Lab Assignment #2: FIR filter design and application

ECE 565, Spring 2008

(posted Mon, Apr 14; due in class Tue, Feb 22)

The purpose of this lab assignment is to design FIR bandpass filters and to apply these filters to real geophysical time series: (1) high-resolution temperature and velocity time series measured on 30 October 2006 at 1.5 m above ground level in the Arizona Meteor Crater; (2) high-resolution microbarometer data measured on 18 March 2008 in Amherst. Design two sets of causal FIR bandpass filters, using (a) a rectangular window and (b) a Hann window, and apply these filters to the given time series. Proceed in the following steps.

(a) Find the equations for the impulse responses $h_r[n]$ and $h_h[n]$ ("r" stands for rectangular, "h" for Hann) in terms of normalized cutoff frequencies ω_{c1} and ω_{c2}, where the window runs from $n = 0$ to including $n = M$.

(b) The METCRAX data show oscillations of the cold-air pool in the crater with a dominant period of about 15 min. The sampling period of the data is 0.05 s. In order to reduce the computational cost for the filtering, compute sequences of block averages over 200 subsequent samples of temperature and zonal velocity (u). This gives time series with one sample every 10 s.

(c) Find ω_{c1} and ω_{c2} such that the cutoff periods are 10 min and 20 min. Choose M such that the magnitude response has 4 ripples in the passband.

(d) Plot the magnitude responses (for rectangular and Hann windows) with linear scaling and with logarithmic scaling (in dB).

(e) What are the periods associated with the highest sidelobes left and right of the passband (for rectangular and Hann windows)?

(f) What are the sidelobe suppressions (in dB) for these two sidelobes (for rectangular and Hann windows)?

(g) Apply the two bandpass filters to the block-averaged temperature and zonal velocity (u) time series. Plot the bandpass-filtered time series together with the block-averaged time series (i.e., 10-s averages) delayed by $M/2$ samples. Explain what you see.

(h) Now, consider the 3-h long sequence of high-resolution pressure time series. The sampling period is 0.105 s. Find ω_{c1} and ω_{c2} such that the cutoff frequencies are 0.1 Hz and 0.3 Hz. Choose M such that the magnitude response has 10 ripples in the passband.

(i) Plot the magnitude responses (for rectangular and Hann windows) with linear scaling and with logarithmic scaling (in dB).

(j) What are the periods associated with the highest sidelobes left and right of the passband (for rectangular and Hann windows)?

(k) What are the sidelobe suppressions (in dB) for these two sidelobes (for rectangular and Hann windows)?

(l) Apply the two bandpass filters to the pressure time series (sampling period 0.105 s). Plot segments (1 min, 2 min, 5 min, or 10 min long) of the bandpass-filtered time series together with the nonaveraged time series delayed by $M/2$ samples. Explain what you see.