

Lab 1: Basic electrical measurements (version 1.1)

WARNING: Do not make voltage measurements while the multimeter is set for current measurements as this will blow the current limiting fuse. Do not turn on the power supply until you have double-checked your circuit. Do not allow the test leads to touch each other as this could cause a disastrous short circuit.

Equipment needed:

Agilent E3631A Triple DC Power Supply

Agilent 34401A Digital Multimeter

Circuit breadboard or ELVIS board

2 sets of test leads (red and black) with banana/EZ Hook ends

Resistors

Jumper wires

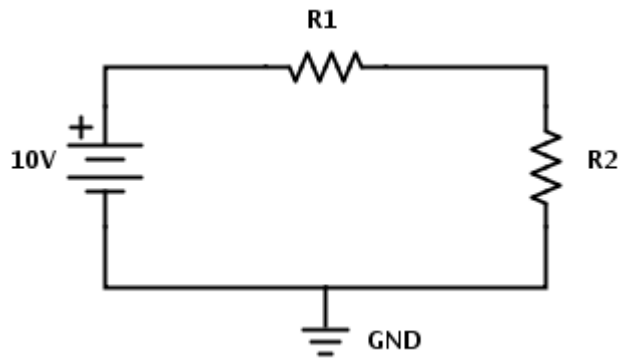
Elementary circuits

From the parts cabinets, select two different resistors with values in the range 300—3000 Ω . Resistance is read using the color band code described in the Appendix below. A careful circuit builder, however, should never trust the marked color code and always directly measure individual components before placing them in a circuit. This is done with a meter such as the Agilent digital multimeter available at each workstation. It has terminals on the front and back. Enable the front terminals with the gray **Terminals** button in the out position. Connect a red and black test lead to the terminals and press the white **Ω 2W** button to select the resistance measurement mode. Record the two resistance values and assign them arbitrarily as R1 and R2.

Note: It is always smart to zero-check an ohmmeter, especially one that is battery powered. Connect the leads together to provide a short circuit input and verify the meter reads close to zero.

Note: Resistance measurements must be made with the target component in isolation. A common error is to measure a resistor when it is wired into a circuit. This will erroneously measure other circuit components that are in parallel. Pinching components to the probe tips with your fingers is also a bad idea because of hand-to-hand resistance is usually of the order of $10^5 \Omega$. The resistor you are trying to measure will be in parallel with your body resistance!

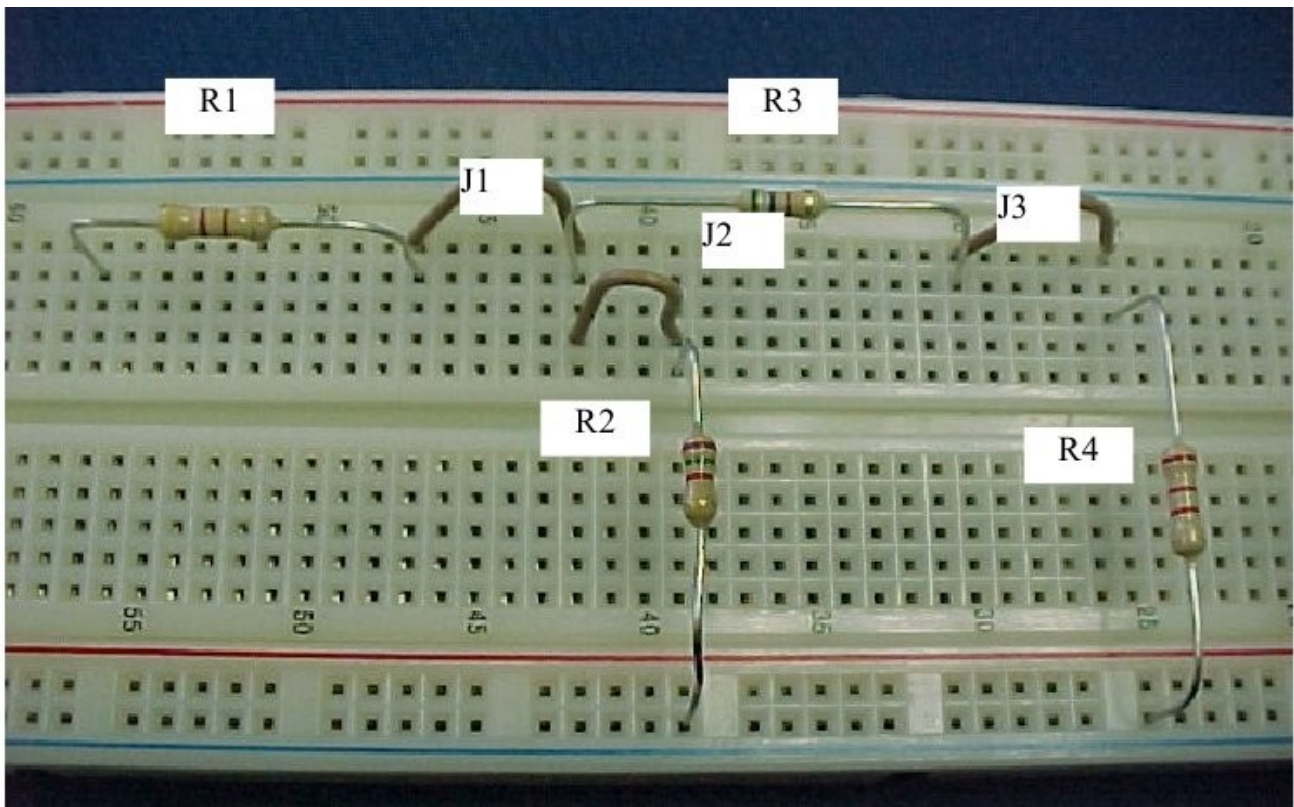
Use Ohm's Law to calculate the current flowing in the following circuit and the voltage drop on each resistor. Use your measured values of R1 and R2.



Circuit 1

The next step is to construct this circuit and verify the calculations. Do this using the breadboard on the ELVIS workstation. The breadboard offers tremendous flexibility for component layout, but the builder must understand which rows and columns are connected.

A photograph of an example four resistor circuit on a much smaller breadboard is below:



Observe that R2 and R4 share the same ground bus (row of holes) that is identified by the adjacent blue line. A second independent bus (row of holes) is just above it, designated by an adjacent red line. The red and blue buses are electrically isolated from each other. A second set of independent bus lines are visible at the top of the photo. In between the top

and bottom bus lines are independent circuit nodes marked with column numbers (25, 30, 35, etc). The five holes that form a single column are all connected. Adjacent columns are not connected.

Jumper wires J1 and J2 and resistor R3 are connected to a common point, which is defined as a circuit node. If you study the photo carefully, you will see that the right terminal of R1, the top terminal of R2, and the left terminal of R3 are all at the same potential. The jumper wires are short circuits – essentially perfect connections between different points on the breadboard. The channel in the middle of the breadboard electrically isolates the columns on the top from the bottom; they are not connected.

Note: This lab does not require power on the ELVIS board. Leave it switched off.

The 10V DC voltage source is provided by the Agilent power supply. Before wiring it to the breadboard, set the voltage to 10V DC. Turn it on and set Output On/Off button to on. Select the +/- 25V supply and adjust the dial to read 10.00 V. Leave the main power button on, but disable the output.

The circuit must be in the form of a closed loop. Current flowing from the positive terminal requires a path back to the power supply negative terminal. In the circuit diagram, the negative terminal of the power supply is connected to GND (ground). Because potential (voltage) is a relative measurement, the ground point is usually designated as a convenient reference point. A typical circuit has many components connected to ground, so it is convenient to set GND on one of the long bus terminal as shown in the above photo.

Complete the assembly of Circuit 1. Use a red test lead to connect the 10V positive output to the unwired R1 terminal and the black test lead to connect the ground potential of the breadboard. One terminal of R2 should be connected to ground. Double-check the circuit for possible shorts and enable the power supply output.

DC voltage measurements

Select the DC Voltage measurement by pressing the appropriate button on the multimeter. Use the red/black test leads to measure the voltage drops across R1 and R2. Record these and compare to the calculated values. The polarity of the measurement is important, so you have to note which lead is connected where and the sign (+ or -) of the voltage readout. Reversing the leads will switch the sign on the measured value.

Note: Modern digital multimeters can display positive and negative voltage. Old-style analog meters cannot and will be damaged if the polarity gets reversed.

DC current measurements

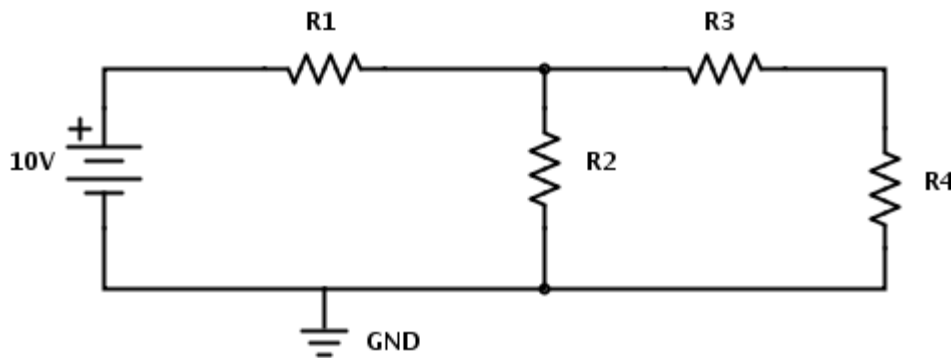
WARNING: Do not make voltage measurements while the multimeter is set for current measurements as this will blow the current limiting fuse.

The current flowing in the Circuit 1 can be directly read on the output of the power supply, but it is instructive to measure it with the digital multimeter. A current measurement is distinctly different from voltage measurement and uses a different input port. Move the red test lead from the **V Ω** input and connect it to the current (**I**) input. Press the **SHIFT** button and select **DC I** to enable the ammeter function.

A voltage measurement is made by placing the test lead across a component, i.e. the meter is in *parallel*. Current, in contrast, is measured by inserting the meter *in series*. To do this, the loop is broken open at a convenient point and the meter is then inserted to complete the circuit. The multimeter presents negligible load on the circuit.

Open the connection between R1 and R2 by placing them in independent holes on the breadboard. Clip the red test lead to R1 and the black lead to R2. The meter is now part of the circuit and can read the current. Enable the power supply output, record the current, and compare it to the calculated value.

Select two more resistors R3 and R4 and measure their values. Repeat the analysis for the following circuit. Produce a table with the calculated values of voltage drop and current for all four resistors (8 values total). Following the same procedure as above, build the circuit and measure the current and voltage. The power supply display will only show the current in R1. Current in resistors R2—R4 must be measured with the multimeter. Compare the measurements with calculations.



Circuit 2

