bjt_widlar.sqproj

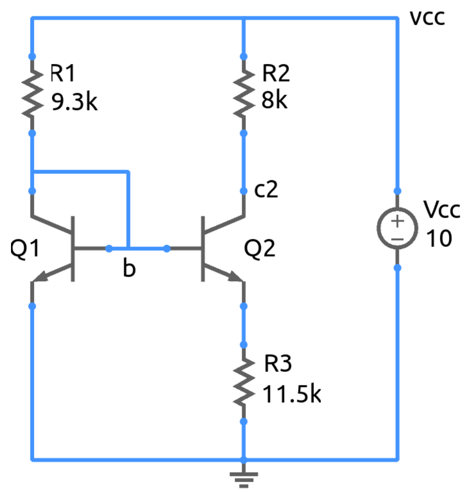

Figure 1: BJT Widlar current source.

Fig. 1 shows the circuit diagram of a Widlar current source. In a simple current mirror (see `bjt_mirror_1.pdf`), the mirrored current cannot be very different from the reference current[1], certainly not by orders of magnitude. In a Widlar current source, a current much smaller than the reference current can be obtained.

Assuming the BJTs to be operating in the active region, we get

$$I_{R1} \approx I_{C1} = \frac{V_{CC} - 0.7}{R_1}\,. \tag{1}$$

Since $I_C \approx I_s e^{V_{BE}/V_T}$ in the active mode, we have $V_{BE} = V_T\,\ln(I_C/I_s)$ for each of the transistors. Using these equations, we can write KVL for the loop involving the two B-E junctions as

$$V_{BE1} = V_{BE2} + I_{C2}\,R_3 \rightarrow V_T\,\ln(I_{C1}/I_{s1}) = V_T\,\ln(I_{C2}/I_{s2}) + I_{C2}\,R_3\,. \tag{2}$$

If the two transistors are identical, we have

$$V_T\,\ln(I_{C1}/I_{C2}) = I_{C2}\,R_3\,. \tag{3}$$

By selecting an appropriate value of R_3, the desired I_{C2} can be obtained.

[1] The two currents are related by the ratio of the areas of the two transistors.

Exercise Set

1. For the component values given in the figure, compute I_{C1} and I_{C2}. Verify with simulation. (Note that computing I_{C2} will involve solving the above nonlinear equation (Eq. 3) in an iterative manner.)

2. Calculate R_3 required for $I_{C2} = 50\,\mu$A. Verify with simulation.

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.

3.