Problem 4.38

$V_{BE} = 0.7 \text{ V}$

$\beta = 200$

\[ I_2 + I_B \]

\[ \frac{47k\Omega}{i_c + i_2 + i_b} \]

\[ i_c = \beta i_b \]

\[ I_2 \downarrow \frac{150k\Omega}{-15V} \downarrow \]

\[ I_2 = \frac{(15 + 0.7)}{(150 \text{ k}\Omega)} = 104 \mu\text{A} \]

\[ 15 = (4.7 \text{ k}\Omega)(i_c + i_2 + i_b) + (47 \text{ k}\Omega)(i_2 + i_b) + 0.7 \]

Substituting $i_c = \beta i_b$ and solving we find $i_b = 8.96 \mu\text{A}$. Then we have $i_c = \beta i_b = 1.79 \text{ mA}$. Finally we have

\[ V_{CE} = V_{CC} - R_C(i_c + i_2 + i_b) = 6.04 \text{ V} \]

Problem 4.39

Many answers exist for this problem. Here is one of them:

We use $\beta = 100$ (which is the average value) in the design calculations. We design so $V_{CE} = 20/3 = 6.67 \text{ V}$, $R_E i_E = 6.67 \text{ V}$ and $R_C i_C = 6.67 \text{ V}$. Then we have $R_C = 6.67/i_C = 1.333 \text{ k}\Omega$ and $R_E = 6.67/i_E = 6.67/i_C = 1.333 \text{ k}\Omega$. We select the closest nominal values of 1.3 k\Omega.

We have $V_2 = V_{BE} + i_E R_E = 0.7 + 6.67 = 7.37 \text{ V}$. $I_B = i_C / \beta = 50 \mu\text{A}$. We design so that $I_2 = 20 I_B = 1 \text{ mA}$. Then we have $R_2 = V_2/I_2 = 7.37 \text{ k}\Omega$ and $R_1 = (V_{CC} - V_2)/(I_2 + I_B) = 12.03 \text{ k}\Omega$.

Finally we select the nominal values $R_2 = 7.5 \text{ k}\Omega$ and $R_1 = 12 \text{ k}\Omega$. 

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To determine the output resistance of an amplifier:

1. Replace the load with a test voltage (or current) source.
Dc circuit:

\[ V_{EQ} = 0.7 \, \text{V} \]
\[ \beta = 100 \]

\[
\begin{array}{|c|c|c|}
\hline
R_E & 0 & 100 \, \Omega \\
\hline
I_{CQ} & 5.30 \, \text{mA} & 5.12 \, \text{mA} \\
r_r & 491 \, \Omega & 509 \, \Omega \\
A_v & -102 & -4.76 \\
Z_{in} & 490 \, \Omega & 10.1 \, \text{k}\Omega \\
\hline
\end{array}
\]

Notice the dramatic effect of the 100-\(\Omega\) emitter resistance on voltage gain and input impedance.

Problem 4.55

\[
R_s' i_b + r_r i_b + (\beta + 1)R_E i_b = 0 \quad \Rightarrow \quad i_b = 0
\]

Therefore we conclude that the \(\beta i_b\) acts as an open circuit and we have \(R_o = R_c\).