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

EEEB273 - Quiz 2 ⊺
SEMESTER 2, ACADEMIC YEAR 2013/2014
Date: 26 November 2013 Time: 15 minutes

Question:

Study **Figure 1** carefully. Assume Q_1 **and** Q_2 **are matched** and neglect i_B. If $v_d = v_{BE1} - v_{BE2}$, then show that:

$$i_{C1} = \frac{I_Q}{1+e^{-v_d/V_T}}$$ [8 marks]

Given V_T **= 26 mV,** I_Q **= 0.8 mA,** and v_d **= -0.05 V; calculate** current i_{C1}.

[2 marks]

$$i_{C1} = I_S e^{v_{BE1}/V_T}\,[1]$$
$$i_{C2} = I_S e^{v_{BE2}/V_T}\,[1]$$
$$I_Q = i_{C1} + i_{C2}\,[1]$$
$$I_Q = I_S\left[e^{v_{BE1}/V_T} + e^{v_{BE2}/V_T}\right]\,[1]$$
$$\frac{i_{C1}}{I_Q} = \frac{1}{1+e^{(v_{BE2}-v_{BE1})/V_T}}\,[2]$$
$$v_d = v_{BE1} - v_{BE2}\,[1]$$
$$i_{C1} = \frac{I_Q}{1+e^{-v_d/V_T}}\,[1]$$
$$i_{C1} = \frac{0.8mA}{1+e^{-(-0.05)/0.026}} = 0.102mA\,[2]$$

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

;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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$$i_{C2} = \frac{I_Q}{1+e^{+v_d/V_T}}$$ [8 marks]

Given V_T **= 26 mV,** I_Q **= 0.8 mA,** and v_d **= -0.05 V; calculate** current i_{C2}.

[2 marks]

$$i_{C1} = I_S e^{v_{BE1}/V_T}[1]$$
$$i_{C2} = I_S e^{v_{BE2}/V_T}[1]$$
$$I_Q = i_{C1} + i_{C2}[1]$$
$$I_Q = I_S\left[e^{v_{BE1}/V_T} + e^{v_{BE2}/V_T}\right][1]$$
$$\frac{i_{C2}}{I_Q} = \frac{1}{1+e^{-(v_{BE2}-v_{BE1})/V_T}}[2]$$
$$v_d = v_{BE1} - v_{BE2}[1]$$
$$i_{C2} = \frac{I_Q}{1+e^{+v_d/V_T}}[1]$$
$$i_{C2} = \frac{0.8mA}{1+e^{(-0.05)/0.026}} = 0.698mA[2]$$

$$i_C = I_S e^{v_{BE}/V_T}\text{; npn}$$
$$i_C = I_S e^{v_{EB}/V_T}\text{; pnp}$$
$$i_C = \alpha i_E = \beta i_B$$
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$$i_{C1} = \frac{I_Q}{1+e^{-v_d/V_T}}$$ [8 marks]

Given V_T **= 26 mV,** I_Q **= 0.7 mA,** and v_d **= +0.05 V; calculate** current i_{C1}.

[2 marks]

$$i_{C1} = I_S e^{v_{BE1}/V_T}\,[1]$$
$$i_{C2} = I_S e^{v_{BE2}/V_T}\,[1]$$
$$I_Q = i_{C1} + i_{C2}\,[1]$$
$$I_Q = I_S\left[e^{v_{BE1}/V_T} + e^{v_{BE2}/V_T}\right][1]$$
$$\frac{i_{C1}}{I_Q} = \frac{1}{1+e^{(v_{BE2}-v_{BE1})/V_T}}\,[2]$$
$$v_d = v_{BE1} - v_{BE2}\,[1]$$
$$i_{C1} = \frac{I_Q}{1+e^{-v_d/V_T}}\,[1]$$
$$i_{C1} = \frac{0.7mA}{1+e^{-(0.05)/0.026}} = 0.6107mA\,[2]$$

$$i_C = I_S e^{v_{BE}/V_T}\text{; npn}$$
$$i_C = I_S e^{v_{EB}/V_T}\text{; pnp}$$
$$i_C = \alpha i_E = \beta i_B$$
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;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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Given V_T **= 26 mV,** I_Q **= 0.7 mA,** and v_d **= +0.05 V; calculate** current i_{C2}.

[2 marks]

$$i_{C1} = I_S e^{v_{BE1}/V_T}\,[1]$$
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$$v_d = v_{BE1} - v_{BE2}\,[1]$$
$$i_{C2} = \frac{I_Q}{1+e^{+v_d/V_T}}\,[1]$$
$$i_{C2} = \frac{0.7mA}{1+e^{(0.05)/0.026}} = 0.0893mA\,[2]$$

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