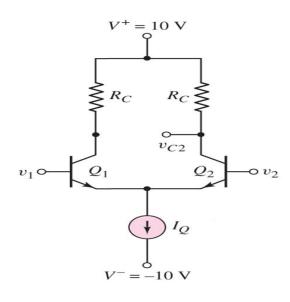
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EEEB273 - Quiz 3	Section:	01 4
SEMESTER 1, ACADEMIC YEAR 2016/2017	Lecturer:	Dr.
Date: 21 July 2016 Time: 15 minutes		

Name:		Dr JBO
Student ID Nu	umber:	Model Answer
Section:	01 A/B	5
Lecturer:	Dr. Ja	maludin Bin Omar

## **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  $V_A = \infty$ . Neglect base currents.

- (a) Design the circuit such that one-sided differential-mode output voltage  $v_0$  taken at  $v_{C2} = 8$  V when a differential-mode input voltage of  $v_d = 0.05$  V is applied. Assume  $v_{cm} = 0$  V. [7 marks]
- (b) Determine the differential-mode input resistance,  $R_{id}$ .



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

[3 marks]

;Small signal

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

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

$$V_T = 26 \,\mathrm{mV}$$

### Figure 1

#### Answer:

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

**(b)** 
$$R_{id} = 2r_{\pi} = \frac{2\beta V_T}{I_{CQ2}} = \frac{2 \times 100 \times 0.026}{0.5mA} = 10.4k\Omega$$
 [1,1,1]

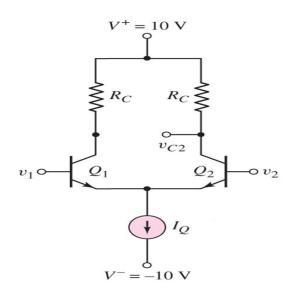
	Name:	DLIDC
	Student ID N	umber: Model
EEEB273 - Quiz 3	Section:	01 A/B
•	Lecturer:	Dr. Jamaludin
Date: 21 July 2016 Time: 15 minutes		

Name:		Dr JBO
Student ID Nu	mber:	Model Answer
Section:	01 A/E	3
Lecturer:	Dr. Ja	maludin Bin Omar

## **Question:**

Consider the BJT differential amplifier in Figure 1. Transistors are matched. The circuit and transistor parameters are  $I_Q = 1.2 \text{ mA}$ ,  $\beta = 110$ , and  $V_A = \infty$ . Neglect base currents.

- (c) Design the circuit such that one-sided differential-mode output voltage  $v_0$  taken at  $v_{C2} = 8$  V when a differential-mode input voltage of  $v_d = 0.05$  V is applied. Assume  $v_{cm} = 0$  V.
- (d) Determine the differential-mode input resistance,  $R_{id}$ .



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

[7 marks]

[3 marks]

;Small signal

 $\beta V_{\pi}$ 

 $\beta = g_m r_{\pi}$ 

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

Figure 1

Answer:

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

Prepared by: Dr Jamaludin Bin Omar

$$A_{d} = \frac{v_{o}}{v_{d}} = \frac{g_{m2}R_{C}}{2} \quad [2] \qquad \qquad r_{\pi} = \frac{P \cdot I}{I_{CQ}}$$

$$g_{m2} = \frac{I_{CQ2}}{V_{T}} = \frac{0.6mA}{26mV} = 23.076mA/V \quad [2] \qquad \qquad r_{o} = \frac{V_{A}}{I_{CQ}}$$

$$A_{d} = \frac{v_{o}}{v_{d}} = \frac{8}{0.05} = \frac{g_{m2}R_{C}}{2} = \frac{(23.076m)R_{C}}{2} \quad [2]$$

$$\Rightarrow R_{C} = \frac{320}{23.076m} = 13.867k\Omega \quad [1] \qquad \qquad V_{T} = 26 \text{ mV}$$

(d) 
$$R_{id} = 2r_{\pi} = \frac{2\beta V_T}{I_{CQ2}} = \frac{2 \times 110 \times 0.026}{0.6mA} = 9.53k\Omega$$
 [1,1,1]

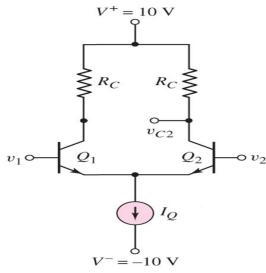
Page 2

	Name:		Dr JBO
	Student ID N	umber:	Model Answer
EEEB273 - Quiz 3	Section:	01 A/I	3
	Lecturer:	Dr. Ja	amaludin Bin Oma
Date: 21 July 2016 Time: 15 minutes			

#### **Question:**

Consider the BJT differential amplifier in Figure 1. Transistors are matched. The circuit and transistor parameters are  $I_Q = 1.2 \text{ mA}$ ,  $\beta = 110$ , and  $V_A = \infty$ . Neglect base currents.

- (e) Design the circuit such that one-sided differential-mode output voltage  $v_0$  taken at  $v_{c2} = 7$  V when a differential-mode input voltage of  $v_d = 0.05$  V is applied. Assume  $v_{cm} = 0$  V.
- (f) Determine the differential-mode input resistance,  $R_{id}$ .



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

;Small signal

 $\beta V_{\pi}$ 

 $\beta = g_m r_{\pi}$ 

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

#### Answer:

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

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Figure 1

$$A_{d} = \frac{v_{o}}{v_{d}} = \frac{g_{m2}R_{c}}{2} \quad [2] \qquad \qquad r_{\pi} = \frac{T}{I_{CQ}}$$

$$g_{m2} = \frac{I_{CQ2}}{V_{T}} = \frac{0.6mA}{26mV} = 23.076mA/V \quad [2] \qquad \qquad r_{o} = \frac{V_{A}}{I_{CQ}}$$

$$A_{d} = \frac{v_{o}}{v_{d}} = \frac{7}{0.05} = \frac{g_{m2}R_{c}}{2} = \frac{(23.076m)R_{c}}{2} \quad [2]$$

$$\Rightarrow R_{c} = \frac{280}{23.076m} = 12.134k\Omega \quad [1] \qquad \qquad V_{T} = 26 \text{ mV}$$

(f) 
$$R_{id} = 2r_{\pi} = \frac{2\beta V_T}{I_{CQ2}} = \frac{2 \times 110 \times 0.026}{0.6mA} = 9.53k\Omega$$
 [1,1,1]

Omar

[7 marks] [3 marks]

	Name:	]	Dr JBO
	Student ID N	Number:	Model An
EEEB273 - Quiz 3	Section:	01 A/B	
SEMESTER 1, ACADEMIC YEAR 2016/2017	Lecturer:	Dr. Jamaludin Bir	
Date: 21 July 2016 Time: 15 minutes			

# nswer in Omar

## **Question:**

Answer:

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

(g) Design the circuit such that one-sided differential-mode output voltage  $v_0$  taken at  $v_{c2} = 7$  V when a differential-mode input voltage of  $v_d = 0.05$  V is applied. Assume  $v_{cm} = 0$  V.

(h) Determine the differential-mode input resistance,  $R_{id}$ .

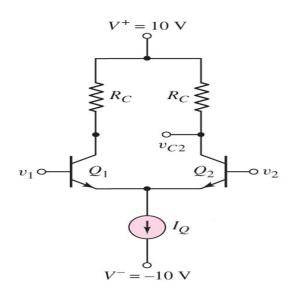


Figure 1

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

 $A_d = \frac{v_o}{v_d} = \frac{7}{0.05} = \frac{g_{m2}R_C}{2} = \frac{(19.231m)R_C}{2}$  [2]

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

 $\Rightarrow R_c = \frac{280}{19\,231m} = 14.56k\Omega$  [1]

 $A_{d} = \frac{v_{o}}{v_{d}} = \frac{g_{m2}R_{C}}{2} \quad [2]$ 

# $i_C = I_S e^{v_{BE}/V_T}$ ; npn $i_C = I_S e^{v_{EB}/V_T}$ ; pnp $i_{C} = \alpha i_{F} = \beta i_{R}$ $i_F = i_R + i_C$ $\alpha = \frac{\beta}{\beta+1}$

[7 marks] [3 marks]

;Small signal



# $r_{\pi} = \frac{\beta V_T}{I_{CO}}$

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

$$V_T = 26 \,\mathrm{mV}$$

**(h)** 
$$R_{id} = 2r_{\pi} = \frac{2\beta V_T}{I_{CQ2}} = \frac{2 \times 100 \times 0.026}{0.5mA} = 10.4k\Omega$$
 [1,1,1]