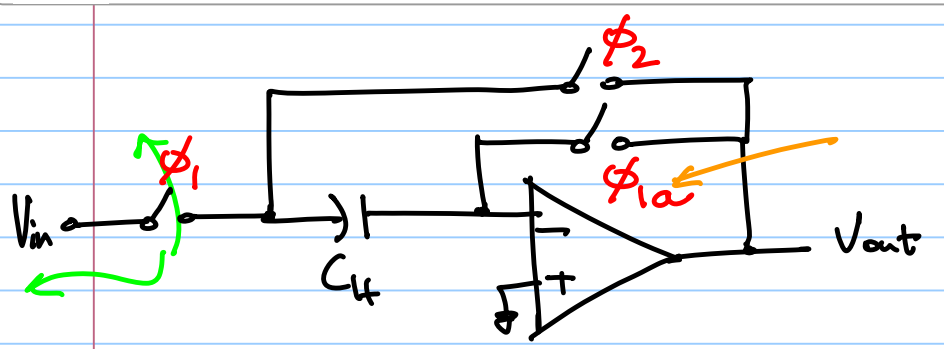
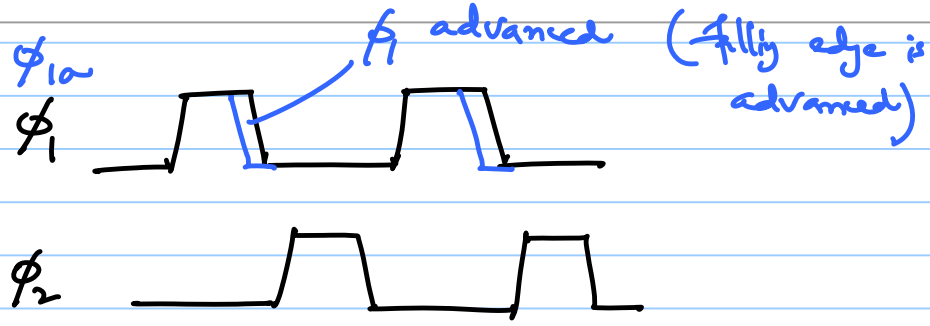
ECE 517 - Lecture 17

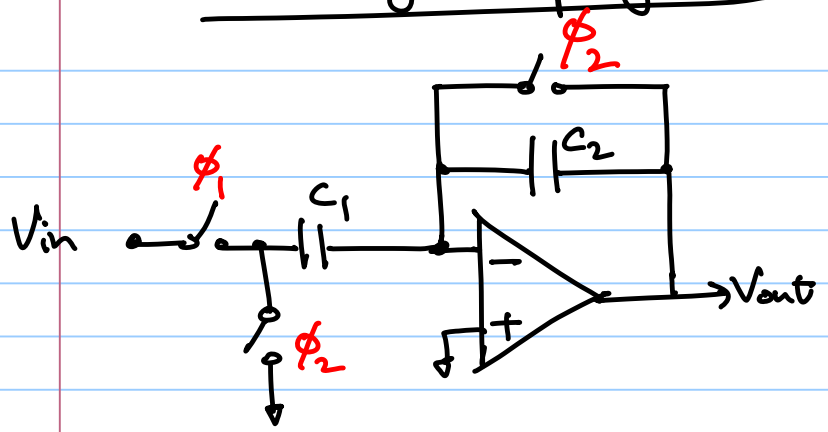
Note Title 3/21/2017



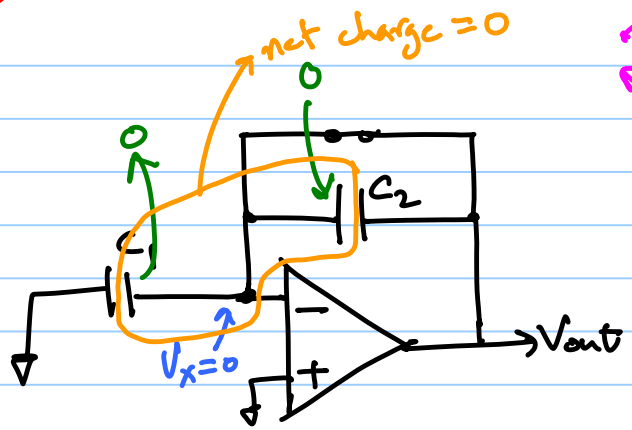


closed loop gain = 1

Inverting Amplifier:

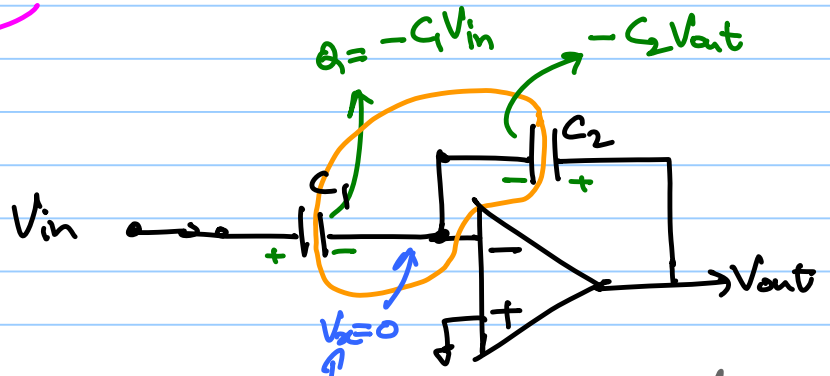


ϕ_2 Reset

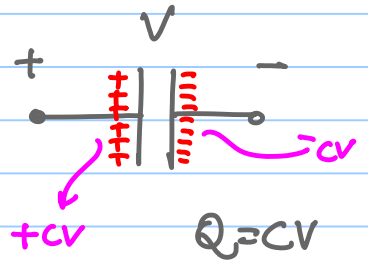


Charge is conserved on the orange surface

ϕ_1 : Amplify



In steady-state in ϕ_1



$Q = CV$

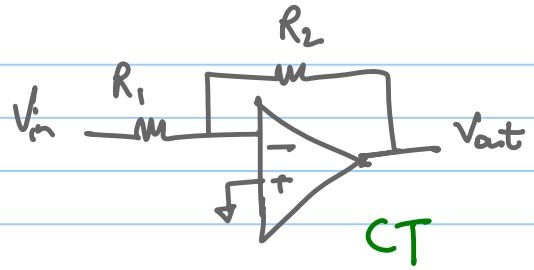
Net Charge $0 = -C_1 V_{in} - C_2 V_{out}$

$\Rightarrow$

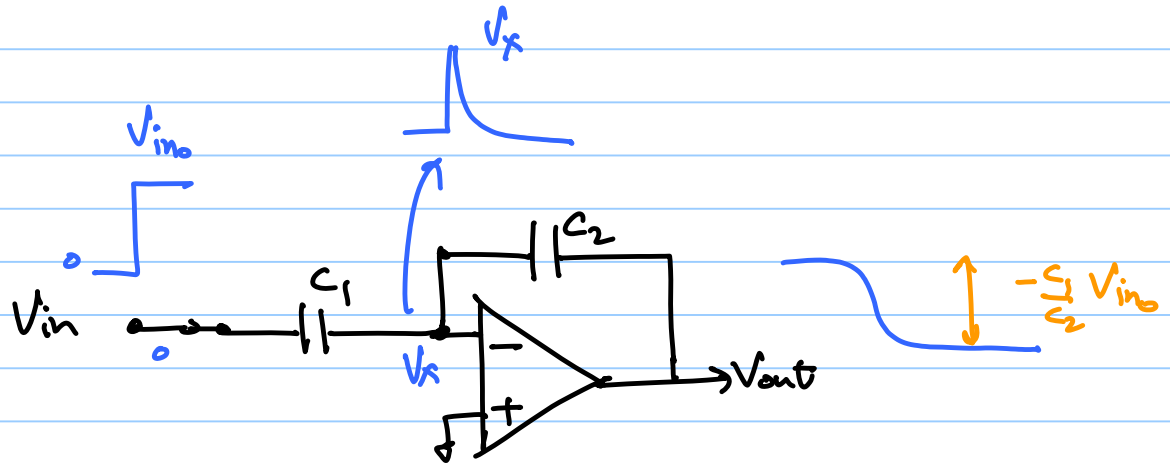
$$\boxed{\frac{V_{out}}{V_{in}} = -\frac{C_1}{C_2}}$$

$\frac{C_1}{C_2} = -2$, very precise ratio

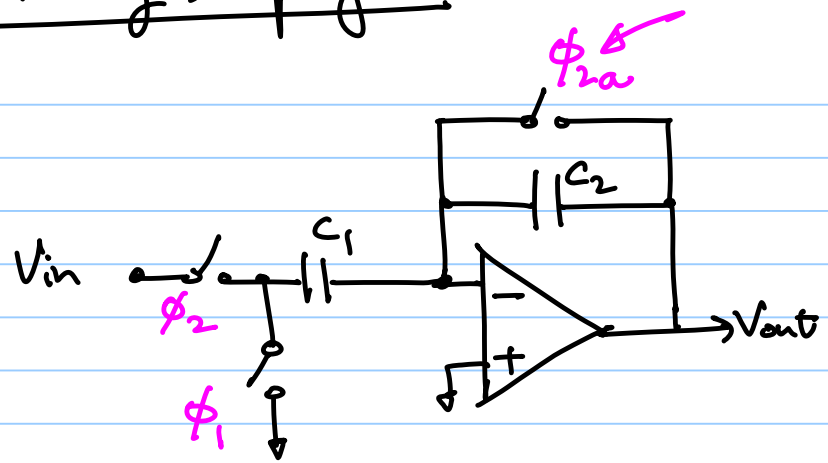
R, C Varies $\pm 20\%$.

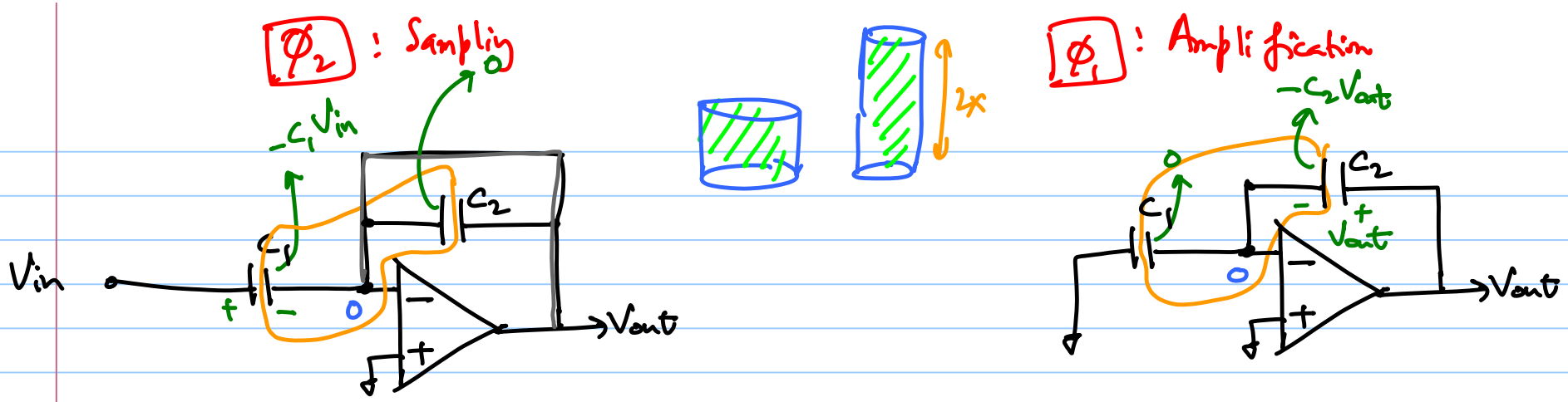


$-\frac{R_2}{R_1}$



Non-inverting amplifier:





$$-C_1V_{in} = -C_2V_{out}$$

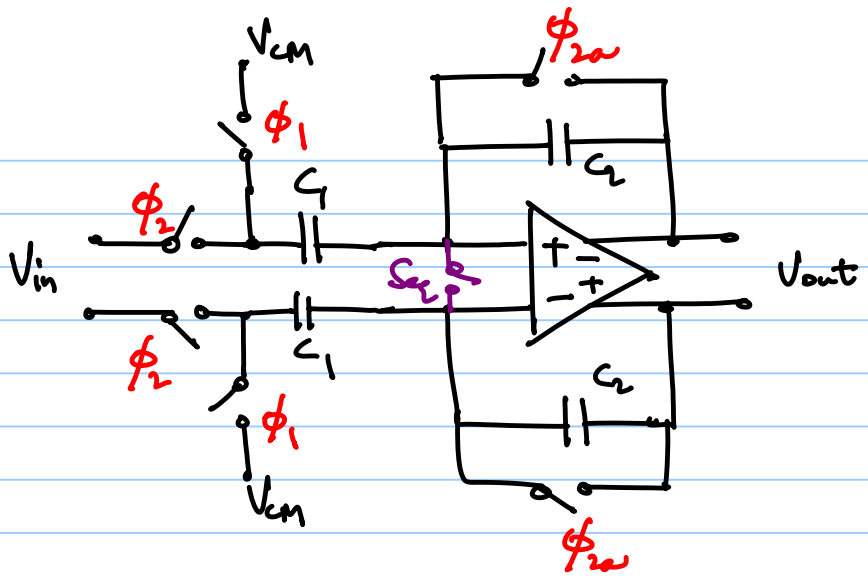
$t = nT_s$

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

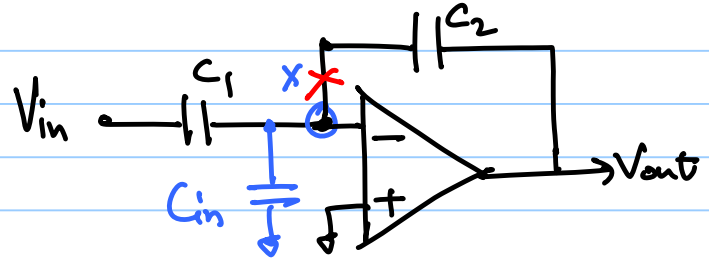
$$-C_1 V_{in}[n-1/2] = -C_2 V_{out}[n]$$

$$\frac{V_{out}}{V_{in}} = +\frac{C_1}{C_2} z^{-1/2}$$

← half clock cycle delay


V_{CM}
ϕ_1
C_1
ϕ_2
V_{in}
S_{C_2}
ϕ_2
C_1
ϕ_1
V_{CM}
ϕ_{2a}
C_2
C_2
ϕ_{2a}
V_{out}

Inverting Amplifier



$$(V_{out} - V_x)sC_2 = V_x sC_{in} + (V_x - V_{in})sC_1 \longrightarrow (1)$$

$$V_{out} = -A_v V_x \longrightarrow (2)$$

$$\frac{V_{out}}{V_{in}} = \frac{A}{1 + A\beta}$$

$A\beta$ = open loop gain

A = forward path gain

$\beta < 1$; feedback ratio

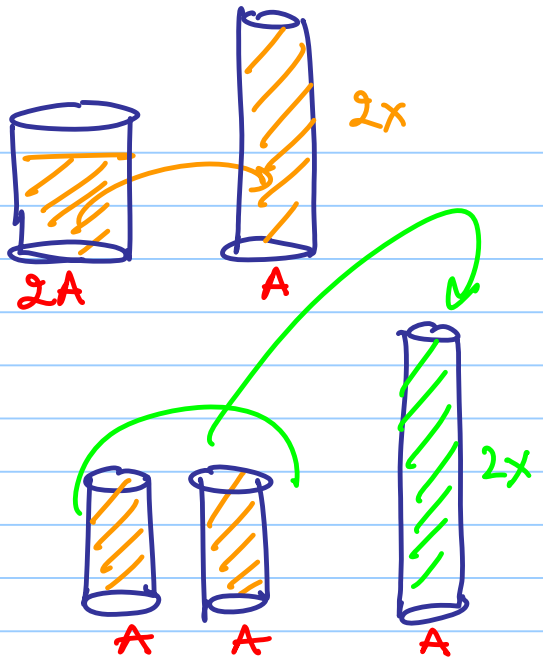
Razavi Book

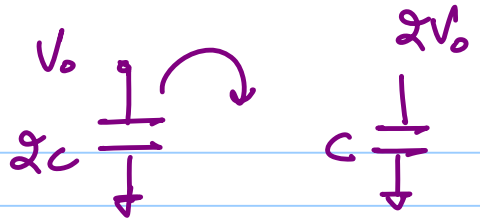
$$\beta = \frac{C_2}{C_2 + C_1 + C_{in}}$$

$$\left|\frac{V_{out}}{V_{in}}\right| \approx \frac{C_1}{C_2}\left[1 - \frac{C_2 + C_1 + C_{in}}{C_2}\cdot\frac{1}{A_{V_1}}\right]$$

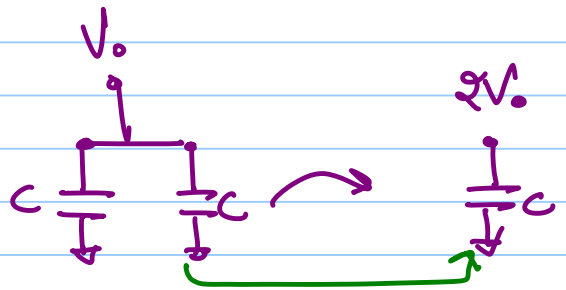
High opamp gain ↑

C_{in} ↓



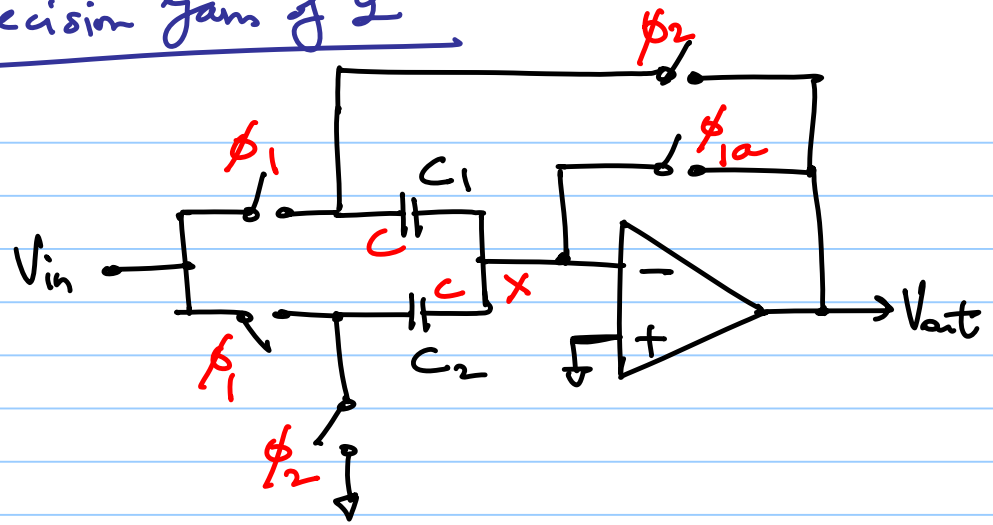


Total cap
$3C$



Total cap
$2C$

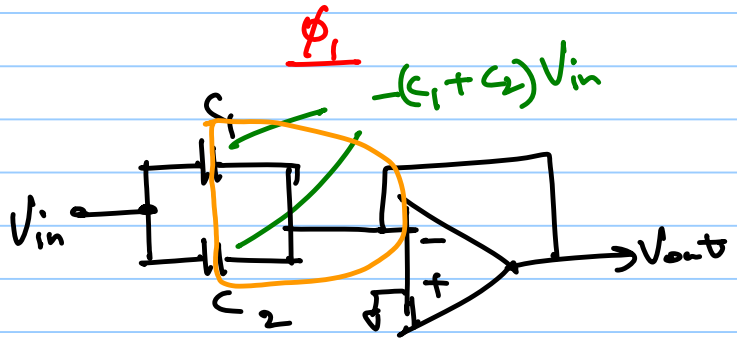
Precision Gain of 2

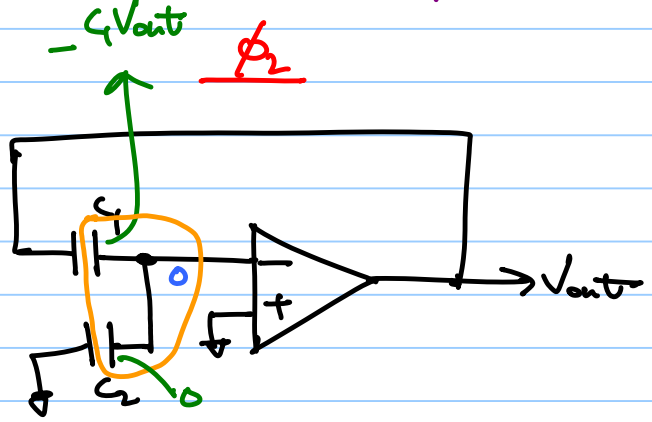


$C_1 = C_2 = C$

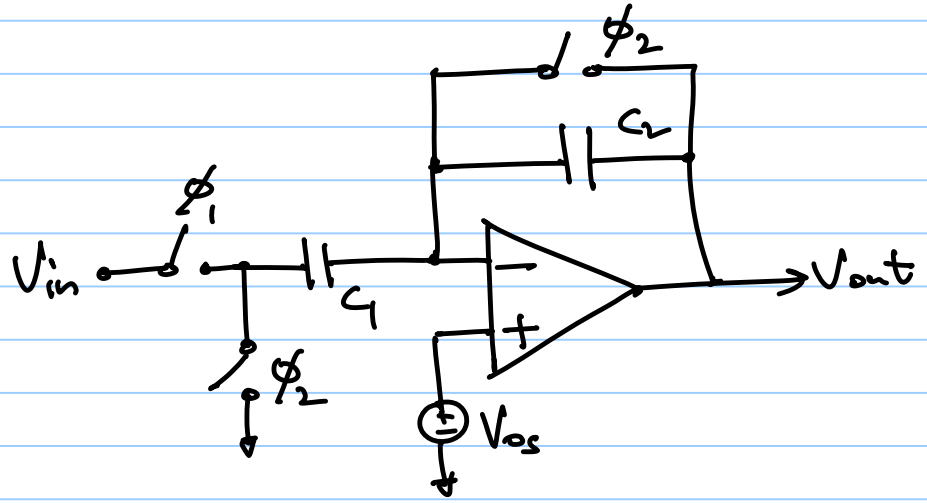
$-(C_1+C_2)V_{in} = -C_1 V_{out}$

$\Rightarrow \frac{V_{out}}{V_{in}} = 1 + \frac{C_2}{C_1} = 2$ for $C_1 = C_2$

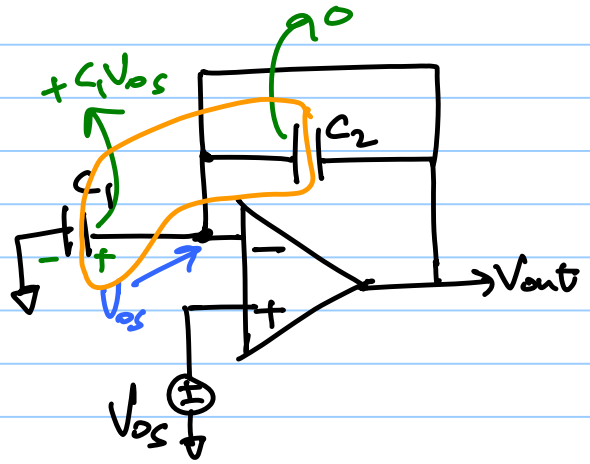




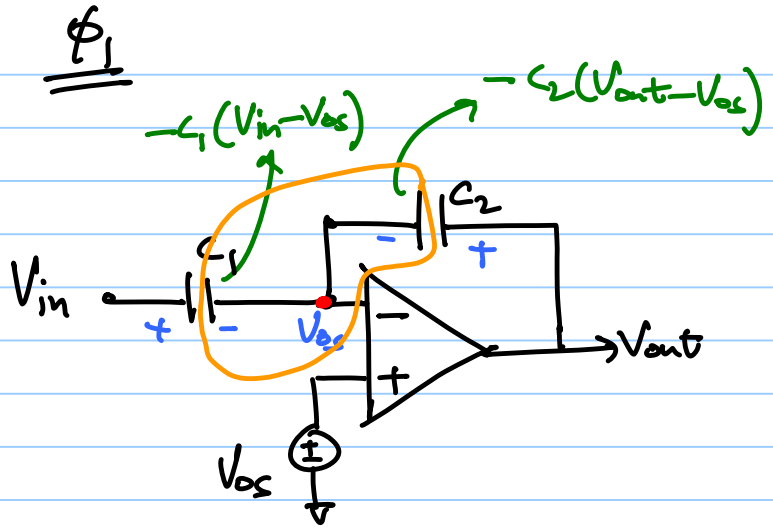
Effect of offset:



ϕ_2



ϕ_1



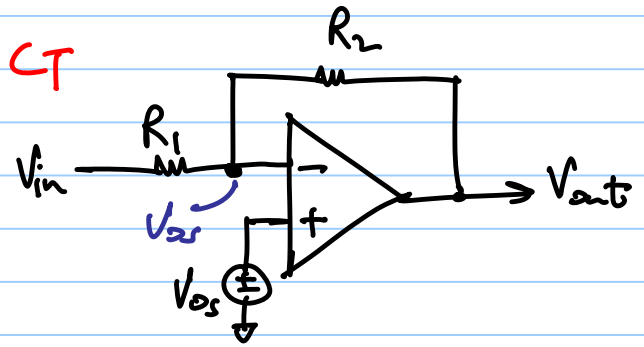
$$+C_1V_{os} = -C_1V_{in} + C_1V_{os} - C_2(V_{out}-V_{os})$$

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

Inherent input offset cancellation

$$-\frac{C_1}{C_2}(V_{in}-V_{os}) + V_{os}$$

CT



$$V_{out} = V_{os} + \frac{(V_{in}-V_{os})R_2}{R_1}$$

Thermal noise