

Exercise 2

1. Simulate the circuit of Figure 1.1 using AIM-spice. Use geometry parameters $W=10\ \mu\text{m}$ and $L=5\ \mu\text{m}$, and the MOSFET model N1 that is described in the file 'modelcards_v30.cir'. In order to obtain sufficient accuracy, set the option RELTOL = 0.00001 before running the simulations.

- Set $R_L = 10\ \text{k}\Omega$, $V_{DD} = 2.000\ \text{V}$, $V_{GS} = 0.800\ \text{V}$, and $V_{bulk} = 0.000\ \text{V}$. How much is the output voltage V_{out} and the drain current I_D ?
- Set now $V_{bulk} = 1\ \text{mV}$. How much is the output voltage V_{out} and the drain current I_D now? Why did they change?
- Set the parameters as in a), but set $V_{GS} = 0.801\ \text{V}$. How much is the output voltage V_{out} and the drain current I_D now?
- It looks like there are two electrodes that can control the output voltage of the circuit: the gate and the bulk terminals. Calculate the voltage gains $\Delta V_{out}/\Delta V_{GS}$ and $\Delta V_{out}/\Delta V_{bulk}$. What can you say about the voltage gain of this circuit from the gate terminal, compared with the voltage gain from the bulk terminal?

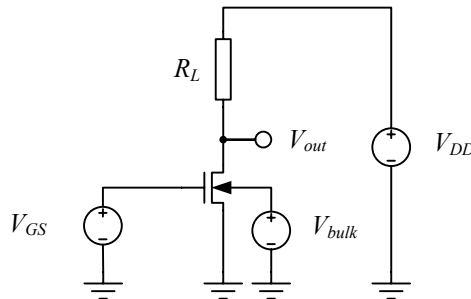


Figure 1.1

2. In order to make an image sensor, an array of $50\ \mu\text{m} \times 50\ \mu\text{m}$ pn-junctions is fabricated on a silicon wafer. The junctions are abrupt, and the junction doping levels are $N_A = 2 \cdot 10^{25}$ atoms/ m^3 and $N_D = 1 \cdot 10^{21}$ atoms/ m^3 . Due to the thermal generation, the intrinsic carrier concentration is $n_i = 1.5 \cdot 10^{16}$ ehp/ m^3 in the room temperature (300K).

- a) Calculate the dark current in one pixel (a $50\ \mu\text{m} \times 50\ \mu\text{m}$ pn-junction) in the room temperature when it is reverse biased with 5V voltage. Hint: calculate first the volume of the depletion region with this bias voltage. Use equations 1.9 and 1.10 in the textbook for calculating the depletion widths.
- b) Estimate the dark current in $70\ ^\circ\text{C}$.
- c) Is the pixel dark current low enough for detecting a light signal that generates 10^3 electron-hole pairs per second inside the pixel depletion region?

3. Repeat the simulation of Example 1.6 (in Johns, Martin: "Analog Integrated Circuit Design") using AIM-Spice. Note that the syntax of the example code in the book is slightly different from the AIM-Spice syntax. As the answer to this problem, submit your AIM-Spice code listing, and the plot that you got by running your program. Note: with most computers, you can save the plot as a graphics file in png-format by clicking the right mouse button and selecting 'Save Image'.