ECE 614 Advanced Analog Ic Design

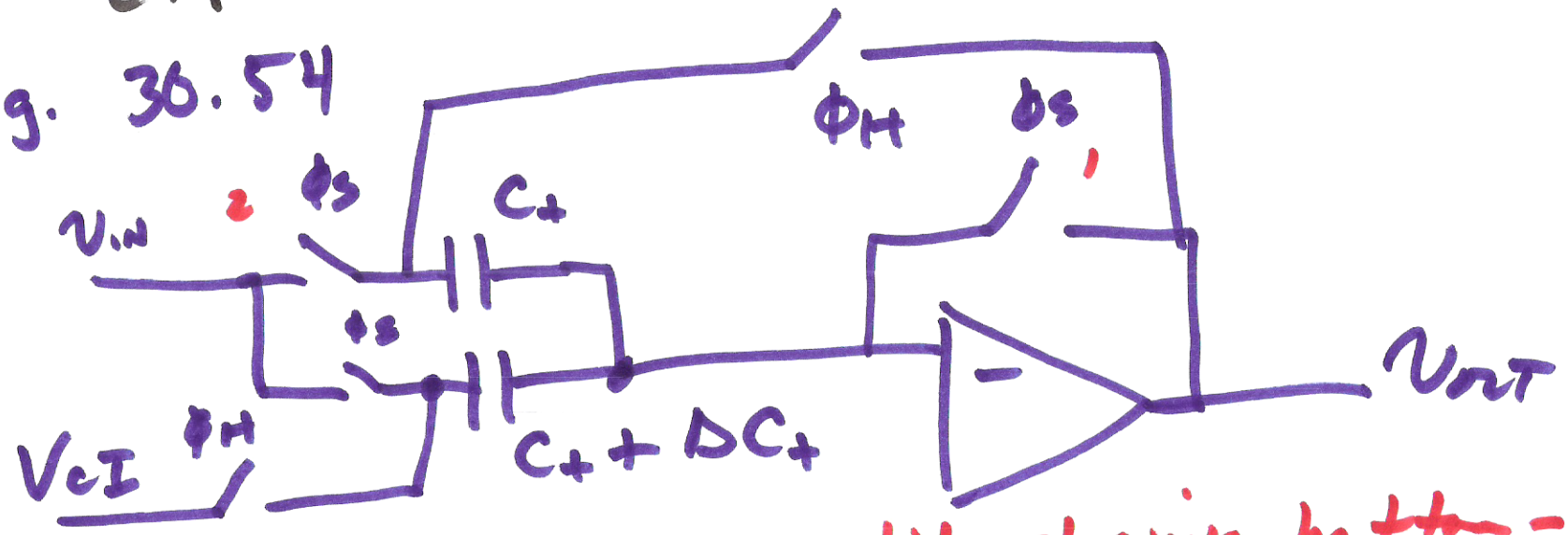
BOISE STATE UNIVERSITY

NOV. 17, 2011

Lecture 24

Capacitor Error Averaging

Fig. 30.54



Not showing bottom-plate sampling

1 shuts off before 2

$$V_{OUT} = \left(1 + \frac{C_+ + \Delta C_+}{C_+}\right) V_{IN} - V_{CI}\left(1 + \frac{\cancel{C_+} \Delta C_+}{C_+}\right)$$

EQ. 30.74

1)

$$V_{out\pm} = \left(2 + \frac{\Delta C_{+-}}{C_{+-}}\right) \cdot V_{in\pm} -$$

$$\left(1 - \frac{\Delta C_{+-}}{C_{+-}}\right) V_{CI\pm}$$

$$V_{out+a} = \underbrace{2V_{in+} - V_{CI+}}_{\text{ideal response}} + \frac{\Delta C_+}{C_+} V_{in+} + \frac{\Delta C_+}{C_+} \cdot V_{CI+}$$

$$V_{out+h} = \left(1 + \frac{C_+}{C_+ + \Delta C_+}\right) V_{in} - V_{CI} \cdot \left(\frac{C_+}{C_+ + \Delta C_+}\right)$$

↗ see Eq. 30.80

2)

$$V_{out+} = V_{CI+} + \frac{C_+}{C_+ + \Delta C_+} \cdot V_{inta+}$$

$$- \frac{C_+}{C_+ + \Delta C_+} \cdot V_{CI+}$$

$$\frac{C_+}{C_+ + \Delta C_+} = \frac{1}{1 + \frac{\Delta C_+}{C_+}} \approx 1 - \frac{\Delta C_+}{C_+}$$

$$\frac{1}{1+x} \approx 1 - x$$

x is small

3)

$$V_{outTh+} = \left(1 - \frac{\Delta C_+}{C_+}\right) \cdot V_{outTa+} + \frac{\Delta C_+}{C_+} \cdot V_{CI+}$$

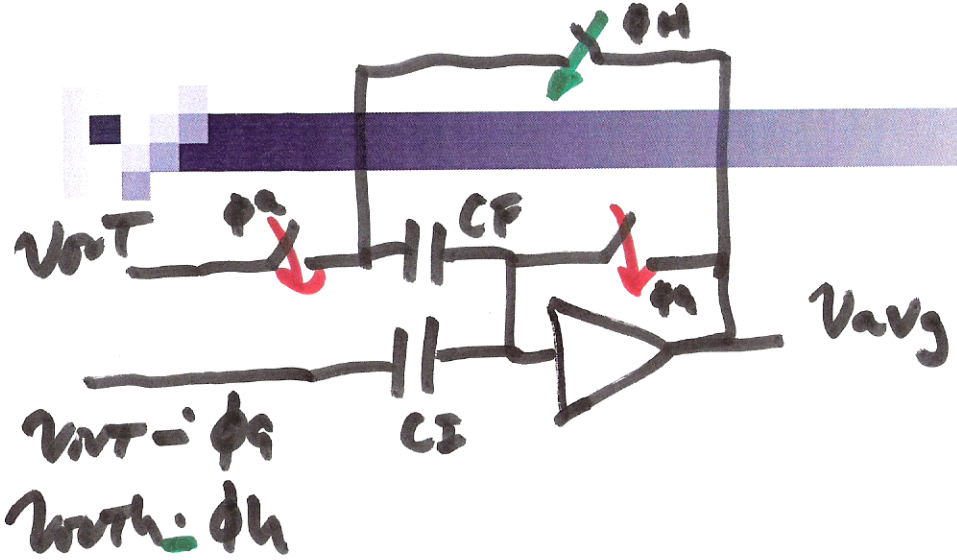
$$V_{outTa+} = 2 \cdot V_{in+} - V_{CI+} + \frac{\Delta C_+}{C_+}\left(V_{in+} - V_{CI+}\right)$$

$$V_{outTh+} = 2V_{in+} - V_{CI+} + \frac{\Delta C_+}{C_+}\left(\cancel{V_{in+}} - \cancel{V_{CI+}}\right)$$

$$+ - \frac{\Delta C_+}{C_+}\left(2V_{in+} - 2V_{CI+}\right) + \cancel{\frac{V_{CI+} \cdot \Delta C_+}{C_+}}$$

$$V_{outTh+} = 2V_{in+} - V_{CI+} - \frac{\Delta C_+}{C_+}\left(V_{in+} - V_{CI+}\right)$$

$$\frac{V_{outTa+} + V_{outTh+}}{2} = 2V_{in+} - V_{CI+}$$



$$Q_{\pm}^{\phi_A} = (V_{OUTA\pm} - V_{cm} \pm V_{OS})C_F + (V_{OUTA\mp} - V_{cm} \pm V_{OS})C_I$$

$$Q_{+}^{\phi_H} = (V_{AVG+} - V_{cm} \pm V_{OS})C_F + (V_{OUTH-} - V_{cm} \pm V_{OS})C_I$$

$$Q_{+}^{\phi_A} = Q_{+}^{\phi_H}$$

$$V_{OUTA+} \cdot C_F + V_{OUTA-} \cdot C_I = V_{AVG+} \cdot C_F + V_{OUTH-} \cdot C_I$$

$$V_{AVG+} = V_{OUTA+} + V_{OUTA-}\frac{C_I}{C_F} \mp V_{OUTH-}\frac{C_I}{C_F}$$

5)

$$V_{avg-}^{+} = V_{OTA-}^{+} + \frac{C_I}{C_F}\left(V_{OTA+}^{-} - V_{OTA-}^{+}\right)$$

$$V_{avg} = V_{avg+} - V_{avg-} = V_{OTA+} - V_{OTA-}$$

$$V_{avg+} - V_{avg-} = \underbrace{2(V_{IN+} - V_{IN-}) - (V_{CI+} - V_{CI-})}_{\text{wanted}}$$

$$+ (V_{IN+} - V_{CI+})\frac{\Delta C_+}{C_+} - (V_{IN-} - V_{CI-})\frac{\Delta C_-}{C_-} -$$

$$\frac{2(V_{IN+} - V_{CI+})}{C_F/C_I} \cdot \frac{\Delta C_+}{C_+} + \frac{\Delta C_- 2(V_{IN-} - V_{CI-})}{C_F/C_E}$$

6)