Keeyen Haghshenas
04/08/19

NMOS HW

1) a) NOR GATE

b) $V_{GS} = 3V$, $V_{GSL} = 5 - V_{DSS}$

$I_{DSLSAT} = I_{DSSOHMIC}$

$.08(2V_{DSS} - V_{DSS}^2/2) \rightarrow \boxed{V_0 = 1.33V}$

c) $V_{GSS} = 3V$

$V_{GSL} = 5V = V_{DSS} \ \angle 5 \quad 2K_S$

$I_{DSL_{SAT}} = I_{DSS\,OHMIC}$

$.4 \times 10^{-3}/2(4 - V_{DSS})^2 \rightarrow \boxed{V_0 = .8V}$

d) $V_{OL} = 1V$

b/c $V_0 = V_T$

2) a) $V_{OH} = V_{DD} - V_T = 4V$

b) $V_{GSS} = 4V$

$.2 \times 10^{-3}/2(4 - V_{DSS})^2 = 1 \times 10^{-3}(3V_{DSS} - V_{DSS}^2/2)$

$\boxed{V_{OL} = V_{DDS} = 0.45V}$

c) $V_{IL} = V_T = 1V$

d) $0.1 \times 10^{-3} \cdot 16 = 1 \times 10^{-3}[V_{GSS} - 1 - 1/2]$

$16 = 10[V_{GSS} - 1.5] \rightarrow = \boxed{3.1V}$

e) $V_{DDS}(av) = (4)/2 = 2$; $V_{GSS} = 4V$; $2 < 4 - 3 \rightarrow$ ohmic

$I_{DS} = 1[(3)2 - 4/2] = 4$

$V_{GSL}(av) = 4.6 + 1.4/2 = 3$

$I_{DSL}(av) = (.2/2)(V_{GSL}(av) - 1)^2 = 0.4$

$I_0 = 4 - .4 = 3.6$

$\angle t = (20pF \ 3.2)/3.6mA = \boxed{17.8nS}$

f) $K_\Omega = 1/.2 = 5V$

$V_{OH} = V_{DD} - V_T = 4V$

$V_{OL} = 4/\sqrt{16} = 4/4 = 1V$

$V_{IH} = 1.5 + (3)^2/16 = \boxed{2.4V}$

a) $V_{out} = 4.5V$

$V_{out} = 4.5 - 1 = 3.5V$

$I = W / (V_{out} - V) = .5 / (? - 1.5V)$

$R = W / I = ... = \boxed{k\Omega}$

b) $V_{in} = 2V \quad V_{out} = 4.5V$

$V = 1.5V / 1.5V^2 = \boxed{1.1mA/2}$

c) $V = \frac{1}{2}... = \boxed{V = 3V}$

$V_{out} = 5 - ... = ... V$

$= 5 - ...V - (...) $

$= 1.5V$

$V_{out} = V_{in} - ...$ ...

the Q is saturated

2) $V_{in} = 2V$

$(...) - (...) = 15.5$

1		
2		
3		0.3mA

5)

a) $V_{GSL} = V_{DD} - V_{DSS}$ $V_{GU} = V_{DD} - V_r = 4V = V_{GSS}$

$3V_{DSS}^2 - 20V_{DSS} + 16 = 0$

$$\boxed{V_{OL} = 0.929V}$$

b) $I_{DS} = 1(4 - .929)^2 = 9.43mA$

$6V_{DSS1}^2 - 12(3)V_{DSS1} + 9.43 = 0$

$$\boxed{V_{DSS1} = .275V}$$

Q_2

$6V_{DSS2}^2 - 12(3.725 - 1)V_{DSS2} + 9.43 = 0$

$$\boxed{V_{DSS2} = .306 V}$$

Q_3

$6V_{DSS3}^2 - 12(3.491 - 1)V_{DSS3} + 9.43 = 0$

$$\boxed{V_{DSS3} = 0.350V}$$

6) a) $V_{GH} = 4V$

b) $3[2V_{DSS} - \frac{1}{2}V_{DSS}^2] = .1(4 - V_{DSS})^2$

$60V_{DSS} - 15V_{DSS}^2 = (4 - V_{DSS})^2$

$4V_{DSS}^2 - 12V_{DSS} - 16 = 0$

$$\boxed{V_{DSS} = 0.25V}$$

c) $I_{DSL} = I_{DSS} = 1.4mA$

7) a) $V_{OH} = 4V$

b) $6V_{DSS}^2 - 35V_{DSS} + 16 = 0$

$$\boxed{V_{DSS} = V_{OL} = 0.454V}$$

c)

$I_{DS} = \frac{2}{2}[3 \cdot .454 - \frac{1}{2} \cdot .454^2] = 1.26mA$

d) $V_{DSS}^2 - 6V_{DS} + 1.26 = 0$

$V_{DS} = .217V$

e) $\Delta T = C \Delta V / F = 100 \cdot 2.4 / 3.6mA = 67nS$

8)

a) 5V

b) $20V_0 - 2.5V_0^2 = 5 - V_0$

$$\boxed{V_0 = .24}$$

c) $V_{iL} = 1V$

d) $V_{DSS} = 1 = V_0$

$0.8 = V_i - 1 - .5 = V_i - 1.5 ; \quad V_i = 2.3$

e) $I_{RD} = 0.5mA$

$V_{DSS}(av) = 2.5V$

$t_{DSS} = [\approx 4.2.5 - 2.5^2/2]$

$= 6.88mA$

$I_0 = 6.38mA \rightarrow \Delta T = 80/6.38mA$

$$\boxed{= 12.5nS}$$

f) $V_{iL} = 1 + .2 = 1.2$

$V_{OH} = 4.9V$

$V_{iH} = .8 + 1.6 = 2.4$

$V_{OL} = .82$

9) a) $5V$

b) $V_0^2 - 5V_0 + 1.8 = 0$ $V_0 = .23V$

c) $V_{iL} = 1.1 V$

d) $V_{iH} - 1.5 = .9$

$\boxed{V_{iH} = 2.4}$

c) $V_0 = .5 \; \& \; 4.5$

d) $.5$

$I_{DSL} = .25 \; mA \; ohmic$

$4.5 \; I_{DSL} = .9 \; mA \; sat$

$I_{DSL} (av) = .57 \; mA$

$V_{DSS} (av) = 2.5V$

$I_{DSS} = 6.55 \; mA$

$I_0 = 6.31 \; mA \Rightarrow t_f = 20pf \cdot .4 / (.31) mA$

$\boxed{= 12.7 \; nS}$

f) $V_{TL} = 1 + 3(\sqrt{30})$

$= 1 + .55 = 1.55V$

$V_{OL} = 5 - (1 - (5/26)^{1/2})$

$V_{OL} = 3 / \sqrt{15} = 0.77V$

$V_{iH} = 1 - 2(-3) / \sqrt{15} = 1 + 1.6 = 2.6$

10) a) $S = 4V$

$V_{TL} @ S = 4V = 1.69V$

$V_{iL} = V_{TL} = 1.69$

$V_{OH} = V_{DD} - V_{TL} = 3.31V$

c) $S = 1V$

$V_{TL} = 1.25V$

$V_{OL} = .94V$

$V_{iH} = 1.65V$