Student ID Number: Model answer

Section:

Lecturer: Dr. Jamaludin Bin Omar

EEEB273 - Quiz 1 00

SEMESTER 1, ACADEMIC YEAR 2015/2016

Date: 11 June 2015 Time: 15 minutes

#### **Question:**

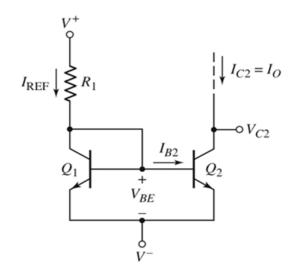
Refer to Figure 1. All transistors are matched.

The circuit parameters are:  $V^+ = 7.5 \text{ V}$  and  $V^- = -7.5 \text{ V}$ .

The transistor parameters are:  $V_{BE}$  (on) = 0.6 V,  $V_A$  = 150 V, and  $\beta$  = 50.

**DESIGN** a two-transistor BJT current source similar to the **Figure 1** using all the parameters given above so that its output resistance  $(R_0)$  is 200 k $\Omega$ . Show clearly all calculations as marks are given according to this.

[10 marks]



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

Figure 1

;Small signal

#### **Answer:**

$$R_{O} = r_{O2} = V_{A} / I_{O}$$
 [2]  

$$I_{O} = V_{A} / R_{O}$$
 [1]  

$$= (150) / (200k)$$
 [0.5]  

$$= 0.75 \text{ mA}$$
 [0.5]  

$$I_{REF} = I_{O} (1 + 2/\beta)$$
 [2]  

$$= (0.75m)(1 + 2/50)$$
 [0.5]  

$$= 0.78 \text{ mA}$$
 [0.5]  

$$R_{1} = (V^{+} - V_{BE} - V^{-}) / I_{REF}$$
 [2]  

$$= (7.5 - 0.6 - (-7.5)) / (0.78m)$$
 [0.5]  

$$= 18.4615 \text{ k}\Omega$$
 [0.5]

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

 $\beta = g_m r_{\pi}$ 

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

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

$$V_{T} = 26 \,\text{mV}$$

Student ID Number: Model answer

Section:

EEEB273 - Quiz 1 oi

SEMESTER 1, ACADEMIC YEAR 2015/2016

Date: 11 June 2015 Time: 15 minutes Lecturer: Dr. Jamaludin Bin Omar

#### **Question:**

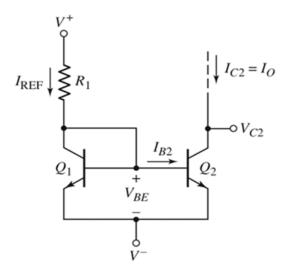
Refer to Figure 1. All transistors are matched.

The circuit parameters are:  $V^+ = 8 \text{ V}$  and  $V^- = -8 \text{ V}$ .

The transistor parameters are:  $V_{BE}$  (on) = 0.6 V,  $V_A$  = 160 V, and  $\beta$  = 50.

DESIGN a two-transistor BJT current source similar to the Figure 1 using all the parameters given above so that its output resistance  $(R_0)$  is 200 k $\Omega$ . Show clearly all calculations as marks are given according to this.

[10 marks]



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

Figure 1

;Small signal

## $\beta = g_m r_{\pi}$ **Answer:**

$R_{O}$	$= r_{02}$	$=V_A/I_O$	[2]
$I_{o}$		$=V_A/R_O$	[1]
		= (160) / (200k)	[0.5]
		= 0.80  mA	[0.5]
$I_{REF}$		$=I_{O}\left(1+2/\beta\right)$	[2]
		$= (0.80 \mathrm{m})(1 + 2/50)$	[0.5]
		= 0.832  mA	[0.5]
$R_1$		$= (V^+ - V_{BE} - V^-) / I_{REF}$	[2]
		= (8 - 0.6 - (-8)) / (0.832m)	[0.5]
		$=18.509 \text{ k}\Omega$	[0.5]

$$r_{\pi} = \frac{P \cdot T}{I_{CQ}}$$

$$g_{m} = \frac{I_{CQ}}{V_{T}}$$

$$r_{o} = \frac{V_{A}}{I_{CQ}}$$

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

Student ID Number: Model answer

Section:

Lecturer: Dr. Jamaludin Bin Omar

EEEB273 - Quiz 1 io

SEMESTER 1, ACADEMIC YEAR 2015/2016

Date: 11 June 2015 Time: 15 minutes

## **Question:**

Refer to Figure 1. All transistors are matched.

The circuit parameters are:  $V^+ = 7.5 \text{ V}$  and  $V^- = -7.5 \text{ V}$ .

The transistor parameters are:  $V_{BE}$  (on) = 0.6 V,  $V_A$  = 150 V, and  $\beta$  = 80.

DESIGN a two-transistor BJT current source similar to the Figure 1 using all the parameters given above so that its output resistance  $(R_0)$  is 200 k $\Omega$ . Show clearly all calculations as marks are given according to this.

[10 marks]

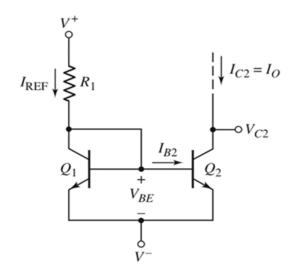


Figure 1

# $i_C = I_S e^{v_{BE}/V_T}$ ; 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

$$\beta = g_m r_{\pi}$$

$$r_{\pi} = \frac{\beta V_{T}}{I_{CQ}}$$

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

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

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

### **Answer:**

$R_{O}$	$= r_{02}$	$=V_A/I_O$	[2]
$I_0$		$=V_A/R_O$	[1]
		= (150) / (200k)	[0.5]
		= 0.75  mA	[0.5]
$I_{REF}$		$=I_O\left(1+2/\beta\right)$	[2]
		$= (0.75 \mathrm{m})(1 + 2/80)$	[0.5]
		= 0.76875  mA	[0.5]
$R_1$		$= (V^+ - V_{BE} - V^-) / I_{REF}$	[2]
		= (7.5 - 0.6 - (-7.5)) / (0.76875m)	[0.5]
		$= 18.7317 \text{ k}\Omega$	[0.5]

Student ID Number: Model answer

Section:

Lecturer: Dr. Jamaludin Bin Omar

EEEB273 - Quiz 1 ii

SEMESTER 1, ACADEMIC YEAR 2015/2016

Date: 11 June 2015 Time: 15 minutes

## **Question:**

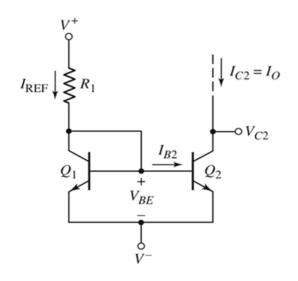
Refer to Figure 1. All transistors are matched.

The circuit parameters are:  $V^+ = 8 \text{ V}$  and  $V^- = -8 \text{ V}$ .

The transistor parameters are:  $V_{BE}$  (on) = 0.6 V,  $V_A$  = 160 V, and  $\beta$  = 80.

DESIGN a two-transistor BJT current source similar to the Figure 1 using all the parameters given above so that its output resistance  $(R_0)$  is 200 k $\Omega$ . Show clearly all calculations as marks are given according to this.

[10 marks]



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

Figure 1

;Small signal

$$\beta = g_m r_{\pi}$$

#### **Answer:**

$R_{o}$	$= r_{02}$	$=V_A/I_0$	[2]
$I_{O}$		$=V_A/R_O$	[1]
		= (160) / (200k)	[0.5]
		= 0.80  mA	[0.5]
$I_{REF}$		$=I_{O}\left(1+2/\beta\right)$	[2]
		$= (0.80 \mathrm{m})(1 + 2/80)$	[0.5]
		= 0.82  mA	[0.5]
$R_1$		$= (V^+ - V_{BE} - V^-) / I_{REF}$	[2]
		=(8-0.6-(-8))/(0.82m)	[0.5]
		$= 18.78 \text{ k}\Omega$	[0.5]

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

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

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