# Digital Electronic Circuits

## Homework #3

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**(… dueApril, 9th, 2009, THURSDAY)**

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For the problem below,

- $\mathbf{V_{DD}=3.3V}$.
- The model parameters for the **MOSFET**s are,

$$\mathbf{\mu_n=385}\text{cm}^2\text{V}^{-1}\text{s}^{-1}\ ,\ \mathbf{\mu_p=130}\text{cm}^2\text{V}^{-1}\text{s}^{-1}$$
$$\mathbf{V_{T0n}=0.52}\text{V}\ ,\ \mathbf{V_{T0p}=-0.65}\text{V}$$
$$\mathbf{t_{ox}=7.5}\text{nm}\ ,\ \mathbf{\varepsilon_0=8.85x10^{-14}}\ \text{F/cm}\ ,\ \mathbf{\varepsilon_{ox,r}=3.9}$$

(body effect can be neglected)

- Allowed minimum device aspects are $\mathbf{W_{min}=0.3\mu}$m, and $\mathbf{L_{min}=0.3\mu}$m.
- Try to minimize the consumed area, while satisfying the desired performance.

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Find the logic function corresponding to the **last digit of your student number** below.

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|---|---|---|
| $\mathbf{Z_0}$ = [ (A+B+C)(D+E)F ] ′ | $\mathbf{Z_1}$ = [ AB+(C+D)+EF ] ′ | $\mathbf{Z_2}$ = [ (A+B)(C+D+EF) ] ′ |
| $\mathbf{Z_3}$ = [ (A+BC)DE+F ] ′ | $\mathbf{Z_4}$ = [ ABC(DE+F) ] ′ | $\mathbf{Z_5}$ = [ (AB+C)(D+E)F ] ′ |
| $\mathbf{Z_6}$ = [ (A+BCD)(E+F) ] ′ | $\mathbf{Z_7}$ = [ AB+C(D+EF) ] ′ | $\mathbf{Z_8}$ = [ A(BC+DE+F) ] ′ |
| | $\mathbf{Z_9}$ = [ A+BC+DEF ] ′ | |

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**a)** Sketch the **CMOS** complex gate realizing **your** logic function.

**b)** Determine the aspects $\mathbf{W_p}$, $\mathbf{W_n}$, $\mathbf{L_p}$ and $\mathbf{L_n}$ for the **MOSFETs**, if $\mathbf{\tau_{PLH}}$ and $\mathbf{\tau_{PHL}}$ are both aimed to be less than **0.25ns**, for an equivalent load capacitance of $\mathbf{C_L=0.25pF}$.

Note#1: Assume that $\mathbf{C_L}$ remains constant (is not affected further by the device dimensions).
Note#2: All nMOSTs will have the same $\mathbf{W_n/L_n}$. All nMOSTs will have the same aspect ratios $\mathbf{W_p/L_p}$

**c)** Calculate $\mathbf{V_{th}}$ of the **CMOS** gate for the device aspects obtained in **(b)**.

**d)** Re-determine the aspects $\mathbf{W_p}$, $\mathbf{W_n}$, $\mathbf{L_p}$ and $\mathbf{L_n}$ for the **MOSFETs** such that $\mathbf{V_{th}= ½V_{DD}}$. Then, calculate the worst-case values for $\mathbf{\tau_{PLH}}$ and $\mathbf{\tau_{PHL}}$, for $\mathbf{C_L=0.25pF}$.