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

EEEB273 - Quiz 2 [Question Set 1]
SEMESTER 1, ACADEMIC YEAR 2010/2011
Date: 28 July 2010

Question:

Figure 1 shows circuit diagram of a BJT current source. Study Figure 1 carefully. All transistors in the circuit are matched. The transistor parameters are: $\beta = 150$, $V_A = 100$ V, and V_{BE} (on) = 0.7 V.

(a) Name the circuit for the current source. [2 marks]
(b) Using I_{B1} as starting point, derive the relationship between I_O and I_{REF}. [5 marks]
(c) Based on given value of β, use approximate value of I_O to estimate the output resistance, R_O, of the current source. [7 marks]
(d) Find g_{m4} and $r_{\pi 4}$. [6 marks]

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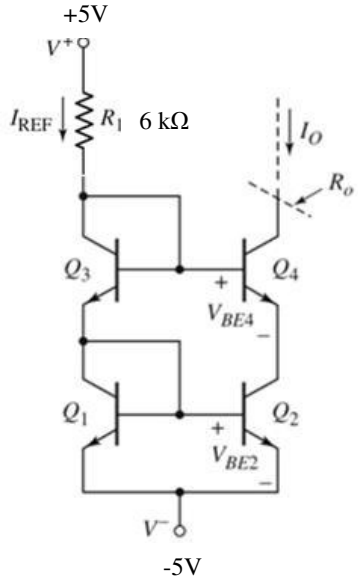

Figure 1

(b)

$I_{C2} = \beta I_{B2} = I_{E4} = \beta I_{B1}$ [1/2]
$I_{C4} = \alpha I_{E4} = (\beta / \beta+1)(\beta I_{B1}) = I_O$ ➔ $I_{B1} = ((\beta+1)/\beta^2) I_O$ [1/2]
$I_{B4} = I_{E4}/ (\beta+1) = (1 / \beta+1)(\beta I_{B1})$ [1/2]

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$I_{E3} = (\beta+2) I_{B1}$ [1/2]
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$I_{REF} = [(\beta^2 + 2\beta + \beta + 2 + \beta)/(\beta+1)] I_{B1}$ [1/2]

$I_{REF} = [(\beta^2 + 2\beta + \beta + 2 + \beta)/(\beta+1)]\ [((\beta+1)/\beta^2)\ I_O]$ [1/2]

$I_O = I_{REF} / [1 + 4/\beta + 2/\beta^2] \approx I_{REF} / [1 + 4/\beta]$ [1/2]

(c) $\beta = 150$ ➔ Approximation: $I_O = I_{REF}$ [1]

$I_{REF} = (V^+ - V_{BE1} - V_{BE3} - V^-) / (R_1) = (5-0.7-0.7-(-5))/6k = 1.433$ mA $= I_O$
[1] [1] [1/2]

$R_O = \beta r_{O4} = \beta V_A / I_O = (150)(100/1.433m) = 10.465$ MΩ
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(d) $g_{m4} = I_O / V_T = (1.433mA)/(26mV) = 55.128$ mA/V
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$r_{\pi 4} = \beta V_T / I_O = (150)(26mV/1.433mA) = 2.721$ kΩ
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Figure 1 shows circuit diagram of a BJT current source. Study Figure 1 carefully. All transistors in the circuit are matched. The transistor parameters are: $\beta = 150$, $V_A = 100$ V, and V_{BE} (on) = 0.7 V.

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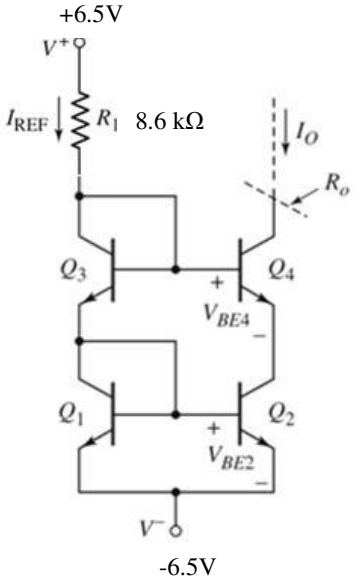

Figure 1

(b)

$I_{C2} = \beta I_{B2} = I_{E4} = \beta I_{B1}$ [1/2]

$I_{C4} = \alpha I_{E4} = (\beta / \beta+1)(\beta I_{B1}) = I_O$ ➔ $I_{B1} = ((\beta+1)/\beta^2) I_O$ [1/2]

$I_{B4} = I_{E4} / (\beta+1) = (1 / \beta+1)(\beta I_{B1})$ [1/2]

$I_{C1} = \beta I_{B1}$ [1/2]

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$R_O = \beta\, r_{O4} = \beta\, V_A / I_O = (150)(100/1.349m) = 11.121\ M\Omega$ [1] [1] [1] [1/2]

(d) $g_{m4} = I_O / V_T = (1.349mA)/(26mV) = 51.878\ mA/V$ [1] [1] [1]

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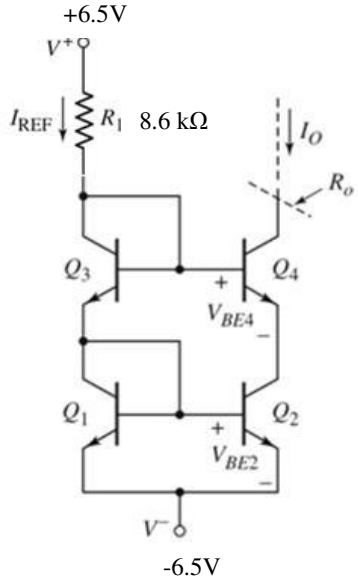

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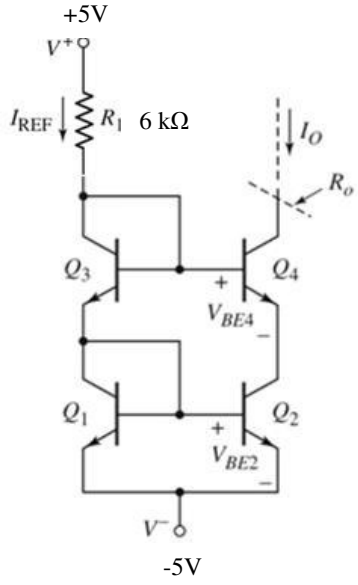

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