VLSI DESIGN
SOLUTION - TUTORIAL 3

Sol. 1.(a) For an ideal and symmetric inverter

$$k_R = k_n / k_p = 1.$$

$$\Rightarrow k_n = k_p.$$

$$\Rightarrow k_n' \left(\frac{W}{L}\right)_n = k_p' \left(\frac{W}{L}\right)_p$$

$$\Rightarrow 140 \times 10^{-6} \left(\frac{W}{L}\right)_n = 60 \times 10^{-6} \left(\frac{W}{L}\right)_p$$

$$\Rightarrow \frac{(W/L)_n}{(W/L)_p} = \frac{60}{140} = \frac{3}{7}$$

$$\Rightarrow \frac{(W/L)_p}{(W/L)_n} = 2.33.$$

(b) $$k_R = k_n / k_p = \frac{k_n' (W/L)_n}{k_p' (W/L)_p} = \frac{140}{60} = 7/3.$$

$$V_{th} = \frac{V_{T0,n} + \sqrt{1/k_R}\,.\,(V_{DD} + V_{T0,p})}{1 + \sqrt{1/k_R}}$$

$$V_{th} = 1.33V$$

Sol. 2

$$k_R = \frac{k_n}{k_p} = \frac{k_n' (W/L)_n}{k_p' (W/L)_p} = \frac{100 \times 10}{42 \times 14} = 1.7$$

$$V_{th} = \frac{V_{T0,n} + \sqrt{1/k_R}\,(V_{DD} + V_{T0,p})}{1 + \sqrt{1/k_R}}$$

$$V_{th} = 1.4813\,V$$

Sol. 3.

$V_{th} = 1.3V$, $V_{DD} = 3V$, $V_{T0,n} = 0.6V$, $V_{T0,p} = -0.82\,V$

$$k_R = \frac{k_n}{k_p} = \left(\frac{V_{DD} + V_{T0,p} - V_{th}}{V_{th} - V_{T0,n}}\right)^2$$

$$\Rightarrow k_R = \left(\frac{0.88}{0.7}\right)^2 = \boxed{1.58}$$

$$\Rightarrow \frac{k_n}{k_p} = \frac{\mu_n C_{ox} \cdot (W/L)_n}{\mu_p C_{ox} (W/L)_p} \Rightarrow \frac{2.2 \times (W/L)_n}{(W/L)_p} = 1.58$$

$$\Rightarrow \frac{(W/L)_p}{(W/L)_n} = 1.392$$

Solution 4.

We know

$$k_R = \frac{k_n}{k_p} = \left(\frac{V_{DD} + V_{T0,p} - V_{th}}{V_{th} - V_{T0,n}}\right)^2$$

$$\Rightarrow k_R = \frac{k_n}{k_p} = \left(\frac{0.7}{0.9}\right)^2 = 0.608$$

$$\Rightarrow k_R = \frac{k_n'(W/L)_n}{k_p'(W/L)_p} = \frac{60 \times (W/L)_n}{20 \times (W/L)_p} = 0.608$$

$$\Rightarrow (W/L)_n / (W/L)_p = 0.20$$