

Common-emitter amplifier (EC_ceamp_1.sqproj)

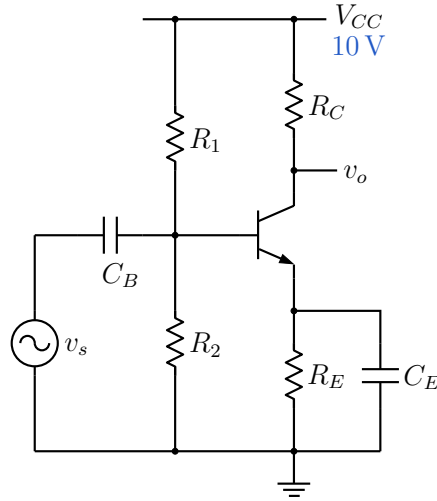


Figure 1: Common-emitter amplifier circuit.

Question: For the common-emitter amplifier shown in Fig. 1, $R_2 = 10\text{ k}$.

- Find R_1 , R_C , R_E to obtain bias quantities $I_C = 1\text{ mA}$, $V_{CE} = 5\text{ V}$, and $V_E = 2\text{ V}$.
- Find the mid-band open-circuit voltage gain A_v^o , i.e., v_o/v_s when no load is connected.

Solution:

- Since $V_E = 2\text{ V}$, $V_B = V_E + V_{BE} = 2 + 0.7 = 2.7\text{ V}$. Ignoring the base current (assuming β to be large), we can write

$$V_B = \frac{R_2}{R_1 + R_2} \times V_{CC} \rightarrow R_1 = 27\text{ k}\Omega. \quad (1)$$

From the condition $I_C = 1\text{ mA}$, we can find R_E as

$$R_E = \frac{V_E}{I_E} \approx \frac{V_E}{I_C} = \frac{2\text{ V}}{1\text{ mA}} = 2\text{ k}\Omega, \quad (2)$$

where we have used $I_E \approx I_C$, neglecting the base current.

Next, we use the condition $V_{CE} = 5\text{ V}$ to obtain R_C as follows.

$$V_{CE} = V_{CC} - V_E - I_C R_C = 5\text{ V} \rightarrow R_C = 3\text{ k}\Omega. \quad (3)$$

(b) To find the mid-band open-circuit gain, we draw the small-circuit equivalent circuit of the amplifier, as shown in Fig. 2. The base-emitter AC voltage v_{be} is the same as the source voltage v_s . The output voltage is

$$v_o = -(g_m v_{be}) \times R_C = -g_m v_s R_C, \quad (4)$$

leading to

$$A_V^o = \frac{v_o}{v_s} = -g_m R_C, \quad (5)$$

where the transconductance $g_m = \frac{I_C}{V_T}$, I_C being the DC collector current and V_T being the thermal voltage (25.85 mV at room temperature). A_V^o can be calculated as

$$A_V^o = -\frac{1 \text{ mA}}{25.85 \text{ mV}} \times 3 \text{ k}\Omega = -116. \quad (6)$$

To verify our answer, we can simulate the circuit with a sinusoidal input voltage with frequency in the mid-band range. The input should be sufficiently small (say, 1 mV) in order to avoid distortion at the output. The gain is then simply the ratio of the magnitude of the output and input voltages.

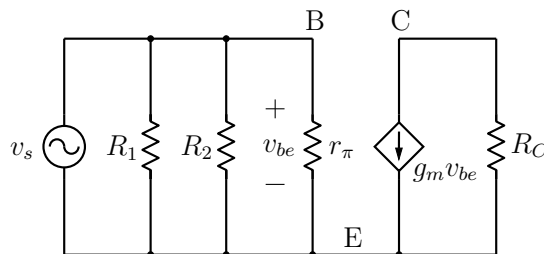


Figure 2: Small-signal equivalent circuit of the common-emitter amplifier of Fig. 1.

SequelApp Exercises: Repeat for the following conditions: $V_E = 3 \text{ V}$, $I_C = 1.5 \text{ mA}$, other circuit parameters being the same as before. Verify your answers using SequelApp.

(Note: Increase tic label resolution when viewing the plots in the App.)