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

EE105 Lab Experiments

Prelab 6: Biasing Circuitry

Solutions

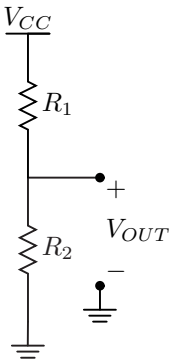


Figure 1: Resistive divider "voltage source"

1. Consider the resistor network shown in Figure 1. Let $V_{CC} = 10\,\text{V}$, $R_1 = 9.35\,\text{k}\Omega$, and $R_2 = 650\,\Omega$. We can turn this resistive divider into a voltage source with an output (source) resistance by taking its Thévenin equivalent. Find the open circuit output voltage and the output resistance of this voltage source.

$$V_{OUT} = V_{CC}\frac{R_2}{R_1 + R_2} = \boxed{650\,\text{mV}}$$
$$R_{out} = R_1 \parallel R_2 = \boxed{607.75\,\Omega}$$

2. Now, consider a BJT voltage source such as the one shown in Figure 2. Size resistor R_C to achieve an output voltage of 650 mV. Let $V_{CC} = 10\,\text{V}$, $I_S = 26.03\,\text{fA}$, and $V_T = 26\,\text{mV}$. Ignore the Early effect for this calculation.

$$\begin{aligned} I_C &= I_S\left(e^{V_{BE}/V_T} - 1\right) \\ &= 26.03 \times 10^{-15}\left(e^{0.650/0.026} - 1\right) \\ &= 1.874\,\text{mA} \end{aligned}$$
$$R_C = \frac{V_{CC} - V_{BE}}{I_C} = \boxed{4.988\,\text{k}\Omega}$$

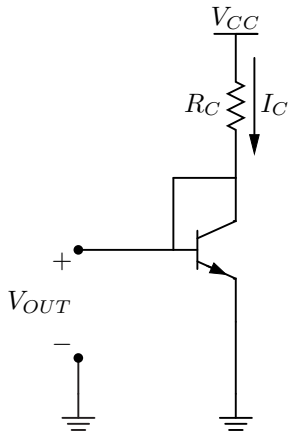


Figure 2: BJT voltage source

3. Find the output impedance and the power dissipated by this BJT voltage source. *Hint: Remember the definition of power, $P = IV$.*

$$R_{out} = \frac{1}{g_m} \parallel r_\pi \approx \frac{1}{g_m} = \frac{V_T}{I_C} = \boxed{13.87\ \Omega}$$
$$P = I_C V_{CC} = \boxed{18.74\ \text{mW}}$$

4. If we were to resize the resistors of our resistive divider (Figure 1) to achieve the same output impedance as the BJT voltage source given the same output voltage, what would be the values of the two resistors? How much power would it draw?

$$R_1 \parallel R_2 = 13.87\ \Omega$$
$$10\frac{R_2}{R_1 + R_2} = 0.65$$
$$\Rightarrow R_1 = \boxed{14.84\ \Omega}$$
$$R_2 = \boxed{213.4\ \Omega}$$
$$I = \frac{V_{CC}}{R_1 + R_2} = 43.8\ \text{mA}$$
$$P = IV_{CC} = \boxed{438\ \text{mW}}$$

5. Consider the circuit shown in Figure 3. Let $V_{CC} = 10$ V and $R = 10\ \text{k}\Omega$. Roughly sketch I_{OUT} vs. V_{OUT}.
6. Find the short circuit output current and the output impedance of the current source.

$$I_{OUT} = \frac{V_{CC}}{R} = \boxed{1\ \text{mA}}$$
$$R_{out} = R = \boxed{10\ \text{k}\Omega}$$

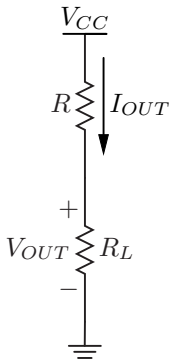
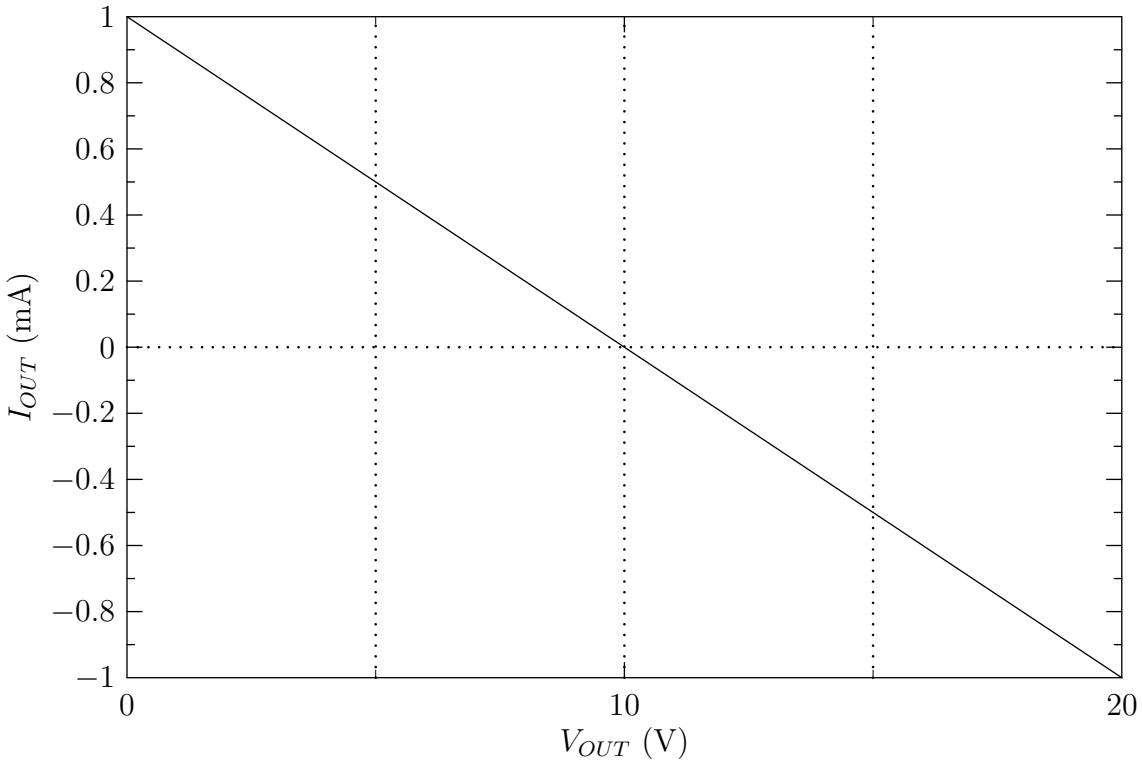


Figure 3: Resistor "current source"



7. Is it possible to increase the output impedance without decreasing the output current and without changing V_{CC}? Explain.

   No it is not. The only way to increase the output resistance is by increasing R. Increasing R will decrease the current by increasing the overall resistance of the branch.