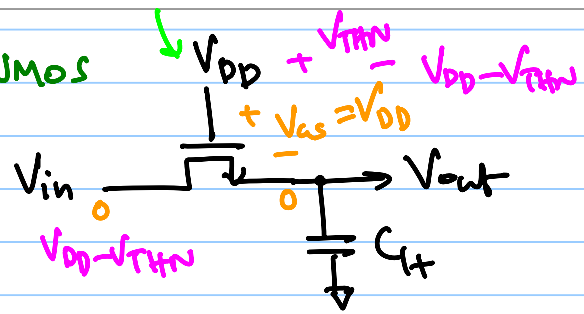
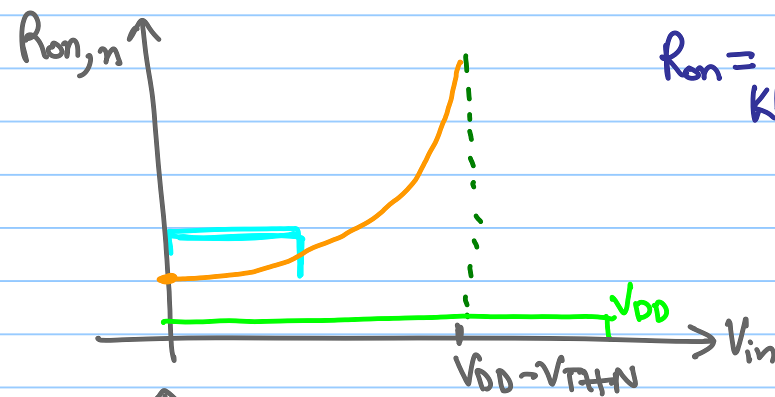
ECE 517 - Lecture 14

Razavi's Book

Note Title 3/2/2017

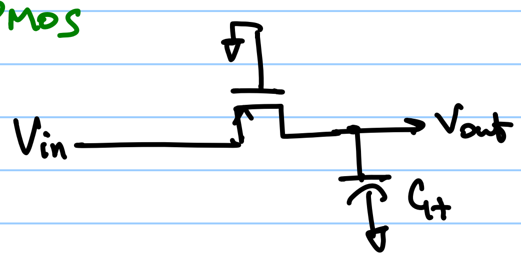
NMOS

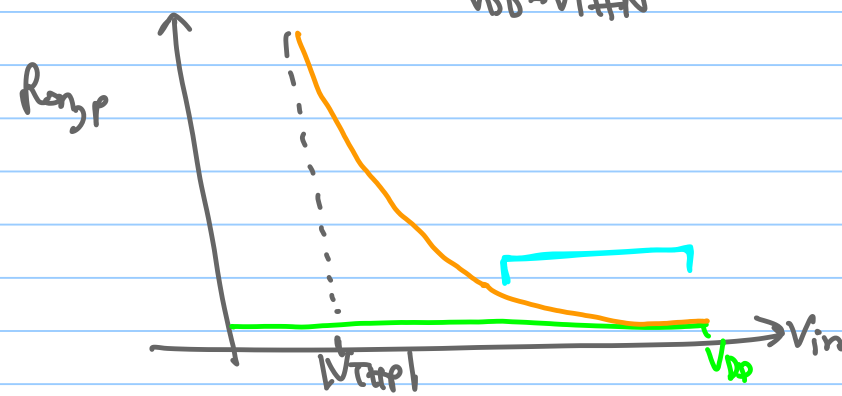




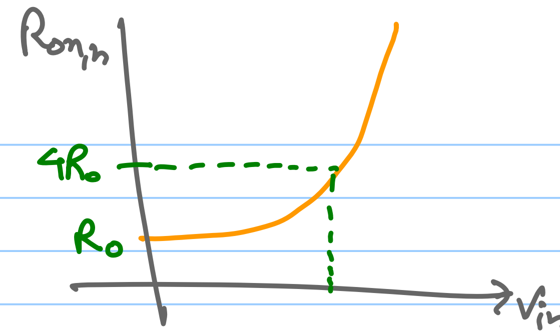
$$R_{on} = \frac{1}{K'_n \frac{W}{L}\left(V_{DD} - V_{in} - V_{THN}\right)}$$

PMOS





Restrict R_{on} to a range of 4:1

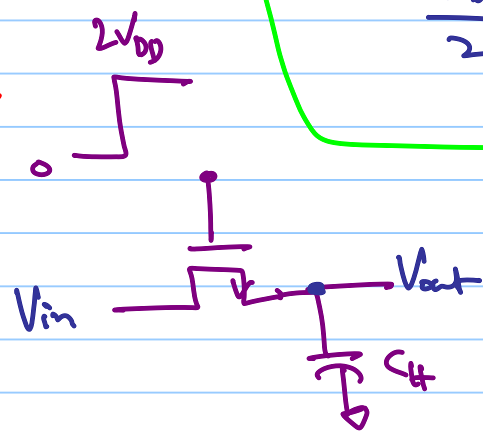


$$V_{in,max} = \frac{3}{4}\left(V_{DD} - V_{THN}\right)$$

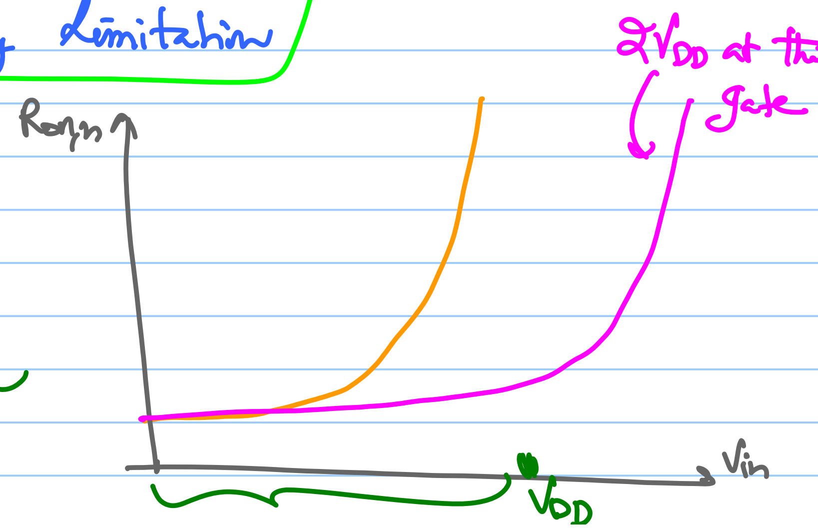
$$\simeq \frac{V_{DD}}{2} \quad \text{for some technologies}$$

↳ severe swing limitation

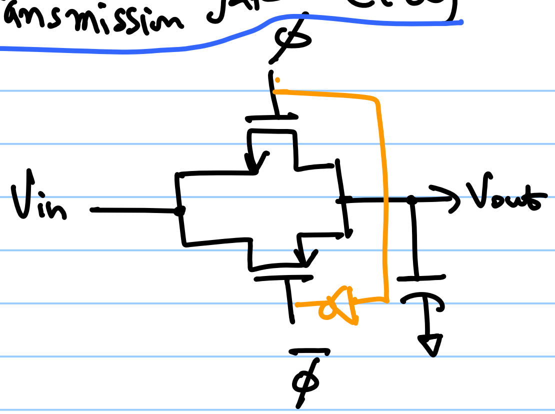
Bootstrapping

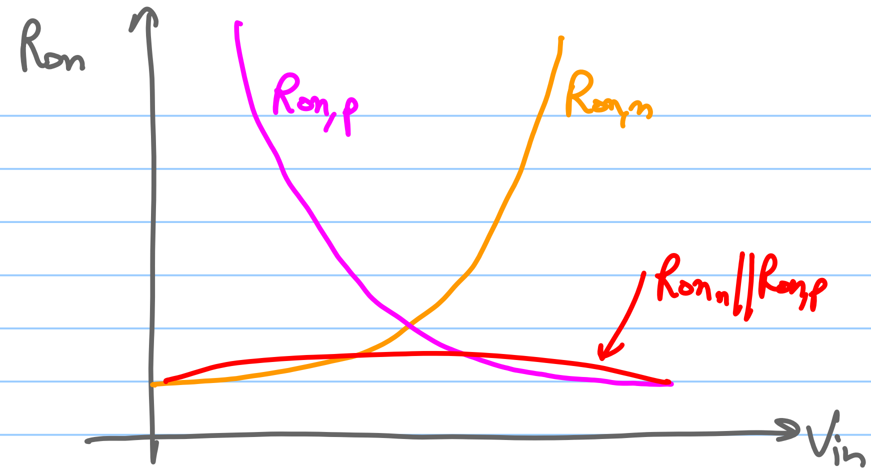


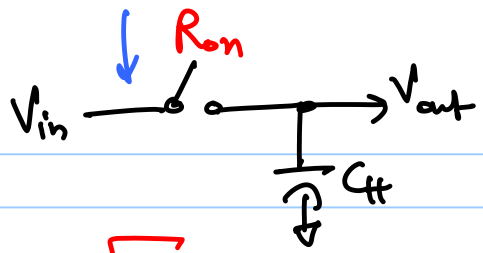
* charge pump
voltage doubler

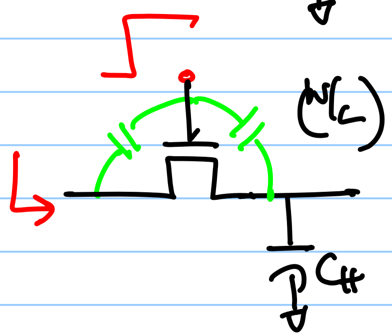


Transmission Gate (TG)









$$\tau = R_{on} C_H$$

↳ $R_{on} \downarrow$

$\Rightarrow \left(\frac{W}{L}\right) \uparrow$

Large W/L

↳ more capacitance

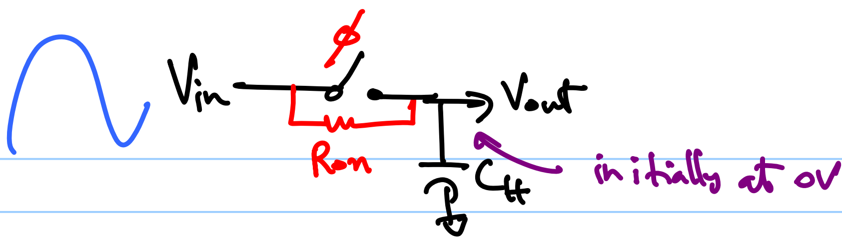
Noise sampled on the capacitor:

$$V_{n,rms} = \sqrt{\frac{kT}{C_H}}$$

↑ SNR of the ADC

$$R_{on} \approx \frac{1}{KP_n \frac{W}{L} (V_{DD} - V_{THN})}$$

in Deep Triode



$$\tau = R_{on} \cdot C_H$$

$$V_{out} = \left(1 - e^{-t/\tau}\right) V_{in}$$

Clock rate $f_s \Rightarrow t_s \leftarrow T_s/2$

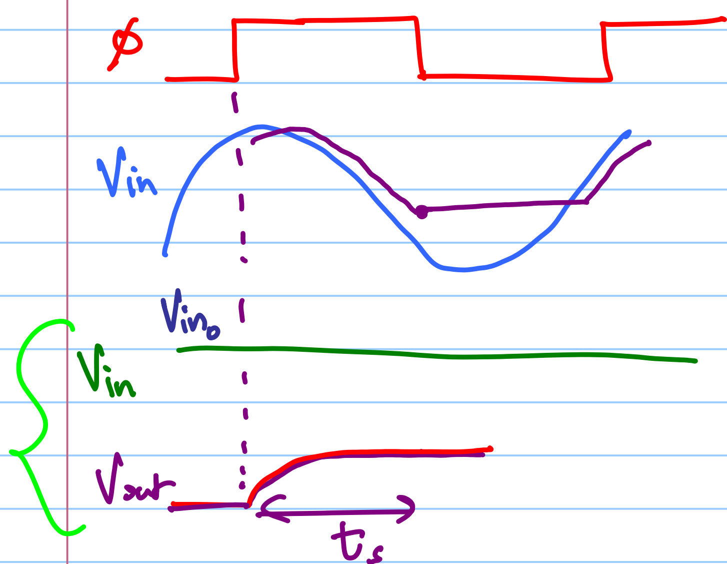
settling time

$$V_{out} = (1-\varepsilon)\, V_{in_0}$$

accuracy

$$1-\varepsilon = 1 - e^{-t_s/\tau}$$

$$\Rightarrow \quad \frac{t_s}{\tau} = \ln(1/\varepsilon)$$

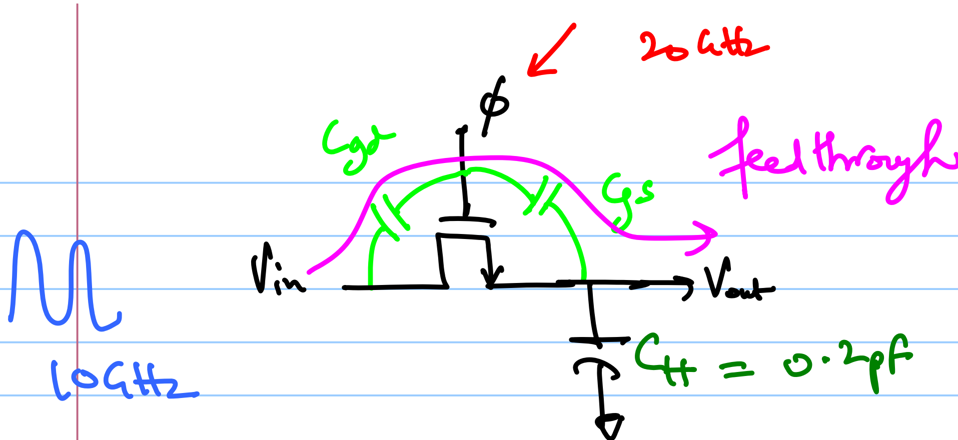


$$t_s = \tau \ln\left(\frac{1}{\varepsilon}\right)$$

$\tau \rightarrow R_{on} C_H$

Settling Accuracy of the Switch

Accuracy	ε	t_s/τ
10%	0.1	2.3
1%	0.01	4.6
0.1%	0.0001	6.9
0.01%	0.00001	9.21

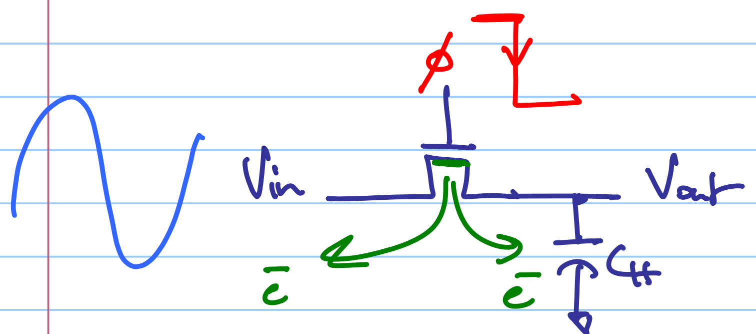


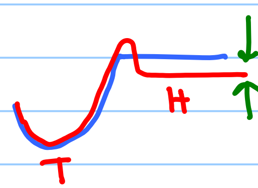
Issues?

↳ Need better topologies at higher speeds to avoid capacitive feedthrough

Precision Considerations

① Channel "charge injection"





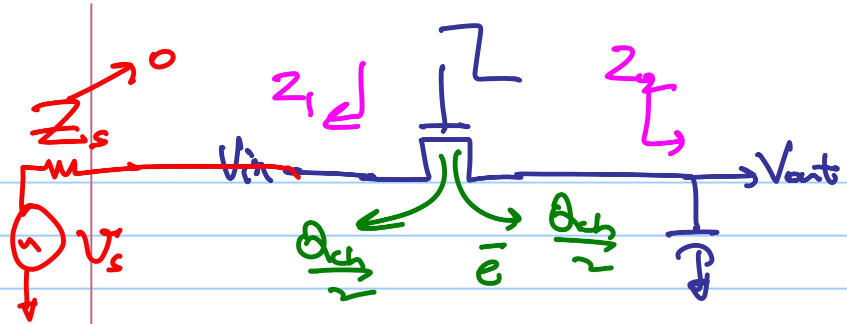
Assuming $V_{out} = V_{in}$

$$Q_{ch} \simeq WLC'_{ox}(V_{DD} - V_{in} - V_{THN})$$

$$\hookrightarrow V_{THN0} + \gamma\left(\sqrt{2\phi_B + V_{in}} - \sqrt{2\phi_B}\right)$$

Non-linear dependence on the input

"Body-Effect"



$\therefore$ $-\frac{Q_{ch}}{2}$ is injected into C_H

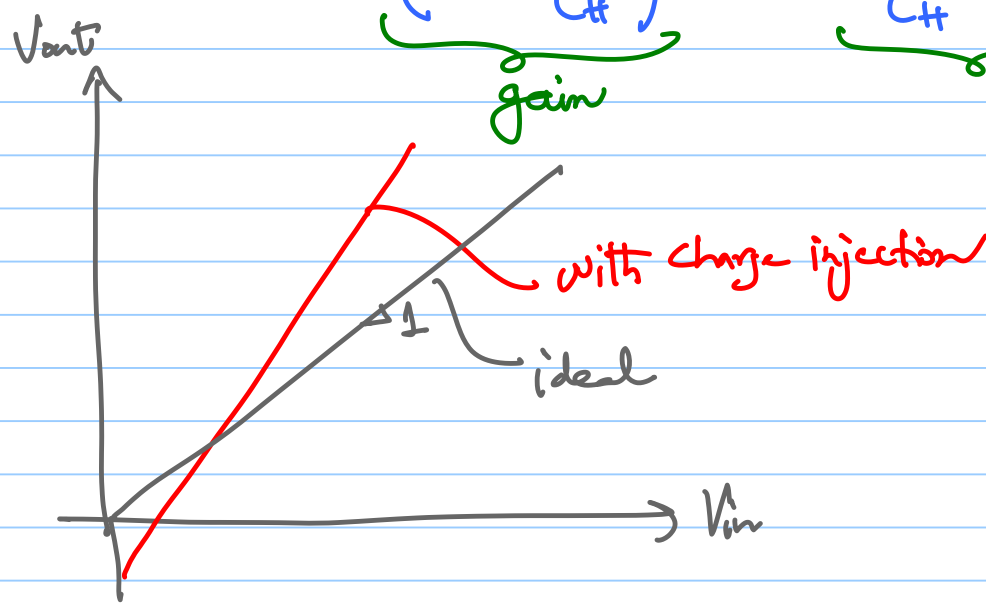
voltage error in the sampled voltage

$$\Delta V = \frac{-WLC'_{ox}\left(V_{DD} - V_{in} - V_{THN}\right)}{2\,C_H} \quad (-ve)$$

$$V_{out} \simeq V_{in} - \frac{WLC_{ox}(V_{DD} - V_{in} - V_{THN})}{C_H}$$

$f(V_{in})$: Body effect

$$= \underbrace{V_{in}\left(1+\frac{WLC_{ox}}{C_H}\right)}_{\text{gain}} - \underbrace{\frac{WLC_{ox}}{C_H}(V_{DD} - V_{THN})}_{\text{offset}}$$



$$V_{out} = \underbrace{V_{in}\left(1+\frac{WLC_{ox}}{C_H}\right)}_{\text{gain}} + \gamma\frac{WLC_{ox}}{C_H}\sqrt{2\phi_B+V_{in}} \rightarrow \text{non-linearity} \times$$

✓

$$\underbrace{-\frac{WLC_{ox}}{C_H}\left(V_{DD}-V_{THn0}+\gamma\sqrt{2\phi_B}\right)}_{\text{offset}}$$ ✓

↳ non-linearity cannot be tolerated