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

EEEB273 - Quiz 1
SEMESTER 2, ACADEMIC YEAR 2016/2017
Date: 25 October 2016 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: $\beta = 100$, $V_{BE}(on) = 0.6$ 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. **[4.5 marks]**

(b) Find the **change in** I_O (i.e. dI_O) if $V_{C2} = 3.2$ V. **[5.5 marks]**

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

Answer:

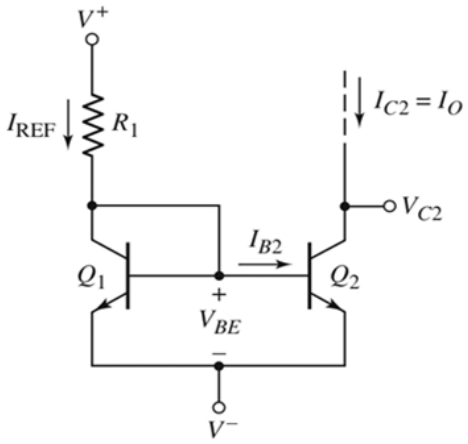

Figure 1

$I_O = I_{C2}$	$= \beta I_{B2}$	[1]
	$= (100)(6\mu) = 0.6$ mA	[0.5]
I_{REF}	$= I_O (1 + 2/\beta)$	[1]
	$= (0.6\text{m})(1 + 2/100) = 0.612$ mA	[0.5]
R_1	$= (V^+ - V_{BE} - V^-) / I_{REF}$	[1]
	$= (7.5 - 0.6 - (-7.5)) / (0.612\text{m}) = 23.529$ kΩ	[0.5]
R_O	$= r_{o2} = V_A / I_O$	[1]
	$= (150) / (0.6\text{m}) = 250$ kΩ	[0.5]
Ori_V_{CE2}	$= V_{CE1} = V_{BE}(on)$ $= 0.6$ V	[1]
New_V_{CE2}	$= V_{C2} - V^-$ $= 3.2 - (-7.5) = 10.7$ V	[1]
dV_{CE2}	= New_V_{CE2} - Ori_V_{CE2} = 10.1 V	[0.5]
dI_O	$= dV_{CE2} / R_O$	[1]
	$= (10.1) / (250\text{k}) = 0.0404$ mA	[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

$$\beta = g_m r_\pi$$
$$_m = \frac{I_{CQ}}{V_T}$$
$$_\pi = \frac{\beta V_T}{I_{CQ}}$$
$$= \frac{V_A}{I_{CQ}}$$
$$_T = 26\,\text{mV}$$

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The circuit parameters are: $V^+ = 7.0$ V and $V^- = -7.0$ V.
The transistor parameters are: $\beta = 100$, $V_{BE}(on) = 0.6$ 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. **[4.5 marks]**

(b) Find the **change in** I_O (i.e. dI_O) if $V_{C2} = 3.3$ V. **[5.5 marks]**

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

Answer:

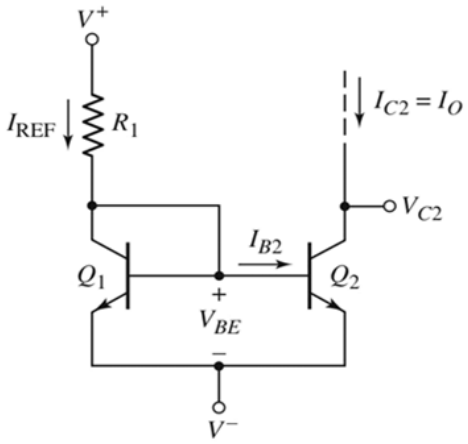

Figure 1

$I_O = I_{C2}$	$= \beta I_{B2}$	[1]
	$= (100)(7\mu) = 0.7$ mA	[0.5]
I_{REF}	$= I_O (1 + 2/\beta)$	[1]
	$= (0.7\text{m})(1 + 2/100) = 0.714$ mA	[0.5]
R_1	$= (V^+ - V_{BE} - V^-) / I_{REF}$	[1]
	$= (7.0 - 0.6 - (-7.0)) / (0.714\text{m}) = 18.767$ kΩ	[0.5]
R_O	$= r_{o2} = V_A / I_O$	[1]
	$= (150) / (0.7\text{m}) = 214.28$ kΩ	[0.5]
Ori_V_{CE2}	$= V_{CE1} = V_{BE}(on)$ $= 0.6$ V	[1]
New_V_{CE2}	$= V_{C2} - V^-$ $= 3.3 - (-7.0) = 10.3$ V	[1]
dV_{CE2}	= New_V_{CE2} - Ori_V_{CE2} = 9.7 V	[0.5]
dI_O	$= dV_{CE2} / R_O$	[1]
	$= (9.7) / (214.28\text{k}) = 0.0453$ mA	[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

$$\beta = g_m r_\pi$$
$$g_m = \frac{I_{CQ}}{V_T}$$
$$r_\pi = \frac{\beta V_T}{I_{CQ}}$$
$$r_o = \frac{V_A}{I_{CQ}}$$
$$V_T = 26\,\text{mV}$$

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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. **[4.5 marks]**

(b) Find the **change in** I_O (i.e. dI_O) if $V_{C2} = 3.2$ V. **[5.5 marks]**

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

Answer:

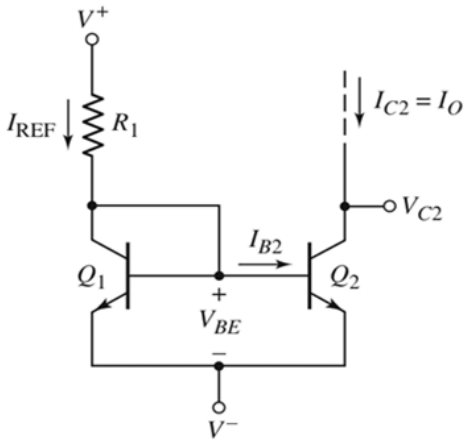

Figure 1

$I_O = I_{C2}$	$= \beta I_{B2}$	[1]
	$= (120)(7\mu) = 0.84$ mA	[0.5]
I_{REF}	$= I_O (1 + 2/\beta)$	[1]
	$= (0.84m)(1 + 2/120) = 0.854$ mA	[0.5]
R_1	$= (V^+ - V_{BE} - V^-) / I_{REF}$	[1]
	$= (7.0 - 0.6 - (-7.0)) / (0.854m) = 15.691$ kΩ	[0.5]
R_O	$= r_{o2} = V_A / I_O$	[1]
	$= (150) / (0.84m) = 178.57$ kΩ	[0.5]
Ori_V_{CE2}	$= V_{CE1} = V_{BE}(on)$ $= 0.6$ V	[1]
New_V_{CE2}	$= V_{C2} - V^-$ $= 3.2 - (-7.0) = 10.2$ V	[1]
dV_{CE2}	= New_V_{CE2} - Ori_V_{CE2} = 9.6 V	[0.5]
dI_O	$= dV_{CE2} / R_O$	[1]
	$= (9.6) / (178.57k) = 0.0537$ mA	[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

$$\beta = g_m r_\pi$$
$$g_m = \frac{I_{CQ}}{V_T}$$
$$r_\pi = \frac{\beta V_T}{I_{CQ}}$$
$$r_o = \frac{V_A}{I_{CQ}}$$
$$V_T = 26\,\text{mV}$$

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Date: 25 October 2016 Time: 15 minutes :

Question:

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The circuit parameters are: $V^+ = 7.5$ V and $V^- = -7.5$ 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 $I_{B2} = 6$ µA. **[4.5 marks]**

(b) Find the **change in** I_O (i.e. dI_O) if $V_{C2} = 3.3$ V. **[5.5 marks]**

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

Answer:

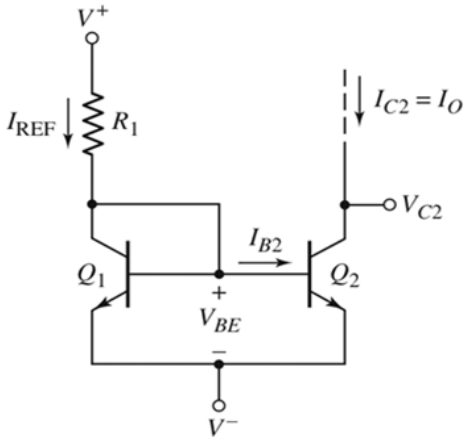

Figure 1

$I_O = I_{C2}$	$= \beta I_{B2}$	[1]
	$= (120)(6\mu) = 0.72$ mA	[0.5]
I_{REF}	$= I_O (1 + 2/\beta)$	[1]
	$= (0.72\text{m})(1 + 2/120) = 0.732$ mA	[0.5]
R_1	$= (V^+ - V_{BE} - V^-) / I_{REF}$	[1]
	$= (7.5 - 0.6 - (-7.5)) / (0.732\text{m}) = 19.672$ kΩ	[0.5]
R_O	$= r_{o2} = V_A / I_O$	[1]
	$= (150) / (0.72\text{m}) = 208.33$ kΩ	[0.5]
Ori_V_{CE2}	$= V_{CE1} = V_{BE}(on) = 0.6$ V	[1]
New_V_{CE2}	$= V_{C2} - V^- = 3.3 - (-7.5) = 10.8$ V	[1]
dV_{CE2}	= New_V_{CE2} - Ori_V_{CE2} = 10.2 V	[0.5]
dI_O	$= dV_{CE2} / R_O$	[1]
	$= (10.2) / (208.33\text{k}) = 0.0489$ mA	[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

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