The AD2's Impedance Analyzer has a source of error we do not account for here (one that is not present when using a DMM). What is this error and what information do we need to minimize it?

ANSWER HERE:
The resistance of the wires causes a slight error. We measured a 2200 Ω resistor and in reality it was 2306 Ω. There was an error of 106 Ω. To minimize this error, we shoud chose a resistor with a lower tolerance level.

Note: For the remainder of this lab, disregard this error (i.e. treat the Impedance Analyzer's measurements as truth).

Resistor Standard Values vs Tolerance

1. Pick 3 resistors with different color codes. If your resistors have 5 bands, consider only the first four bands. Measure their values with your AD2. Compare their stated values and tolerances (color code) with your measured analyzer results. (Do not exceed R_{ref} by a factor of 10)

WORK SHEET HERE: $\frac{\text{MEASURED-MARKED}}{\text{MARKED}}(100\%)$

Resistor #	Marked	AD2 Measured	% Deviation from Marked	Tolerance
R_1	100Ω	95.1Ω	-4.9%	+/- 5%
R_2	3.3KΩ	3.36KΩ	1.8%	+/- 5%
R_3	220Ω	219.1Ω	-0.41%	+/- 5%

Is the % Deviation greater or less than the indicated tolerance?

ANSWER HERE:
They were all less than the indicated tolerance.

2. If you look at a standard list of 20% resistors available, you will see 1000 ohms and 1500 ohms but not 1200 ohms. Why? If you look at 5% resistors, would the results be different? Why? [An explanation of resistor values can be found at this site. Be sure to watch the video. Also, here.] Hint: Think about what tolerance means and how it differs from measurement error.

ANSWER HERE: With a +/- 20% tolerance, a given resistor can cover a large range of values. For instance, the 1000 ohm resistor could read from 800 - 1200 Ω and the 1500 Ω resistor could read from 1200 - 1800 Ω. The overlap is redundant for 1200 Ω resistors. For 5%, the gap is less since the +/- is lower - there is a difference.

3. Pick two resistors that are approximately two orders of magnitude different e.g. 22 Ω and 2,200 (See Figures 1-2, 1-3, and 1-4. Do not exceed R_{ref} by a factor of 10)
   a. Measure them carefully. Note their actual values rather than the color code indicated value.
   b. Measure them in series and parallel connections.

WORK SHEET HERE:

R_1 Measured Value: 21.7 Ω R_2 Measured Value: 2306 Ω

R_{Series} Value: 2327 Ω $R_{Parallel}$ Value: 21.3

   c. Compare R_{series} to the two individual resistors. Then compare $R_{parallel}$ to the two individual resistors.
   d. In the series connection, which resistor dominates the resistance measurement and why? Try to explain without using the equation.
   e. In the parallel connection, which resistor dominates the resistance measurement and why? Try to explain without using the equation.

ANSWERS HERE:

d) The resistor with the larger resistance dominates. Series is an addition, so it makes sense the larger addend (resistor) dominates.

e) The resistor with the lesser resistance dominates. The voltage will follow the path of least resistance.

WORK SHEET HERE:

Record your measurement v_{R1} at Channel 1: -3.495V

Solve for the current i (use labeled resistances): 0.0156A

Calculate R1's power as: $v_{R1} * i =$ +0.055

V = i R

3. Passive Sign Convention is a standard rule in circuit theory that denotes what the sign of a component's power is when it either absorbs or generates energy. Under this convention, a positive sign for power means a component is absorbing energy while a negative sign for power means a component is generating energy.

   If the previous steps were followed correctly, you will find that the calculated power for R1 does not make sense using Passive Sign Convention. Why does it not make sense (hint: notice how R1 is warm) and how can you correct this calculation?

ANSWER HERE:

The 1+ and 1− in the circuit diagram are swapped. This caused the Voltage to be negative. This made the power be negative when it should be positive. To fix this, swap the 1+ and 1−.

Unloaded and Loaded Voltage Dividers

We will investigate the effect that loading has on a voltage divider circuit. Loading, as you recall from lecture, is the demand for current from a voltage source. That demanded current has an effect on the performance of the circuit. We will be measuring the amount of that performance change.

You will need the following components:

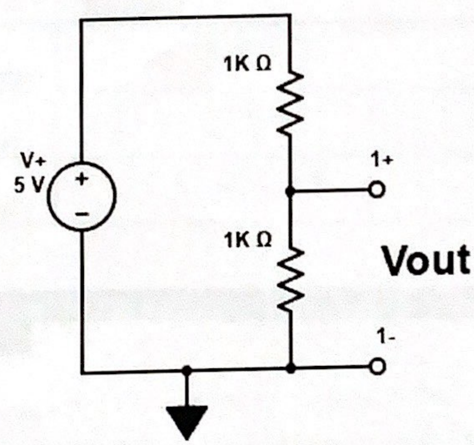
1 KΩ resistors (2)

3.3 KΩ resistor

Breadboard

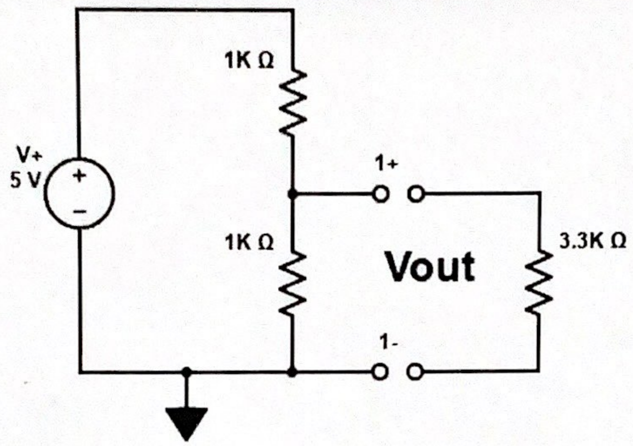
AD2

1. Construct the voltage divider circuit as shown below. This is an unloaded voltage divider.



2. Measure V_{out} at Channel 1 as shown. Record the value here 2.51 V .

3. Now load the circuit by attaching the 3.3 KΩ load resistor across the lower 1 KΩ resistor, as shown below. The 3.3 KΩ resistor is now demanding current from the voltage divider.



4. Measure the new V_{out} as in Step 2. Record the value here: 2.182 V
5. Fill out the following table:

$V_x = \frac{V_0 R_1}{R_1 + R_2}$

	UNLOADED VOLTAGE DIVIDER	LOADED VOLTAGE DIVIDER
V_{out} (measurement)	2.51 V	2.182 V
$V_{upper 1K}$ (calculation)	2.49 V	2.818 V
I_{total} (calculation)	0.0025 A	0.0028 A

V=IR

5 = I (1767)

Why does an increase in total current result in lower output voltage of the loaded voltage divider circuit?

V=IR

The lower resistance from the parallel resistors outweighs the significance of the increase in current. This causes voltage to actually decrease. With a greater amount of current, the first resistor consumes more voltage. This causes the voltage for the second resistor to decrease.