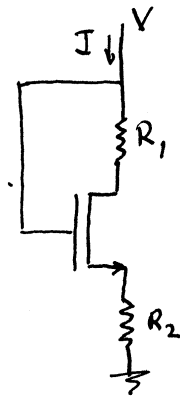


DEVICES – Ph.D. Qualifying Exam Spring 2008

1. (6%) Consider an n-channel MOSFET connected as shown. It has a positive threshold voltage V_T
- Sketch the current I as a function of the voltage V if both resistances are zero, ($R_1 = R_2 = 0$). Make sure your sketch has the correct qualitative features. Locate V_T on the plot.
 - Now suppose $R_1 = R$, and $R_2 = 0$. indicate how the plot in part a) would change. (e.g. using a dotted line) R has some finite value comparable to that channel resistance.
 - Now suppose $R_1 = 0$, and $R_2 = R$. Is the plot the same as in part b)? Show the difference if any.



2. (6%) Consider a p-n junction diode that is light-sensitive. It can act both as a light detector and as a solar cell.
- Sketch the current voltage characteristic of the diode with and without illumination. Clearly identify the curves and make sure they are in correct relation to each other.
 - Sketch a simple circuit with a battery and a resistor that you could use to connect the diode as an effective light detector. Show where you would measure a voltage output.
 - Suppose the I-V characteristic with no light applied is given by $I = \alpha V^2$ for $V > 0$ and $I = 0$ for $V < 0$. Assume α does not change when the diode is illuminated.
If you short circuit the diode with light applied, the current flowing through the diode is $-I_L$. Given this information calculate the maximum power $|P|$ that the diode could deliver to an external circuit. As a function of α and I_L .

3. (3%) A p-n junction can be thought of as an insulating region between two conductors. Sketch how the small signal AC capacitance of the junction would vary as a function of reverse DC bias voltage (the so called CV plot) for two cases: Both sides of the junction lightly doped, and both sides of the junction heavily doped. Show the two curves in correct relation to each other. (Assume the capacitance is the same at zero dc bias voltage.)
4. (5%) Consider a bipolar junction transistor
- a) What are some of the consequences, positive (improving performance) and negative (degrading performance) of making the base thinner and thinner?
 - b) What are some of the consequences, positive and negative, of increasing the base doping?