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| Name: | **Dr JBO** |
| Student ID Number: | **Model Answer** |
| Section: 02 A/B | |
| Lecturer: Dr. Jamaludin Bin Omar | |

EEEB273 - Quiz 3
SEMESTER 2, ACADEMIC YEAR 2016/2017
Date: 24 November 2016 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 input voltages of $v_1 = 0.20$ **V** and $v_2 = 0.15$ **V** are applied. [7 marks]

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

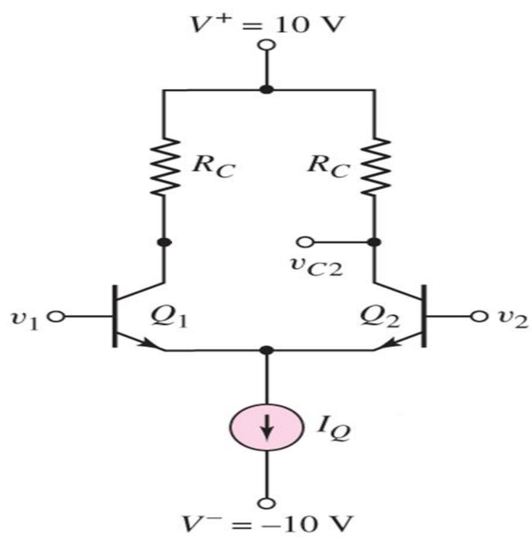


**Figure 1**

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

; 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

$$A_d = \frac{v_o}{v_d} = \frac{g_{m2} R_C}{2};\quad v_d = 0.20 - 0.15 = 0.05\text{ V}\quad [2]$$

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

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

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

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

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SEMESTER 2, ACADEMIC YEAR 2016/2017
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**Question:**

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

**(a) Design** the circuit such that one-sided differential-mode output voltage taken at $\boldsymbol{v_{C2} = 7.9}$ **V** when input voltages of $\boldsymbol{v_1 = -0.15}$ **V** and $\boldsymbol{v_2 = -0.20}$ **V** are applied. [7 marks]

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

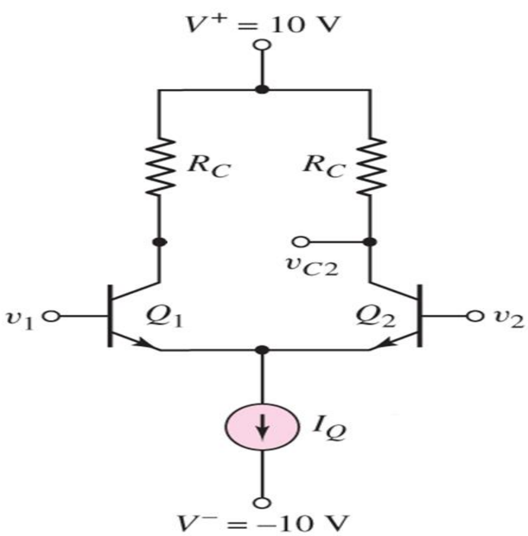


**Figure 1**

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

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

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

$$i_E = i_B + i_C$$

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

;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

$$A_d = \frac{v_o}{v_d} = \frac{g_{m2}R_C}{2};\quad v_d = -0.15 - (-0.20) = 0.05\text{ V} \quad [2]$$

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

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

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

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

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Date: 24 November 2016 Time: 15 minutes ;

**Question:**

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

**(a) Design** the circuit such that one-sided differential-mode output voltage taken at $\boldsymbol{v_{C2} = 8.1}$ **V** when input voltages of $\boldsymbol{v_1 = 0.35}$ **V** and $\boldsymbol{v_2 = 0.30}$ **V** are applied. [7 marks]

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

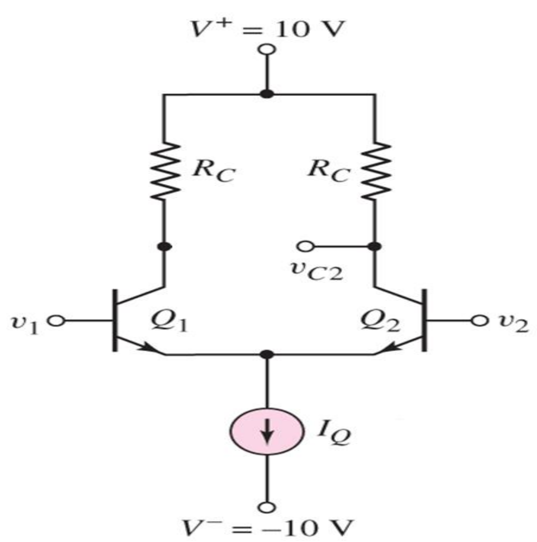


**Figure 1**

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

$$A_d = \frac{v_o}{v_d} = \frac{g_{m2}R_C}{2};\quad v_d = 0.35 - 0.30 = 0.05\text{ V} \quad [2]$$

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

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

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

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

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SEMESTER 2, ACADEMIC YEAR 2016/2017
Date: 24 November 2016 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 input voltages of $v_1 = -0.35$ **V** and $v_2 = -0.40$ **V** are applied. [7 marks]

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

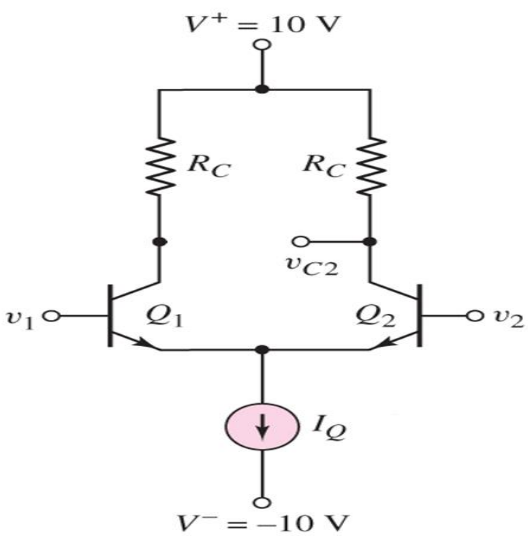


**Figure 1**

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

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

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

$$i_E = i_B + i_C$$

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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

$$A_d = \frac{v_o}{v_d} = \frac{g_{m2}R_C}{2};\quad v_d = -0.35 - (-0.40) = 0.05\text{ V} \quad [2]$$

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

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

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

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