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LINEAR INTEGRATED CIRCUITS

PART-03

DC Analysis of BJT Differential Amplifier Circuit

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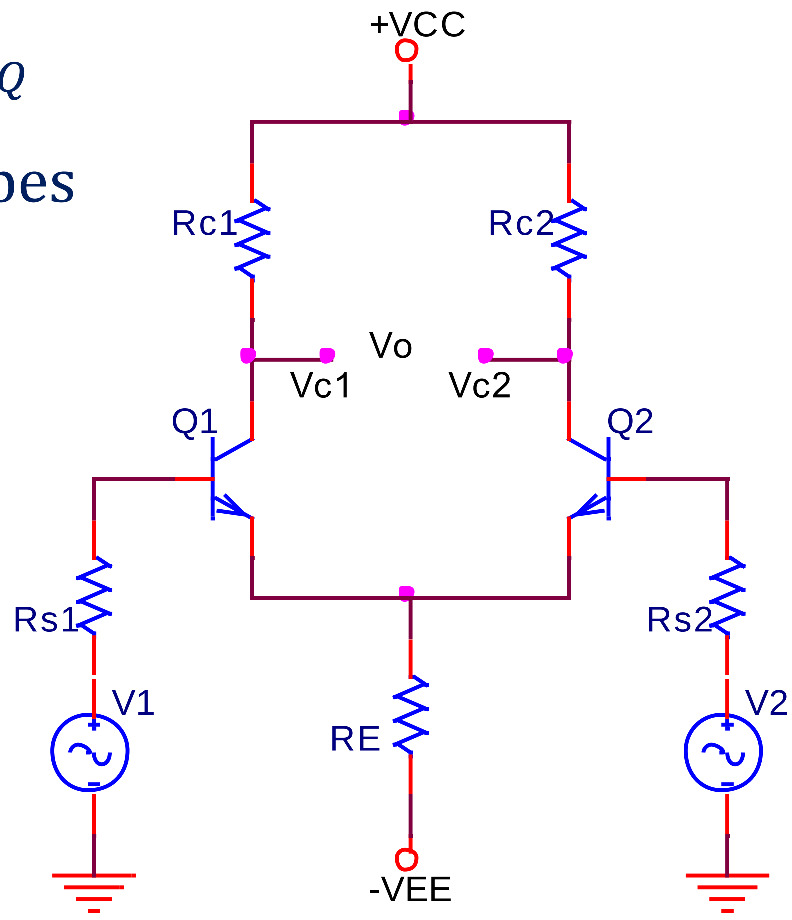
DC Analysis

It involves determination of operating-point current I_{CQ} and voltage V_{CEQ}. This analysis remains same for all types of BJT Differential Amplifiers, whether it is a

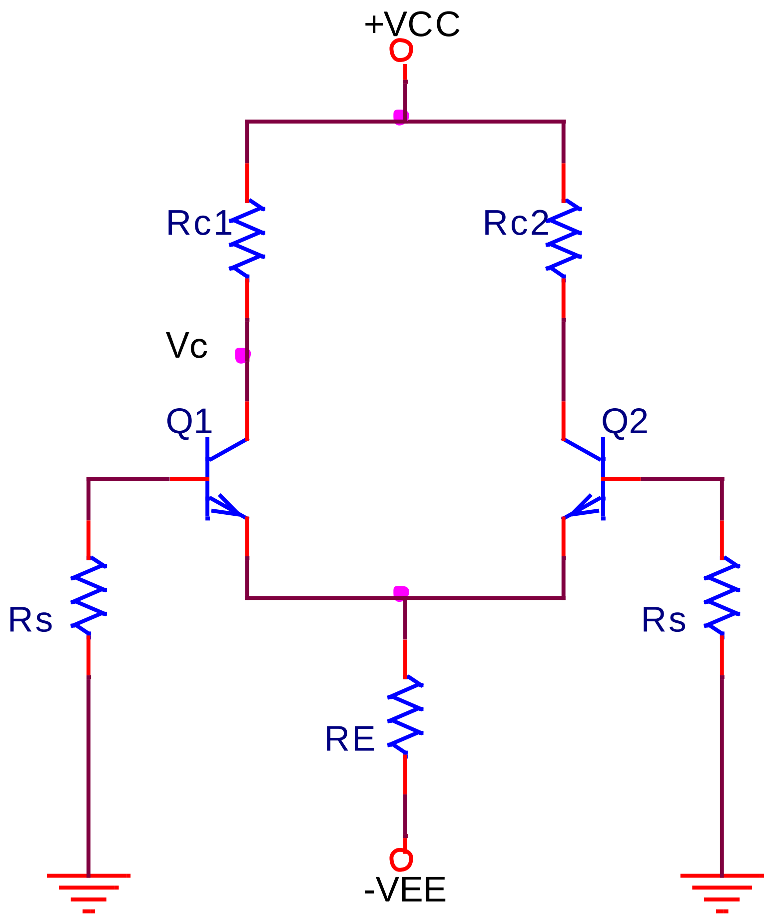
1. Dual Input Balanced Output
2. Dual Input Unbalanced Output
3. Single-Input Balanced Output
4. Single-Input Unbalanced Output



DC Analysis of Differential Amplifier

Important consideration for DC Analysis

1. Identical BJTs Q_1 & Q_2 are connected in symmetry
2. Hence, they will have same I_{CQ} and V_{CEQ}
3. Amplifier has two DC supplies; $+V_{CC}$ and $-V_{EE}$
4. Reduce input AC signals to zero; $V_1 = V_2 = 0.$
5. Source resistances are same; $R_{s1} = R_{s2} = R_s$



Determination of I_C

To determine I_C apply let's use KVL

$$R_s I_B + V_{BE} + 2I_E R_E = V_{EE} \quad (1)$$

We know that $I_B = (I_C \cong I_E)/\beta$. Let's put I_B in (1)

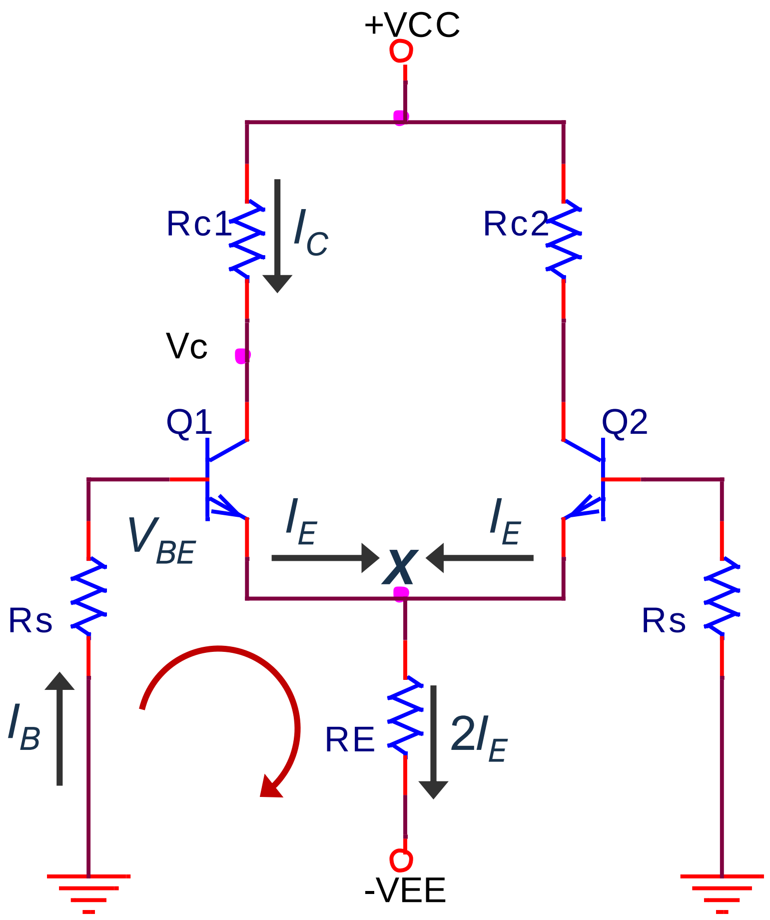
$$R_s\, I_E/\beta + V_{BE} + 2I_E R_E = V_{EE}$$

$$(R_s/\beta + 2R_E)I_E = V_{EE} - V_{BE}$$

$$I_E = \frac{V_{EE} - V_{BE}}{(R_s/\beta + 2R_E)} \cong I_C$$

Further $R_s/\beta \ll 2R_E$

$$I_C = I_E = \frac{V_{EE} - V_{BE}}{2R_E}$$



Determination of V_{CEQ}

V_{CE} is given as

$$V_{CE} = V_C - V_E \qquad (2)$$

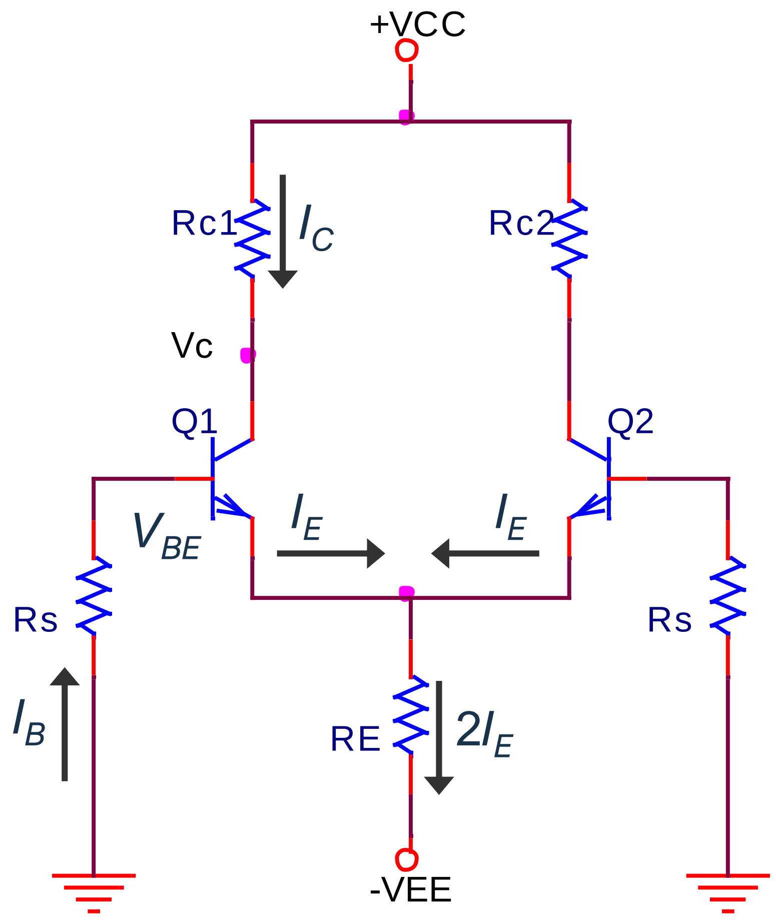
If we assume $R_{C1} = R_{C2} = R_C$, using KVL collector terminal voltage

$$V_C = V_{CC} - I_C R_C$$

Further, $V_{BE} = V_B - V_E$ but $V_B = -I_B R_s \cong 0$ that leads to $V_E \cong -V_{BE}$. Substitute V_C and V_E in (2)

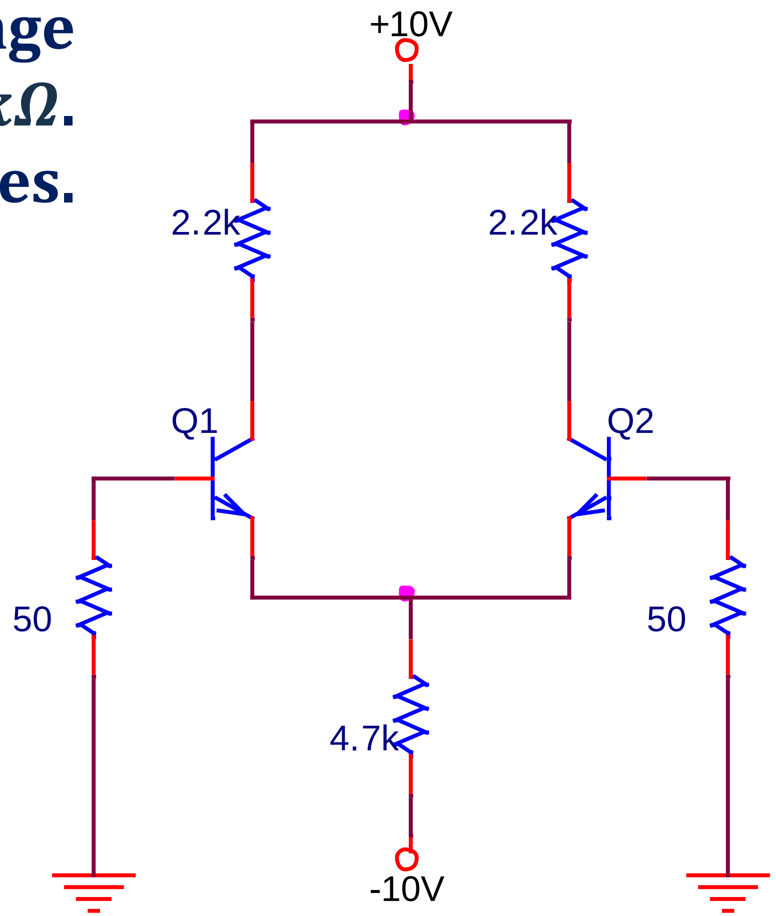
$$V_{CE} = (V_{CC} - I_C R_C) - (-V_{BE})$$

$$V_{CE} = V_{CC} + V_{BE} - I_C R_C$$



Numerical Problem

Determine operating points current and voltage when $R_{s1} = R_{S2} = 50\Omega$, $R_E = 4.7k\Omega$ and $R_C = 2.2k\Omega$. Transistors are biased using ±10V voltage supplies. Assume DC current gain $\beta = 100$.



Operating point Collector current I_C is given by

$$I_C = \frac{V_{EE} - V_{BE}}{(R_s/\beta + 2R_E)}$$

$$I_C = \frac{10 - 0.7}{(50/100 + 2 * 4.7\text{k})} = \frac{9.3}{0.5 + 9400}$$

$$I_C = 0.989\text{mA}$$

Numerical Problem

Whereas operating point voltage V_{CEQ} is given as

$$V_{CEQ} = V_{CC} + V_{BE} - I_C R_C$$

$$V_{CEQ} = 10 + 0.7 - 0.989\text{m} * 2.2\text{k}$$

$$V_{CEQ} = 10 + 0.7 - 2.18$$

$$V_{CEQ} = 8.52\text{V}$$