**Name: KEY** **Id#**

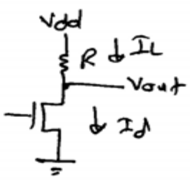
## COE 360, Term 071

## Principles of VLSI Design
## Quiz# 6

Due date: Saturday, Dec.8, 2007

**Q1.** Design a **Resitive-load Inverter** with $V_{OH}$=5v, $V_{OL}$=0.2v, and Average DC power 250 µW. Assume that $V_{tn}$=1v and $\mu_n$Cox=50.5 uA/V$^2$. Assume that the used technology is 0.5um.

By KCL, $I_L = I_d$




when $V_{in} = V_{OH}$, $V_{out} = V_{OL}$

$V_{gd} = V_{OH} - V_{OL} = 5 - 0.2 > V_t \Rightarrow$ transistor is in Linear mode.

$$\Rightarrow \frac{V_{dd} - V_{OL}}{R} = \frac{\beta_n}{2}\left[2(V_{DD} - V_t)V_{OL} - V_{OL}^2\right]$$

$$\Rightarrow \frac{5 - 0.2}{R} = \frac{\beta_n}{2}\left[2(5-1)\,0.2 - (0.2)^2\right]$$

$$\Rightarrow \frac{4.8}{R} = \frac{\beta_n}{2}\left[1.56\right]$$

$$\Rightarrow \beta_n = \frac{2 * 4.8}{1.56\ R} = \frac{6.154}{R}$$

$$\text{Average DC power} = \frac{V_{dd}}{2} \cdot I = \frac{V_{dd}}{2}\frac{(V_{dd} - V_{OL})}{R}$$

$$\Rightarrow 250\,\mu W = \frac{5}{2}\,\frac{4.8}{R}$$

$$\Rightarrow R = \frac{2.5 \times 4.8}{250\,\mu} = \underline{\underline{48\ K\Omega}}$$

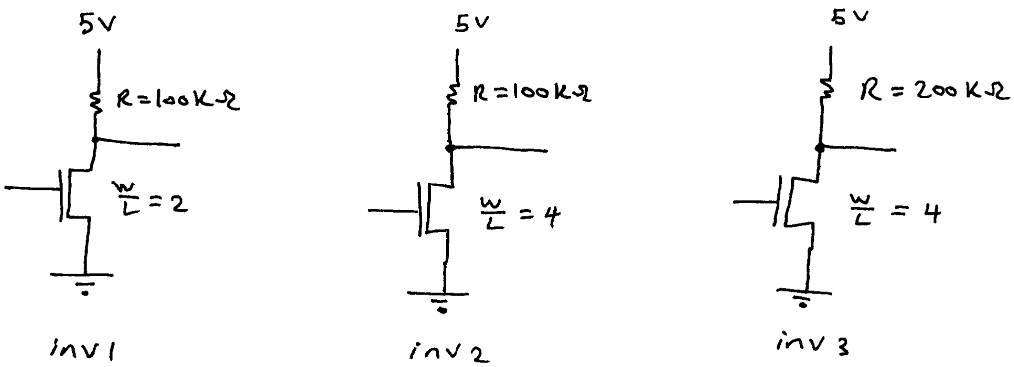
$$\Rightarrow \beta_n = \frac{6.154}{48K} = 128.2\ \mu\frac{A}{V^2}$$

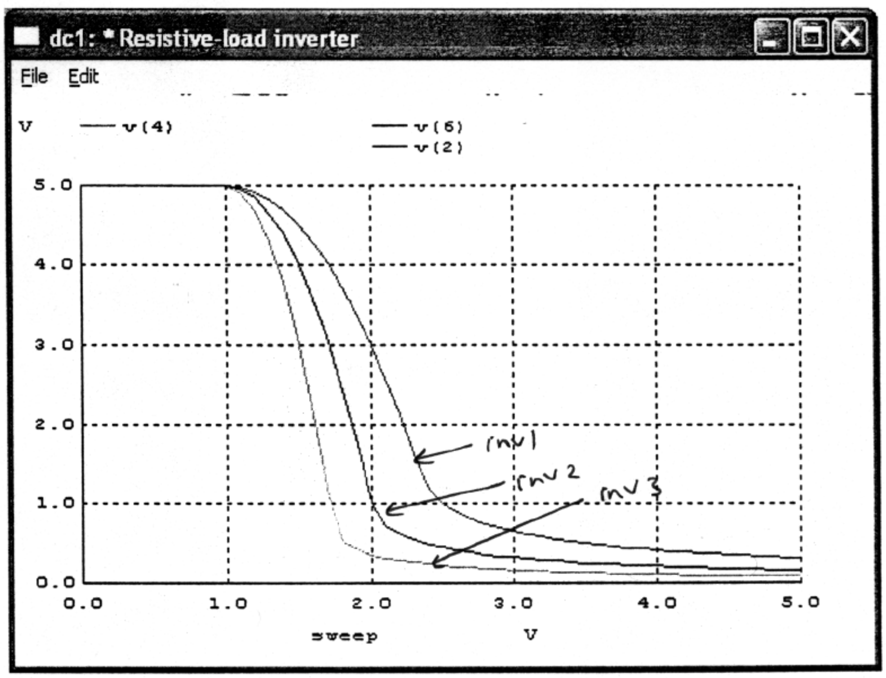
$$\Rightarrow \mu_n C_{ox}\frac{W}{L} = 128.2\ \mu\frac{A}{V^2}$$

$$\Rightarrow \frac{W}{L} = \frac{128.2\,\mu}{50.5\,\mu} = \underline{\underline{2.539}}$$

$$\Rightarrow L = \underline{\underline{0.5\,\mu m}} \qquad W = L * 2.539 = \underline{\underline{1.269}}\ \mu m$$

**Q2.** Given the following three resistive-load inverters and the three voltage transfer characteristic graphs for the three inverters, select the voltage-transfer characteristic graph that corresponds to each inverter. Show your answer in the given graph. Justify your answer.




$$V_{OL} = \frac{R_d}{R_d + R_L} V_{dd}$$

<u>inv1</u> : $V_{OL} \simeq \dfrac{\frac{1}{2} V_{dd}}{\frac{1}{2} + 100K} = \dfrac{\frac{1}{4}}{\frac{1}{4} + 50K} V_{dd}$

<u>inv2</u> : $V_{OL} \simeq \dfrac{\frac{1}{4} V_{dd}}{\frac{1}{4} + 100K}$

<u>inv3</u> : $V_{OL} \simeq \dfrac{\frac{1}{4} V_{dd}}{\frac{1}{4} + 200K}$

$\Rightarrow V_{OL}(inv3) < V_{OL}(inv2) < V_{OL}(inv1)$