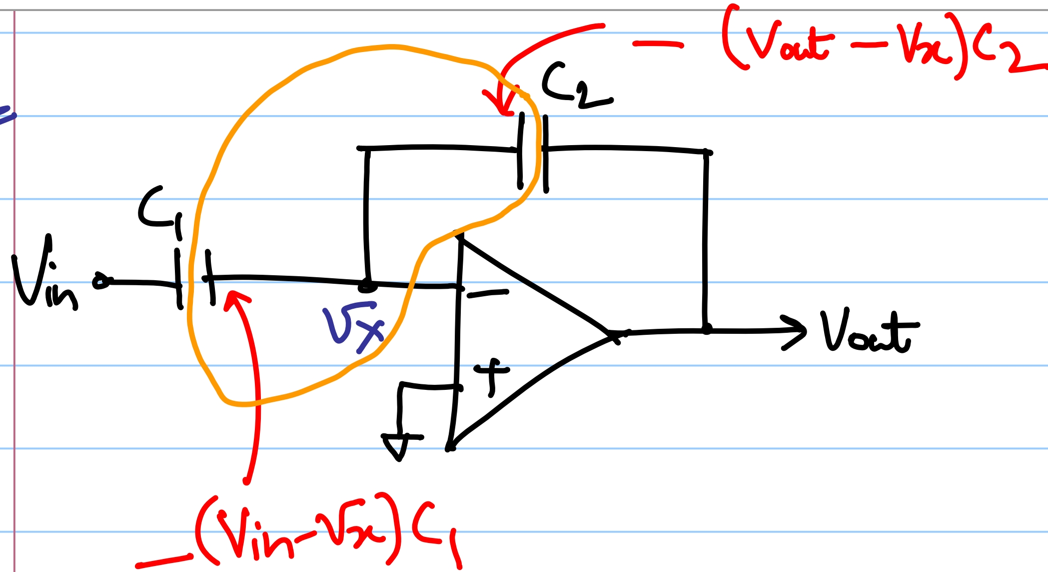
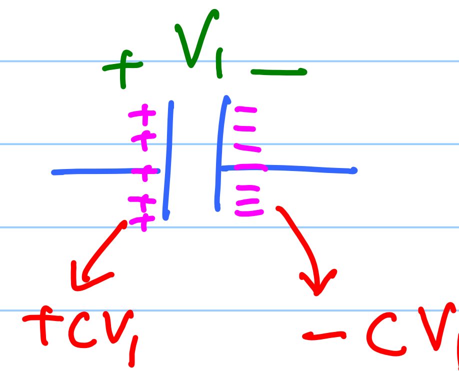
ECE 614 – Lecture 18

Note Title 10/23/2014

ϕ_2



$Q_x = 0$



$$V_{out} = (0 - V_x)A_v$$

$$\Rightarrow \quad V_x = -\frac{V_{out}}{A_v} \longrightarrow (1)$$

$$Q_x = \quad 0 = -(V_{in} - V_x)C_1 - (V_{out} - V_x)C_2 = 0$$

$$\Rightarrow \quad C_2 V_{out} = -C_1 V_{in} + (C_1 + C_2)V_x$$

$$\Rightarrow$$

$$\Rightarrow \quad V_{out} = -\frac{C_1}{C_2} V_{in} + \left(\frac{C_1+C_2}{C_2}\right) V_x \longrightarrow \text{(2)}$$

$$\Rightarrow \quad V_{out} = -\frac{C_1}{C_2} V_{in} - \left(\frac{C_1+C_2}{C_2}\right) \cdot \frac{V_{out}}{A_v}$$

$$\Rightarrow \quad V_{out} = \frac{-C_1/C_2 \, V_{in}}{1 + \left(\frac{C_1+C_2}{C_2}\right) \cdot \frac{1}{A_v}}$$

$$\beta = \frac{C_2}{C_1+C_2}$$

$$= -\frac{C_1}{C_2} \cdot V_{in} \, \frac{1}{1+\frac{1}{A\beta}}$$

$$\Rightarrow \quad \boxed{\frac{V_{out}}{V_{in}} \simeq -\frac{C_1}{C_2}\left(1-\frac{1}{A\beta}\right)}$$

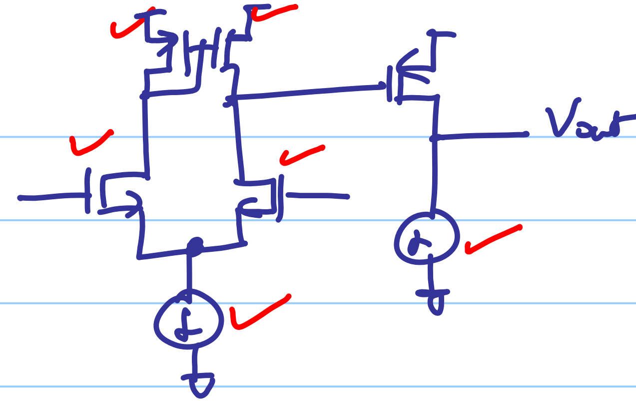
$$A\beta >> 1$$

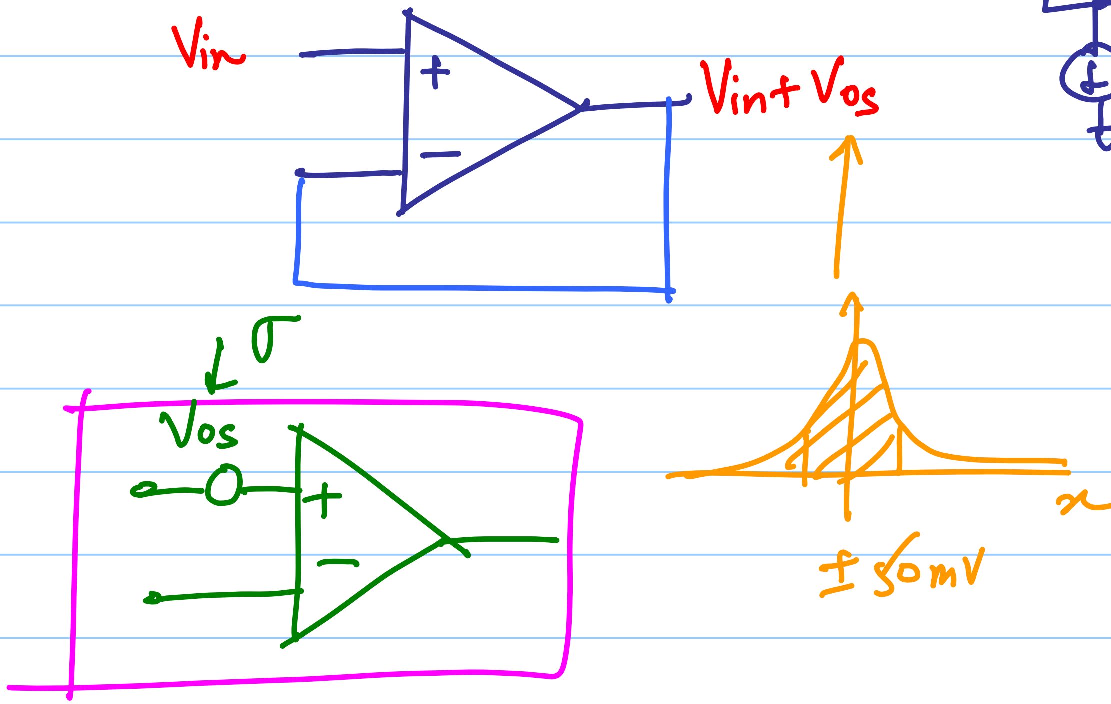
$$\Rightarrow A >> 1$$

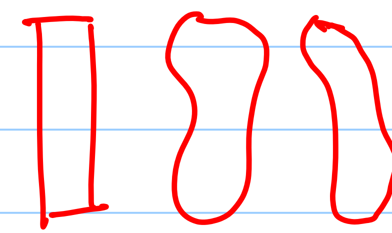
$$\Rightarrow V_x \Rightarrow 0$$

for $A\beta >> 1 \quad \Rightarrow \quad \frac{V_{out}}{V_{in}} = -\frac{C_1}{C_2}$

Effect of offset

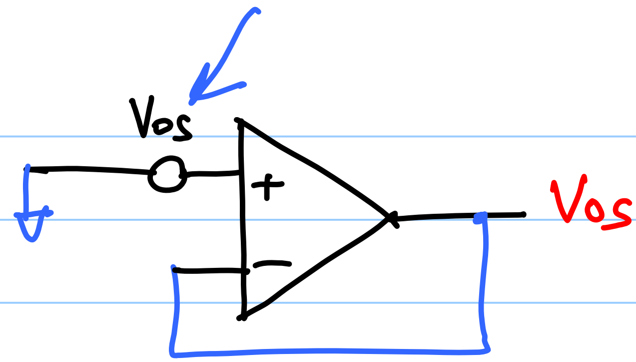




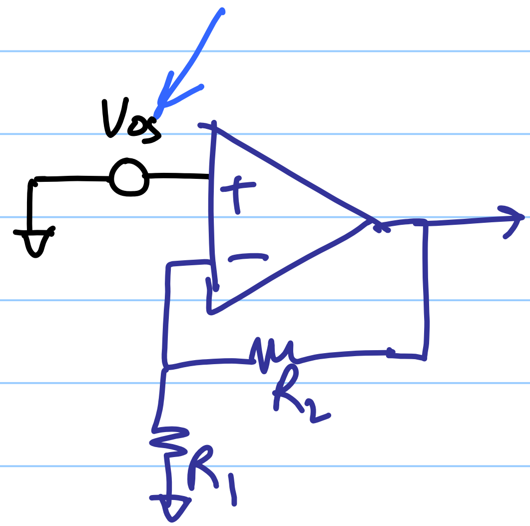


$\Delta\left(\frac{W}{L}\right) \propto \frac{1}{\sqrt{WL}}$

ΔV_{THN}



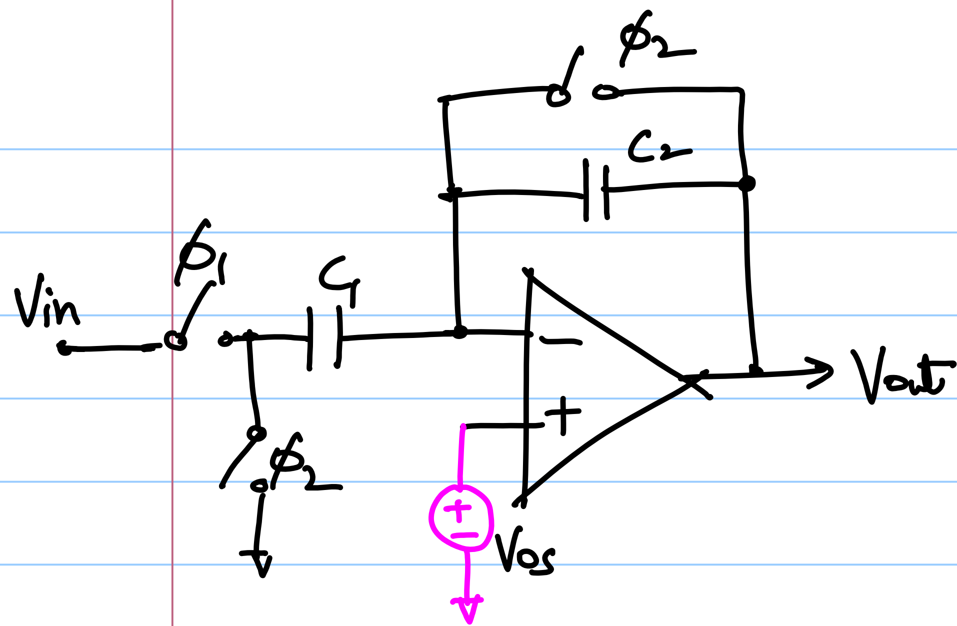
Offset $\triangleq$ DC noise

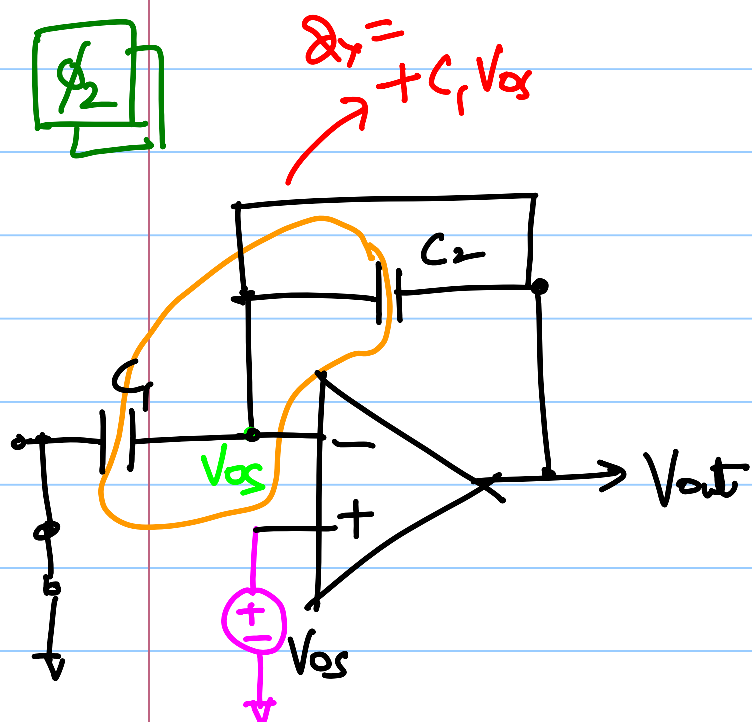


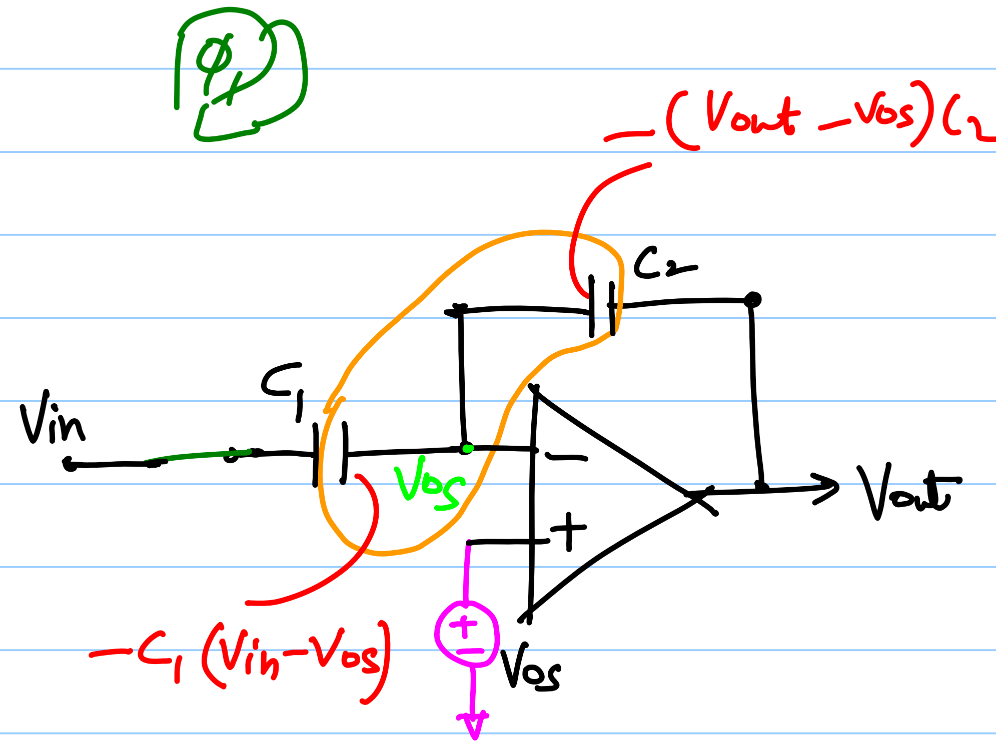
$V_{os}\left(1+\frac{R_2}{R_1}\right)$

Input referred offset

1


ϕ_2
C_2
ϕ_1
Vin
C_1
ϕ_2
Vout
Vos


ϕ_2
$Q_x = +C_1 V_{os}$
C_2
C_1
Vos
Vout
Vos


ϕ_1
$-(V_{out} - V_{os})C_2$
C_2
C_1
Vin
Vos
Vout
$-C_1(V_{in} - V_{os})$
Vos

$$-C_1 V_{in} + \cancel{C_1 V_{os}} - C_2 V_{out} + C_2 V_{os} = + \cancel{C_1 V_{os}}$$

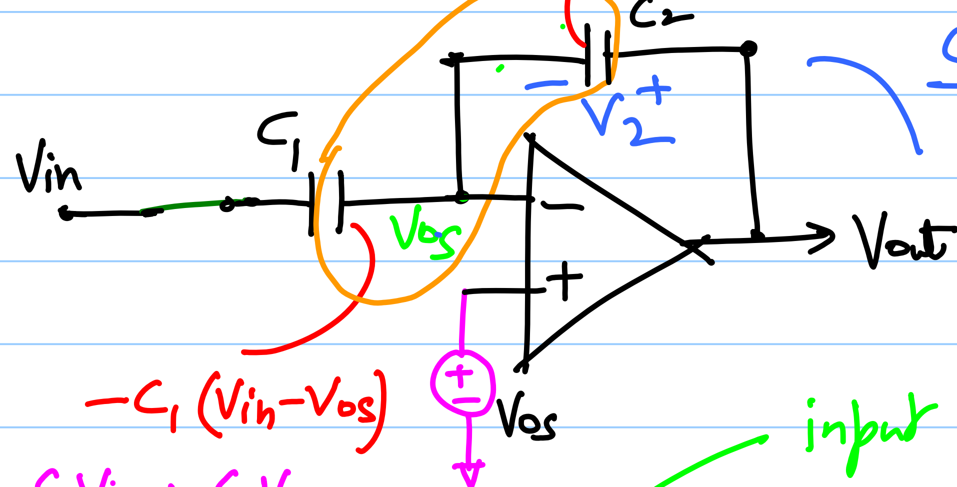
$$V_{out} = -\frac{C_1}{C_2} V_{in} + V_{os}$$

unity-gain for offset instead of a gain in a CT amplifier

$-(V_{out} - V_{os})C_2$

$\cancel{V_{in}}\ \cancel{V_{os}}$

$\dfrac{C_1 V_{in}}{C_2} + V_{os}$



$-C_1(V_{in} - V_{os})$

$-C_1 V_{in} + C_1 V_{os}$

input offset cancellation

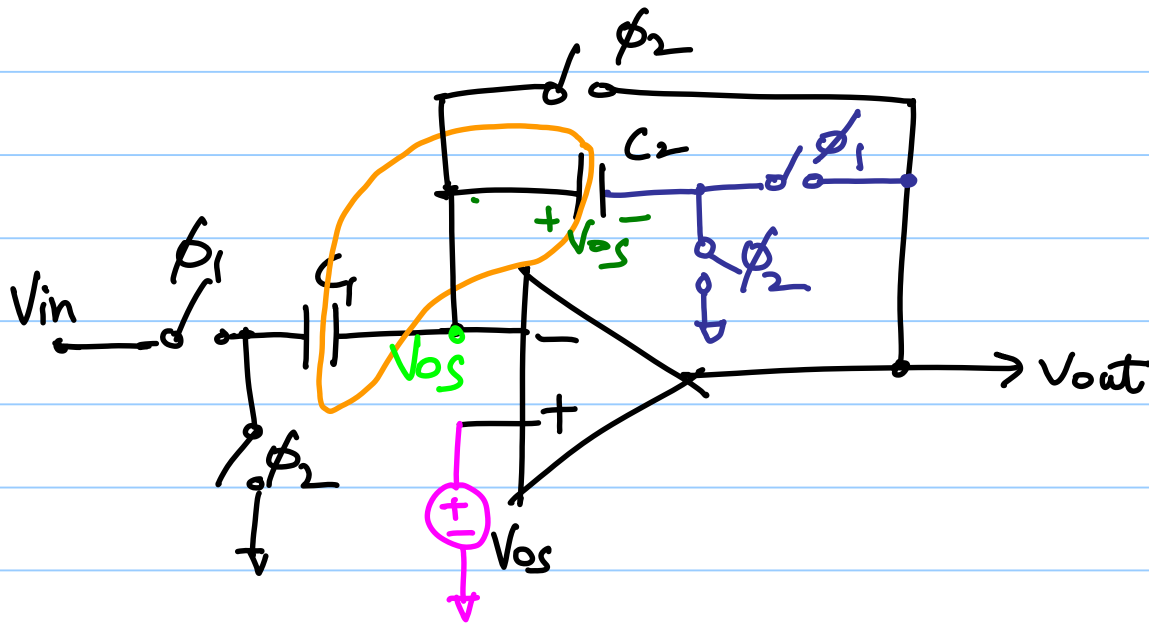
* C_1 is charged to $(V_{in} - V_{os})$ instead of V_{in}

↳ no offset in the voltage across C_2

$$\Rightarrow V_2 = \frac{C_1 V_{in}}{C_2}$$

$$\Rightarrow V_{out} = V_2 + V_{os} = \frac{C_1}{C_2} V_{in} + V_{os}$$

Correction of offset in C_2



$= V_{os} - \frac{C_1}{C_2} V_{in}$

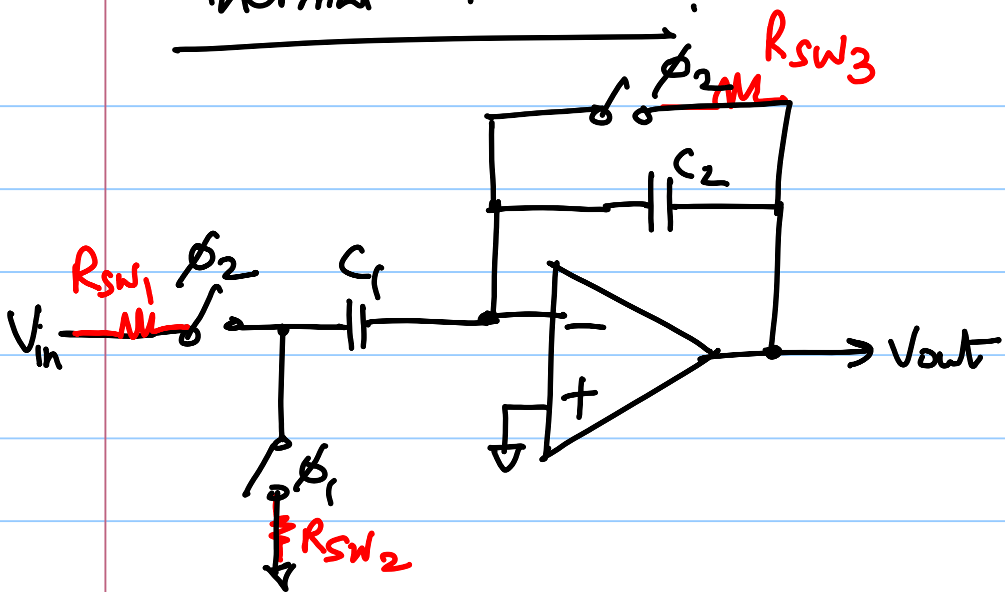
ϕ_2: charge C_2 to V_{os} instead of 0V

ϕ_1: $\Rightarrow$ $V_{out} = -\frac{C_1}{C_2} V_{in}$ $\Rightarrow$

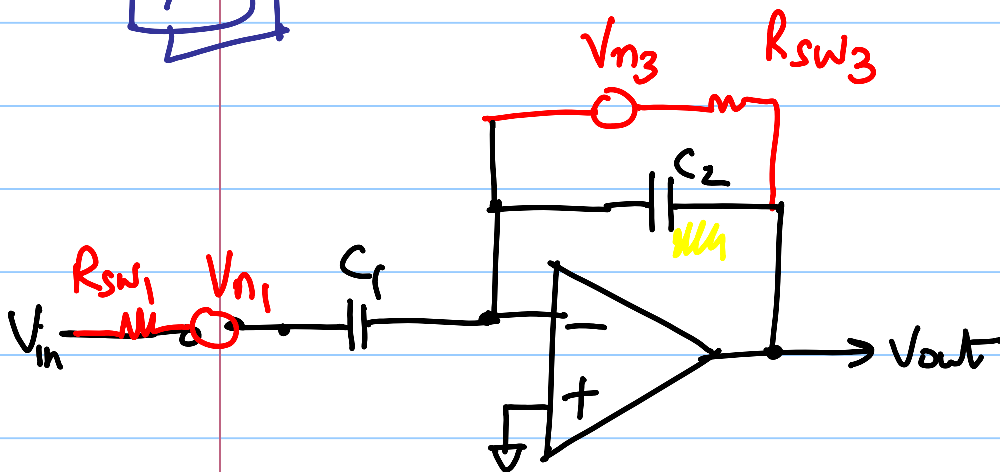
Analyze for charge-injection

Thermal Noise :

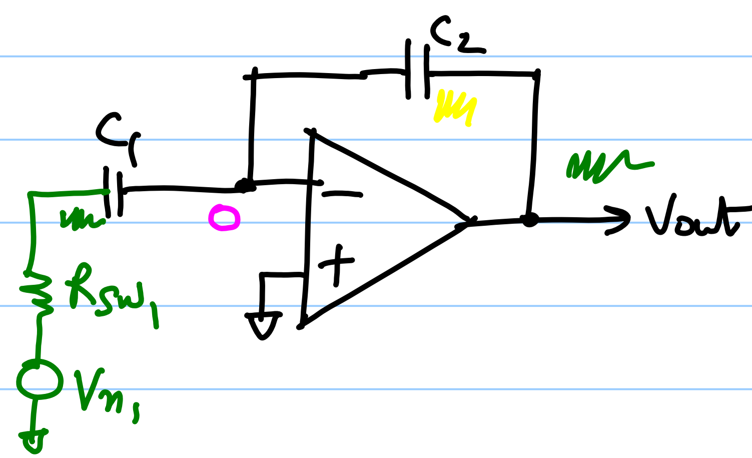
Non-inverting



ϕ_2



ϕ_1



ϕ_2

$R_{sw_1} \Rightarrow C_1$ has noise variance $\frac{kT}{C_1}$

$R_{sw_3} \Rightarrow C_2$ has noise variance $\frac{kT}{C_2}$

ϕ_1

$R_{sw_1} \Rightarrow \left(\frac{kT}{C_1}\right)$

$\Rightarrow$ at the output $\Rightarrow$ $\frac{kT}{C_1}\left(\frac{C_1}{C_2}\right)^2$ ②

$R_{sw_3} \Rightarrow$ Its contribution during ϕ_2

③ $\left(\frac{kT}{C_2}\right)$ is held on C_2

$R_{sw_2} \Rightarrow$ Results in a noise $\frac{kT}{C_1}$ on C_1

and gets amplified to

① $\frac{kT}{C_1}\left(\frac{C_1}{C_2}\right)^2$ at the output.

Total output noise $= 2 \times \frac{KT}{C_1}\left(\frac{C_1}{C_2}\right)^2 + \frac{KT}{C_2}$

$\Rightarrow$ Input referred noise $\Rightarrow$ $$\frac{2 \times \frac{KT}{C_1}\left(\frac{C_1}{C_2}\right)^2 + \frac{KT}{C_2}}{\left(C_1/C_2\right)^2}$$

input referred mean square noise voltage $= \frac{KT}{C_1}\left[2 + \frac{C_2}{C_1}\right]$

$= \frac{KT}{C_1} \times 2.5$ for gain $= 2 = \frac{C_1}{C_2}$

input referred RMS noise $= \sqrt{2.5\,\frac{KT}{C_1}}$ for gain $= 2$

In general

$$V_{rms,in} = \sqrt{\frac{KT}{C_1}\left(2 + \frac{C_2}{C_1}\right)}$$

A_{CL}^{-1}

Design $\Rightarrow$ for SNR $\Rightarrow$ find C_1

$\frac{C_1}{C_2} = 2$

Start with SNR spec

$\Rightarrow C_2 = \frac{C_1}{\text{gain}}$