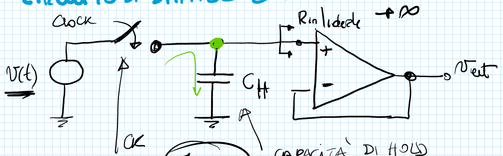
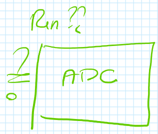
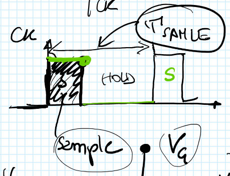
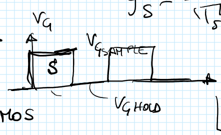
CIRCUITO DI "SAMPLE & HOLD"

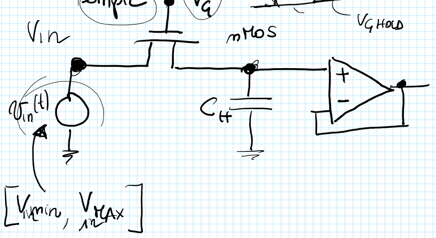






$$f_S = \frac{1}{T_{SAMPLE}}$$





- SAMPLE nMOS on ohmico
- HOLD nMOS spento

* SAMPLE nMOS on ohmico

nMOS $R_{ds_{on}} \triangleq \left[\frac{\partial I_D \text{ ohmico}}{\partial V_{DS}}\right]^{-1} = \frac{1}{2k_n(V_{GS}-V_{Tn})}$

$V_{GS} > V_{Tn}$

$(V_{GD} > V_{Tn})$

$V_G - V_S > V_{Tn}$

$V_G > V_S + V_{Tn} = V_{Tn} + V_{S\,max}$

- HOLD nMOS off

$V_{GS} < V_{Tn}$

$(V_{GD} < V_{Tn})$

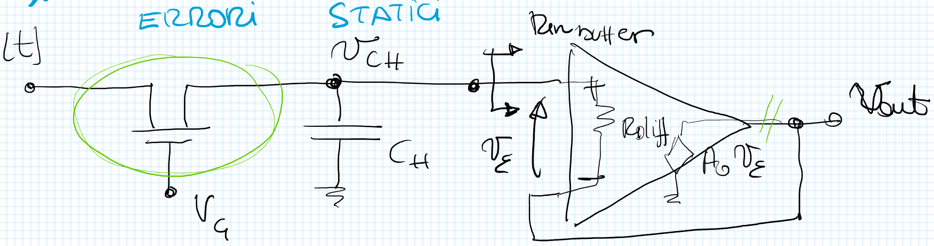
$V_G - V_S < V_{Tn}$

$V_{G_m} < V_{Tn} + V_{S\,min}$

NON IDEALITÀ DEL CIRCUITO DI S&H

1. * errori statici → guadagno finito dell'opamp del buffer; → Rin finito del buffer
2. * limitazione sulla minima durata del tempo di sample
3. * limitazione sulla massima durata del tempo di hold
4. * iniezione di carica

ERRORI STATICI



idealmente $v_{out} = v_{CH}$ perchè $G_{buffer}|_{ideale} = 1$

$v_{CH} = v_{in}$ perchè Rin buffer → ∞ (oppure se $R_{ds_{on}} = 0$)

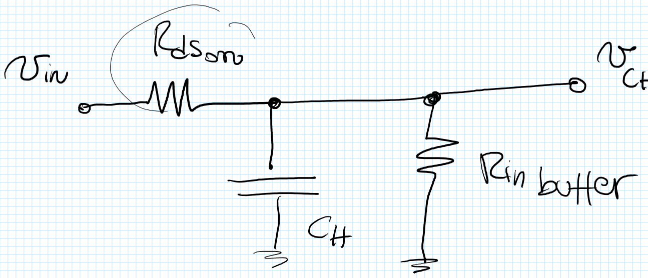
$$G_{reale\ buffer} = \frac{G_{ideale}}{1 - \frac{1}{G_{loop}}} = \qquad G_{loop} = -A_0$$

1 $\qquad A_0 \qquad v_{out} = \frac{A_0}{\ }\, v_{..}$

$$1 - 1/G_{loop}$$

$$= \frac{1}{1 + 1/A_0} = \frac{A_0}{A_0 + 1} \qquad v_{out} = \frac{A_0}{A_0 + 1} v_{CH}$$

$$R_{in\,buffer} = R^0_{in\,buffer} \left(1 - G^*_{loop}\right) = R_{diff}\left(1 + A_0\right) = 10^6\,\Omega \left(1 + 10^5\right) = 10^{11}\,\Omega = 100\,G\Omega\;!!$$

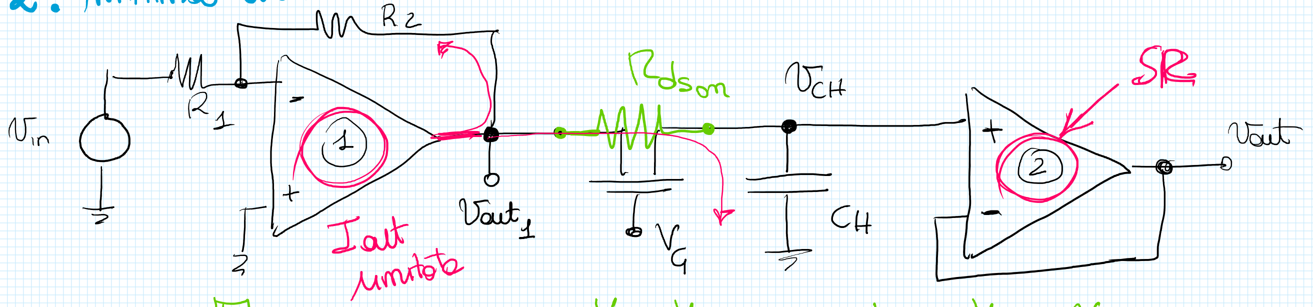


$$v_{CH}\Big|_{regime} = \frac{R_{in\,buffer}}{R_{in\,buffer} + R_{dson}} v_{in}$$

$$R_{dson} \simeq 10\,\Omega$$

$$\frac{10^{11}}{10^{11} + 10} \simeq 1$$

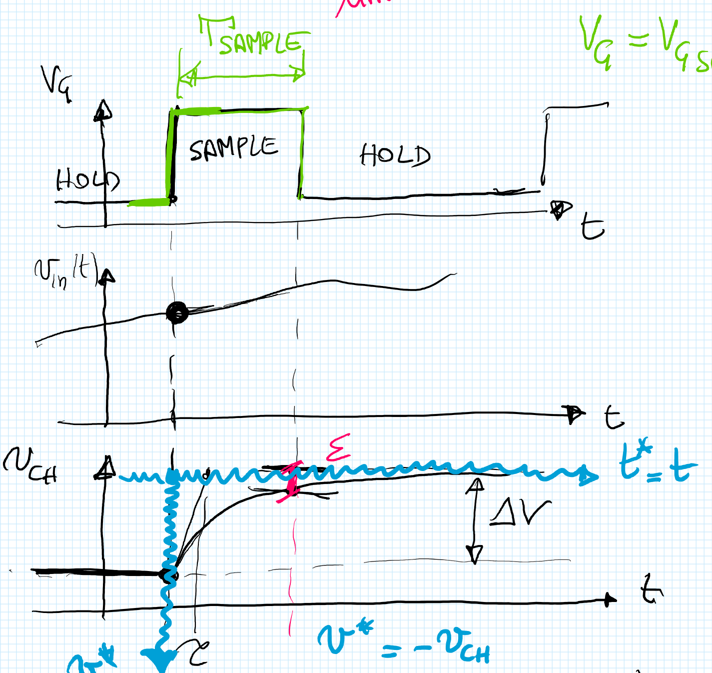
2. minima durata del Tempo di SAMPLE

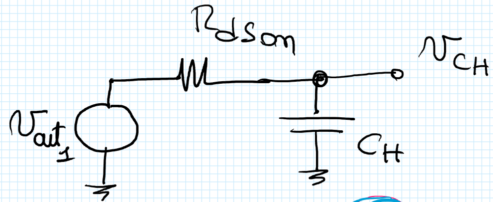


$V_G = V_{G\,SAMPLE}$ t.c. $V_{GS} > V_{Tn}$, $V_{GD} > V_{Tn}$ nMOS ohmic

$$f_{SAMPLING} = \frac{1}{T_{SAMPLE} + T_{HOLD}}$$

↑ freq. di campionamento





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

$$v_{CH} = \Delta V - \Delta V \exp\left(-t/\tau\right)$$

$$v_{CH}(T_{SAMPLE}) = \Delta V - \varepsilon \Rightarrow \Delta V - \varepsilon = \Delta V - \Delta V \exp\left(-\frac{T_{SAMPLE}}{\tau}\right)$$

$$v^*(t) = \Delta V \exp\left(-t/\tau\right)$$

$$\boxed{\Delta V \exp\left(-\frac{T_{SAMPLE}}{\tau}\right) = \varepsilon}$$

$$v^*(T_{SAMPLE}) = \varepsilon$$

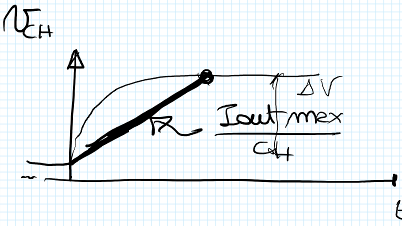
$$T_{SAMPLE} = -\tau \ln \frac{\varepsilon}{\Delta V} = \tau \ln \frac{\Delta V}{\varepsilon}$$

$$T_{SAMPLE_{min}} = -\tau \ln \frac{\varepsilon}{\Delta V} = \tau \ln \frac{\Delta V}{\varepsilon}$$

in presenza di limitazioni introdotte dagli opamp

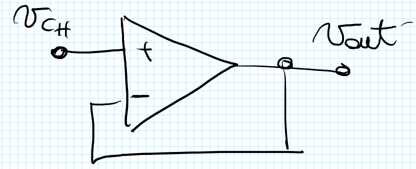
- Iout limitata

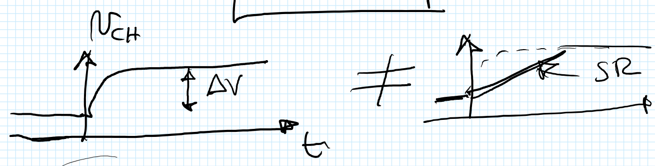
$$\left.\frac{dv_{CH}}{dt}\right|_{max} = \frac{I_{out\,max}}{C_H}$$



- SR del 2° opamp

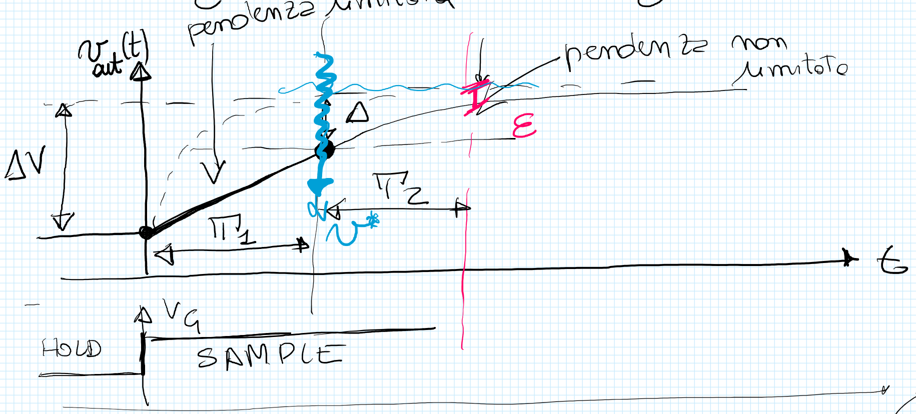
$$\left.\frac{dv_{out}}{dt}\right|_{max} = SR$$





Se $\frac{\Delta V}{\tau} > SR$ oppure $\frac{\Delta V}{\tau} > \frac{I_{out\,max}}{C_H}$ $\Rightarrow$ LIMITAZIONE

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



$$T_{SAMPLE}\Big|_{MIN} = T_1 + T_2$$

$$v_{exp}(t) = \Delta V \exp(-t/\tau)$$

$$\left.\frac{dv_{exp}}{dt}\right|_{max} = \Delta V/\tau$$

nel caso di limitazione da SR $\quad \frac{\Delta}{\tau} = SR$

$$T_1 = T_{SR} = \frac{\Delta V - \Delta}{SR} = \frac{\Delta V - SR\,\tau}{SR} = \frac{\Delta V}{SR} - \tau$$

$T_2 \Rightarrow$ salita esponenziale $\quad v^* = \Delta \exp(-t/\tau)$

$$v^*(T_2) = \varepsilon$$

$$\varepsilon = \Delta \exp(-T_2/\tau)$$

$$T_2 = \tau \ln \frac{\Delta}{\varepsilon}$$

$$T_{SAMPLE}\Big|_{min} = T_1 + T_2 = \frac{\Delta V}{SR} - \tau + \tau \ln \Delta/\varepsilon$$