Handout #18
E84: Fall ‘07
10/15/07

E84: Lab 1

Objectives

- To understand the use of a breadboard and wiring of basic circuits from schematics.
- To gain familiarity with some basic electrical laboratory equipment, specifically, the multimeter.
- To build some circuits we’ve analyzed in class and verify the various circuit characteristics.
- To learn how resistors are coded and how to determine the resistance based on the color bands printed on them.
- To gain comfort designing an RC circuit that must exhibit particular design characteristics.

Prelab Reading

When you arrive in the lab, you will be given a brief tutorial on how to use your protoboard, the interconnection of the sockets, how to use the power supplies and how to use an analog multimeter and a digital multimeter. After this introduction, you will be given time to build the circuits assigned in the lab and “play” with the equipment to get a good feel for how things work and what buttons do what. The equipment is rugged, so you should feel comfortable to turn knobs and “see what happens.”

Power supply: The power supply is your “battery”, or your “DC Voltage Source.” As you’ll find in lab, the power supply can be connected directly to the protoboard. From there, you’ll be able to interconnect resistors and other elements to create a complete circuit. When using the power supply, it is important to connect ground so you can close the loop.

Protoboard: This will be easier to visualize when you actually receive the protoboard, but the quick explanation is that there are rows of internally connected sockets. Sticking wires into sockets that are in the same row connects them electrically. The columns of interconnected rows are separated by a ‘bridge’ that gives room for a chip to straddle the bridge so wires can be connected to the various pins on the chip. Depending on the protoboard, there are also vertically connected sockets that are generally used to give easy access to power and ground throughout your circuits.

Analog Multimeter: The analog multimeter is a device that can measure resistance, current and voltage. The mode of the meter can be changed through a knob on the front of the device. Leads are plugged into the meter and then the probes can be connected to various elements in a circuit to determine resistance, voltage and current. The mode that the meter is in determines where the leads are plugged in. When measuring resistance, it is important that the circuit is not closed. When **measuring**

voltages, the circuit should be on and the meter introduced in **parallel** to the element of interest. When **measuring current**, the meter must be placed in **series** in the location where you are interested in measuring current – either immediately before or immediately after the element of interest. Knobs can be adjusted to increase the precision of the readings.

An analog multimeter works using a **d'Arsonval movement**. This is a device that converts an electric current into movement of a pointer needle through the interaction of the current and a magnetic field. Remember that a wire with current "I" in a magnetic field, "B" is acted on by a force F=IxB (read "I cross B"), meaning that the force acts perpendicular to the current and the magnetic field. This force can be translated into an angular deflection that is proportional to the current.

Digital Multimeter: The digital multimeter can provide the same measurements as an analog multimeter but much more precisely.

Resistor Codes: To "code" the value of resistance, resistors contain color bands that each represent a number. Four bands are used to encode the resistance.

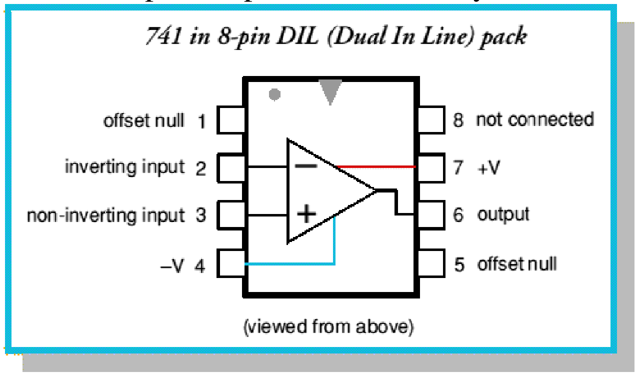
Band 1: Represents the 1st digit of the resistance
Band 2: Represents the 2nd digit of the resistance
Band 3: Represents the power of 10 that is multiplied by the two digit resistance represented in bands 1 and 2.
Band 4: Represents the tolerance: Gold=5%, Silver=10%, No band=20%

The resistor codes for the first three bands are as follows:

0	Black
1	Brown
2	Red
3	Orange
4	Yellow
5	Green
6	Blue
7	Violet
8	Gray
9	White

So, for example, a resistor that has the following four bands: Brown, Red, Brown, Silver has a resistance of $12 \times 10^1 = 120\ \Omega$ and is accurate to within 10%. So, the resistor is between 108 Ω and 132 Ω.

Opamps: The 741 chip has 8 pins, however only 5 will be used.

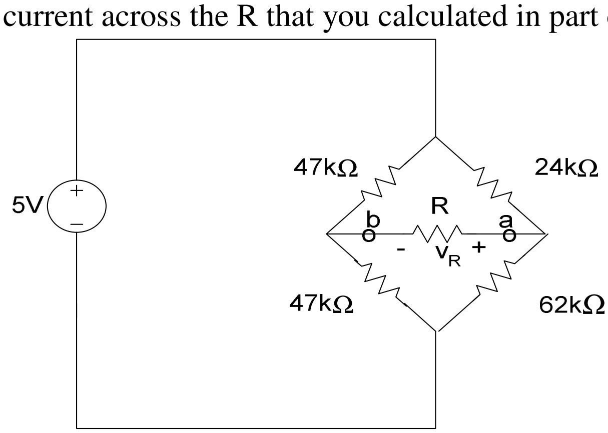


The 5 pins that we'll use are the inverting input, the non-inverting input, the –V, the +V and the output. For now, we will ignore the offset nulls.

More on the Power Supply: The power supply is able to supply voltages ranging from –20 to +20V. There are multiple "outputs" from the power supply including "+6V", "Com", "+20V" and "-20V." There is also a "Ground" that we'll ignore for now. The "Com" output is actually what we've been using as ground. This will be important in our circuit, so you should know how to locate that. The "+6V" output will output a programmable voltage ranging from 0 to 6V. The "+20V" will output a programmable voltage ranging from 0 to 20V. The "-20V" output will give a voltage exactly negative of the voltage at the "+20V" lead. These are useful for providing supplies to things that need positive and negative voltage to work… like, say, an op-amp.

Prelab Questions

1) Multimeters have an internal resistance associated with them. Explain briefly the requirements on that resistance in terms of the mode it is in. Meaning, when measuring voltage, what would be a good internal resistance of the meter? How about when measuring current?
2) You have 3 resistors – each labeled (Yellow, Violet, Red, Gold). If they are placed in parallel, what is the range of possible equivalent resistances?
3) For the following circuit, determine:
    a. the equivalent resistance as seen by the voltage source
    b. the equivalent resistance as seen by terminals a and b
    c. R in order to make V_R=+0.5V
    d. What is the current across the R that you calculated in part c?



4) Create a wiring diagram for a non-inverting amplifier with a gain of +2, using 1kΩ and 2kΩ resistors, the power supply and a 741 Op-amp chip. Label all pins that need to be connected to something.
5) Design an RC circuit that will allow you to charge the capacitor to a voltage of 5 Volts and will take long enough to discharge that you'll be able to watch the value dropping on your meter. Specifically it should be 95% charged after 1 minute. You will have a 5 volt supply, resistors ranging from 10Ω to 3.6MΩ and, the following capacitors available to you: 0.001μF, 0.0047μF, 0.0068μF, 0.02μF, 0.033μF, 0.01μF, 0.15μF, 0.33μF, 0.5μF, 1μF, 3.3μF, 33μF, 47μF, 100μF, 220μF, 330μF. Draw and label your design. Now, using your design, what is the voltage across the capacitor after 30 seconds?

Lab Assignment

Part 1: Find three resistors labeled "Yellow, Violet, Red, Gold" and connect them in parallel. Using the multimeter, determine the equivalent resistance. Was it as predicted?

Part 2: Using your protoboard and the voltage supply, create the circuit drawn in Prelab Problem #3. Before you add the voltage supply and the bridge resistor, R, measure the equivalent resistance as seen by the source and as seen by terminals a and b using the analog multimeter. Does it match your theoretical value? Now measure the resistances using the digital multimeter. Note any differences.

Now add your "R" resistor as calculated in the prelab and connect a 5 Volt power supply to the circuit. To connect a 5 Volt power supply, you'll need to adjust the variable voltage supply and measure it to verify it is 5 Volts. Measure the voltage across the "bridge" resistor. Now, redesign your circuit so you can measure the current going through the "bridge" resistor.

Part 3: Using the wiring diagram from Prelab question #4, build a non-inverting amplifier. Here, you'll have to adjust your power supply to be giving +5V out of the "+6V" output and at least +11V and –11V out of the "+20V" and "-20V" outputs.

Part 4: Build the RC circuit you designed in Prelab question #5. Connect the circuit with a 5 volt source and quickly connect the multimeters to see the voltage across the resistor and the capacitor simultaneously. Start timing and verify the voltage across the capacitor after 30 seconds. Looking at the voltage across the resistor and the capacitor simultaneously will require two people and two multimeters. Now, quickly turn off the power supply and close the RC circuit. Think about what this means before just doing it. Watch the values of the voltages as the capacitor discharges. What happens if you repeat the experiment with a small change: turn on the power supply, let the capacitor fully charge, then turn off and disconnect the power supply, wait 5 minutes before closing the RC circuit?