Lab Exercise 02 Voltage Dividers

The objectives of this lab exercise are for students:

- ☐ 1. to understand voltage and signal generation,
- ☐ 2. to understand voltage and signal measurement,
- ☐ 3. to become familiar with the instruments used for voltage and signal generation and measurement,
- ☐ 4. to become familiar with prototyping circuits,
- ☐ 5. to deepen an understanding of voltage dividers,
- ☐ 6. to model real circuits,
- ☐ 7. to learn to acquire voltage measurements with the myRIO, and
- ☐ 8. to learn to plot and export plots in MATLAB.

Lab 02.1 Materials

The following materials are required for each lab station:

1. a PC with LabVIEW installed,[1]
2. a myRIO configured with LabVIEW,[2],
3. a multimeter,
4. a dc power supply,
5. a breadboard,
6. jumper wires,
7. the following resistors:
   - ☐ 1. two 1.5 MΩ,
   - ☐ 2. one 2.2 MΩ,
   - ☐ 3. one 3.3 MΩ, and
   - ☐ 4. one 4.7 MΩ.
8. a function generator,
9. an oscilloscope,
10. two BNC cables, and
11. a BNC Y- or T-connector.

Lab 02.2 Building a voltage divider circuit

- ☐ 1. Measure and record the actual resistance of each resistor (use a multimeter).

[1]See Resource 2 for more details on the LabVIEW software configuration.
[2]See Resource 3 for more details on the myRIO software configuration.

	R_1	R_2	R_3	R_4	R_5
nominal (MΩ)	1.5	1.5	2.2	3.3	4.7
measured (MΩ)					

☐ 2. Connect the two 1.5 MΩ resistors in series.
☐ 3. Connect the dc power supply across the series resistors.
☐ 4. By following the procedure in Section 02.01, set the power supply as a voltage source at 10 V.

Lab 02.3 Measuring with a multimeter voltage dividers powered by a dc power suppy

Use the voltage divider circuit built in the previous section and a multimeter to make measurements.

☐ 1. Measure and record the voltage across each resistor, separately.

	v_{R_1}	v_{R_2}
measured (V)		

☐ 2. Measure and record the voltage across both resistors, together (this is the same as measuring the source voltage).

	$\widetilde{V}_s$
measured (V)	

☐ 3. Record the voltage and current readings on the dc power supply.

	V_s (V)	I_s (mA)
readings		

output resistor

☐ 4. Replace the R_2 resistor (let's call it the *output resistor*) with a 2.2 MΩ resistor and repeat and record (in the table below) the voltage measurement.
☐ 5. Repeat for the 3.3 MΩ and 4.7 MΩ resistors.

When you've finished the above steps, you should have data to fill in Table 02.1.

output res.	R_2	R_3	R_4	R_5
nominal R_i (MΩ)	1.5	2.2	3.3	4.7
measured $\widetilde{R}_i$ (MΩ)				
measured $\widetilde{V}_s$ (V)				
measured $\tilde{v}_{R_i}$ (V)				

Table 02.1: table of voltage divider measurements from the multimeter for each output resistor.

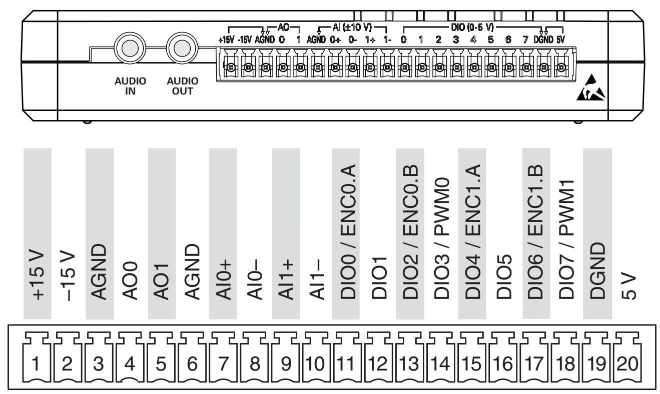

Figure 02.14: myRIO Connector `C` (from Instruments (2013)).

Lab 02.4 Measuring and powering voltage divider circuits with a myRIO

☐ 1. Build your original voltage divider circuit with two 1.5 MΩ resistors in series, but this time do not connect the dc power supply to the circuit. As before, define the "free" terminal of R_2 to be ground.

☐ 2. Connect a myRIO to power and to your workstation computer via USB.

☐ 3. We will be using the MSP connector named `C` on the side of the myRIO shown in Figure 02.14.

☐ 4. With jumper wires, connect the analog output ground channel `AGND` (`3`) to the ground of your circuit (choose ground to be one of the “free” ends of the series resistors).

☐ 5. Connect the analog output channel `AO1` (`5`) to the opposite end of the series resistors such that the analog voltage supplied via `AO1` and

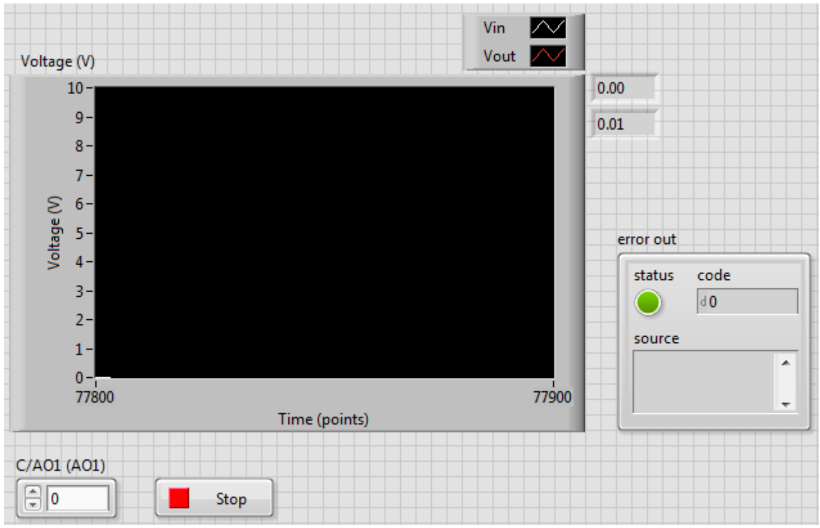

Figure 02.15: how the front panel of your VI might look.

`AGND` is applied across both resistors, together.

☐ 6. Connect both `AGND` (6) and `AI0-` (8) to the circuit's ground.

☐ 7. Connect `AI0+` (7) to the node shared by the two resistors—call the resistor you've just connected between `AI0+` and `AGND` your "output" resistor (it should be R_2 at this point).

☐ 8. Create a new LabVIEW myRIO project. Edit `Main.vi` such that it has the following functionality:

- ☐ a. outputs an analog voltage from `AO0` that can be updated from the front panel, continuously;
- ☐ b. measures the analog voltage from `AIO+`, continuously;
- ☐ c. plots the output and input voltages on the same chart, continuously; and
- ☐ d. displays digital readouts of the current voltage output and input, continuously. The front panel of Figure 02.15 and corresponding block diagram of Figure 02.16 show one way of realizing this VI.

☐ 9. Using your VI, set the source voltage to each of the values $(0, 1, \cdots, 10)$ V. Manually record the corresponding voltage measurements in Table 02.2.

☐ 10. Repeat these measurements for output resistors with nominal resistances 2.2 MΩ, 3.3 MΩ, and 4.7 MΩ. Manually record the corresponding voltage measurements in Table 02.2

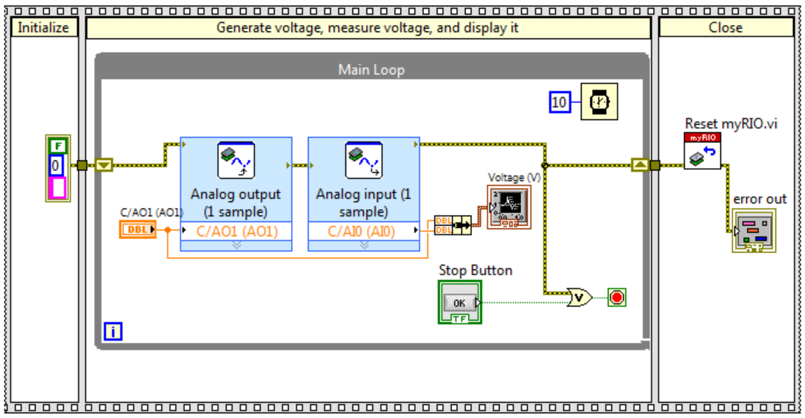

Figure 02.16: how the block diagram of your VI might look.

	V_s (V)	0	1	2	3	4	5	6	7	8	9	10
R_2	$\widetilde{V}_s$ (V)											
	$\tilde{v}_{R_2}$ (V)											
R_3	$\widetilde{V}_s$ (V)											
	$\tilde{v}_{R_3}$ (V)											
R_4	$\widetilde{V}_s$ (V)											
	$\tilde{v}_{R_4}$ (V)											
R_5	$\widetilde{V}_s$ (V)											
	$\tilde{v}_{R_5}$ (V)											

Table 02.2: table of voltage divider measurements from the myRIO for each output resistor.

Lab 02.5 Signals generated and measured

☐ 1. Switch the function generator to the following settings:

☐ a. sine wave,
☐ b. frequency: 10 kHz, and
☐ c. 5 V_{pp}.

☐ 2. Connect the function generator `OUTPUT` to `CH1` of the oscilloscope. Make sure your oscilloscope (especially `CH1`) has the following settings:

  ☐ a. ac coupling,
  ☐ b. `VERT MODE` either `CH1` or `DUAL`,
  ☐ c. `TRIGGER` on `AUTO` and `CH1`, and
  ☐ d. multiplication factor `1X`.

☐ 3. Adjust the oscilloscope settings until a stable wave is found.
☐ 4. Estimate and record the peak-to-peak amplitude and period from the oscilloscope screen. (Use the cursors!)

$\widetilde{V}_s = \tilde{v}_{R_2}$ (V_{pp})	T (ms)

☐ 5. Change the function generator signal waveform to a square wave, then a triangle wave, then a sawtooth. Finally, change it back to a sine wave.
☐ 6. Decrease the function generator frequency to 10 Hz.
☐ 7. Adjust the `TIME/DIV` on the oscilloscope until you can see the dot tracing across the screen.
☐ 8. Profit.

Lab 02.6 Report requirements

Write a report on your laboratory activities using the template given. Include the following elements:

☐ 1. A **circuit analysis** of each circuit configuration (using generic resistor values, e.g. R_1 and R_2). Don't forget to properly model each source!
☐ 2. A **plot of multimeter measurements** of voltage input ($\widetilde{V}_s$) and output ($\tilde{v}_{R_i}$) versus resistor value. Use markers only, like $\times$ or $\circ$. Include on the same plot corresponding **theoretical predictions** based on measured input voltage and measured resistance values (i.e. don't use the nominal values). For these theoretical predictions, use continuous lines without markers.
☐ 3. A **plot of myRIO measurements** (manually recorded) of measured input voltage $\widetilde{V}_s$ versus output voltage $\tilde{v}_{R_i}$ for each output resistor R_i. Include on the same plot corresponding **theoretical predictions** based on $\widetilde{V}_s$ and R_i.

☐ 4. Include a **table** of all **multimeter measurements** (resistance and voltage).

It may be helpful to take photos during the laboratory procedure. These can be included in your report.