

Homework 2 (EAS 8803: SEISMOLOGY II - SPRING SEMESTER 2008)

Total points: 100. Due 03/03/2008

1. The most critical specification of a data logger is its dynamic range, which is defined as the ratio of the largest on-scale measurement divided by the smallest resolvable measurement. Modern seismometers record on digital recorders, which convert the analogue voltage seismometer output to digital counts. The nominal dynamic range is determined by the number of bits used to characterize the voltage. Please compute the dynamic range in terms of both decibels (dB) and orders of magnitude for the following types of digitizers: 8, 12, 16, 20, 24 bits. (Note: One bit is used to determine whether the signal is positive or negative, and each additional bit represents a factor of 2 in dynamic range). (15 point)
2. Consider a system with a pole and a zero on the real axis of the s-plane. Let the pole position be $(-6.28318, 0)$, and the zero position $(0.628318, 0)$. Please plot the amplitude part of the frequency response function. What is the contribution of the pole and zero to the frequency response function? (15 point)
3. The standard Guralp CMG-3 ESP (a weak-motion broadband velocity sensor) has a natural frequency of 0.033 Hz (30 s), and a damping factor of 0.707 (critical). Please compute the poles and zeros and the normalization factor (at 1 Hz) for this seismometer (15 point).
4. Please plot the amplitude and phase spectra of the instrument responses for the following types of seismometers. In addition, please obtain the normalization factor at 1 Hz and plot the pole and zeros on the z-plane for each seismometer (20 point):

Name	Natural Freq.	Damping	Zeros	Poles
Streckeisen STS2	0.0083 Hz (120 s)	0.707 critical	Two at zero	$-0.037 + 0.037i$ $-0.037 - 0.037i$ $-118.752 + 423.4880i$ $-118.752 - 423.4880i$ -251.3270
Guralp CMG-3 ESP	0.033 Hz (30 s)	0.707 critical	Two at zero	$-0.147 + 0.147i$ $-0.147 - 0.147i$
Mark Products L-4C3D	1 Hz	0.707 critical	Two at zero	$-4.44 + 4.44i$ $-4.44 - 4.44i$
Mark Products L-22D	2 Hz	0.707 critical	Two at zero	$-8.88 + 8.88i$ $-8.88 - 8.88i$

5. Please download the instrument response information from the following website (35 points):
http://geophysics.eas.gatech.edu/people/zpeng/Teaching/EAS8803_S08/misc/RESP.BK.PKD.HHZ
 The original data (counts) in SAC format can be downloaded from the following website:
http://geophysics.eas.gatech.edu/people/zpeng/Teaching/EAS8803_S08/misc/BK.PKD.HHZ.SAC

The original data (counts) in ASCII format can be downloaded from the following website:

http://geophysics.eas.gatech.edu/people/zpeng/Teaching/EAS8803_S08/misc/BK_PKD_HHZ_SAC.dat
(You can directly copy them from /home1/zpeng/html/Teaching/EAS8803_S08/misc directory).

(a) Verify that the Stage 0 (field B058F04) sensitivity is a multiplication of the gain of previous stage (5 point).

(b) Please use evalresp command to extract, then plot the amplitude and phase spectra of the instrument response (5 point).

(c) Please write your own code to remove the instrument response based on either the pole-zeros, or the evalresp output to obtain the true velocity in the unit of m/s. Please compare with your results with those obtained using the SAC or GSAC transfer function (25 point).

Note:

1. Your code can be written in any scientific languages (e.g., Fortran, C, Matlab). Please make sure that the code can be compiled under standard Linux machine. Please submit your code electronically to zpeng@gatech.edu, and submit a write-up that includes all the figures.
2. The MatSAC package can be downloaded from the following link:
http://geophysics.eas.gatech.edu/people/zpeng/Teaching/Sac_Tutorial_2006/MatSAC.tar.gz
Use `fget_sac` to read the SAC binary format data into Matlab.