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

EEEB273 - Quiz 3 ☺☺
SEMESTER 1, ACADEMIC YEAR 2015/2016
Date: 13 July 2015 Time: 15 minutes

Question:

Consider the BJT differential amplifier in **Figure 1**. Transistors are matched. The circuit and transistor parameters are $I_Q = 1$ **mA**, $\beta = 100$, and $V_A = \infty$.

(a) Design the circuit such that one-sided differential-mode output voltage taken at $v_{C2} = 8$ **V** when a differential-mode input voltage of $v_d = 0.05$ **V** is applied. [7 marks]

(b) Determine the differential-mode input resistance, R_{id}. [3 marks]

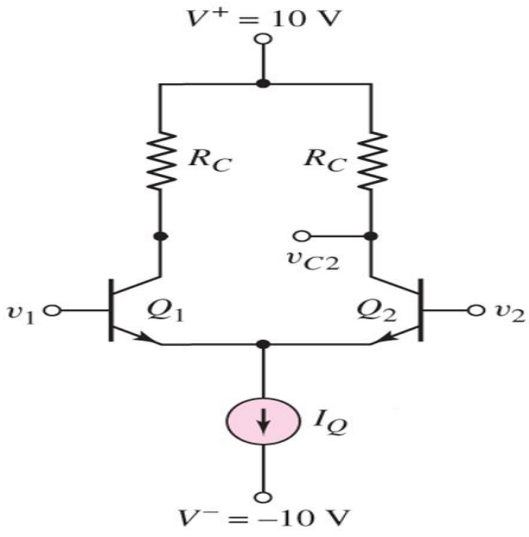

Figure 1

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

;Small signal

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

$$V_T = 26\text{ mV}$$

Answer:

(a) The differential-mode voltage gain is given by

$$A_d = \frac{v_o}{v_d} = \frac{g_{m2}R_C}{2} \quad [2]$$

$$g_{m2} = \frac{I_{CQ2}}{V_T} = \frac{0.5mA}{26mV} = 19.231mA/V \quad [2]$$

$$A_d = \frac{v_o}{v_d} = \frac{8}{0.05} = \frac{g_{m2}R_C}{2} = \frac{(19.231m)R_C}{2} \quad [2]$$

$$\Rightarrow R_C = \frac{320}{19.231m} = 16.64k\Omega \quad [1]$$

(b) $R_{id} = 2r_\pi = \dfrac{2\beta V_T}{I_{CQ}} = \dfrac{2\times 100\times 0.026}{0.5mA} = 10.4k\Omega$ [1,1,1]

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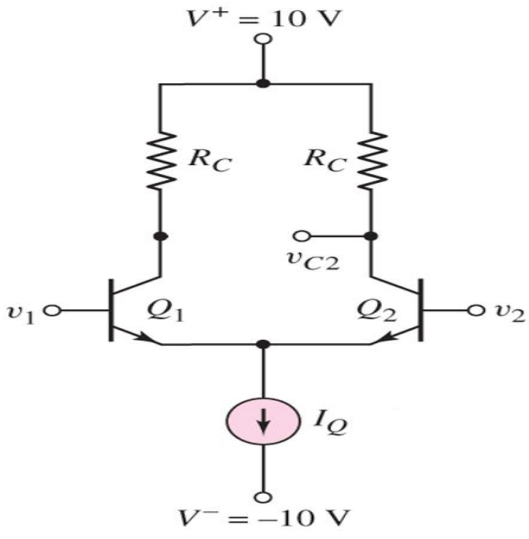
Date: 13 July 2015 Time: 15 minutes

Question:

Consider the BJT differential amplifier in **Figure 1**. Transistors are matched. The circuit and transistor parameters are $I_Q = 1.1$ **mA**, $\beta = 100$, and $V_A = \infty$.

(a) Design the circuit such that one-sided differential-mode output voltage taken at $v_{C2} = 7.9$ **V** when a differential-mode input voltage of $v_d = 0.05$ **V** is applied. [7 marks]

(b) Determine the differential-mode input resistance, R_{id}. [3 marks]



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;Small signal

$$\beta = g_m r_\pi$$
$$g_m = \frac{I_{CQ}}{V_T}$$
$$r_\pi = \frac{\beta V_T}{I_{CQ}}$$
$$r_o = \frac{V_A}{I_{CQ}}$$
$$V_T = 26\ \text{mV}$$

Answer:

(a) The differential-mode voltage gain is given by

$$A_d = \frac{v_o}{v_d} = \frac{g_{m2}R_C}{2} \quad [2]$$

$$g_{m2} = \frac{I_{CQ2}}{V_T} = \frac{0.55mA}{26mV} = 21.153mA/V \quad [2]$$

$$A_d = \frac{v_o}{v_d} = \frac{7.9}{0.05} = \frac{g_{m2}R_C}{2} = \frac{(21.153m)R_C}{2} \quad [2]$$

$$\Rightarrow R_C = \frac{316}{21.153m} = 14.938k\Omega \quad [1]$$

(b) $R_{id} = 2r_\pi = \dfrac{2\beta V_T}{I_{CQ}} = \dfrac{2\times 100\times 0.026}{0.55mA} = 9.45k\Omega$ [1,1,1]

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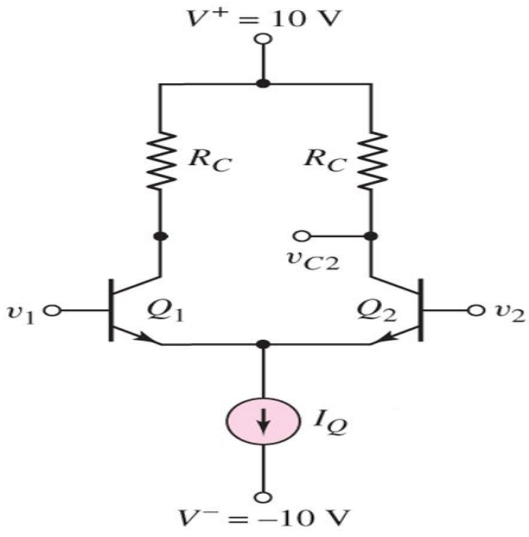
Date: 13 July 2015 Time: 15 minutes

Question:

Consider the BJT differential amplifier in **Figure 1**. Transistors are matched. The circuit and transistor parameters are $I_Q = 0.9$ **mA**, $\beta = 100$, and $V_A = \infty$.

(a) Design the circuit such that one-sided differential-mode output voltage taken at $v_{C2} = 8.1$ **V** when a differential-mode input voltage of $v_d = 0.05$ **V** is applied. [7 marks]

(b) Determine the differential-mode input resistance, R_{id}. [3 marks]



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;Small signal

$$\beta = g_m r_\pi$$
$$g_m = \frac{I_{CQ}}{V_T}$$
$$r_\pi = \frac{\beta V_T}{I_{CQ}}$$
$$r_o = \frac{V_A}{I_{CQ}}$$
$$V_T = 26\ \text{mV}$$

Answer:

(a) The differential-mode voltage gain is given by

$$A_d = \frac{v_o}{v_d} = \frac{g_{m2}R_C}{2} \quad [2]$$

$$g_{m2} = \frac{I_{CQ2}}{V_T} = \frac{0.45mA}{26mV} = 17.307mA/V \quad [2]$$

$$A_d = \frac{v_o}{v_d} = \frac{8.1}{0.05} = \frac{g_{m2}R_C}{2} = \frac{(17.307m)R_C}{2} \quad [2]$$

$$\Rightarrow R_C = \frac{324}{17.307m} = 18.72k\Omega \quad [1]$$

(b) $R_{id} = 2r_\pi = \dfrac{2\beta V_T}{I_{CQ}} = \dfrac{2\times 100\times 0.026}{0.45mA} = 11.55k\Omega$ [1,1,1]

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Date: 13 July 2015 Time: 15 minutes

Question:

Consider the BJT differential amplifier in **Figure 1**. Transistors are matched. The circuit and transistor parameters are $I_Q = 1.2$ **mA**, $\beta = 100$, and $V_A = \infty$.

(a) Design the circuit such that one-sided differential-mode output voltage taken at $v_{C2} = 7.8$ **V** when a differential-mode input voltage of $v_d = 0.05$ **V** is applied. [7 marks]

(b) Determine the differential-mode input resistance, R_{id}. [3 marks]

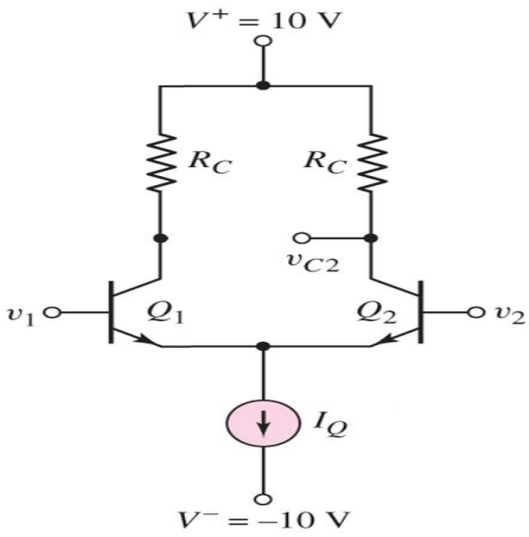

Figure 1

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$$i_C = \alpha i_E = \beta i_B$$
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$$\alpha = \frac{\beta}{\beta+1}$$

;Small signal

$$\beta = g_m r_\pi$$
$$g_m = \frac{I_{CQ}}{V_T}$$
$$r_\pi = \frac{\beta V_T}{I_{CQ}}$$
$$r_o = \frac{V_A}{I_{CQ}}$$
$$V_T = 26\ \text{mV}$$

Answer:

(a) The differential-mode voltage gain is given by

$$A_d = \frac{v_o}{v_d} = \frac{g_{m2}R_C}{2} \quad [2]$$

$$g_{m2} = \frac{I_{CQ2}}{V_T} = \frac{0.6mA}{26mV} = 23.076mA/V \quad [2]$$

$$A_d = \frac{v_o}{v_d} = \frac{7.8}{0.05} = \frac{g_{m2}R_C}{2} = \frac{(23.076m)R_C}{2} \quad [2]$$

$$\Rightarrow R_C = \frac{312}{23.076m} = 13.52k\Omega \quad [1]$$

(b) $R_{id} = 2r_\pi = \dfrac{2\beta V_T}{I_{CQ}} = \dfrac{2\times 100\times 0.026}{0.6mA} = 8.67k\Omega$ [1,1,1]