

Mark:

EE3110 Analogue Electronic Circuits

Monolithic Circuit 2

Name: _____ Student Number: _____ Date: _____

Q1. Consider the diff-amp in Figure 1, with circuit parameters: $V^+ = 10\text{ V}$, $V^- = -10\text{ V}$, $I_Q = 1\text{ mA}$, and $R_C = 10\text{ k}\Omega$. The transistor parameters are: $\beta = \infty$ (neglect base currents), $V_A = \infty$, and $V_{BE(\text{on})} = 0.7\text{ V}$. Determine i_{C1} and v_{CE1} for common-mode voltages $v_{B1} = v_{B2} = v_{CM} = 0, -5\text{ V}$, and $+5\text{ V}$ respectively.

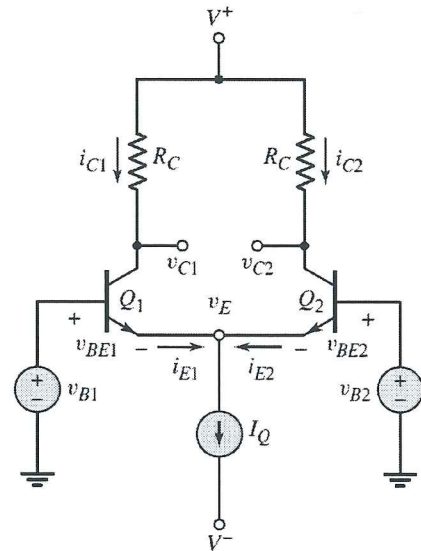


Figure 1

$$i_{C1} = i_{C2} = \frac{I_Q}{2} = 0.5\text{ mA}$$

$$v_{C1} = V^+ - i_{C1} R_C$$

$$= 10 - (0.5)(10) = 5\text{ V}$$

$$v_{C2} = v_{C1} = 5\text{ V}$$

$$\text{For } v_{CM} = 0, \quad v_E = v_{B1} - V_{BE1} = -0.7\text{ V}$$

$$\therefore v_{CE1} = v_{C1} - v_E = 5 - (-0.7) = 5.7\text{ V}$$

$$\text{For } v_{CM} = -5, \quad v_E = -5 - 0.7 = -5.7\text{ V}$$

$$\therefore v_{CE1} = v_{C1} - v_E = 5 - (-5.7) = 10.7\text{ V}$$

↑
not possible

this implies Q_1 is saturate $\therefore v_{CE1} < V^+$

$$\text{For } v_{CM} = 5\text{ V}, \quad v_E = 5 - 0.7 = 4.3\text{ V}$$

$$v_{CE1} = 5 - 4.3\text{ V} = 0.7\text{ V}$$

- Q2. Design a voltage level shifter based on the circuit in figure 2 for shifting any input voltage V_I by $-5V$ at V_O . Determine R_1 and R_2 if the I_{CQ} of Q_2 is $200\mu A$ and $\beta = 150$, $V_{BE2} = 0.6V$, $V^+ = 10V$ and $V^- = -10V$. You may assume the transistor properties of Q_1 and Q_2 are identical.

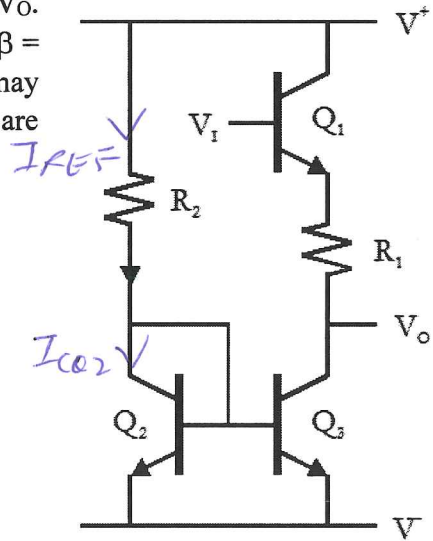


Figure 2

$$I_{CQ2} = 200\mu A$$

$$I_{REF} = I_{CQ2} \left(1 + \frac{2}{\beta}\right)$$

$$\therefore R_2 = \frac{V^+ - V^- - V_{BE2}}{I_{REF}}$$

$$= \frac{V^+ - V^- - V_{BE2}}{I_{CQ2} \left(1 + \frac{2}{\beta}\right)} = 95.72 K\Omega$$

$$V_O = V_I - V_{BE1} - I_{CQ2} R_1$$

$$\Rightarrow R_1 = \frac{(V_I - V_O) - V_{BE1}}{I_{CQ2}} = \frac{5 - 0.6}{200\mu A} = 22 K\Omega$$