Prelab 3

Wednesday, February 26, 2020 5:29 PM

$NML = V_{iL} - V_{oL}$

Part 1

$k_p'\left(\frac{W_p}{L_p}\right) = k_n'\left(\frac{W_n}{L_n}\right)$

$W_p = \frac{k_n' W_n L_p}{k_p' L_n} = \frac{432 \cdot 2 \cdot 0.1}{108 \cdot 0.1} = 8\,\mu m$

$\frac{k_n'}{2}\frac{W_N}{L_N}(V_{GS} - V_{TN})^2(1 + \lambda_N(V_{DS} - V_{DSSAT})) = \frac{k_p'}{2}\frac{W_p}{L_p}(V_{SG} + V_{TP})^2(1 + \lambda_p(V_{SD} - V_{SDSAT}))$

(V_{th}: $V_{GS} - V_{TN}$; $V_{SG} + V_{TP}$: $1.2\,V = V_{DD} - V_{th}$; $\lambda = 0$)

$432 \cdot 2\,(V_{th} - 0.4)^2 = 108 \cdot 8\,(1.2 - V_{th} - 0.4)^2$

$V_{th} = 0.6\,V$

$k_n' W_n (V_{th} - 0.4)^2 = k_p' W_p \cdot 2 (1.2 - V_{th} - 0.4)^2$

$V_{th} = 0.634\,\mu m$

As you decrease K_R, V_{th} goes up

Part 2

$t_{rise} = t_{fall}$

$t_{fall} = \frac{C_L \Delta V}{I_{DNavg}} = \frac{25 \times 10^{-12} \cdot (0.8(1.2))}{I_{DNAVG}} = 13.59_{NS}$

G — D1, S1

$V_{DS} = V_{10\%} / V_{90\%} = (0.1 \cdot 1.2)/(0.9 \cdot 1.2)$

$V_{GS} = V_{in} = 1.2$

$k_n' \frac{W_N}{L_N}\left[(V_{GS} - V_{TN})V_{DS} - \frac{V_{DS}^2}{2}\right] + \frac{k_n'}{2}\frac{W_N}{L_N}(V_{GS} - V_{TN})^2$ (10%: V_{DS}; 90%: V_{GS})

$432 \cdot \frac{2}{0.1}\left[(1.2 - 0.4)0.12 - \frac{0.12^2}{2}\right] + \frac{432}{2} \cdot \frac{2}{0.1}(1.2 - 0.4)^2$

$I_{DNAVG} = 1.766 \times 10^{-15}$

Part 3

$T = 2\,\tau_p\,FO\,n$ ← number of inverter stages

τ_p: delay; FO: fanout

Period

$\Delta t \propto C$

$\Delta t_1 = K C_{Leff} = t_{delay(NL)}$

$\Delta t_2 = K(C_{Leff} + C_{ext}) = t_{delay(L)}$

$\frac{t_{load}}{t_{no\,load}} = \frac{C_{Leff} + C_{ext}}{C_{Leff}}$

$t_{no\,load}(C_{Leff} + C_{ext}) = t_{load}\,(C_{Leff})$

$t_{no\,load} C_{Leff} + t_{no\,load} C_{ext} = t_{load} C_{Leff}$

$t_{no\,load} C_{ext} = t_{load} C_{Leff} - t_{no\,load} C_{Leff}$

$C_{Leff} = \frac{t_{no\,load} C_{ext}}{t_{load} - t_{no\,load}}$