`bjt_mirror_2.sqproj`

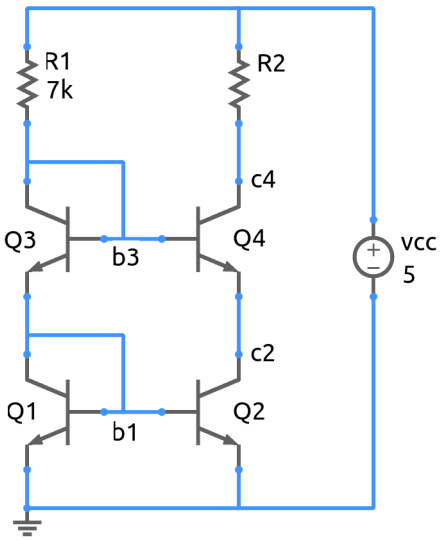

Figure 1: Circuit schematic for cascode current mirror.

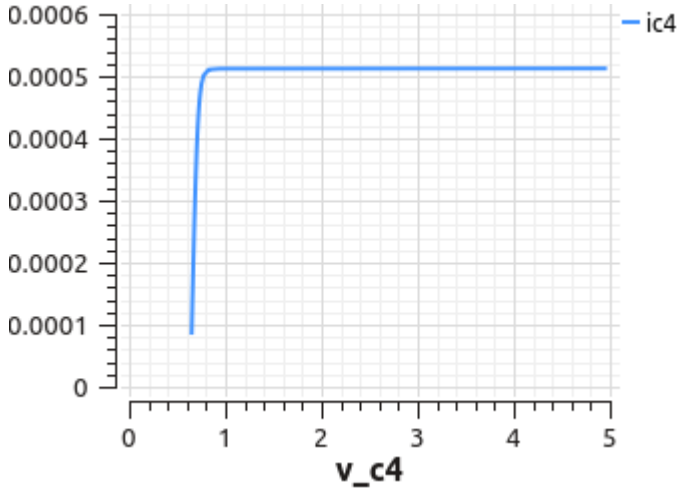

Figure 2: I_{C4} versus V_{C4} for the current mirror of Fig. 1.

Shown in Fig. 1 is a cascode current mirror which has the desirable feature of a high output resistance. Transistors Q_1 and Q_2 provide the basic mirror action. The high output resistance of the current mirror can be understood qualitatively as follows. The collector voltage of Q_2, given by

$$V_{C2} = V_{BE1} + V_{BE3} - V_{BE4}\,, \tag{1}$$

remains equal to one V_{BE} with respect to ground, irrespective of V_{C4} as long as the trasistors are in the active region. The current I_{C2} (and therefore I_{C4}) remains constant even if V_{C4} changes substantially. With small-signal analysis, the output resistance of the cascode current mirror can be obtained as $\beta\, r_{o4}/2$, where $r_{o4} = V_{A4}/I_{C4}$ is the output resistance of Q_4. Clearly, we can expect this current mirror to perform much better than the simple current mirror seen in `bjt_mirror_1.sqproj`.

Ignoring base currents, the output current I_{C4} is equal to I_{C1} which is given by,

$$I_{C1} \approx \frac{V_{CC} - 2V_{BE}}{R_1}\,. \tag{2}$$

Fig. 2 shows a plot of I_{C4} versus V_{C4} obtained by varying R_2.

Exercise Set

1. From the simulation results, calculate the value of the output resistance $(\partial I_{C4}/\partial V_{C4})^{-1}$. Compare it with the simple current mirror seen in `bjt_mirror_1.sqproj`.

2. As V_{C4} is reduced, the currents starts dropping at some point. At what value of V_{C4} do you expect this to happen? Explain.

3. Design a cascode current source for $I_{C4} = 1$ mA. Verify your design by simulation. Find the new output resistance $(\partial I_{C4}/\partial V_{C4})^{-1}$, and explain quantitatively how it has changed with respect to the earlier value.

References

1. A. S. Sedra, K. C. Smith, and A. N. Chandorkar, *Microelectronic Circuits: Theory and Applications*, Fifth edition, Oxford University Press, 2009.

2. P. R. Grey and R. G. Meyer, *Analysis and Design of Analog Integrated Circuits,* John Wiley and Sons, 1995.