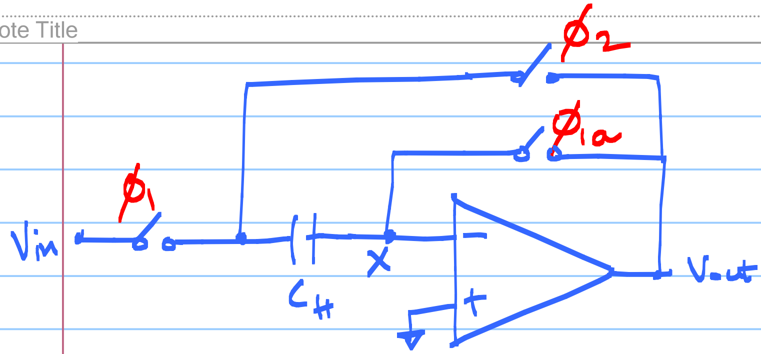
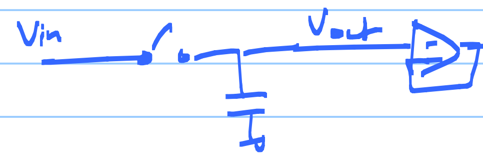
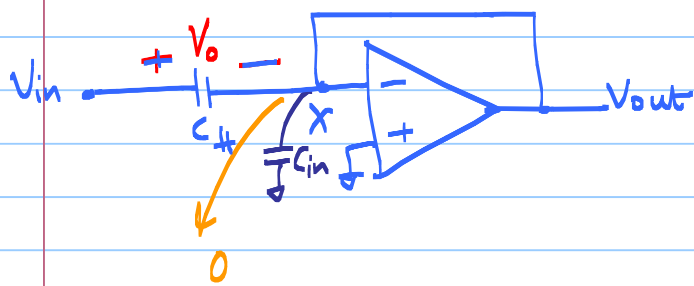
ECE 614 — Lecture 16

Note Title 10/25/2012

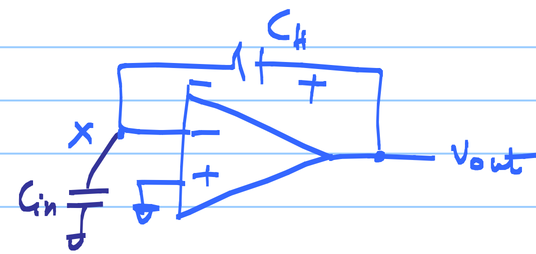




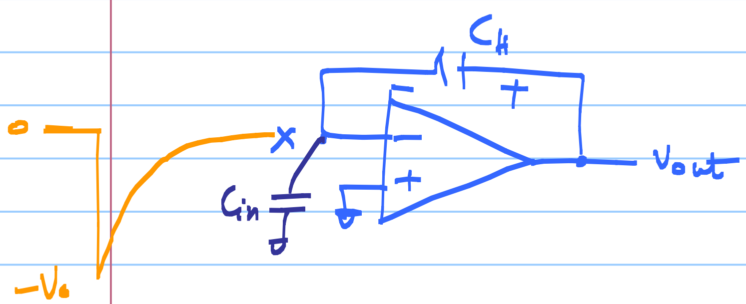
$\underline{\phi_1}$ Sampling mode

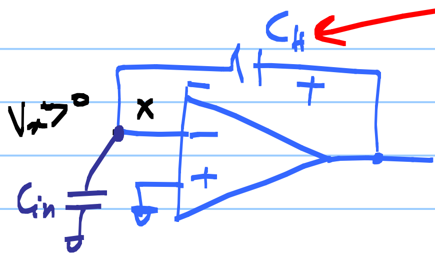


$\underline{\phi_2 \text{ (amplification)}}$



Av =





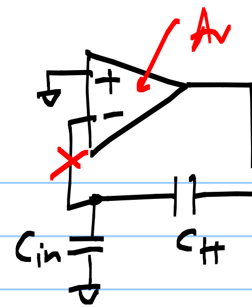
comes from $\sqrt{\frac{kT}{C}}$

$V_{out} = V_o(1-\epsilon)$

$$\frac{1}{\beta A_v} = \frac{1}{A_v \cdot \frac{C_H}{C_H + C_{in}}}$$

$A_v \to \infty$

$C_{in} \downarrow$

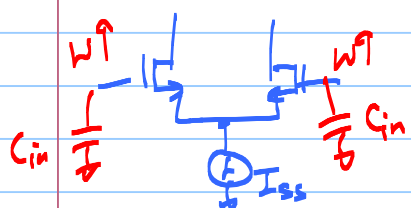


$$\beta = \frac{\frac{1}{sC_{in}}}{\frac{1}{sC_H} + \frac{1}{sC_{in}}}$$

$$\beta = \frac{C_H}{C_H + C_{in}} < 1$$

loop-gain $= \beta A_v$

gain error $\simeq \frac{1}{\beta A_v}$



$I_{SS} \to$ fixed

$W\uparrow$, $g_m\uparrow$

$V_{ov}\downarrow \Rightarrow g_m r_o \uparrow$

$f_T \downarrow$

Ex.

$C_{in} = 0.5\,pF$

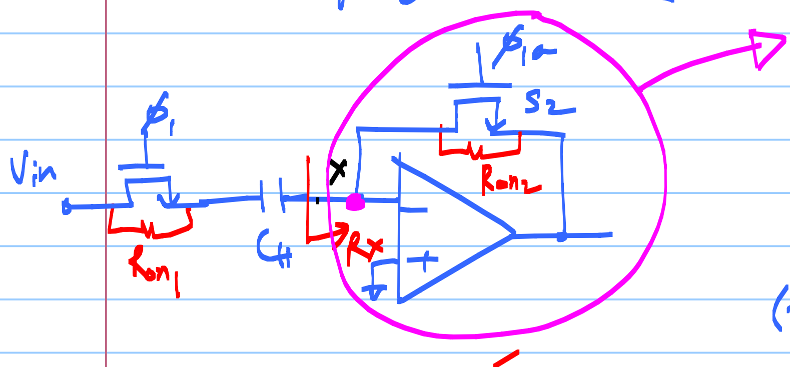
$C_{f} = 2\,pF$

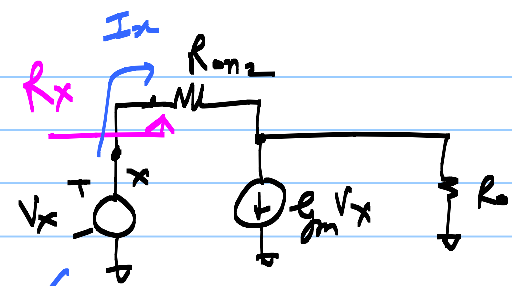
gain error of $0.1\% \rightarrow 0.01\%$ $\Rightarrow$ 60dB precision

$\rightarrow A_v \geq 1250 > 60\,dB \longrightarrow > 80\,dB$

Speed Considerations

Sampling mode (ϕ_1)





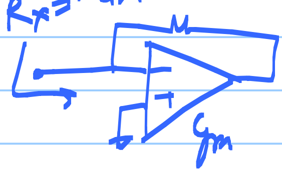
$$(I_x - g_m V_x) R_o + I_x R_{on_2} = V_x$$

$$\Rightarrow R_x = \frac{V_x}{I_x} = \frac{R_o + \cancel{R_{on_2}}}{\cancel{1+}\, g_m R_o} \simeq \frac{1}{g_m}$$

$$g_m R_o >> 1$$

$$R_{on_2} << R_o$$

$R_x = 1/G_m$

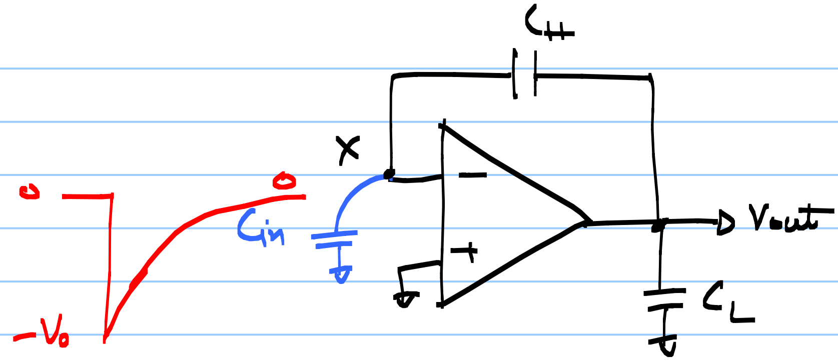


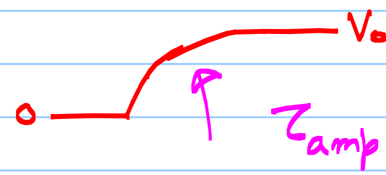
$$\tau_{samp} = \left(R_{on_1} + \frac{1}{g_m}\right) \cdot C_H$$

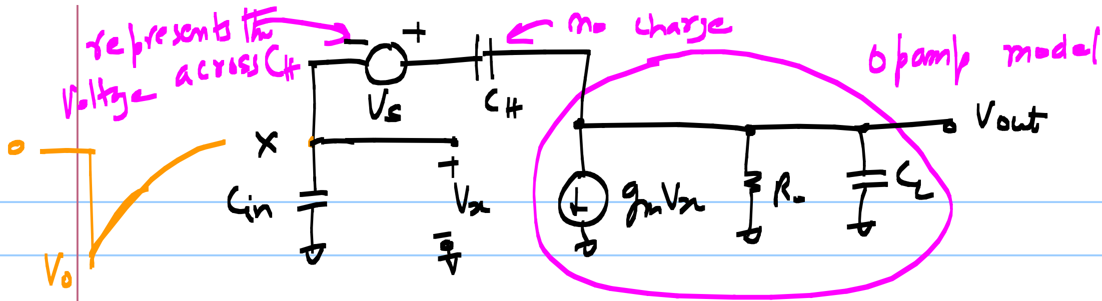
$$5\,\tau_{samp} \leq \frac{T_s}{2} \Leftarrow \text{Settling accuracy}$$

amplification phase (ϕ_2)

$$f_{3dB} = \beta f_{un} = \frac{C_H}{C_H + C_{in}} \cdot f_{un}$$







$$\frac{V_{out}}{V_s}(s) = ?$$

KCL:

$$V_{out}\left(\frac{1}{R_o} + sC_L\right) + g_m V_x = \left(V_s + V_x - V_{out}\right) \cdot sC_H \longrightarrow (1)$$

KVL:

current thru C_{in} $\Rightarrow$ sC_{in}

$$V_x \cdot \frac{sC_{in}}{sC_H} + V_x + V_s = V_{out} \longrightarrow (2)$$

Solve (1) & (2)

$$\frac{V_{out}}{V_s}(s) = R_o \cdot \frac{(g_m + sC_{in})\,C_H}{R_o\left[C_L C_{in} + C_{in} C_H + C_H C_L\right] + g_m R_o C_H + C_H + C_{in}}$$

$$(g_m R_o)\,C_H \gg C_H,\ C_{in}$$

$$\simeq \frac{(g_m + sC_{in})\,C_H}{\boxed{(C_L C_{in} + C_{in} C_H + C_H C_L)}\,s + \boxed{g_m C_H}}$$

Single-pole opamp

$$\omega_{un} = \frac{g_m}{C_L}$$

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

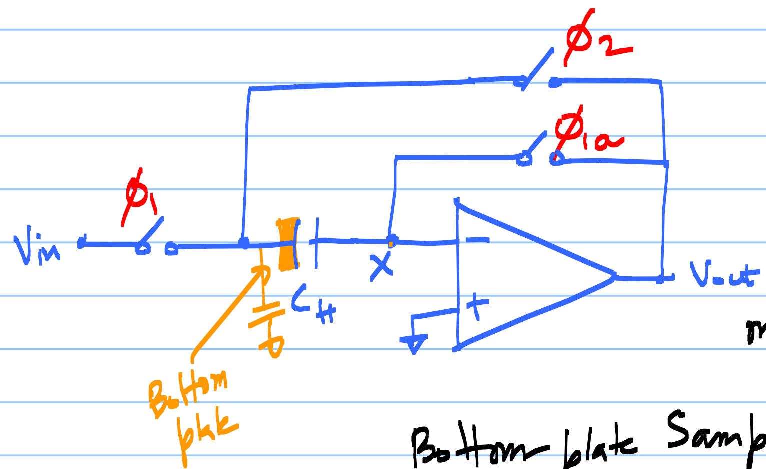
$$C_{in} \ll C_L,\ C_H, \quad \tau_{amp} \simeq \frac{C_L}{g_m} = \frac{1}{\omega_{un}}$$

minimize C_{in}

$$f_{3dB} = \beta \cdot f_{un}$$

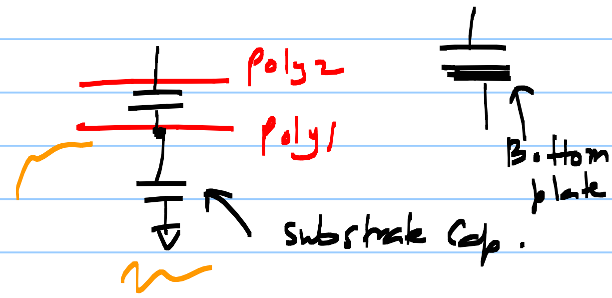
$f_{un} \leftarrow C_L$

$\beta \rightarrow \dfrac{C_H}{C_H + C_{in}}$



minimize C_{in}

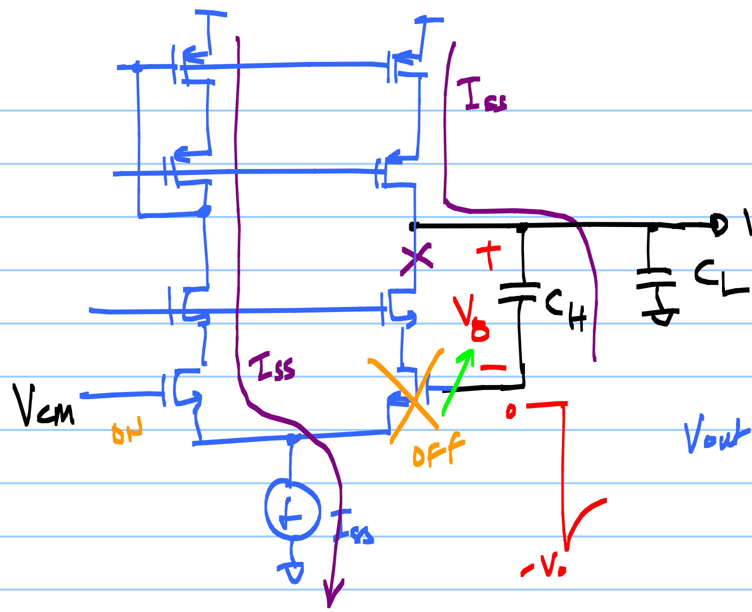
Bottom-plate Sampling

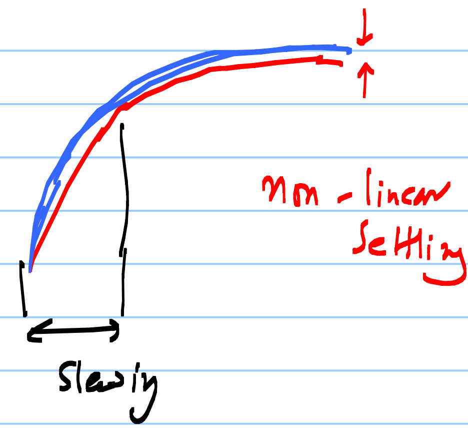


* Substrate noise
* more C_{poly_sub} Cap.

$V_{out} = \frac{I_{ss}}{C_L}$ slewing

$\cancel{g_m V_{in}}$ Linear

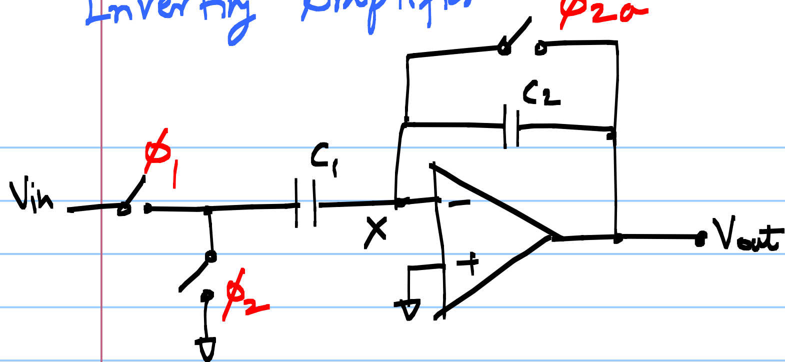


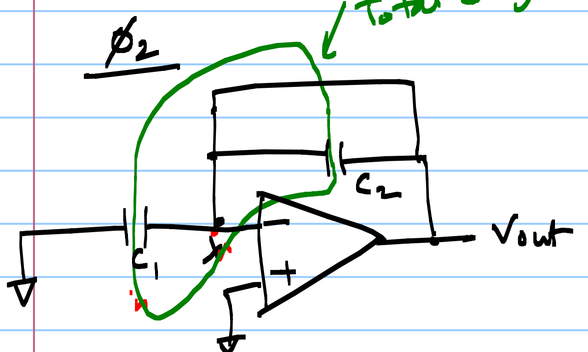


Limit slewing period to $\frac{1}{4} T_{settling}$

$\leq \frac{T_s}{8}$

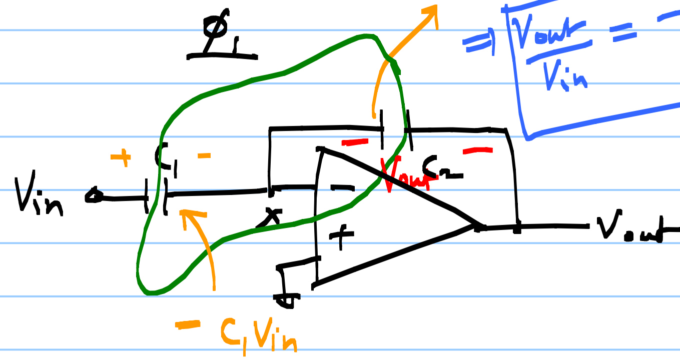
Inverting Amplifier



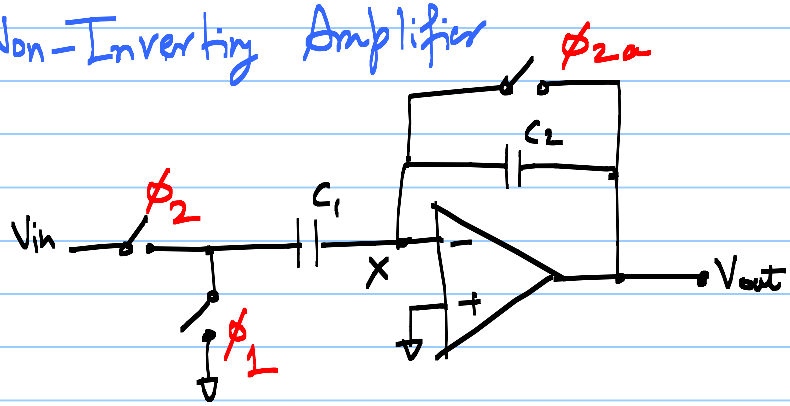


$+ C_1 V_{in} = - C_2 V_{out}$

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



Non-Inverting Amplifier



flip the sampling phase

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