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 function 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.](image)

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 $1\kOmega$ 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?
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.

(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 $G = \frac{V_{out}}{V_{in}}$

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.](image)

(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**

![Non-inverting amp circuit diagram](image)

**Figure 5: The non-inverting amp.**

(a) *Show mathematically that you expect the gain to be given by \(1 + \frac{R_F}{R_1}\). Measure the gain to verify this using resistor values in the range 3K to 200K.

**The inverting amp**

![Inverting amp circuit diagram](image)

**Figure 6: The inverting amp.**

(a) *Show mathematically that you expect the gain to be given by \(-\frac{R_F}{R_1}\). 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?