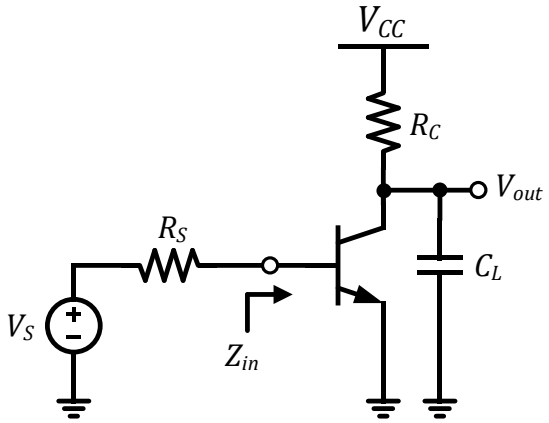
EE 538 Spring 2020
Analog Circuits for Sensor Systems
University of Washington Electrical & Computer Engineering

Instructor: Jason Silver
Midterm

Please show your work.

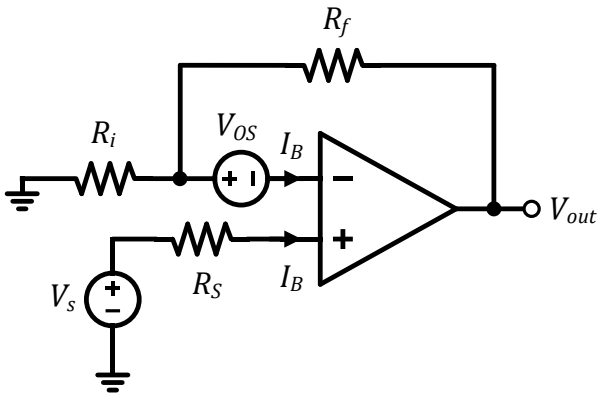
Problem 1: Common-emitter amplifier



For the following, V_{CC} = 5V, V_S = 1V, R_S = 1kΩ, I_{bias} = 100μA, R_C = 10kΩ, C_L = 10pF, β = 100, V_A = 100V, V_T = 25mV, and I_S = 10^{-16}A.

a) (10 points) Calculate the input impedance of the amplifier, Z_{in}. *Note: This does not include* R_S.
b) (10 points) Find an expression for the transfer function, V_{out}/V_S. Be sure to account for attenuation due to Z_{in}.
c) (10 points) Calculate the DC gain and transit frequency f_T.

Problem 2: Opamp nonidealities



Assume the opamp has infinite gain and bandwidth. V_{OS} = 1mV, and $I_B = -1\text{nA}$. $R_f = 10R_i$.

a) (15 points) Determine an expression for the output offset voltage, including the contributions from both V_{OS} and I_B.
b) (10 points) Assuming R_S = 0, calculate values for R_i and R_f that result in zero output offset.
c) (10 points) Assuming R_S = 1k and V_{OS} = 0, calculate values for R_i and R_f that result in zero output offset.

Problem 3. Opamp AC and transient analysis

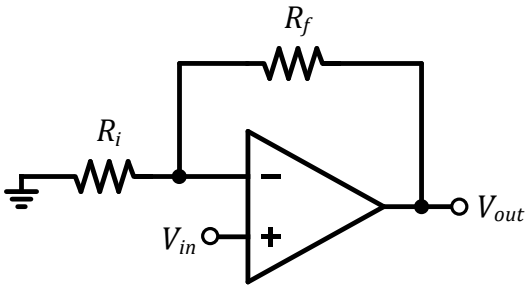


Figure 3a. Non-inverting amplifier

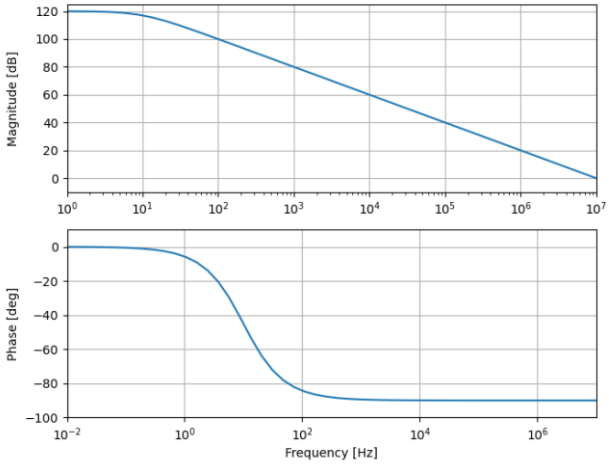


Figure 3b. Opamp open-loop frequency response

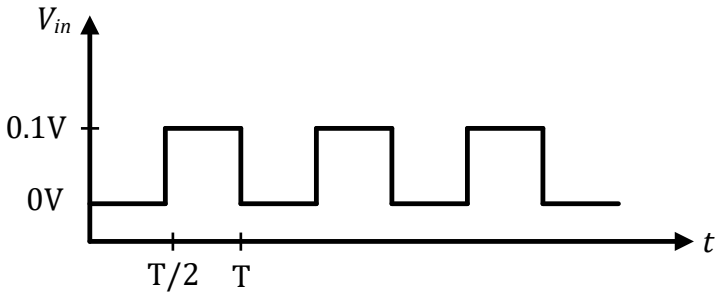


Figure 3. Input waveform for c) and d)

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

a) (10 points) Determine the DC gain and the 3dB frequency of the closed loop transfer function (V_{out}/V_{in}).
b) (7.5 points) Provide an expression for the transient response of the amplifier for a voltage step input of 0 to 100mV. Sketch the response and label all relevant times/voltages.
c) (10 points) Assume the amplifier is driven by the input waveform shown in Fig 3c. Determine the minimum period T for which 0.1% settling is achieved during each half-period (integer multiples of $T/2$). Sketch the output waveform.
d) (7.5 points) Calculate the total worst-case error in the output voltage (at the end of each half-period) if the resistors have a tolerance of 0.1%.