Refer to Eq. 4.83.

For each transistor:

\[ V_{BB} = 15 \times \frac{47}{100 + 47} = 4.8 \text{ V} \]

\[ R_B = R_1 \parallel R_2 = \frac{100 \parallel 47}{47} = 32 \text{ k}\Omega \]

\[ I_E = \frac{4.8 - 0.7}{3.9 + \frac{32}{101}} = 0.97 \text{ mA} \]

\[ I_C = 0.99 \times 0.97 = 0.96 \text{ mA} \]

\[ R_{B1} = R_{B2} = 32 \text{ k}\Omega \]

\[ g_m = g_m = \frac{0.96}{0.025} = 38.4 \text{ mA/V} \]

\[ R_{T1} = R_{T2} = \frac{100}{38.4} = 2.6 \text{ k}\Omega \]

\[ R_C1 = R_C2 = 6.8 \text{ k}\Omega \]

\[ R_{01} = R_{02} = \infty \text{ (no value was specified for } V_A) \]

(c) \[ R_{in1} = R_{B1} \parallel R_{T1} = 32 \parallel 2.6 = 2.4 \text{ k}\Omega \]

\[ \frac{V_{b1}}{V_b} = \frac{R_{in1}}{R_s + R_{in1}} = \frac{2.4}{5 + 2.4} = 0.32 \text{ V/V} \]

(d) \[ R_{in2} = R_{B2} \parallel R_{T2} = 32 \parallel 2.6 = 2.4 \text{ k}\Omega \]

\[ V_{b2} = -g_m V_{T1} (R_{C1} \parallel R_{in2}) \]

\[ = -38.4 V_{b1} (6.8 \parallel 2.4) \]

\[ \frac{V_{b2}}{V_{b1}} = -68.1 \text{ V/V} \]
(8) \( V_o = -9 \times 2 \times U_{in2} (R_{c2} || R_l) \)
\[ = -38.4 \times U_{in2} (6.8 \times 2) \]
\[ \frac{V_o}{U_{in2}} = -59.3 \ V/V \]

(9) \[ \frac{V_o}{V_i} = \frac{V_{bi1}}{V_i} \times \frac{V_{bi2}}{V_{bi1}} \times \frac{V_o}{V_{bi2}} \]
\[ = 0.32 \times 68.1 \times 59.3 \]
\[ = 1292 \ V/V \]

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(a) \( I_C = 0.99 \ mA \)
\[ V_C = I_C R_E + V_{BE} \]
\[ + I_B R_B \]
\[ = 1 \times 0.175 + 0.7 \]
\[ + 0.01 \times 100 \]
\[ = 1.875 \ V \]

(b) \( i_e = \frac{V_i}{R_e + R_E} \)
\[ = \frac{V_i}{25 + 175} \]
\[ = \frac{V_i}{200 \Omega} \]
\[ = \frac{V_i}{0.2 \ k\Omega} \]

Node equation at C:
\[ \frac{V_o - V_i}{100 \ k\Omega} + \alpha i_e + \frac{V_o}{10 \ k\Omega} = 0 \]
\[ 0.01 V_o - 0.01 V_i + 0.99 \frac{V_i}{0.2} + 0.1 V_o = 0 \]
\[ \Rightarrow \frac{V_o}{V_i} = -44.9 \ V/V \]
Refer to Fig. P4.89.

\[ R_i = \frac{V_r}{I_e} = \frac{V_r}{0.5} = 50 \Omega \]

To find the voltage gain \( v_b/v_i \), first note that

\[\frac{V_b}{V_i} = \frac{R_i}{R_s + R_i} = \frac{50}{50 + 50} = 0.5\]

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Refer to Fig. P4.91.

(a) \( I_e = \frac{9 - 0.7}{1 + \frac{100}{\beta r t}} \)

For \( \beta = 20 \),

\[ I_e = \frac{8.3}{1 + \frac{100}{20}} = 1.444 \text{mA} \]

\[ V_e = 1.44 \times 1 = 1.44 \text{V} \]

\[ V_B = 1.44 + 0.7 = 2.14 \text{V} \]

For \( \beta = 20 \),

\[\frac{V_e}{V_s} = \frac{9.8}{10 + 9.8} = \frac{0.5}{0.5 + 0.0174} \]

\[= 0.478 \text{ V/V} \]

For \( \beta = 200 \),

\[\frac{V_e}{V_s} = \frac{50.3}{10 + 50.3} = \frac{0.5}{0.5 + 0.0045} \]

\[= 0.827 \text{ V/V} \]

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7-3
DC analysis

\[ I_e = \frac{4.5 - 0.7}{2 + \frac{10 + 10}{101}} = 1.73 \text{ mA} \]

\[ I_c = 0.99 \times 1.73 = 1.71 \text{ mA} \]

\[ g_m = \frac{I_c}{V_T} = 68.5 \text{ mA/V} \]

\[ r_e = \frac{V_I}{I_E} = 14.5 \Omega \]

\[ r_T = \frac{\beta}{g_m} = \frac{100}{68.5} = 1.46 \Omega \]
Simplified equivalent circuit:

\[ V_o = \left( g_m V_T + \frac{V_T}{R_i} \right) R_e \]

\[ = \left( 68.5 + \frac{1}{1.27} \right) 1.67 \frac{V_T}{R_i} \]

\[ = 115.7 \frac{V_T}{R_i} \]

\[ i_i = \frac{V_T}{R_i} = \frac{V_T}{1.27} \]

\[ V_b = V_T + V_o = 116.7 \frac{V_T}{R_i} \]

\[ R_i = \frac{V_b}{i_i} = \frac{116.7 \frac{V_T}{R_i}}{1.27} = 148.2 \Omega \]

\[ \frac{V_o}{V_s} = \frac{V_b}{V_s} \frac{V_o}{V_b} \]

\[ = \frac{R_i}{R_i + R_e} \frac{115.7 \frac{V_T}{R_i}}{116.7 \frac{V_T}{R_i}} \]

\[ = \frac{148.2}{148.2 + 10} \times \frac{115.7}{116.7} = 0.93 \text{ V/V} \]
With $C_B$ open-circuited so that bootstrapping is eliminated, we obtain the following equivalent circuit model:

\[ R_i = 10 \, \text{k}\Omega \]
\[ R_{ib} = R_i + (\beta+1) \times 2 \]
\[ = 1.46 + 101 \times 2 = 203.46 \, \text{k}\Omega \]

\[ R_i = 20 \, \text{k}\Omega / 203.46 \]
\[ = 18.21 \, \text{k}\Omega \] (much lower than the value obtained with bootstrapping)

\[ V_b = \left( g_m \frac{V_{in}}{R_i} + \frac{V_{in}}{R_i} \right) \times 2 \, \text{k}\Omega \]
\[ = \left( 68.5 + \frac{1}{1.46} \right) \times 2 \, V_{in} = 138.4 \, V_{in} \]

\[ V_b = \frac{V_o}{V_b} \times V_b = \frac{R_i}{R_i + R_i} \times V_b \]
\[ = \frac{18.21}{10 + 18.21} \times 138.4 = 0.64 \, \text{V/V} \] (much lower than the value obtained with bootstrapping)

This is due to the lower $R_i$. (continued below)

Boostrappping raises the component of input resistance due to the base biasing network.
There are 4 input combinations:

When any input is high, \((V_x \text{ and/or } V_y)\) high, \(V_o = 0.2V\).

When both inputs are low,
\[(V_x \text{ and } V_y)\) are low \(V_o = \text{ low}\).