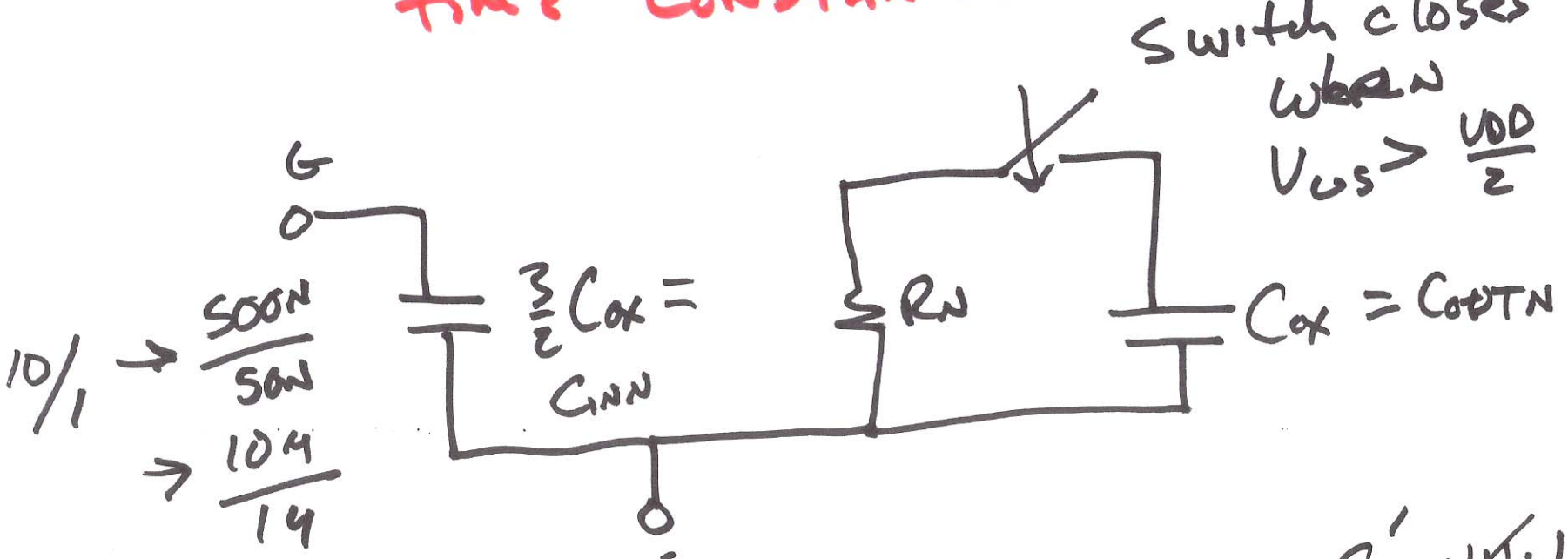
Process characteristic time constant.



$$\tau_N = R_N \cdot C_{ox} = \frac{VDD}{\frac{K_{PN}}{2}\cdot\frac{W}{L}\left(VDD - V_{THN}\right)^2} \cdot C'_{ox} \cdot W \cdot L$$

$$\boxed{\tau_N \propto L^2}$$

$(L \cdot scale)$

$1 \cdot 1\mu m = 1\mu m$

$1 \cdot \underbrace{50N\text{-}m}_{Scale} = 50N\text{-}$

$\tau_P = 3\tau_N$

true for long channel

1)

Short-channel Processes

$$\tau_N = R_N \cdot C_{ox} = \frac{V_{DD}}{I_{ON} \cdot W} \cdot C'_{ox} \cdot L \cdot W$$

$$\boxed{\tau_N \propto L}$$

↖ short-channel

$$\tau_P = 2 \cdot \tau_N$$ ↙

Long channel

$\tau_N = 25ps$, $\tau_P = 75ps$

short channel

$\tau_N = 2.1ps$, $\tau_P = 4.2ps$

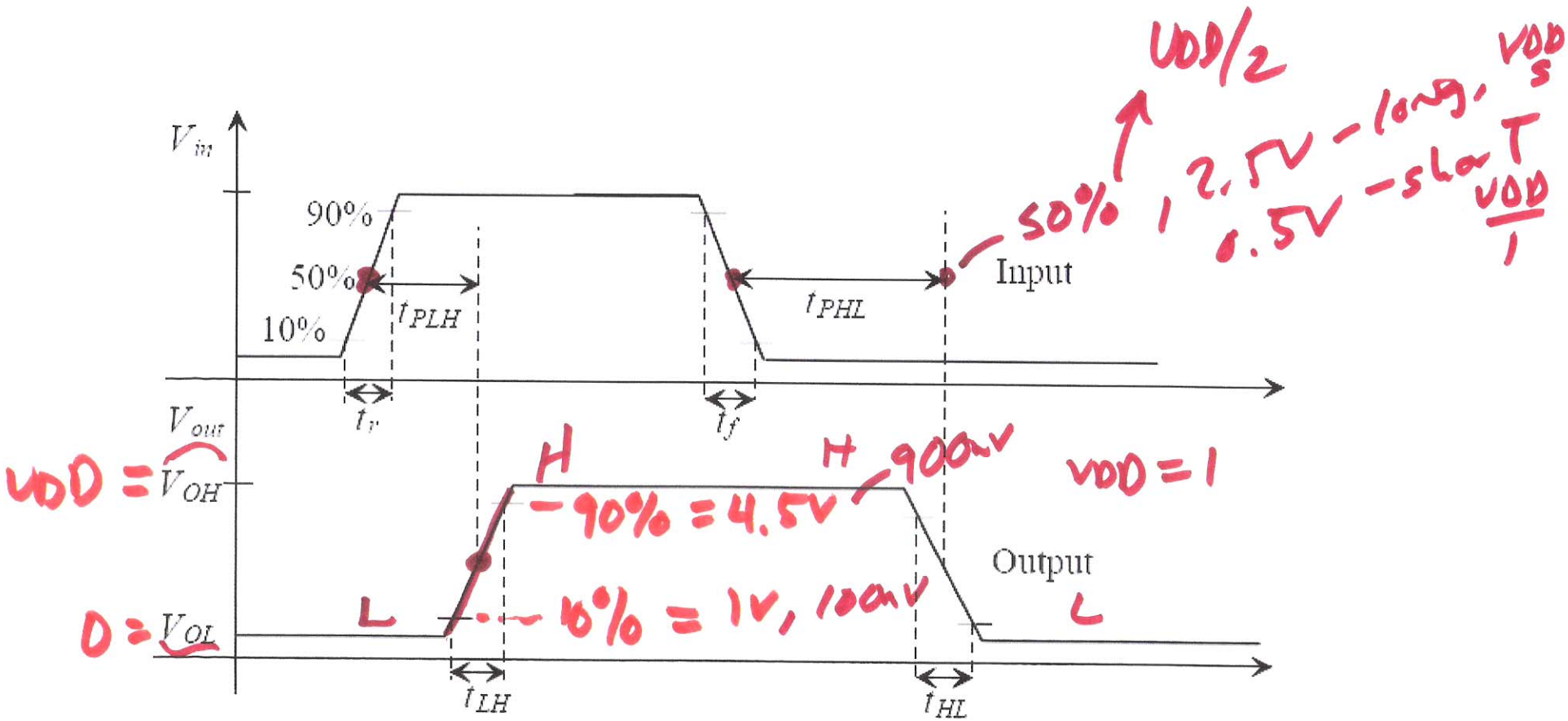
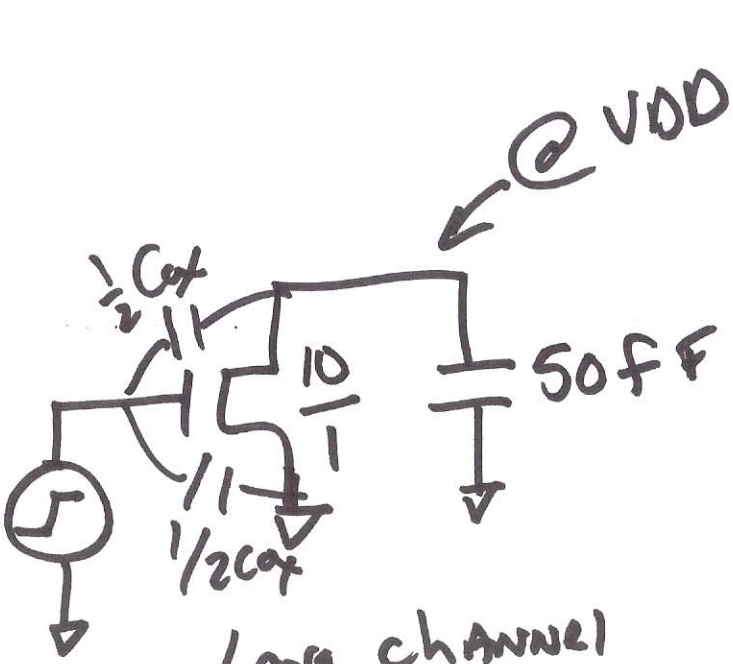


Figure 10.9 Definition of delays and transition times.



$R_N = 15K \cdot \frac{1}{10}$

$= 1.5K$

$C_{ox}' = 1.75 \frac{fF}{\mu m^2}$

Long channel

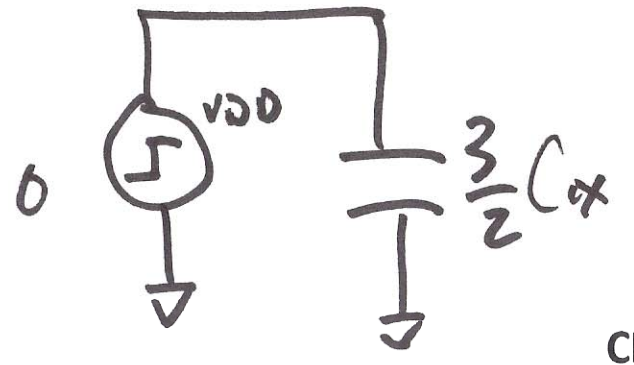
scale = 1μm

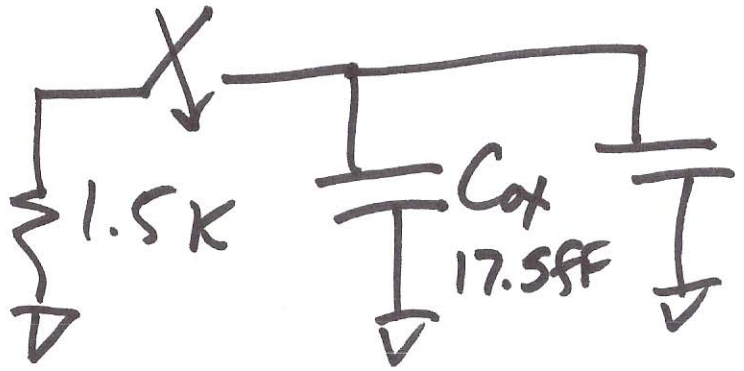
$C_{ox} = 10 \cdot 1 \cdot (scale)^2 \cdot 1.75 fF$

$C_{ox} = 17.5 fF$

$\frac{W}{L} = \frac{10}{1} = \frac{10\mu}{1\mu}$

$RC = 1.5K \cdot 67.5fF$





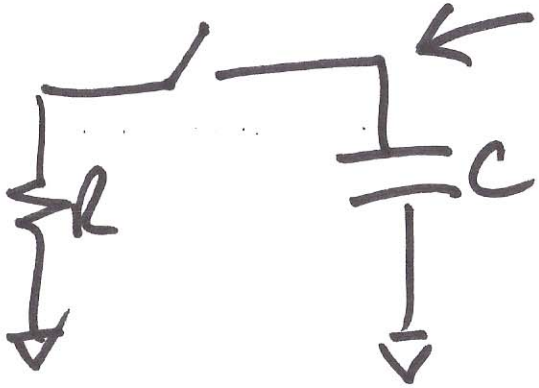
$RC = 101 ps$

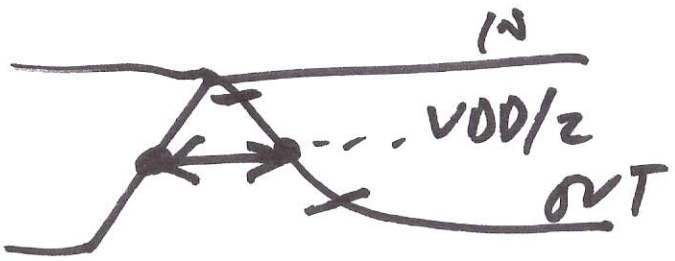
$t_d = 70 ps$

$t_d = 0.7RC$

4)

$V_{OUT}(t) = V_{DD} e^{-t/RC}$





$t_d = 0.7RC$

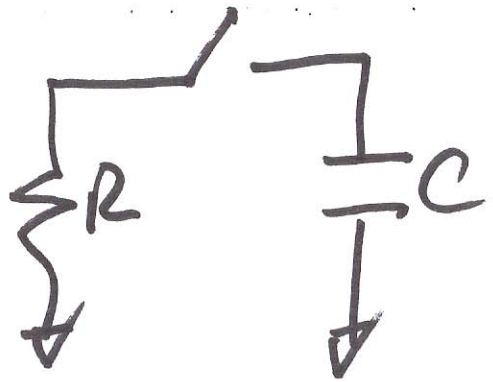
$t_d = 70ps$

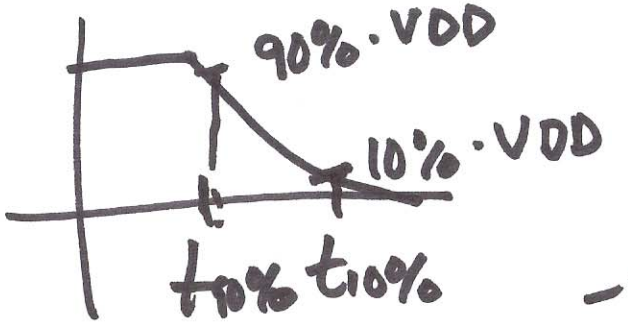
t_{delay} measured at 50% points

$$\frac{V_{DD}}{2} = V_{DD} e^{-t_d/RC}$$

$$\ln \frac{1}{2} = \ln e^{-t_d/RC}$$

$$-.7 = -t_d/RC$$





$-t_{90\%}/RC$

$.9VDD = VDD\, e^{-t_{10\%}/RC}$

$.1VDD = VDD\, e^{-t_{10\%}/RC}$

$\ln a - \ln b = \ln \frac{a}{b}$

$t_{90\%} = -RC \ln .9$

$t_{10\%} = -RC \ln .1$

$t_f = t_{10\%} - t_{90\%} = -RC(\ln .1 - \ln .9)$

$= -RC \ln \frac{1}{9}$

$= RC \ln 9$

$t_f = 2.2RC$

$t_f = 220ps$

$t_d = 70ps$

$t_f = 220ps$

6)