EE3101 Lab 1: FIR Digital Filters Design

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Report:

Part 2.1

1. Using the filter length estimation formula:

$$\alpha_s = -20\log\delta_s = 80\text{dB}$$
$$\delta_s = 0.0001$$
$$\delta_p = 0.001$$
$$\Delta f = \frac{(4500 - 4000)}{10000} = 0.05$$
$$L = \frac{-20\log\sqrt{\delta_s\delta_p} - 13}{14.6\Delta f} + 1$$
$$= 79$$

Filter order $= 79$

Using firpmord, Filter order $= 80$

4. Both of the filters failed to meet the given specification which is $\delta_p = 0.001$, $\alpha_s = 80\text{dB}$. Hence, the filter order is increased to 81 to design the filter again. Using filter order 81, the filter meets the given specification.

5. Final filter length $= 82$

Part 2.2

a. Optimal interpolation factor,

$$\lambda_1 = \frac{3600}{8000},\ \lambda_2 = \frac{3200}{8000},\ \beta = \frac{400}{8000}$$

$$M = \frac{1}{\sqrt{\beta} - \lambda_1 - \lambda_2 + 1}$$
$$= 2.68 \approx 2 \ \text{(must be even number for high pass filter)}$$

b. The bandegdes of bandedge shaping filter:

$$f_{a,p} = M(0.5 - \lambda_1) = 2\left(0.5 - \frac{3600}{8000}\right) = 0.1$$
$$f_{a,s} = M(0.5 - \lambda_2) = 2\left(0.5 - \frac{3200}{8000}\right) = 0.2$$

The bandedges of masking filter:

$$f_{Ma,p} = \lambda_1 = \frac{3600}{8000} = 0.45$$
$$f_{Ma,s} = \frac{m-1}{M} + 0.5 - \lambda_2 = 0.5 - \frac{3200}{8000} = 0.1$$

c. Length of the filter:

$$L = \frac{-20\log\left(\sqrt{\delta_p \delta_s}\right) - 13}{14.6\Delta f} + 1 = \frac{-20\log\left(\sqrt{\delta_p \delta_s}\right) - 13}{14.6\Delta f} + 1 = \frac{3.219}{\Delta f} + 1$$

$$\Delta f = \lambda_1 - \lambda_2 = 0.05$$
$$\Delta f_{Ma} = \frac{1}{M} + \lambda_1 + \lambda_2 - 1 = 0.35$$

Length of bandedge shaping filter:

$$L_a = \frac{3.219}{\Delta f} + 1 = 65.38 \approx 66$$

Length of masking filter:

$$L_{Ma} = \frac{3.219}{\Delta f_{Ma}} + 1 = 10.197 \approx 11$$

d. According to Matlab, length of bandedge shaping filter $= 73$, length of masking filter $= 11$. They are not much different with the values calculated in (c).

Part 2.3

a. Optimum interpolation factor,

$$M_{opt} = \frac{1}{2\sqrt{0.2-0.194}} = 6.45 \approx 6$$

b.

M	Case	Bandedges of $H_a(z)$		Bandedges of $H_{ma}(z)$		Bandedges of $H_{mc}(z)$		L_a	L_{ma}	L_{mc}	L_{total}
		$f_{a,p}$	$f_{a,s}$	$f_{ma,p}$	$f_{ma,s}$	$f_{mc,p}$	$f_{mc,s}$				
4	B	0.200	0.224	0.056	0.200	0.194	0.300	111	20	26	157
5	B	0.000	0.030	0.006	0.200	0.194	0.200	89	15	440	544
6	A	0.164	0.200	0.194	0.300	0.139	0.200	75	26	45	146
7	A	0.358	0.400	0.194	0.228	0.091	0.200	64	78	26	168
8	B	0.400	0.448	0.181	0.200	0.194	0.300	56	140	26	222

c. Based on the Table, the optimum interpolation factor is 6 as L_{total} is the least.

Conclusion:

In this lab, I have learnt to use both filter length estimation formula and Matlab program to calculate the filter length and design the filter. I have also learnt to design filter using the interpolated finite impulse response technique. This lab has provided me a better understanding on filter design especially designing using the interpolated finite impulse response technique.