BJT Widlar current source (mirror) `(EC_bjt_widlar_1.sqproj)`

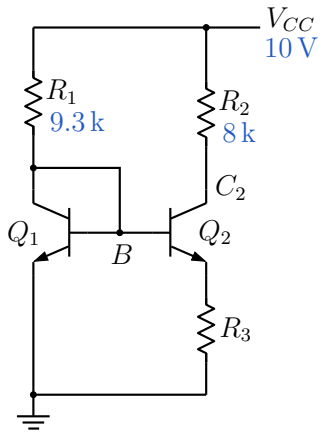

Figure 1: Widlar current source using bipolar transistors.

Question: Consider the Widlar current source shown in Fig. 1.

(a) Find R_3 in order to obtain $I_{C2} = 10\,\mu$A.

(b) For the above value of R_3, what is V_{C2}?

Solution:

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

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

Solving this equation for R_3 (with $V_T = 0.02585\,$V), we obtain $R_3 = 11.9\,$k. The collector voltage of Q_2 is

$$V_{C2} = V_{CC} - I_{C2}R_2 = 10 - 10\,\mu\text{A} \times 8\,\text{k}\Omega = 9.92\,\text{V}. \tag{4}$$

SequelApp Exercises: For the Widlar current source of Fig. 1,

(a) Find R_3 in order to obtain I_{C2} equal to (i) $20\,\mu$A, (ii) $30\,\mu$A.

(b) Find I_{C2} for R_3 equal to (i) $7.5\,$k, (ii) $15\,$k.

Verify your answers using SequelApp.