Phy 415 Lab 7 2009 Field Effect Transistors

Prelab

1. Predict for the measurements of part __1 which resistances are low, moderate or very high.
2. An n channel JFET has a V_P=-2.5 V and a I_{DSS} of 4 mA.

   a) Plot or sketch the current versus V_{gs}, $I_{DS} = I_{DSS}\left(1 - \frac{V_{gs}}{V_P}\right)^2$ for -2.5<V_{gs}<0.6.

   b) For the current source of lab part__4, what resistor is necessary to give 1 mA output?

   c) What is the transconductance $g_m = \frac{2I_{DSS}}{-V_P}$?

   d) What resistor is required to give a gain of 10 for part ___3.6, $G = R_D g_m$?

   e) For the source follower circuit of lab part ___5.1, compute the expected gain of $G = \frac{R_S g_m}{1 + R_S g_m}$. What gain do you expect for part ___5.3?

3. A p channel JFET has a V_P=+2.5 V and a I_{DSS} of -4 mA. Sketch the current versus Vgs, $I_{DS} = I_{DSS}\left(1 - \frac{V_{gs}}{V_P}\right)^2$ for -0.6<V_{gs}<2.5.

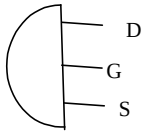

Figure 1. Top view of n channel 2N3819 JFET pins. Gate is in the middle.

___1.Checking the FETs on the ohmmeter

___1.1. Ohmmeter

Plug banana-to-alligator cables into the DVM and set it on 20 MΩ scale.

___1.2.N channel JFET

Take an n-channel JFET type 2N3819. Its pin connections are shown in Figure 1. Measure the resistance for the 6 combinations in the table.

Red lead ↓	Gate	Source	Drain	←Black Lead
Gate	NA			
Source		NA		
Drain			NA	

___1.3. P channel JFET

Take a p-channel JFET type 2N5460. Its pin connections are shown in Figure 2. Measure the 6 resistances.

Red lead ↓	Gate	Source	Drain	←Black Lead
Gate	NA			
Source		NA		
Drain			NA	

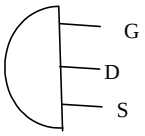

Figure 2. Top view of p channel JFET 2N5460 pins. Gate is on top.

___2.Set up the breadboard

___2.1.Connect Power supply, Wavetek, and Voltmeter to breadboard

Connect columns on the breadboard to the +V and ground of the Kepco. Connect the Wavetek function generator "hi" output to a breadboard column. Connect the Wavetek ground to the power supply ground. Set the Wavetek on dc. Connect red and black banana-to-alligator clip cables to the voltmeter, and attach a wire to each clip lead. Stick the leads into the ground and Wavetec columns on the breadboard for now.

___2.2. Computer Voltage Probes

Connect wires to the red and black alligator clips on the voltage probes. It will really help avoid confusion to use one color wires for probe 1 and a different color for probe 2. Stick the black side of both probes into the ground column and the red sides into the wavetek column. Observe the voltages read on the probes (these appear on the lower part of the screen even **without** hitting "collect"), and verify that the calibration is correct. If not, calibrate.

___3. N channel JFET operation

___3.1. N channel JFET Switch

Using the 2N3819, wire the circuit shown in Figure 3. Set the Kepco to +10 V. Use voltage probe 1 to measure the gate voltage, V_{gs}. Turn the wavetek dc offset off (so V_{gs} Is zero). Is the LED lit?

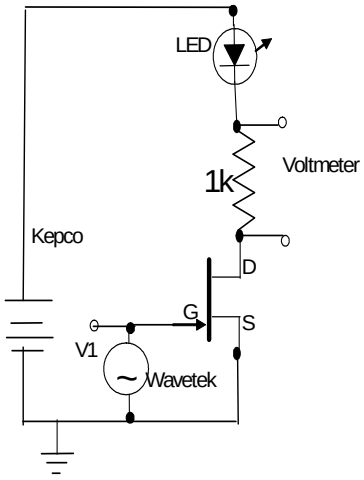

Figure 3. The n channel JFET as a switch.

___3.2. IDSS

Use the voltmeter to measure the drain current by measuring the voltage across the 1k resistor. What is the current? **I=_____.** Note that if the current is as high as 8 mA, it is being limited by the Kepco voltage (reduced by the LED drop) through the 1 kΩ resistor. If necessary, increase the Kepco voltage or reduce the resistor until the current is being limited by the FET. ($I < \frac{V_{Kepco} - 1.4}{R}$). Record the current value, **IDSS=_____.**

___3.3.V_p

Adjust the wavetek dc offset (it should be negative) until the LED turns off and the current goes to zero. Record the value of the gate to source voltage, **$V_{gs}=V_p$=_____.** (It may be necessary to measure it with the voltmeter rather than the probe if it is less than -6 volts.)

___3.4.Characteristic curve

Remove the voltmeter and use voltage probe 2 to measure the voltage across the resistor. Click on "collect" and adjust the wavetek voltage over a range that keeps the transistor on and the voltages less than ±6 V probe maximums. What is the dependence of current on V_{gs}? It should be roughly quadratic, much less steep than for the npn transistor. Save the data.

___3.5. Plot

Plot the measured data along with the theoretical quadratic, $I_{DS} = I_{DSS}\left(1 - \frac{V_{gs}}{V_P}\right)^2$.

___**3.6. Amplifier**

Move voltage probe 2 to measure the drain source voltage, V_{DS}. Click on "Collect" and adjust the wavetek voltage over a small range near zero. The gain of the amplifier is the slope of the output (probe 2) versus the input (probe 1). What is the gain? **G=_____.** Compare it to the theoretical gain. What resistor is required to give a gain of 10? **R=_____.** Try it. **Measured gain=_____.** Put the 1 k Ω resistor back before proceding.

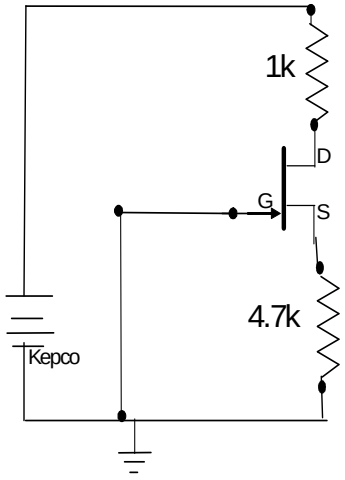

Figure 5. The FET transistor as a current source.

__4. N channel JFET Current source

___**4.1. Wire**

Return to the n channel JFET. Wire the circuit of Figure 5. Measure the voltage across the upper 1 k resistor and hence the current. **I=_____.**

___**4.2. Vary V**

Vary the Kepco voltage. Is there a range over which the current is independent of voltage?

___**4.3.Vary R**

Change the lower resistor to produce a current of 1 mA across the upper 1 k resistor. **R=_____**

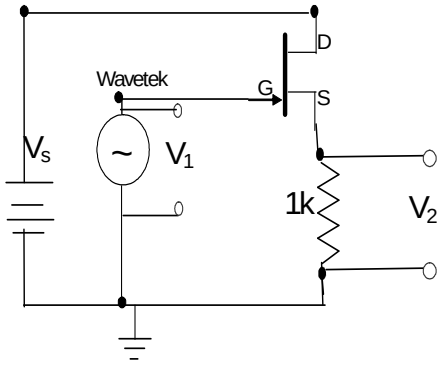

Figure 4. The FET source follower.

__5. Source Follower

___**5.1.FET Source Follower**

Wire the source follower circuit shown in Figure 4. Adjust the wavetek voltage until V_{gs} is about -5 V (you can read the value with the voltmeter). The current should be about zero (probe 2) and the collector-emitter voltage nearly equal to the power supply voltage. Adjust the wavetek voltage to make V_{gs} less negative until the transistor turns on, and observe the current go up and V_{DS} go down. At what V_{gs} does the transistor turn on? **V_{gs}=_____**

___**5.2. Take data**

Click on "collect" and adjust the wavetek voltage. The slope of the plot is the gain of the source follower. How much less than one is it? **Gain=_____** Save the data.

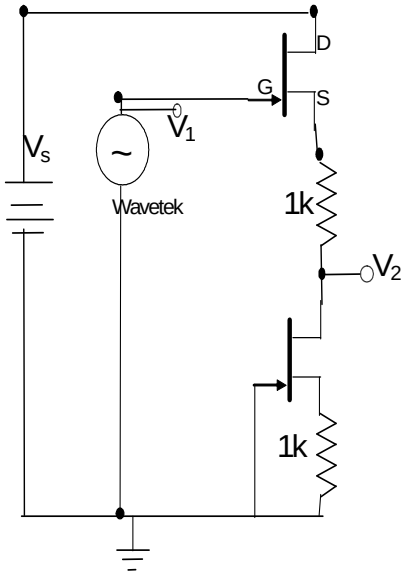

Figure 6. The source follower with a current source instead of a source resistor.

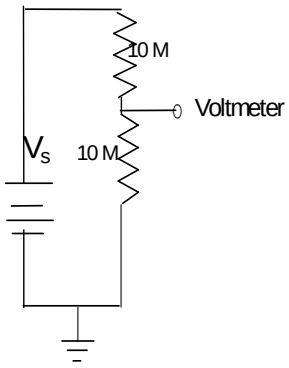

Figure 7. Voltage divider.

___5.3. Add a current source

Add a second FET wired as a current source, as shown in Figure 6. What is the gain of the source follower now?
Gain=_____

___6. Source follower with high impedance input

___6.1. Voltage divider

Disconnect the wavetek input from the source follower, put two 10M resistors on the breadboard, wired as a voltage divider between the 10V power supply and ground, as shown in Figure 7. Try to measure the output of the voltage divider with the voltmeter or the computer voltage probes. Why don't they give the right answer of 5 Volts?

___6.2. Source follower

Use the divider as the input to the source follower (instead of the wavetek). **Is the output 5 Volts?** Would an npn emitter follower work? (What would the base current be in this circuit?)

___7.P channel JFET operation

___7.1. P channel JFET Switch

Swap the p channel 2N5460 into Figure 3.
Remember that the pin connections are different.
Swap the cable to set the Kepco to -10 V. Use voltage probe 1 to measure the gate voltage, V_{gs}. Turn the wavetek dc offset off (so V_{gs} Is zero). Reverse the LED. You should now have circuit Figure 8. Is the LED lit?

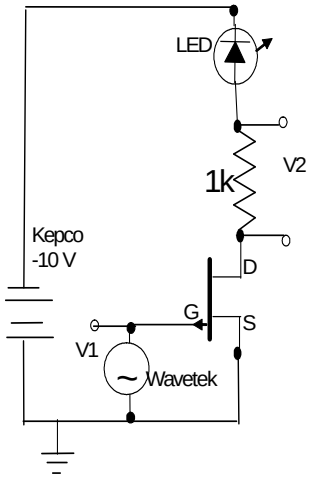

Figure 8. The p channel JFET as a switch.

___7.2. IDSS

Measure the drain current by measuring the voltage across the 1k resistor. What is the current?
I=_____. If necessary, increase the magnitude of the Kepco voltage or reduce the resistor until the current is being limited by the FET. Record the current value, **IDSS=_____.** (It may be necessary to use the voltmeter rather than the voltage probe if the voltage is less than -6 V)

___7.3. V_p

Adjust the wavetek dc offset (it should be positive) until the LED turns off and the current goes to zero. Record the value of the gate to source voltage,
$V_{gs}=V_p=$_____. (It may be necessary to measure it with the voltmeter rather than the probe if it is more than 6 volts.)

___7.4.Characteristic curve

With voltage probe 2 across the resistor, click on "collect" and adjust the wavetek voltage over a range that keeps the transistor on and the voltages less than ±6 V probe maximums. What is the dependence of current on V_{gs}? Save the data.

___7.5. Plot

Plot the measured data along with the theoretical quadratic.