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

EEEB273 - Quiz 1 T
SEMESTER 2, ACADEMIC YEAR 2014/2015
Date: 6 November 2014 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: $\beta = 100$, $V_{BE}(\text{on}) = 0.6$ V, and $V_A = 150$ V.

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

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

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

Answer:

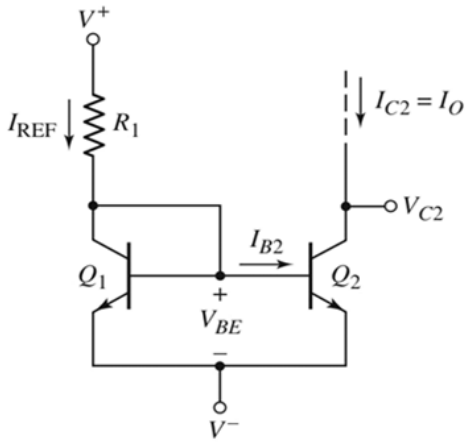

Figure 1

$I_O = I_{C2}$	$= \beta I_{B2}$	[1]	
	$= (100)(6\mu)$	[1]	
	$= 0.6$ mA	[0.5]	
I_{REF}	$= I_O (1 + 2/\beta)$	[1]	
	$= (0.6\text{m})(1 + 2/100)$	[1]	
	$= 0.612$ mA	[0.5]	
R_1	$= (V^+ - V_{BE} - V^-) / I_{REF}$	[1.5]	
	$= (7.5 - 0.6 - (-7.5)) / (0.612\text{m})$		[1]
	$= 23.529$ kΩ	[0.5]	
R_O	$= r_{o2} = V_A / I_O$	[1]	
	$= (150) / (0.6\text{m})$	[0.5]	
	$= 250$ kΩ	[0.5]	

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

;Small signal

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

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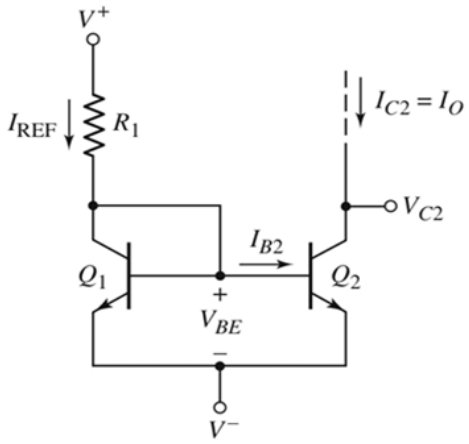

Figure 1

$I_O = I_{C2}$	$= \beta I_{B2}$	[1]
	$= (100)(7\mu)$	[1]
	$= 0.7$ mA	[0.5]
I_{REF}	$= I_O (1 + 2/\beta)$	[1]
	$= (0.7\text{m})(1 + 2/100)$	[1]
	$= 0.714$ mA	[0.5]
R_1	$= (V^+ - V_{BE} - V^-) / I_{REF}$	[1.5]
	$= (7.0 - 0.6 - (-7.0)) / (0.714\text{m})$	[1]
	$= 18.767$ kΩ	[0.5]
R_O	$= r_{o2} = V_A / I_O$	[1]
	$= (150) / (0.7\text{m})$	[0.5]
	$= 214.28$ kΩ	[0.5]

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

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Question:

Refer to **Figure 1**. All transistors are matched.
The circuit parameters are: $V^+ = 7.0$ V and $V^- = -7.0$ V.
The transistor parameters are: $\beta = 120$, $V_{BE}(on) = 0.6$ V, and $V_A = 150$ V.

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

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

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

Answer:

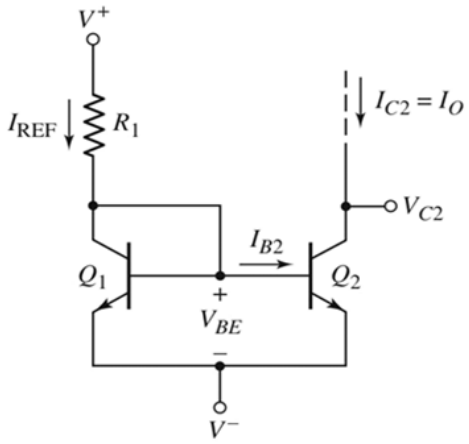

Figure 1

$I_O = I_{C2}$	$= \beta I_{B2}$	[1]
	$= (120)(7\mu)$	[1]
	$= 0.84$ mA	[0.5]
I_{REF}	$= I_O (1 + 2/\beta)$	[1]
	$= (0.84m)(1 + 2/120)$	[1]
	$= 0.854$ mA	[0.5]
R_1	$= (V^+ - V_{BE} - V^-) / I_{REF}$	[1.5]
	$= (7.0 - 0.6 - (-7.0)) / (0.854m)$	[1]
	$= 15.691$ kΩ	[0.5]
R_O	$= r_{o2} = V_A / I_O$	[1]
	$= (150) / (0.84m)$	[0.5]
	$= 178.57$ kΩ	[0.5]

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

;Small signal

$$\beta = g_m r_\pi$$
$$r_\pi = \frac{\beta V_T}{I_{CQ}}$$
$$g_m = \frac{I_{CQ}}{V_T}$$
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(a) **Design** a two-transistor current source using all the parameters given above so that $I_{B2} = 6$ µA. [8 marks]

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

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

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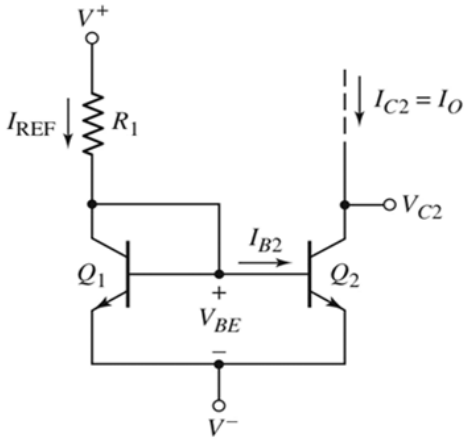

Figure 1

$I_O = I_{C2}$	$= \beta I_{B2}$	[1]
	$= (120)(6\mu)$	[1]
	$= 0.72$ mA	[0.5]
I_{REF}	$= I_O (1 + 2/\beta)$	[1]
	$= (0.72m)(1 + 2/120)$	[1]
	$= 0.732$ mA	[0.5]
R_1	$= (V^+ - V_{BE} - V^-) / I_{REF}$	[1.5]
	$= (7.5 - 0.6 - (-7.5)) / (0.732m)$	[1]
	$= 19.672$ kΩ	[0.5]
R_O	$= r_{o2} = V_A / I_O$	[1]
	$= (150) / (0.72m)$	[0.5]
	$= 208.33$ kΩ	[0.5]

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

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

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

$$i_E = i_B + i_C$$

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

;Small signal

$$\beta = g_m r_\pi$$

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

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