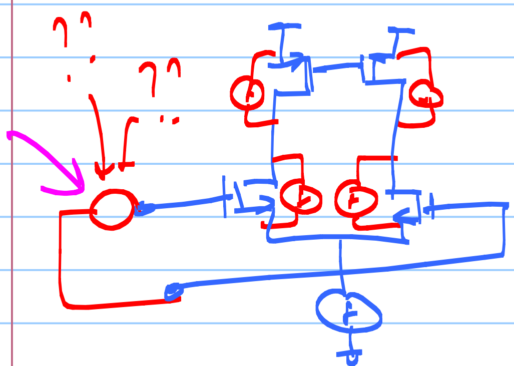
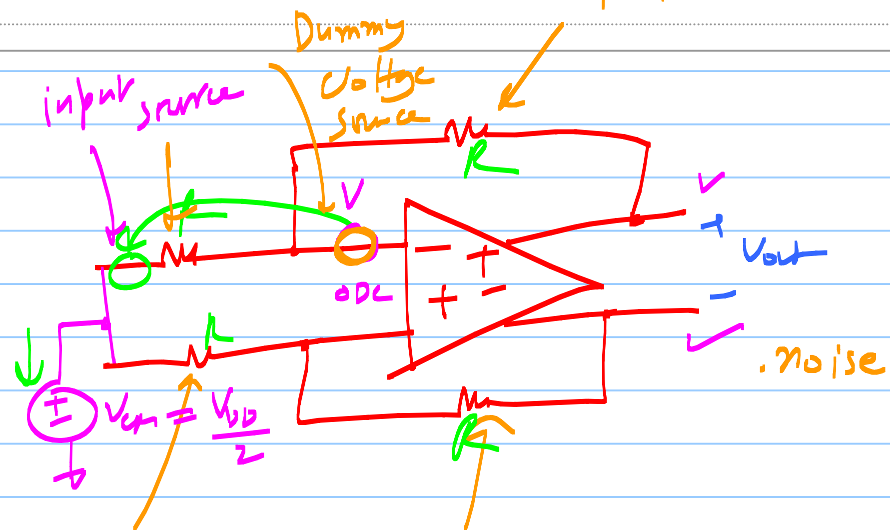
ECE 614 – Lecture 14

Note Title 10/18/2012

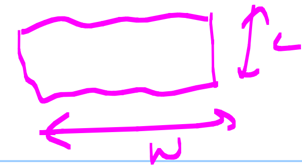




feedback doesn't change $\overline{V_{in}^2}$ of the forward path

↳ assuming that 'β' resistors are noiseless

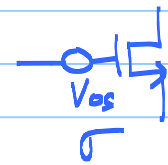
$$\sigma_{\Delta WL} \propto \frac{1}{\sqrt{WL}} = \frac{1}{\sqrt{Area}}$$



RC

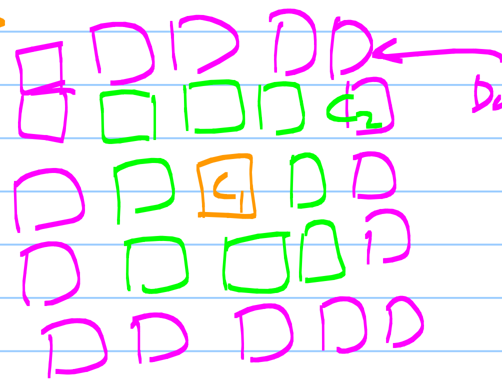
R → ≤±1%   ±15%

C → ≤±1%   ±15%



"Mismatch Analysis"

$\boxed{\frac{C_1}{C_2}}$ ≤ 0.01%



Dummy

for the sampling circuit

Ideally $\Rightarrow$ $V_{out} = V_{in}$

$$V_{out} = \underbrace{V_{in}\left(1+\frac{WLC_{ox}}{C_H}\right)}_{} + \gamma \frac{WLC_{ox}}{C_H}\sqrt{2\phi_B + V_{in}}$$

$$- \underbrace{\frac{WLC_{ox}}{C_H}\left(V_{DD} - V_{THN_0} + \gamma\sqrt{2\phi_B}\right)}_{\text{DC offset}}$$

$$V_{out} = \alpha_1 V_{in} + \alpha_0 + \alpha_2 f\left(\sqrt{V_{in}}\right)$$

$$\sqrt{x_1 + x_2} \neq \sqrt{x_1} + \sqrt{x_2}$$

$$\sqrt{1+x} = 1 + a_1 x + \frac{a_2 x^2}{\lfloor 2} + \frac{a_3 x^3}{\lfloor 3} + \cdots$$

distortion terms

FoM

Speed – precision tradeoff

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

$\Delta V_{CI}\uparrow$

$$F = \frac{1}{\tau \cdot \Delta V}$$

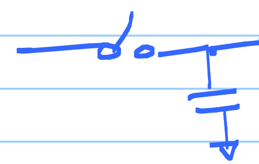
$R_{on} C_H$

$$\frac{WL C_{ox}}{C_H}\left(V_{DD} - V_{in} - V_{THN}\right)$$

$$\frac{1}{\mu_n C_{ox}\left(\frac{W}{L}\right)\left(V_{DD} - V_{in} - V_{THN}\right)} \cdot C_H$$

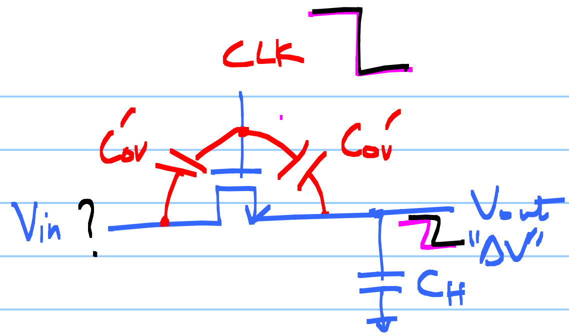
first order

$$F = \frac{1}{\tau \Delta V} = \frac{\mu_n}{L^2}$$



Clock-feedthrough

T/H



C_{ov}' ← overlap cap per unit width

$$\Delta V_{CF} = V_{CLK} \cdot \frac{W C_{ov}'}{W C_{ov}' + C_H}$$

ΔV ⇒ independent of input-level

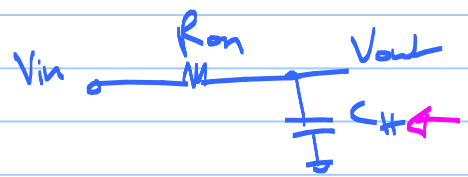
↳ constant offset in the sampled output

$W \uparrow \Rightarrow \Delta V_{CF} \uparrow$

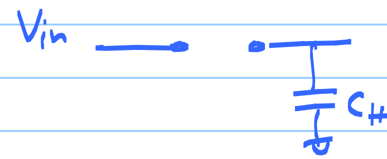
$C_H \gg W C_{ov}'$

$\frac{KT}{C}$:

$\phi = 1$



$\phi = 0$



$V_{in_0} + \overline{V_n}$

$V_{n,rms} \Rightarrow \sqrt{\frac{KT}{C}}$

Large C_H

↓

lower speed or more power

Single stage opamp: $f_{un} \simeq \frac{g_{m1}}{2\pi C_L}$

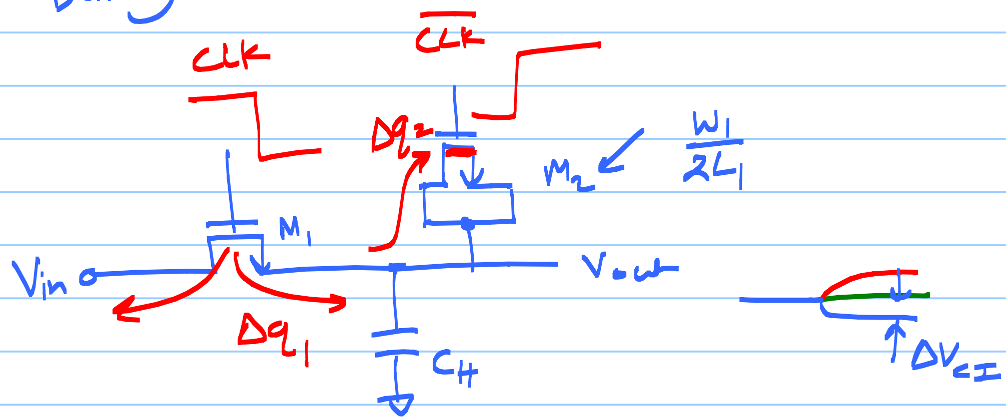
$$SNR = 20 \log_{10}\left(\frac{V_{out,rms}}{V_{n,rms}}\right)$$

$\boxed{SNR}\uparrow \Rightarrow \boxed{C_H}\uparrow$

$6.02\,\boxed{N_{eff}} + 1.76$

Charge Injection Cancellation

① Dummy Switch → deterministic error.



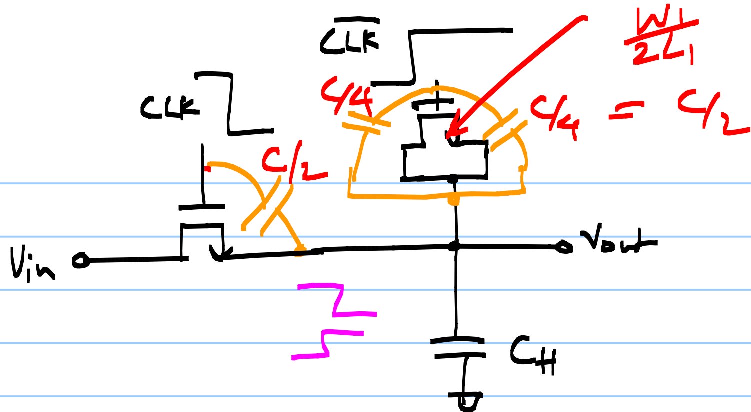
for perfect cancellation

$$\Delta q_1 = \Delta q_2$$

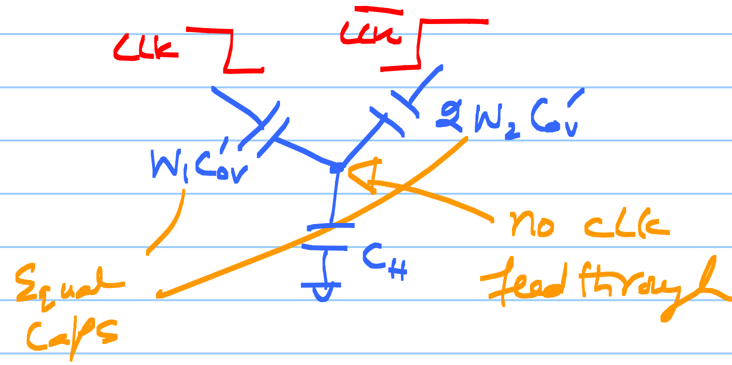
$$\Rightarrow \frac{W_1 L_1 C_{ox}}{2}\left(V_{CLK} - V_{in} - V_{THN_1}\right) = W_2 L_2 C_{ox}\left(V_{CLK} - V_{in} - V_{THN_2}\right)$$

$L_1 = L_2$, $W_2 = \frac{W_1}{2}$

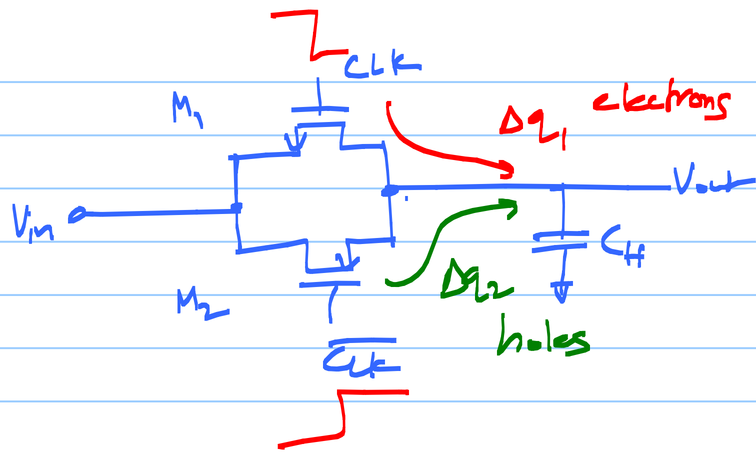
Assumption $\Rightarrow \Delta q_1 = \frac{Q_{ch}}{2}$



$$\left(\frac{W}{L}\right)_2 = \frac{1}{2}\left(\frac{W}{L}\right)_1$$



② Complementary Switches (TG)



∗ for $\Delta q_1 = \Delta q_2$

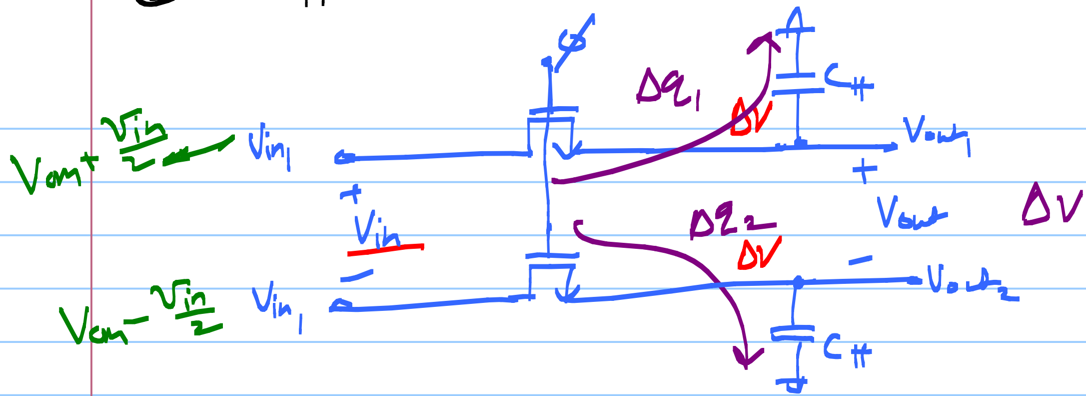
$$W_1 L_1 C_{ox} (V_{CLK} - V_{in} - V_{THN}) \triangleq W_2 L_2 C_{ox} (V_{in} - |V_{THP}|)$$

⇒ Cancellation occurs only for one value of V_{in}!

↳ Not true for $\forall V_{in}$

∗ doesn't cancel the clock feedthrough as the overlapping caps for NMOS & PMOS are not equal.

③ Differential Circuits



$$\Delta Q_1 - \Delta Q_2 = WL\,C_{ox}\left[(V_{in_2} - V_{in_1}) + (V_{THN_2} - V_{THN_1})\right]$$

$$= WL\,C_{ox}\Big[\underbrace{(V_{in_2} - V_{in_1})}_{V_{in}} + \gamma\Big(\underbrace{\sqrt{2\phi_B + V_{in_2}} - \sqrt{2\phi_B + V_{in_1}}}_{\text{non-linear term}}\Big)\Big]$$

odd function

$$f(V_{in}) = \gamma\sqrt{2\phi_B + V_{cm} + \frac{V_{in}}{2}}$$

$$= \underbrace{f(V_{in}) - f(-V_{in})}_{\text{odd function}}$$

$$g_{odd}(x) = f(x) - f(-x)$$

↳ has only odd terms in the Taylor series expansion

<u>Unity - Gain Sampler / Buffer</u>