Field Effect Transistors and Op Amps I

The Field Effect Transistor

This lab begins with some experiments on a junction field effect transistor (JFET), type 2N5458 and then continues with op amps using the TL082/084 dual/quad op amp chips. Details of these devices, including pin-out, can be found on the data sheets in the supplementary reading section on your web page. Items marked with an asterisk (*) should be done before coming to lab.

Pinch-off bias

Set up the circuit below. Use the LabView program JFET.vi to measure the drain current I_D as a fuction of the Gate-Source voltage V_{GS}. Remember that the variable gate voltage is negative and you should keep it in the range 0 to 5V. You should find that the drain current decreases with the gate voltage until a point where it is essentially zero. This is the so-called pinch-off voltage.

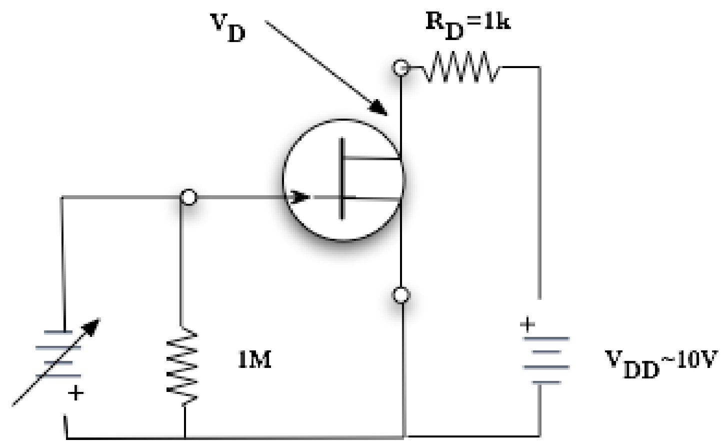

Figure 1: FET Circuit.

Compare your answer for the pinch-off voltage with the rather liberal limits given on the data page for "Gate-Source Cutoff Voltage".

Common-source transfer characteristics

The program measures the current by measuring the voltage drop across the 1kΩ drain resistor. Make a copy of the computer plot of drain current vs. gate-source voltage and paste it into your notebook. Compare your plot to the one in the data sheet. Are the plots similar? Does your plot have the right curvature?

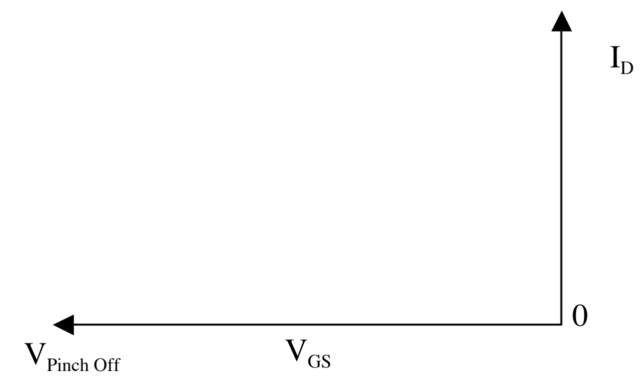

Figure 2: Drain Current vs. Gate Source Voltage.

Self-bias

Redo the circuit replacing the computer-generated voltages with a power supply for V_{DD} and a signal generator for the variable input voltages as shown in Figure 3. Choose a value of R_S to give the following circuit a good operating point. For a good operating point, the drain voltage is between 3 and 7 volts. Note that the AC signal on the input is not relevant in determining the operating point and may be disconnected for this part.

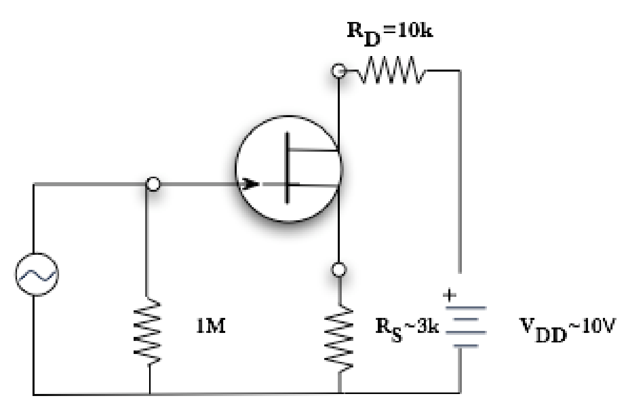

Figure 3: FET Amplifier.

(Hint: For my FET a value $R_S = 3k\Omega$ worked well)

Amplifier

The circuit above is an amplifier. The signal at the drain will be larger than the input signal on the gate.

(a) *Explain why this is an inverting amplifier.

(b) The gain of the amplifier depends upon the transconductance g_m. From Figure 5 on the data page, show that you expect $g_m \approx 10^{-3}$ mho. (Recall that a mho is a reciprocal ohm.)

(c) *The gain is defined as $G = V_{out}/V_{in}$

Show that:

$$G = \frac{g_m R_D}{1 + g_m R_S}$$

And therefore that you expect a gain of about 2.5.

(d) Measure the gain of your amplifier circuit and compare with expectation.

Op Amps I

Build the circuits below using the TL082 dual or TL084 quad op amp. Remember to connect ±15 volt supplies to the chip.

The voltage follower

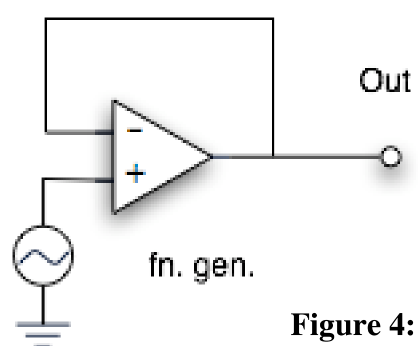

Figure 4: Voltage Follower.

(a) Use an oscilloscope to compare the input and output. Are they the same?
(b) Make the input zero volts by grounding it. Use a DMM to discover whether the output is precisely zero volts. Possible the output will be a few millivolts. That represents offset within the op amp.

The non-inverting amp

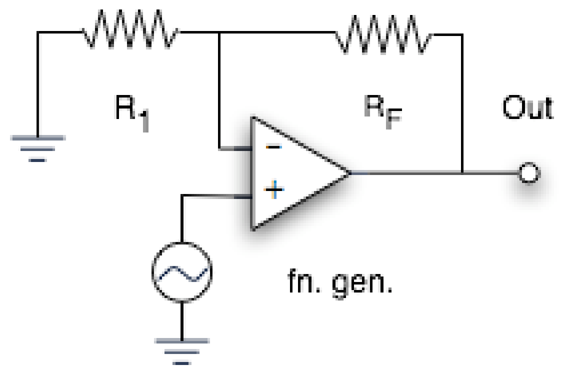

Figure 5: The non-inverting amp.

(a) *Show mathematically that you expect the gain to be given by $1+ R_f/R_1$. Measure the gain to verify this using resistor values in the range 3K to 200K.

The inverting amp

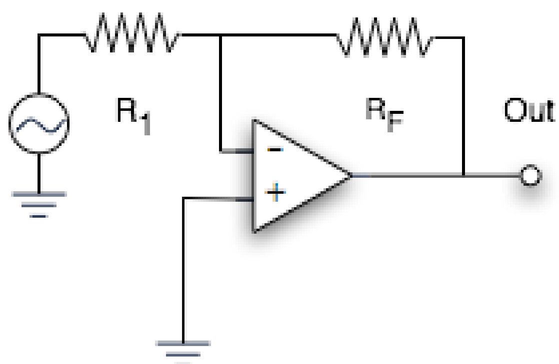

Figure 6: The inverting amp.

(a) *Show mathematically that you expect the gain to be given by $-R_f/R_1$. Measure the gain to verify this using resistor values in the range 3K to 200K.
(b) Replace a fixed resistor by a potentiometer. Can you vary the gain of the amplifier using this control?