Name:	**Dr JBO**
Student ID Number:	**Model Answer**
Section:	01 A/B
Lecturer:	Dr. Jamaludin Bin Omar

EEEB273 - Quiz 4 .
SEMESTER 2, ACADEMIC YEAR 2017/2018
Date: 6 December 2017 Time: 15 minutes

Question:

Figure 1 shows a differential amplifier with **PNP three-transistor** current mirror connected as an active load. The circuit are connected to $V^+ = 3$ **V,** $V^- = -3$ **V**, and $I_Q = 0.6$ **mA.** The transistors parameters are $\beta = 120$, $V_{A1} = V_{A2} = 110$ **V**, $V_{A3} = V_{A4} = 90$ **V**, and $V_{A5} = \infty$.

(a) **Determine** the open-circuit differential-mode voltage gain (A_d). **[5 marks]**

(b) **What** is the output resistance (R_O) of the differential amplifier? **[2 marks]**

(c) **Find** the value of load resistance R_L that reduces the differential-mode gain to **80 percent** of the open-circuit value. **[3 marks]**

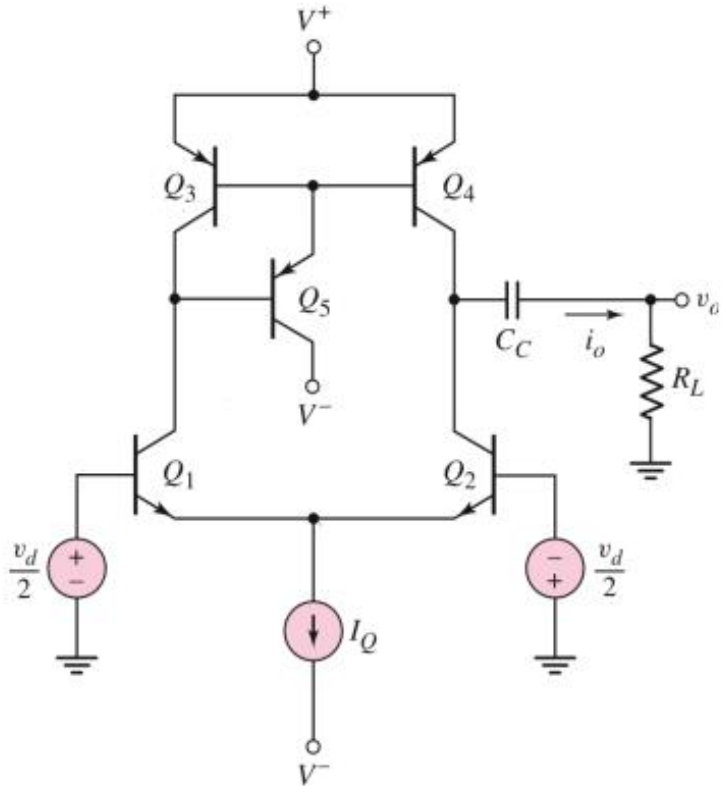

Figure 1

$$i_C = I_S e^{v_{BE}/V_T}\text{; npn}$$

$$i_C = I_S e^{v_{EB}/V_T}\text{; pnp}$$

$$i_C = \alpha i_E = \beta i_B$$

$$i_E = i_B + i_C$$

$$\alpha = \frac{\beta}{\beta + 1}$$

;Small signal

$$\beta = g_m r_\pi$$

$$g_m = \frac{I_{CQ}}{V_T}$$

$$r_\pi = \frac{\beta V_T}{I_{CQ}}$$

$$r_o = \frac{V_A}{I_{CQ}}$$

$$V_T = 26mV$$

Answer:

(*a*)

$A_d = g_{m2}\left(r_{o2} \parallel r_{o4}\right)$ [1]

$g_{m2} = \dfrac{I_{CQ}}{V_T} = \dfrac{0.6m/2}{26m} = 11.538 \text{ mA/V}$ [1]

$r_{o2} = \dfrac{V_{A2}}{I_{CQ}} = \dfrac{110}{0.6m/2} = 366.67 \text{ kq}$ [1]

$r_{o4} = \dfrac{V_{A4}}{I_{CQ}} = \dfrac{90}{0.6m/2} = 300 \text{ kq}$ [1]

$A_d = (11.538m)\left(366.67k \parallel 300k\right) = 1903.78$ [1]

(*b*)

$R_O = r_{o2} \parallel r_{o4} = 366.67k \parallel 300k = 165 \text{ kq}$ [2]

(*c*)

$A_d = g_{m2}\left(r_{o2} \parallel r_{o4} \parallel R_L\right)$ [1]

$A_d = (0.8)(1903.78) = 1523 = (11.538m)\left(366.67k \parallel 300k \parallel R_L\right)$ [1]

$R_L = 659.965 \text{ kq}$ [1]

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(a) **Determine** the open-circuit differential-mode voltage gain (A_d). **[5 marks]**

(b) **What** is the output resistance (R_O) of the differential amplifier? **[2 marks]**

(c) **Find** the value of load resistance R_L that reduces the differential-mode gain to **85 percent** of the open-circuit value. **[3 marks]**

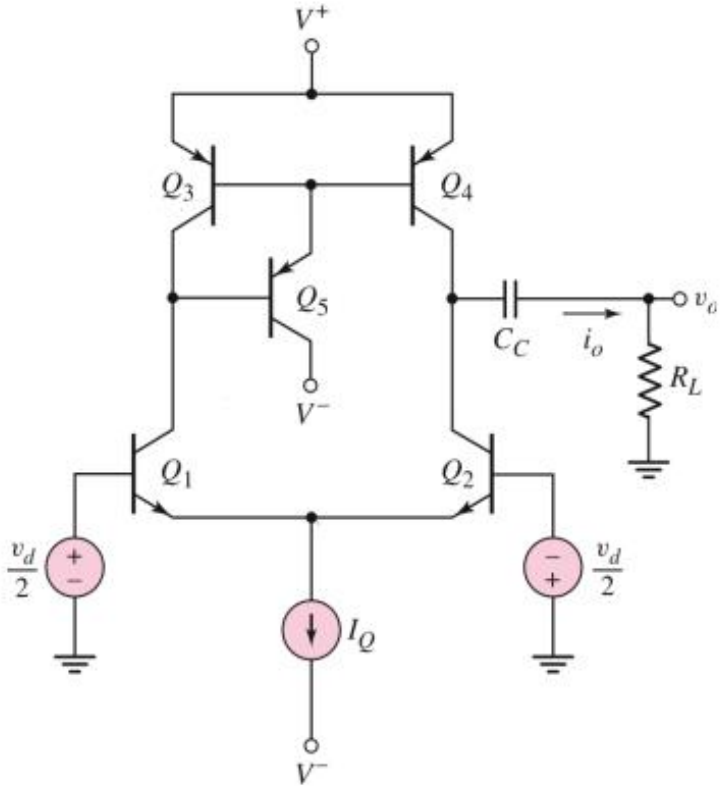

Figure 1

Answer:

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$$V_T = 26mV$$

(a)

$A_d = g_{m2}\left(r_{o2} \parallel r_{o4}\right)$ [1]

$g_{m2} = \dfrac{I_{CQ}}{V_T} = \dfrac{0.6m/2}{26m} = 11.538\,\text{mA/V}$ [1]

$r_{o2} = \dfrac{V_{A2}}{I_{CQ}} = \dfrac{120}{0.6m/2} = 400\,\text{kq}$ [1]

$r_{o4} = \dfrac{V_{A4}}{I_{CQ}} = \dfrac{80}{0.6m/2} = 266.67\,\text{kq}$ [1]

$A_d = (11.538m)\left(400k \parallel 266.67k\right) = 1846$ [1]

(b)

$R_O = r_{o2} \parallel r_{o4} = 400k \parallel 266.67k = 160\,\text{kq}$ [2]

(c)

$A_d = g_{m2}\left(r_{o2} \parallel r_{o4} \parallel R_L\right)$ [1]

$A_d = (0.85)(1846) = 1569.18 = (11.538m)\left(400k \parallel 266.67k \parallel R_L\right)$ [1]

$R_L = 906.712\,\text{kq}$ [1]

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Figure 1 shows a differential amplifier with **PNP three-transistor** current mirror connected as an active load. The circuit are connected to $V^+ = 3$ **V,** $V^- = -3$ **V**, and $I_Q = 0.6$ **mA.** The transistors parameters are $\beta = 120$, $V_{A1} = V_{A2} = 100$ **V**, $V_{A3} = V_{A4} = 110$ **V**, and $V_{A5} = \infty$.

(a) **Determine** the open-circuit differential-mode voltage gain (A_d). **[5 marks]**

(b) **What** is the output resistance (R_O) of the differential amplifier? **[2 marks]**

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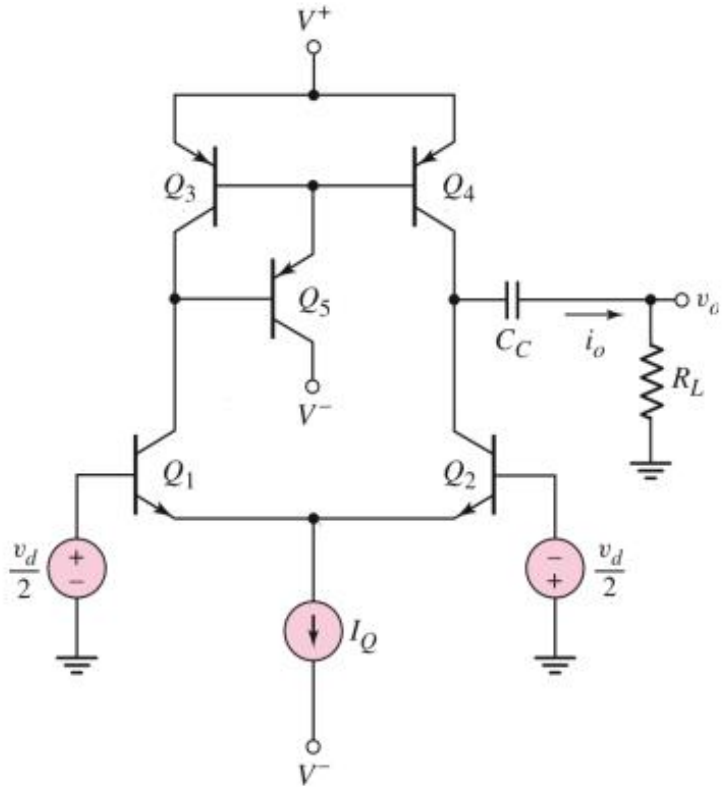

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Answer:

(a)

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$g_{m2} = \dfrac{I_{CQ}}{V_T} = \dfrac{0.6m/2}{26m} = 11.538\,\text{mA/V}$ [1]

$r_{o2} = \dfrac{V_{A2}}{I_{CQ}} = \dfrac{100}{0.6m/2} = 333.33\,\text{kq}$ [1]

$r_{o4} = \dfrac{V_{A4}}{I_{CQ}} = \dfrac{110}{0.6m/2} = 366.67\,\text{kq}$ [1]

$A_d = (11.538m)\left(333.33k \parallel 366.67k\right) = 2014.56$ [1]

(b)

$R_O = r_{o2} \parallel r_{o4} = 400k \parallel 266.67k = 174.6\,\text{kq}$ [2]

(c)

$A_d = g_{m2}\left(r_{o2} \parallel r_{o4} \parallel R_L\right)$ [1]

$A_d = (0.85)(2014.56) = 1712.38 = (11.538m)\left(333.33k \parallel 366.67k \parallel R_L\right)$ [1]

$R_L = 989.497\,\text{kq}$ [1]

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(a) **Determine** the open-circuit differential-mode voltage gain (A_d). **[5 marks]**

(b) **What** is the output resistance (R_O) of the differential amplifier? **[2 marks]**

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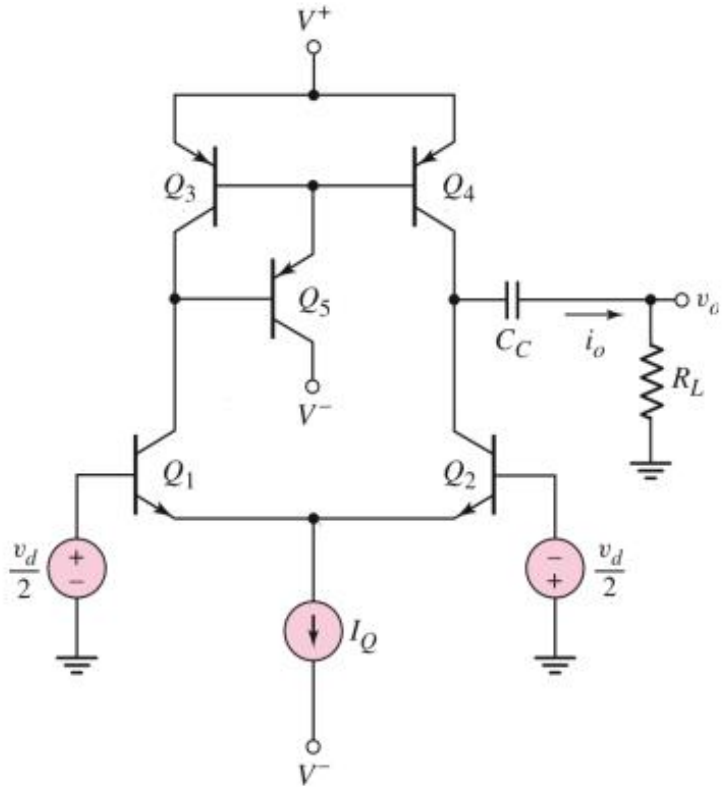

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$r_{o2} = \dfrac{V_{A2}}{I_{CQ}} = \dfrac{90}{0.6m/2} = 300\,\text{kq}$ [1]

$r_{o4} = \dfrac{V_{A4}}{I_{CQ}} = \dfrac{140}{0.6m/2} = 466.67\,\text{kq}$ [1]

$A_d = (11.538m)\left(300k \parallel 466.67k\right) = 2106.94$ [1]

(*b*)

$R_O = r_{o2} \parallel r_{o4} = 300k \parallel 466.67k = 182.6\,\text{kq}$ [2]

(*c*)

$A_d = g_{m2}\left(r_{o2} \parallel r_{o4} \parallel R_L\right)$ [1]

$A_d = (0.8)(2106.94) = 1685.55 = (11.538m)\left(300k \parallel 466.67k \parallel R_L\right)$ [1]

$R_L = 730.571\,\text{kq}$ [1]