UNIVERSITY OF CALIFORNIA AT BERKELEY
College of Engineering
Department of Electrical Engineering and Computer Sciences

EE105 Lab Experiments

Prelab 5: Single Stage BJT Amplifiers: Common Collector and Common Base

Solutions

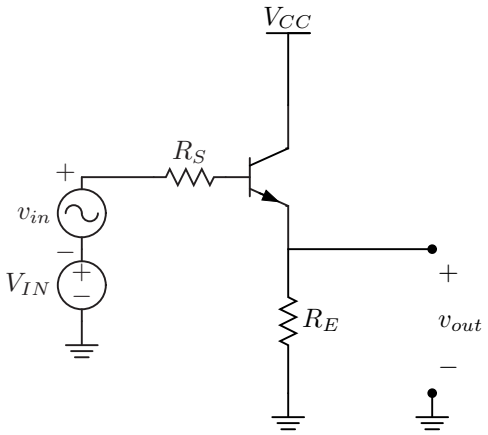
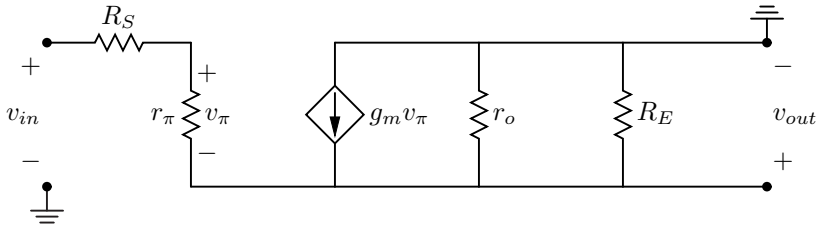


Figure 1: Common collector amplifier

1. Draw the small signal model for a common collector amplifier shown in Figure 1.



2. State (do not derive) the formulas for the input impedance, output impedance, and voltage gain of a common collector amplifier.

$$R_{in} = \boxed{r_\pi + (\beta+1)R_E}$$

$$R_{out} = \boxed{R_E \parallel \left(\frac{r_\pi + R_S}{\beta+1}\right)} \approx \frac{1}{g_m} + \frac{R_S}{\beta}$$

$$A_v = \boxed{\frac{g_m R_E}{g_m R_E + 1}} \approx 1$$

3. Using the following parameters, calculate the numerical values of the properties above: $I_S = 26.03$ fA, $R_S = 10$ kΩ, $R_E = 100$ Ω, $V_{IN} = 6.350$ V, and $\beta = 270$. Ignore the Early effect and make approximations when appropriate.

$$
\begin{aligned}
I_C &= I_S\left(e^{(V_{IN}-I_E R_E)/V_T} - 1\right) \\
&\approx I_S\left(e^{(V_{IN}-I_C R_E)/V_T} - 1\right) \\
I_C &= 56.112 \text{ mA} \\
g_m &= \frac{I_C}{V_T} \\
g_m &= 2.16 \text{ S} \\
R_{in} &\approx r_\pi + \beta R_E = \frac{270}{2.16} + 270 \cdot 100 \\
&\approx \boxed{27 \text{ kΩ}} \\
R_{out} &\approx \frac{1}{g_m} + \frac{R_S}{\beta} \\
R_{out} &= \boxed{37.5 \text{ Ω}} \\
A_v &= \frac{g_m R_E}{g_m R_E + 1} = 0.9954 \\
&\approx \boxed{1}
\end{aligned}
$$

4. How do these properties compare to those of the common emitter amplifier?

The input impedance is higher, output impedance is much lower, and the gain is unity (which is much lower than the gain of the common emitter amplifier).

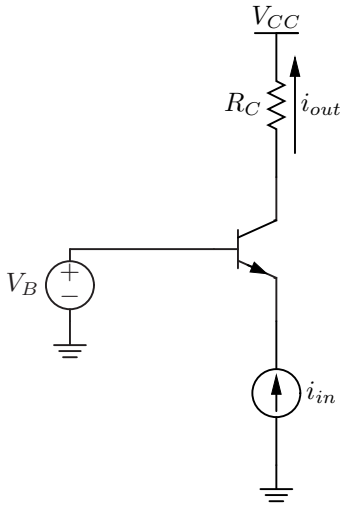
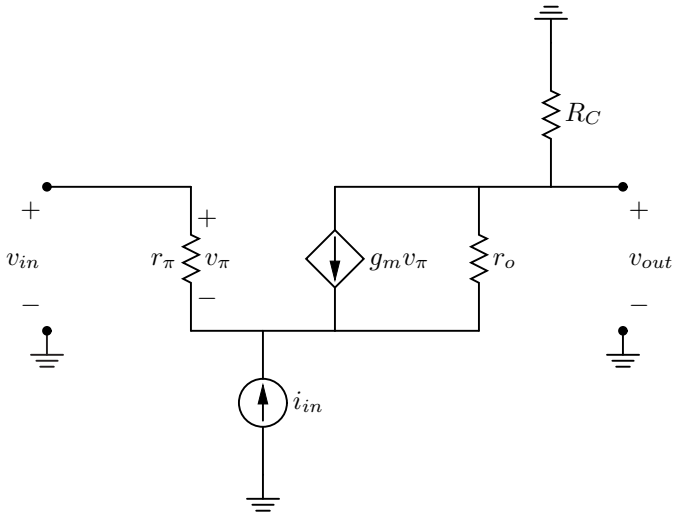


Figure 2: Common base amplifier

5. Draw the small signal model for the common base amplifier shown in Figure 2. *Note: The current*

source i_{in} is a small-signal AC current source, not a DC current source, so you must include it in the small-signal model.



6. State (do not derive) the formulas for input impedance, output impedance, and current gain ($A_i = i_{out}/i_{in}$) of a common base amplifier.

$$R_{in} = \boxed{\frac{r_\pi}{\beta+1}} \approx \frac{1}{g_m}$$
$$R_{out} = \boxed{R_C}$$
$$A_i = \boxed{\frac{\beta}{\beta+1}} \approx 1$$

7. Using the following parameters, calculate the numerical value of the properties above: $I_S = 26.03$ fA, $R_C = 1$ kΩ, and $V_{BE} = 640$ mV. Ignore the Early effect and make approximations when appropriate.

$$R_{in} \approx \frac{1}{g_m}$$
$$g_m = \frac{I_C}{V_T}$$
$$I_C = (26.03\text{ fA})(e^{V_B/V_T} - 1)$$
$$I_C = 1.276\text{ mA}$$
$$g_m = 49.07\text{ mS}$$
$$R_{in} = \boxed{20.83\ \Omega}$$
$$R_{out} = R_C = \boxed{1\text{ k}\Omega}$$
$$A_i \approx \boxed{1}$$

8. How do R_{in} and R_{out} compare to those of the common emitter amplifier?

   The input impedance is smaller than that of a common emitter amplifier. The output impedance is about the same as that of a common emitter amplifier.