## ECE 331: Electronics Principles I Fall 2013

## Lab #4: Circuit Design with MOSFETs

## Pre-lab due on Tuesday, Nov. 12, before noon

## Pre-lab

- A. For a Common Source amplifier with resistive load as shown below, assume power supply voltage  $V_{DD} = 1.8 \text{ V}$ ,  $k_n' = 330 \text{ }\mu\text{A/V}^2$ ,  $V_{tn} = 550 \text{ }\text{mV}$ , body terminal has been grounded and *Lmin* = 0.18  $\text{ }\mu\text{m}$ .  $\lambda = 0 \text{ }\text{V}^{-1}$ ,  $I_D = 1\text{ }\text{mA}$ , W/L = 10,
  - What is the minimum  $V_{out}$  to make the transistor working in Saturation?
  - > What is the maximum output signal swing  $(V_{out}max V_{out}min)$ ?
  - > What is the value of  $R_D$  to get a voltage gain of 10 V/V?
  - ➤ If  $\lambda = 0.1 \text{ V}^{-1}$ , for  $V_{out} = 1 \text{ V}$ ,  $I_D = 1 \text{ mA}$ , use the  $R_D$  value you just found from the previous part, what is the voltage gain now?
  - > If we drive a load resistance from  $V_{out}$  node, would the gain of the amplifier be changed or not? Why?



- **B.** Assume  $V_{DD} = 5$ V and identical devices with  $V_{tn} = 1$ V,  $k_n' = 0.8$  mA/V<sup>2</sup> and  $\lambda = 0.02 \text{ V}^{-1}$ .

  - Find *R* so that the circuit gives *I* = 100 μA for *Vout* = *V<sub>GS</sub>*. Here, assume λ = 0 for simplicity.
    Find the lower voltage limit for operation in Saturation, as well as output resistance *r*<sub>0</sub> and the change of *I* per volt in the saturation region.



**C.** For a Common Source amplifier with active load, given  $V_{DD} = 3V$ ,  $V_{tn} = |V_{tp}| = 0.6V$ ,  $k_n' = 200 \,\mu\text{A/V}^2$ ,  $k_p' = 65 \,\mu\text{A/V}^2$ , for both of the NMOS and PMOS transistors,  $W = 4\mu\text{m}$ ,  $L = 0.4 \,\mu\text{m}$ ,  $V_A$ \_NMOS = 20V and  $V_A$ \_PMOS = 10V,  $I_{REF} = 100 \,\mu\text{A}$ , find



- ➤ What is the voltage gain (small signal) of this amplifier?
- What is the maximum output voltage to make the amplifier work properly?
- What is the minimum output voltage to make the amplifier work properly?