

## HOMEWORK 2

**Due: April 15, 2013, at 13:00**

- **Add this page as the title page to your homework.**
- **Submissions will be made to the instructor on paper. Electronic submissions (by e-mail, etc.) will not be accepted.**
- **Late submissions will not be accepted.**
- **The homework must be your own work.**

**Any homework which does not comply to the rules above, will receive an automatic grade of zero.**

**Assume the following parameters unless stated otherwise:**

$$V_{DD}=5\text{ V}, V_{tn}=0.8\text{ V}, V_{tp}=-0.9\text{ V}, \mu_n C_{ox}=100\text{ }\mu\text{A/V}^2, \mu_p C_{ox}=35\text{ }\mu\text{A/V}^2$$

$$L_{min}=W_{min}=0.35\text{ }\mu\text{m}, C_L=0.6\text{ pF}$$

The logic function  $Z = \overline{(AC + BC)EF + F}$  is given. Minimum size transistors will be used unless stated otherwise.

- a) Draw the complex CMOS circuit realizing the logic function Z.
- b) Calculate and simulate the threshold voltage ( $V_{TH}$ ) of the circuit obtained in a) under the assumption that all inputs are changed simultaneously.
- c) Calculate and simulate the worst case propagation delays ( $\tau_{PLH}$ ,  $\tau_{PHL}$ ) of the circuit obtained in a).
- d) Calculate the propagation delays ( $\tau_{PLH}$ ,  $\tau_{PHL}$ ) of the circuit obtained in a) for the case when the inputs are A="1", B="0", C="1" E="0", F="0".
- e) Draw the CMOS transmission-gate-based circuit realizing the logic function Z.

**Attach the SPICE output file (only for DC) and schematic view of your design with node voltages and transistor currents to your homework.**

**Attach the simulation result plots related to b) and c).**

**Compare the simulation results in b) and c) with your calculations.**  
**Comment on all your results.**

### MOS parameters to be used for simulations

(The table should be completed with any extra parameters given above)

Parameter	NMOS	PMOS
TOX	9E-9	9E-9
XJ	1.6000000E-07	1.7000001E-07
VSAT	8.4294280E04	1.3081252E05
CJ	0.001000266	0.001121
PB	0.6882682	0.895226
MJ	0.3595262	0.4476
CJSW	2.040547E-10	2.481E-10
PBSW	0.6882682	0.895226
MJSW	0.2003879	0.3683619
CGDO	3.665E-10	3.28E-10
CGSO	3.665E-10	3.28E-10