

## ECE 408      HOMEWORK #3 (CH. 13)

### FILTER DESIGN AND ANALYSIS TOOL (FDA Tool) OF MATLAB 7

Open **MATLAB 7**. (Start→All Programs→MATLAB 7)

Click **Start** in the lower left corner of MATLAB window (This is not the Start of MS Windows). Then select **Toolboxes® Signal Processing® Filter Design & Analysis Tool (FDA Tool)**.

Filter Design & Analysis Tool window pops up.

Choose

Filter Type: Lowpass

Design Method: IIR, Butterworth

Filter Order: Minimum order

Window Specifications: (For FIR filters)

Frequency Specifications

Units: Hz

F<sub>s</sub> (sampling rate): 8000

F<sub>pass</sub> (passband cutoff frequency): 1500

F<sub>stop</sub> (stopband cutoff frequency): 2000

Magnitude Specifications

Units: dB

A<sub>pass</sub> (maximum loss in the passband): 2

A<sub>stop</sub> (minimum loss in the stopband): 35

Click on **Design Filter**.

Click the icons on top to see

Filter Specifications

Magnitude Response

Phase Response

Magnitude and Phase Response

Group Delay

Impulse Response

Step Response

Pole/Zero Plot

Filter Coefficients

To copy the plots to Word, **View® Filter Visualization Tool**. Another window pops up. Click **Edit ® Copy Figure**. Open Word. Click **Edit ® Paste**. Resize the figure.

Filter Realization

After the completion of filter design, click on the icon called **Realize Model** (the first button on the lower left corner of the FDA Tool window). Double click inside the filter block. The detailed filter realization diagram shows up. This is the **cascade implementation**. To change it to Direct Form II implementation, click **Edit® Convert to Single Section**. To convert to other structures, click **Edit® Convert Structure....**

Select the structure and click on Build. Double click inside the filter block. The detailed filter realization diagram shows up.

To export the coefficients, click **File** ® **Export...** In the Export window, select Text-file for Export to. Click OK. Specify the location and file name and click **Save** to complete the export.

1. Design a digital IIR filter with the following specifications:

Filter type = lowpass filter  
Maximum loss in the passband = 2 dB  
Minimum loss in the stopband = 35 dB  
Passband cutoff frequency = 1500 Hz  
Stopband cutoff frequency = 2000 Hz  
Sampling rate = 8000 Hz  
Approximation = Butterworth

- (a) What is the order of the digital filter?
- (b) Find the poles and zeros of the digital filter and plot pole-zero diagram.
- (c) Find the coefficients of the filter.
- (d) Plot the magnitude response and phase response of the filter.
- (e) Plot the impulse response and step response of the filter.
- (f) Plot the group delay of the filter.
- (g) Draw the direct form II structure of the filter.
- (h) Draw the cascade structure of the filter.

2. Repeat Problem 1 using Chebyshev I approximation.

3. Repeat Problem 1 using Chebyshev II approximation.

4. Repeat Problem 1 using elliptic approximation.

5. Design a digital IIR filter with the following specifications:

Filter type = highpass filter  
Maximum loss in the passband = 3 dB  
Minimum loss in the stopband = 45 dB  
Passband cutoff frequency = 2500 Hz  
Stopband cutoff frequency = 1500 Hz  
Sampling rate = 8000 Hz  
Approximation = Butterworth

- (a) What is the order of the digital filter?
- (b) Find the poles and zeros of the digital filter and plot pole-zero diagram.
- (c) Find the coefficients of the filter.

- (d) Plot the magnitude response and phase response of the filter.
- (e) Plot the impulse response and step response of the filter.
- (f) Plot the group delay of the filter.
- (g) Draw the direct form II structure of the filter.
- (h) Draw the cascade structure of the filter.

6. Repeat Problem 5 using Chebyshev I approximation.

7. Repeat Problem 5 using Chebyshev II approximation.

8. Repeat Problem 5 using elliptic approximation.

9. Design a digital IIR filter with the following specifications:

Filter type = bandpass filter

Maximum loss in the passband = 2 dB

Minimum loss in the stopband = 25 dB

Lower passband cutoff frequency = 1500 Hz

Upper passband cutoff frequency = 2000 Hz

Lower stopband cutoff frequency = 1000 Hz

Upper stopband cutoff frequency = 2500 Hz

Sampling rate = 8000 Hz

Approximation = Butterworth

- (a) What is the order of the digital filter?
- (b) Find the poles and zeros of the digital filter and plot pole-zero diagram.
- (c) Find the coefficients of the filter.
- (d) Plot the magnitude response and phase response of the filter.
- (e) Plot the impulse response and step response of the filter.
- (f) Plot the group delay of the filter.
- (g) Draw the direct form II structure of the filter.
- (h) Draw the cascade structure of the filter.

10. Repeat Problem 9 using Chebyshev I approximation.

11. Repeat Problem 9 using Chebyshev II approximation.

12. Repeat Problem 9 using elliptic approximation.

13. Design a digital IIR filter with the following specifications:

Filter type = bandstop filter

Maximum loss in the passband = 2 dB

Minimum loss in the stopband = 37 dB

Lower passband cutoff frequency = 1100 Hz

Upper passband cutoff frequency = 2700 Hz

Lower stopband cutoff frequency = 1600 Hz  
Upper stopband cutoff frequency = 2100 Hz  
Sampling rate = 8000 Hz  
Approximation = Butterworth

- (a) What is the order of the digital filter?
- (b) Find the poles and zeros of the digital filter and plot pole-zero diagram.
- (c) Find the coefficients of the filter.
- (d) Plot the magnitude response and phase response of the filter.
- (e) Plot the impulse response and step response of the filter.
- (f) Plot the group delay of the filter.
- (g) Draw the direct form II structure of the filter.
- (h) Draw the cascade structure of the filter.

14. Repeat Problem 13 using Chebyshev I approximation.

15. Repeat Problem 13 using Chebyshev II approximation.

16. Repeat Problem 13 using elliptic approximation.