GIVEN: $\left(\frac{W}{L}\right)_N = \frac{2}{1}$ $\left(\frac{W}{L}\right)_P = \frac{5}{1}$ CMOS INVERTER

$V_{DD} = 2.5V$ $C = 0.2\,pF$

FIND: t_r, t_f & τ_p

SOLN:

$$t_r = 3(1.2)\,R_{ONP}\,C$$

$$= 3.6\left(\frac{1}{K_P\,|V_{gs}-V_{to}|}\right)C$$

$$= 3.6\left(\frac{1}{5(40\mu)\,|(-2.5+0.6)|}\right)20\times10^{-12}$$

$$= 1.89\,nS$$

$$t_f = 3(1.2)\,R_{ON_N}\,C$$

$$= 1.89\,nS$$

AS YOU WOULD HOPE FROM SYMMETRY!

$$\tau_{PLH} = 1.2\,R_{ONP}\,C = 0.63\,nS$$

$$\tau_{PHL} = 1.2\,R_{ON_N}\,C = 0.63\,nS$$

$$\tau_p = 0.63\,nS$$

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GIVEN: $\tau_p = 200\ ps$ $\quad V_{DD} = 1.5V$

$C = 100\ fF$ $\quad V_{to} = 0.5\ \&\ -0.5V$

FIND: SYMMETRICAL CMOS DESIGN

SOLN: WE WANT $\tau_{pHL} = \tau_{pLH} = \tau_p$

SO

$$0.2\ ns = 1.2\left(\frac{1}{\left(\frac{W}{L}\right)_N 100\mu\,|1.5-0.5|}\right) 0.1\ pF$$

$$\left(\frac{W}{L}\right)_N = \frac{6}{1} \quad \text{AND SO} \quad \left(\frac{W}{L}\right)_p = \frac{100}{40}\left(\frac{6}{1}\right)$$

$$= \frac{15.0}{1}$$

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GIVEN: 5W DISSIPATION

5M GATES

FIND: A) $P_{AVE, GATE}$

B) FOR 5MHz SWITCHING... C_{MAX} FOR

$V_{DD} = 3.3\ V,\ 2.5V,\ 1.8V$

SOLN: A) $\frac{5W}{5M} = 1\ \mu W/GATE$

B) $P = CV^2f$

SO... $1\ \mu W = C(3.3)^2(5M)$

$C = 0.018\ pF$

OR @ $V = 2.5\ V$

$C = 0.032\ pF$

OR @ $V = 1.8\ V$

$C = 0.62\ pF$

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GIVEN: INVERTER OF PROB 24

FIND: POWER DELAY PRODUCT
POWER DISSIPATED @ $f = 100\,MHz$

SOLN:

$$PDP = \frac{CV_{DD}^2}{5}$$

$$PDP = \frac{(0.2p)(2.5)^2}{5} = 0.25\,pJ$$

$V=2$ $\quad PDP = 0.16\,pJ$

$V=1.8$ $\quad PDP = 0.13\,pJ$

AND $\quad P = CV_{DD}^2 f = 0.2p(2.5)^2(100M)$
$= 125\,\mu W$

$V=2$ $\quad P = 80\,\mu W$

$V=1.8$ $\quad P = 64.8\,\mu W$

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