Hayden Fuller
IE lab 7

Pre-Lab Exercise 1
If necessary, add the pwrmos library as indicated on the first page of the laboratory.

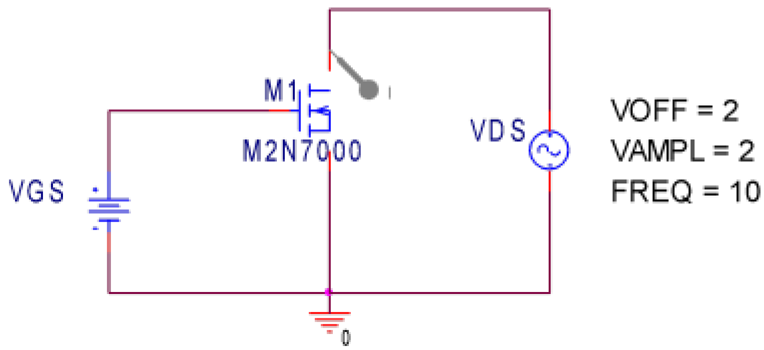
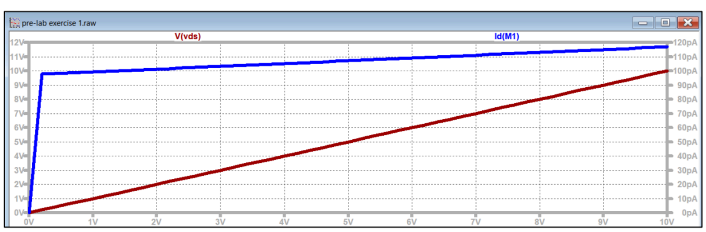


Figure 1: MOSFET circuit

In PSpice, implement the MOSFET circuit shown above. The FET part is 2N7000 in the pwrmos library.

1. 1. Plot the MOSFET current ID-versus-VDS curve for VGS = 1 V. Vary VDS by running a DC sweep from 0 V to 10 V with an increment of 0.2 V. You can obtain I-V curves by placing a current probe as shown above. Edit the Axis Settings under the Plot tab. How would you describe the ID-versus-VDS curve (for VGS = 1 V)?

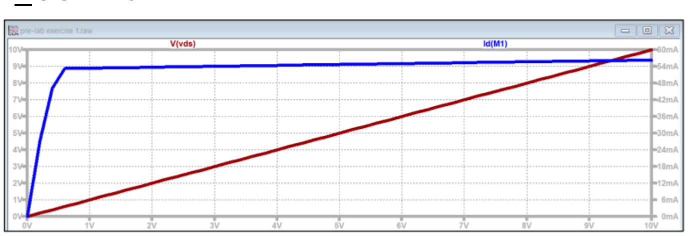
V_GS=1V



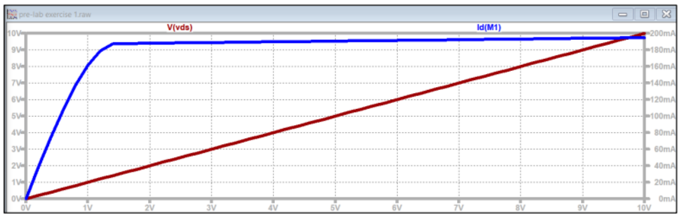
Linear from 0V to 0.22V. Beyond that, saturation and very small slope, around 0.1uA, extremely small

2. 2. Repeat for VGS = 2 V, 2.5 V and 3 V. For each case, determine the approximate saturation current (where the current levels off). What is the dependence of the drain saturation current (ID,sat) on the gate-source voltage (VGS)?

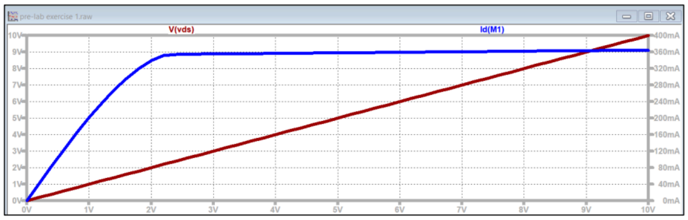
V_GS=2: 54mA



V_GS=2.5V: 190mA



$V_{GS}=3V$: 360mA



$I_{DSat} \propto V_{GS}$, so as V_{GS} goes up, I_{DSat} goes up. In order to have higher I_D, you must supply higher V_{GS}.

Exercise 1: Investigate MOSFET operation in ohmic mode

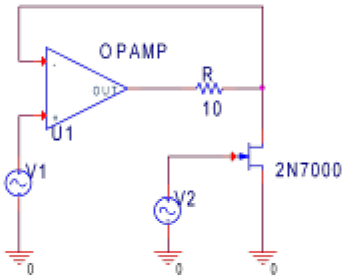


Figure 6: MOSFET analysis circuit

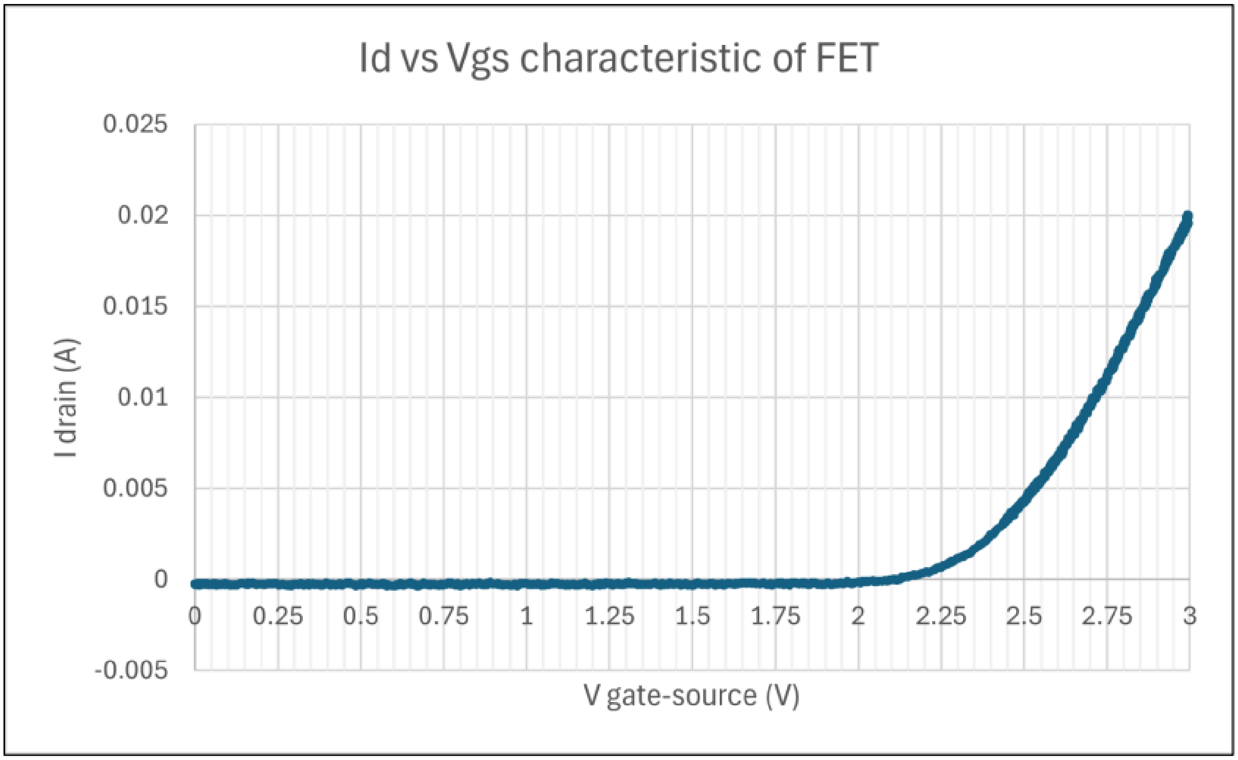
Implement the circuit in Figure 6. Use 15 / –15V voltage supply levels for the LF351/LF353 amplifier

1. 1. Set the positive amplifier input, V1 (VDS), to a 0.1 V DC using one of the Mobile Studio / Discovery Board channels. Set the gate input, V2 (VGS), to the MOSFET to a 1 kHz, 3 Vpp triangle wave with a 1.5 V DC offset using the other channel (the high voltage should be 3 V and the low voltage should be 0 V).
2. 2. Measure the current through resistor, IR = ID , (Ohm's Law). Recall, you will need to use differential measurements to measure the voltage across the resistor.

	Channel 1	Channel 2
DC	130 mV	100 mV
True RMS	144 mṼ	100 mṼ
AC RMS	62 mṼ	2 mṼ

V_R=130mV-100mV=30mV
I_R=V_R/R=30mV/10ohm=3mA

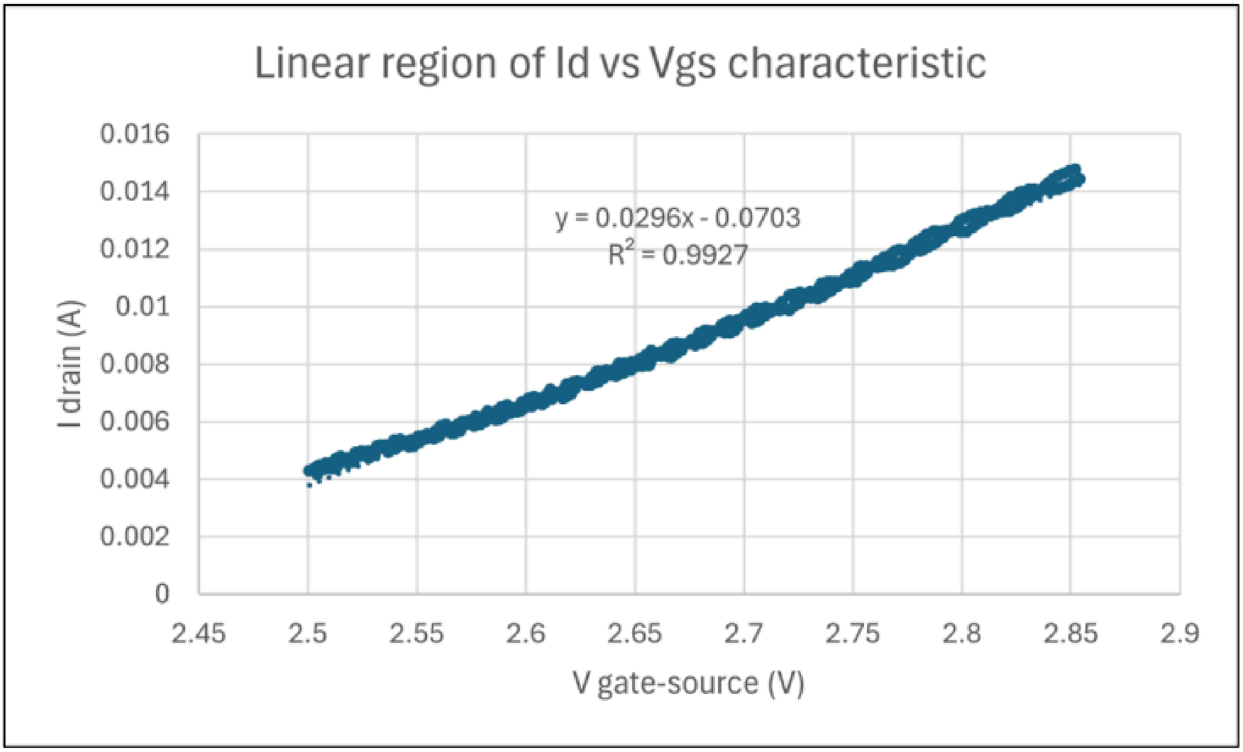
3. 3. Export the data or use the Math functions to plot the I-V characteristics of the MOSFET, ID-versus-VGS



4. 4. Estimate the threshold voltage for the MOSFET, VGS ≈ VTN , by determining the voltage at which point the current starts flowing through the MOSFET.

Around V_GS=2.25V~=V_TH

5. 5. Estimate the kn parameter by determining the slope of the linear portion of the ID-versus-VGS curve.
   Recall, in the ohmic region
   ID = kn [(VGS – VTN) VDS – ½ VDS 2]
   with a linear approximation for the condition VDS << VGS – VTN
   ID = kn ’ (WG /LG) [(VGS – VTN) VDS] where kn = kn ’ (WG /LG)
   Record the values you measured in part 4 and 5. Use those values in the other Exercises. Save the transistor for the other Exercises. Keep the circuit. If you wind up losing your transistor, use the circuit to again determine the threshold voltage and transconductance parameter of your new transistor



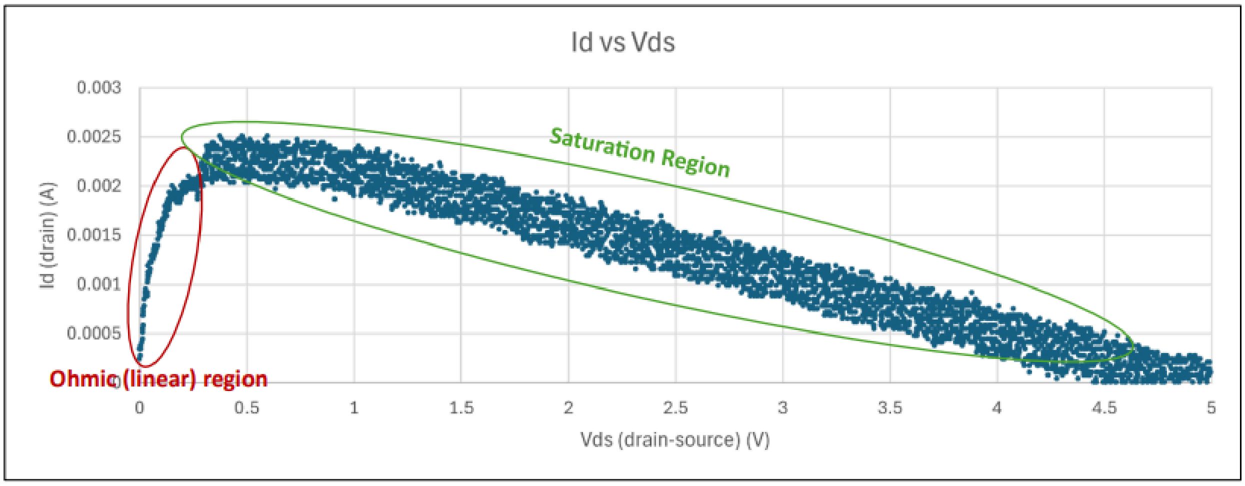
kn=0.0296
Or possibly kn=0.0296/Vds, but we couldn't measure these values simultaneously with a single ADII.

6. 6. Set the positive amplifier input, V1 (VDS), to a 1 kHz, 5 Vpp triangle wave with a 2.5 V DC offset using the other channel (the high voltage should be 5 V and the low voltage should be 0 V). Set V2 (VGS) to DC and adjust the gate input such that you start to see current flowing through the resistor (the resistor voltage becomes nonzero for part of the cycle). Make a note of that threshold voltage and compare it to your earlier estimate. Increase the gate voltage by 0.04 V (DC) such that you see a larger current through the resistor.

V_GS=2.1V, I_D=0.038mA
V_GS=2.2V, I_D=0.500mA
V_GS=2.25V, I_D=0.850mA
V_GS=2.3V, I_D=1.520mA
Around 1mA at V_GS=2.25V, so V_TH=2.25V was accurate

7. 7. Measure the current through the resistor and the drain source voltage, VDS . Again, export the data or use the Math function to plot ID versus VDS . In the plot, identify the ohmic region and the saturation region. In this case, exporting the data is useful so that you can plot multiple curves on the same graph.

V_GS=2.3+0.04=2.34V:



8. 8. Repeat part 7, generating several curves increasing VGS by 0.04 V each time. If the result starts to look 'strange', you are close to the limit of the component characteristics. In your report, try to put the ID-versus-VDS plots on a single graph for comparison.

For V_DS above, V_GS=2.34V, saturation region has a downward sagging slope,
As V_GS increases, the slope becomes flatter