TP N°2

Design and analysis of typical
FIR and IIR digital filters.

Lab Equipments :
      1- PC with Matlab software installed.
      2- Headphone.

Lab Work:

    I. **Filters Design with FDATool** GUI

In this part, first we will exactly follow and use the Matlab example to design and analyze an octave-band filter in the Getting Started With Signal Processing Toolbox to get familiar with this powerful tool. Then, we will use similar procedure to design a notch filter and export its coefficients to be used in the last part of this experiment to suppress a single tone from a corrupted spoken word.

An octave is the interval between two frequencies having a ratio of 2:1. An octave-band filter is a bandpass filter with high cutoff frequency approximately twice that of the low cutoff frequency.

The class of an octave filter is determined by its allowable passband ripple and its stopband attenuation.

I.1. Designing the Octave-band Filter

   1. Start **FDATool** from the MATLAB command line by typing: Fdatool

The FDATool dialog opens with a default filter. Its filter information is summarized in the upper left (Current Filter Information) and its filter specifications are depicted in the upper right. In addition to displaying filter specification, this upper right pane displays filter responses and filter coefficients.

The bottom half of FDATool shows the Filter Design panel, where you specify the filter parameters. Other panels, such as Import filter from workspace and Pole/Zero Editor, which you access with the buttons on the lower left, are also displayed in this area. If you have other products installed, you may see additional buttons. Note that when you open FDATool, Design Filter is not enabled. You must make a change to the default filter design in order to enable Design Filter. This is true each time you want to change the filter design. Changes to radio button items or drop down menu items such as those under
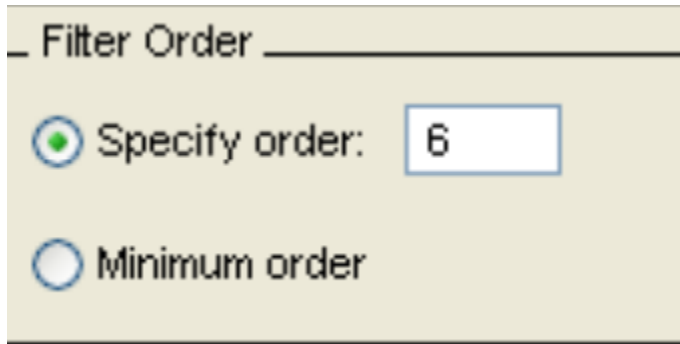Response Type or Filter Order enable Design Filter immediately. Changes to specifications in text boxes such as Fs, Fpass, and Fstop require you to click outside the text box to enable Design Filter.
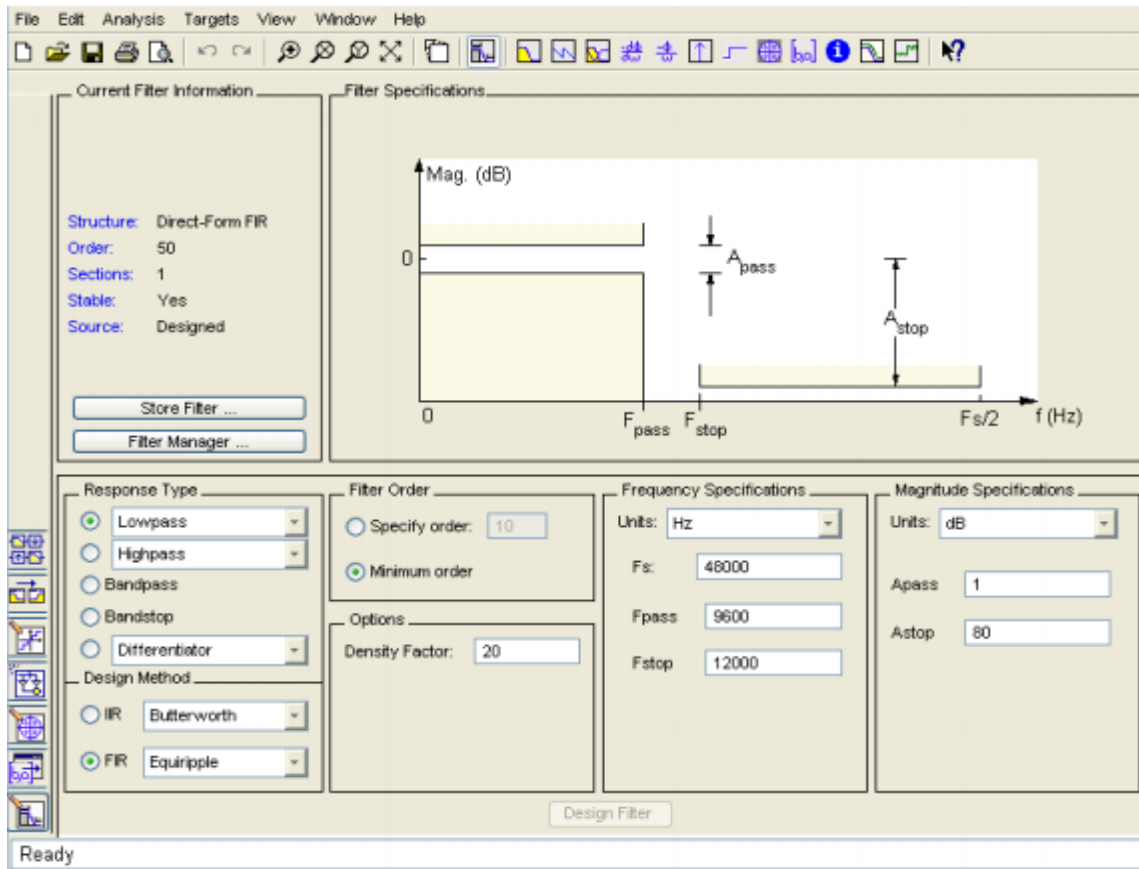
2. In the Response Type pane, select Bandpass.
3. In the Design Method pane, select IIR, and then select Butterworth.
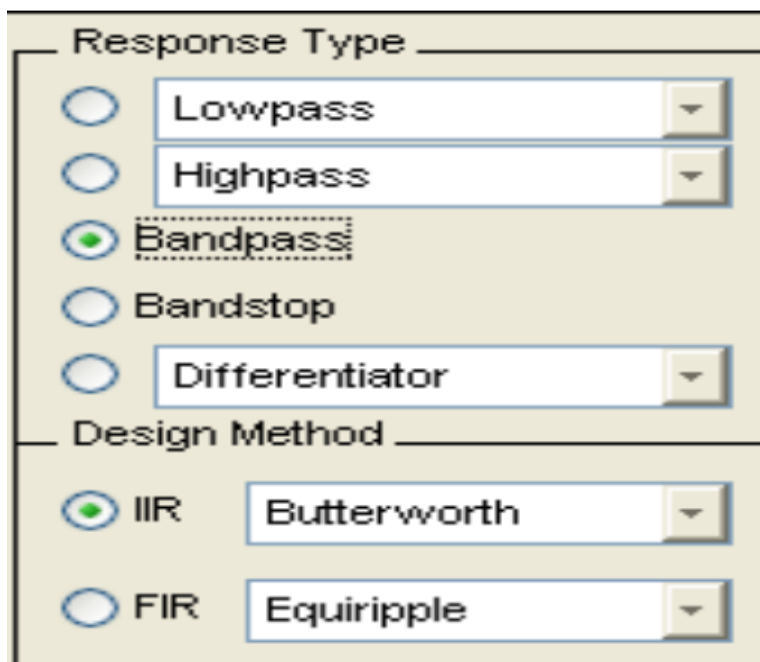
4. For the Filter Order, select Specify order, and then enter 6.

Filter Order

(●) Specify order: 6

(○) Minimum order

5. Set the Frequency Specifications as follows:

Set the Frequency Specifications as follows:

Parameter	Setting	Description
Units	Hz	Units for the parameters
Fs	48000	Sampling frequency
Fc1	22	First cutoff frequency (i.e., the frequency preceding the passband at which the magnitude response is 3 dB below the passband gain)
Fc2	45	Second cutoff frequency (i.e., the frequency following the passband at which the magnitude response is 3 dB below the passband gain)

Frequency Specifications

Units: Hz

Fs: 48000

Fc1: 22

Fc2: 45

Magnitude Specifications

The attenuation at cutoff

frequencies is fixed at 3 dB

(half the passband gain)

6. After specifying the filter design parameters, click the Design Filter button at the bottom of the design panel to compute the filter coefficients. The display updates to show the magnitude response of the designed filter.
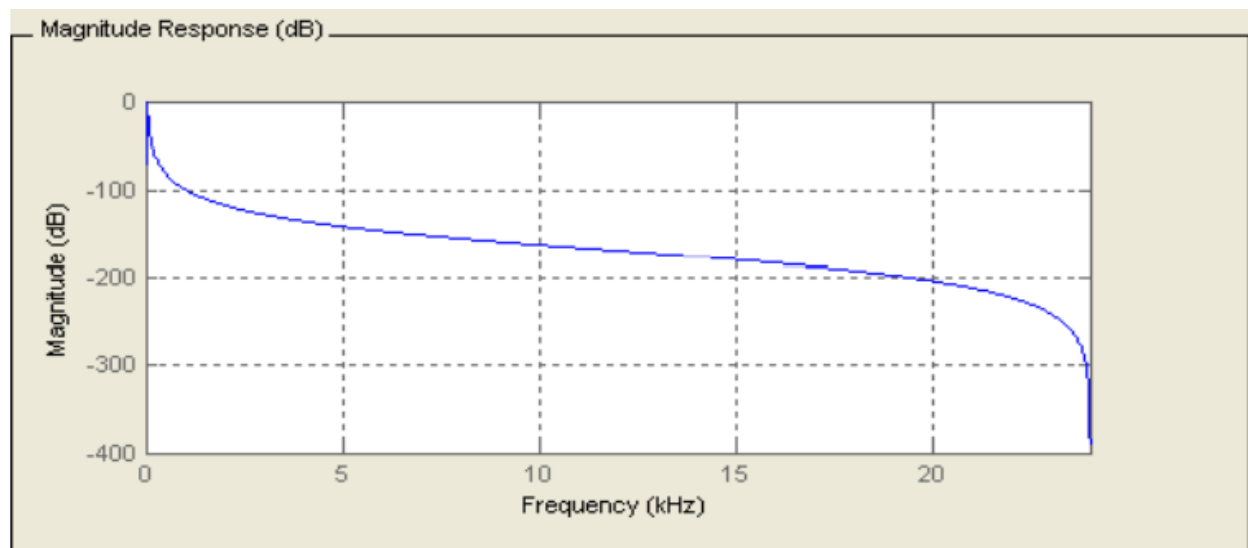

Notice that the Design Filter button is disabled after you compute the coefficients for your filter design. This button is enabled again if you make any changes to the filter specifications.

7. Click the **Store Filter** button.

Current Filter Information

Structure: Direct-Form II,
Second-Order
Sections

Order: 6

Sections: 3

Stable: Yes

Source: Designed

Store Filter ...

Filter Manager ...

8. In the Store Filter dialog, change the filter name to Bandpass Butterworth-1 and click OK to save the filter in the Filter Manager.

Store Filter

Enter filter name to be stored in the Filter Manager

Bandpass Butterworth-1

OK   Cancel
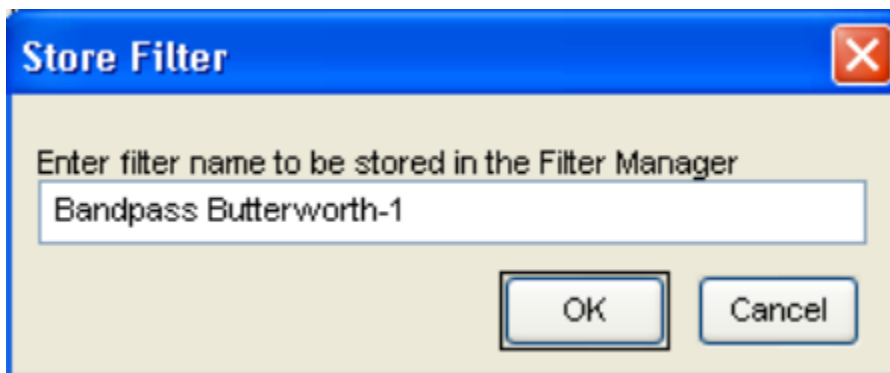
I.2. **Analyzing the Octave-band Filter**

After designing the filter, you can view the following filter responses in the display region by clicking on the associated toolbar button or by selecting the desired response from the Analysis menu.

Response	Toolbar Button Image
Filter specifications	
Magnitude response	
Phase response	
Magnitude and Phase responses	
Group delay	
Phase delay	
Impulse response	
Step response	
Pole-zero plot	
Filter coefficients	
Filter information	

9. Examine the displayed magnitude response of the filter.
10. Display other responses, as desired. Click the appropriate buttons, shown in the table above or select the desired response from the Analysis menu.
11. Click the Filter coefficients button to display the filter coefficients.

```
Filter Coefficients

SOS matrix:
1   0   -1   1   -1.998004047691447   0.998035939422696
1   0   -1   1   -1.998946837397759   0.998955846695791
1   0   -1   1   -1.996976892222879   0.996993830096889
Scale Factors:
0.001504214157022
0.001504214157022
0.001503084951555
1.000000000000000
```

I.3. Designing and Analyzing the Notch Filter

12. Start FDATool from the MATLAB command line by typing fdatool.
13. In the **Response Type** pane, select **Notching.**
14. In the Design Method pane, select IIR, and then select single notch.

15. In the frequency specifications pane, type 11025 for Fs and 3000 for Fnotch, select Bandwidth and type 200.
16. Click the Design Filter button at the bottom of the design panel to compute the filter coefficients.
17. From the View menu, select filter visualization too, a new window is opened and showing the magnitude response. You need to print or save this figure to include it in your report.
18. In the filter visualization window, select phase response, impulse response and filter coefficients and save or print this information to include it in your report.
19. In the filter design and analysis tool window, select Export from the File menu, a small window with Export title will be opened.
20. In the Export window, select Workspace for Export to, Coefficients for Export As.
21. In the Variable Names, type NumNotch for Numerator and type DenNotch for Denominator, then click Export. The filter coefficients are now available in the present Workspace and can be verified by typing whos.

II. Bibliography

- Digital Signal Processing Laboratory UsingTMS320C6713 DSP Starter Kit Jordan University of Science & Technology Department of Electrical Engineering by Dr. Jehad Ababneh Eng. Yara Obeidat.
- Digital Signal Processing and Applications with the TMS320C6713 and TMS320C6416 DSK SECOND EDITION by Rulph Chassaing Worcester Polytechnic Institute and Donald Reay Heriot-Watt University