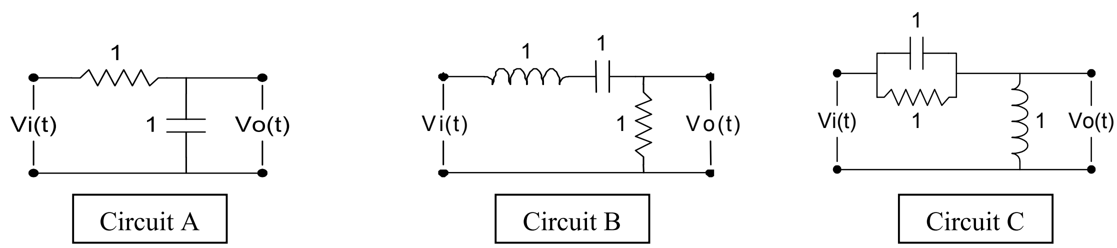
Beam Stability - Thursday homework set

Problem 1

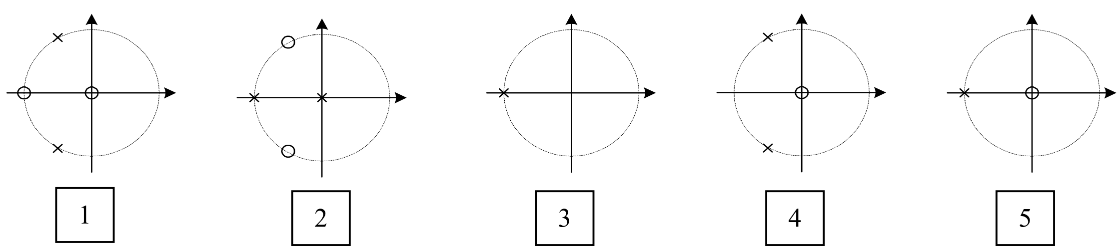
Three circuits below comprise no more than one each of an inductor, a capacitor, and a resistor. Five Laplace transform pole-zero plots, Bode plots, and step responses are also shown.

a) For each of the three circuits, match the appropriate pole-zero plots, frequency-response plots, and step responses.

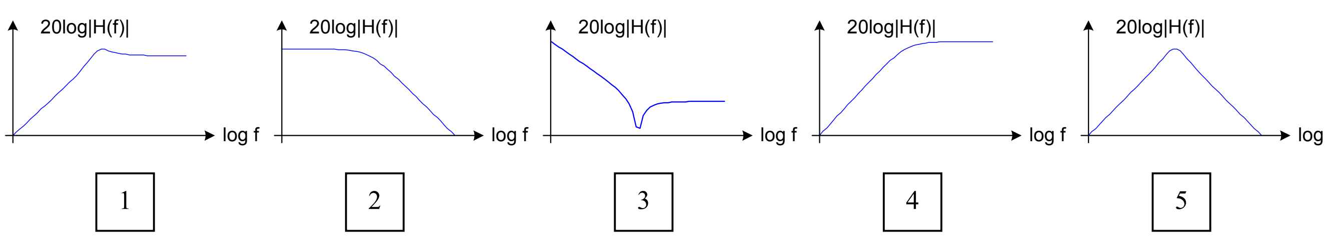
b) Write down a Laplace transfer function for each of the five pole-zero plots.



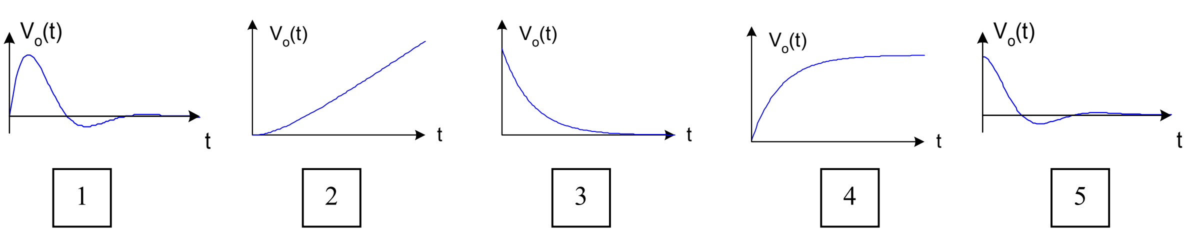
Pole-Zero Plots



Frequency-Responses



Step Responses



Problem 2

A lowpass filter with transfer function **H[z]** has passband and stopband ripple of **δp** and **δs**, as shown in Figure P3 (both are <<1). What is the passband and stopband ripple of two such filters in cascade? Generalize this result for **M** such cascaded filters [Hint: You do not need to know or to compute **H[z]**]

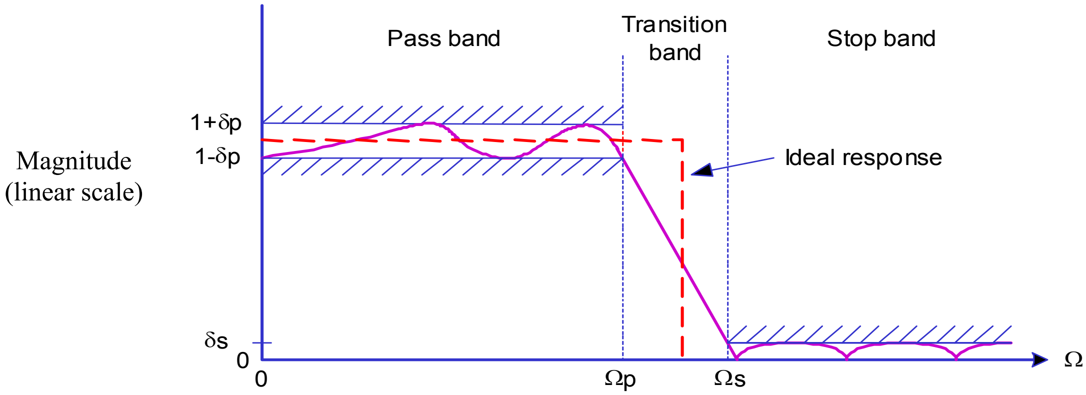


Figure P3

Problem 4
A continuous-time signal **x(t)** is composed of a linear combination of sinusoidal signals of frequencies 300Hz, 400Hz, 1.3kHz, 3.6kHz, and 4.3kHz. The signal is sampled at a 2kHz rate, and the sampled sequence passed through an ideal digital lowpass filter with a cutoff frequency of 900Hz, generating a signal **y(t)**. When the signal is reconstructed, what frequencies are present?

Problem 5
A 16-bit ADC has Gaussian analog front-end noise of +/-3 LSB rms, temperature drift of 2ppm / degree C, and differential non-linearity of 0.05 LSB. The ADC is sampling at 10k samples/sec.

a) In an environment where temperature varies by +/-2 degrees C over a 24-hr period, what is the maximum effective resolution achievable short-term (seconds) and long-term (hours) by averaging samples?
b) What is the effective bandwidth of the combination of digitizer and averager? (Note: an averager bandwidth is half the frequency of the first null in its magnitude response)

Problem 6
An analog anti-alias filter is required to meet the following specifications:

- Maximum position to be measured = +/-5 mm
- Minimum signal bandwidth = 300Hz.
- Smallest signal to be resolved at 300Hz = 1um peak.
- Smallest position change to be resolved at DC = 0.2um
- Sampling rate = 5kHz

a) Design an analog anti-alias filter transfer function to meet these specifications.
b) Determine minimum number of effective bits resolution required for the ADC.

Problem 3
A Bandpass signal has information in a +/-1MHz bandwidth, centered on a 19.8MHz carrier.

a) What is the lowest frequency that can be used to sample the signal such that the information can be completely recovered?
b) What is the longest sample/hold integration time before the signal amplitude is attenuated by 3dB? [Hint: the sample/hold circuit averages the input signal for the duration of its integration time]
c) Using the frequency calculated in Part (c), how far could the ADC clock frequency deviate from nominal if the perceived frequency content of the information is to remain accurate within 0.1%? (Note: ignore aliasing effects)