Class #4: DC Measurements using M1K Board and ALICE Voltmeter

Purpose: The objective of this experiment is to introduce you to wiring circuits on protoboards and make voltage and current measurements using a voltmeter.

Background: Before doing this experiment, students should be able to

- Recognize which rows of holes represent connections on a protoboard.
- Know and be able to apply Ohm's Law $V = IR$ to determine any one of the three parameters given the values of the other two.

Learning Outcomes: Students will be able

- Physically wire up circuits on protoboards.
- Troubleshoot and debug wiring mistakes on a protoboard.
- Make DC voltage measurements across circuit elements.
- Calculate DC current through circuit elements.

Resources Required:

- Resistors: 470Ω, 4.7kΩ (4700Ω), 1MΩ (1000000Ω) (in your parts kit)
- LED (any color) (in your parts kit)
- ADALM1000 (M1K board) – will be used as voltage source and dual channel voltmeter

Pre-Lab

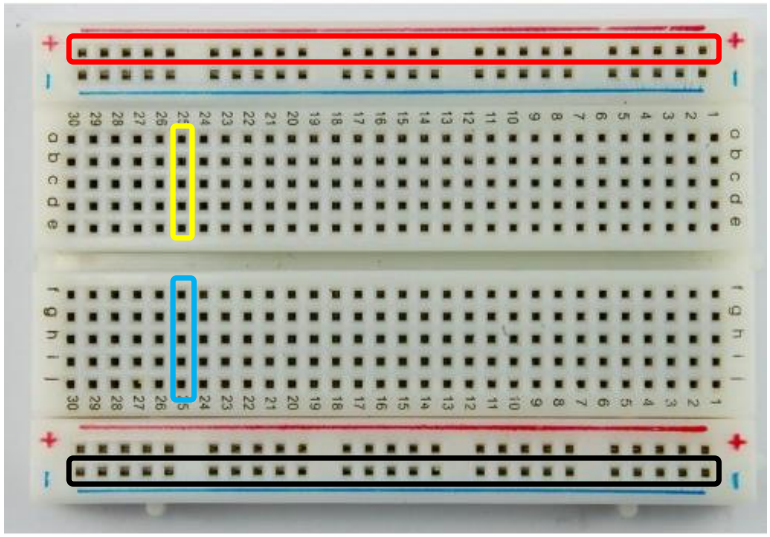
Required Viewing: Before beginning the lab, each team member must watch the video posted for this experiment.

Due: January 31st, 11:59 pm eastern on Gradescope. (one submission per group of 2 students)

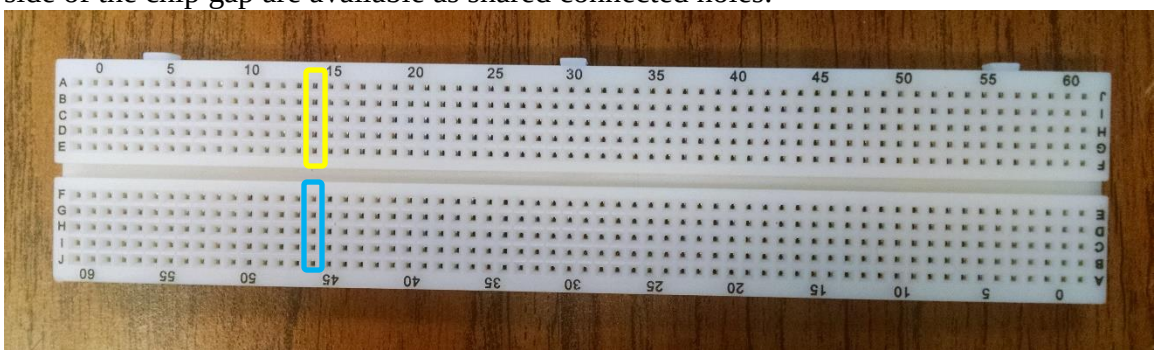
Notes: Every student needs to build their own circuits and verify that the circuit is working correctly. If you are having trouble getting your circuit to work, do not hesitate to ask for help.

Background/Review:

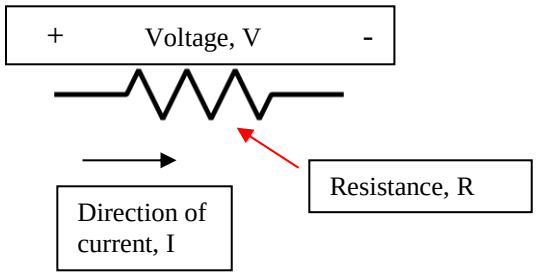
Protoboards: On this page, you can see various combinations of holes that are connected together on an example protoboard. You should remember this information from watching the video. A common small protoboard is shown in the figure below. Each circled section is an example of one entire set of connected holes. The long sets on the 'sides' are typically called buses and are used for power/ground connections. Note: The yellow and blue sets of holes are not connected, the gap between them is a chip gap. The red circled positive bus at the 'top' is **not** connected to the uncircled positive bus at the 'bottom'. When building circuits, each set of holes represents a shared connection (node) between various components. Note that your protoboard may not have the long sets of holes (buses).



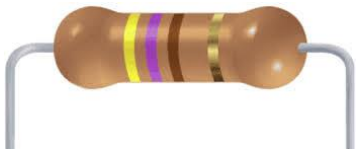
If you purchased the Analog Devices parts kit, the included protoboard is shown below. In this case, the power buses are not part of the board. Only the banks of five holes on either side of the chip gap are available as shared connected holes.



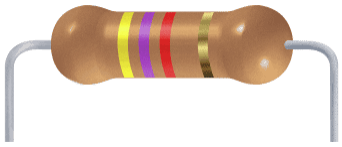
Resistors: Resistors are devices that drop a voltage and allow current to flow. One of the most important equations in Electrical Engineering is Ohm's Law, which describes the relationship between voltage, current and resistance. This equation is a simple linear relationship, V = IR, VOLTAGE = (CURRENT)*(RESISTANCE). These concepts will be discussed in more detail as the course progresses. Resistors are devices that obey Ohm's Law.



In this experiment, you will be using three different resistors. To identify the resistors, check their color code.



470Ω (Yellow-Violet-Brown)



4.7kΩ (Yellow-Violet-Red)

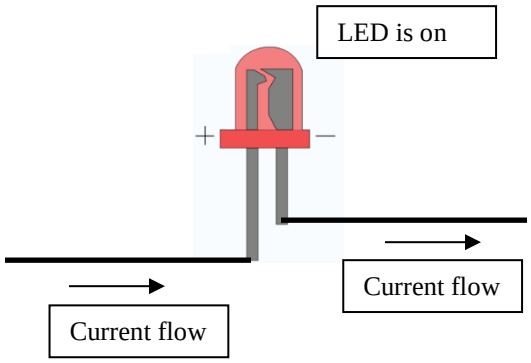
1MΩ (Brown-Black-Green)

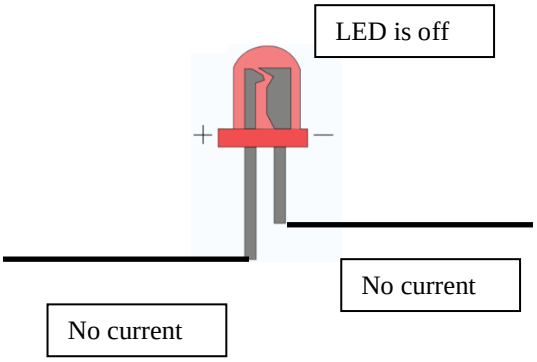
Digi-Key provides an online color code calculator (you can find quite a few by googling). The website has a number of useful web pages and is a resource if you are interested in buying electronics.

https://www.digikey.com/en/resources/conversion-calculators/conversion-calculator-resistor-color-code-4-band

The top of your parts kit also has the resistor color code.

LEDs: Light Emitting Diodes (LEDs) are devices that emit light when current flows through them. An important characteristic is that they only turn on (emit light) when current flows from the anode (positive side) to the cathode (negative side). When no current is flowing, the LED is off (no light is emitted). Current cannot flow in the opposite direction (unless you burn it out). We will see more details about LEDs as the course progresses.

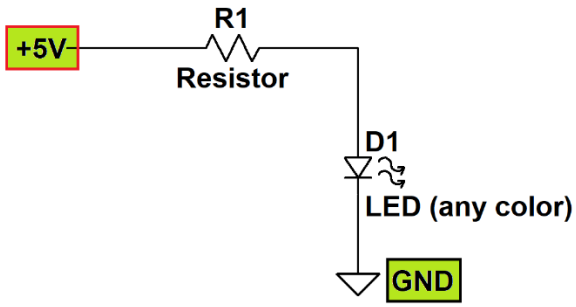




Voltmeters: Voltmeters are devices that are used to measure voltage across a circuit element or between two points on a circuit. For this experiment, we will use the Alice voltmeter tool to measure DC voltages. The videos to watch before class describe how to use this tool and make connections between M1K board and your circuit (built on the Protoboard).

For This Experiment: Watch "videos before class" before you start

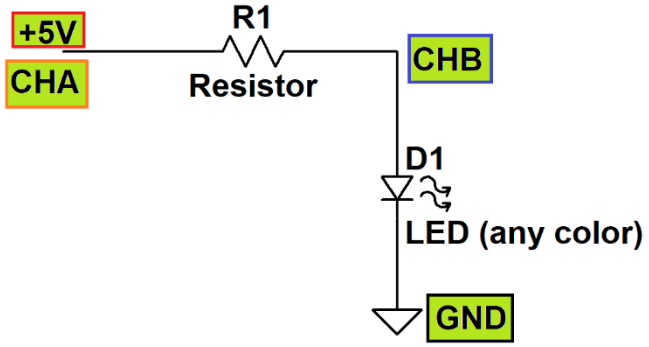
1. We want to build the circuit shown in the schematic below. When the circuit is successfully constructed, the LED will turn on (glow). Using the connected holes on a protoboard, we can connect the various devices.



LED circuit

Implement the circuit using a 470Ω resistor. If the LED does not turn on, you have made a mistake. One possibility is that the LED is in 'backwards'. If that doesn't work, double check your wiring to make sure that the connections exist.

2. Now that the circuit is working, use the Alice Voltmeter tool to measure the voltage across the resistor (with the circuit on). Place the CHA (or AIN) and CHB (or BIN) as indicated by the circuit diagram below. Now "run" the voltmeter and note down CA-V channel A voltage (with respect to ground), CB-V channel B voltage (with respect to ground). Using these voltage measurements and the information discussed in the videos, answer the following.



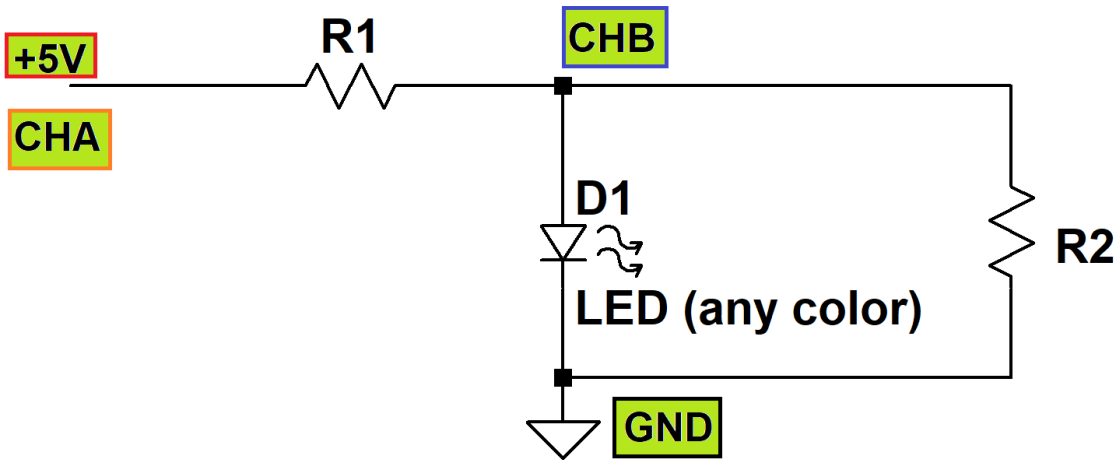
What voltage do you measure across the resistor?
Answer on Template

The current through the resistor is the same as the current through the LED. Using Ohm's Law, V = IR, what is the current through the LED?
Answer on Template

3. Replace the 470Ω resistor with a 4.7kΩ resistor.
   Did the LED get brighter or dimmer? Measure the voltage across the resistor and determine the current again? Is the current larger or smaller?
   Answer on Template

4. Replace the 4.7kΩ resistor with a 1MΩ resistor.
   Did the LED get brighter or dimmer? Measure the voltage across the resistor and determine the current again? Is the current larger or smaller? What trend do you notice between current and LED brightness?
   Answer on Template

5. Implement a slightly more complicated circuit shown below. Build the circuit with R1 = R2 = 470Ω. When successfully built, the LED should be on.



6. Measure the voltage across both resistors.
   Why do you think the voltages are different? This question is not necessarily easy to answer and will be discussed later in the course.
   Answer on Template