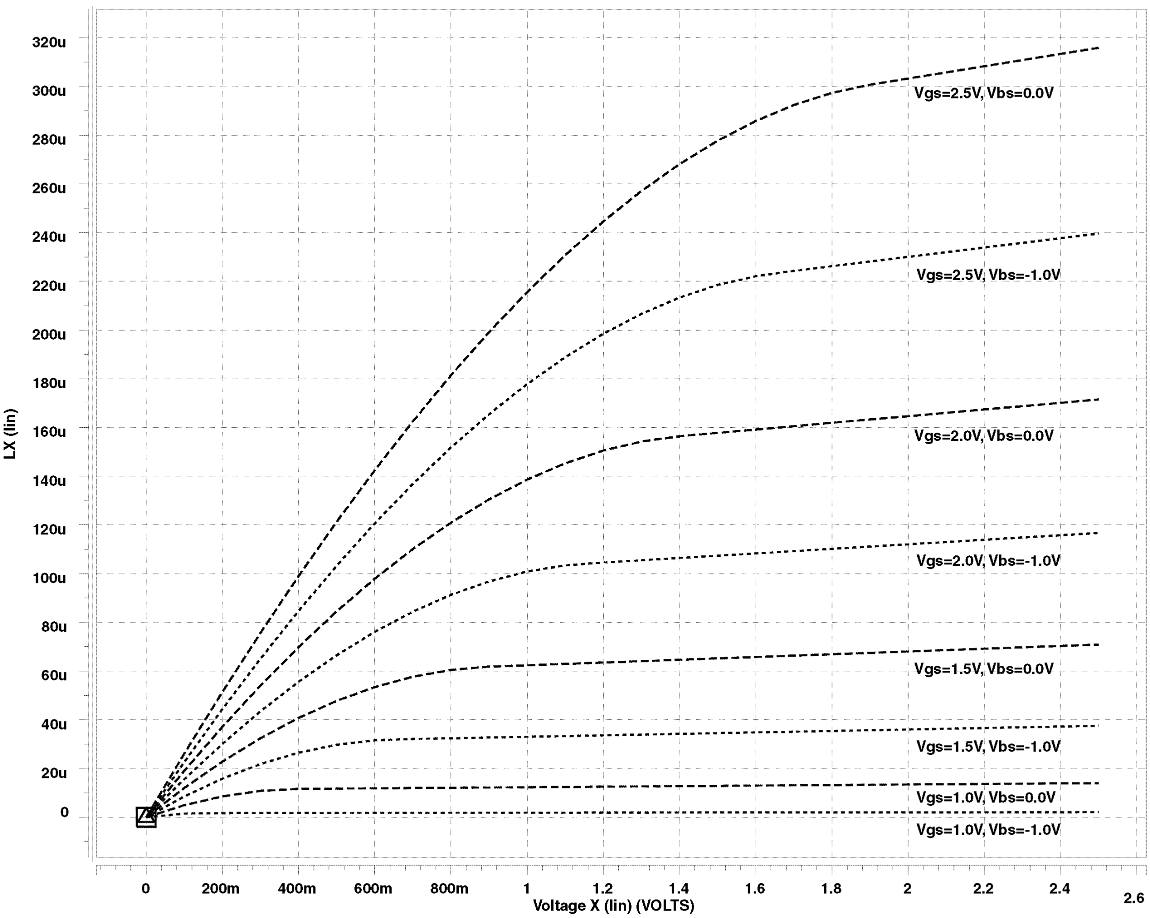
UNIVERSITY OF CALIFORNIA
College of Engineering
Department of Electrical Engineering and Computer Sciences
Last modified on January 31, 2003 by Huifang Qin (huifangq@eecs.berkeley.edu)

Jan Rabaey *Homework #2* *EECS 141*
Due Thu., February 6th, 5pm @ 558 Cory

Problem 1 – Extracting Unified Model Parameters from Simulation

Below is another I-V transfer curve of a NMOS transistor operating under slightly different conditions:



In this problem, the objective is to use a transfer curve like the one above to obtain information about the transistors. The transistor has (W/L)=(2/1). You may also assume that velocity saturation does not play a role in this example. Also assume $-2\Phi_F = 0.6V$

1A From the figure above, determine the following parameters: V_{T0}, γ, λ.

The following part requires you to generate I-V curves for a PMOS transistor. This requires you to have SPICE properly configured on your account, as you worked through in homework 1.

Make sure you add the following line to your deck:

```
.lib '~ee141/MODELS/g25b.mod' TT
```

1B Using SPICE, generate the family of curves for a PMOS transistor with the following parameters.

Supply Voltage = 2.5V
W/L = 2.0u/0.25u
Sweep V_{DS} from -2.5V to 0V in 0.1V increments
V_{GS} = -0.7V, -1.1V, -1.5V, -1.9V, -2.3V
V_{BS} = 0V, 0.5V, 1.2V

Problem 2 – Device Parameters Part 2

Below is a table showing a set of measurements performed on a newly fabricated MOS transistor by an EE143 student. He presented these data as a challenge for you to figure out his experiment setup using your EE141 knowledge. You are convinced that these measurements and a few assumptions will get you the information that you need.

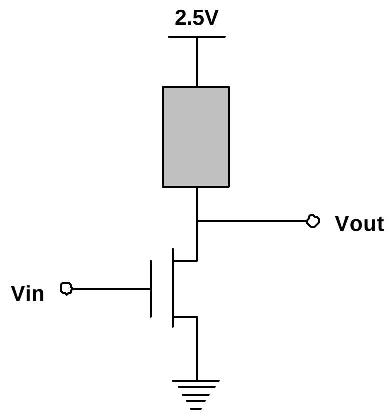
Measurement Number	V_{GS}	V_{DS}	V_{SB}	I_D	Operation Region
1	-2.5V	-2.5V	0	-84.375uA	
2	1.0V	1V	0	0.0	
3	-0.7V	-0.8V	0	-1.04uA	
4	-2.0V	-2.5V	0	-56.25uA	
5	-2.5V	-2.5V	-0.8V	-72.0uA	
6	-2.5V	-1.5V	0	-80.625uA	
7	-2.5V	-0.8V	0	-66.56uA	

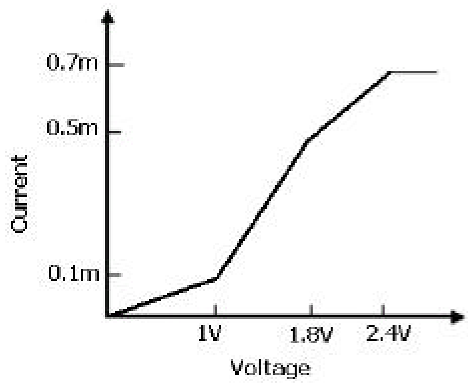
You may assume that V_{DSAT} = -1.0V and $|-2\Phi_F|$ = 0.6V.

2A Is the measured transistor a PMOS or an NMOS device? Explain your answer.
2B From measurements above, determine the following parameters: V_{T0}, γ, λ.
2C Now, to really impress your friend, complete the missing column in the table above using the values you obtained in 2B. Fill in either "LINEAR", "CUTOFF", "SATURATION", or "VEL. SATURATION." (You don't have to recopy the whole table, just the last column is sufficient) Explain your judgment briefly.

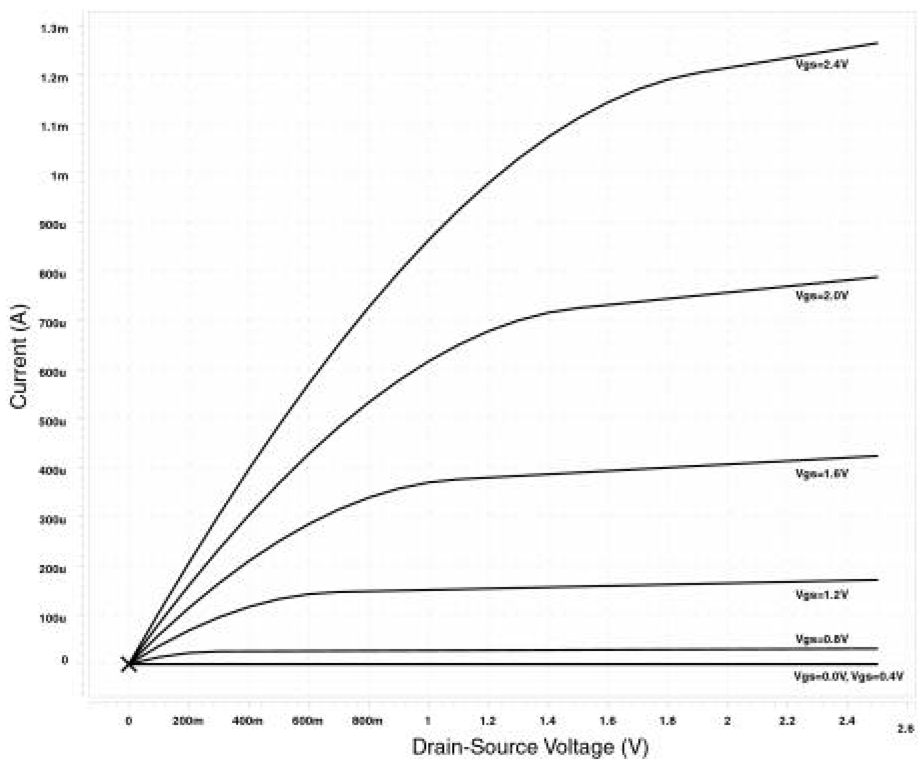
Problem 3 – Generating a Voltage Transfer Characteristic

The circuit below features an NMOS transistor that is coupled with a non-linear load device represented by the shaded box. Accompanying the figure is the I-V characteristic for this non-linear load device.





Of course, we also have the family of I-V curves for our NMOS transistor given below:



3A Draw the VTC for this circuit. Determine (or estimate, if necessary, from your VTC) the following parameters: V_{OH}, V_{OL}, V_M

3B This circuit can be used as an alternative to a traditional CMOS inverter (where the non-linear device is a PMOS transistor). From the concepts discussed thus far in lecture and from the results of your VTC, what are the **disadvantages** of this method?

Problem 4 –VTC and Noise Margins Analysis of Different Inverter Implementations

An old implementation of MOS inverters is shown in Fig a., in which a diode connected NMOS transistor is used as the load. The standard inverter implementation is shown in Fig b. Compare the following characteristics of the two inverters:

4A Find V_{OH}, V_{OL}, V_M using the quadratic equations.
4B What's the noise margin of the two inverters? Comment on the results.
4C Use HSPICE to plot the VTC of the two inverters. Compare the differences in VTC curves, robustness and regeneration (applying the output of an inverter to another inverter in the same implementation) of each inverter.

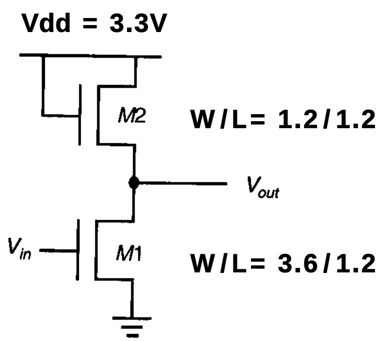


Fig. a

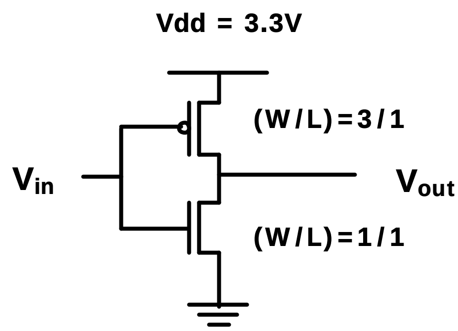


Fig. b

Use the following parameters:

NMOS: V_{T0}=0.6V, k'=20 $\mu A/V^2$, γ=0.5 $V^{1/2}$, λ=0.05 V^{-1};
PMOS: V_{T0}=-0.6V, k'= 7 $\mu A/V^2$, γ=0.5 $V^{1/2}$, λ=0.1 V^{-1}