

## Mosfet problem 11

$$V_T = 0.2V$$

$$k_n = 4 \text{ mA/V}^2$$

$$V_{G1} = 2V$$

assume: saturation

$$V_{GS} = 2V > V_T$$

$$\begin{aligned}\therefore i_d &= \frac{k_n}{2} V_{OV}^2 = \frac{k_n}{2} (V_{GS} - V_T)^2 \\ &= \frac{4}{2} (2 - 0.2)^2 \\ &= 6.48 \text{ mA}\end{aligned}$$

$$\therefore V_{D2} = 2 - 1 \times 6.48 = -4.48V$$

$\therefore$  assumption wrong

assume: triode

$$\begin{aligned}V_{GS} = 2V > V_T \quad \therefore i_d &= k(V_{OV} V_{DS} - \frac{1}{2} V_{DS}^2) \\ &= k((V_{GS} - V_T) V_{DS} - \frac{1}{2} V_{DS}^2) \\ &= 4(1.8 V_{DS} - \frac{1}{2} V_{DS}^2)\end{aligned}$$

$$\Rightarrow \frac{2 - V_{O2}}{1} = 4 \left( 1.8 V_{O2} - \frac{1}{2} V_{O2}^2 \right)$$

$$\Rightarrow V_{O2} = 0.26 \text{ or } 3.84$$

$$\therefore V_{O2} = 0.26 \text{ V}$$

$$\therefore V_{DS} = 0.26 < V_{OV} = V_{GS} - V_T = 1.8$$

$$\therefore I_D = \frac{2 - 0.26}{1} = 1.74 \text{ mA}$$

mosfet 12

$$V_T = 0.5, k_n = 1.6$$

assume: saturation

$$V_D = V_G$$

$$V_S = 0$$

$$\therefore i_D = \frac{k}{2} (V_{GS} - V_T)^2$$

$$\Rightarrow \frac{1.8 - V_D}{13.9} = \frac{1.6}{2} (V_D - 0.5)^2$$

$$\therefore V_D = 0.11 \text{ or } 0.79$$

$$\therefore V_D = 0.79$$

$$\therefore V_{GS} - V_T = V_G - V_T = 0.79 - 0.5 = 0.29V$$

$$\therefore V_D > V_{GS} - V_T$$

$\therefore$  assumption correct.

## mosfet 14

a) assume: saturation

$$1 = \frac{0.5}{2} (V_{GS} - V_T)^2$$

$$\Rightarrow 1 = 0.25 (-V_S - 0.8)^2$$

$$\therefore V_S = 1.2, -2.8$$

$$V_{GS} = -2.8 > V_T$$

$$\therefore V_{DS} = 5 + 2.8 = 7.8 \text{ V}$$

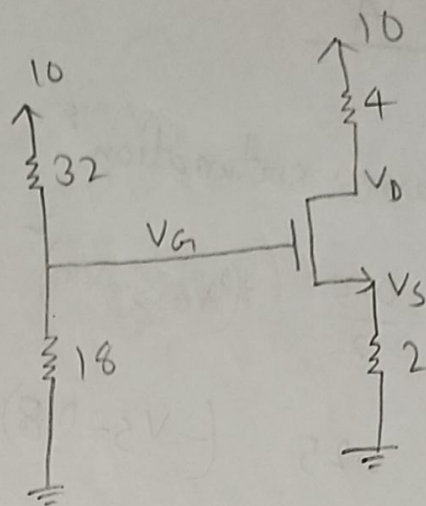
$$\therefore V_{GS} - V_T = 2.8 - 0.8 = 2 \text{ V}$$

$$\therefore V_{DS} > V_{OV}$$

$\therefore$  assumption correct.

mosfet 17

$$V_{G1} = \frac{18}{32+18} \times 10$$
$$= 3.6V$$



assume: saturation  $[V_{DS} \geq V_{OV}]$

$$i_d = \frac{K}{2} V_{OV}^2$$

$$\Rightarrow \frac{V_S}{2} = \frac{K}{2} (V_{G1} - V_T)^2$$

$$\Rightarrow V_S = 0.5 (3.6 - V_S - 0.8)^2$$

$$\therefore V_S = 1.23 \text{ or } 6.37$$

$\checkmark$                        $\times$

$$\therefore i_d = \frac{1.23}{2} = 0.62 \text{ mA}$$

$$\therefore V_D = 10 - 0.62 \times 4 = 7.252$$

$$\therefore V_{DS} = 6.29$$

$$\therefore V_{OV} = V_{G1} - V_T = 3.6 - 1.23 - 0.8 = 1.57$$

$$\therefore V_{DS} > V_{OV} \quad [\text{assumption correct}]$$

mosfet 20

assume both mosfet in saturation

for first mosfet

$$i_d = \frac{5}{2} (V_{GS} - V_T)^2$$
$$= \frac{5}{2} (V_{D1} - V_{D2} - V_T)^2 \quad \text{--- (I)}$$

for second mosfet

$$i_d = \frac{5}{2} (V_{GS} - V_T)^2$$
$$= \frac{5}{2} (V_{D2} - V_T)^2 \quad \text{--- (II)}$$

$$i_d = \frac{2.5 - V_{D1}}{2.8} \quad \text{--- (III)}$$

$$\textcircled{I}, \textcircled{II} \Rightarrow V_{D1} - V_{D2} - V_T = \pm (V_{D2} - V_T)$$

$$(+), V_{D1} - V_{D2} - V_T = V_{D2} - V_T$$

$$\Rightarrow V_{D1} - 2V_{D2} = 0$$

$$(-), V_{D1} - V_{D2} - V_T = -V_{D2} + V_T$$

$$\Rightarrow V_{D1} = 2V_T = 2V$$

0.178

mosfet 21

assume both in saturation

$$\therefore \frac{k_n}{2} (V_{G1S} - V_T)^2 = \frac{k_n}{2} (0 - V_2 - V_T)^2$$

$$\Rightarrow (2.5 - V_1 - 1)^2 = (V_2 + 1)^2$$

$$\Rightarrow (1.5 - V_1) = \pm (V_2 + 1)$$

(+)

$$1.5 - V_1 = V_2 + 1$$

$$\Rightarrow V_1 + V_2 = 0.5 \quad \text{--- (I)}$$

(-)

$$1.5 - V_1 = -V_2 - 1$$

$$\Rightarrow V_1 - V_2 = 2.5 \quad \text{--- (II)}$$

assume active

$$-15 + 4i_b + 4i_c - 1 + 50i_b$$

$$+ 0.7 + 3i_e + 1 = 0$$

$$\Rightarrow 4i_b + 400i_b + 50i_b$$

$$+ 30i_b = 14.3$$

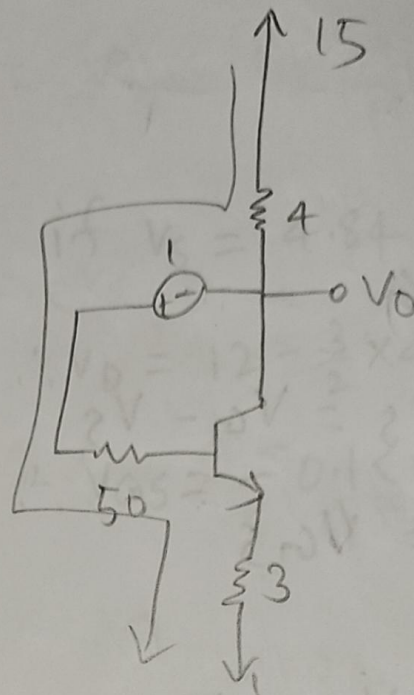
$$\Rightarrow i_b = 0.0189 \text{ mA}$$

$$V_c = 15 - 4(i_b + 100i_b)$$

$$= 7.34 \text{ V}$$

$$V_e = 3 \times i_b \times 101 + 1 = 6.73$$

$$\therefore V_{CE} = 0.61 > 0.2$$



$$\beta = 100$$

for

$m_2$

$$V_D = V_G$$

$$\Rightarrow V_D - V_S = V_G - V_S$$

$$\Rightarrow V_{DS} = V_{GS}$$

$$\therefore V_{DS} > V_{GS} - V_T$$

$m_2$  is in saturation)

$$\therefore i_{D2} = \frac{K}{2} (V_{GS} - V_T)^2$$

$$\Rightarrow \frac{V_S}{4} = \frac{2}{2} (V_D - V_S - 1)^2$$

$$\Rightarrow \frac{V_S}{4} = \left(12 - \frac{3}{2} V_S - V_S - 1\right)^2$$

$$\Rightarrow \frac{V_S}{4} = \left(11 - \frac{5}{2} V_S\right)^2 = 121 - 55 V_S + \frac{25}{4} V_S^2$$

$$\Rightarrow V_A = 484 - 220 V_S + 25 V_S^2 \Rightarrow 25 V_S^2 - 221 V_S + 484 = 0$$

$$i_{D2} = \frac{12 - V_D}{\frac{1}{\beta_3}} = \frac{V_S}{\frac{1}{\beta_2}}$$

$$\Rightarrow 24 - 2V_D = 3V_S$$

$$\Rightarrow V_D = \frac{24 - 3V_S}{2}$$

$$= 12 - \frac{3}{2} V_S$$

$$\therefore V_S = 4, 4.84$$

if  $V_S = 4,$

$$\therefore V_D = 12 - \frac{3}{2} \times 2 = 6$$

$$V_{GS} = 6 - 4 = 2 > V_T$$

$$\therefore V_{DS} = 2 > V_{GS} - V_T$$

$$I_{RD1} = \frac{12-6}{6} = 1$$

for  $m_1,$

$$V_G = 6V$$

$$V_S = 0$$

assume : triode

$$i_D = k \left( V_{ov} V_{DS} - \frac{1}{2} V_{DS}^2 \right)$$

$$\Rightarrow 5 - V_D = k \left( (V_{GS} - V_T)(V_D - V_S) - \frac{1}{2} (V_D - V_S)^2 \right)$$

$$\Rightarrow 5 - V_D = \frac{1}{2} \left( (6-1)V_D - \frac{1}{2} V_D^2 \right)$$

$$\Rightarrow 10 - 2V_D = 5V_D - \frac{1}{2} V_D^2$$

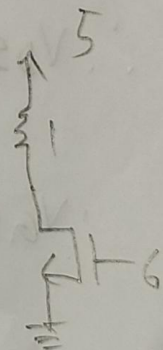
$$\Rightarrow \frac{1}{2} V_D^2 - 7V_D + 10 = 0$$

$$\Rightarrow V_D^2 - 14V_D + 20 = 0$$

if  $V_S = 4.84$

$$\therefore V_D = 12 - \frac{3}{2} \times 4.84 = 4.74$$

$$\therefore V_{GS} = -0.1 < V_T$$



$$V_D = 12.38, 1.61$$

$$\therefore V_{DS} = 1.61 < V_{GS} - V_T$$

$$\therefore I_{D2} = 5 - 1.61 = 3.39 \text{ mA}$$

4s.

$$\frac{1}{2}K(V_{GS}-V_{TS})^2 + \frac{2(5-V_{GS})}{1} = \frac{V_{GS}}{2}$$

$$\Rightarrow (4-V_S)^2 + 10 - 2V_S = V_S$$

$$\Rightarrow 16 - 8V_S + V_S^2 + 10 - 3V_S = 0$$

$$\Rightarrow V_S^2 - 11V_S + 26 = 0$$

$$\therefore V_S = 7.56, 3.43$$

X                      ✓

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

$$\therefore V_{DS} = 6 - 3.43 = 2.57$$

$$\therefore V_{GS} - V_T = 5 - 3.43 - 1 = 0.57$$

$$\therefore V_{DS} > V_{GS} - V_T$$

c) assume: saturation

$$-10 + 4i_b + 0.8 + i_e \neq 0$$

$$\Rightarrow 4i_b + i_e = 9.2 \quad \text{--- (I)}$$

$$-10 + i_e - i_b + 0.2 + i_e = 0$$

$$\Rightarrow -i_b + 2i_e = 9.8 \quad \text{--- (II)}$$

$$\textcircled{I}, \textcircled{II} \Rightarrow i_b = 0.95$$

$$i_e = 5.37$$

$$\therefore \frac{i_e}{i_b} = \frac{5.37 - 0.95}{0.95} = 4.65 < \beta$$

$$\therefore V_c = 10 - (5.37 - 0.95) = 5.58$$

$$\therefore V_e = 5.37$$