Exercise 1

Consider the two-stage amplifier in Fig. 1. The circuit parameters, at T = 25°C, are the following:

\[ V_{DD} = 9 \text{ V}, \quad R_g = 1 \text{ k}\Omega, \quad R_{G1} = R_{G2} = 100 \text{ k}\Omega, \quad R_D = 5.6 \text{ k}\Omega, \quad R_F = 20 \text{ k}\Omega, \quad R_S = 1 \text{ k}\Omega, \quad R_E = 2.2 \text{ k}\Omega; \]
\[ R_C = 10 \text{ k}\Omega, \quad C_g = 10 \text{nF}, \quad C_F = 1 \mu\text{F}. \]

\( Q_1: V_{BE} = -0.7 \text{ V}; \quad \beta_F = 100; \quad \beta_0 = 100; \quad r_0 = +; \)

\( Q_2: V_T = 3 \text{ V}; \quad I_{DSS} = 2.25 \text{ mA}; \quad r_0 = +; \)
\[ V_T = 25 \text{ mV}. \]

Considering all capacitors to be equivalent to open circuits, determine:

1. the operating points \((V_{DS}, I_D)\) of \(Q_1\) and \((V_{CE}, I_C)\) of \(Q_2\).

Assuming all capacitors to be equivalent to short circuits at the frequencies of interest, determine also:

2. the voltage gain of the amplifier, \(A_v = \frac{v_o}{v_i}\);
3. the input resistance indicated in the figure.

Applying the time constant method and neglecting capacitor \(C_F\), determine also:

4. an estimation of the low frequency bandwidth limit of the amplifier.
Exercise 2

Consider the operational amplifier configuration shown in Fig. 2. The circuit parameters are the following:

\[ R_1 = 1 \, \text{k\Omega}; \quad R_2 = 33 \, \text{k\Omega}. \]

\[ A(s) = \frac{A_0}{\left(1+\frac{s}{\omega_{p1}}\right)\left(1+\frac{s}{\omega_{p2}}\right)} \quad [\text{V/V}], \text{ with } A_0 = 10^5 \, [\text{V/V}]; \quad \omega_{p1} = 10^2 \, \text{rad/s}; \quad \omega_{p2} = 5 \cdot 10^3 \, \text{rad/s}. \]

Determine:

1. an estimation of the circuit phase margin without \( C_C \);
2. a block diagram representation of the amplifier, consistent with feedback theory;
3. the value of \( C_C \) that, ideally, makes the low pass filter bandwidth equal to the inverting amplifier’s one (before compensation);
4. the new phase margin after \( C_C \) is placed in the circuit.