November 17, 2022

# ECEN 325

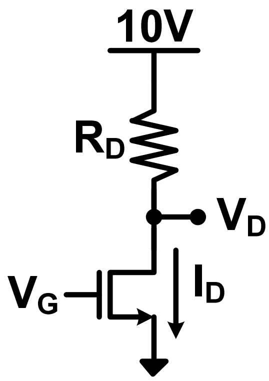
## Homework #7

Due: December 1, 2022, 11:59PM

**Homeworks will not be received after due.**

Instructor: Sam Palermo

1. **(10 points)** For the circuit below, use the following NMOS parameters.
   $KP_N=\mu_n C_{ox}=100\mu A/V^2$, $V_{TN}=0.7V$, $W=10\mu m$, $L=1\mu m$.



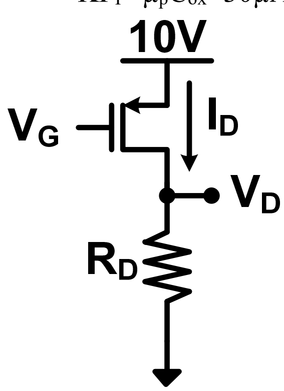

What is the **maximum $R_D$** such that the transistor remains in the saturation region with

- $V_G = 1V$
- $V_G = 2V$

With $V_G=2V$, what are **$I_D$ and $V_D$** with

- $R_D = 5k\Omega$
- $R_D = 15k\Omega$

2. **(10 points)** For the circuit below, use the following PMOS parameters.
   $KP_P=\mu_p C_{ox}=30\mu A/V^2$, $V_{TP}=-1V$, $W=10\mu m$, $L=1\mu m$.




What is the **maximum $R_D$** such that the transistor remains in the saturation region with

- $V_G = 8.5V$
- $V_G = 7.5V$

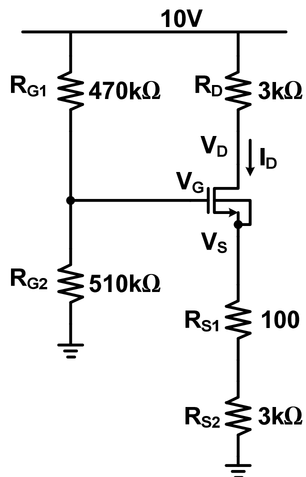
With $V_G=7.5V$, what are **$I_D$ and $V_D$** with

- $R_D = 20k\Omega$
- $R_D = 40k\Omega$

3. **(20 points – 10pts calc., 10pts Multisim)** MOSFET DC Operating Points and AC small signal parameters.

a) For the MOSFET circuit below, calculate the DC values for $V_D$, $V_G$, $V_S$, and $I_D$. Compute the AC small signal parameters $g_m$ and $r_o$. Assume the transistor $\beta = KP_N(W/L) = 102mA/V^2$ and $V_{TN} = 2.0V$. For the calculation of $r_o$ ONLY, assume that $\lambda = 0.01V^{-1}$. You can neglect $\lambda$ effects in the DC calculations, ie assume $\lambda = 0$ for the DC calculations.

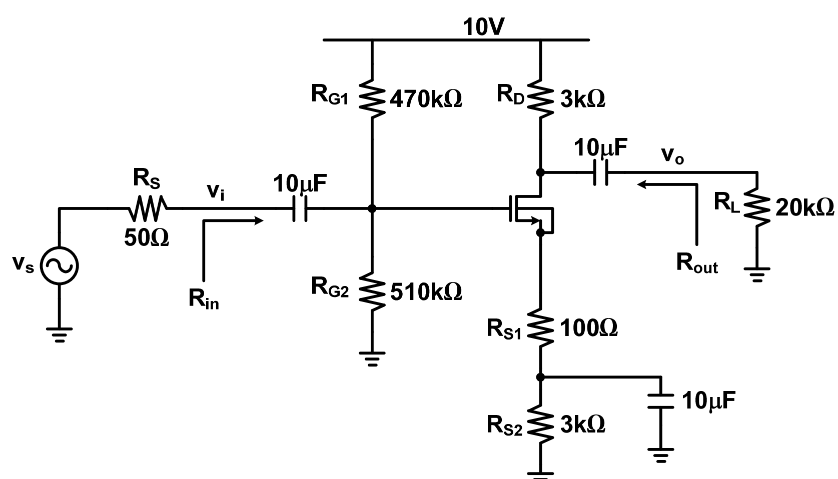
b) Verify the DC operating points in Multisim using the 2N7000 NMOS transistor. Note, the NMOS body terminal is automatically tied to the source, as shown in the schematic. This is true whether you use the default Multisim 2N7000 model or the custom NMOS model. If you use the custom model, which has a nicer symbol, you will need to edit the transistor's $KP_N = 102mA/V^2$ (note W/L=1 by default) and $V_{TN} = 2.0V$. See the additional notes if you want to use the custom model.



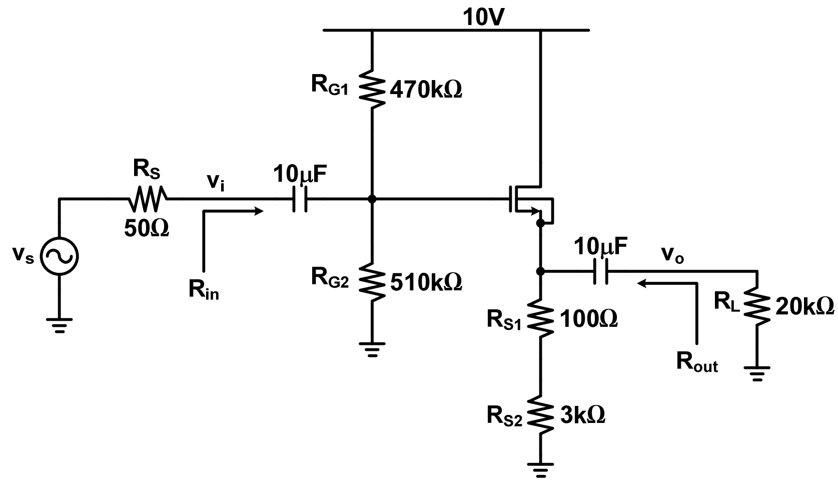

4. **(20 points – 10pts calc., 10pts Multisim)** Common Source Amplifier.

a) For the common source amplifier below, calculate the small signal gain $A_v = v_o/v_i$ (from the transistor gate to the output node), the input resistance $R_{in}$, the output resistance $R_{out}$, and the overall voltage gain $G_v = v_o/v_s$ (from the voltage source to the output node). Assume that the capacitors act as AC shorts and that the transistor's $r_o$ is infinite (can be neglected). Note, you can use the small signal parameters that you solved for in Problem 3.

b) Simulate in Mutlisim. Plot the magnitude in dB (or dbΩ) of $A_v$, $G_V$, $R_{in}$, and $R_{out}$ versus frequency from 100Hz to 100kHz.



5. **(20 points – 10pts calc., 10pts Multisim)** Common Drain Amplifier.
Repeat parts a) and b) from Problem 4 for the common drain amplifier.




6. **(20 points – 10pts calc., 10pts Multisim)** Common Gate Amplifier.
Repeat parts a) and b) from Problem 4 for the common gate amplifier.