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

EEEB273/EEEB2014 - Quiz 1 .
SEMESTER 2, ACADEMIC YEAR 2018/2019
Date: 25 October 2018 Time: 15 minutes

Question:

Refer to **Figure 1**. All transistors are matched.

The circuit parameters are: $V^+ = 8$ V and $V^- = -8$ V.

The transistor parameters are: $\beta = 50$, $V_{BE}(\text{on}) = 0.6$ V, and $V_A = 120$ V.

(a) **Design** a three-transistor current source using all the parameters given above so that $I_{B2} = 6$ µA. [8 marks]

(b) **Calculate** the **output resistance (R_O)** of the three-transistor current source. [2 marks]

Show clearly all calculations as marks are given according to this.

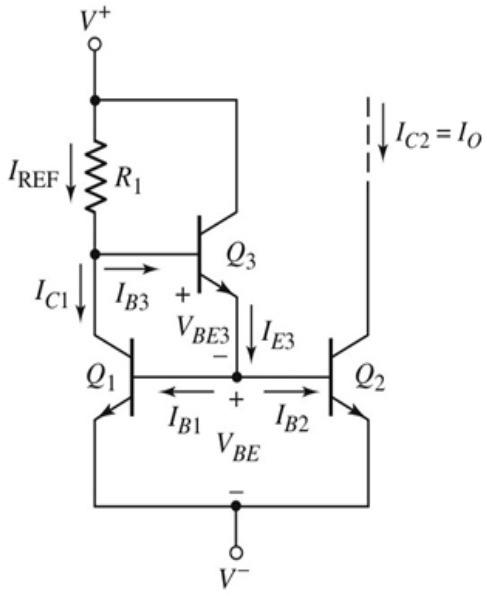

Figure 1

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

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

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

$$i_E = i_B + i_C$$

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

;Small signal

$$\beta = g_m r_\pi$$

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

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

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

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

Answer:

(a) Design

$I_O = I_{C2}$	$= \beta I_{B2}$	[1]
	$= (50)\ (6\ \mu A)$	[0.5]
	$= 0.3$ mA	[0.5]
I_{REF}	$= I_O\ [1 + 2/\beta(1 + \beta)]$	[2]
	$= (0.3\text{m})[1 + 2/(50\text{x}51)]$	[0.5]
	$= 0.3002$ mA	[0.5]
R_1	$= (V^+ - 2V_{BE} - V^-) / I_{REF}$	[2]
	$= (8 - 2\text{x}0.6 - (-8)) / (0.3002\ \text{m})$	[0.5]
	$= 49.2946$ kΩ	[0.5]

(b) Calculate R_O

$R_O = r_{O2}$	$= V_A / I_O$	[1]
	$= (120\ \text{V}) / (0.3\ \text{mA})$	[0.5]
	$= 400$ kΩ	[0.5]

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Question:

Refer to **Figure 1**. All transistors are matched.

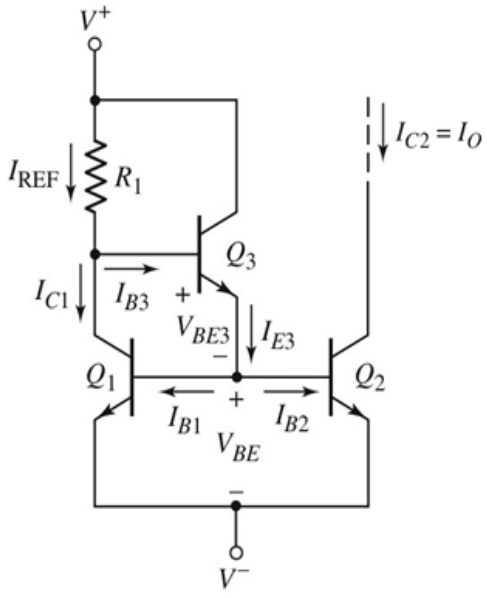
The circuit parameters are: $V^+ = 8$ V and $V^- = -8$ V.

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

(c) **Design** a three-transistor current source using all the parameters given above so that $I_{B2} = 7$ µA. [8 marks]

(d) **Calculate** the **output resistance (R_O)** of the three-transistor current source. [2 marks]

Show clearly all calculations as marks are given according to this.



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

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

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

Answer:

(a) Design

I_O	$= I_{C2}$	$= \beta I_{B2}$	[1]
		$= (50)\ (7\ \mu A)$	[0.5]
		$= 0.35$ mA	[0.5]
I_{REF}		$= I_O\ [1 + 2/\beta(1 + \beta)]$	[2]
		$= (0.35\text{m})[1 + 2/(50\text{x}51)]$	[0.5]
		$= 0.3502$ mA	[0.5]
R_1		$= (V^+ - 2V_{BE} - V^-) / I_{REF}$	[2]
		$= (8 - 2\text{x}0.6 - (-8)) / (0.3502\text{ m})$	[0.5]
		$= 42.2615$ kΩ	[0.5]

(b) Calculate R_O

R_O	$= r_{O2}$	$= V_A / I_O$	[1]
		$= (160\text{ V}) / (0.35\text{ mA})$	[0.5]
		$= 457.14$ kΩ	[0.5]

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Date: 25 October 2018 Time: 15 minutes

Question:

Refer to **Figure 1**. All transistors are matched.

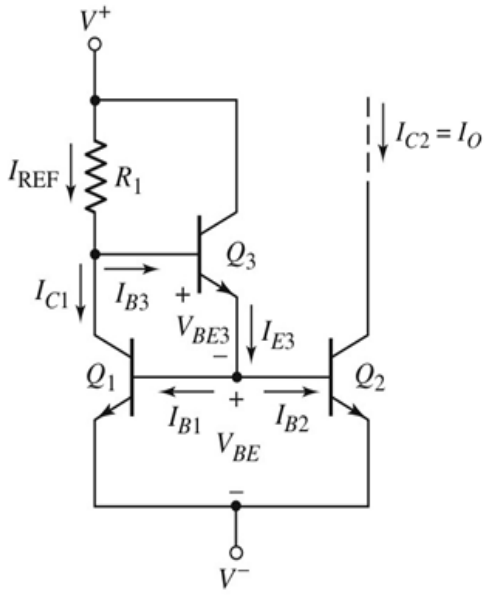
The circuit parameters are: $V^+ = 7.5$ V and $V^- = -7.5$ V.

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

(e) **Design** a three-transistor current source using all the parameters given above so that $I_{B2} = 6$ µA. [8 marks]

(f) **Calculate** the **output resistance** (R_O) of the three-transistor current source. [2 marks]

Show clearly all calculations as marks are given according to this.



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

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

Answer:

(a) Design

I_O	$= I_{C2}$	$= \beta I_{B2}$	[1]
		$=$ (80) (6 µA)	[0.5]
		$=$ 0.48 mA	[0.5]
I_{REF}		$= I_O [1 + 2/\beta(1 + \beta)]$	[2]
		$=$ (0.48m)[1 + 2/(80x81)]	[0.5]
		$=$ 0.4801 mA	[0.5]
R_1		$= (V^+ - 2V_{BE} - V^-) / I_{REF}$	[2]
		$=$ (7.5 – 2x0.6 – (-7.5)) / (0.4801 m)	[0.5]
		$=$ 28.744 kΩ	[0.5]

(b) Calculate R_O

R_O	$= r_{O2}$	$= V_A / I_O$	[1]
		$=$ (150 V) / (0.48 mA)	[0.5]
		$=$ 312.5 kΩ	[0.5]

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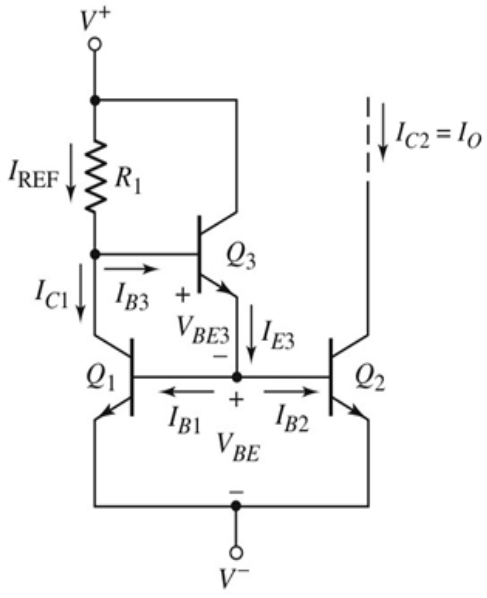
The transistor parameters are: $\beta = 80$, $V_{BE}(\text{on}) = 0.6$ V, and $V_A = 160$ V.

(g) **Design** a three-transistor current source using all the parameters given above so that $I_{B2} = 7$ µA. [8 marks]

(h) **Calculate** the **output resistance** (R_O) of the three-transistor current source. [2 marks]

Show clearly all calculations as marks are given according to this.



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$$\beta = g_m r_\pi$$

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

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

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

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

Answer:

(a) Design

I_O	$= I_{C2}$	$= \beta\, I_{B2}$	[1]
		$= (80)\ (7\ \mu\text{A})$	[0.5]
		$= 0.56$ mA	[0.5]
I_{REF}		$= I_O\ [1 + 2/\beta(1 + \beta)]$	[2]
		$= (0.56\text{m})[1 + 2/(80\text{x}81)]$	[0.5]
		$= 0.5601$ mA	[0.5]
R_1		$= (V^+ - 2V_{BE} - V^-) / I_{REF}$	[2]
		$= (7.5 - 2\text{x}0.6 - (-7.5)) / (0.5601\ \text{m})$	[0.5]
		$= 24.638$ kΩ	[0.5]

(b) Calculate R_O

R_O	$= r_{O2}$	$= V_A / I_O$	[1]
		$= (160\ \text{V}) / (0.56\ \text{mA})$	[0.5]
		$= 285.714$ kΩ	[0.5]