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

EEEB273 - Quiz 4
SEMESTER 1, ACADEMIC YEAR 2017/2018
Date: 25 July 2017 Time: 15 minutes

Question:

Consider the differential amplifier with active load in **Figure 1**, biased with I_Q **= 0.24 mA**. Assume an Early voltage of V_A **= 120 V** for all transistors. Determine: [10 marks]

(a) The **open-circuit ($R_L = \infty$)** differential-mode voltage gain.
(b) The differential-mode voltage gain when R_L **= 120 kΩ**.

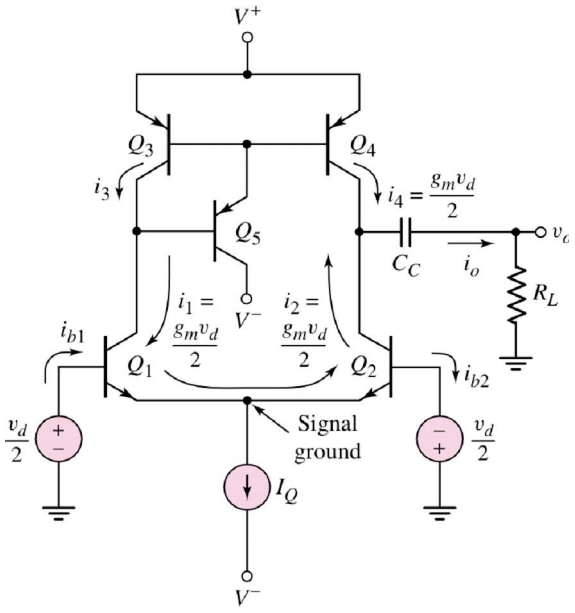

Figure 1

$$i_C = I_S e^{v_{BE}/V_T}\ ;\text{npn}$$
$$i_C = I_S e^{v_{EB}/V_T}\ ;\text{pnp}$$
$$i_C = \alpha i_E = \beta i_B$$
$$i_E = i_B + i_C$$
$$\alpha = \frac{\beta}{\beta+1}$$

Answer:

$I_Q = 0.24mA; I_{C2} = I_{C4} = I_Q/2 = 0.12mA$ [1]

$(i) Open-loop$

$A_d = g_{m2}(r_{o2} \| r_{o4})$ [2]

$g_{m2} = I_{C2}/V_T = 0.12m/26m = 4.615mA/V$ [1]

$r_{o2} = V_A/I_{C2} = 120/0.12m = 1M\Omega$ [1]

$r_{o4} = V_A/I_{C4} = 120/0.12m = 1M\Omega$ [1]

$A_d = (4.615m)(1M \| 1M) = 2307.5$ [1]

$(ii) R_L = 120k\Omega$

$A_d = g_{m2}(r_{o2} \| r_{o4} \| R_L)$ [2]

$A_d = (4.615m)(1M \| 1M \| 120k) = 446.6$ [1]

;Small signal

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

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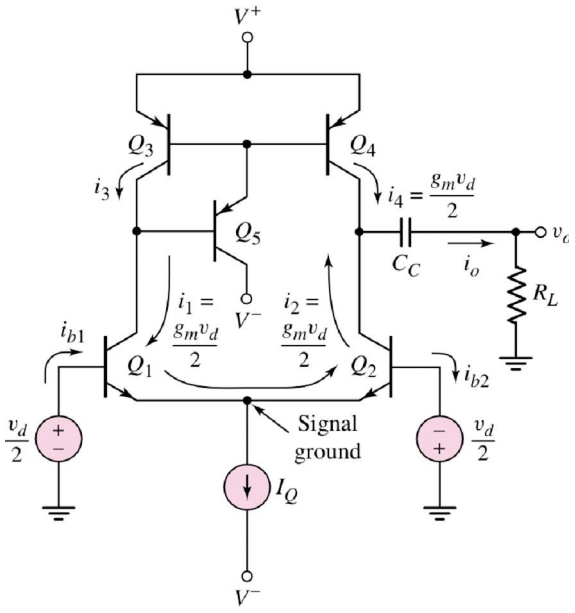
Question:

Consider the differential amplifier with active load in **Figure 1**, biased with I_Q **= 0.24 mA**. Assume an Early voltage of V_A **= 100 V** for all transistors. Determine: [10 marks]

(a) The **open-circuit ($R_L = \infty$)** differential-mode voltage gain.
(b) The differential-mode voltage gain when R_L **= 120 kΩ**.



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$r_{o2} = V_A/I_{C2} = 100/0.12m = 833.3k\Omega$ [1]

$r_{o4} = V_A/I_{C4} = 100/0.12m = 833.3k\Omega$ [1]

$A_d = (4.615m)(833.3k \| 833.3k) = 1923$ [1]

$(ii) R_L = 120k\Omega$

$A_d = g_{m2}(r_{o2} \| r_{o4} \| R_L)$ [2]

$A_d = (4.615m)(833.3k \| 833.3k \| 120k) = 430$ [1]

;Small signal

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

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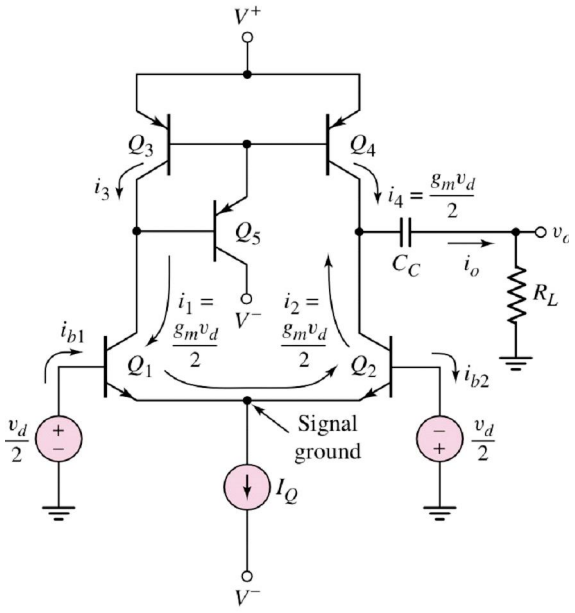

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$(ii) R_L = 100k\Omega$

$A_d = g_{m2}(r_{o2} \| r_{o4} \| R_L)$ [2]

$A_d = (4.615m)(1M \| 1M \| 120k) = 384.6$ [1]

;Small signal

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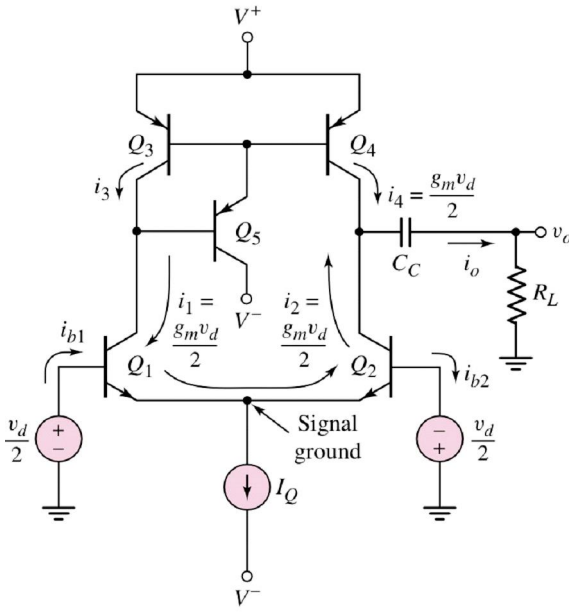

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$(ii) R_L = 100k\Omega$

$A_d = g_{m2}(r_{o2} \| r_{o4} \| R_L)$ [2]

$A_d = (4.615m)(833.3k \| 833.3k \| 100k) = 372$ [1]

;Small signal

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