

UNIVERSITY OF CALIFORNIA AT BERKELEY
College of Engineering
Department of Electrical Engineering and Computer Science

R. W. Brodersen,
S. Emami, and D. Sobel

Homework #1
(Due 9/8/04)

EECS140
Fall 2004

1. Figure 1 shows the measured I_D - V_{DS} curves of a $5\mu\text{m}/0.15\mu\text{m}$ (W/L) NMOS transistor. (the data file is attached)

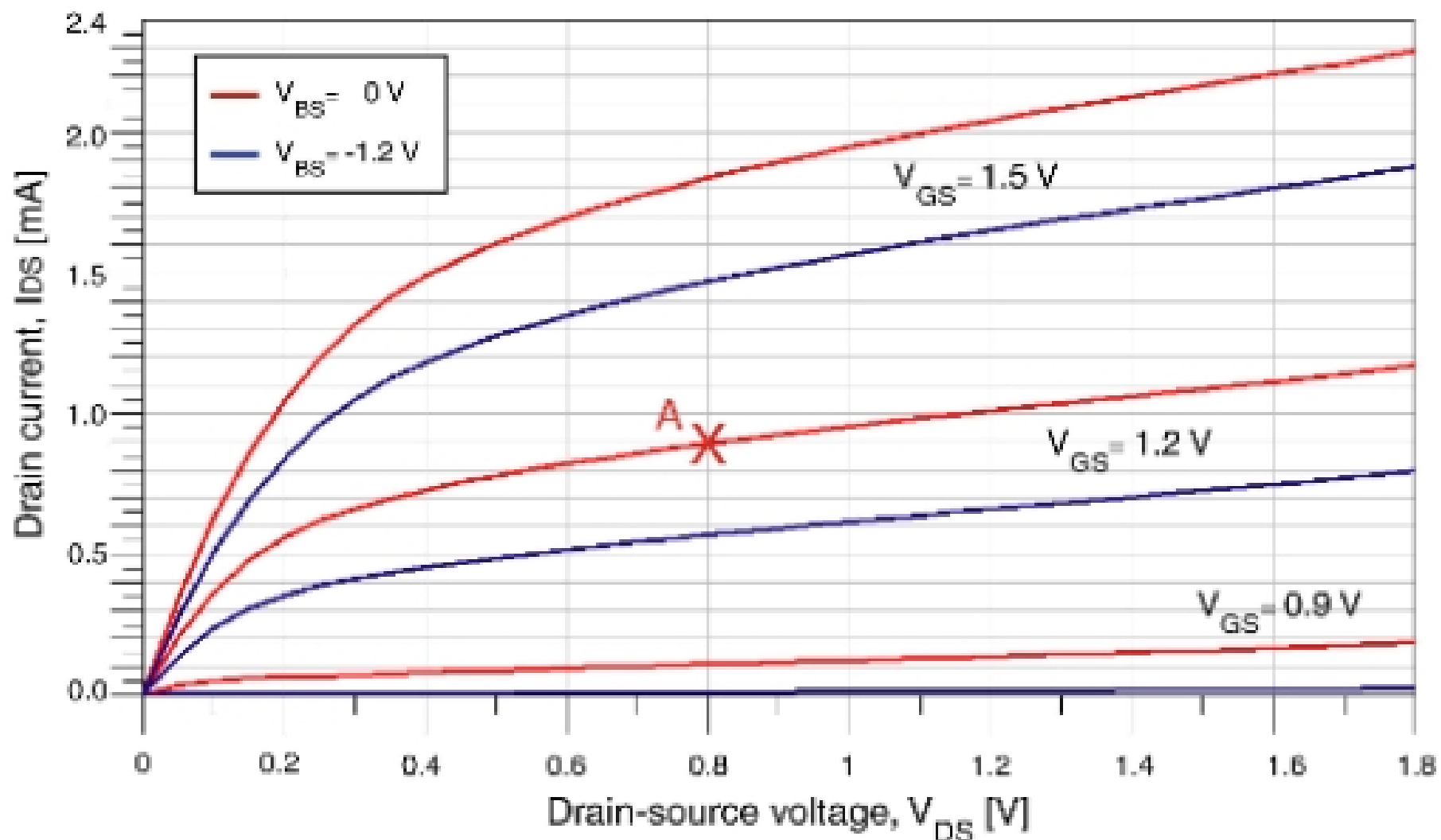


Figure 1

- a) Estimate the model parameters (Level 1) V_{T0} , γ , k' , and λ of this transistor. (Assume $\phi_f = 0.3$ V)
- b) Calculate the small signal parameters (g_m , g_{mb} , and r_o) at the operating point A. ($V_{GS} = 1.2$ V, $V_{BS} = 0$, $V_{DS} = 0.8$ V)
- c) Use the results of part (a) to complete the `.model` statement of the following HSPICE netlist to simulate the I_D - V_{DS} curves of figure 1. (the red curves, since $V_{BS} = 0$)

```
.option nomod post
```

```
.model xtor nmos level=1 vt0=xxx gamma=xxx lambda=xxx kp=xxx capop=0
```

```
m1 d g 0 0 xtor w=5u l=0.15u
```

```
vds d 0 dc=0.8
```

```
vgs g 0 dc=1.2
```

```
.probe dc id=i1(m1)
.dc vds start=0 stop=1.8 step=0.01 vgs 0.9 1.5 0.3

.end
```

d) Copy the netlist file (xxx.sp) to your working directory and execute HSPICE and Awaves:

```
c199.> hspice xxx.sp >! xxx.lis
>info: ****hspice job concluded
c199.> awaves &
```

e) View the results from Awaves and print out the I_D - V_{DS} curves. Compare the measured and simulated curves and comment on the results.
(Load the design from **Design**→**Open**, and choose the waveform by the **Results Browser**)

f) Modify the netlist (to provide $V_{BS} = -1.2$ V) and repeat part (d) and (e) for the blue curves of figure 1.

2. Figure 2 shows the measured $\log(I_D) - V_{GS}$ curves of the same NMOS transistor. (the data file is attached)

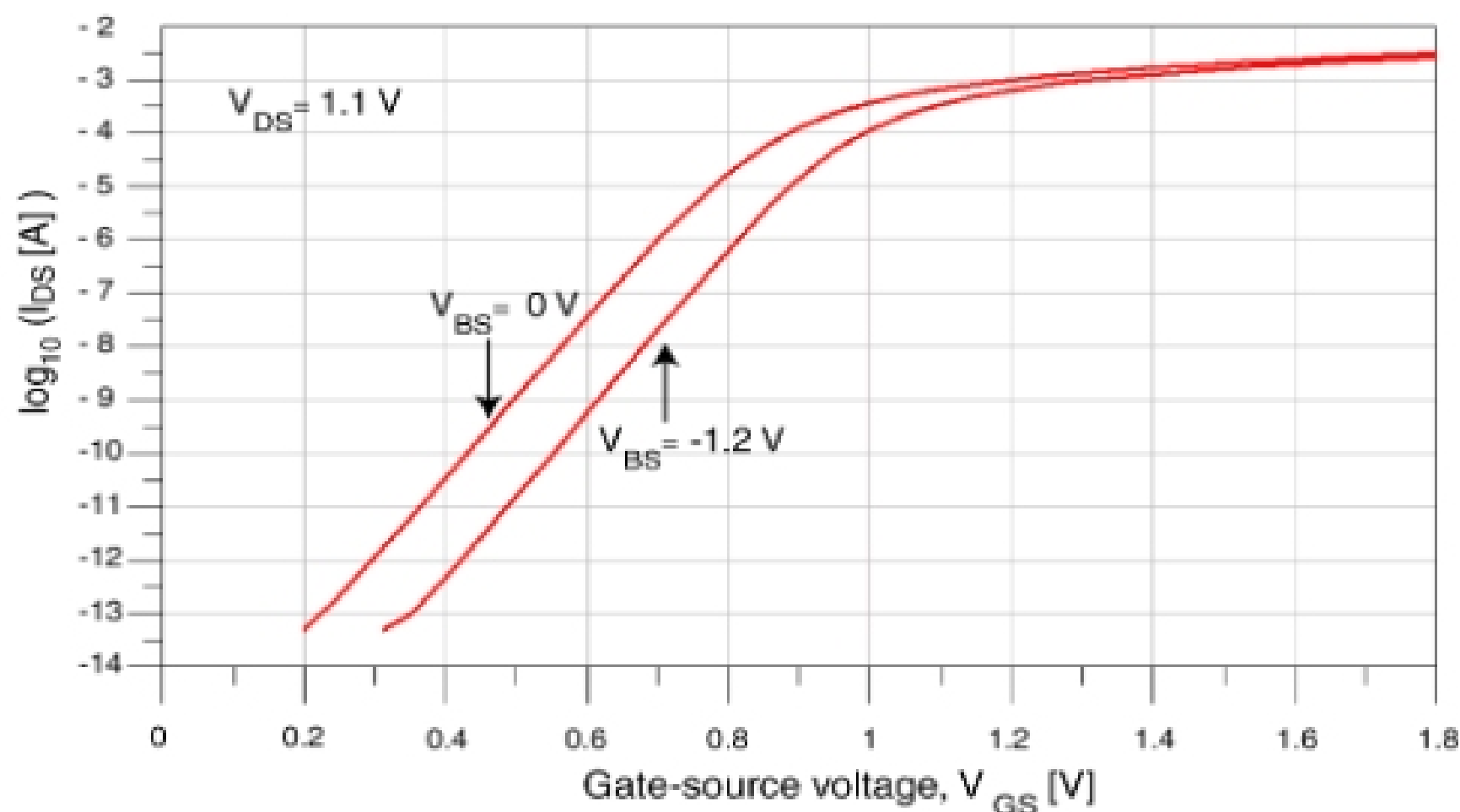


Figure 2

a) Assume the sub-threshold current can be approximated with $I_d = I_0 e^{\frac{(V_{GS} - V_{th})}{nV_T}}$, where $V_T = 26$ mV. Estimate the value of n for this transistor.

b) Use the extracted model and procedure of problem 1 to simulate and print out the curves shown in figure 2 ($\log(I_D) - V_{GS}$) and normal $I_D - V_{GS}$ curves. Comment on the accuracy of the simulation results for different regions of operation.