Basic Measurements I

Physics 251

Spring 2025

The purpose of this lab is to gain some familiarity with the equipment you will use this semester. You have 1 variable power supply, a digital multimeter (DMM; Rigol DM3058E), a powered proto-typing board (protoboard), a function generator (25 MHz, Rigol DG1022) and an oscilloscope (Rigol DS1054). The function generator and scope will not be used in this lab.

Powered Prototyping board

The powered prototyping board you will use all semester provides for you the needed power ($\pm$15 Volts, and 5 Volts for all your projects. The grid of holes is backed by spring loaded clips designed to grip 22 gauge wire. It is important to **not** use thicker wire, or you will permanently damage the ability of the clips to make electrical contact. Use the provided hook up wire kits and the provided breadboarding wire to make connections.

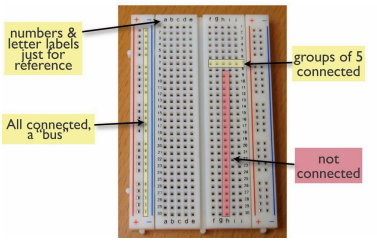

Figure 1: Connections in a prototyping board.

- Use the buses (the long horizontal strips shown in Figure 1 for power and ground connections. Good bus habits will save you lots of time and trouble with complicated circuits by making your circuit wiring more transparent and by removing unnecessary clutter.
- Build your circuits compactly. Long leads between components introduce stray capacitance and can result in oscillations or high frequency [e.g., radio frequency (RF)] pickup.
- For clarity, signals should flow from left to right; place input signals on the left side of the board, circuitry in the middle, and output signals on the right side.
- Use color-coding to make your wiring clear: try to use red wire for power connections, and black for ground connections. This will help enormously when working with complex circuits later in this course.

Voltage Measurements

1. Turn the DMM on (There is a switch in the back that must be turned on before using the power switch in front). Set the switch for the Auto DC voltage scale. You will find it most convenient to

replace the existing probe cables with the red and black banana plug cables for what follows.

2. Turn the power to the protoboard on. Making use of clip leads, connect black (ground) lead to the ground of the protoboard, and use the red lead to check the three available voltages from the protoboard (nominally they will be +5, +15, and -15V). Record these voltages with their uncertainties (you will have to watch the DMM readings fluctuate in order to determine the uncertainty on each voltage.

3. Use the Rng+, Rng-, and REL buttons and describe what they do in your lab notebook.

Resistance measurements

In general, when making resistance measurements with an ohmmeter, the resistance being measured cannot be connected to anything else.

1. Get the following three resistors: 4.7K, 10K, and 39K.

2. Set your DMM for resistance measurements and measure the value for each resistor. You may find clip leads useful here.

3. Using your protoboard (it can be powered off for this part) connect the three resistors in series. Measure the resistance of the series combination. Check this value against that given by the formula.

4. Now, connect the three resistors in parallel. Measure the resistance of the combination and check it against the formula.

Current Measurements

Current measurements are more difficult than voltage measurements. To measure I, the meter must be placed in series with the device through which the current is to be measured.

1. Using 15 volts provided by the protoboard, measure the current through any one of the resistors and check it against Ohm's law. Put the resistor on the protoboard for this measurement, and use the wire jumper kit to enable attaching of the DMM in series with the resistor. Make sure to switch the DMM to current mode, and current should flow into the red lead and out of the black lead.

2. Connect a circuit with the two largest resistors in parallel with each other and the parallel combination in series with the smallest resistor. With 15 volts across this parallel and series combination:
   (a) Compute the current through each resistor.
   (b) Measure the current through each resistor. This will involve some disconnecting and reconnecting in order to measure the current through each resistor in the circuit.
   (c) (Obviously) Do you computations agree with your measurements?
3. When done with this section, disconnect the DMM from the protoboard and return it to DC Auto mode for the next section.

Diode Characteristics

The purpose of this part of the lab is to make a plot of V vs I for a diode. Use either a 1N4148 or a 1N461 diode and connect it in series with a 2K resistor. Connect the series combination to the variable voltage supply. It turns out that it matters which way you connect a diode in a circuit. You will be connecting it both ways, however, so it doesn't matter which way you choose first. Figure 2 shows the diode in both forward bias and in reverse bias mode.

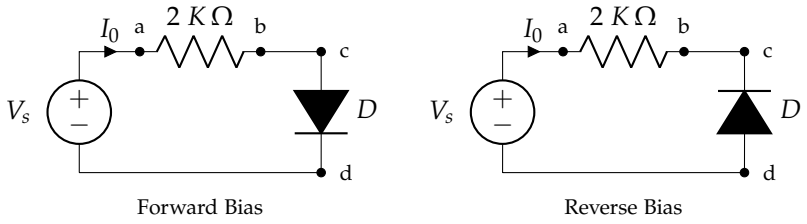

Figure 2: A diode in forward bias and in reverse bias.

- Start your measurements with a low supply voltage. Use your DMM to measure the voltage across the diode (V_{cd}). To measure the current, use your DMM to measure the voltage across the resistor (V_{ab}). Then compute the current (I_0) from Ohm's law.
- When you have finished, reverse the diode and repeat the process. Your results will be very different.
- Make a single plot of your results as follows: Call one set of measurements Positive (both I and V are positive) and the other negative (both I and V are negative). Make a plot of V vs I, using at least 15 different voltages. It's more important to have more closely spaced points where the current I_0 is rapidly changing.