Example 8-6: Comb-Filtering Trumpet Signal.

Purpose:

Consider a signal consisting of the superposition of two actual trumpets, one playing note A, at a fundamental frequency of 440 Hz, and another playing note B, at a fundamental frequency of 494 Hz. The signal was sampled at the standard CD sampling rate of 44100 samples/s. Design and implement a discrete-time comb filter to eliminate the signal of the trumpet playing note A, while keeping the signal of note B. Use $a = 0.99$.

Inputs:

Signal of two actual trumpets playing notes A and B from the file `twotrumpetsAB.mat`.
fr=fundamental in Hz of note to reject.
fs=sampling rate in sample/s.
a=α=radius of poles.

Outputs:

Plot and sound of two-trumpets signal.
Plot and sound of filtered two-trumpets.
Spectrum of two-trumpets signal.
Frequency response H of comb filter.

Comments:

- The first sound is the two trumpets.
  Hit any key to hear the filtered signal.
- The input signal consists of two actual trumpets playing notes A and B. Their fundamental frequencies are 440 and 494 Hz, respectively. The period of the trumpet playing note B is $\frac{1}{494} \approx 2$ ms. This is apparent in the waveform plot of the filtered two-trumpets signal.
- Frequency response of comb filter in red.
  Spectrum of two-trumpets signal in blue.
- Uses the simpler comb filter form that eliminates harmonics at frequencies whose fundamental divides fs in Hz.
- The two-trumpets spectrum has been multiplied by 10 for plot visibility.

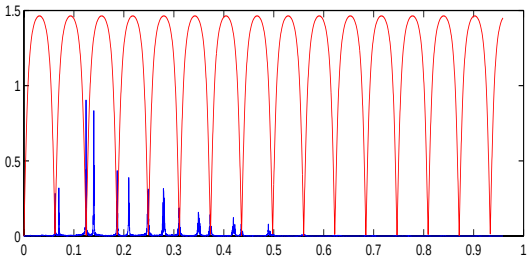

Figure 1: Frequency response of comb filter (red) and spectrum of two-trumpets signal (blue).

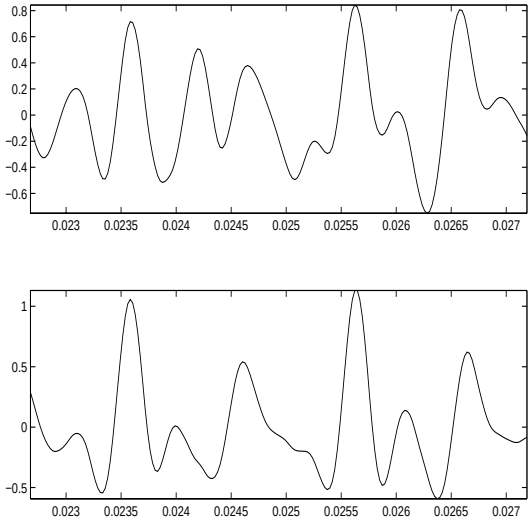

Figure 2: Two-trumpets (top), filtered two-trumpets (bottom) waveforms.

Program:

```
clear;load 'twotrumpetsAB.mat'
fr=436;%Note A is to be rejected
fs=44100;aa=0.99;N=length(X);
n=round(fs/fr);%See Comments
B=[1 zeros(1,n) -1];
A=[1 zeros(1,n) -aa^n];
W=2*pi/N*[0:4999];EW=exp(j*W);
H=polyval(B,EW)./polyval(A,EW);
FX=10*abs(fft(X))/N; subplot(211),
plot(W,FX(1:5000),W,abs(H),'r')
Y=filter(B,A,X);
I=[1000:1199];T=I/fs;figure
subplot(211),plot(T,X(I))
subplot(212),plot(T,Y(I))
soundsc(X,fs),pause,soundsc(Y,fs)
```