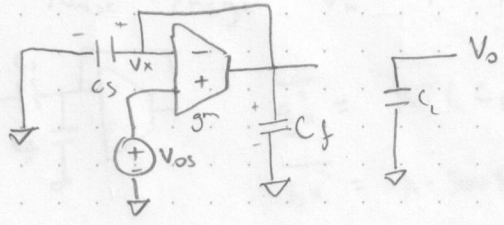
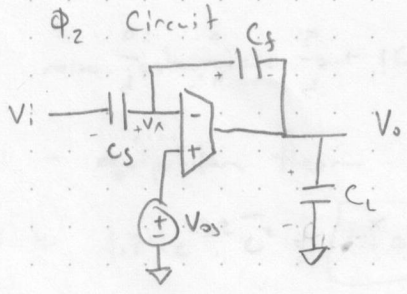
4) $f_{clk} = 10MHz$ $T_{\phi_1} = T_{\phi_2} = \frac{T_{clk}}{2}$ $C_s = C_L = 2pF$ $C_f = 1pF$ $G_m = 1mS$ $r = 1$ $\alpha = 3$

a) Voltage gain from V_i to V_o

ϕ_1 circuit



ϕ_2 Circuit



$Q = C \cdot V_c$ $\qquad Q_L = C_L \cdot V_o$

$V_x \approx$ virtual gnd $\cong V_{os}$

ϕ_1, $V_{cs} = V_{cf} = V_{os}$ $\quad Q_x = 0$

ϕ_2, $V_{cs} = V_x - V_i$ $\quad V_{cf} = V_x - V_o$ $\quad Q_x = 0$

$Q_x = 0 = C_s(V_x - V_i) + C_f(V_x - V_o) = C_s V_x - C_s V_i + C_f V_x - C_f V_o$

$C_f V_o = C_s V_x - C_s V_i + C_f V_x = V_x(C_s + C_f) - C_s V_i$

$V_x = V_{os} \sim 0$

$C_f V_o = -C_s V_i$

$\frac{V_o}{V_i} = -\frac{C_s}{C_f} = \frac{-2pF}{1pF} = -2$

$\frac{sC_f}{C_f + sC_s}$

b) $V_{os} = 10mV$ $\quad A_v = 100$

ϕ_1 $\quad V_c = V_{os} \cdot \frac{A}{1+A}$

ϕ_2 $\quad V_o = A(V_{in} - V_c + V_{os}) = A\left(V_{in} - V_{os}\frac{A}{1+A} + V_{os}\right)$

$V_o = AV_{in} + AV_{os}\left(1 - \frac{A}{1+A}\right) \Rightarrow A\left(1 - \frac{A}{1+A}\right) = A - \frac{A^2}{1+A} = 0.99$

$V_o = AV_{in} + 0.99 \cdot V_{os} - A\beta V_o$ $\quad \beta = \frac{C_f}{C_f + C_s} = \frac{1}{3}$

$V_o + A\beta V_o = AV_{in} + 0.99 V_{os}$

$V_o(1 + A\beta) = AV_{in} + 0.99 V_{os}$ $\quad V_o = \frac{AV_{in} + .99 V_{os}}{1 + A\beta}$ $\quad V_i = 0$, $V_o = \frac{V_{os} \cdot 0.99}{1 + A\beta}$

Input referred noise $\sim \frac{V_{os}}{A}$