bjt_mirror_3.sqproj

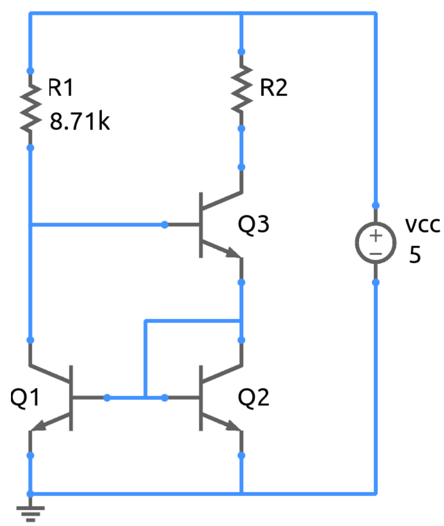

Figure 1: Circuit schematic for Wilson current mirror.

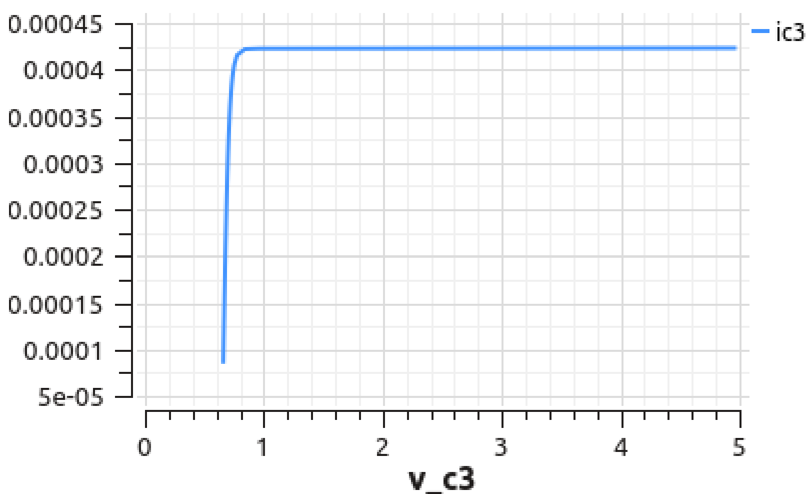

Figure 2: I_{C3} versus V_{C3} for the current mirror of Fig. 1.

Shown in Fig. 1 is a Wilson current mirror which has the desirable feature of a high output resistance. Assuming that the transistors are operating in the active region, the collector voltage of Q_1 is given by

$$V_{C1} = V_{BE2} + V_{BE3}\,. \tag{1}$$

The current I_{R1} is therefore

$$I_{R1} \approx \frac{V_{CC} - 2V_{BE}}{R_1}\,. \tag{2}$$

Ignoring base currents, this current get mirrored as I_{C3}. With small-signal analysis, the output resistance of the cascode current mirror can be obtained as $\beta\, r_{o3}/2$, where $r_{o3} = V_{A3}/I_{C3}$ is the output resistance of Q_3. Clearly, we can expect this current mirror to perform much better than the simple current mirror seen in `bjt_mirror_1.sqproj`.

The Wilson current mirror exhibits another desirable property, viz., a weak dependence of the load current (I_{C3} in the above circuit) on β, as seen from the following equation.

$$I_{C3} = I_{R1}\left[1 - \frac{2}{\beta^2 + 2\,\beta + 2}\right]. \tag{3}$$

Fig. 2 shows a plot of I_{C3} versus V_{C3} obtained by varying R_2.

Exercise Set

1. From the simulation results, calculate the value of the output resistance $(\partial I_{C3}/\partial V_{C3})^{-1}$. Compare it with the simple current mirror seen in `bjt_mirror_1.sqproj`.

2. As V_{C3} is reduced, the currents starts dropping at some point. At what value of V_{C3} do you expect this to happen? Explain.

3. Design a cascode current source for $I_{C3} = 1$ mA. Verify your design by simulation. Find the new output resistance $(\partial I_{C3}/\partial V_{C3})^{-1}$, 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.