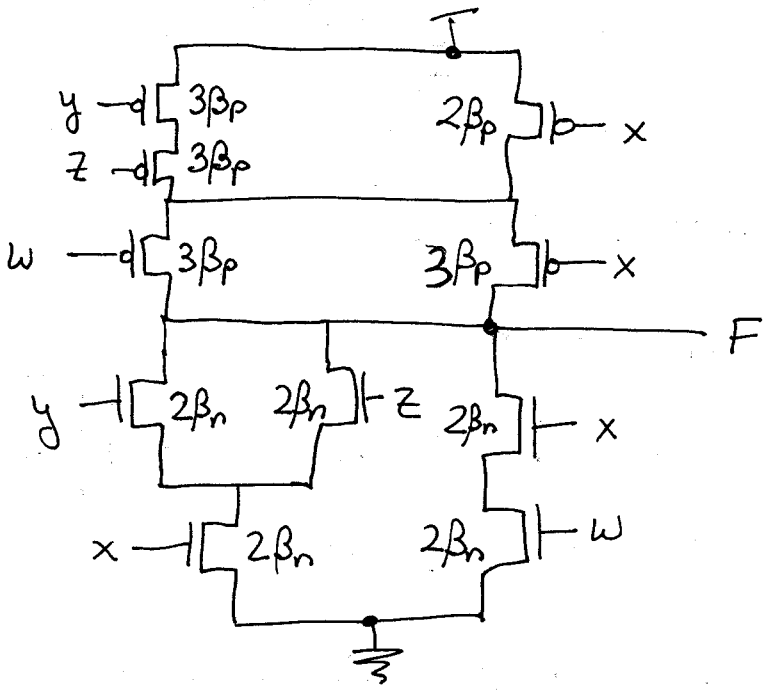
7.12) $F = \overline{x \cdot (y+z) + x \cdot w}$

(a)




(b) sizes on FETs

(c) Worst Case Path would be $y_p \rightarrow z_p \rightarrow w_p$ : rise

nFETS : $x y \bar{z} \bar{w}$

$\bar{y}_n \rightarrow x_n$ : fall

pFETS : $\bar{y} \bar{z} \bar{w} x$

## Problem 2

Estimate Rise & fall time $\beta_n = 60 \frac{\mu A}{V^2}$ $\beta_p = 30 \frac{\mu A}{V^2}$ $V_{DD} = 5V$ $V_T = 0.7V$

$t_r = 2.2\,\tau_r = 26.42$ ns
$t_f = 2.2\,\tau_f = 19.67$ ns

$\tau_r$ worst case: transistors pB & pA

$$\tau_r = C_L (R_{PA} + R_{PB}) + C_{N1} R_{PB} = \boxed{12.01 \text{ ns}}$$

$$R_{PA} = \frac{1}{\beta_p (2)(4.3V)} = 3.87 \text{ K}\Omega$$

$$R_{PB} = \frac{1}{\beta_p (1)(4.3V)} = 7.75 \text{ K}\Omega$$

$\tau_f$ worst case: transistors nC, nB, nD

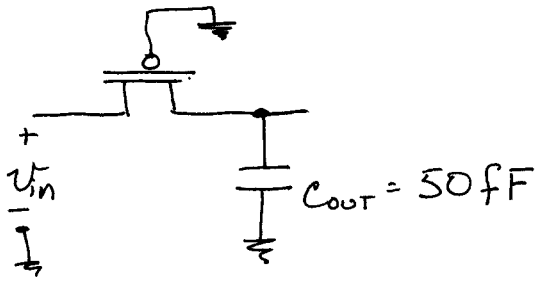
$$R_{nC} = R_{nB} = \frac{1}{\beta_n (1)(4.3V)} = 3.87 \text{ K}\Omega$$

$$R_{nD} = \frac{1}{\beta_n (4)(4.3V)} = 968\ \Omega$$

$$\tau_f = C_L (R_{nC} + R_{nB} + R_{nD}) + C_{N2} (R_{nB} + R_{nD}) + C_{N3} R_{nD}$$

$$= 8.94 \text{ ns}$$

7.15)




$\left(\frac{W}{L}\right)_p = 8 \quad k'_p = 60\ \mu A/V^2 \quad V_{DD} = 3.3\ V \quad |V_{TP}| = 0.8\ V$

(a) FIND FALL TIME

$V_{SG} = V_{OUT}$

$V_{SD} = V_{OUT}$

$$t_f \approx 18\,\tau_p = 18\,R_p C_{OUT} = 750\ ps$$

(b) $t_r = 2.94\,\tau_p = 2.94\,R_p C_{OUT} = 123\ ps$