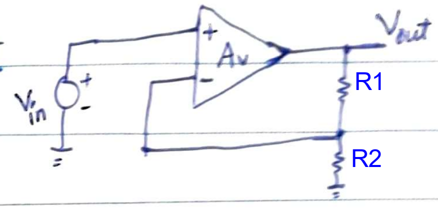
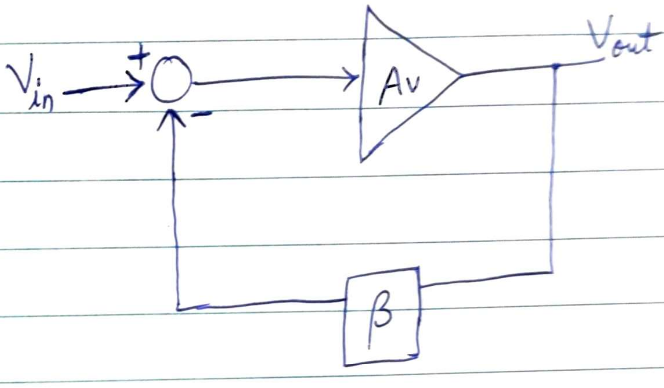
EE 204 : Analog Circuits

Assignment 1 : Solution

1





$$\text{Gain} = \frac{V_{out}}{V_{in}} = \frac{A_v}{1 + A_v\beta}$$

where, $\beta = \frac{R2}{R1 + R2}$

(a) $$\text{Gain} = \frac{A_v}{1 + A_v\beta} = \frac{10^4}{1 + 10^4 \times 0.1} = \boxed{9.99}$$

[1 Mark]

OR

$$\text{Gain} = \frac{A_v}{1 + A_v\beta} \approx \frac{1}{\beta} \quad (\because A_v\beta >> 1) = \frac{1}{0.1} = \boxed{10}$$

[1 Mark]

(b) $V_{out} = \text{Gain} \times V_{in}$

$= 9.99 \times 0.15$

$= \boxed{1.4985\ V}$ [1 Mark]

OR

$V_{out} = \text{Gain} \times V_{in}$

$= 10 \times 0.15$ [1 Mark]

$= \boxed{1.5\ V}$

(c) Voltage at (−)ve terminal $= \beta \times V_{out}$

$= 0.1 \times 1.4985$

$\boxed{= 0.14985\ V}$

[1 mark]

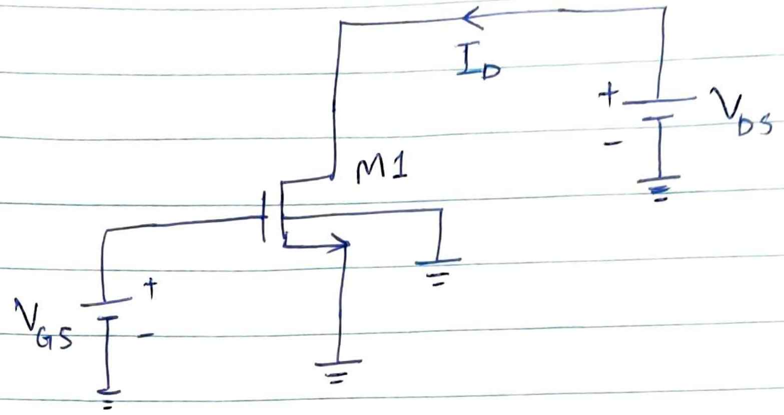
OR

Voltage at (−)ve terminal $= \beta \times V_{out}$

$= 0.1 \times 1.5$

$\boxed{= 0.15\ V}$ [1 Mark]

2



$$\left(\frac{W}{L}\right)_{M1} = \frac{3\,\mu m}{1\,\mu m}$$

$$0 < V_{GS} < 1.8\,V$$

$$V_t = 0.4\,V$$

$$0 < V_{DS} < 1.8\,V$$

$$\mu C_{ox} = 260\,\mu A/V^2$$

(a)

(i) $V_{GS} < 0.4\,V$, $0 < V_{DS} < 1.8\,V$ [0.5 Marks]

(ii) $0.4 < V_{GS} < 1.8\,V$, $0 < V_{DS} < V_{GS} - V_t$ [0.5 Marks]

(iii) $0.4 < V_{GS} < 1.8\,V$, $V_{DS} > V_{GS} - V_t$ [0.5 Marks]

(b) $$I_D \Big|_{\text{ohmic region}} = \mu C_{ox} \frac{W}{L} \left[(V_{GS} - V_t) V_{DS} - \frac{V_{DS}^2}{2} \right]$$

$$I_D \Big|_{\text{saturation region}} = \frac{1}{2} \mu C_{ox} \frac{W}{L} \left[V_{GS} - V_t \right]^2$$

[0.5] Marks of each Correct Calculation

2(b) Sample Calculations :-

Set 1 : $V_{GS} = 0.6\ V$

Ohmic region calculations :-

$$V_{DS} < V_{GS} - V_t$$
$$V_{DS} < 0.6 - 0.4\ V$$
$$V_{DS} < 0.2\ V$$

[0.5 Marks] Point 1 : $V_{DS} = 0.15\ V$

$$I_D = \mu C_{ox} \frac{W}{L} \left[(V_{GS} - V_t) V_{DS} - \frac{V_{DS}^2}{2} \right]$$

$$= 260 \times 3 \times \left[(0.6 - 0.4) \times 0.15 - \frac{0.15^2}{2} \right] \mu A$$

$$= 14.625\ \mu A$$

[0.5 Marks] point 2 : $V_{DS} = 0.08\ V$

$$I_D = \mu_n C_{ox} \frac{W}{L} \left[(V_{GS} - V_t) V_{DS} - \frac{V_{DS}^2}{2} \right]$$

$$= 260 \times 3 \times \left[(0.6 - 0.4) \times 0.08 - \frac{0.08^2}{2} \right] \mu A$$

$$= 9.984\ \mu A$$

Saturation Region Calculations :-

$$V_{DS} > V_{GS} - V_t$$

$$V_{DS} > 0.6 - 0.4 \text{ V}$$

$$V_{DS} > 0.2 \text{ V}$$

[0.5 Marks] point 1 : $V_{DS} = 0.4\text{V}$

$$I_D = \frac{1}{2} \mu C_{ox} \frac{W}{L} (V_{GS} - V_t)^2$$

$$= \frac{1}{2} \times 260 \times 3 \times (0.6 - 0.4)^2 \ \mu\text{A}$$

$$= 15.6 \ \mu\text{A}$$

[0.5 Marks] point 2 : $V_{DS} = 0.8\text{V}$

$$I_D = \frac{1}{2} \mu C_{ox} \frac{W}{L} (V_{GS} - V_t)^2$$

$$= \frac{1}{2} \times 260 \times 3 \times (0.6 - 0.4)^2 \ \mu\text{A}$$

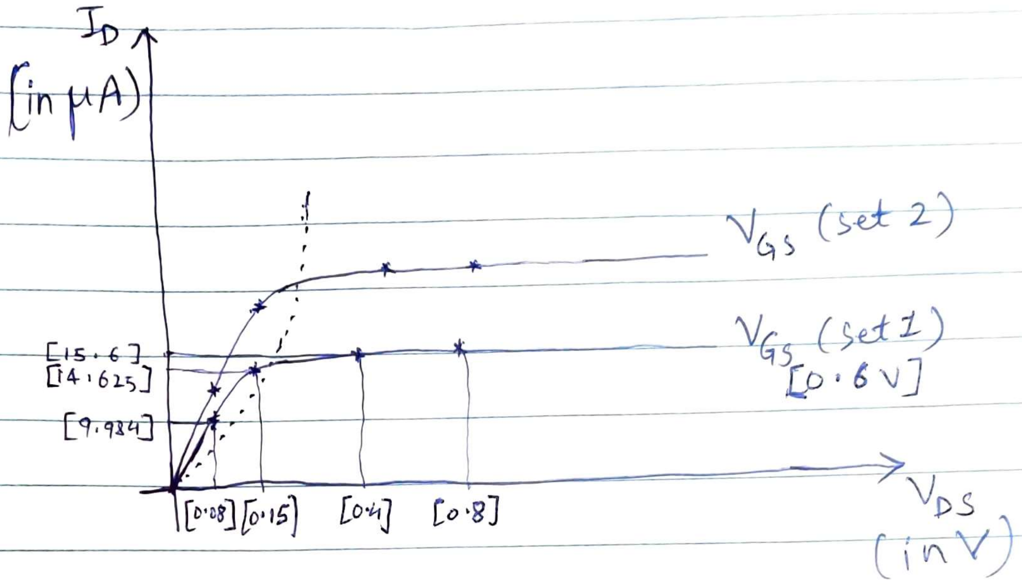
$$= 15.6 \ \mu\text{A}$$

Similarily for Set 2 there will be 4 points [0.5 Marks] for each calculation.

Then fill in the Table.

	Set 1 $V_{GS} = 0.6\ V$		Set 2 $V_{GS} =$	
	V_{DS} (in V)	I_D (in μA)	V_{DS} (in V)	I_D (in μA)
Ohmic	0.08	9.984		
	0.15	14.625		
Saturation	0.4	15.6		
	0.8	15.6		

(c)



Correct sketch [1 Mark]
points on graph [0.5 Marks]

Note: Values on graph in [ ] brackets are only sample calculations of part (b).