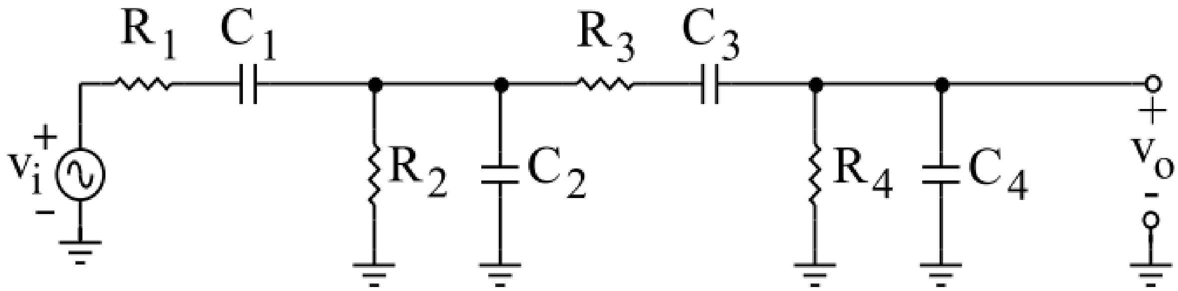
ELEC 301 - Project 1

P1. The figure below shows a simple four-pole RC filter. With proper selection of the values of R_1, R_2, R_3, R_4, C_1, C_2, C_3, and C_4, this circuit becomes a band pass filter. We will use the method of OC and SC time constants to find the transfer function of such a filter.



Four-pole RC filter

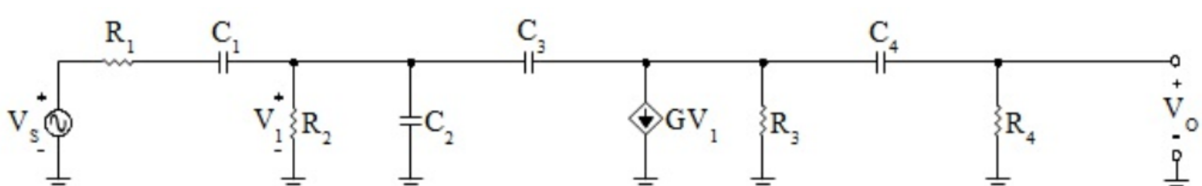
Initial component values for the RC filter circuit:

R_1	R_2	R_3	R_4	C_1	C_2	C_3	C_4
50 Ω	500 Ω	500 Ω	500 Ω	20 µF	100 pF	500 nF	100 pF

1A. Run an AC simulation on the circuit over a frequency range from at least 3 decades below the low frequency 3-dB point to at least 3-decades above the high frequency 3-dB point. Plot the Bode plots, both magnitude and phase, for the circuit. Graphically identify and record the locations of each of the poles of the transfer function.

1B. Increase the value of C_3 to1µF, 2 µF, 5 µF, and 10 µF and rerun the AC simulation recording the effect on the low frequency poles for each C_3 value. Determine the error percentage in the calculated low-frequency 3-dB point (calculated using the method of OC and SC time constants) as compared to those obtained from the simulation for each value of C_3 value (including the initial C_3 = 500 nF).

P2. The figure below shows a basic transconductance amplifier. It has been designed with $R_1 = 50\ \Omega$, $R_2 = 1\ k\Omega$, $R_3 = R_4 = 2\ k\Omega$, $C_1 = 4\ \mu F$, $C_2 = 10\ pF$, $C_3 = 2\ pF$, $C_4 = 2\ \mu F$ and $G = 0.1S$.

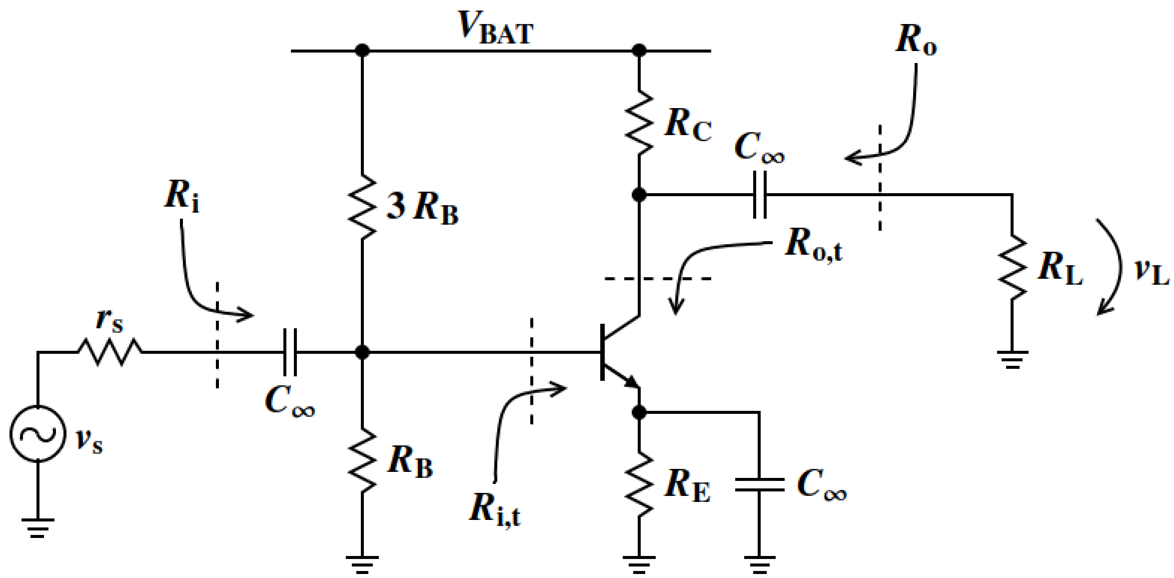


Basic transconductance amplifier

2A. Calculate the mid band gain and the locations of all of the poles (and any zeros) of the circuit P2 using Miller's theorem and the method of OC and SC time constants.

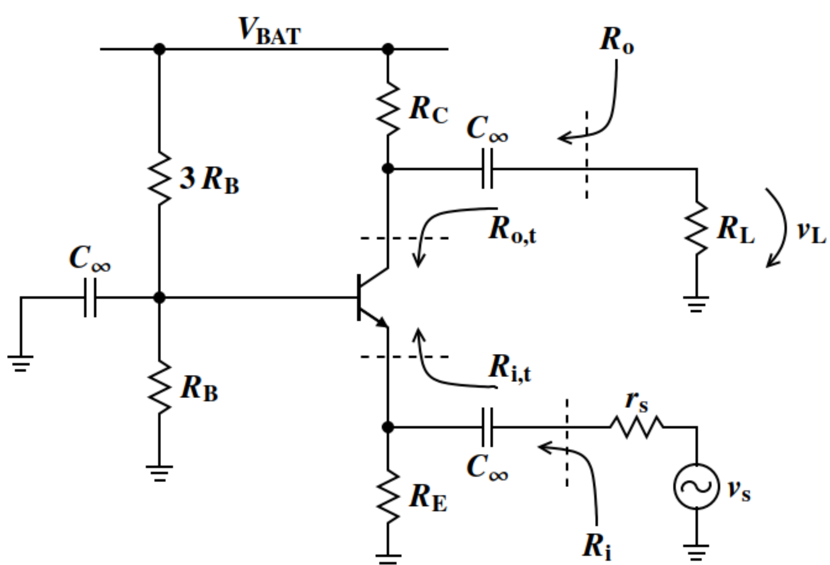
2B. Run an AC simulation on the circuit over a frequency range from at least 3 decades below the low frequency 3-dB point to at least 3-decades above the high frequency 3-dB point. Plot the Bode plots, both magnitude and phase, for the circuit. Identify and record the location of each pole (and any zeros) of the transfer function using the magnitude plot and compare these with the values calculated in part A, above. Also, calculate the error percentage in the estimated 3-dB points (calculated using the values of the pole locations obtained in part A, above) as compared to those obtained from the simulation.

P3. We consider the following circuit, with the following numerical values:
V_{BAT}=16V (supply voltage), R_B=20kΩ, R_C=4kΩ, R_E=2kΩ, r_s=100Ω, R_L=40kΩ (load resistance), C∞->∞ (coupling/bypass capacitors), β=200, VA=200V (Early voltage).



3A. Introduce the circuit in Spice and simulate and separately calculate (in midband) the input resistances R_i, R_{it} and the output resistances R_o, R_{ot}
3B. Remove C_E=C_∞ from the circuit (so that R_E is not shunted anymore for the ac analysis). Simulate and recompute (in midband) the input resistances R_i, R_{it} and the output resistances R_o, R_{ot}. Comment upon how the presence of R_E affects the input and output resistances.

P4. We consider the common-base amplifier stage below, with the following numerical values: V_{BAT}=16V (supply voltage), R_B=20kΩ, R_C=4kΩ, R_E=2kΩ, r_s=100Ω, R_L=40kΩ (load resistance), C∞->∞ (coupling/bypass capacitors), β=200, VA=200V (Early voltage). v_s is a small-signal voltage source.



4A. Introduce the circuit in Spice and simulate and separately calculate (in midband) the input resistances R_i, R_{it} and the output resistances R_o, R_{ot}. Make a comparison with the results obtained for the (3A) case.