EE 105 | Discussion 8

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**S&S 7.125**

**7.125** For the common-emitter amplifier shown in Fig. P7.125, let $V_{CC} = 15$ V, $R_1 = 27$ kΩ, $R_2 = 15$ kΩ, $R_E = 2.4$ kΩ, and $R_C = 3.9$ kΩ. The transistor has $\beta = 100$. Calculate the dc bias current $I_C$. If the amplifier operates between a source for which $R_{\text{sig}} = 2$ kΩ and a load of 2 kΩ, replace the transistor with its hybrid-π model, and find the values of $R_{\text{in}}$, and the overall voltage gain $v_o/v_{\text{sig}}$.

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**Figure P7.125**

For the common-emitter amplifier shown in Fig. P7.125, let $V_{CC} = 15$ V, $R_1 = 27$ kΩ, $R_2 = 15$ kΩ, $R_E = 2.4$ kΩ, and $R_C = 3.9$ kΩ. The transistor has $\beta = 100$. Calculate the dc bias current $I_C$. If the amplifier operates between a source for which $R_{\text{sig}} = 2$ kΩ and a load of 2 kΩ, replace the transistor with its hybrid-π model, and find the values of $R_{\text{in}}$, and the overall voltage gain $v_o/v_{\text{sig}}$.

![Diagram](image-url)
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[Diagram of the amplifier circuit]

Figure P7.125

$I_C = \alpha I_E = \frac{\beta}{\beta + 1} I_E$

$\frac{\beta I_E}{\beta + 1} = \beta I_B$

$I_E = \frac{V_E}{R_E} = \frac{V_{BB} - I_B R_B - V_{BE}}{R_E}$

$V_{BB} = \frac{R_2}{R_1 + R_2} V_{CC}$

$I_B = \frac{I_E}{\beta + 1}$

$I_E (1 + \frac{R_B}{\beta + 1} R_E ) = \frac{V_{BB} - V_{BE}}{R_E}$

$I_C = \alpha I_E = \frac{\alpha (V_{BB} - V_{BE})}{R_E} \left[ \frac{R_E + R_B}{(\beta + 1)} \right]^{-1}$
For the common-emitter amplifier shown in Fig. P7.125, let $V_{CC} = 15\,\text{V}$, $R_1 = 27\,\text{k}\Omega$, $R_2 = 15\,\text{k}\Omega$, $R_E = 2.4\,\text{k}\Omega$, and $R_C = 3.9\,\text{k}\Omega$. The transistor has $\beta = 100$. Calculate the dc bias current $I_C$. If the amplifier operates between a source for which $R_{\text{sig}} = 2\,\text{k}\Omega$ and a load of 2 kΩ, replace the transistor with its hybrid-$\pi$ model, and find the values of $R_{\text{in}}$, and the overall voltage gain $v_o/v_{\text{sig}}$.

\[ I_C = \frac{\beta (V_{BB} - V_{BE})}{R_E + R_B/(\beta + 1)} \]

\[ V_{BB} = 5.357\,\text{V} \]

\[ R_B = 9.643\,\text{k}\Omega \]

\[ I_C = 1.85\,\text{mA} \]

in midband, SC large capacitors & DC small capacitors

\[ Z_C = \frac{1}{j\omega C} \]
For the common-emitter amplifier shown in Fig. P7.125, let $V_{CC} = 15 \text{ V}$, $R_1 = 27 \text{ k}\Omega$, $R_2 = 15 \text{ k}\Omega$, $R_E = 2.4 \text{ k}\Omega$, and $R_C = 3.9 \text{ k}\Omega$. The transistor has $\beta = 100$. Calculate the dc bias current $I_C$. If the amplifier operates between a source for which $R_{\text{sig}} = 2 \text{ k}\Omega$ and a load of 2 k\Omega, replace the transistor with its hybrid-$\pi$ model, and find the values of $R_{\text{in}}$, and the overall voltage gain $v_o/v_{\text{sig}}$. 

\[ g_m = \frac{I_F}{V_T} = 71 \text{ mA} \left( \frac{25.9 \text{ mV}}{V_T} \right) \text{ (or } 25 \text{ or } 3) \]

\[ R_{\text{in}} = R_E || R_C = R_1 || R_2 || r_{\text{\pi}} \]

\[ R_{\text{sig}} = 2 \text{ k}\Omega \]

\[ v_{\text{sig}} = \frac{v_o}{v_{\text{\pi}}} = \frac{V_{\text{BE}}}{V_T} \]

\[ v_0 = -g_m R_0 \]

\[ \frac{v_o}{v_{\text{\pi}}} = \frac{-R_0}{R_{\text{in}} || R_C} \text{ (voltage divider)} \]
D **7.121** The MOSFET in the circuit of Fig. P7.121 has $V_t = 0.8 \text{ V}$, $k_n = 5 \text{ mA/V}^2$, and $V_A = 40 \text{ V}$.

(a) Find the values of $R_s$, $R_D$, and $R_G$ so that $I_D = 0.4 \text{ mA}$, the largest possible value for $R_D$ is used while a maximum signal swing at the drain of $\pm 0.8 \text{ V}$ is possible, and the input resistance at the gate is $10 \text{ M}\Omega$. Neglect the Early effect. $R = r_o$

(b) Find the values of $g_m$ and $r_o$ at the bias point.

(c) If terminal Z is grounded, terminal X is connected to a signal source having a resistance of $1 \text{ M}\Omega$, and terminal Y is connected to a load resistance of $10 \text{ k}\Omega$, find the voltage gain from signal source to load.

(d) If terminal Y is grounded, find the voltage gain from X to Z with Z open-circuited. What is the output resistance of the source follower?

- $R_G = 10 \text{ M}\Omega$
- $V_G = 0 \text{ V}$
- $V_f = -V_{GS}$

\[ I_D = \frac{k_n V_{ov}}{2^2} \]

\[ V_{ov} = \frac{4 \times 0.4 \text{ V}}{4} = V_{GS} - V_t = -V_B - 0.8 \text{ V} = 0.4 \text{ V} \]

\[ V_f = -1.2 \text{ V} \Rightarrow V_{GS} = 1.2 \text{ V} \]

\[ V_f - V_{ss} = I_D R_S \Rightarrow R_S = 9.5 \text{ k}\Omega \]
D *7.121* The MOSFET in the circuit of Fig. P7.121 has $V_t = 0.8 \, \text{V}$, $I_n = 5 \, \text{mA/V}^2$, and $V_A = 40 \, \text{V}$.

(a) Find the values of $R_S$, $R_D$, and $R_G$ so that $I_D = 0.4 \, \text{mA}$, the largest possible value for $R_D$ is used while a maximum signal swing at the drain of $\pm 0.8 \, \text{V}$ is possible, and the input resistance at the gate is $10 \, \text{M}\Omega$. Neglect the Early effect.

$$V_{D,\text{min}} = V_G - V_t = 0 - 0.8$$

$$V_{D,\text{min}} = -0.8 \, \text{V}$$

$$R_D = \frac{V_{DD} - V_D}{I_D} = \frac{5 - 0}{0.4 \, \text{mA}} = \left[12.5 \, \text{k}\Omega = R_D \right]$$
(b) Find the values of $g_m$ and $r_o$ at the bias point.
(c) If terminal Z is grounded, terminal X is connected to a signal source having a resistance of 1 MΩ, and terminal Y is connected to a load resistance of 10 kΩ, find the voltage gain from signal source to load.

\[
g_m = k_n V_{ov} = \mu_n C_{ox} \frac{w}{L} (V_{gs} - V_t) = \frac{2I_D}{V_{ov}}
\]

\[
r_o = \frac{V_A}{I_p} = 100 \text{ kΩ}
\]

\[
g_m = 2m \frac{A}{V} = 2s
\]
If terminal Y is grounded, find the voltage gain from X to Z with Z open-circuited. What is the output resistance of the source follower?