CSE251 ASSIGNMENT 3

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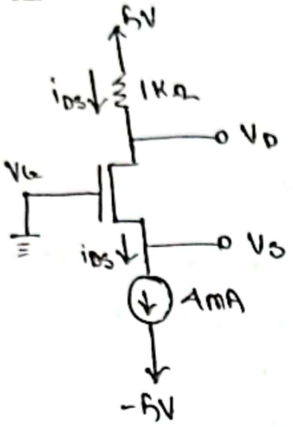
SECTION: 12

CamScanner

(1) Part a.



(a) $V_G = 0V$, $i_{DS} = 4mA$

(b) $I_{DS} = \frac{5 - V_D}{1}$

$4 = 5 - V_D$

$V_D = 1\,V$

(c) Let the mosfet be in saturation region.

$I_{DS} = \frac{1}{2} K V_{OC}^2$

$= \frac{1}{2} K (V_{GS} - V_{TN})^2$

$= \frac{1}{2}(4)[(0 - V_S) - 1]^2$

$4 = \frac{1}{2}(4)[-V_S - 1]^2$

$2 = (-V_S - 1)^2$

$2 = V_S^2 + 2V_S + 1$

$V_S^2 + 2V_S - 1 = 0$

$V_S = -1+\sqrt{2}, V_S = -1-\sqrt{2}$

Here,

$V_{GS} = V_G - V_S$
$= 0 - (-1+\sqrt{2})$
$= -0.41 \ngtr 1$ ✗

$V_{DS} = V_D - V_S$
$= 1 - (-1+\sqrt{2})$
$= 0.586 \ngtr 1.41$ ✗

$V_{OC} = (V_G - V_S) - V_T$
$= (-1+\sqrt{2}) - 1$
$= \sqrt{2} = 1.41$

$V_{GS} = V_G - V_S$
$= 0 - (-1-\sqrt{2})$
$= 2.41 > 1$ ✓

$V_{DS} = V_D - V_S$
$= 1 - (-1-\sqrt{2})$
$= 3.41 > -3.14$ ✓

$\therefore$ The assumption is correct.

$\therefore V_S = -1-\sqrt{2} = -2.41$ V

$V_{OC} = (V_G - V_S) - 1$
$= (-1-\sqrt{2}) - 1$
$= -3.14$

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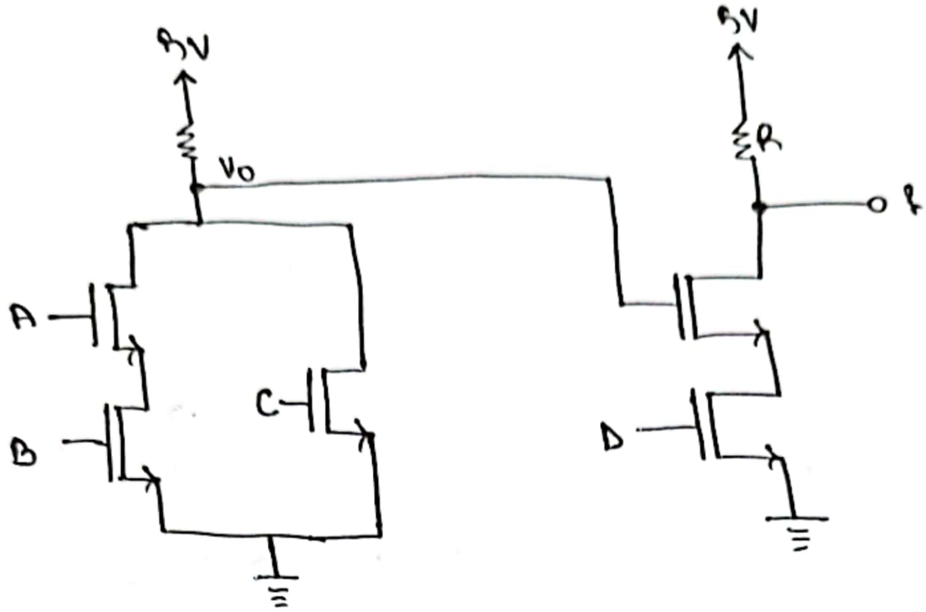
Part b



$V_o = \overline{AB + C}$

$f = \overline{(\overline{AB+C})D}$

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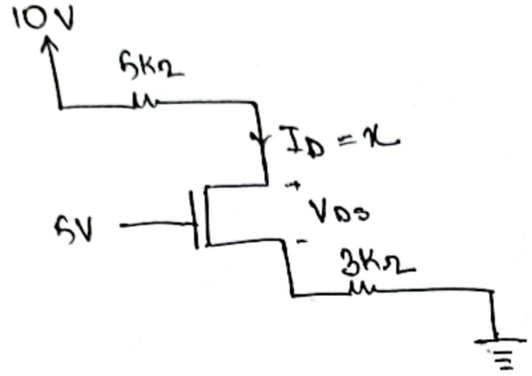
(2)



$$I_D = \frac{10 - V_D}{5} \Rightarrow x = \frac{10 - V_D}{5}$$

$$\Rightarrow V_D = 10 - 5x$$

$$I_D = \frac{V_S - 0}{3} \Rightarrow x = \frac{V_S}{3}$$

$$\Rightarrow V_S = 3x$$

Let the mosfet be in the saturation region

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

$$= \frac{1}{2} K \left[(V_G - V_S) - V_T\right]^2$$

$$= \frac{1}{2}(2)\left[(5 - 3x) - 1\right]^2$$

$$I_D = (4 - 3x)^2$$

$$x = (4 - 3x)^2$$

$$x = 9x^2 - 24x + 16$$

$$9x^2 - 25x + 16 = 0$$

$$x = 1.778,\ x = 1$$

$x = 1.778$

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

$= [5 - 3(1.778) - 1]$

$V_{DS} = -\frac{4}{3} = -1.333$

$x = 1$

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

$= (5 - 3) - 1$

$V_{DS} = 1$

$u = 1.778$

$V_{GS} = V_G - V_S$

$= 5 - 3(1.778)$

$= -\frac{1}{3} \ngtr 1$ ✗

$V_{DS} = V_D - V_S$

$= (10 - 5u) - 3u$

$= [10 - 5(1.778)] - 3(1.778)$

$= -4.33 \ngtr -1.33$ ✗

$u = 1$

$V_{GS} = V_G - V_S$

$= 5 - 3(1)$

$= 2 > 1$ ✓

$V_{DS} = V_D - V_S$

$= (10 - 5) - 3(1)$

$= 2 \geq 1$ ✓

∴ The assumption is correct

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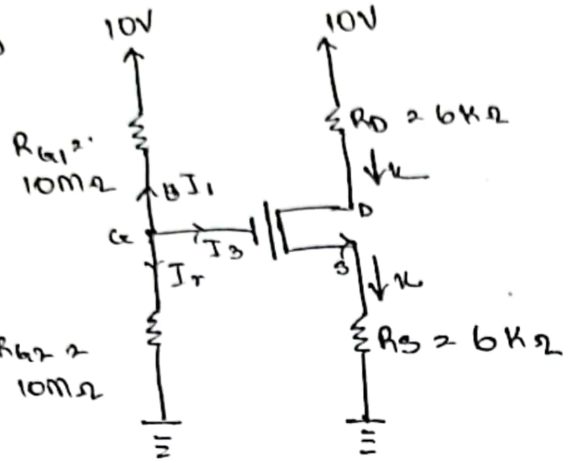
(3)



$I_{DS} = x$

$I_{DS} = \frac{10 - V_D}{6} \Rightarrow x = \frac{10 - V_D}{6} \Rightarrow 6x = 10 - V_D \Rightarrow V_D = 10 - 6x$

$I_{DS} = \frac{V_S - 0}{6} \Rightarrow x = \frac{V_S - 0}{6} \Rightarrow V_S = 6x$

$\frac{V_G - 10}{10 \times 10^{-3}} + \frac{V_G - 0}{10 \times 10^{-3}} = 0$

$V_G = 5V$

$I_1 = \frac{5 - 10}{10 \times 10^{-3}}$

~~$I_1 = 500 K\Omega = I_2$~~

$I_1 = I_2 = 500$ mA

$I_3 = 0$ mA

$I_{DS} = \frac{1}{2} K V_{OC}^2$

$x = \frac{1}{2}(1)(V_{GS} - V_{TN})^2$

$x = \frac{1}{2}(1)((5 - 6x) - 1)^2$

$2x = (4 - 6x)^2$

$36x^2 - 48x + 16 = 2x$

$36x^2 - 50x + 16 = 0$

$x = \frac{8}{9}, \; x = \frac{1}{2}$

$I_{DS} = \frac{8}{9}$ mA, $I_{DS} = \frac{1}{2}$ mA

$x = \frac{8}{9}$

$V_D = 10 - 6\left(\frac{8}{9}\right)$

$V_D = \frac{14}{3}$ V

$V_S = 6\left(\frac{8}{9}\right)$

$V_S = \frac{16}{3}$ V

$V_{OC} = (V_G - V_S) - V_T$

$= \left(5 - \frac{16}{3}\right) - 1 = -\frac{4}{3}$

$V_{GS} = \left(5 - \frac{16}{3}\right) = -\frac{1}{3} \not> 1$

$V_{DS} = \left(\frac{14}{3} - \frac{16}{3}\right) = -\frac{2}{3} > -\frac{4}{3}$ ✓

$x = \frac{1}{2}$

$V_D = 10 - 6\left(\frac{1}{2}\right)$

$V_D = 7V$

$V_S = 6\left(\frac{1}{2}\right)$

$V_S = 3V$

$V_{OC} = (V_G - V_S) - V_T$

$= (5 - 3) - 1 = 1$

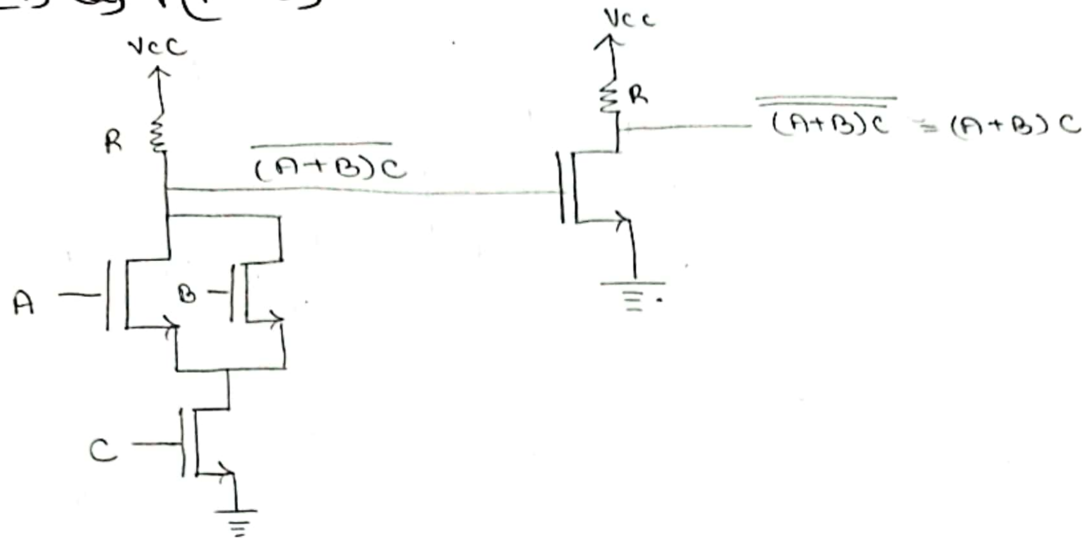
$V_{GS} = (5 - 3) = 2 > 1$ ✓

$V_{DS} = (7 - 3) = 4 > 1$ ✓

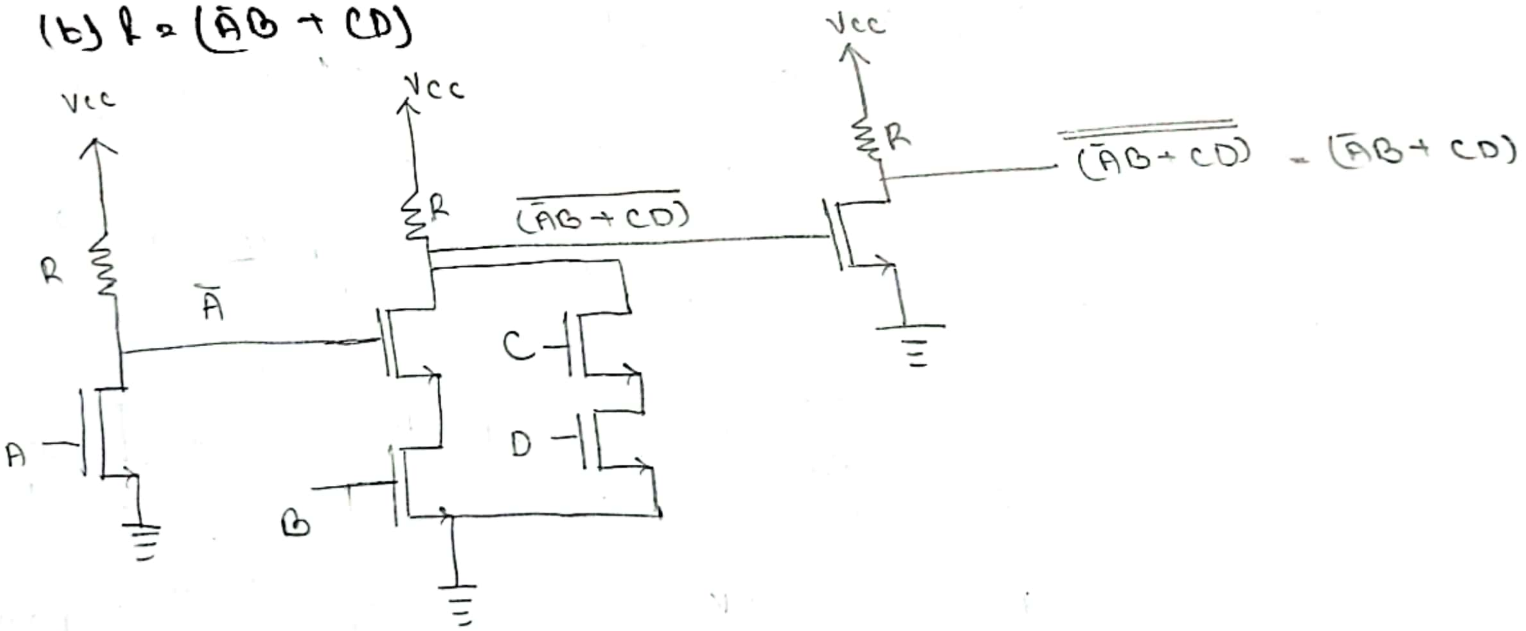
∴ The assumption is correct.

∴ $V_D = 7V$, $V_S = 3V$, $I_D = 0.5$ mA

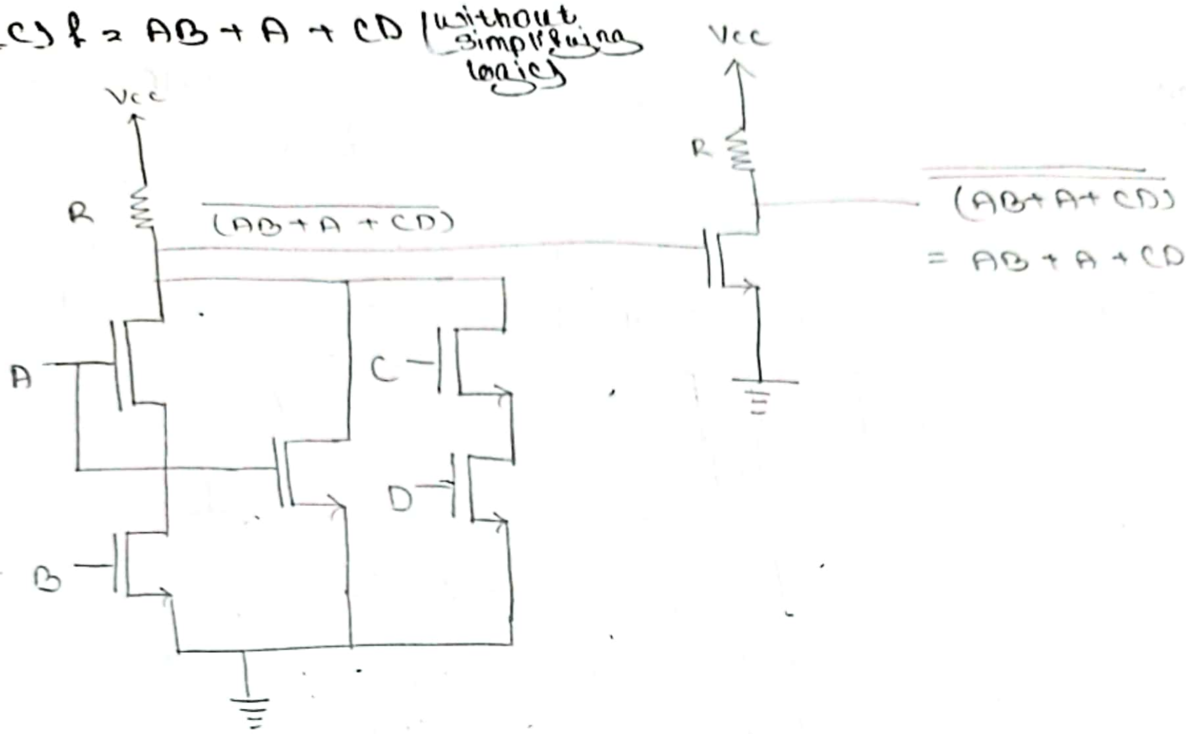
(4) (a) f = (A+B) C



(b) f = ($\bar{A}$B + CD)



(c) $f = AB + A + CD$ (without simplifying logic)

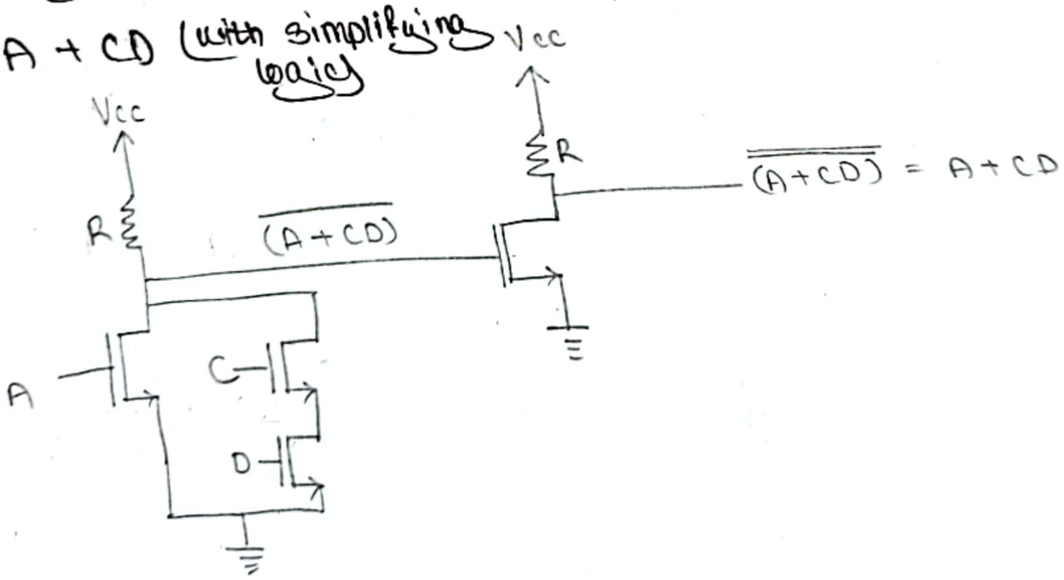


$B + 1 = 1$

$f = A(B + 1) + CD$

$= A(1) + CD$

$= A + CD$ (with simplifying logic)



BONUS: $I_D = \frac{1}{2}KV_{oc}^2$ $K = K_n'\frac{W}{L}$, $V_{oc} = V_{GS} - V_T$

$= \frac{1}{2}K_n'\frac{W}{L}(V_{GS} - V_T)^2$

V_{oc} ↑↑,

$V_{oc} = (V_G - V_S) - V_T$ [V_G & V_T remains same]

V_{oc} doubles∴ V_S doubles...

$V_{DS} = V_D - V_S$ [V_D remains same]

V_{DS} decreases the same amount as V_S doubles.

$I_D = \frac{1}{2}K(2V_{oc})^2$

$I_{D_{new}} = 2K(V_{oc})^2$

$I_D = I_{new}$

$\frac{1}{2}\cancel{K}(V_{oc})^2 = 2\cancel{K}(V_{oc})^2$

$\frac{I_D}{I_{D_{new}}} = 4$

$I_{D_{new}} = \frac{I_D}{4}$

changing V_{oc} has no ~~eff~~ change on the process ~~of~~ of K.

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