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Quiz: 4

Circuit Parameters:

$k_n' = 200\,\mu A' = 0.2\ mA$

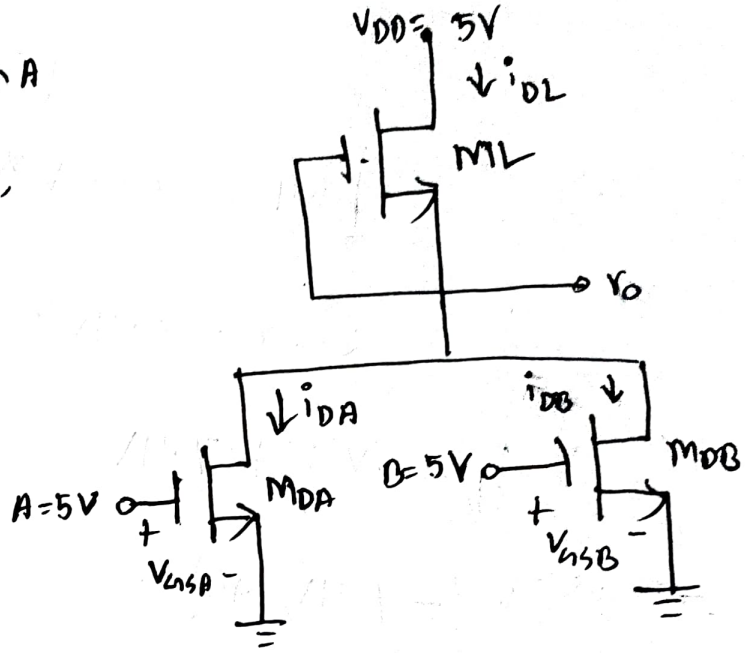
$V_{TNL} = -0.5V$, $V_{TNA} = 1V$,

$V_{TNB} = 1.5V$

$\left(\frac{W}{L}\right)_L = 1$

$\left(\frac{W}{L}\right)_A = 2$

$\left(\frac{W}{L}\right)_B = 3$



(a) As, this is a nor gate, when two inputs are high, output will a low voltage. So, V_o is small.

Here,

$V_{GSL} = V_{GL} - V_{SL} = 0V$

$V_{DSL} = V_{DL} - V_{SL}$.

$= 5 - V_o$ [large value]

$V_{DSL} \geq V_{GSL} - V_{TNL} = 0 - (-0.5) = 0.5$

$\Rightarrow 5 - V_o \geq 0.5$

So, M_L in saturation mode.

Assuming
M_{DA}, M_{DB} is triode mode.

$$i_{DL} = i_{DA} + i_{DB}$$

$$\Rightarrow k_n' \left(\frac{W}{L}\right)_L (0.5)^2 = k_n' \left(\frac{W}{L}\right)_A \left(2(5-1)V_o - V_o^2\right) + k_n' \left(\frac{W}{L}\right)_B \left(2(5-1.5)V_o - V_o^2\right)$$

$$\Rightarrow \frac{1}{20} = \left[0.4 \times (8V_o - V_o^2)\right] + \left[0.6 \times (7V_o - V_o^2)\right]$$

$$\Rightarrow \frac{1}{20} = 3.2V_o - 0.4V_o^2 + 4.2V_o - 0.6V_o^2$$

$$\Rightarrow \frac{1}{20} = -V_o^2 + 7.4V_o$$

$$\Rightarrow V_o^2 - 7.4V_o + \frac{1}{20} = 0$$

$$\Rightarrow V_o = \begin{cases} 7.393 & \text{[Not valid]} \\ 6.763 \times 10^{-3} \end{cases}$$

So, $\boxed{V_o = 6.763 \times 10^{-3}\ V}$ (Ans)

(b)

As,

this is a nor gate, and inputs are high, the output voltage will be low.

Therefore

$$V_{GSL} = V_{GL} - V_{SL} = 0V$$

$$V_{DSL} = V_{DL} - V_{SL}$$

$$= 5 - V_o \text{ [large value]}$$

Thus,

$$V_{DSL} \geq V_{GSL} - V_{TNL} = 0.5$$

$$\Rightarrow 5 - V_o \geq 0.5$$

For this, M_L must be in saturation mode.

Power dissipation of load transistor:

$V_o = 6.763 \times 10^{-3} V$

So, $P = \Delta V \times I_{DL}$

$$i_{DL} = \frac{1}{20} = 0.05\ mA$$

So, $P = (5 - 6.763 \times 10^{-3}) \times 0.05$

$= \boxed{0.2497\ mW}$ Power dissipation of load transistor

(Ans)