ECE 615 CMOS Mixed-Signal

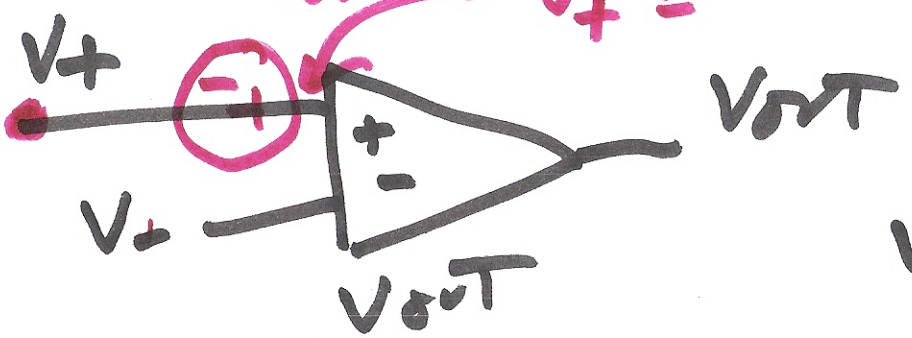
BOISE STATE UNIVERSITY

Lecture 6 September 13, 2010

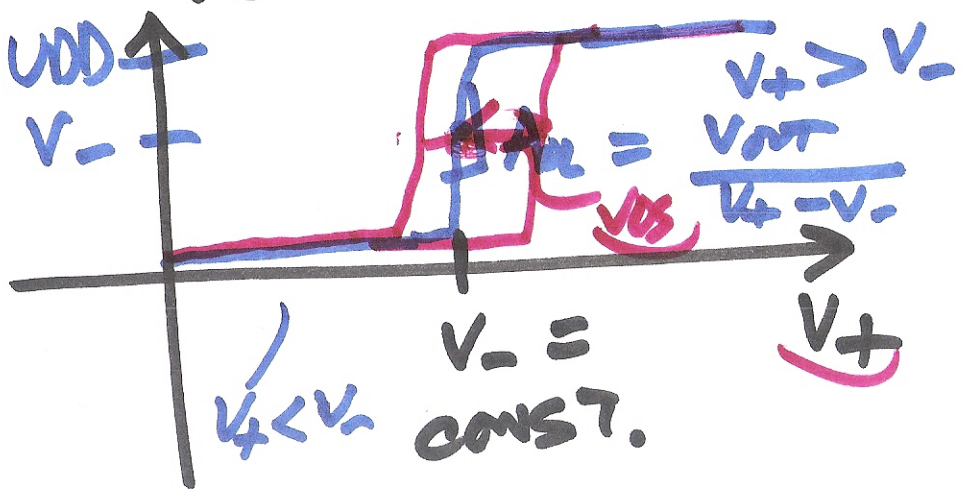
offset Voltage

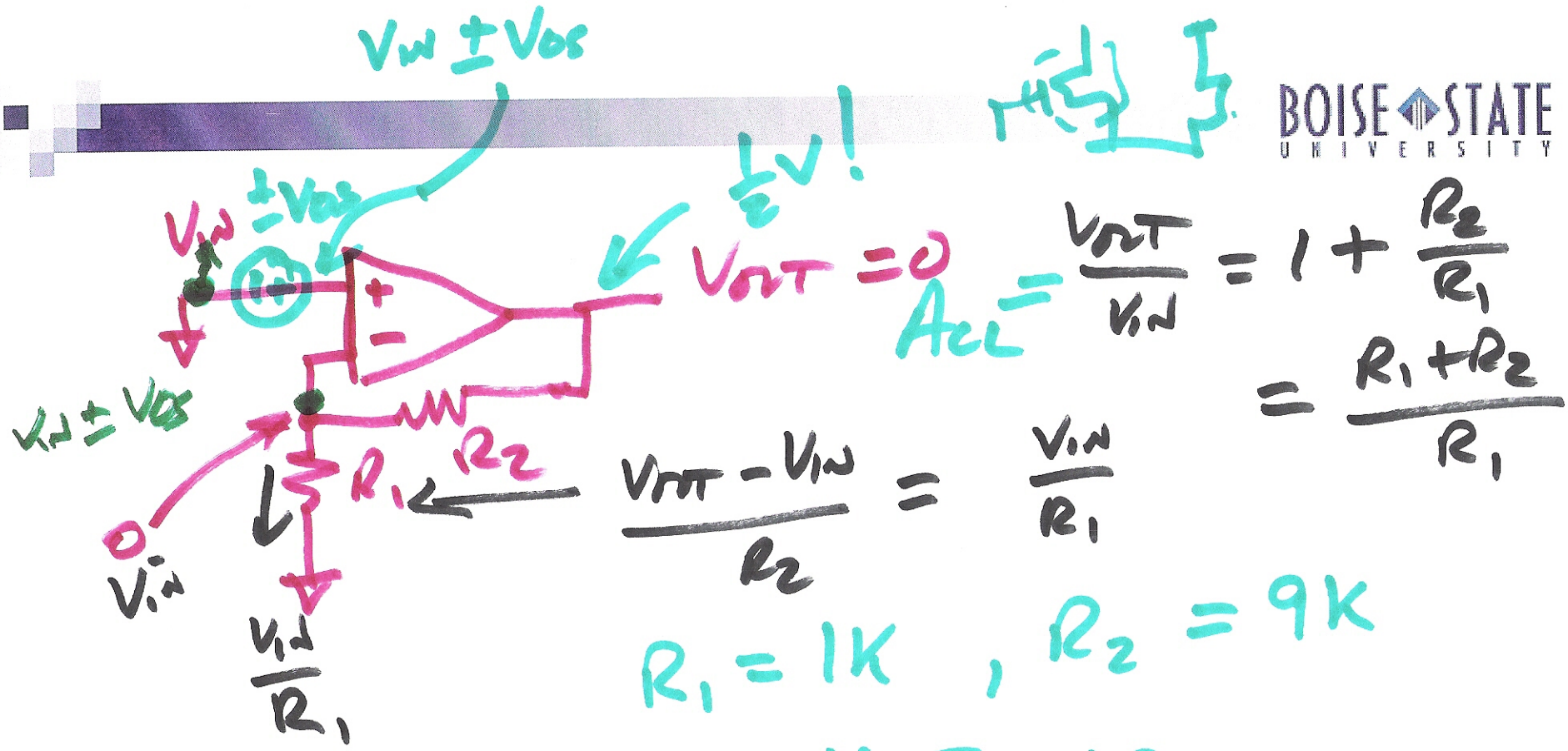
V_{OS} ← input referred offset

$V_+ \pm V_{OS}$



$V_- = \text{CONST}$





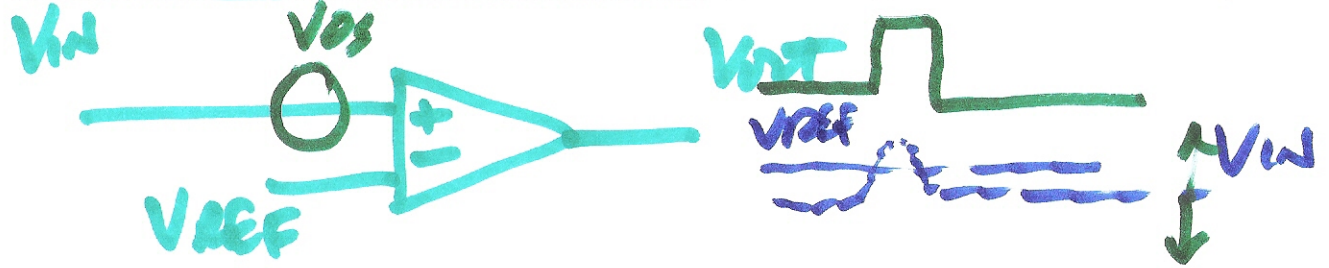
$$A_{CL} = \frac{V_{OUT}}{V_{IN}} = 1 + \frac{R_2}{R_1} = \frac{R_1 + R_2}{R_1}$$

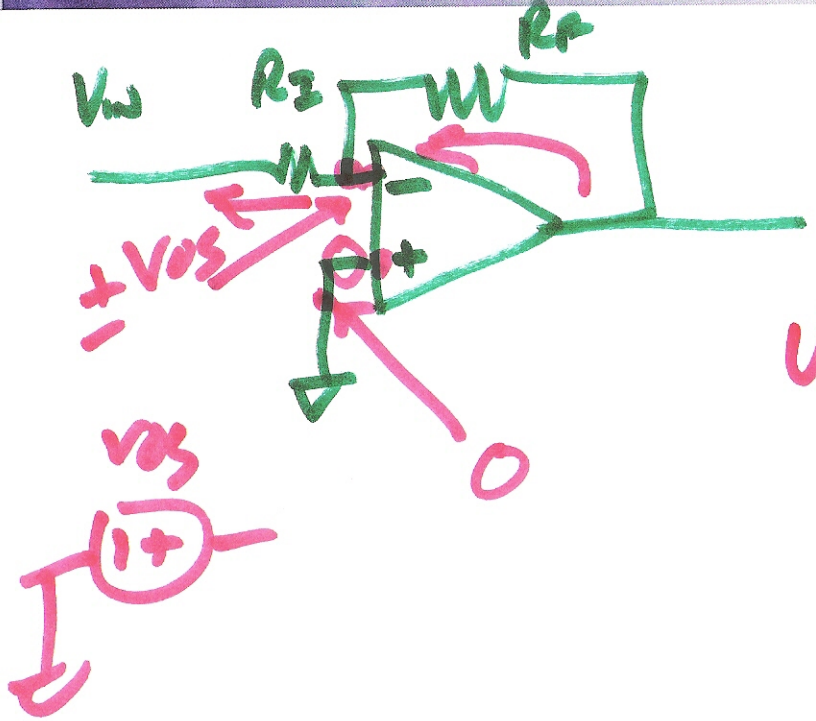
$$\frac{V_{OUT} - V_{IN}}{R_2} = \frac{V_{IN}}{R_1}$$

$R_1 = 1K$, $R_2 = 9K$

$$\frac{V_{OUT}}{V_{IN}} = 10$$

What happens if $\pm V_{OS} = \pm 50mV$?





$$V_{OUT} = V_{in}\left(-\frac{R_F}{R_I}\right)$$

$$V_{OS}\Big|_{V_{in}=0}$$

$$\frac{\pm V_{OS}}{R_I} = \frac{V_{OUT} \mp V_{OS}}{R_F}$$

$$\pm V_{OS}\left(\frac{1}{R_I} + \frac{1}{R_F}\right) = \frac{V_{OUT}}{R_F}$$

$$\frac{V_{OUT}}{\pm V_{OS}} = 1 + \frac{R_F}{R_I}$$

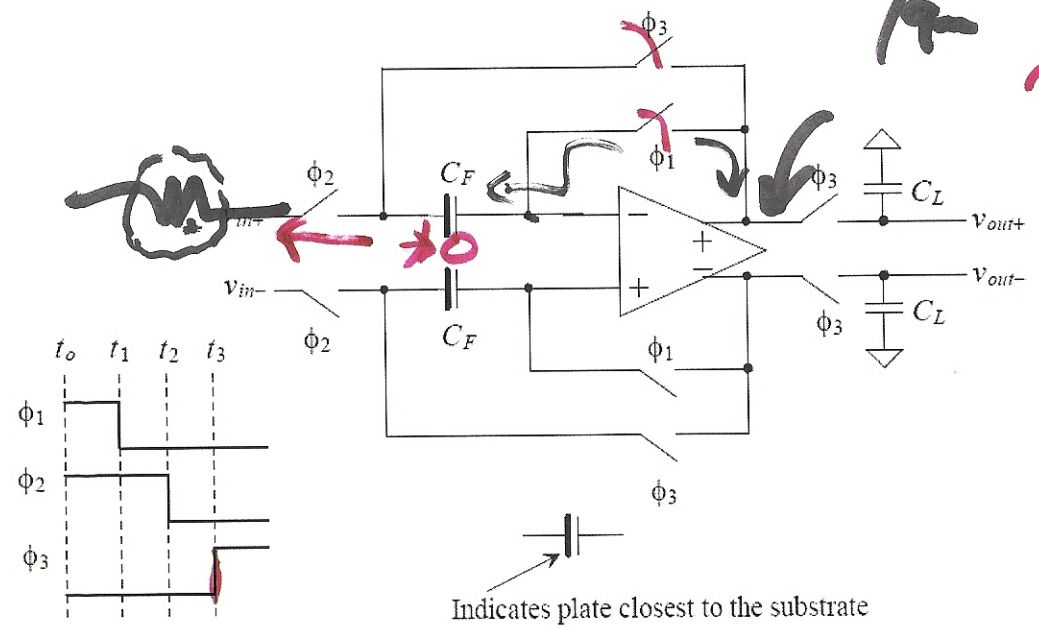
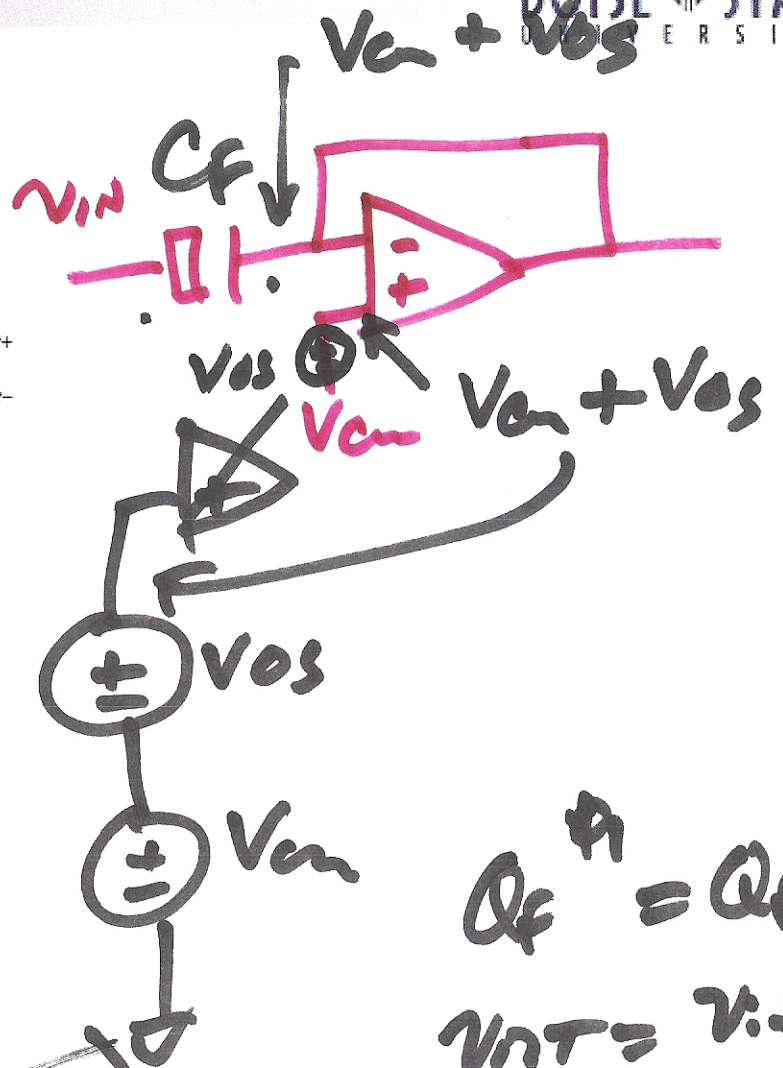


Figure 2.39 Fully-differential S/H differential topology.

$CV=Q$

V_{cm}



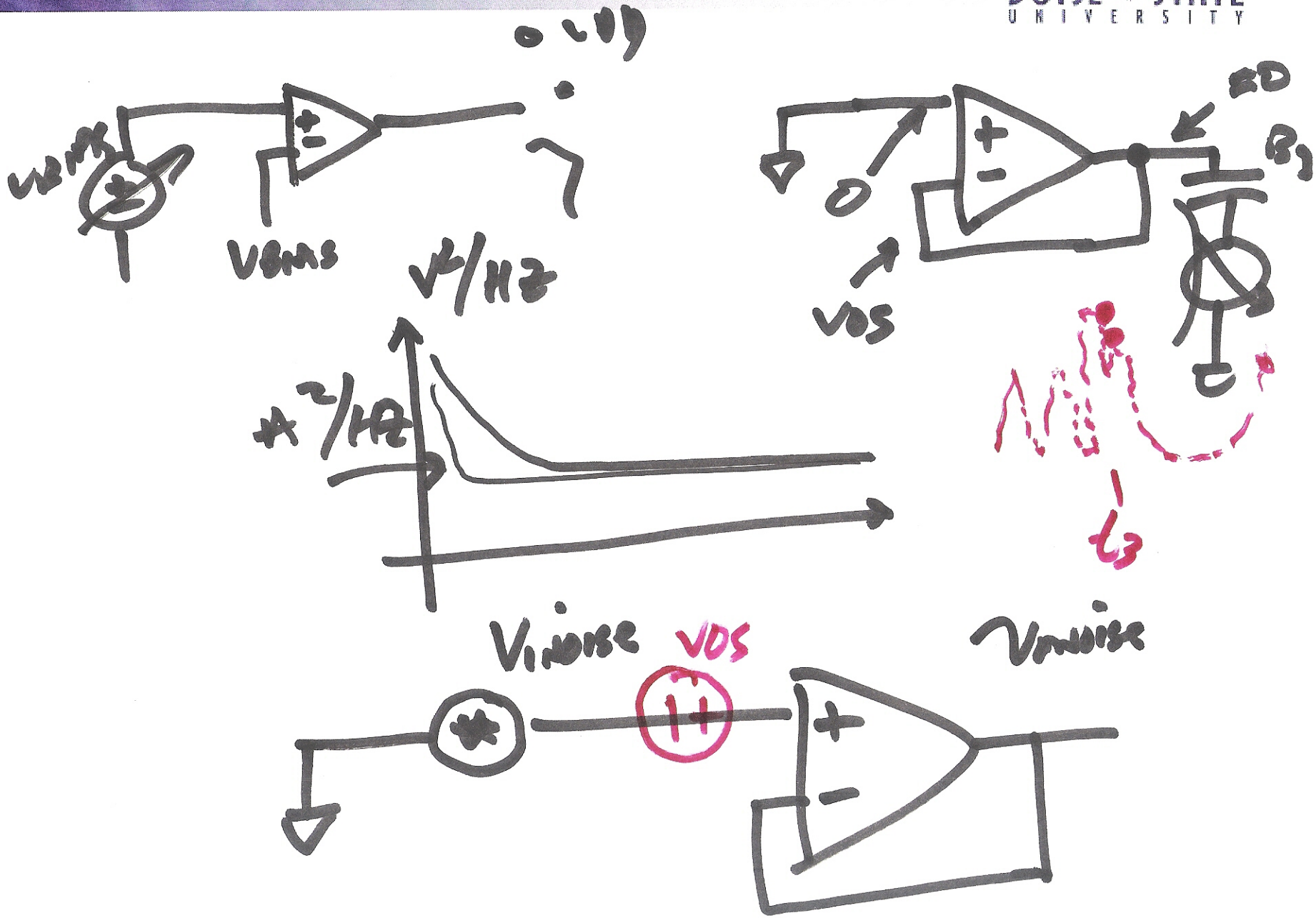
$Q_F^{\phi_1} = C_F \cdot (V_{IN} - V_{cm} + V_{OS})$

$Q_F^{\phi_3} = C_F (V_{OUT} - V_{cm} + V_{OS})$

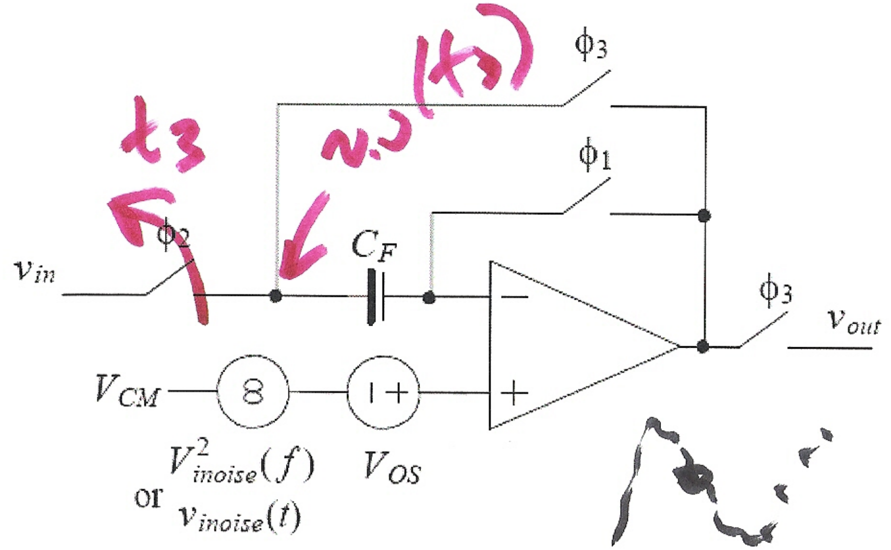
$Q_F^{\phi_1} = Q_F^{\phi_3}$

$V_{OUT} = V_{IN}$

4)



5)



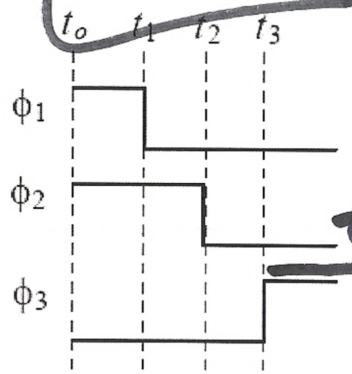


Figure 2.41 S/H with input-referred offset and noise shown.

$$Q_F^{\phi_1} = C_F \cdot \left(v_{IN}(t_3) - V_{cm} - V_{OS} - v_{inoise}(t_3)\right)$$

$$Q_F^{\phi_1} = C_F\left(v_{IN}(t_3) - V_{cm} - V_{OS} - v_{inoise}(t_3)\right)$$

$$\| $$

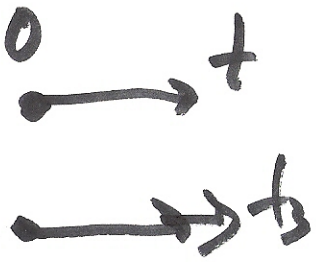
$$Q_F^{\phi_3} = C_F\left(v_{OUT}(t) - V_{cm} - V_{OS} - v_{noise}(t)\right)$$

$$v_{OUT}(t) = v_{IN}(t_3) + v_{noise}(t) - v_{noise}(t_3)$$

$$t_3 < t < t_3 + \frac{T_s}{2}$$

b) $V_{onoise}(f) = V_{inoise}(f) + v_{noise}($

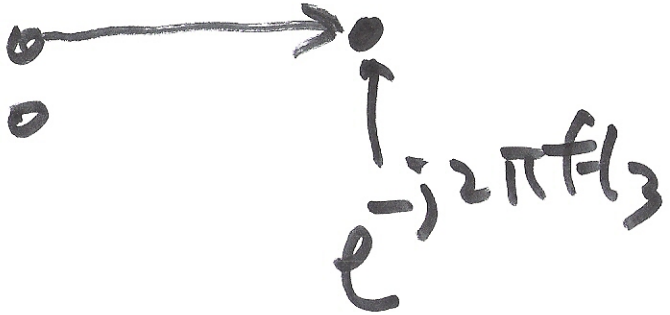
$$V_{oNoise}(t) = V_{iNoise}(t) - V_{iNoise}(t-t_3)$$



$$V_{oNoise}(f) = V_{iNoise}(f)\left(e^{j2\pi ft} - e^{j2\pi f t_3}\right)$$

$$= V_{iNoise}(f)\, e^{+j2\pi f t_3}\left(e^{j2\pi f(t-t_3)} - 1\right)$$

$$V_{iNoise}(f)\left(e^{-j2\pi f t_3} - e^{-j2\pi f t_3}\right) e^{-j2\pi f t_3}$$



$$V_{iNoise}(f)\left(e^{-j2\pi f(t_3+t)} - e^{-j2\pi f(t_3)}\right) e^{j2\pi f(t+t_3)}$$

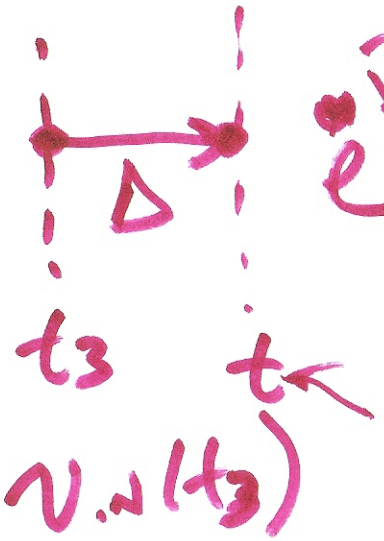
$$V_{iNoise}\, e^{-j2\pi f t_3}\left(e^{-j2\pi f t}\Big|_{-TS/2}^{TS/2} - 1\right)$$

7)

$$V_{output}(f) = V_{input}(f)\, e^{j2\pi f t_3} \cdot \frac{T_s}{2} \left(\frac{e^{j2\pi f (t - t_3)} - 1}{e^{j2\pi f t_3}} \right) \left(\frac{1 - e^{-j2\pi f (t - t_3)}}{e^{-j2\pi (t - t_3)}} \right)$$

$$= 1 - z^{-1}$$

$\frac{V_{output}}{V_{input}}$



$$e^{\frac{j2\pi f(t-t_3)}{\Delta}}$$

$$v_{inoise}(t_3)\; e^{-j2\pi f t_3}$$

$$v_{inoise}(f)$$

$$v_{inoise}\left(e^{-j2\pi f t} - e^{-j2\pi f t_3}\right) \quad (2.73)$$

$$v_{inoise}\, e^{-j2\pi f t_3}\left(e^{j2\pi f(t_3-t)} - 1\right)$$

$$t = t_3 + \frac{T_s}{2}$$

9)

CDS