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

EEEB273 - Quiz 4 [Question Set 1]
SEMESTER 1, ACADEMIC YEAR 2010/2011
Date: 1 September 2010

Question:

The differential amplifier with an active load shown in **Figure 1** is biased with a constant current source of **0.15 mA.** Power supplies for V^+ and V^- are +10 V and -10 V, respectively. Transistor parameters are β = 100 V and V_A = 120 V.

(a) Determine I_O such that the dc currents in the differential amplifier are balanced. [4 marks]

(b) Determine the differential-mode voltage gain if a load resistance R_L = 330 kΩ is connected to the output. [6 marks]

Answer:

(a)

$I_O = I_{B3} + I_{B4}$ [1]

$= I_{C3}/\beta + I_{C4}/\beta = (I_{C3} + I_{C4})/\beta$ [1]

$= (I_Q/2 + I_Q/2)/\beta = I_Q/\beta$ [1]

$I_O = (0.15\text{m})/100 =$ **1.5 μA** [1]

(b)

$A_d = g_m\,(r_{O2} \parallel r_{O4} \parallel R_L)$

$= (g_m)/(1/r_{O2} + 1/r_{O4} + 1/R_L)$ [1]

$g_m = I_{CQ} / V_T = I_Q / (2V_T)$

$= (0.15\text{m})/(2\text{x}26\text{m}) = 2.885$ mA/V [1]

$r_{O2} = V_{A2} / I_{CQ} = (2V_{A2})/ I_Q$

$= (2\text{x}120)/(0.15\text{m}) = 1600$ kΩ [1]

$r_{O4} = V_{A4} / I_{CQ} = (2V_{A4})/ I_Q$

$= (2\text{x}120)/(0.15\text{m}) = 1600$ kΩ [1]

$R_L = 330$ kΩ

$A_d = g_m\,(r_{O2} \parallel r_{O4} \parallel R_L)$

= (2.885m) (1600k || 1600k || 330k) [1]

= 673.93 kΩ [1]

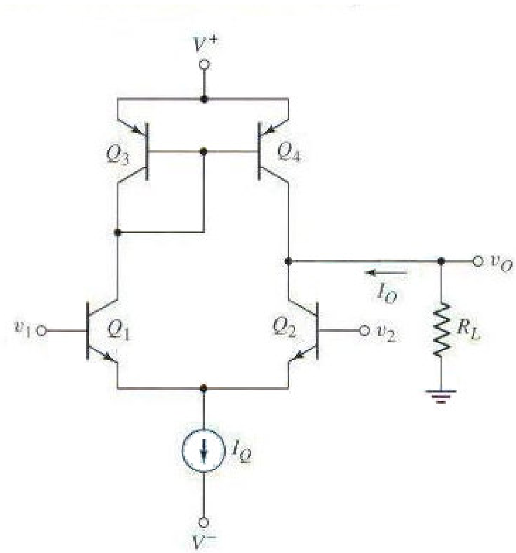

Figure 1

Name: **Dr JBO - Model Answer**

Student ID Number:

Section: 01A / 01B

Lecturer: Dr. Jamaludin Bin Omar

EEEB273 - Quiz 4 [Question Set 2]
SEMESTER 1, ACADEMIC YEAR 2010/2011
Date: 1 September 2010

Question:

The differential amplifier with an active load shown in **Figure 1** is biased with a constant current source of **0.15 mA.** Power supplies for V^+ and V^- are +10 V and -10 V, respectively. Transistor parameters are β = 120 V and V_A = 100 V.

(c) Determine I_O such that the dc currents in the differential amplifier are balanced. [4 marks]

(d) Determine the differential-mode voltage gain if a load resistance R_L = 300 kΩ is connected to the output. [6 marks]

Answer:

(a)

$I_O = I_{B3} + I_{B4}$ [1]

$= I_{C3}/\beta + I_{C4}/\beta = (I_{C3} + I_{C4})/\beta$ [1]

$= (I_Q/2 + I_Q/2)/\beta = I_Q/\beta$ [1]

I_O = (0.15m)/120 = **1.25 μA** [1]

(b)

$A_d = g_m\,(r_{O2} \,||\, r_{O4} \,||\, R_L)$

$= (g_m)/(1/r_{O2} + 1/r_{O4} + 1/R_L)$ [1]

$g_m = I_{CQ} / V_T = I_Q / (2V_T)$

= (0.15m)/(2x26m) = 2.885 mA/V [1]

$r_{O2} = V_{A2} / I_{CQ} = (2V_{A2}) / I_Q$

= (2x100)/(0.15m) = 1333 kΩ [1]

$r_{O4} = V_{A4} / I_{CQ} = (2V_{A4}) / I_Q$

= (2x100)/(0.15m) = 1333 kΩ [1]

R_L = 300 kΩ

$A_d = g_m\,(r_{O2} \,||\, r_{O4} \,||\, R_L)$

= **(2.885m) (1333k || 1333k || 300k)** [1]

= **596.82 kΩ** [1]

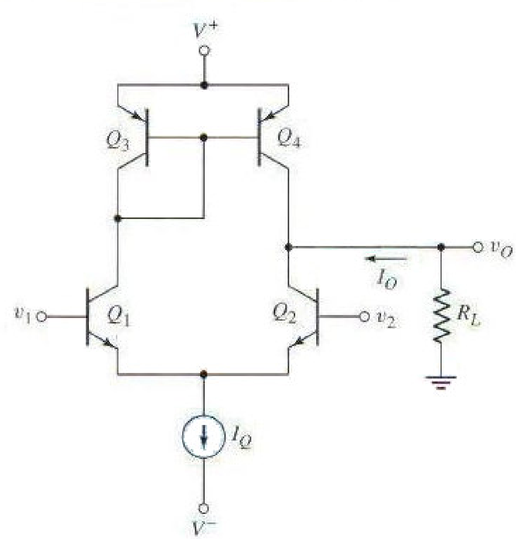

Figure 1

Name: **Dr JBO - Model Answer**
Student ID Number:
Section: 05A / 05B
Lecturer: Dr. Jamaludin Bin Omar

EEEB273 - Quiz 4 [Question Set 1]
SEMESTER 1, ACADEMIC YEAR 2010/2011
Date: 1 September 2010

Question:

The differential amplifier with an active load shown in **Figure 1** is biased with a constant current source of **0.18 mA.** Power supplies for V^+ and V^- are +10 V and -10 V, respectively. Transistor parameters are β = 100 V and V_A = 150 V.

(e) Determine I_O such that the dc currents in the differential amplifier are balanced. [4 marks]

(f) Determine the differential-mode voltage gain if a load resistance R_L = 250 kΩ is connected to the output. [6 marks]

Answer:

(a)

$I_O = I_{B3} + I_{B4}$ [1]
$= I_{C3}/\beta + I_{C4}/\beta = (I_{C3} + I_{C4})/\beta$ [1]
$= (I_Q/2 + I_Q/2)/\beta = I_Q/\beta$ [1]
I_O = (0.18m)/100 = **1.8 µA** [1]

(b)

$A_d = g_m (r_{O2} \| r_{O4} \| R_L)$
$= (g_m)/(1/r_{O2} + 1/r_{O4} + 1/R_L)$ [1]

$g_m = I_{CQ} / V_T = I_Q / (2V_T)$
= (0.18m)/(2x26m) = 3.462 mA/V [1]

$r_{O2} = V_{A2} / I_{CQ} = (2V_{A2})/ I_Q$
= (2x150)/(0.18m) = 1667 kΩ [1]

$r_{O4} = V_{A4} / I_{CQ} = (2V_{A4})/ I_Q$
= (2x150)/(0.18m) = 1667 kΩ [1]

R_L = 250 kΩ

$A_d = g_m (r_{O2} \| r_{O4} \| R_L)$
= (3.462m) (1667k || 1667k || 250k) [1]
= 665.68 kΩ [1]

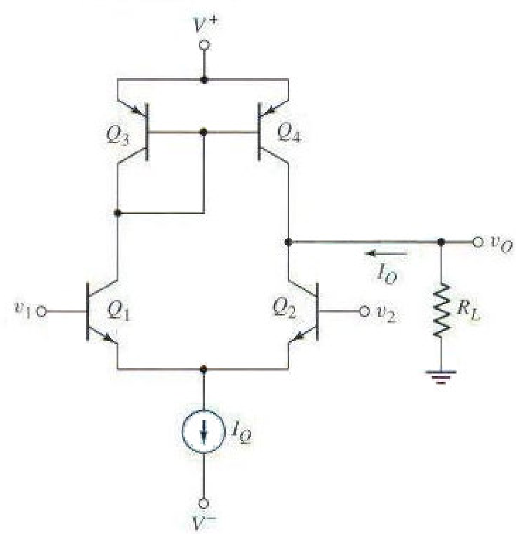

Figure 1

Name:	**Dr JBO - Model Answer**
Student ID Number:	
Section: 05A / 05B	
Lecturer: Dr. Jamaludin Bin Omar	

EEEB273 - Quiz 4 [Question Set 2]
SEMESTER 1, ACADEMIC YEAR 2010/2011
Date: 1 September 2010

Question:

The differential amplifier with an active load shown in **Figure 1** is biased with a constant current source of **0.18 mA.** Power supplies for V^+ and V^- are +10 V and -10 V, respectively. Transistor parameters are β = 120 V and V_A = 150 V.

(g) Determine I_O such that the dc currents in the differential amplifier are balanced. [4 marks]

(h) Determine the differential-mode voltage gain if a load resistance R_L = 470 kΩ is connected to the output. [6 marks]

Answer:

(a)

I_O	$= I_{B3} + I_{B4}$	[1]
	$= I_{C3}/\beta + I_{C4}/\beta = (I_{C3} + I_{C4})/\beta$	[1]
	$= (I_Q/2 + I_Q/2)/\beta = I_Q/\beta$	[1]
I_O	$= (0.18\text{m})/120 = \mathbf{1.5\ \mu A}$	[1]

(b)

A_d	$= g_m (r_{O2} \| r_{O4} \| R_L)$	
	$= (g_m)/(1/r_{O2} + 1/r_{O4} + 1/R_L)$	[1]
g_m	$= I_{CQ} / V_T = I_Q / (2V_T)$	
	$= (0.18\text{m})/(2\text{x}26\text{m}) = 3.462$ mA/V	[1]
r_{O2}	$= V_{A2} / I_{CQ} = (2V_{A2})/ I_Q$	
	$= (2\text{x}150)/(0.18\text{m}) = 1667$ kΩ	[1]
r_{O4}	$= V_{A4} / I_{CQ} = (2V_{A4})/ I_Q$	
	$= (2\text{x}150)/(0.18\text{m}) = 1667$ kΩ	[1]
R_L	$= 470$ kΩ	
A_d	$= g_m (r_{O2} \| r_{O4} \| R_L)$	
	$= (3.462\text{m}) (1667\text{k} \| 1667\text{k} \| 470\text{k})$	[1]
	$= \mathbf{1040.23\ k\Omega}$	[1]

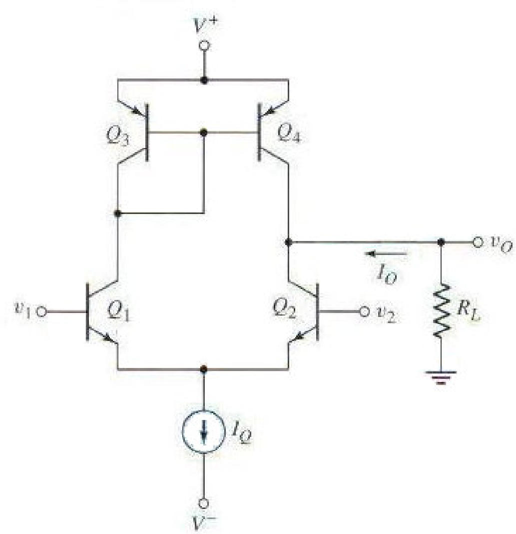

Figure 1