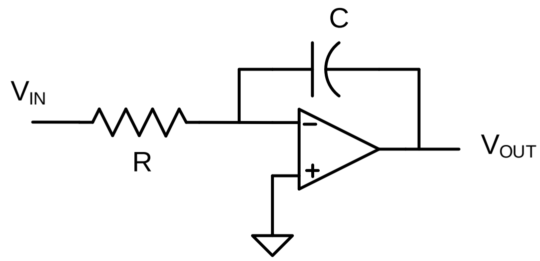
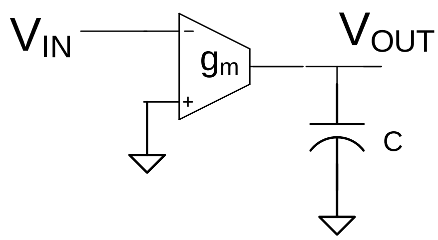
EE 508
Homework 4
Fall 2024
Due Monday Dec 3

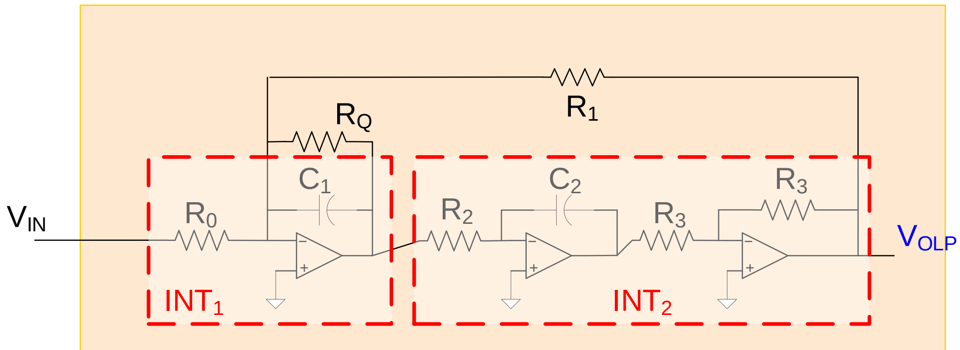
Problem 1 A Miller inverting integrator and a g_m-C integrator are shown below. The integrator Q factor was used for comparing different Op-Amp based integrators. Compare the Q-factor of the two integrators shown and comment on their relative performance.





Problem 2 Design a 6[th]-order Leapfrog Butterworth lowpass filter using OTAs and capacitors with a 3dB band edge of 10KHz and with 3dB passband ripple. Compare a SPICE simulation of your filter's response with the desired response. Assume the transconductors are ideal.

Problem 3 Repeat Problem 2 using cascaded biquads where the biquad structures are based upon the two-integrator loop shown below (with $R_0=R_1=R_2=R_3=R$ and $C_1=C_2=C$) .

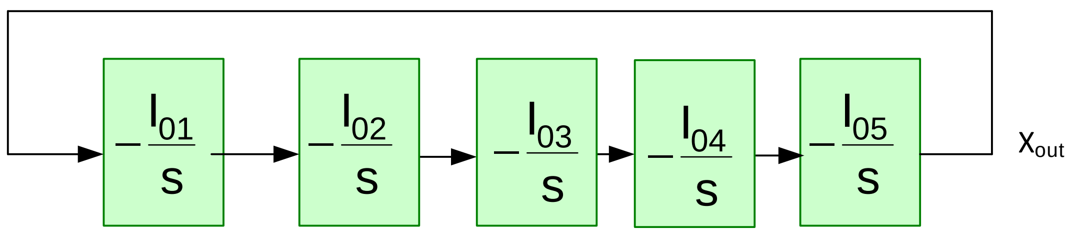


A Popular Second-Order Lowpass Filter

Problem 4 Numerically compare by simulation the sensitivity of the magnitude of the transfer function at 5 KHz for the Leapfrog filter and the cascaded biquad filters designed in the previous problems with respect to the capacitor C that is in the middle integrator in the Leapfrog structure and with respect to C2 in the cascaded biquad approach where C2 is in the biquad section with the middle band edge. Repeat this comparison at the 3dB band edge of 10KHz for both structures.

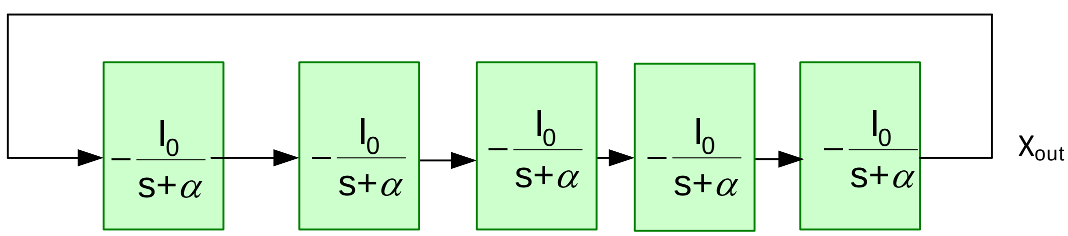
Problem 5 Consider the cascade of 5 inverting integrators shown where the unity gain frequency of the integrators may all be different.

a) Determine the pole locus of this structure assuming all devices are operating linearly.
b) How will the pole locus change if the unity gain frequency of the middle integrator is continually adjusted up and down by 50% of the nominal value

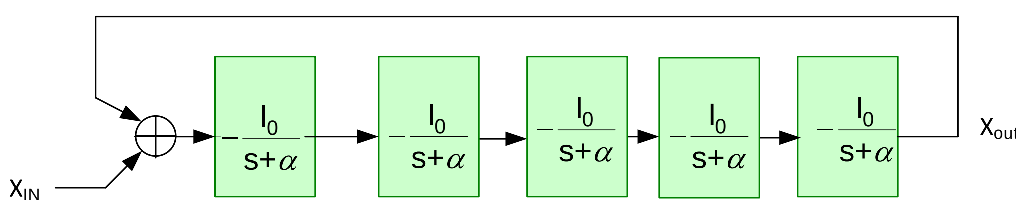


Problem 6 Consider the integrator cascade shown in part (a) below where the term $I_0 = 10^4\pi$.

a) Determine the value of α needed to place the right-most pole pair on the imaginary axis.
b) What will be the frequency of oscillation with this value for α?
c) If the circuit is modified by adding a summer to the input as shown in part (b), determine the value needed to obtain a bandpass filter with a 3dB bandwidth that is 10% of the center frequency.
d) What is the center frequency and the bandwidth of the filter you obtained in part c)?



(a)



(b)

Problem 7 A simple OTA is shown below where the current mirror is ideal and the transistors are matched.

a) If the tail current is 10uA, determine W/L of the transistors so that V_{EB} for the devices is 1V. Use any process you are comfortable with.
b) What is the transconductance gain of this OTA?
c) Attach a load resistor to the output with one terminal grounded so that the voltage gain of the OTA is 10.
d) What will be the gain of the voltage amplifier designed in part c) if the tail current is reduced wo 2uA?
e) Determine the RMS noise voltage at the output due to the thermal noise sources present in the OTA and the thermal noise source in the resistor. Comment on the the relative contribution to the noise at the output due to the resistor and the transistors in the OTA