**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.

Pinch-off bias

Set up the circuit below. Remember that the gate is connected to the negative terminal of the variable supply. Start with the variable supply at minimum and measure the voltage at the drain V_D. You should find that V_D is rather small because there is enough drain current to drop most of the supply voltage across R_D.


Figure 1: FET Circuit.
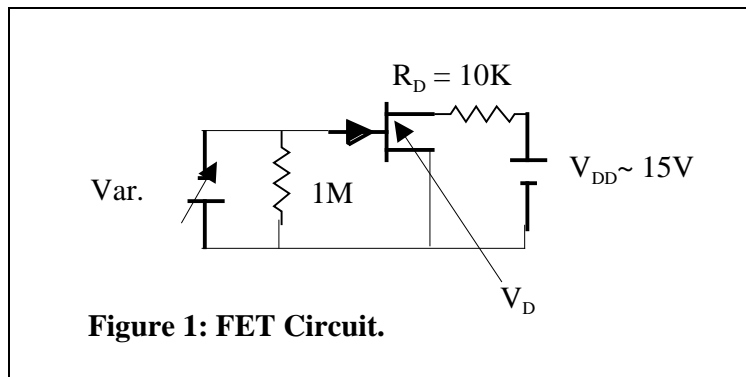
Now make the gate voltage more negative until the drain current is essentially zero. (Recognized because the drain voltage is almost as large as the supply V_{DD}.

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

Using the circuit above, make a plot like Figure 4 on the data page, plotting drain current vs. gate-source voltage. For gate voltages ranging from –0.7 to the pinch-off voltage (all negative) measure the drain current by measuring the voltage drop across the 10k drain resistor. Does your plot have the right curvature?

Figure 2: Drain Current vs. Gate Source Voltage.
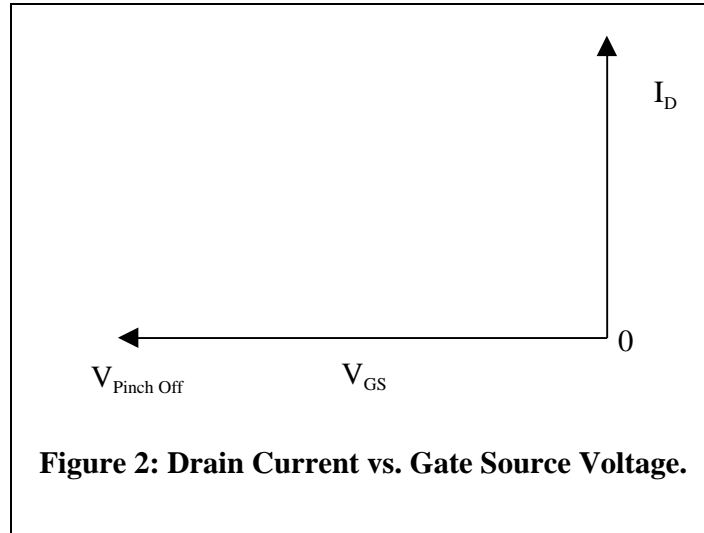
Self-bias

The right value of resistor in the source circuit can lead to a good value of gate-source voltage. 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 5 and 10 volts. Note that the AC signal on the input is not relevant in determining the operating point and may be disconnected for this part.

   (Hint: For my FET a value R_S = 1k   worked well)

Figure 3: FET Amplifier.
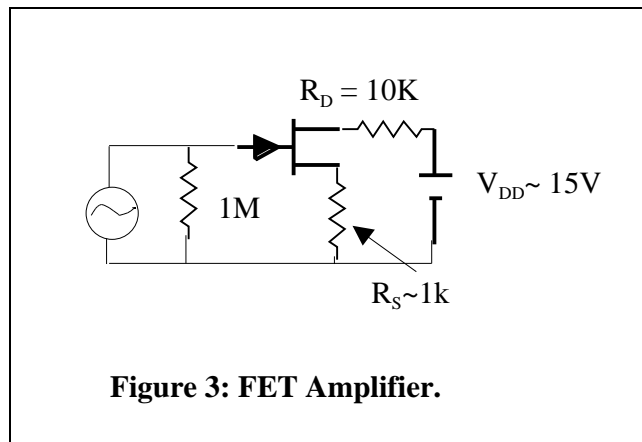
Amplifier

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 3 on the data page, show that you expect g_m 10^{-3} mho. (Recall that a mho is a reciprocal ohm.)

(c) The gain is defined as $G = V_{out}/V_{in}$
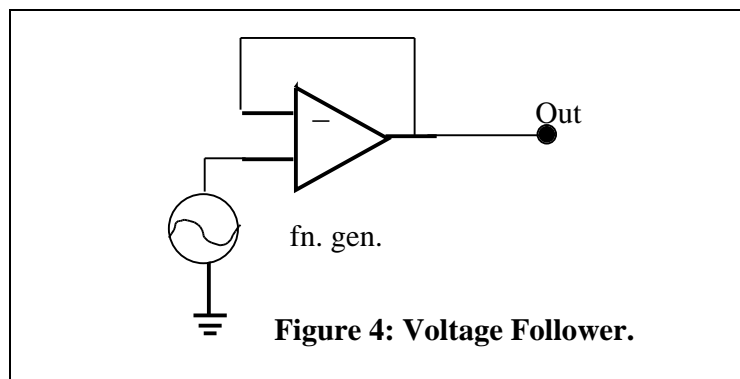
Show that: $$G = \frac{g_m R_D}{1 + g_m R_S}$$

And therefore that you expect a gain of about 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 DVM 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.
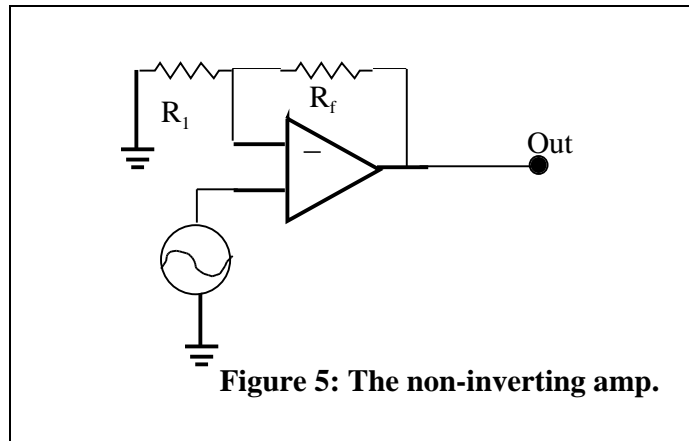
(a) Show mathematically that you expect the gain to be given by $1 + R_f/R_1$. Measure the gain to find out using resistor values in the range 3K to 200K.

The inverting amp

Figure 6: The inverting amp.
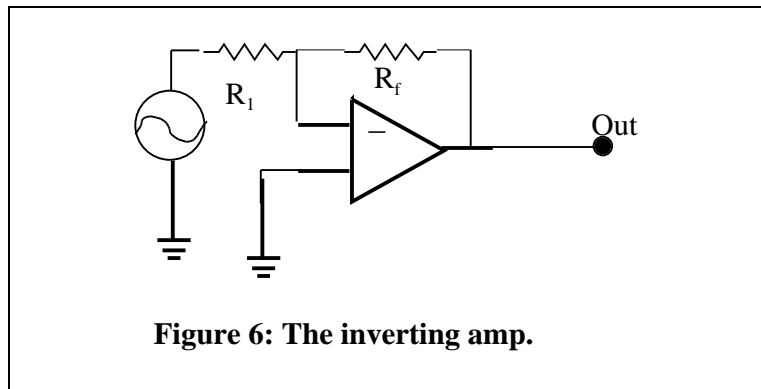
(a) Show mathematically that you expect the gain to be given by $-R_f/R_1$. Measure the gain to find out using resistor values in the range 3K to 200K.
(b) Replace a fixed resistor by a potentiometer. Can you vary the gain of the amplifier using this control?