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EE3110 Analogue Electronic Circuits

Tutorial – Monolithic Circuit

Name: _____ Student Number: _____ Date: _____

Q1. Consider the two-transistor current source shown in figure 1. The circuit parameters are $V^+ = 10\text{ V}$, $V^- = -10\text{ V}$, and $R_1 = 15\text{ k}\Omega$. The transistor parameters are $\beta = 75$, $V_{BE(on)} = 0.7\text{ V}$, and $V_A = \infty$. Determine I_{REF} , I_O , and R_O .

Hint:
$$I_{REF} = \frac{V^+ - V^- - V_{BE}}{R_1}$$

$$I_{C2} = I_O = \frac{I_{REF}}{1 + \frac{2}{\beta}} \quad R_O \approx r_o = \frac{V_A}{I_O}$$

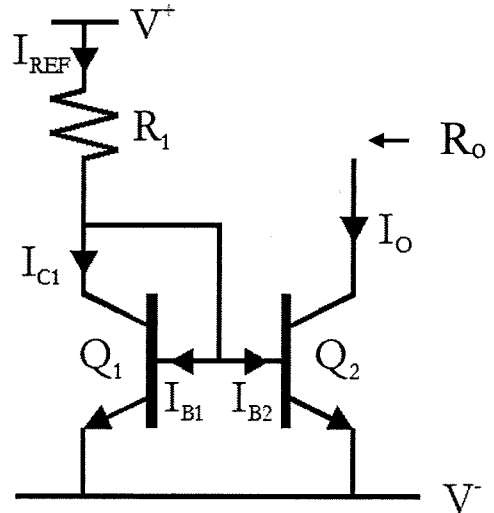


Figure 1

$$I_{REF} = \frac{10 - (-10) - 0.7}{15\text{ k}}$$

$$= 1.2867\text{ mA}$$

$$I_O = \frac{I_{REF}}{\left(1 + \frac{2}{\beta}\right)} = \frac{1.2867}{1.02667} = 1.253\text{ mA}$$

$$R_O \rightarrow \frac{V_A}{I_O} \rightarrow \infty$$

Q2. Consider the Widlar current source in Figure 2. The bias voltages are $V^+ = 3\text{ V}$ and $V^- = -3\text{ V}$. Design the circuit such that $I_O = 20\mu\text{A}$ and $I_{REF} = 100\mu\text{A}$. Assume $V_{BE1} = 0.6\text{ V}$ and $V_A = \infty$, and neglect base currents. Determine R_1 and R_E .

Hint: $I_O R_E = V_T \ln\left(\frac{I_{REF}}{I_O}\right)$, $V_T = 25\text{ mV}$

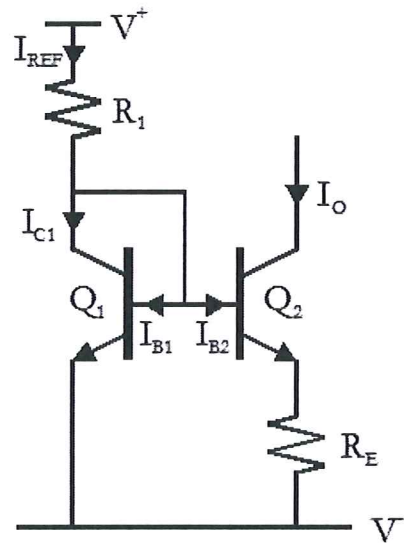


Figure 2

solⁿ

$$I_{REF} = \frac{V^+ - V^- - V_{BE1}}{R_1}$$

$$R_1 = \frac{V^+ - V^- - V_{BE1}}{I_{REF}}$$

$$= \frac{3 + 3 - 0.6}{100\mu\text{A}} = 5.4 \times 10^4 \Omega = 5.4\text{ k}\Omega$$

Again, $R_1 = 5.4\text{ k}\Omega$

$$I_O R_E = V_T \ln\left(\frac{I_{REF}}{I_O}\right)$$

$$\Rightarrow 20 \times 10^{-6} R_E = 25 \times 10^{-3} \ln\left(\frac{100 \times 10^{-6}}{20 \times 10^{-6}}\right)$$

$$\Rightarrow R_E = \frac{25 \times 10^{-3}}{20 \times 10^{-6}} \ln 5$$

$$= 2011.8 \Omega$$

$$R_E \approx 2\text{ k}\Omega$$