

## Simulation Exercise - 1

The TSMC 180 nm technology which you will be using for your simulations in the course, can handle a voltage range from 0V to 1.8V for both  $V_{GS}$  and  $V_{DS}$ . If you exceed this range, the transistor will enter breakdown region, rendering it unusable.

**Problem-1:** Obtain the transfer characteristics ( $I_D$  v/s  $V_{GS}$ ) and output characteristics ( $I_D$  v/s  $V_{DS}$ ) of the NMOS and PMOS transistor. For the PMOS transistor,  $V_{GS}$  and  $V_{DS}$  will change to  $V_{SG}$  and  $V_{SD}$  respectively.

- Simulate the transfer characteristics of an NMOS transistor for  $V_{DS} = 0V, 0.9V$  and  $1.8V$ . Vary  $V_{GS}$  from  $0V$  to  $1.8V$  and use  $W/L = 1\mu m/0.18\mu m$ . Plot the curves on a single graph and compare. What is the threshold voltage of NMOS and PMOS transistors you see in simulations?
- Repeat the above exercise for a PMOS transistor.
- Simulate the output characteristics of an NMOS transistor for  $V_{GS} = 0V, 0.8V$  and  $1.4V$ . Vary  $V_{DS}$  from  $0V$  to  $1.8V$  and use  $W/L = 1\mu m/0.18\mu m$ . Plot the curves on a single graph and compare. Find the value of  $V_{DS}$  at which the transistor enters saturation region.
- Repeat the above exercise for a PMOS transistor.
- Calculate the value of  $\mu_n C_{ox}$ ,  $\mu_p C_{ox}$ ,  $\lambda_n$  and  $\lambda_p$  for the NMOS and PMOS transistors from these simulations. This will be useful later.

**Problem-2:** Determine the small signal parameters ( $g_m$ ,  $r_{ds}$ ) of the NMOS and PMOS transistors at  $V_{GS} = 0.8V$ .

**Problem-3:** For an NMOS device in saturation, plot  $I_D$  vs  $W$  (for a constant length) and  $I_D$  vs  $L$  (for a constant width). Use  $V_{GS} = 0.8V$  and appropriate  $V_{DS}$ . Compare it with calculated values obtained from the equation discussed in class. Discuss your observations and explain any discrepancies you see.