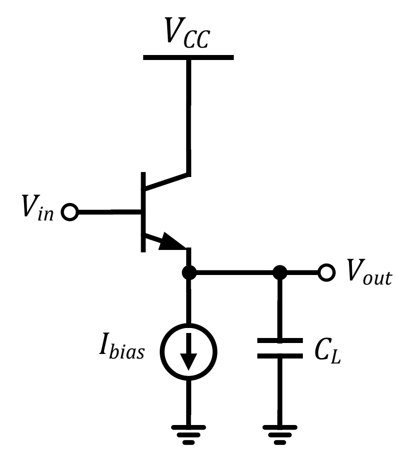
EE 538 Spring 2020
Analog Circuits for Sensor Systems
University of Washington Electrical & Computer Engineering

Instructor: Jason Silver

Practice Midterm

Please show your work.

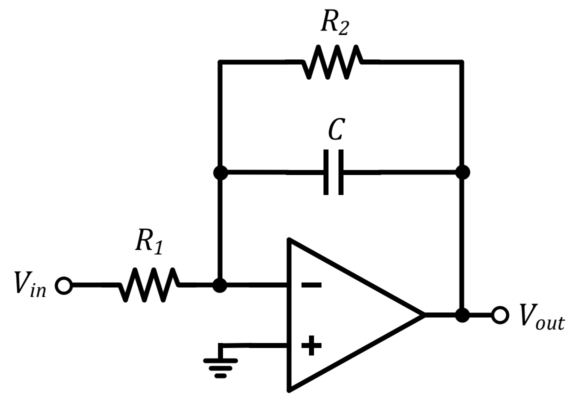
Problem 1: Emitter-follower analysis



For the following, V_{CC} = 5V, V_{IN} = 1V, I_{bias} = 1mA, C_L = 30pF, and $I_S = 10^{-16}$A.

a) Calculate the DC value of V_{out}. For this step, assume $V_A = \infty$.
b) Calculate the small-signal DC gain (v_{out}/v_{in}) if V_A = 100V.
c) Calculate the small-signal output resistance of the emitter follower if V_A = 100V.
d) Calculate the transit frequency (f_T) of the emitter follower.
e) Suppose we replace the BJT with a MOSFET with $V_{GS} - V_{TH}$ = 0.25V to construct a source follower. Ignoring r_o of the MOSFET, what is the new transit frequency?

Problem 2: Filter analysis and design



Assume the opamp has infinite gain and bandwidth, with input bias current I_B = 1nA.

a) Ignoring bias current, derive an expression for the closed-loop transfer function of the filter.
b) Design the filter (choose R_1, R_2, and C) to have a DC gain of 20dB and a 0.1% settling time of 10μs.
c) Still ignoring bias current, derive an expression for the closed-loop step response. Sketch the response for an input step of 0 to 1V and label all relevant times/voltages.
d) Re-sketch the closed-loop step response, accounting for the effect of input bias current.
e) Modify the design to reduce/eliminate the effect of the input bias current.

Problem 3. Opamp circuit design

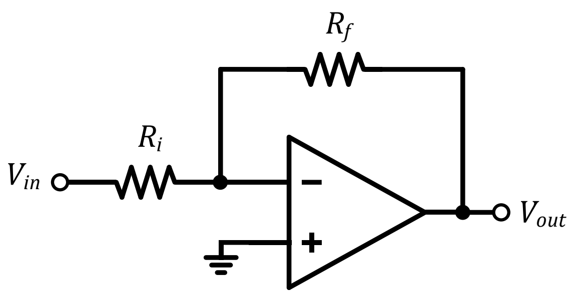


Figure 3a. Inverting amplifier

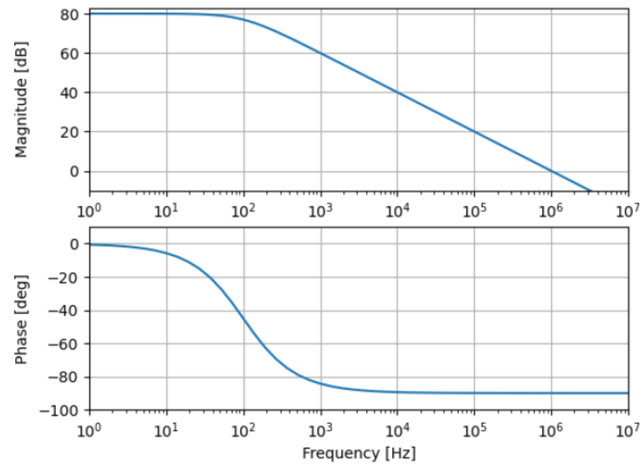


Figure 3b. Opamp open-loop frequency response

Assume ideal input/output resistances (R_{in} and R_o) for the opamp. Let $R_f = 10R_{in}$.

a) Determine the gain and the 3dB frequency of the closed loop transfer function.
b) Calculate the closed-loop gain error at DC and 100Hz.
c) Suppose you want to use this amplifier to amplify the voltage of a sensor with an equivalent source resistance of 1kΩ. Determine the values of R_i and R_f to achieve a DC gain of 10V/V and less than 0.1% input attenuation due to loading (*you can ignore finite gain for this step).*
d) Based on your answer to part c), is this a good choice of circuit for the application? How could it be improved?