

**CSE 462 VLSI Design**  
**Assignment 2: MOS Transistors**  
**Due Monday September 13, 2004**

1. Determine the mode of operation, (saturation, linear, or cutoff) and drain current  $I_d$  for each of the biasing configurations a-f given below. Assume that the long-channel MOSFET model is valid for these devices. Use the following transistor bias data, assuming  $V_{SB}$  is 0 in all cases:

	NMOS	PMOS
$k'$	$115 \mu\text{A}/\text{V}^2$	$30 \mu\text{A}/\text{V}^2$
$V_{T0}$	0.43 V	-0.40 V
$\lambda$	$0.06 \text{ V}^{-1}$	$-0.10 \text{ V}^{-1}$

		$V_{GS}$	$V_{DS}$
(a)	NMOS	2.5 V	2.5 V
(b)	PMOS	-0.5 V	-1.5 V
(c)	NMOS	3.3 V	2.2 V
(d)	PMOS	-2.5 V	-1.8 V
(e)	NMOS	0.6 V	0.1 V
(f)	PMOS	-2.5 V	-0.7 V

2. Velocity saturation:
- Re-derive the MOS IV relationships on pages 19–23 of the *MOS Transistor* lecture notes assuming that the device is in velocity saturation.
  - Given a standard I-V plot of a MOSFET ( $I_D$  on the y-axis,  $V_{DS}$  on the x-axis, and a family of curves for different values of  $V_{GS}$ ), describe two ways of determining graphically if the device has short-channel velocity saturation effects.
3. A short-channel NMOS transistor has  $V_{DSAT} = 0.6 \text{ V}$  and  $k' = 100 \mu\text{A}/\text{V}^2$ . In addition, the following data points were measured in the lab with  $V_{BS} = 0$ :

	$V_{GS}$ (V)	$V_{DS}$ (V)	$I_D$ ( $\mu\text{A}$ )
1	2.5	1.8	1812
2	2	1.8	1297
3	2	2.5	1361

- Determine  $V_{T0}$ .
  - Determine  $\lambda$ .
  - Determine  $W/L$ .
  - What additional data would you need to collect in order to determine the body effect parameter,  $\gamma$ ? Describe in detail what measurements you would make under what biasing conditions, and what equation(s) you would solve to get the result. (You don't need to actually solve the equations for this exercise.)
4. Given the I-V characteristics of the NMOS device shown below, determine  $V_{T0}$ ,  $\lambda$ , and  $\gamma$ . Assume that  $W/L = 1$ ,  $-2\Phi_F = 0.6 \text{ V}$ , and that velocity saturation does not play a role.

