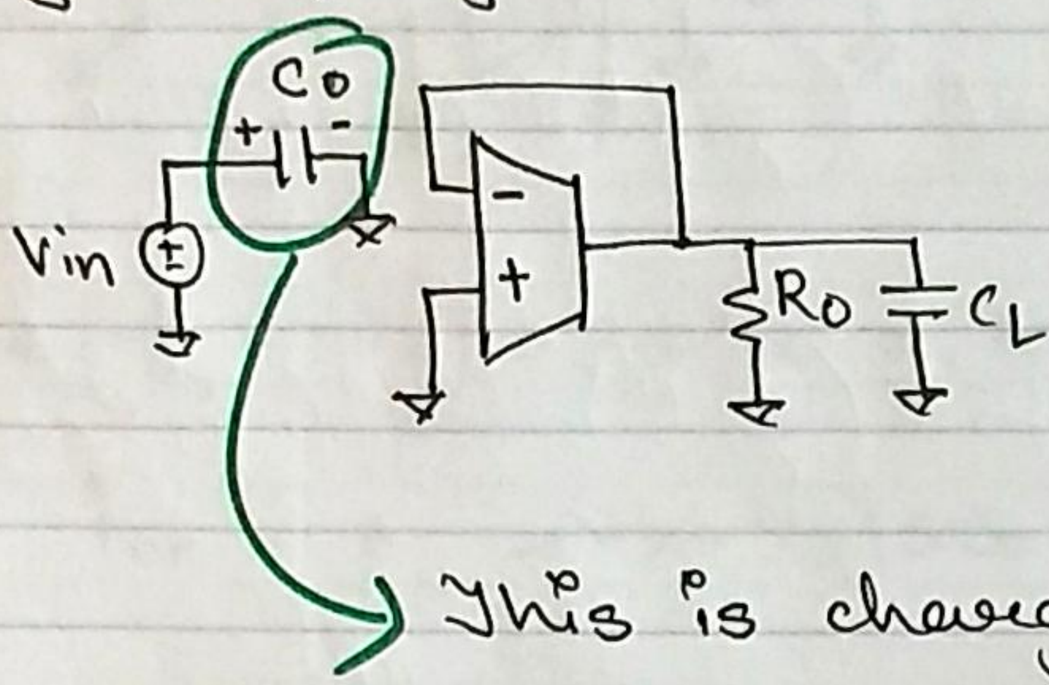
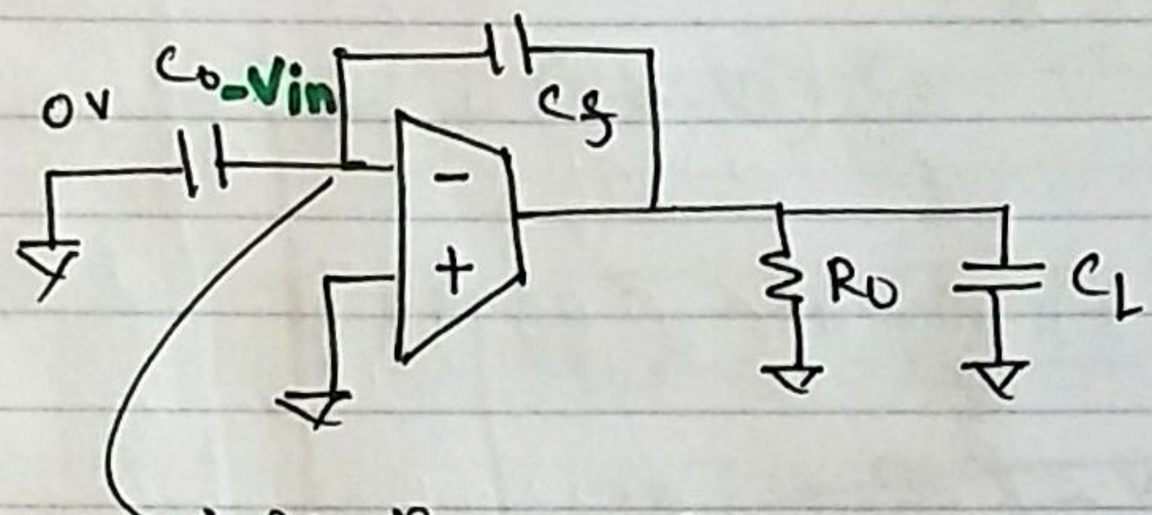
Settling behavior of the SW circuit

During sampling phase:



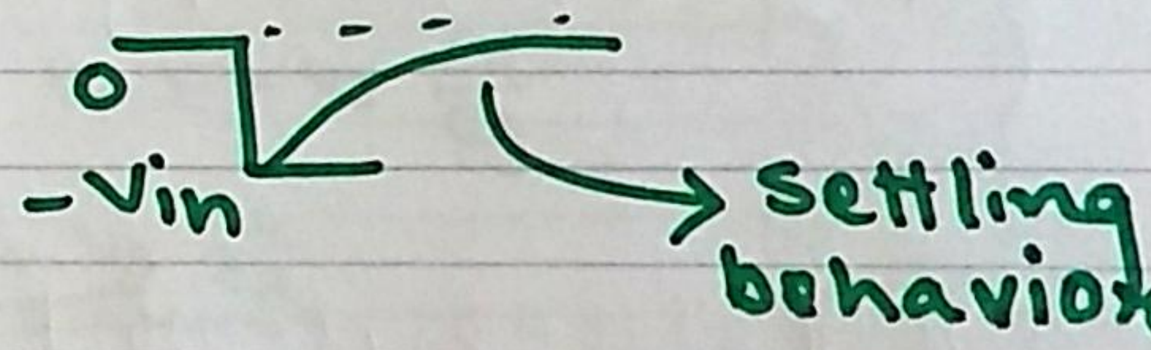
This is charged to Vin

During ~~amplico~~ amplification phase

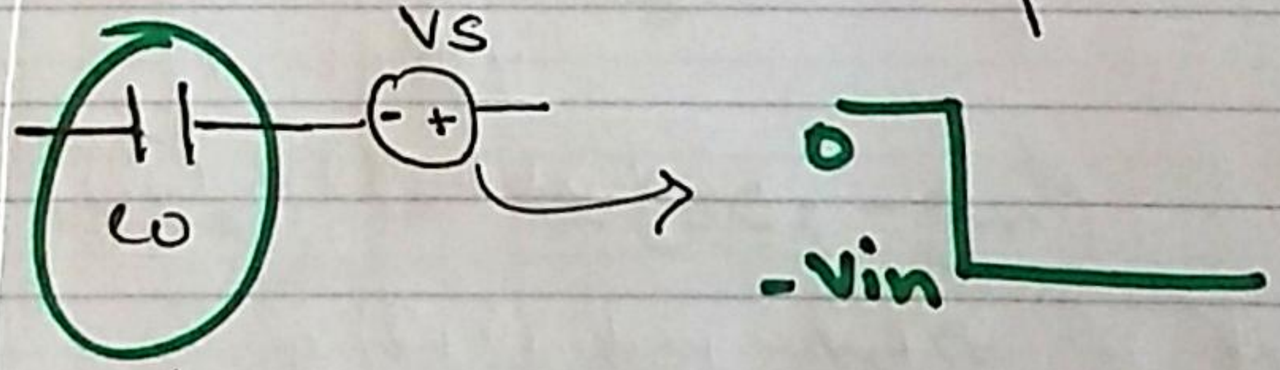


This node sees a sudden step

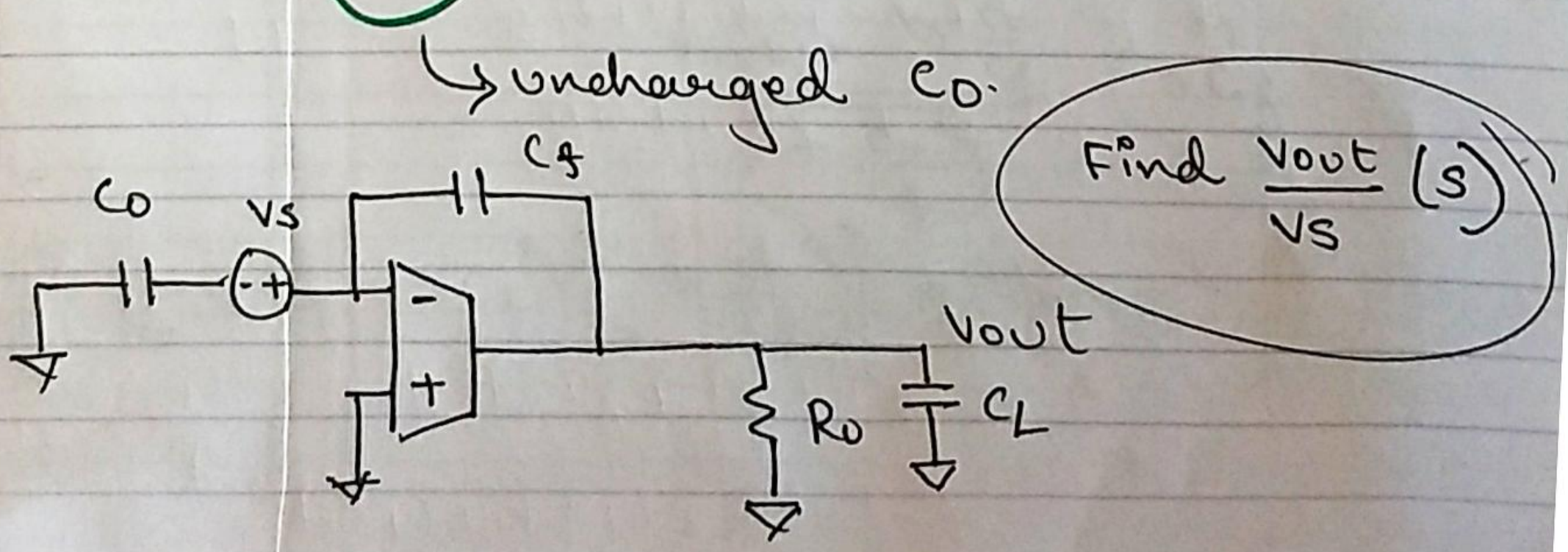
Voltage across a capacitor cannot change instantaneously

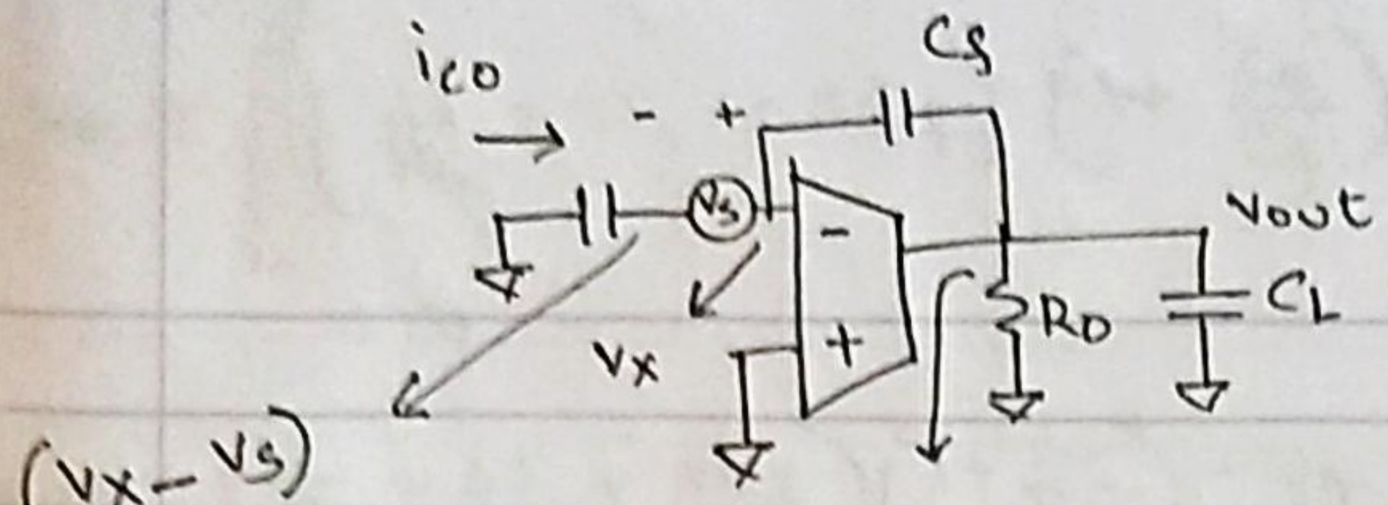


For analysis, the Co can be replaced by



↳ uncharged Co.





$$V_{out}\left(\frac{1}{R_O} + sC_L\right) + g_m V_x = (V_x - V_{out})sC_g$$

$$i_{CO} = + \; -(V_x - V_S)sC_O$$

$$V_{out} = V_x - \frac{i_{CO}}{sC_g}$$

$$V_{out} = V_x + (V_x - V_S)\frac{C_O}{C_g}$$

$$V_{out} = V_x\left(1 + \frac{C_O}{C_g}\right) - V_S\frac{C_O}{C_g}$$

$$\Rightarrow V_S\frac{C_O}{C_g} = V_x\left(1 + \frac{C_O}{C_g}\right) - V_{out}$$

$$\Rightarrow V_x\left(1 + \frac{C_O}{C_g}\right) = V_{out} + V_S\frac{C_O}{C_g}$$

$$\Rightarrow V_x = \frac{V_{out} + V_S\frac{C_O}{C_g}}{1 + \frac{C_O}{C_g}}$$

$$V_{out}\left(\frac{1}{R_O} + sC_L + sC_g\right) = V_x(sC_g - g_m)$$

$$= \frac{V_{out} + V_S\frac{C_O}{C_g}}{\left(1 + \frac{C_O}{C_g}\right)}(sC_g - g_m)$$

$$\Rightarrow V_{out}\left[\left(\frac{1}{R_O} + sC_L + sC_g\right)\left(1 + \frac{C_O}{C_g}\right)\right] = \left(V_{out} + V_S\frac{C_O}{C_g}\right)(sC_g - g_m)$$

$$\Rightarrow V_{out}\left[\left(\frac{1}{R_o}+sC_L+sC_f\right)\left(1+\frac{C_o}{C_f}\right)+g_m-sC_f\right]=-g_mV_s\frac{C_o}{C_f}$$

$$\Rightarrow V_{out}\left[\left(\frac{1}{R_o}+sC_L+sC_f\right)\left(1+\frac{C_o}{C_f}\right)+g_m-sC_f\right]=-g_mV_s\frac{C_o}{C_f}$$

$$\Rightarrow V_{out}\left[\frac{1}{R_o}\left(1+\frac{C_o}{C_f}\right)+sC_L\left(1+\frac{C_o}{C_f}\right)+sC_o+g_m\right]=-g_mV_s\frac{C_o}{C_f}$$

$$\Rightarrow \frac{V_{out}}{V_S}=\frac{-g_m\frac{C_o}{C_f}}{\frac{1}{R_o}\left(1+\frac{C_o}{C_f}\right)+sC_L\left(1+\frac{C_o}{C_f}\right)+sC_o+g_m}$$

$$=\frac{-g_mC_o}{\frac{1}{R_o}(C_o+C_f)+sC_L(C_o+C_f)+sC_oC_f+g_mC_f}$$

$$=\frac{-g_mC_o}{\frac{1}{R_o}(C_o+C_f)+s\left[C_LC_o+C_LC_f+C_oC_f\right]R_o+g_mC_f}$$

$$=\frac{-g_mC_oR_o}{(C_o+C_f)+s\left[C_LC_o+C_LC_f+C_oC_f\right]R_o+g_mR_oC_f}$$

$$=\frac{-g_mC_oR_o}{g_mR_oC_f+C_o+C_f}$$

$$=\frac{}{1+\dfrac{s\left(C_LC_o+C_LC_f+C_oC_f\right)R_o}{g_mR_oC_f+C_o+C_f}}$$

$\rightarrow$ (2)