1)

$$R_{pd} = \frac{L_n}{U_n C_{ox} \cdot W_n (V_{DD} - V_{Tn})} \Rightarrow \frac{1u}{(350u)(2u)(2-.5)} = \boxed{952\,\Omega}$$

$$R_{pu} = \frac{L_p}{U_p C_{ox} \cdot W_p (V_{DD} - V_{Tp})} \Rightarrow \frac{1u}{(70u)(2u)(2-.5)} = \boxed{4762\,\Omega}$$

$$T_{HL} = R_{pd} \cdot C_L = 952 \cdot 3pF = \boxed{14.3\text{ ns}}$$

$$T_{LH} = R_{pu} \cdot C_L = 4762 \cdot 3pF = \boxed{2.86\text{ ns}}$$

2)

$$R_{pd} = \text{Above equation} = \frac{.18u}{(350u)(.18u)(2-.3)} = \boxed{1681\,\Omega}$$

$$R_{pd} = \text{Above equation} = \frac{.18u}{(70u)(.18u)(2-.2)} = \boxed{7937\,\Omega}$$

$$T_{HL} = 1681 \cdot 8fF = \boxed{13.4\text{ ps}}$$

$$T_{LH} = 7937 \cdot 8fF = \boxed{63.5\text{ ps}}$$

$$V_{trip} = \frac{V_{Tn} + (V_{DD} + V_{Tp})\sqrt{\frac{U_p}{U_n} \cdot \frac{W_2}{W_1} \cdot \frac{L_1}{L_2}}}{1 + \sqrt{\frac{U_p}{U_n} \cdot \frac{W_2}{W_1} \cdot \frac{L_1}{L_2}}} = \frac{.3 + (2-.2)\sqrt{\frac{70}{350} \cdot \frac{.18}{.18} \cdot \frac{.18}{.18}}}{1 + \sqrt{\frac{70}{350} \cdot \frac{.18}{.18} \cdot \frac{.18}{.18}}} = \boxed{.764\,V}$$

3)

$$\frac{V_{DD}}{2} = \frac{V_{Tn} + (V_{DD} + V_{Tp})\sqrt{\frac{u_p}{u_n} \cdot \frac{W_2}{W_1} \cdot \frac{L_1}{L_2}}}{1 + \sqrt{\frac{u_p}{u_n} \cdot \frac{W_2}{W_1} \cdot \frac{L_1}{L_2}}} \Rightarrow \frac{.3 + (2 - .2)\sqrt{\frac{70}{350} \cdot \frac{W_2}{W_1} \cdot \frac{.18}{.18}}}{1 + \sqrt{\frac{70}{350} \cdot \frac{W_2}{W_1} \cdot \frac{.18}{.18}}} \Rightarrow$$

$$\frac{2}{2} = 1 = \frac{.3 + (1.8)\sqrt{\frac{W_2}{W_1} \cdot .2}}{1 + \sqrt{\frac{W_2}{W_1} \cdot .2}} \Rightarrow .7 + \sqrt{\frac{W_2}{W_1} \cdot .2} = (1.8)\sqrt{\frac{W_2}{W_1} \cdot .2} \Rightarrow$$

$$.7 + \sqrt{\frac{W_2}{W_1} \cdot .2} = \sqrt{\frac{W_2}{W_1} \cdot .648} \Rightarrow .49 + \frac{W_2}{W_1} \cdot .2 = \frac{W_2}{W_1} \cdot .648 \Rightarrow .49 = \frac{W_2}{W_1} \cdot .448 \Rightarrow$$

$$\boxed{\frac{W_2}{W_1} = 1.094}$$

4)

$$R_{PD} == R_{PU} \Rightarrow \frac{L_n}{u_n C_{ox} (W_n)(V_{DD} - V_{Tn})} = \frac{L_p}{u_p C_{ox} (W_p)(V_{DD} - V_{Tp})} \Rightarrow$$

$$\frac{.18u}{(350u)(W_n)(2 - .3)} = \frac{.18u}{(70u)(W_p)(2 - .2)} \Rightarrow \frac{.18u \cdot 70u \cdot 1.8 \cdot W_p}{.18u \cdot 350u \cdot 1.7 \cdot W_n} = 1 \Rightarrow$$

$$\boxed{\frac{W_p}{W_n} = 4.72}$$

5)

$$V_{TRP} = \frac{V_{DD}}{2} = \frac{V_{Tn} + (V_{DD} + V_{Tp})\sqrt{\frac{u_p}{u_n} \cdot \frac{W_2}{W_1} \cdot \frac{L_1}{L_2}}}{1 + \sqrt{\frac{u_p}{u_n} \cdot \frac{W_2}{W_1} \cdot \frac{L_1}{L_2}}} \Rightarrow \frac{.5 + (2 - .5)\sqrt{\frac{70}{350} \cdot \frac{W_2}{W_1} \cdot \frac{L_1}{L_2}}}{1 + \sqrt{\frac{70}{350} \cdot \frac{W_2}{W_1} \cdot \frac{L_1}{L_2}}} = \frac{2}{2}$$

$$\frac{.5 + 1.5\sqrt{\frac{W_2}{W_1} \cdot \frac{L_1}{L_2} \cdot .2}}{1 + \sqrt{\frac{W_2}{W_1} \cdot \frac{L_1}{L_2} \cdot .2}} = 1 \Rightarrow \sqrt{\frac{W_2}{W_1} \cdot \frac{L_1}{L_2} \cdot .45} = .5 + \sqrt{\frac{W_2}{W_1} \cdot \frac{L_1}{L_2} \cdot .2} \Rightarrow \frac{W_2}{W_1} \cdot \frac{L_1}{L_2} \cdot .45 = .25 + \frac{W_2}{W_1} \cdot \frac{L_1}{L_2} \cdot .2$$

$$\frac{W_2}{W_1} \cdot \frac{L_1}{L_2} \cdot .25 = .25 \qquad \frac{W_2}{W_1} \cdot \frac{L_1}{L_2} = 1$$

if $W_1 = L_1 = .18u$,

$$\frac{W_2}{L_2} = 1 \qquad \boxed{W_2 = L_2 = .18u}$$

6) For V_H: $V_{in} = 0 = \frac{U_p C_{ox} \cdot W_2}{2 \cdot L_2} \cdot (V_H - V_{DD} - V_{Tp})^2 \Rightarrow \frac{70 \cdot .18}{2 \cdot .18}(V_H - 2 - .5)^2 \Rightarrow$

$35(V_H - 1.5)^2 = 0 \quad \boxed{V_H = 1.5}$

For V_L: $V_{in} = 2 = \frac{U_n C_{ox} \cdot W_1}{L_1} \cdot \left(V_{in} - V_{Tn} - \frac{V_L}{2}\right)V_L = \frac{350 \cdot .18}{.18}\left(2 - .5 - \frac{V_L}{2}\right)V_L$

$2 = 350\left(1.5 - \frac{V_L}{2}\right)V_L \Rightarrow .0057 = 1.5V_L - \frac{V_L^2}{2} \quad V_L^2 - 3V_L = -.0114$

$\boxed{V_L = .0038}$

...

12) $C_{in} = \frac{3 + \text{inputs}}{4} \cdot C_{ref} \qquad A = \text{inputs}(3 \cdot W_{p_{min}} + \text{inputs} \cdot W_{n_{min}}) \cdot L_{min}$

$W_{p_{Min}} = W_{n_{Min}}$ For equal worst case rise/fall

a) $C_{in} = \frac{3+8}{4} \cdot C_{ref} = \frac{11}{4} C_{ref} \qquad A = 8(3 \cdot W + 8 \cdot W)L = 88 \cdot W \cdot L$

b) $C_{in} = \frac{3+4}{4} \cdot C_{ref} = \frac{7}{4} C_{ref}$

$A = 2 \cdot (4(3W + 4W)L) + 2(3W + 2W)L + 4 \cdot WL = 70WL$

c) $C_{in} = \frac{3+2}{4} C_{ref} = \frac{5}{4} C_{ref}$

$A = 4(2(3W + 2W)L) + 4(3W + 4W)L + 4WL = 72WL$

d) $C_{in} = \frac{3+2}{4} C_{ref} = \frac{5}{4} C_{ref}$

$A = 4(2(3+2)WL) + 2(2(3W + 2W)L) + 2(3W + 2W)L = 70WL$

13) For equal size, $t_{LH} == t_{HL}$ For min, $t_{LH} \,!= t_{HL}$

$$R_{pu} = \frac{L_p}{U_p C_{ox} \cdot W_p (V_{DD} + V_{Tp})} \qquad R_{pd} = \frac{L_n}{U_n C_{ox} \cdot W_n (V_{DD} - V_{Tn})}$$

Eq Rise/Fall: $R_{pd} = \frac{.18}{(350u)(.18)(2-.5)} = 1904.76$

$$T_{LH} = T_{HL} = 30_{ff} \cdot R_{pd} = \boxed{57.142 \text{ ps}}$$

Min sized:

$$R_{pu} = \frac{.18}{(70u)(.18)(2-.5)} = 9532.81 \qquad R_{pd} = 1904.76$$

$$T_{LH} = 30_{ff} \cdot R_{pu} = \boxed{285.714 \text{ps}} \qquad T_{HL} = 30_{ff} \cdot R_{pd} = \boxed{57.142 \text{ps}}$$

...

16) $T_{prop} = \frac{OD_2}{OD_1} \cdot t_{ref} + \frac{C_{ap}}{OD_2} \cdot t_{ref}$

a) $T_{prop} = \frac{800 fF}{4} \cdot t_{ref} = \boxed{200 \, t_{ref}}$

b) $T_{prop} = \frac{8}{1} t_{ref} + \frac{64}{8} t_{ref} + \frac{800}{64} = \frac{57}{2} t_{ref} = \boxed{28.5 \, t_{ref}}$

c) $T_{prop} = 1 \, t_{ref} + \frac{64}{1} t_{ref} + \frac{800}{64} t_{ref} = \frac{155}{2} t_{ref} = \boxed{77.5 \, t_{ref}}$

...

20)

a) $$V_{Trip} = \frac{V_{Tn} + (V_{DD} + V_{Tp})\sqrt{\frac{u_p}{u_n} \cdot \frac{W_2}{W_1} \cdot \frac{L_1}{L_2}}}{1 + \sqrt{\frac{u_p}{u_n} \cdot \frac{W_2}{W_1} \cdot \frac{L_1}{L_2}}}$$

$$V_{Trip} = 2.5 = \frac{1.5 + (5 - .5)\sqrt{1 \cdot \frac{W_p}{W_n} \cdot \frac{L_n}{L_p}}}{1 + \sqrt{1 \cdot \frac{W_p}{W_n} \cdot \frac{L_n}{L_p}}} \Rightarrow$$

$$2.5 + 2.5\sqrt{\frac{W_p}{W_n} \cdot \frac{L_n}{L_p}} = 1.5 + (4.5)\sqrt{\frac{W_p}{W_n} \cdot \frac{L_n}{L_p}} \Rightarrow$$

$$1 = 2\sqrt{\frac{W_p}{W_n} \cdot \frac{L_n}{L_p}} \Rightarrow \frac{1}{2} = \sqrt{\frac{W_p}{W_n} \cdot \frac{L_n}{L_p}} \quad \frac{1}{4} = \frac{W_p}{W_n} \cdot \frac{L_n}{L_p}$$

$$\boxed{W_p = L_p = L_n = 1u \quad W_n = 4u}$$

b) For $T_{HL} = T_{LH}$, nothing would change from above.

Therefore: $W_p = L_p = L_n = 1u \quad W_n = 4u$