Name:	**Dr JBO**
Student ID Number:	**Model answer**
Section: 01A/B 02A/B	
Lecturer: Dr. Jamaludin Bin Omar	

EEEB273 - Quiz 2
SEMESTER 2, ACADEMIC YEAR 2015/2016
Date: 16 Nov 2015 Time: 15 minutes .

Question:

Refer to the **Wilson** current source shown in **Figure 1**. Assume the reference current I_{REF} is **0.25 mA**. The transistor parameters are V_{BE} **(on) = 0.7 V**, V_A **= 120 V**, and β **= 80**.

(a) Determine the output resistance R_O looking into the collector of Q_3. [7 marks]

(b) What is the change in I_O as the output voltage change by **+5 Volts**? [3 marks]

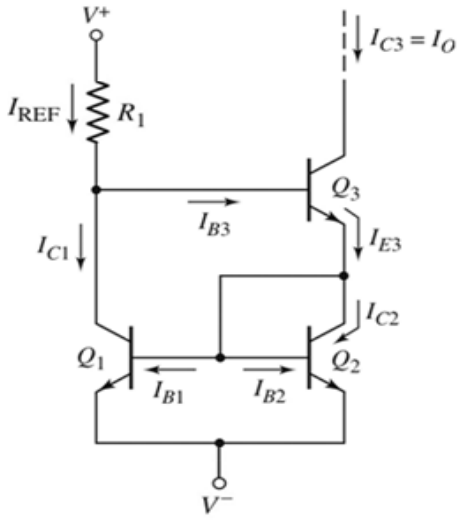

Figure 1

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

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

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

$$i_E = i_B + i_C$$

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

$$;\text{Small signal}$$

$$\beta = g_m r_\pi$$

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

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

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

Answer:

(a)		
I_O	$= I_{REF} / [1 + 2/\beta(2+\beta)]$	[1]
	$= (0.25m)/[1 + 2/(80 \times 82)]$	[1]
	$= 0.2499$ mA	[1]
R_O	$= (\beta r_{O3}) / 2 \quad = (\beta V_A) / (2 I_O)$	[2]
	$= (80 \times 120) / (2 \times 0.2499m)$	[1]
	$= 19.205$ MΩ	[1]
(b)		
I_O	$= dV_O / R_O$	[1]
	$= 5 / 19.205M$	[1]
	$= 0.26$ µA	[1]

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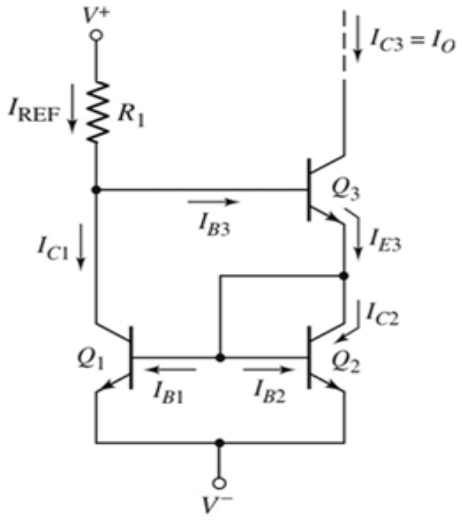
Question:

Refer to the **Wilson** current source shown in **Figure 1**. Assume the reference current I_{REF} is **0.25 mA**. The transistor parameters are V_{BE} **(on) = 0.7 V**, V_A **= 100 V**, and β **= 80**.

(a) Determine the output resistance R_O looking into the collector of Q_3. [7 marks]

(b) What is the change in I_O as the output voltage change by **+4.5 Volts**? [3 marks]



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

Answer:

(a)

I_O	$= I_{REF} / [1 + 2/\beta(2+\beta)]$	[1]
	$= (0.25m)/[1 + 2/(80 \times 82)]$	[1]
	$= 0.2499$ mA	[1]
R_O	$= (\beta r_{O3}) / 2 \quad = (\beta V_A) / (2 I_O)$	[2]
	$= (80 \times 100) / (2 \times 0.2499m)$	[1]
	$= 16.004$ MΩ	[1]

(b)

I_O	$= dV_O / R_O$	[1]
	$= 4.5 / 16.004M$	[1]
	$= 0.281$ µA	[1]

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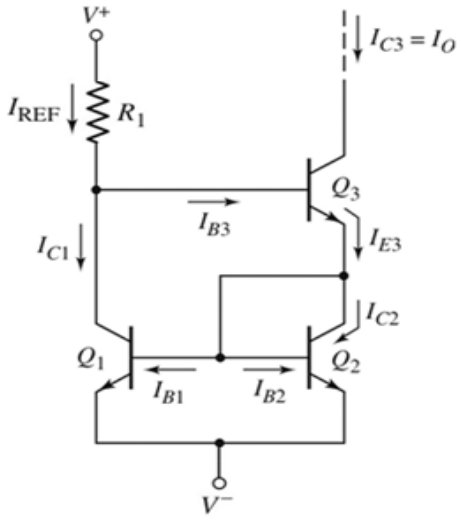
Question:

Refer to the **Wilson** current source shown in **Figure 1**. Assume the reference current I_{REF} is **0.25 mA**. The transistor parameters are V_{BE} **(on) = 0.7 V**, V_A **= 120 V**, and β **= 90**.

(a) Determine the output resistance R_O looking into the collector of Q_3. [7 marks]

(b) What is the change in I_O as the output voltage change by **+4.5 Volts**? [3 marks]



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

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

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

Answer:

(a)

I_O	$= I_{REF} / [1 + 2/\beta(2+\beta)]$	[1]
	$= (0.25m)/[1 + 2/(90 \times 92)]$	[1]
	$= 0.2499$ mA	[1]
R_O	$= (\beta r_{O3}) / 2 \quad = (\beta V_A) / (2 I_O)$	[2]
	$= (90 \times 120) / (2 \times 0.2499m)$	[1]
	$= 21.605$ MΩ	[1]

(b)

I_O	$= dV_O / R_O$	[1]
	$= 4.5 / 21.605M$	[1]
	$= 0.208$ µA	[1]

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Question:

Refer to the **Wilson** current source shown in **Figure 1**. Assume the reference current I_{REF} is **0.25 mA**. The transistor parameters are V_{BE} **(on) = 0.7 V**, V_A **= 100 V**, and β **= 90**.

(a) Determine the output resistance R_O looking into the collector of Q_3. [7 marks]

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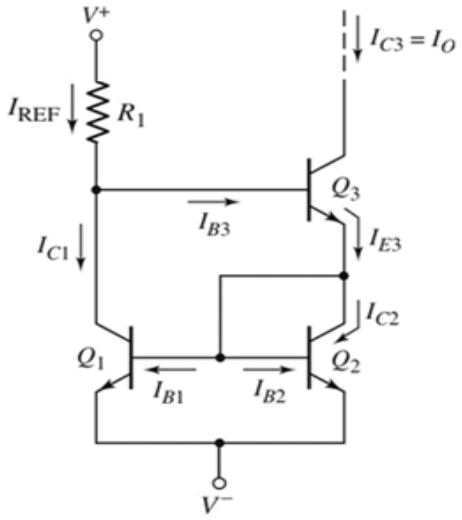

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Answer:

(a)

I_O	$= I_{REF} / [1 + 2/\beta(2+\beta)]$	[1]
	$= (0.25m)/[1 + 2/(90 \times 92)]$	[1]
	$= 0.2499$ mA	[1]
R_O	$= (\beta r_{O3}) / 2 \quad = (\beta V_A) / (2 I_O)$	[2]
	$= (90 \times 100) / (2 \times 0.2499m)$	[1]
	$= 18.004$ MΩ	[1]

(b)

I_O	$= dV_O / R_O$	[1]
	$= 5 / 18.004M$	[1]
	$= 0.278$ µA	[1]