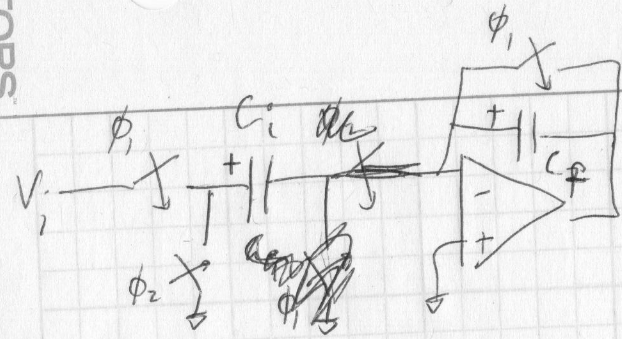
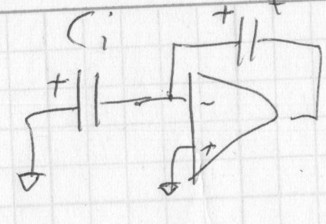
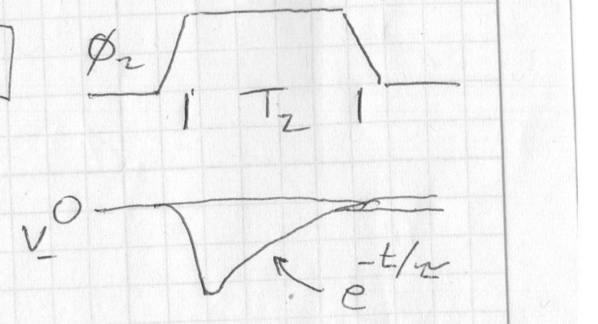
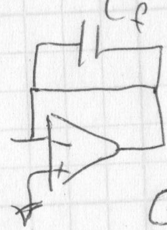






ϕ_1: V_i C_i $Q_{i+} = V_i C_i$



$Q_{f+} = 0$

after settling

$V_- = 0 \Rightarrow Q_{i+,2} = Q_{i-,2} = 0$

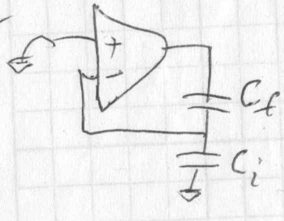
$Q_{f+,2} = Q_{i-,1} = -V_i C_i$

$V_{out} = V_- - V_{Cf} = 0 - \frac{Q_{f+,2}}{C_f} = +\frac{C_i}{C_f} V_i$

- must have op-amp stable in unity gain!
- must be able to pull output to ground

how fast?

ϕ_2



$f = \frac{C_f}{C_f + C_i}$ $\left(\neq \frac{1}{C_i/C_f}\right)$

if $C_i = 8C_f$

$A_v = 8$

$f = \frac{1}{9}$

$n = 7 \Rightarrow 0.1\%$

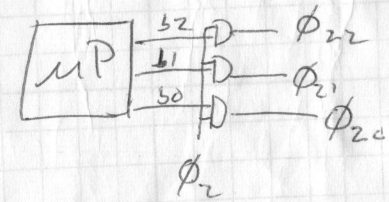
$\omega_{pCL} = f\omega_u$

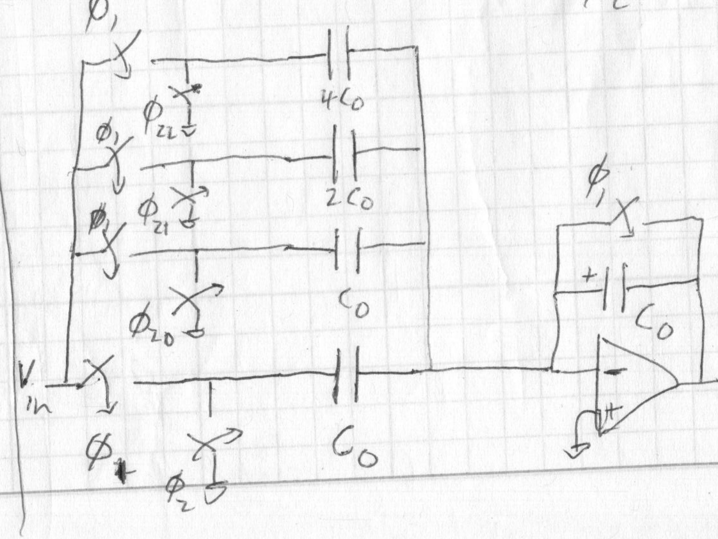
$\tau = \frac{1}{f\omega_u}$

need $n\tau < T_2$

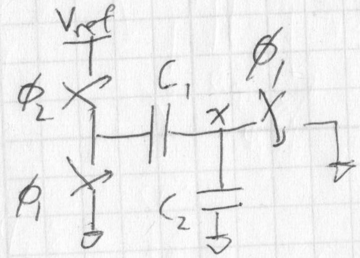
$\frac{n}{f\omega_u} < T_2$ $\omega_u > \frac{n}{fT_2}$

Programmable gain

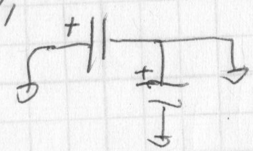




Cap DAC

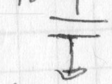


$\phi_1 = 1$



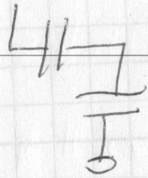
$Q_x = Q_{1-} + Q_{2+} = 0$

$\phi_1 = 0, \phi_2 = 0$



Q_x still 0

$\phi_2 = 1$

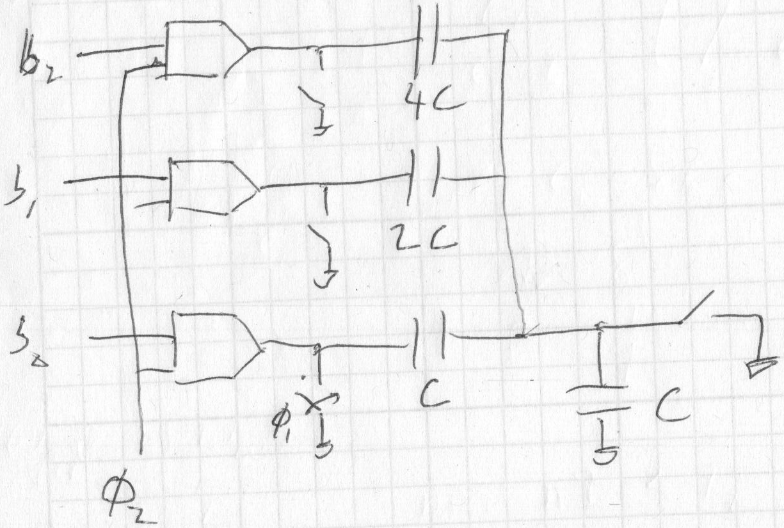


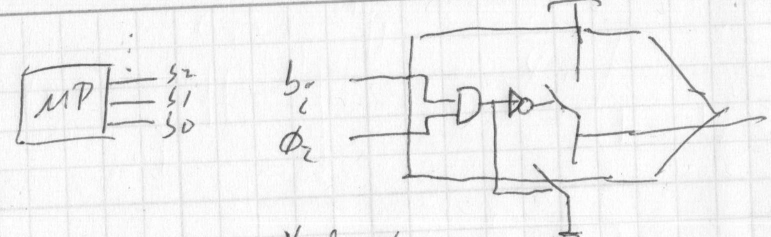
$Q_x = Q_{1-} + Q_{2+} = 0$

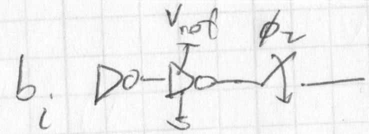
$= -C_1(V_{ref} - V_x) + C_2 V_x$

$(C_1 + C_2) V_x = C_1 V_{ref}$

$V_x = \frac{C_1}{C_1 + C_2} V_{ref}$



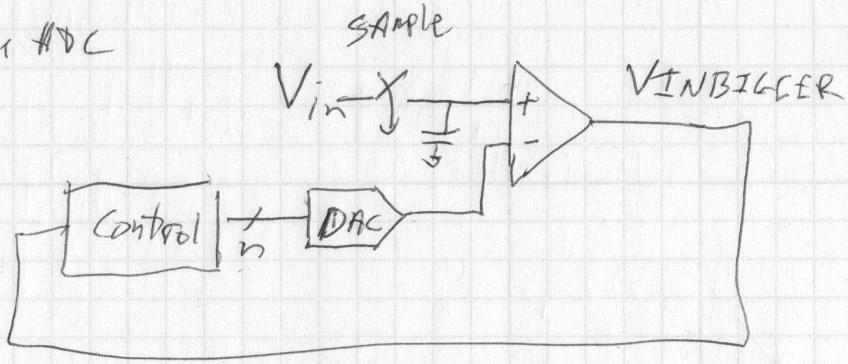


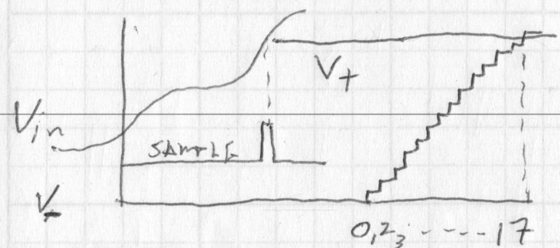


$V_o = \begin{cases} Z & \phi_2 = 0 \\ b & \phi_2 = 1 \end{cases}$

$B = [b_2 b_1 b_0]$	C_1	C_2	V_{out}
0 [0 0 0]	0	8C	0
1 [0 0 1]	C	7C	$\frac{1}{8} V_{ref}$
2 [0 1 0]	2C	6C	$\frac{2}{8} V_{ref}$
7 [1 1 1]	7C	1C	$\frac{7}{8} V_{ref}$

Single ADC





$$V_{id} = V_{in} - \frac{B}{2^N} V_{ref}$$

problems: slow - binary search

variable input offset