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

EEEB273 - Quiz 4
SEMESTER 2, ACADEMIC YEAR 2015/2016
Date: 14 December 2015 Time: 15 minutes

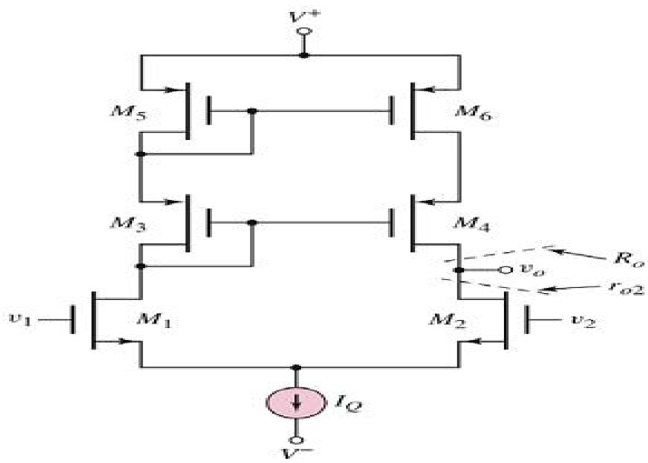
Question:

For a **MOSFET** differential amplifier with **cascode active load** shown in **Figure 1** the transistor parameters are g_m **= 1.2 mA/V** for all transistors**;** K_n **= 0.4 mA/V^2** and λ_n = **0.020 V^{-1}** for **N-MOSFET** transistors**;** and λ_p = **0.015 V^{-1}** for **P-MOSFET** transistors.

Find bias current (I_Q) and **calculate** one-sided differential mode gain (A_d) with output taken at v_o**. Show clearly** all formula used and calculations done as marks are given according to this.

[10 marks]

Answer:



; N – MOSFET

$$v_{DS}(\text{sat}) = v_{GS} - V_{TN}$$

$$i_D = K_n[v_{GS} - V_{TN}]^2$$

$$K_n = \frac{k_n'}{2} \cdot \frac{W}{L}$$

; P – MOSFET

$$v_{SD}(\text{sat}) = v_{SG} + V_{TP}$$

$$i_D = K_p[v_{SG} + V_{TP}]^2$$

$$K_p = \frac{k_p'}{2} \cdot \frac{W}{L}$$

; Small signal

$$g_m = 2\sqrt{K_? I_{DQ}}$$

$$r_o \cong \frac{1}{\lambda I_{DQ}}$$

g_m	$= 2\sqrt{[K_{n2} \times I_{DQ}]}$	
	$= 2\sqrt{[K_{n2} \times (I_Q/2)]}$	
I_Q	$= [g_m / 2]^2 \times [2 / K_{n2}]$	[1]
	$= [g_m]^2 / [2 K_{n2}]$	
	$= [1.2\text{m}]^2 / [2 \times 0.4\text{m}] = 1.8$ mA	[1]
I_{DQ}	$= I_Q / 2 = 0.9$ mA	[1]
r_{o2}	$= 1 / (\lambda_n I_{DQ})$	[1]
	$= 1 / (0.020 \times 0.9\text{m}) = 55.556$ kΩ	[1]
r_{o4}	$= r_{o6} = 1 / (\lambda_p I_{DQ})$	[1]
	$= 1 / (0.015 \times 0.9\text{m}) = 74.074$ kΩ	[1]
R_O	$= g_m r_{o4} r_{o6}$	
	$= (1.2\text{m})(74.074\text{k})(74.074\text{k})$	
	$= 6.584$ MΩ	[1]
A_d	$= g_m (r_{o2} \parallel R_O)$	[1]
	$= (1.2\text{m})(55.556\text{k} \parallel 6.584\text{M})$	
	$= 66.109$ V/V	[1]

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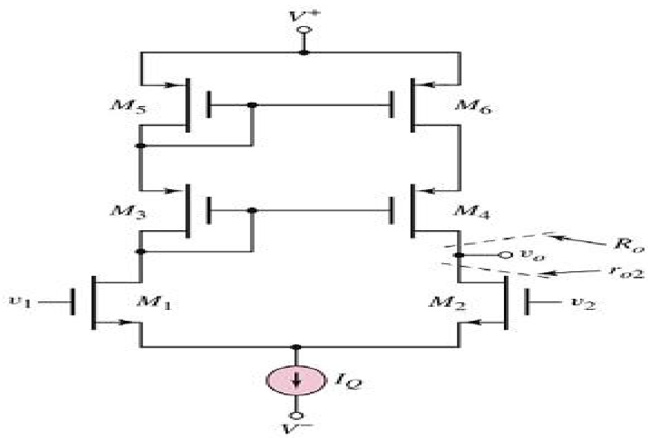
Question:

For a **MOSFET** differential amplifier with **cascode active load** shown in **Figure 1** the transistor parameters are $\boldsymbol{g_m}$ **= 1.3 mA/V** for all transistors**;** $\boldsymbol{K_n}$ **= 0.4 mA/V**^{2} and $\boldsymbol{\lambda_n}$ = **0.015 V**$^{-1}$ for **N-MOSFET** transistors**;** and $\boldsymbol{\lambda_p}$ = **0.020 V**$^{-1}$ for **P-MOSFET** transistors.

Find bias current (I_Q) and **calculate** one-sided differential mode gain ($\boldsymbol{A_d}$) with output taken at $\boldsymbol{v_o}$**. Show clearly** all formula used and calculations done as marks are given according to this.

[10 marks]

Answer:



; N – MOSFET

$$v_{DS}(\text{sat}) = v_{GS} - V_{TN}$$

$$i_D = K_n [v_{GS} - V_{TN}]^2$$

$$K_n = \frac{k_n'}{2} \cdot \frac{W}{L}$$

; P – MOSFET

$$v_{SD}(\text{sat}) = v_{SG} + V_{TP}$$

$$i_D = K_p [v_{SG} + V_{TP}]^2$$

$$K_p = \frac{k_p'}{2} \cdot \frac{W}{L}$$

; Small signal

$$g_m = 2\sqrt{K_? I_{DQ}}$$

$$r_o \cong \frac{1}{\lambda I_{DQ}}$$

g_m = 2 √ [K_{n2} x I_{DQ}]
= 2 √ [K_{n2} x (I_Q/2)]

I_Q = [g_m / 2]^2 x [2 / K_{n2}] **[1]**
= [g_m]^2 / [2 K_{n2}]
= [1.3m]^2 / [2 x 0.4m] = 2.113 mA **[1]**

I_{DQ} = I_Q / 2 = 1.056 mA **[1]**

r_{o2} = 1 / (λ_n I_{DQ}) **[1]**
= 1 / (0.015 x 1.056m) = 63.116 kΩ **[1]**

r_{o4} = r_{o6} = 1 / (λ_p I_{DQ}) **[1]**
= 1 / (0.020 x 1.056m) = 47.337 kΩ **[1]**

R_O = g_m r_{o4} r_{o6}
= (1.3m)(47.337k)(47.337k)
= 2.913 MΩ **[1]**

A_d = g_m (r_{o2} || R_O) **[1]**
= (1.3m)(63.116k || 2.913M)
= 80.311 V/V **[1]**

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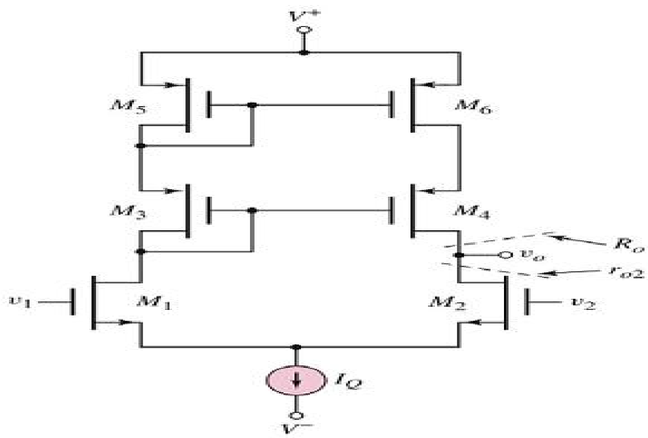
Question:

For a **MOSFET** differential amplifier with **cascode active load** shown in **Figure 1** the transistor parameters are g_m **= 1.4 mA/V** for all transistors**;** K_n **= 0.4 mA/V^2** and λ_n = **0.020 V^{-1}** for **N-MOSFET** transistors**;** and λ_p = **0.015 V^{-1}** for **P-MOSFET** transistors.

Find bias current (I_Q) and **calculate** one-sided differential mode gain (A_d) with output taken at v_o**. Show clearly** all formula used and calculations done as marks are given according to this.

[10 marks]

Answer:



; N – MOSFET

$$v_{DS}(\text{sat}) = v_{GS} - V_{TN}$$

$$i_D = K_n[v_{GS} - V_{TN}]^2$$

$$K_n = \frac{k_n'}{2} \cdot \frac{W}{L}$$

; P – MOSFET

$$v_{SD}(\text{sat}) = v_{SG} + V_{TP}$$

$$i_D = K_p[v_{SG} + V_{TP}]^2$$

$$K_p = \frac{k_p'}{2} \cdot \frac{W}{L}$$

; Small signal

$$g_m = 2\sqrt{K_? I_{DQ}}$$

$$r_o \cong \frac{1}{\lambda I_{DQ}}$$

g_m	$= 2\sqrt{[K_{n2} \times I_{DQ}]}$	
	$= 2\sqrt{[K_{n2} \times (I_Q/2)]}$	
I_Q	$= [g_m/2]^2 \times [2/K_{n2}]$	[1]
	$= [g_m]^2 / [2 K_{n2}]$	
	$= [1.4\text{m}]^2 / [2 \times 0.4\text{m}] = 2.450$ mA	[1]
I_{DQ}	$= I_Q/2 = 1.225$ mA	[1]
r_{o2}	$= 1/(\lambda_n I_{DQ})$	[1]
	$= 1/(0.020 \times 1.225\text{m}) = 40.816$ kΩ	[1]
r_{o4}	$= r_{o6} = 1/(\lambda_p I_{DQ})$	[1]
	$= 1/(0.015 \times 1.225\text{m}) = 54.422$ kΩ	[1]
R_O	$= g_m r_{o4} r_{o6}$	
	$= (1.4\text{m})(54.422\text{k})(54.422\text{k})$	
	$= 4.146$ MΩ	[1]
A_d	$= g_m (r_{o2} \parallel R_O)$	[1]
	$= (1.4\text{m})(40.816\text{k} \parallel 4.146\text{M})$	
	$= 56.586$ V/V	[1]

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Date: 14 December 2015 Time: 15 minutes

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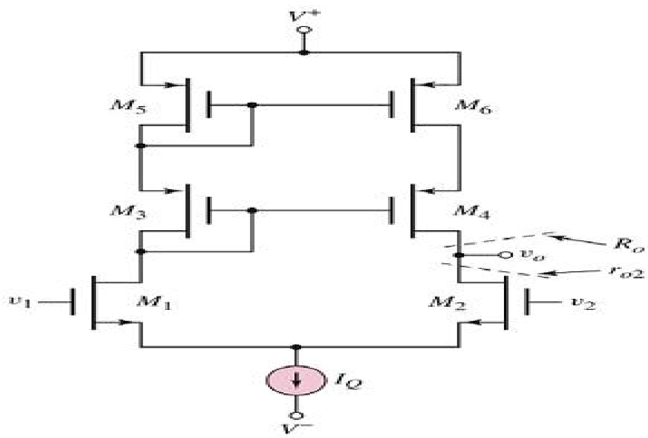
Question:

For a **MOSFET** differential amplifier with **cascode active load** shown in **Figure 1** the transistor parameters are g_m **= 1.5 mA/V** for all transistors; K_n **= 0.4 mA/V**^{2} and λ_n = **0.015 V**$^{-1}$ for **N-MOSFET** transistors; and λ_p = **0.020 V**$^{-1}$ for **P-MOSFET** transistors.

Find bias current (I_Q) and **calculate** one-sided differential mode gain (A_d) with output taken at v_o. **Show clearly** all formula used and calculations done as marks are given according to this.

[10 marks]

Answer:



; N – MOSFET

$$v_{DS}(\text{sat}) = v_{GS} - V_{TN}$$

$$i_D = K_n[v_{GS} - V_{TN}]^2$$

$$K_n = \frac{k_n'}{2} \cdot \frac{W}{L}$$

; P – MOSFET

$$v_{SD}(\text{sat}) = v_{SG} + V_{TP}$$

$$i_D = K_p[v_{SG} + V_{TP}]^2$$

$$K_p = \frac{k_p'}{2} \cdot \frac{W}{L}$$

; Small signal

$$g_m = 2\sqrt{K_{?} I_{DQ}}$$

$$r_o \cong \frac{1}{\lambda I_{DQ}}$$

g_m = 2 √ [K_{n2} x I_{DQ}]
= 2 √ [K_{n2} x (I_Q/2)]

I_Q = [g_m / 2]^2 x [2 / K_{n2}] [1]
= [g_m]^2 / [2 K_{n2}]
= [1.5m]^2 / [2 x 0.4m] = 2.813 mA [1]

I_{DQ} = I_Q / 2 = 1.406 mA [1]

r_{o2} = 1 / (λ_n I_{DQ}) [1]
= 1 / (0.015 x 1.406m) = 47.407 kΩ [1]

r_{o4} = r_{o6} = 1 / (λ_p I_{DQ}) [1]
= 1 / (0.020 x 1.406m) = 35.556 kΩ [1]

R_O = g_m r_{o4} r_{o6}
= (1.5m)(35.556k)(35.556k)
= 1.896 MΩ [1]

A_d = g_m (r_{o2} || R_O) [1]
= (1.5m)(47.407k || 1.896M)
= 69.377 V/V [1]