EE321 Lab

MOS Field Effect Transistors (MOSFETs), Part II

The purpose of this lab is to build and test several MOSFET-based circuits. Two MOSFET packages will be used: the CMOS 4007 integrated circuit that contains 6 MOSFET's (3 n-channel and 3 p-channel), and an IRF710 single MOSFET (n-channel, high-power). A few reminders about the CMOS 4007 IC:

- The n-channel bodies are connected to pin 7 and must be kept at the most negative voltage used in the circuit.

- The p-channel bodies are connected to pin 14 and must be kept at the most positive voltage used in the circuit.

- The drain and source are interchangeable on Q2 (p-channel MOSFET, pins 1, 2 and 3) and Q5 (n-channel MOSFET, pins 4, 5 and 3).

- Ground all unused pins.

- Take anti-static precautions.

1. **CMOS Digital Logic Inverter:** Build the CMOS digital logic inverter discussed in section 4.10 of Sedra and Smith, and shown here in figure 1. The input should be preset to go from 0 V to 10 V. The input resistor protects diode junctions that would be forward biased if the input exceeds its range.

   - Test the circuit and carefully sketch the transfer curve. Label the axis with the proper units. It should be similar to that shown in figure 4.56 of Sedra and Smith.
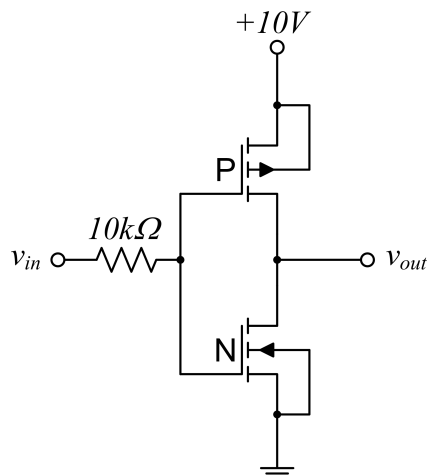   - Does it act like an inverter? How would you characterize it as a digital device?

Figure 1: CMOS digital logic inverter.

2. **Current Mirror:** The current mirror circuit is a popular means of realizing a constant-current source. The circuit is discussed in section 4.5.4 of Sedra and Smith, and shown here in figure 2. Build and test the circuit using MOSFETs in the 4007 package.
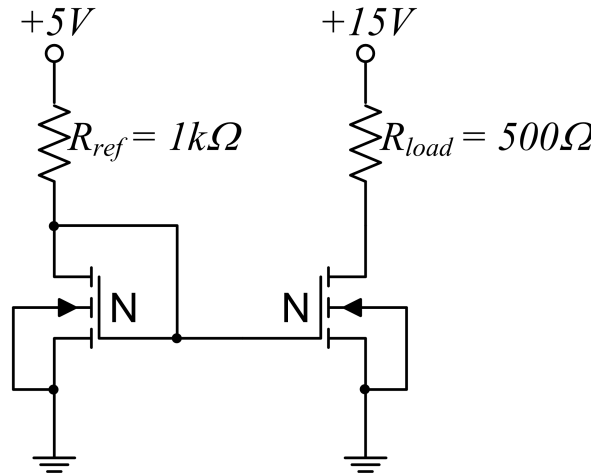
Figure 2: MOSFET current mirror.

- The reference current for the mirror is determined by R_{ref}. Measure the voltage across R_{ref} and R_{load} and confirm that the currents are about the same.

- Vary the +15V supply and/or load resistor (within reason) to confirm the load current varies little. Characterize your variation in current versus supply and/or resistor variation.

3. **Power Switch:** Another common use of MOSFETs is for solid state switches. Design, build and test a MOSFET circuit that acts as a high-power switch and turns a lamp (rated at 5 V, 60 mA) on and off.

   - Use an n-channel, power MOSFET (IRF710 shown in figure 3) and 0.2 Hz square wave input that switches between 0 V and 5 V. Sketch the circuit you used and note whether it worked as expected.

   - Connect the input to keep the lamp on with 5 V across it. Measure the V_{DS}. What is the on resistance of the MOSFET (assume the lamp draws its rated current)? Estimate the power dissipated by the MOSFET. How large (Watts) of a lamp can this MOSFET turn on?
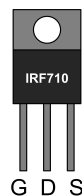

Figure 3: N-Channel Power MOSFET pin-out.

Pre-Lab

Read the lab before answering these questions.

1. Label pin numbers you will use to construct the inverter shown in figure 1. Can you take advantage of the layout of the MOSFETs on the chip?

2. Label pin numbers you will use to construct the current mirror shown in figure 2.

3. What are the maximum power, maximum continuous current, maximum drain to source voltage, surge current and gate threshold voltage ratings for the IRF710 MOSFET?

4. For part 3 of this lab there are two different designs for a circuit to turn on a lamp or other device. The N-channel-power FET acts like an on-off switch, and thus, must be placed in series with the lamp. The choice is whether the switch or the lamp is connected to ground with the other connected to the power supply.

   - Draw both circuits.
   - Find the drain and source voltages for the OFF condition. Find the necessary gate voltage for both circuits in this OFF condition.
   - Find the drain and source voltages for the ON condition. Assume V_{DS} is 0.1 V when on and a V_{GS} of 5 V is sufficient. Find the necessary gate voltage for both circuits in this ON condition.
   - Which circuit will work better for this lab?