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Section:	01A / 01B
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EEEB273 - Quiz 4 [Question Set 1]
SEMESTER 2, ACADEMIC YEAR 2010/2011
Date: 8 February 2011

Question:

The differential amplifier as shown in **Figure 1** has a pair of PMOS transistors as input devices and a pair of NMOS transistors connected as an active load. The circuit is biased with I_Q = **0.2 mA,** and the transistor parameters are: $K_n = K_p$ = 0.1 mA/V^2, λ_n = 0.01 V^{-1}, λ_p = 0.015 V^{-1}, V_{TN} = 1 V, and V_{TP} = -1 V.

(a) Find the open-circuit differential-mode voltage gain, A_d. [5 marks]

(b) Calculate the output resistance, R_O, of the circuit. [5 marks]

Answer:

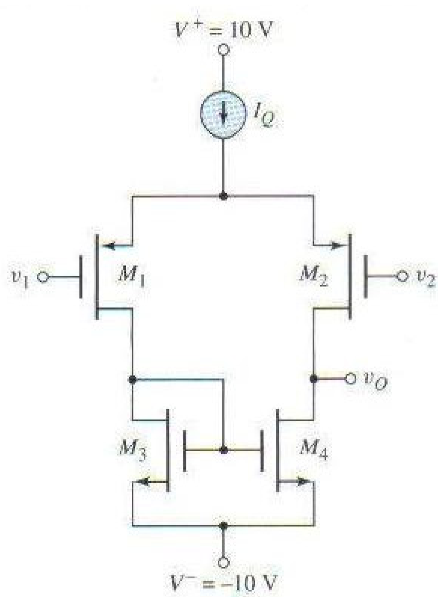

Figure 1

(a)

$$g_{m2} = 2\sqrt{K_p I_{DQ2}} = 2\sqrt{K_p (I_Q/2)}$$ **[1]**

$$g_{m2} = 2\sqrt{(0.1m)(0.1m)} = 0.2mA/V$$

r_{o2} = $1/(\lambda_p I_{DQ2}) = 1/(\lambda_p (I_Q/2))$
= 1/((0.015)(0.1m)) = 0.667 MΩ **[1]**

r_{o4} = $1/(\lambda_n I_{DQ4}) = 1/(\lambda_n (I_Q/2))$
= 1/((0.01)(0.1m)) = 1 MΩ **[1]**

A_d = $g_{m2}(r_{o2} \parallel r_{o4})$ **[1]**
= (0.2m)(0.667M ǁ 1M)
= 80 **[1]**

(b)

r_{o2} = $1/(\lambda_p I_{DQ2}) = 1/(\lambda_p (I_Q/2))$
= 1/((0.015)(0.1m)) = 0.667 MΩ **[1.5]**

r_{o4} = $1/(\lambda_n I_{DQ4}) = 1/(\lambda_n (I_Q/2))$
= 1/((0.01)(0.1m)) = 1 MΩ **[1.5]**

R_O = $r_{o2} \parallel r_{o4}$
= 0.667M ǁ 1M = 400 kΩ **[2]**

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EEEB273 - Quiz 4 [Question Set 2]
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Date: 8 February 2011

Question:

The differential amplifier as shown in **Figure 1** has a pair of PMOS transistors as input devices and a pair of NMOS transistors connected as an active load. The circuit is biased with I_Q = **0.3 mA,** and the transistor parameters are: $K_n = K_p$ = 0.1 mA/V^2, λ_n = 0.015 V^{-1}, λ_p = 0.01 V^{-1}, V_{TN} = 1 V, and V_{TP} = -1 V.

(c) Find the open-circuit differential-mode voltage gain, A_d. [5 marks]

(d) Calculate the output resistance, R_O, of the circuit. [5 marks]

Answer:

(a)

$$g_{m2} = 2\sqrt{K_p I_{DQ2}} = 2\sqrt{K_p (I_Q/2)}$$
$$g_{m2} = 2\sqrt{(0.1m)(0.15m)} = 0.245 mA/V \quad [1]$$

r_{o2} = $1/(\lambda_p I_{DQ2}) = 1/(\lambda_p (I_Q/2))$
= 1/((0.01)(0.15m)) = 0.667 MΩ **[1]**

r_{o4} = $1/(\lambda_n I_{DQ4}) = 1/(\lambda_n (I_Q/2))$
= 1/((0.015)(0.15m)) = 0.444 MΩ **[1]**

A_d = $g_{m2}(r_{o2} \parallel r_{o4})$
= (0.245m)(0.667M ‖ 0.444M)
= 65.3 **[2]**

(b)

r_{o2} = $1/(\lambda_p I_{DQ2}) = 1/(\lambda_p (I_Q/2))$
= 1/((0.01)(0.15m)) = 0.667 MΩ **[1.5]**

r_{o4} = $1/(\lambda_n I_{DQ4}) = 1/(\lambda_n (I_Q/2))$
= 1/((0.015)(0.15m)) = 0.444 MΩ **[1.5]**

R_O = $r_{o2} \parallel r_{o4}$
= 0.667M ‖ 0.444M = 266.7 kΩ **[2]**

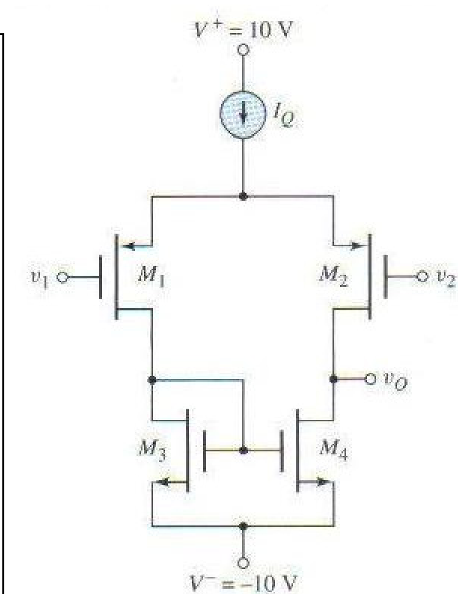

Figure 1