

Project Overview

Folded cascode biasing

Switched capacitor circuits

Examples: Low Dropout Regulator

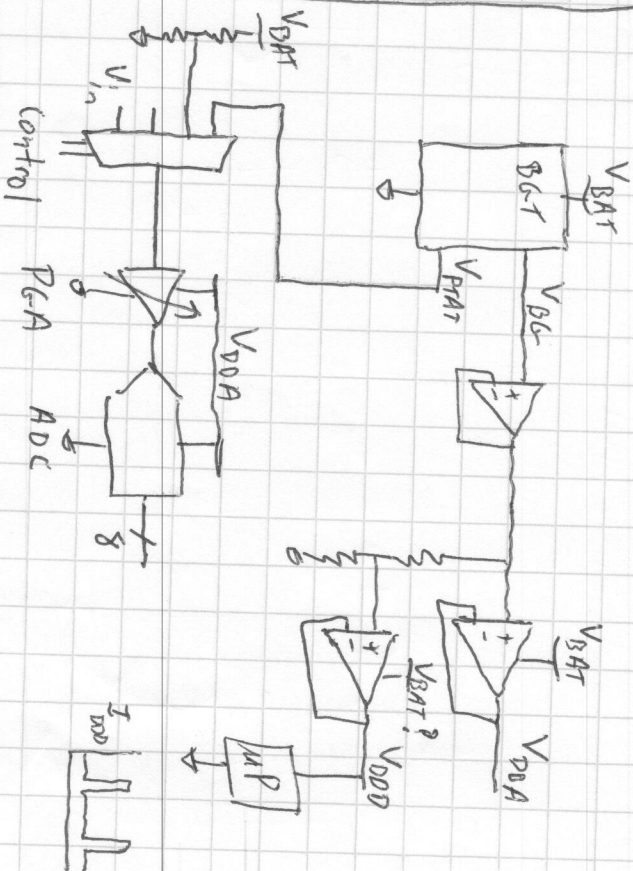
e.g. Analog Devices

Charge-Redistribution ADC e.g. TI

at least 5 op-amps: BGT, 2 regs, PGA, ADC

Differential supply, input CM mode, output filter
Forces differential topology

Embedded MP - or -
Project - who needs op-amps?



Switched Capacitor Circuits

Capacitors well-matched to MOS capacitances

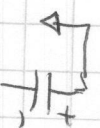
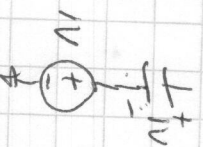
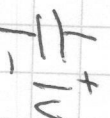
$$+ \frac{1}{-}$$

$$Q = CV$$

$$Q = +Q_+$$

$$Q = -Q_+$$

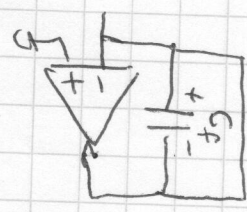
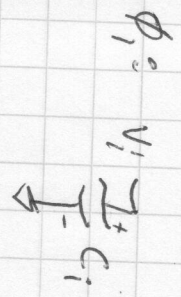
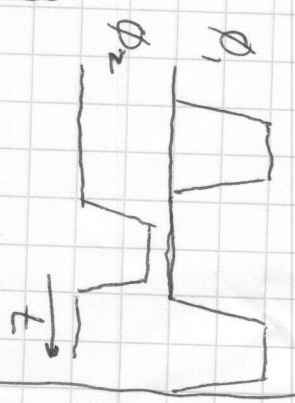
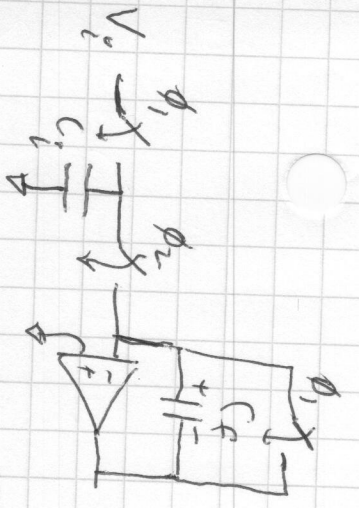
$$\frac{1}{-} \approx -$$



W11L2

165P

140



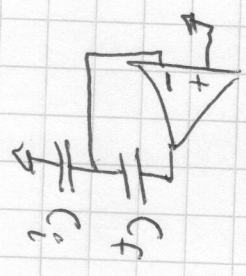
$$Q_{i+} = V_i C_i$$

$$Q_{f+} = 0$$

Feedback perspective

ϕ_1 must be stable in unity gain

ϕ_2 :

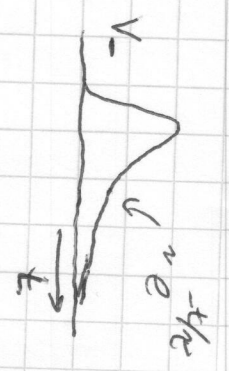
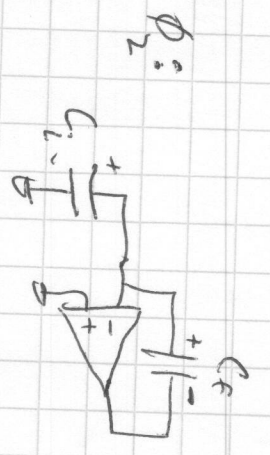


$$f = \frac{C_f}{C_f + C_i}$$

$$\omega_{pCL} = f \omega_u$$

$$\tau = \frac{1}{f \omega_u}$$

gain accuracy $\frac{1}{Af}$



After things settle $V_- = V_+ = 0 \Rightarrow Q_{i+} = 0$

all charge on C_{i+} must move to C_{f+}

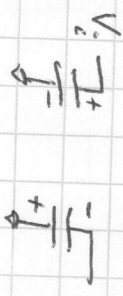
$$Q_{f+} = V_i C_i$$

$$V_f = \frac{Q_{f+}}{C_f} = V_i \frac{C_i}{C_f}$$

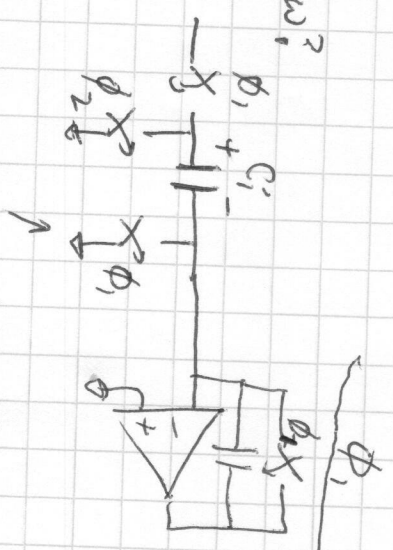
$$V_o = V_- - V_f = 0 - V_i \frac{C_i}{C_f} \quad \text{inverting amplifier}$$

Need positive gain so V_i, V_o both > 0

just flip capacitor around



How?



do we need this one?