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

EEEB273 - Quiz 1 .
SEMESTER 1, ACADEMIC YEAR 2018/2019
Date: 5 June 2018 Time: 15 minutes

Question:

Refer to a two-transistor BJT current source shown in **Figure 1**. All transistors are matched.
The circuit parameters are: $V^+ = 7.5$ V, $V^- = -7.5$ V, and $R_1 = 18$ kΩ.
The transistor parameters are: V_{BE} (on) = 0.6 V, $V_A = 150$ V, and $\beta = 50$.

Calculate the **Output resistance** (R_O) of the two-transistor BJT current source shown in the **Figure 1** using all the parameters given above. **Show clearly all calculations** as marks are given according to this. [10 marks]

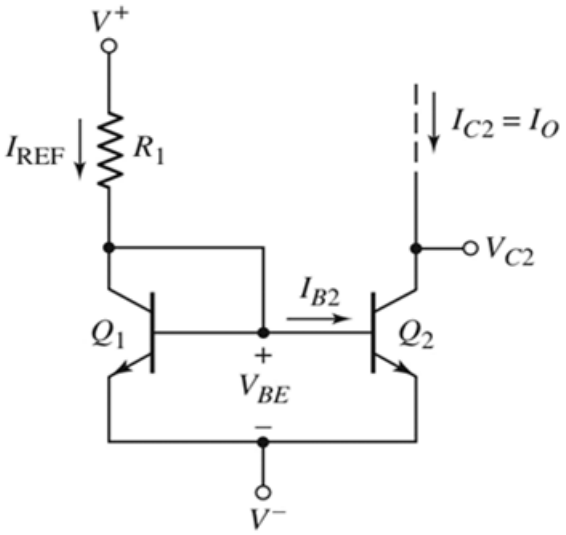

Figure 1

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

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

$$i_C = \beta i_B = \frac{\beta}{1+\beta} i_E$$

$$i_E = i_B + i_C$$

$$;\text{Small signal}$$

$$\beta = g_m r_\pi$$

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

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

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

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

Answer:

I_{REF}		$= (V^+ - V_{BE} - V^-) / R_1$	[2]
		$= (7.5 - 0.6 - (-7.5)) / (18k)$	[0.5]
		$= 0.8$ mA	[0.5]
I_O		$= I_{REF} / (1 + 2/\beta)$	[2]
		$= (0.8m) / (1 + 2/50)$	[0.5]
		$= 0.7692$ mA	[0.5]
R_O		$= r_{O2}$	[1]
r_{O2}		$= V_A / I_O$	[2]
		$= (150) / (0.7692m)$	[0.5]
→	R_O	$= 195$ kΩ	[0.5]

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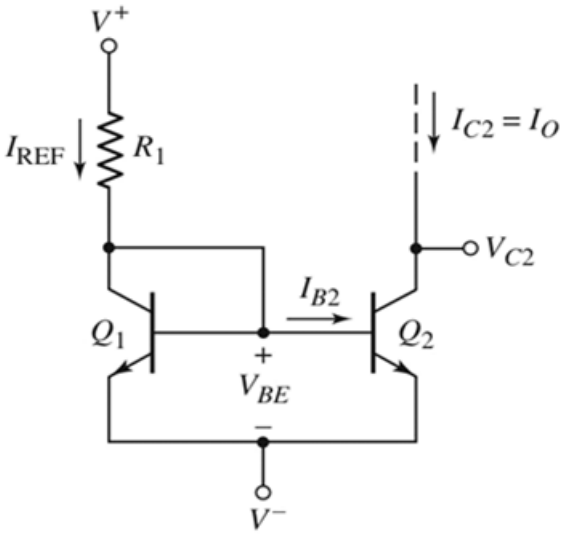
Question:

Refer to a two-transistor BJT current source shown in **Figure 1**. All transistors are matched.
The circuit parameters are: $V^+ = 8$ V, $V^- = -8$ V, and $R_1 = 18.5$ kΩ.
The transistor parameters are: V_{BE} (on) = 0.6 V, $V_A = 160$ V, and $\beta = 50$.

Calculate the **Output resistance** (R_O) of the two-transistor BJT current source shown in the **Figure 1** using all the parameters given above. **Show clearly all calculations** as marks are given according to this. [10 marks]



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

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

Answer:

I_{REF}		$= (V^+ - V_{BE} - V^-) / R_1$	[2]
		$= (8 - 0.6 - (-8)) / (18.5k)$	[0.5]
		$= 0.8324$ mA	[0.5]
I_O		$= I_{REF} / (1 + 2/\beta)$	[2]
		$= (0.8324m) / (1 + 2/50)$	[0.5]
		$= 0.8004$ mA	[0.5]
R_O		$= r_{O2}$	[1]
r_{O2}		$= V_A / I_O$	[2]
		$= (160) / (0.8004m)$	[0.5]
→	R_O	$= 199.9$ kΩ	[0.5]

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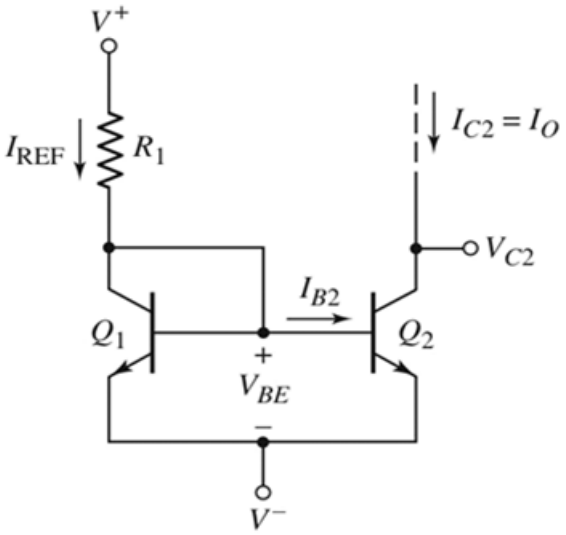
Question:

Refer to a two-transistor BJT current source shown in **Figure 1**. All transistors are matched.

The circuit parameters are: $V^+ = 7.5$ V, $V^- = -7.5$ V, and $R_1 = 19$ kΩ.

The transistor parameters are: V_{BE} (on) = 0.6 V, $V_A = 150$ V, and $\beta = 60$.

Calculate the **Output resistance** (R_O) of the two-transistor BJT current source shown in the **Figure 1** using all the parameters given above. **Show clearly all calculations** as marks are given according to this. [10 marks]



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

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

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

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

Answer:

I_{REF}	$= (V^+ - V_{BE} - V^-) / R_1$	[2]
	$= (7.5 - 0.6 - (-7.5)) / (19k)$	[0.5]
	$= 0.7579$ mA	[0.5]
I_O	$= I_{REF} / (1 + 2/\beta)$	[2]
	$= (0.7579m) / (1 + 2/60)$	[0.5]
	$= 0.7334$ mA	[0.5]
R_O	$= r_{O2}$	[1]
r_{O2}	$= V_A / I_O$	[2]
	$= (150) / (0.7334m)$	[0.5]
→ R_O	$= 204.5$ kΩ	[0.5]

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The circuit parameters are: $V^+ = 8$ V, $V^- = -8$ V, and $R_1 = 19.5$ kΩ.
The transistor parameters are: V_{BE} (on) = 0.6 V, $V_A = 160$ V, and $\beta = 60$.

Calculate the **Output resistance** (R_O) of the two-transistor BJT current source shown in the **Figure 1** using all the parameters given above. **Show clearly all calculations** as marks are given according to this. [10 marks]

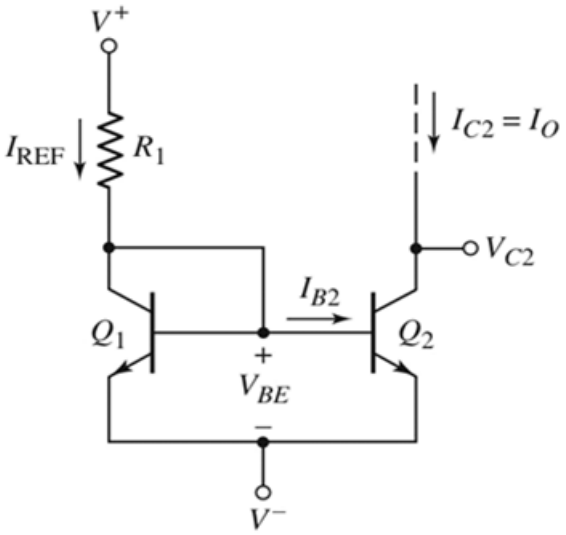

Figure 1

Answer:

I_{REF}		$= (V^+ - V_{BE} - V^-) / R_1$	[2]
		$= (8 - 0.6 - (-8)) / (19.5k)$	[0.5]
		$= 0.7897$ mA	[0.5]
I_O		$= I_{REF} / (1 + 2/\beta)$	[2]
		$= (0.7897m) / (1 + 2/60)$	[0.5]
		$= 0.7643$ mA	[0.5]
R_O		$= r_{O2}$	[1]
r_{O2}		$= V_A / I_O$	[2]
		$= (160) / (0.7643m)$	[0.5]
→	R_O	$= 209.3$ kΩ	[0.5]

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

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

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

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