UNIVERSITY OF SASKATCHEWAN
ELECTRICAL ENGINEERING 461.3

Questions

1. Design a lowpass filter using the window method. Assume a passband gain of 2, peak ripple of 0.01, passband corner frequency of $\frac{\pi}{8}$ and stopband corner frequency of $\frac{\pi}{4}$. Confirm your design meets specifications, by implementing it in MATLAB. What is peak ripple in your implementation? Why is the peak ripple much better than the specified peak ripple 0.01?

2. Design a highpass filter using the Hann window method. Assume a passband gain of 1, stopband corner frequency of $\frac{\pi}{8}$ and passband corner frequency of $\frac{\pi}{4}$. Confirm your design meets specifications, by implementing it in MATLAB. What is the calculated peak ripple and the measured peak ripple for your implementation?

3. Given the following magnitude response for a linear phase filter to be designed using a Kaiser window,

$$\begin{aligned} |H(e^{j\omega})| &\leq 0.005, && 0 \leq |\omega| \leq 0.25\pi, \\ 0.9 \leq |H(e^{j\omega})| &\leq 1.1, && 0.4\pi \leq |\omega| \leq 0.65\pi, \\ |H(e^{j\omega})| &\leq 0.001, && 0.75\pi \leq |\omega| \leq \pi. \end{aligned}$$

   (a) Deterimine the minimum order for the filter and the value for the Kaiser window shape factor?

   (b) How many samples will the filter delay a signal input to the filter?

   (c) Generate an expression for $h_d[n]$.

4. Given the following amplitude response for a linear phase filter to be designed using a Kaiser window,

$$\begin{aligned} 0.9 \leq A(e^{j\omega}) &\leq 1.1, && 0 \leq |\omega| \leq 0.2\pi, \\ -0.06 \leq A(e^{j\omega}) &\leq 0.06, && 0.3\pi \leq |\omega| \leq 0.475\pi, \\ 1.9 \leq A(e^{j\omega}) &\leq 2.1, && 0.525\pi \leq |\omega| \leq \pi. \end{aligned}$$

   (a) The ripple of the low pass component and high pass component can interfere with each other. Assuming the worst case, where the peak ripples overlap, what is the maximum value of δ?

   (b) What transition width should be used to calculate the filter order?

   (c) What is the order of the filter?

   (d) What is the value for β?

   (e) Implement the filter in MATLAB to check your filter meets the specifications.

5. Design a low pass filter using a Kaiser window, where $\delta = 0.001, \omega_p = 0.4\pi$ and $\omega_s = 0.5\pi$. Does the filter meet specs, check by implementing the filter in MATLAB. Write a MATLAB program that plots the impulse response on one figure window, the amplitude response in a second figure window and on a third figure window the magnitude response in dB. Use the MATLAB function `fir1` to calculate the impulse response for the filter. Appropriately label the plots. Publish your m-file as a pdf document with suitable section headings.

6. Design a high pass filter using a Kaiser window, where $\delta = 0.001, \omega_p = 0.6\pi$ and $\omega_s = 0.5\pi$. Implement the filter by converting the lowpas filter design in the previous question into a high pass filter. If the order of the filter in the previous question is odd, will the filter designed in this question be a high pass filter? Write a MATLAB program that plots the impulse response on one figure window, the amplitude response in a second figure window and on a third figure window the magnitude response in dB. Use the MATLAB function `fir1` to calculate the impulse response for the filter. Appropriately label the plots. Publish your m-file as a pdf document with suitable section headings.

7. A type I HPF is needed, where $\omega_s = 0.7\pi, \omega_p = 0.8\pi, \delta_s = 0.0004$ and $\delta_p = 0.001$. Design a filter that meets the above specifications using both, the windows design approach and the Kaiser window design approach. Select the best filter for the implementation, providing a justification for your choice. Write a MATLAB program that plots the magnitude response in dB of the first design approach in one figure window and the magnitude response in dB of the second design approach in a second figure window. Use the MATLAB function `fir1` to calculate the impulse response for the filter. Appropriately label the plots. Publish your m-file as a pdf document with suitable section headings.

8. A filter has the following specifications: a passband from 200 Hz to 500 Hz, a transition width of 50 Hz, 0.1 dB pass band ripple, 60 dB stop band attuenuation and a sampling rate of 2 kHz. Design a filter that meets the above specifications using the Kaiser window design approach. Does the filter meet spec? If not, make the necessary modifications to meet spec. Write a MATLAB program that plots the magnitude response in dB of the filter as a function of frequency with units Hz. Use the MATLAB function `fir1` to calculate the impulse response for the filter. Appropriately label the plots. Publish your m-file as a pdf document with suitable section headings.

9. Specifications for a lowpass filter includes a passband corner frequency of $\frac{\pi}{4}$, a stopband corner frequency of $\frac{3\pi}{8}$, a passband ripple of 0.172 dB and a stopband attenuation of 40 dB.

   (a) Design a linear phase equiripple FIR filter. Estimate the order of the filter by comparing the estimates from techniques proposed by Bellanger, Kaiser, and Harris with firpmord. In this part only use firpmord to estimate the order for comparison with the other techniques. Use MATLAB to confirm your filter meets specifications.

   (b) Design a linear phase equiripple FIR filter. Use the full capabilities of firpmord in the design of the filter. Use MATLAB to confirm your filter meets specifications.

10. Specifications for a digital filter are given by:

$$
\begin{aligned}
|H(e^{j\omega})| &= \pm 0.01, && 0 \le |\omega| \le 0.25\pi, \\
|H(e^{j\omega})| &= 1 \pm 0.004, && 0.35\pi \le |\omega| \le 0.7\pi, \\
|H(e^{j\omega})| &= \pm 0.01, && 0.8\pi \le |\omega| \le \pi.
\end{aligned}
$$

    Design a linear phase equiripple FIR filter. Use MATLAB to confirm your filter meets specifications.