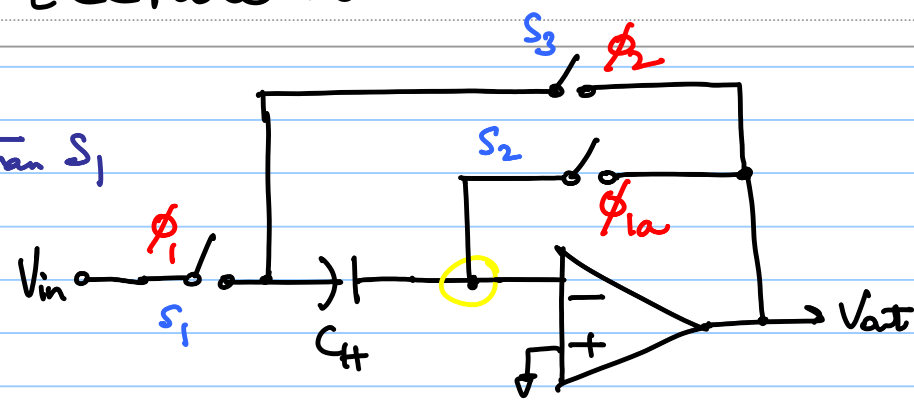
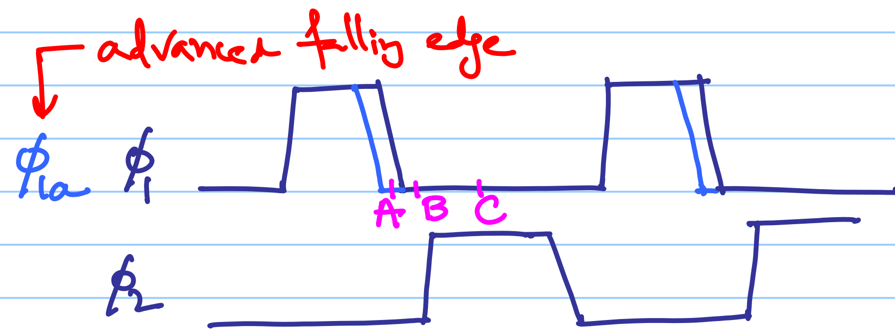
ECE 517 - Lecture 16

Note Title 3/9/2017

Turn off switch S_2 earlier than S_1

$\Rightarrow$ ϕ_{1a} & advanced falling edge



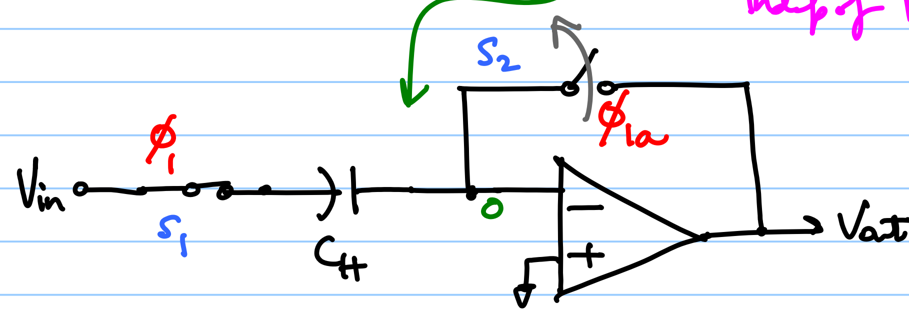


(A)

$\Delta q_{L_2} = WLC_{ox}(V_{clk} - V_{THN_2})$ ✓✓

$\Delta q_{L_2} = WLC_{ox}(V_{clk} - V_x - V_{THN_2})$, with $V_x \to 0$

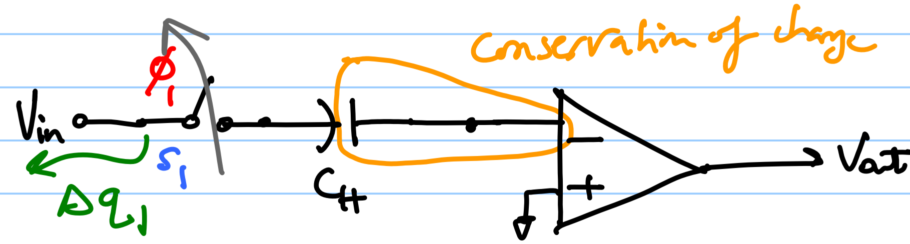
indep of V_{in}.



(B)

$\Delta q_{L_1} = WLC_{ox}(V_{clk} - V_{in} - V_{THN_1})$

All of q_1 is absorbed into V_{in}



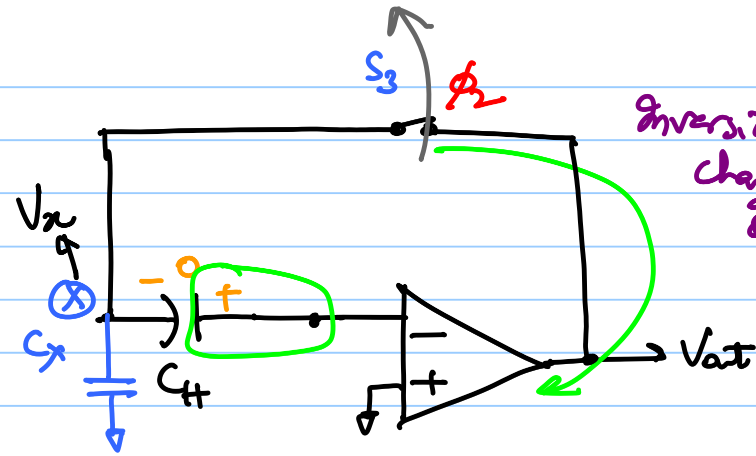
(C)

$V_{in} \simeq 0$

Total charge at node-X $= V_x \simeq 0$

$$C_x V_x - (V_{out} - V_x) C_H = 0 \longrightarrow (1)$$

& $$V_x = -\frac{V_{out}}{A} \longrightarrow (2)$$



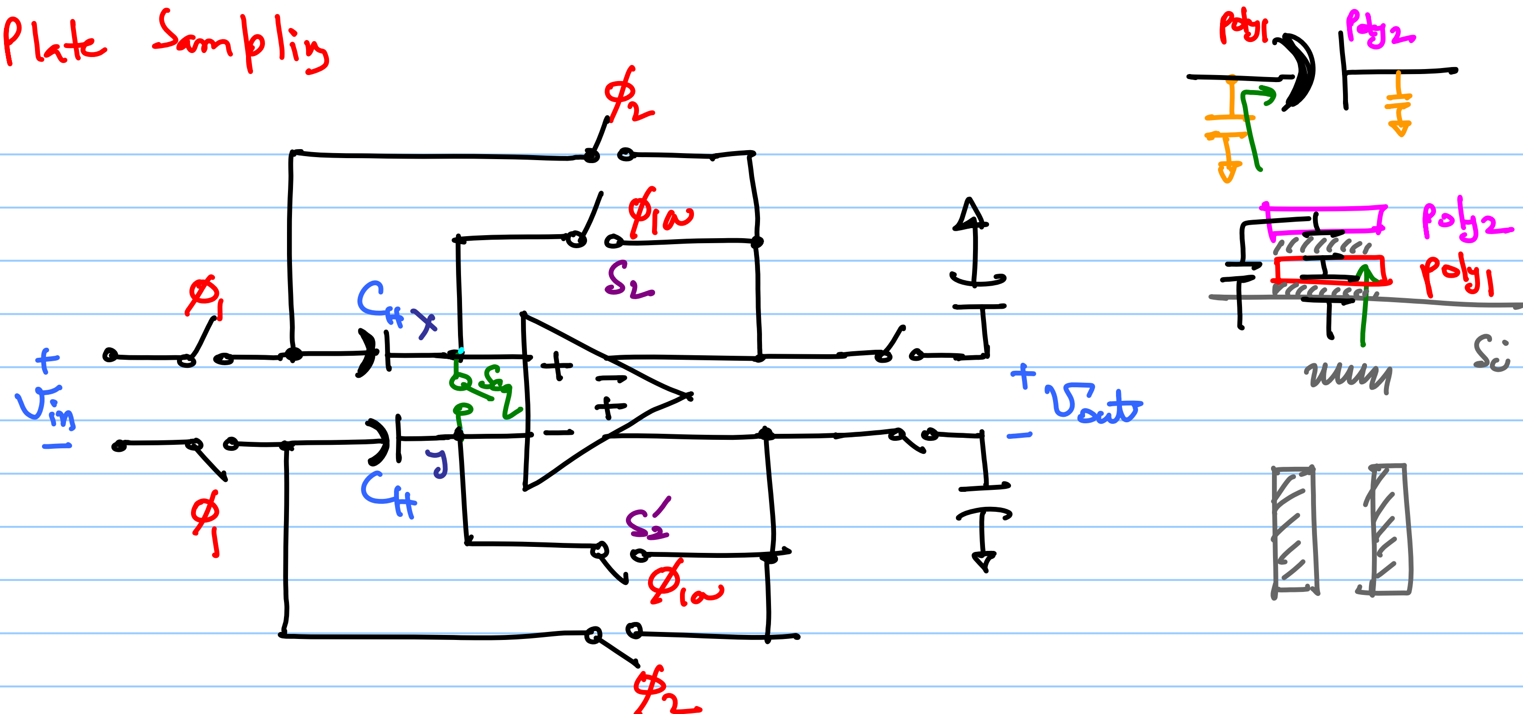
$(0 - V_x) A = V_{out}$

$$-(C_x + C_H)\frac{V_{out}}{A} - V_{out} C_H = 0$$

$\Rightarrow V_{out} = 0$

$\Rightarrow$ This result is independent of ΔI_1

Bottom Plate Sampling



* S_2 & S_2' CI mismatch → creates CM disturbance at X & Y

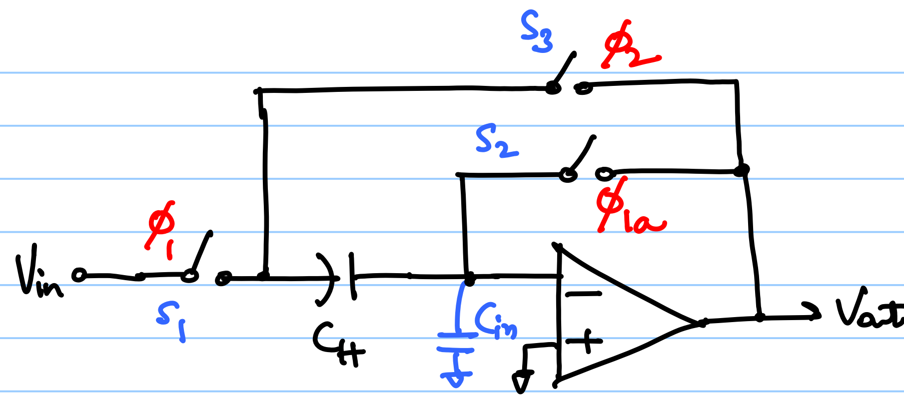
↳ add another switch S_{eq}

S_{e_2}

↳ turns off slightly after S_2 & S_2'
but before S_1 & S_1'

↳ equalizes (averages out) the charge at nodes x + y

Finite Gain:



f_s

$f_{un} \leftarrow$ opamp unity gain frequency

$A_v \leftarrow$ DC gain

$SR \leftarrow$ slew rate

offset

$$V_{out} \simeq V_0 \left[1 - \underbrace{\frac{1}{A_v}\left(\frac{C_{in}}{C_H} + 1 \right)}_{\epsilon} \right]$$

$\epsilon \longrightarrow$ precision

feedback factor in ϕ_2 mode

$$\beta = \frac{C_H}{C_H + C_{in}}$$

Ex.

$C_{in} = 0.5pF$

$C_H = 2pF$

└→ $A_v \geq 1250$ for a precision of 0.1%   (> 60dB)

with $C_{in} = 0 \Rightarrow$ 1000 ⇒ 60dB

⇒ S/H

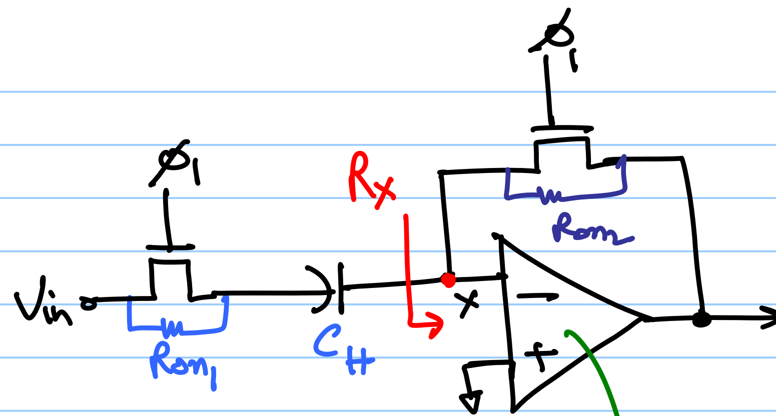
gain error, settling error } o/p error $< \frac{1}{2}$ LSB $= \frac{V_{ref}}{2^{N+1}}$

Thermal noise ⇒ $\propto \sqrt{\frac{kT}{C}}$ should also be well below $\frac{1}{2}$ LSB.

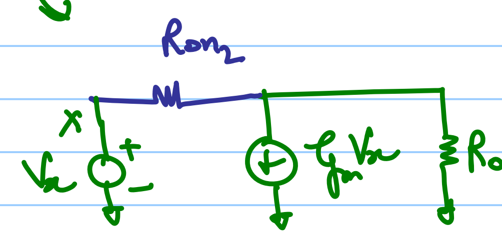
Speed Consideration:

See Razavi for more Analysis

a) Sample Mode



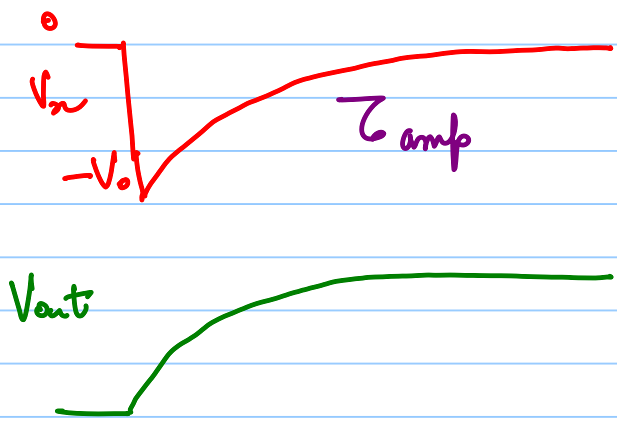
$$R_x \simeq \frac{R_o + R_{on_2}}{1 + g_m R_o}$$

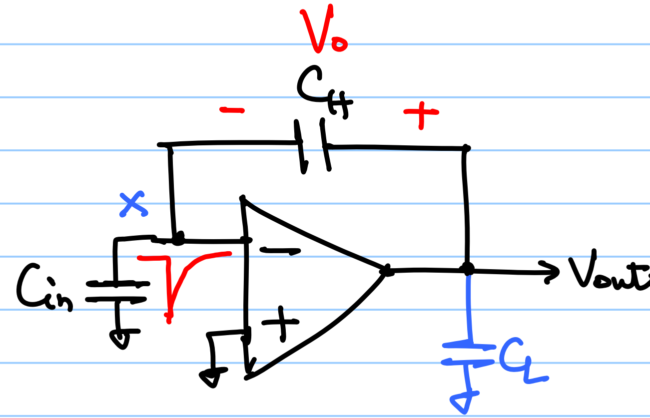


time constant for the sampling phase

$$\tau_{samp} = \left(R_{on_1} + \frac{1}{g_m}\right) C_H$$

b) Amplification Mode





$$\tau_{amp} = \frac{C_L C_{in} + C_{in} C_H + C_H C_L}{g_m C_H}$$

if $C_{in} \ll C_L, C_H$ then

$$\tau_{amp} \simeq \frac{C_L}{g_m}$$ ← expected Result

speed f_s

settling accuracy ϵ

C_L

$\Rightarrow g_m \Leftarrow f_{un}$

$g_m \Downarrow I_{bias} \Rightarrow$ Power

$$f_{un} = \begin{cases} \dfrac{g_m}{C_L} & \text{Single-stage} \\ \dfrac{g_{m1}}{C_c} & \text{Two-stage} \end{cases}$$

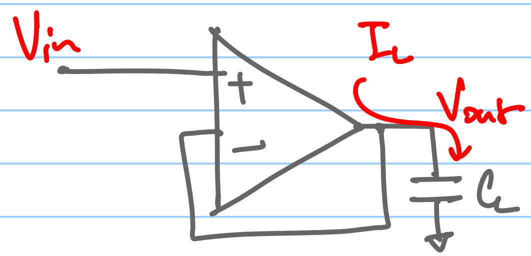
C_c ↑ Miller Compensation Cap

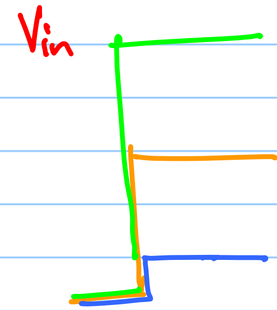
↳ C_{in} degrades both the speed and precision of the unity-gain sampler buffer

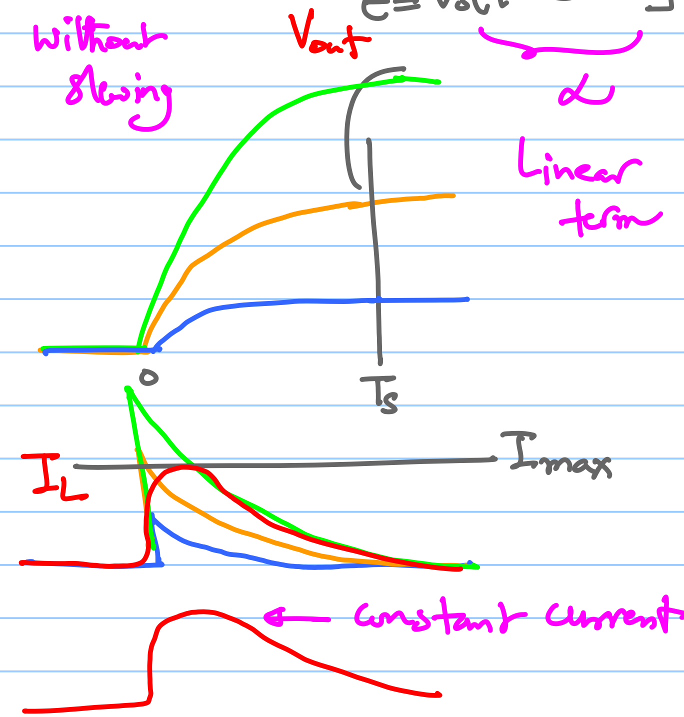
Slewing in opamp

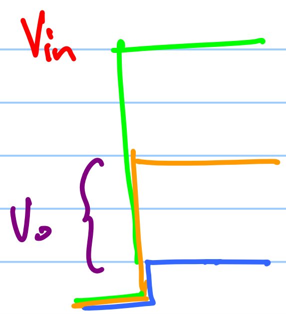
$$I_L = C_L \frac{dV_{out}}{dt}$$

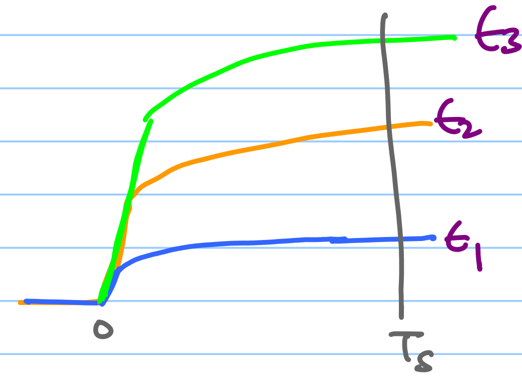
$$\epsilon = V_0\left[1 - e^{-T_s/\tau}\right]$$











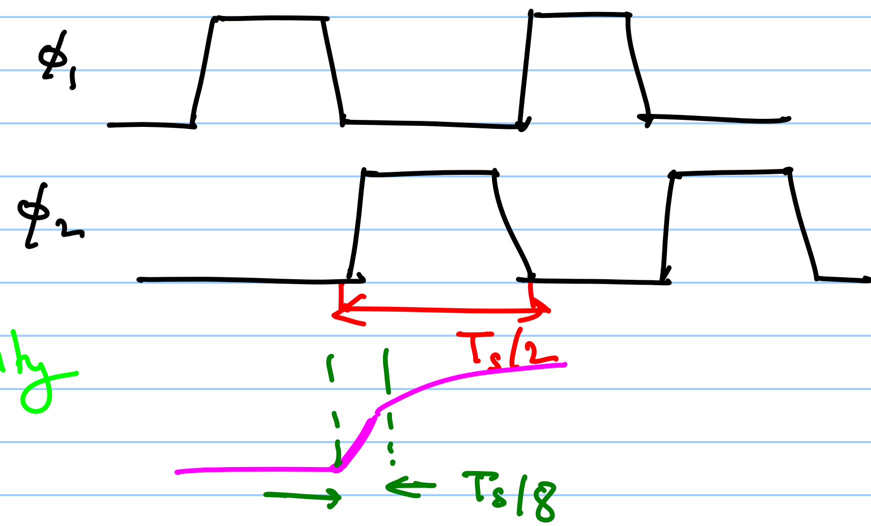
↳ settling errors
ϵ_1, ϵ_2, ϵ_3 are
input dependent

↳ Non linearity!

Rule of Thumb:

The opamp should not slew for more than 25% of the settling period

→ Look at the SFDR for Non Linearity



$$T_s \le \frac{T_{clk}}{2}$$

$$SR = \begin{cases} \frac{I_{ss}}{C_L} & \text{1-stage} \\ \frac{I_{ss}}{C_c} & \text{2-stage Miller with class AB} \end{cases}$$

(I_{ss}: tail current in the diff pair)