ECE2280 Homework #7 Spring 2014

1. (a) The table below lists different cases for an NMOS transistor with V_t=1V. In each case the voltages at the source, gate, and drain (relative to the circuit ground) are specified. You are required to complete the table entries. Note that Vov is called the overdrive voltage and is equal to ($|V_{GS}|$-$|V_t|$).

V_S	V_G	V_D	$\|V_{GS}\|$	$\|V_{OV}\|$	$\|V_{DS}\|$	Region of Operation
+1.0	+1.0	+2.0				
+1.0	+2.5	+1.5				
0	+2.5	+1.0				
-1.0	0	+1.0				

(b) The table below lists different cases for a PMOS transistor with V_t=-1V. In each case the voltages at the source, gate, and drain (relative to the circuit ground) are specified. You are required to complete the table entries. Note that Vov is called the overdrive voltage and is equal to ($|V_{GS}|$-$|V_t|$).

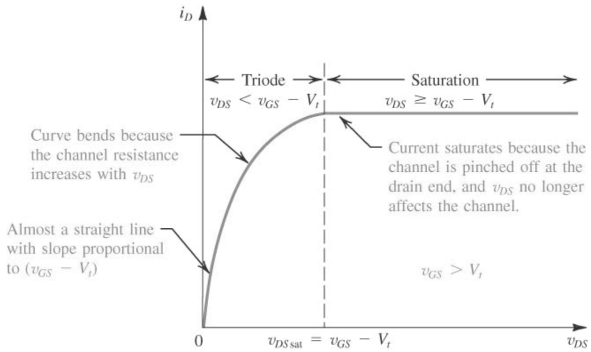
V_S	V_G	V_D	$\|V_{GS}\|$	$\|V_{OV}\|$	$\|V_{DS}\|$	Region of Operation
+2.0	+2.0	0				
+2.0	0	0				
+2.0	0	+1.5				

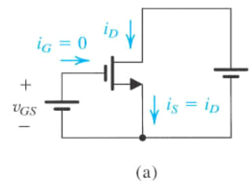
2. Various NMOS and PMOS transistors, numbered 1 to 4, are measured in operation, as shown in the table at the bottom of the page. For each transistor, find the values of V_t and $\mu C_{ox}(W/L)$ that apply and complete the table, with V in volts, I in μA, and $\mu C_{ox}(W/L)$ in μA/V^2. The Type is either PMOS or NMOS.

Case	**Transistor**	V_S	V_G	V_D	I_D	**Type**	**Mode**	$\mu C_{ox}(W/L)$	V_t
a	1	0	2	5	100				
	1	0	3	5	400				
b	2	5	3	-4.5	50				
	2	5	2	-0.5	450				
c	3	5	3	4	200				
	3	5	2	0	800				
d	4	-2	0	0	72				
	4	-4	0	-3	270				

3. Explain in your own words and drawings as needed how, when(under what conditions), and in what direction the current flows in the mosfet. Be specific as to what is happening at the gate, drain, and source.

4. Explain in your own words all the different regions of Fig. 5.7. Describe the current flow relationship of each region.





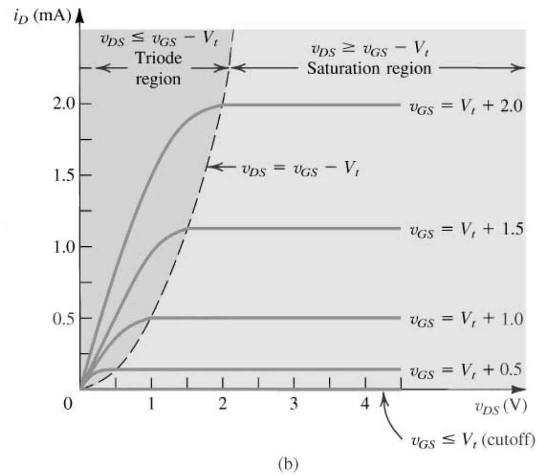


Fig 5.7

Fig. 5.31

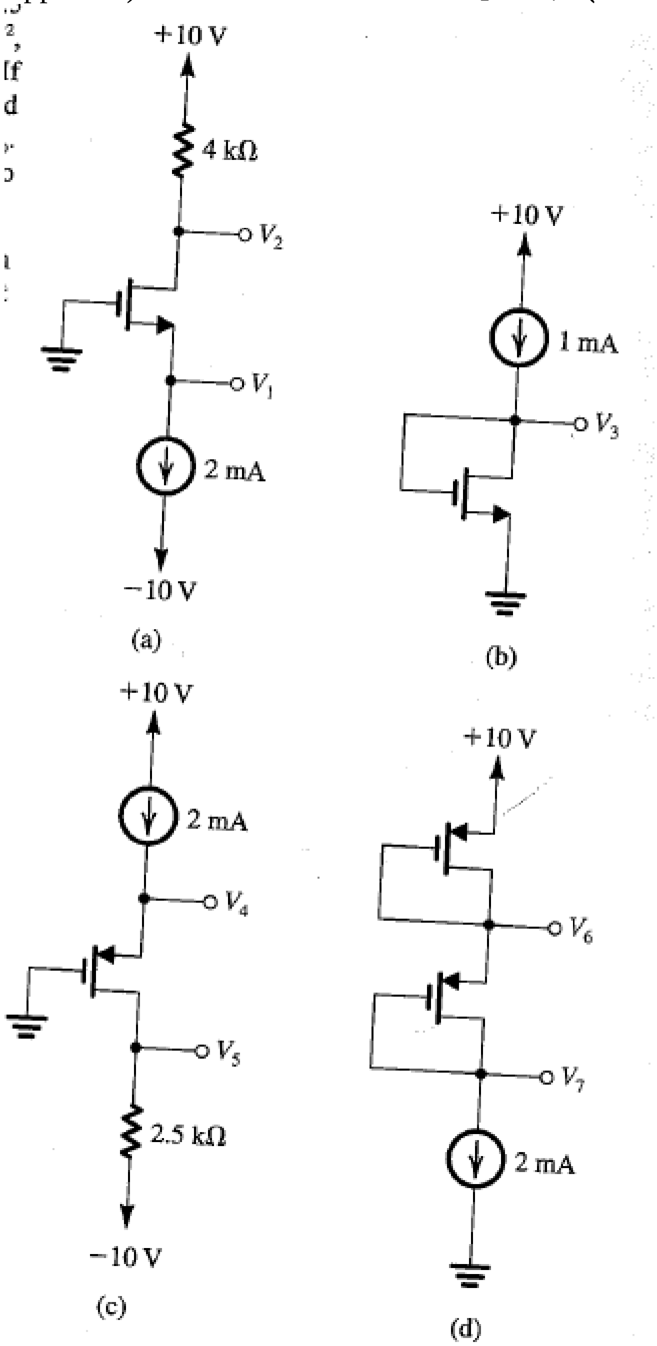
[Figures taken from Sedra/Smith]

5. a) Explain in your own words the difference between Fig. 5.7 and Fig. 5.31.

b) An NMOS transistor with V_D=1V and V_S=0V has V_t=0.4V and $k_n'(W/L)$=1mA/V^2. Sketch and clearly label I_D versus V_G varying in the range 0 to +1.8V. Give equations for the various portions of the resulting graph.

c) Explain in your own words how the PMOS differs from the NMOS transistor.

6 and 7. In the circuits below, transistors are characterized by $|V_t|$=2V and $k_n'(W/L)$=1mA/V^2, and λ=0.
(a) Find the labeled voltages V_1 through V_7.
(b) In each of the circuits, replace the current source with a resistor. Select the resistor value to yield a current as close to that of the current source as possible, while using 1% standard resistor values(in Appendix). Find the new values of V_1 to V_7. ***(worth 2 problems)***



8. Use: V_t=1V

   $k_n'(W/L)=2A/V^2$

   λ=0 for all transistors

   The 4A current source is not ideal and may have a voltage drop across it.

   For DC analysis, assume that the capacitors act as open.

Solve the circuit for the **DC** values:

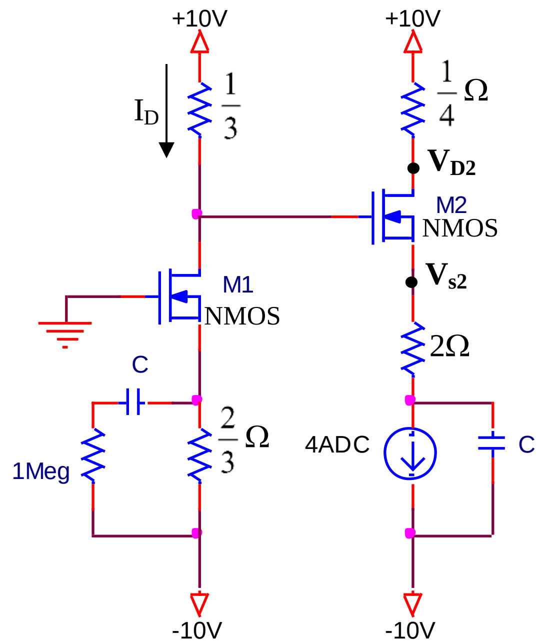
(a) The Q-point for transistor M2

(b) V_{s2}

(c) I_D

(d) V_{D2}

(e) Verify that the transistor M2 is saturated.



9. Use: V_t=1V

   $k_n'(W/L)=2mA/V^2$

   λ=0 for all transistors

   The 1mA current source is not ideal and may have a voltage drop across it.

Solve the circuit for the **DC** values:

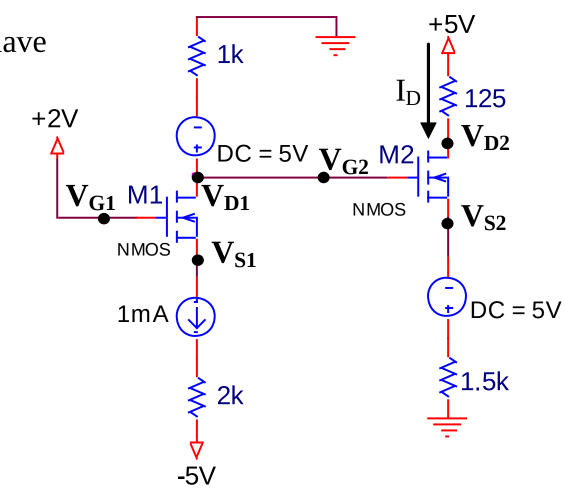
(a) The Q-point for transistor M1

(b) V_{s1}

(c) I_D

(d) V_{D2}

(e) Verify that the transistor M2 is saturated.



10. Let V_t=2V, $k_n'(W/L)$=180µA/V^2. Assume $I_D=I_S$=10mA, and λ=0.

(a) Draw the small-signal equivalent circuit using the hybrid-π model and by assuming all capacitors become shorts. Remember to remove all DC sources when drawing the AC. Vin is an AC signal.

(b) Calculate the value for g_m.