Transistors IV: Field Effect Transistors

Physics 251

Fall 2022

In this last transistor lab, you'll build three circuits: a MOSFET switch, a JFET Source-Follower, and a JFET Emitter-Amplifier. Both FETs and BJTs can be used to accomplish the same things. In this lab, you will look at three FET circuits similar to previously studied BJT circuits. Make sure you check the pin-outs for the two FETs. They are not the same, so search for the data sheet to obtain the pin-out.

Part 1: MOSFET Switch

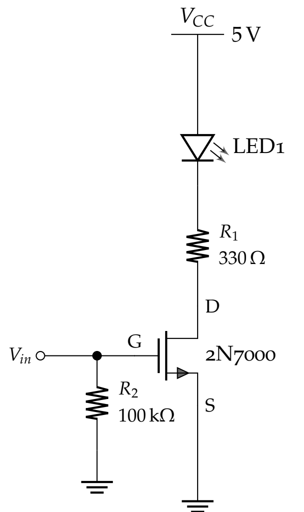

Figure 1: A MOSFET switch. Make sure to look up the data sheet for the 2N7000 to find the pinout, and be careful as this transistor is very static sensitive.

The circuit shown in Figure 1 uses a 2N7000 MOSFET. Be careful when handling this part. Static electricity can easily destroy the transistor. Before picking it up, ground yourself by touching a good ground such as one of the metal parts on the scope. This circuit is simpler than the emitter follower you built earlier. The gate is controlled by voltage instead of by the base current needed by the BJT switch. If V_g is above about 2 volts, the switch is on. For $V_g = 0$, the switch is off. Since there is no gate current, the $100\,K\Omega$ resistor puts the gate at ground when there is no input signal. (Actually, the resistor can be omitted and the input connected to 5 V to turn the switch on or to ground to turn it off.)

Part 2: JFET Source Follower

This circuit (Figure 2) is similar to the emitter follower you made previously. Use a J 310 to make your follower. A source follower differs from an emitter follower in the biasing, which may seem a little tricky. For a JFET, the *gate must be at a lower voltage than the source*. This is accomplished here by the two resistors. Resistor R_1 puts the DC voltage of the gate at 0 (no gate current flows). There is, however, some source current which flows through the R_2 resistor. This puts the source above ground and, therefore, at a higher voltage than the gate.

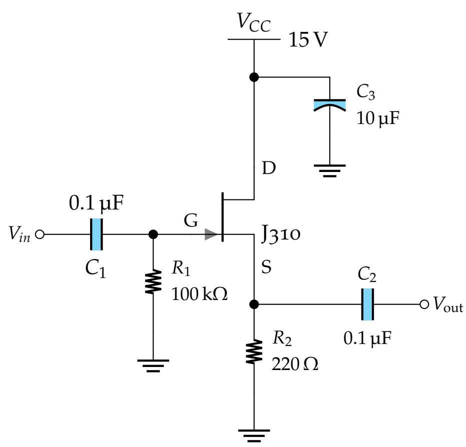

Figure 2: JFET source follower.

Measurements

For this circuit,

1. Measure all DC voltages (V_g, V_d, V_s) with no input signal. Calculate the source current.
2. Check the small signal gain at 100 Hz up to 1 or 2 MHz. Plot dB vs $\log(f)$ as you did in previous labs.
3. Try to measure the small signal input and output impedances.
4. For a 10 kHz input, look at large signal performance. How big can the signal be before you observe clipping?

Part 3: JFET Common Source Amplifier

This circuit (Figure 3) can be used for gain. Biasing is accomplished in the same way as for the source follower. Again, use a J 310 to make the circuit.

Measurements

Make the same series of measurements as for the follower; i.e.,

1. Measure all DC voltages (V_g, V_d, V_s) with no input signal. Calculate the source current.
2. Check the small signal gain at 100 Hz up to 1 or 2 MHz. Plot dB vs $\log(f)$ as you did in previous labs.
3. Try to measure the small signal input and output impedances.
4. For a 10 kHz input, look at large signal performance. How big can the signal be before you observe clipping?

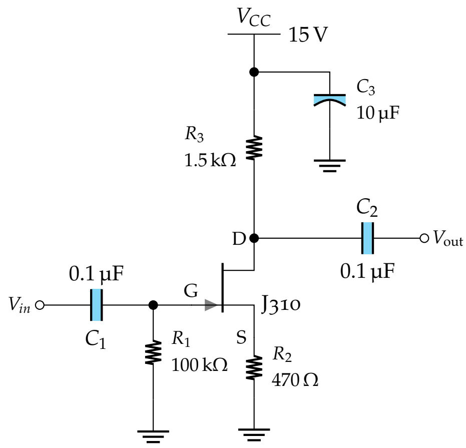

Figure 3: JFET source amplifier.

Increasing the gain

You should be able to significantly increase the gain by bypassing the source resistor with a capacitor as you did for the common emitter amplifier. Choose a capacitor whose reactance,

$$X_c = \frac{1}{2\pi f C},$$

is somewhat smaller than the source resistor at the lowest frequency of interest. Measure the small signal gain of your circuit from 100 Hz up to 2 MHz. Plot dB vs $\log(f)$ as usual.