ECE 454/554 HW05 IIR Filter Design

Assignment is due Wednesday, December 7 at Noon

This assignment will take a fair amount of time to do well, so it would be to your benefit to start it very soon.

This exercise involves the design of several lowpass and bandpass FIR and IIR filters. It will use the MATLAB `designfilt` function. For both filter types you should not specify the filter order – let the function determine the minimum order that will achieve your other specifications.

The assignment involves the design of FIR and IIR filters that meet the following requirements:

Lowpass filter:

- PassbandFrequency = 20 kHz -- Upper passband frequency
- StopbandFrequency = 24 kHz – Lower stopband frequency
- PassbandRipple = 0.5 dB – Maximum passband attenuation or ripple
- StopbandAttenuation = 65 dB – Minimum stopband attenuation
- SampleRate = 60 kHz
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Bandpass filter #1

- StopbandFrequency1 = 8 kHz -- Upper end of lower stopband frequency
- PassbandFrequency1 = 10 kHz -- Lower passband frequency
- PassbandFrequency2 = 20 kHz -- Upper passband frequency
- StopbandFrequency2 = 22 kHz -- Lower end of upper stopband frequency
- StopbandAttenuation1 = 65 dB
- PassbandRipple = 0.5 dB
- StopbandAttenuation2 = 65 dB
- SampleRate = 60 kHz

Bandpass filter #2

Same as Bandpass filter # 1 except with significantly steeper filter skirts by increasing StopbandFrequency1 and decreasing StopbandFrequency2. You may choose the new limits.

For this assignment for each of the three filters you should use all of the following filter design methods:

FIR Filters:

- Equiripple
- Kaiser

IIR Filters

- Butterworth
- Chebyschev I
- Chebyschev II
- Elliptic

This implies a total of 18 filter designs using three different sets of requirements:

You need to submit three files for this assignment:

- Your MATLAB .m file that computes all of the filter designs and produces the appropriate fvtool results needed to complete the spreadsheet
- A completed spreadsheet that fills in all the yellow cells of the supplied template
- A document file that describes your observations.

Regarding the spreadsheet, you should provide your own estimate of the cost of the circuit to perform the necessary tasks. You can use the new cryptocurrency "Bobcoins" wherein the cost of a delay (z^{-1}) is one Bobcoin. The cost of a multiplier (and its associated accumulator) is a number of Bobcoins that is more than the cost of a delay. You may pick your own value for that. Then once you determine the number of delays and multipliers required for each of the implementations, you can then provide its cost.

For the IIR filters, you can use fvtool to provide a polezero plot and click on one of the poles nearest the z=1 circle. That will give you the coordinates from which you can determine the maximum pole radius. Subtracting that radius from one will give you the distance to the point of instability.

You can also use the group delay plot to find the maximum group delay for each implementation. Note that you can click on the peak of the group delay within the passband for the IIR filters and it should show you the value in number of samples. You can then convert that to microseconds.

Once the spreadsheet is complete you are able to make some observations.

Consider the distance of the nearest pole to the $|z|=1$ circle. Is there a risk that being close to that circle might mean that you might need greater arithmetic precision in your multipliers for the implementation and that could increase the cost and power requirements in order to ensure stability? We do not have the tools to quantify that, but it could be a significant concern.

Considering implementation cost and other performance metrics, for each of the three sets of requirements, is there one or more filter designs for each of them that you think would be good candidates and conversely are there some designs that fail to be good candidates?

I hope you find this assignment provides some insights into the tradeoffs of various design options.