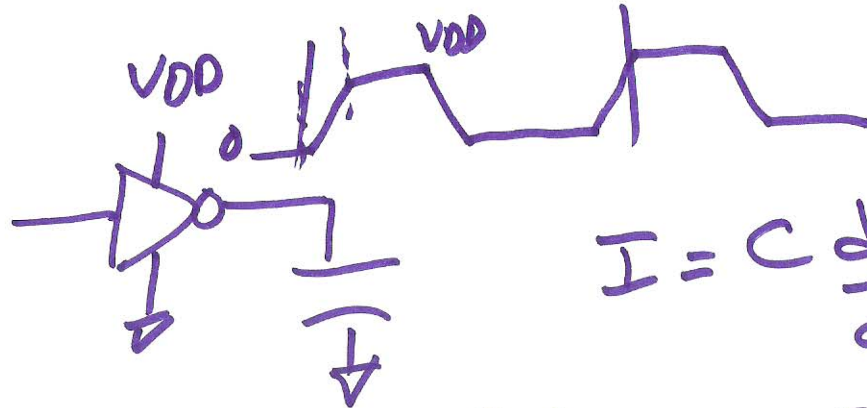
EE 421 / ECG 621
Digital IC Design

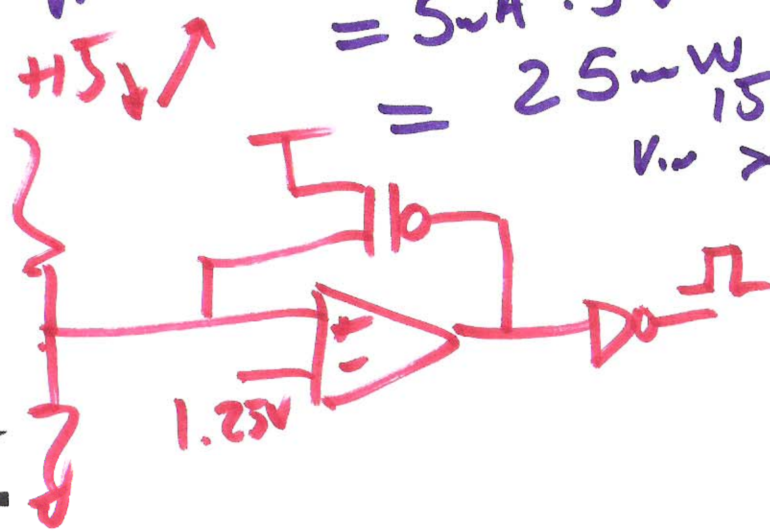


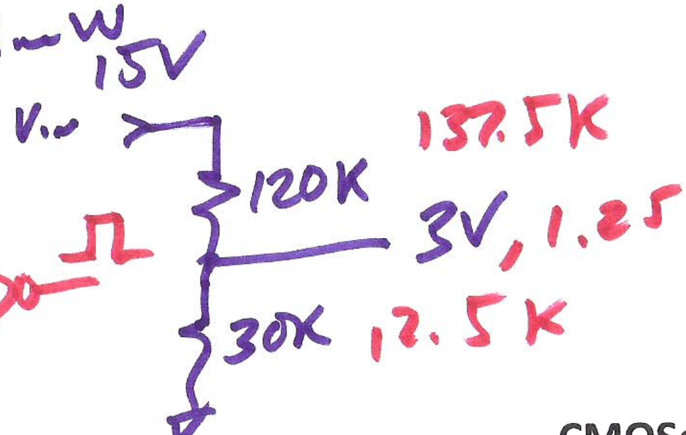
$$I = C\frac{dV}{dt} = C\cdot\frac{VDD}{1ns}$$

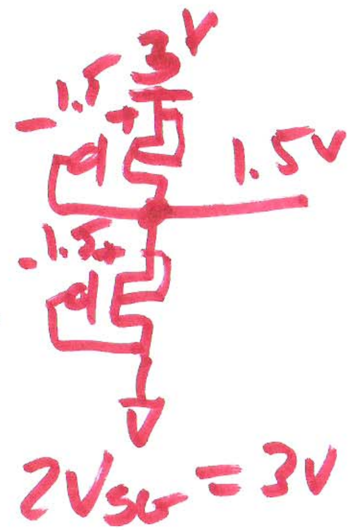
$$I_{AVG} = 50mA\cdot\frac{1ns}{10ns} = 5mA \qquad C = \frac{50mA\cdot 1ns}{5V} = 10pF$$

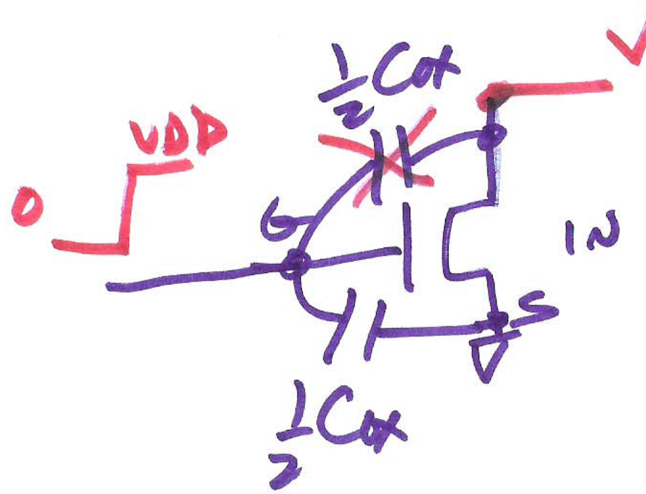
$$P_{AVG} = I_{AVG}\cdot VDD$$
$$= 5mA\cdot 5V$$
$$= 25mW$$

$$E = \frac{1}{2}C\,VDD^2$$

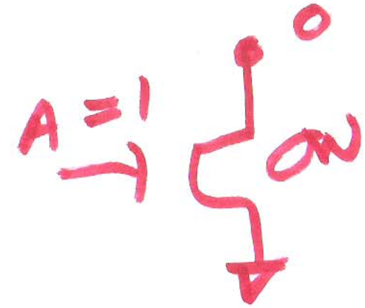






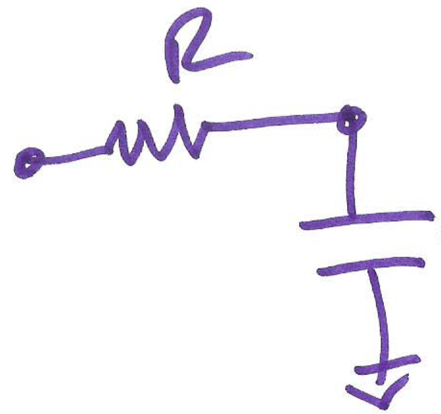


in triode



Before switching

$Q_1 = (0 - VDD)\frac{1}{2}C_{ox}$



$t_d = 0.7RC$

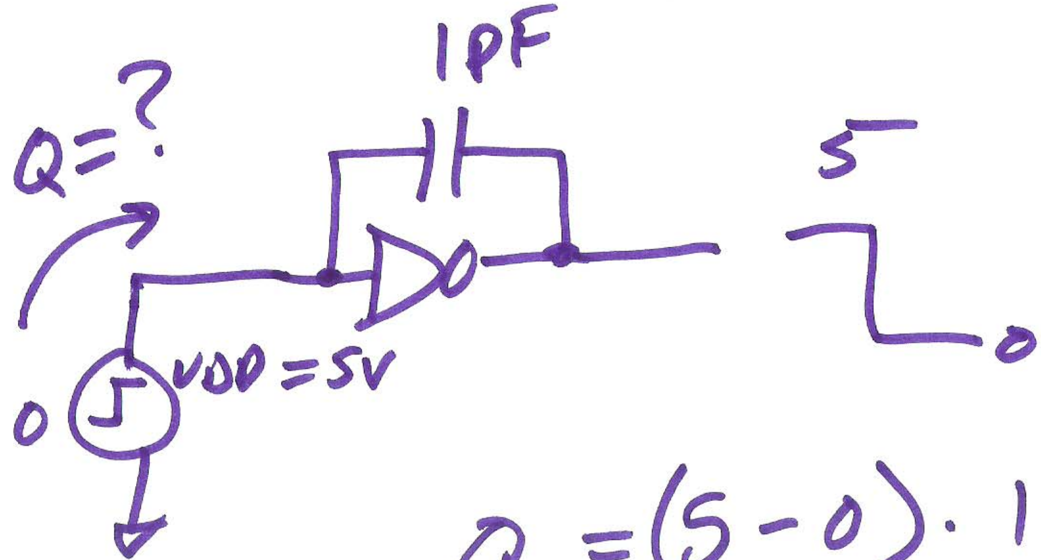
$Q_2 = (VDD - 0)\frac{1}{2}C_{ox}$

$C = \frac{1}{2}C_{ox} = C_{ox}$

$\frac{3}{2}C_{ox}$

$Q_2 - Q_1 = 2VDD \cdot \frac{1}{2} \cdot C_{ox}$

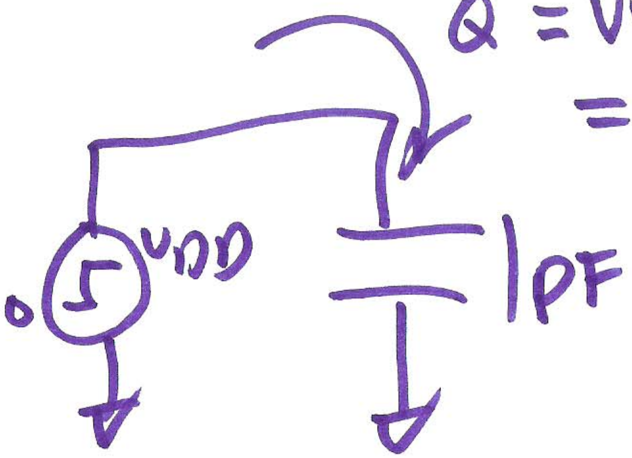
$= VDD \cdot C_{ox}$



$$Q = VDD \cdot 1pF = 5pC$$

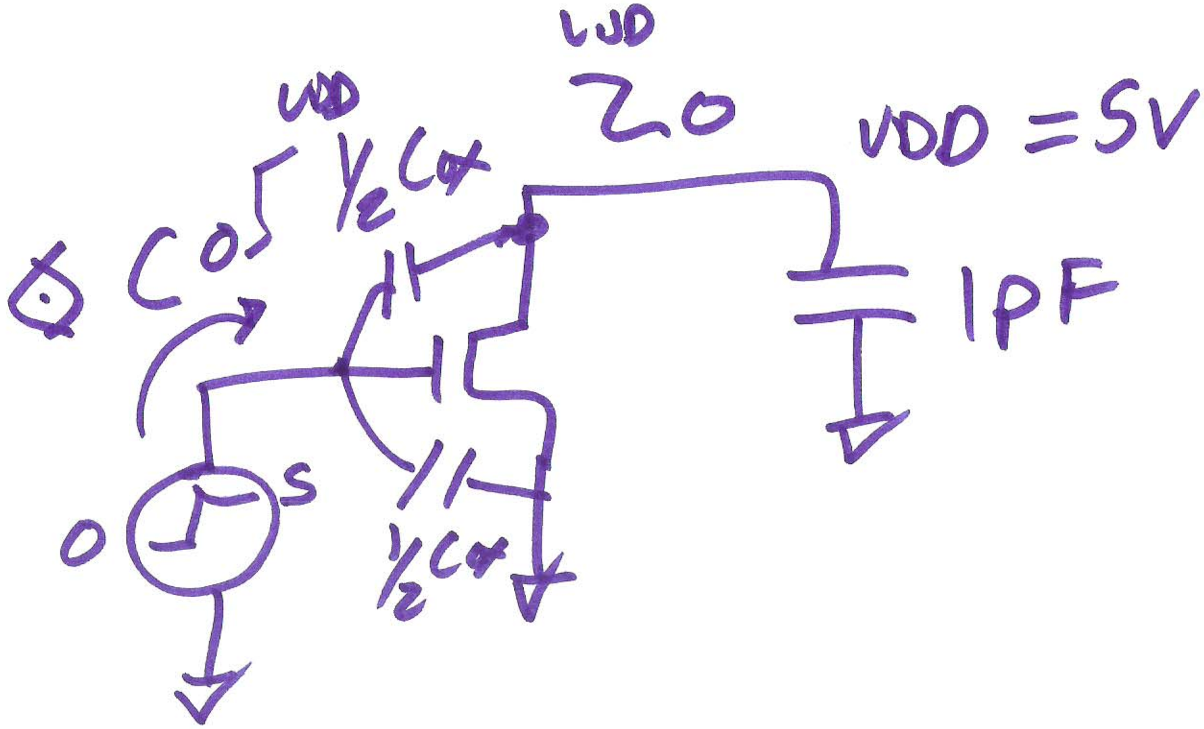
$$Q_1 = (5-0) \cdot 1pF$$

$$Q_2 = (0-5) \cdot 1pF$$

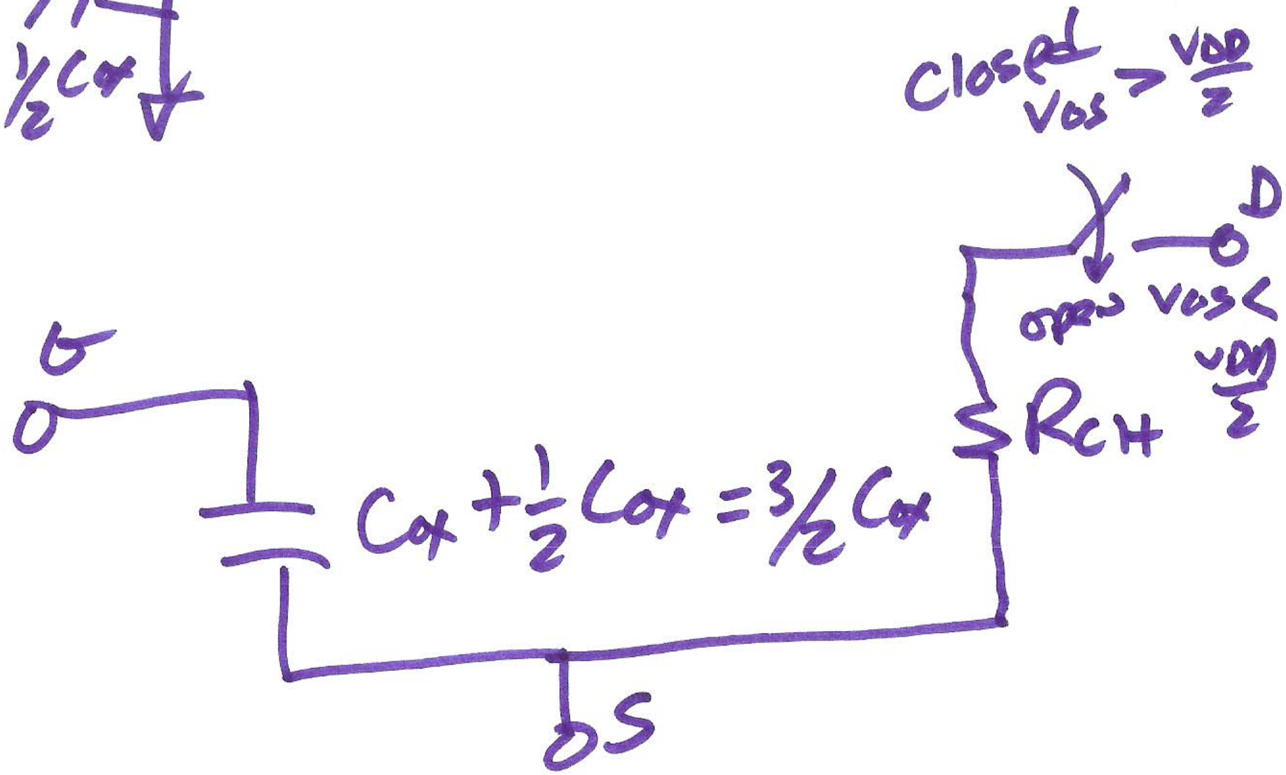


$$Q_T = Q_1 - Q_2 = 5 \cdot 2 \cdot 1pF = VDD \cdot 2 \cdot 1pF$$

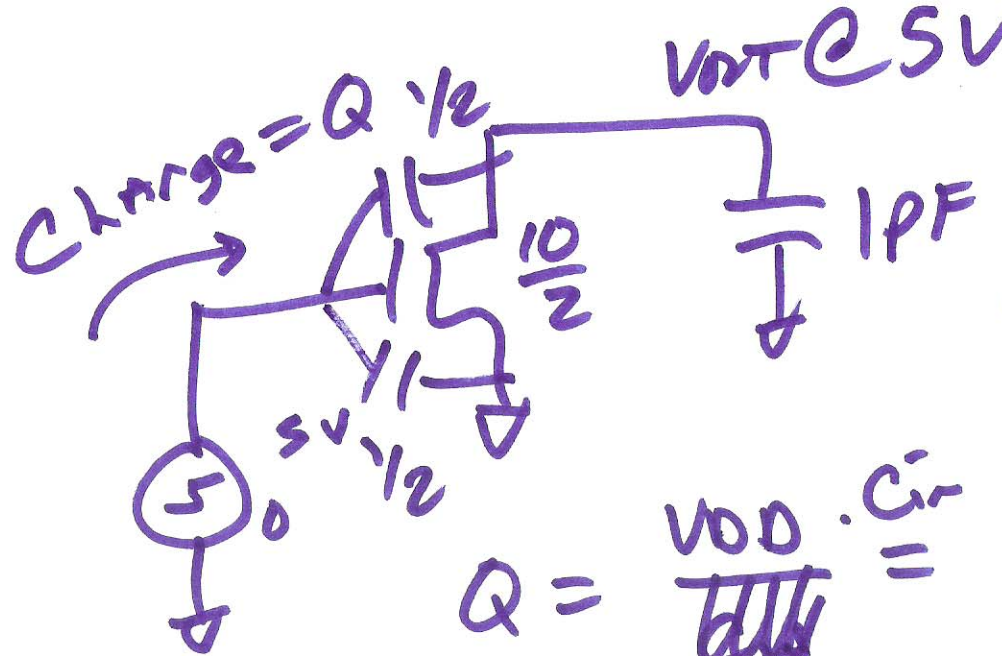
$$\underline{\underline{Q_T = 10pC}}$$



VDD
1/2 Cox
VDD
2 0
VDD = 5V
C 0
1pF
S
0
1/2 Cox



Closed Vos > VDD/2
D
open Vos < VDD/2
G
RCH
Cox + 1/2 Cox = 3/2 Cox
S



$CV = Q$

$$Q = \frac{VDD}{\cancel{}} \cdot C_{in} = \frac{VDD}{\cancel{}} \cdot \frac{3}{2} C_{ox} = \frac{5V \, \frac{3}{2} C_{ox}}{\cancel{}}$$

$$C_{ox} = C_{ox}' \cdot W \cdot L \,(\text{scale}^2) = 2.5 \frac{fF}{\mu m^2} \cdot 3\mu \cdot .6\mu$$

$$= 4.5 fF$$

$$Q = 5 \cdot 4.5 fF \cdot \frac{3}{2}$$

$$Q = \underline{\underline{22.5 fF \cdot \frac{3}{2}}} = \underline{\underline{33.7 fC}}$$

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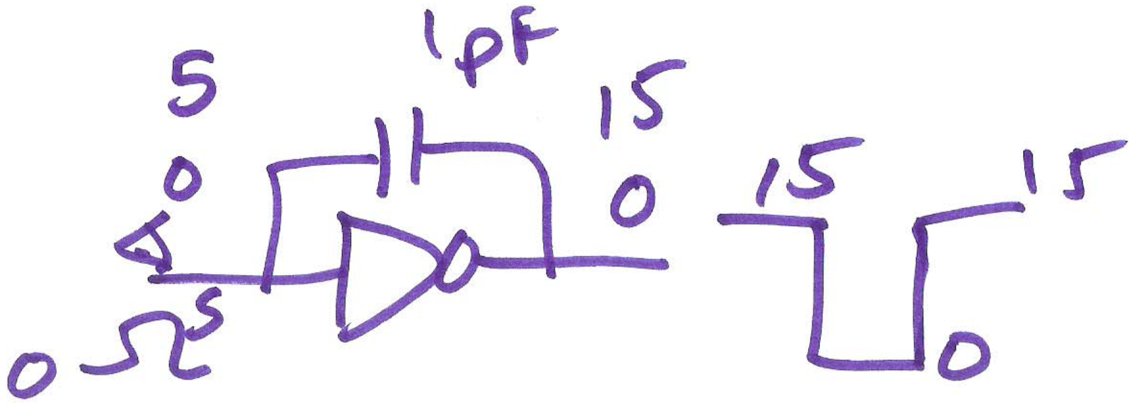

$(15-0)\,1pF$

$(0-5)\,1pF$

$4 \cdot VDD \cdot 1pF$

$= VDD \cdot \underline{\underline{4\,pF}}$

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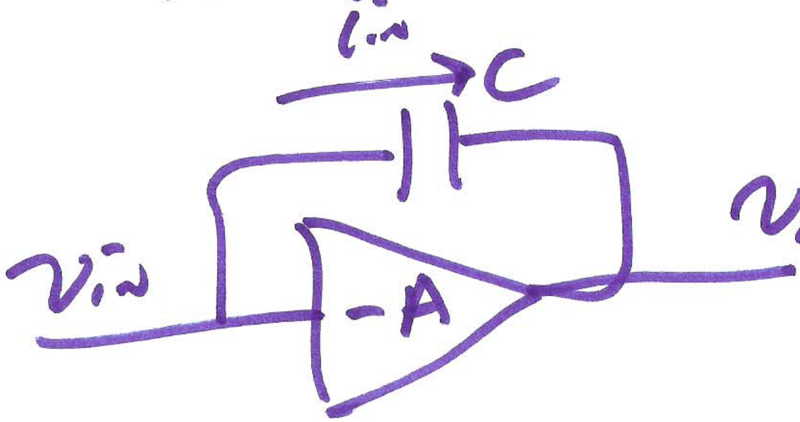
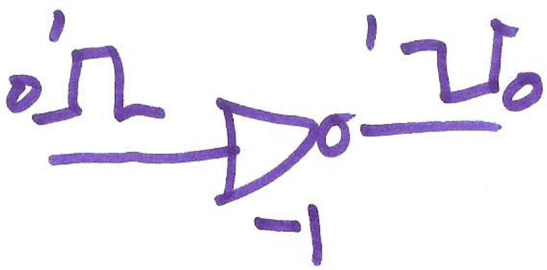
Miller effect

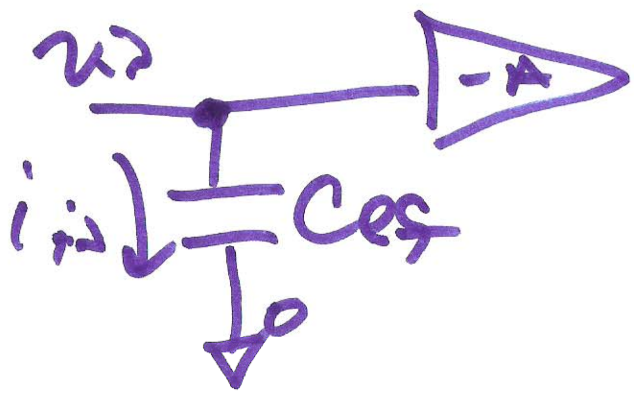


$v_{OUT} = -A \cdot v_{in}$



$$i_{in} = \frac{v_{in} - (-A v_{in})}{1/j\omega C} \quad \text{(Ohm's law)}$$

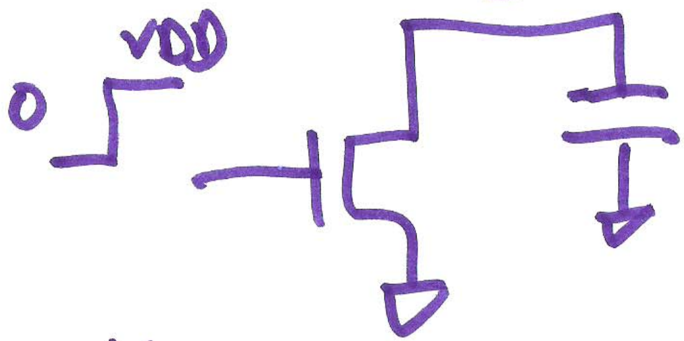
$$i_{in} = j\omega C(1+A) \cdot v_{in}$$



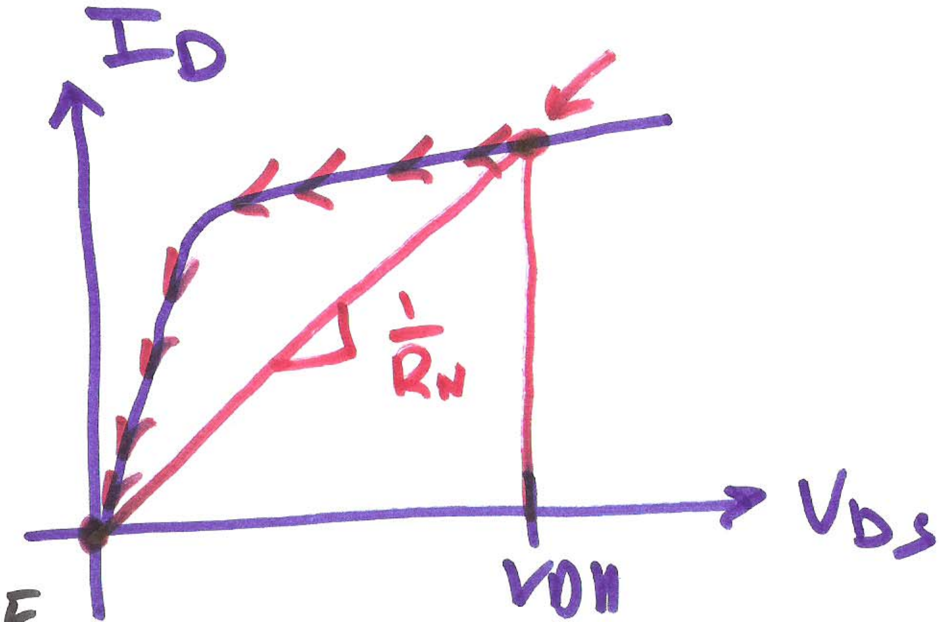
$$i_{in} = \frac{v_{in} - 0}{1/j\omega C_{eq}}$$

$$C_{eq} = C(1+A)$$

init @ VDD



$V_{GS} = VDD$



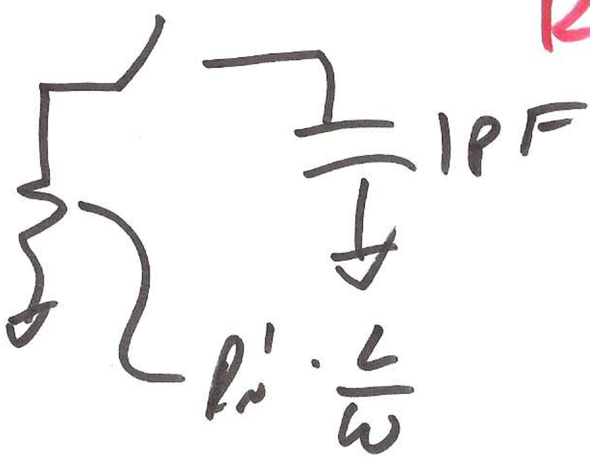
$t_d = 0.7 \cdot 5K \cdot 1pF$
$= 3.5nS$

$$R_N = \frac{VDD}{\frac{KPN}{2} \cdot \frac{W}{L}(VDD - V_{THN})^2}$$

$$R_N = R_N' \cdot \frac{L}{W} = \cancel{1.1mA}$$

$$= \frac{5}{1.1mA} = 4.54K$$

$$R_N' = \frac{\cancel{W}\,10}{\cancel{L}\,2} \cdot 4.54 \simeq 25K$$



$25K \cdot \frac{2}{10} \simeq 5K$

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