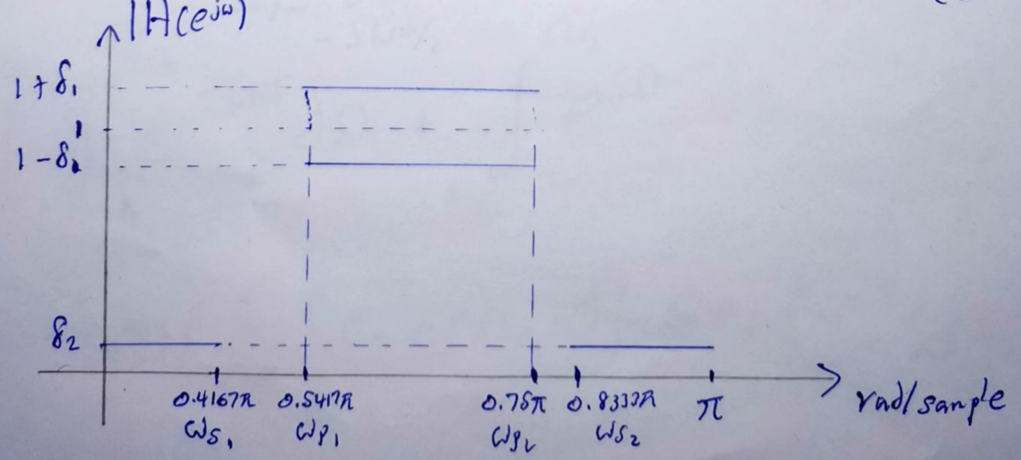
We can convert the above analog domain frequencies in to digital domain frequencies using the relation,

$$\omega = \frac{2\pi\Omega}{\Omega_{sm}} \Rightarrow$$

ω (rad/sample)	Ω (rad/sec)
$\omega_{p_1} = 0.5417\pi$	$\Omega_{p_1} = 1300$
$\omega_{p_2} = 0.75\pi$	$\Omega_{p_2} = 1800$
$\omega_{s_1} = 0.4167\pi$	$\Omega_{s_1} = 1000$
$\omega_{s_2} = 0.8333\pi$	$\Omega_{s_2} = 2000$

* now It can be see that $\omega_{p_1}, \omega_{p_2}, \omega_{s_1}, \omega_{s_2} < \left(\frac{\omega_{sm}}{2}\right)$ Nyquist rate.

$\Rightarrow$



1) Designing the FIR filter using Kaiser window to above BPF specification.

- Cut off frequency calculation.

$$B_t = \min[(\Omega_{p_1} - \Omega_{s_1}), (\Omega_{s_2} - \Omega_{p_2})]$$

$$= \min[(1300 - 1000), (2000 - 1800)]$$

$$= \min[(300, 200)] = 200 \quad rad/s$$

$$\therefore \Omega_{c_1} = \Omega_{p_1} - \frac{B_t}{2} \quad , \quad \Omega_{c_2} = \Omega_{p_2} + \frac{B_t}{2}$$

$$\Omega_{c_1} = 1200 \text{ rad/s} \qquad \Omega_{c_2} = 1900 \text{ rad/s}$$

frequency Responce of the Idel BPF,

$$H(e^{j\Omega T}) = \begin{cases} 1 & \text{for } -\Omega_{c_2} \leq \Omega \leq -\Omega_{c_1} \\ 1 & \text{for } \Omega_{c_1} \leq \Omega \leq \Omega_{c_2} \\ 0 & \text{otherwie} \end{cases}$$

where T sample period.

Ideal Impulse Responce,

$$h(nT) = \frac{1}{\Omega_{sm}} \int_{-\Omega_{sm}/2}^{\Omega_{sm}/2} H(e^{j\Omega T}) e^{j\Omega nT} d\Omega$$

$$= \frac{1}{\Omega_{sm}} \left[\int_{-\Omega_{c_2}}^{-\Omega_{c_1}} e^{j\Omega nT} d\Omega + \int_{\Omega_{c_1}}^{\Omega_{c_2}} e^{j\Omega nT} d\Omega \right]$$

$$\Rightarrow h(nT) = \frac{1}{n\pi} \left[\sin c[\Omega_{c_2} nT] - \sin c[\Omega_{c_1} nT] \right]$$

• Kaiser window parameters

$$\delta_1 = \frac{10^{0.05(\tilde{A}_p)} - 1}{10^{0.05(\tilde{A}_p)} + 1} = 0.00576$$

$$\delta_2 = 10^{-0.05(\tilde{A}_a)} = 0.002512$$

$$\delta = \min\{\delta_1, \delta_2\} = 0.002512$$

∴ parameter alpha (α) (or β parameter)

$$\alpha = 0.1102(\tilde{A}_a - 8.7) = 4.77166$$

parameter D.

$$D = \frac{\tilde{A}_a - 7.95}{14.36} = 3.0675$$

order of the filter $M \doteq \left\lceil \frac{\Omega_s D}{B_t} \right\rceil = 74$

** In ~~mat~~ lab order is determined by kaiserord function.

length of the Kaiser window $N = M+1 = 75$

now using the Kaiser window function, the equation of Kaiser window $W_K(nT)$ can be generated.

this $w_k(nT)$ is symmetric around 0 and have N points.

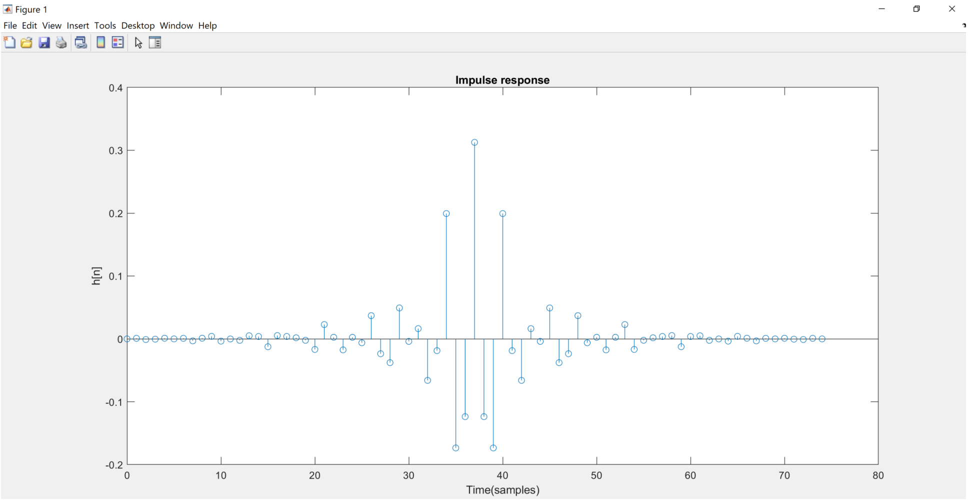


Figure 1
File Edit View Insert Tools Desktop Window Help
Impulse response
h[n]
Time(samples)
0.4
0.3
0.2
0.1
0
-0.1
-0.2
0
10
20
30
40
50
60
70
80

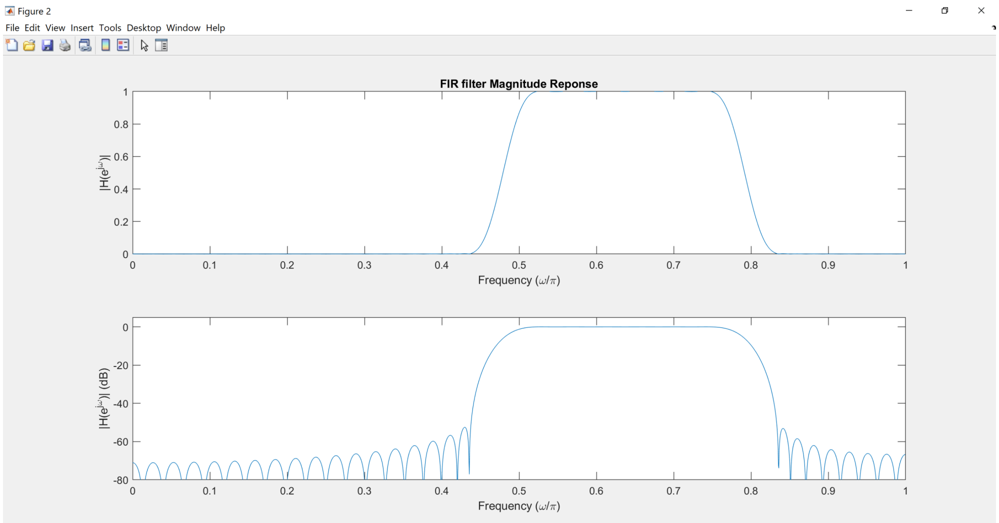


Figure 2
File Edit View Insert Tools Desktop Window Help
FIR filter Magnitude Reponse
|H(e^{jω})|
Frequency (ω/π)
|H(e^{jω})| (dB)
Frequency (ω/π)
1
0.8
0.6
0.4
0.2
0
-20
-40
-60
-80
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9

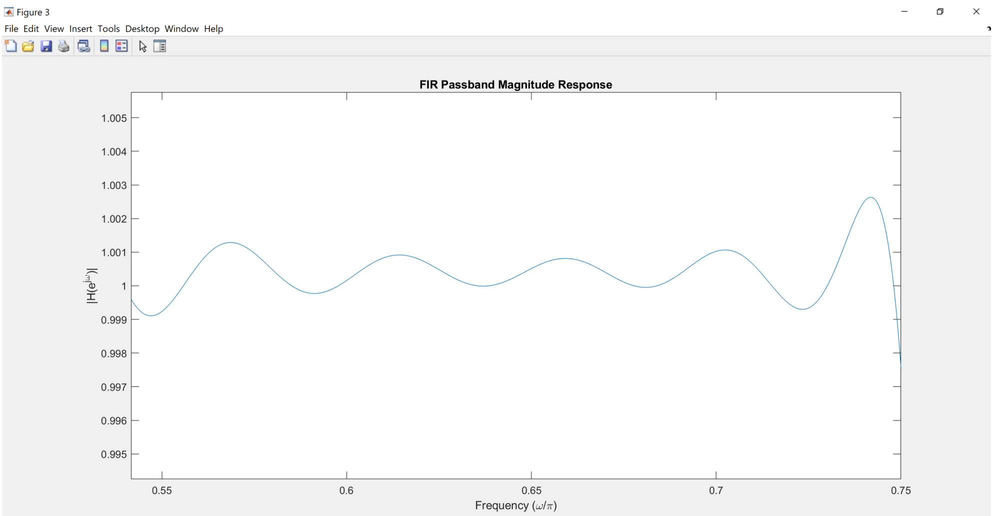


Figure 3
File Edit View Insert Tools Desktop Window Help
FIR Passband Magnitude Response
|H(e^{jω})|
Frequency (ω/π)
1.005
1.004
1.003
1.002
1.001
1
0.999
0.998
0.997
0.996
0.995
0.55
0.6
0.65
0.7
0.75

now by shifting $\left(\frac{N-1}{2}\right)$ both of the $h(nT)$

and $W_H(nT)$ we have causal

Impulse response fore the BPF

which N points.

2) Designing the IIR filter using Bilinear Transformation method to have specified BPF.

$D = 1 \Rightarrow$ we have to realize the BPF using Chebyshev filter approximation.

first we have to have digital frequencies of the frequencies Analog domain :- ω_{s_1}, ω_{p_1}, ω_{p_2}, ω_{s_2}

then use the mapping

$$\Omega = \frac{2}{T} \tan\left(\frac{\omega}{2}\right)$$

this equation is used to pre-warp the digital frequencies and have s-domain frequencies. since T is arbitary we take T = 1 for clarity. then transformation become

$$\Omega = 2 \tan\left(\frac{\omega}{2}\right)$$

now we have s-domain prewarped ~~cut~~ BPF filter frequencies

$$\Omega'_{s_1}, \Omega'_{p_1}, \Omega'_{p_2}, \Omega'_{s_2}$$

now using the cheb1ord function we get the order of the chebyshev filter and using ~~cheby~~ ~~cheb1ord~~ ~~function~~ cheby1 we get Numerator, and Denominator coefficients of the H(s)

Now using

$$S = \frac{2}{T}\left(\frac{z-1}{z+1}\right)$$. let T=1

Bilinear transformation.

we get the H(z) of filter. this is done by bilinear() function which gives the coefficient of Numerator and Denominator of H(z)

~~using~~ ~~we~~ ~~can~~ ~~see~~ ~~th~~

using impz() function we can see that h(nT) (impulse response) of the filter is causal have ~~~~ 347 points.

03) leangth of impulse respons of FIR filter, $h_{FIR(nT)} := 75$

length of impulse respon of IIR filte, $h_{IIR(nT)} := 347$

=> ~~Clem~~ more computational power need for IIR filter

2) a)

	Numerator Coefficients	Denominator Coefficients
Z^12	0.0002	1
Z^11	0	4.8254
Z^10	-0.009	14.1501
Z^9	0	28.6998
Z^8	0.0023	45.0606
Z^7	0	55.9344
Z^6	-0.003	56.6232
Z^5	0	46.4895
Z^4	0.0023	31.1138
Z^3	0	16.4405
Z^2	-0.0009	6.72
Z^1	0	1.8949
Z^0	0.0002	0.3273

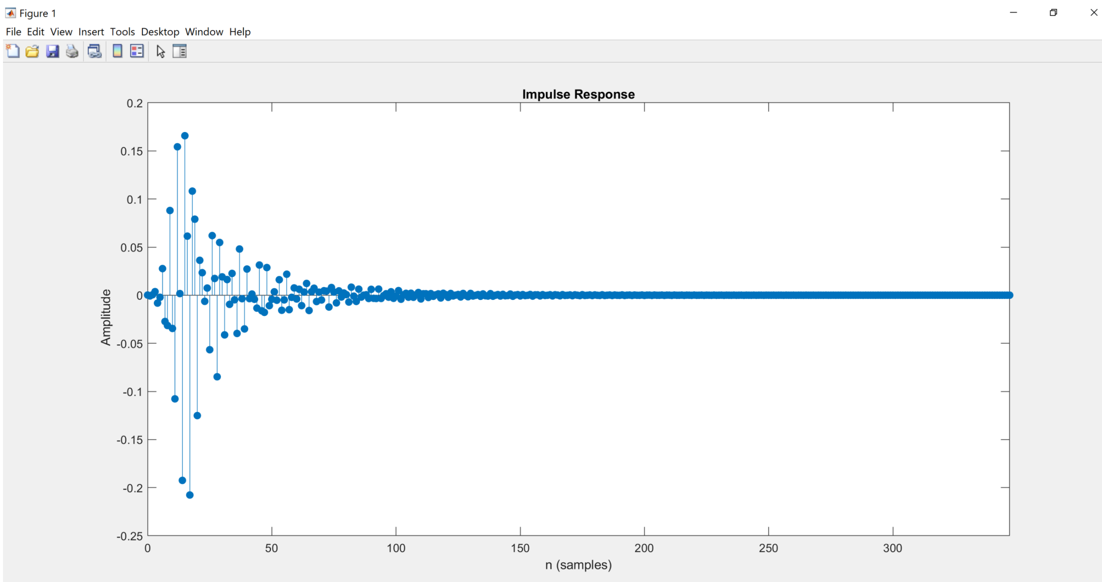


Figure 1
File Edit View Insert Tools Desktop Window Help
Impulse Response
Amplitude
n (samples)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
0
50
100
150
200
250
300

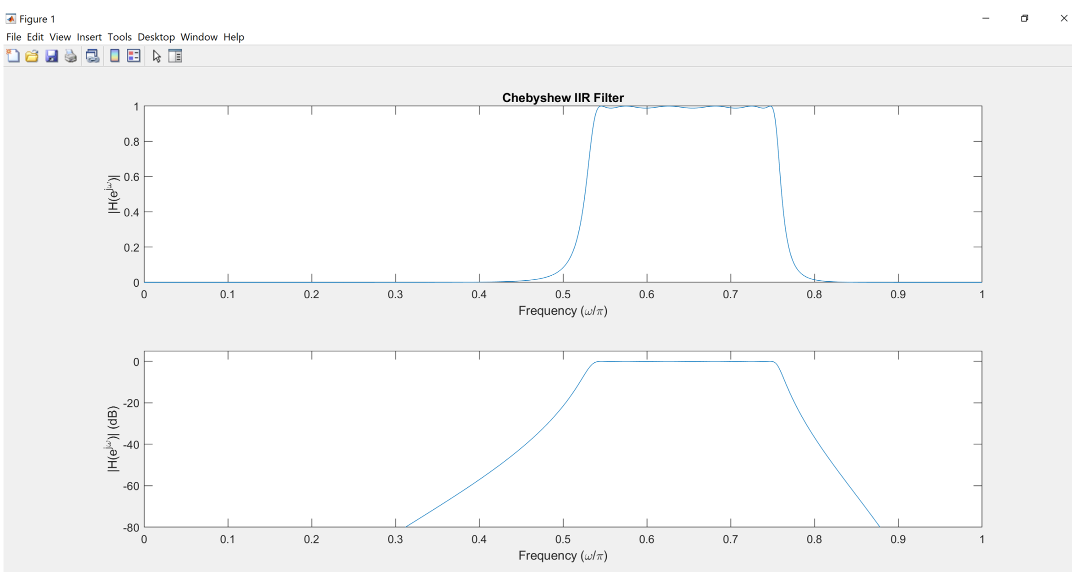


Figure 1
File Edit View Insert Tools Desktop Window Help
Chebyshew IIR Filter
|H(e^{jω})|
Frequency (ω/π)
|H(e^{jω})| (dB)
Frequency (ω/π)

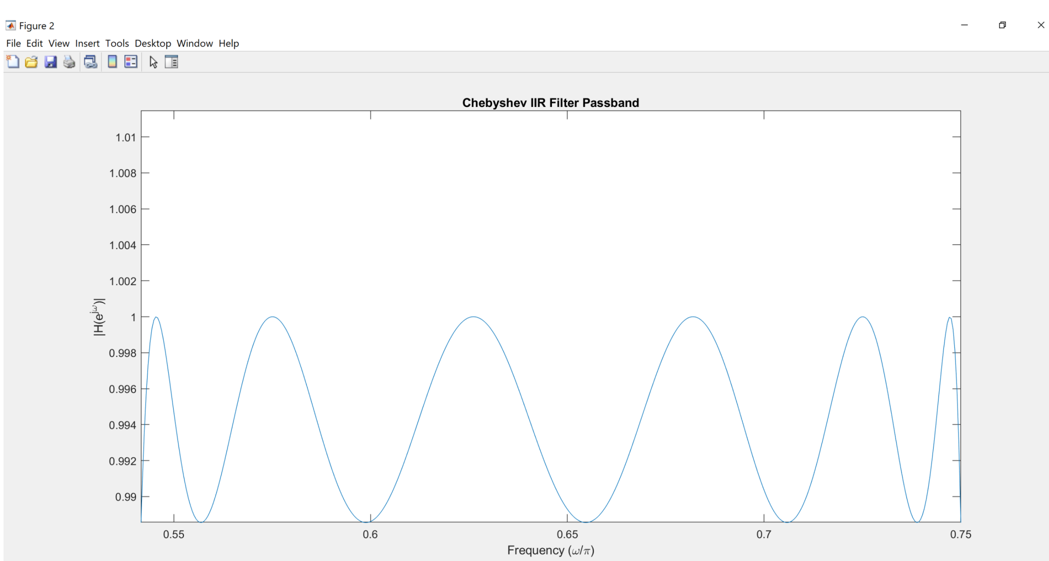


Figure 2
File Edit View Insert Tools Desktop Window Help
Chebyshev IIR Filter Passband
|H(e^{jω})|
Frequency (ω/π)
1.01
1.008
1.006
1.004
1.002
1
0.998
0.996
0.994
0.992
0.99
0.55
0.6
0.65
0.7
0.75