Lab Exercise 03 RC Circuit Response

In this lab, we will be measuring the time-response of the voltage across a capacitor in an RC circuit, such as that of Figure 03.1. We will apply an input voltage and measure the v_o response with an NI myRIO device, export it to a data file, import that data file into MATLAB, plot the data, derive an analytic model, and compare the analytic model to the data.

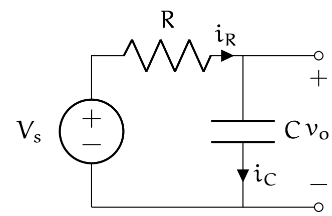

Figure 03.1: RC circuit

The objectives of this lab exercise are for students:

1. to explore transient circuit response,
2. to deepen their understanding of RC circuits,
3. to learn to acquire and log data with a microcontroller board (myRIO),
4. to learn to export the acquired data to MATLAB,
5. to model real circuits and compare the theory and experiment, and
6. to learn to better plot and export plots in MATLAB.

Lab 03.1 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 breadboard,
- ☐ 5. jumper wires,
- ☐ 6. a 100 kΩ resistor,
- ☐ 7. a 10 μF capacitor,

Lab 03.2 Build the circuit

Use the following procedure to build the circuit.

- ☐ 1. Measure and record the actual resistance R of the resistor and capacitance C of the capacitor with 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.

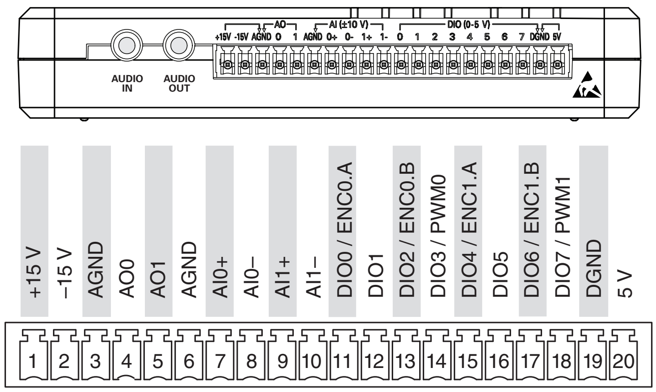

Figure 03.2: myRIO Connector `C` (from Instruments (2013)).

	R (kΩ)	C (μF)
nominal	100	10
measured		

☐ 2. Build the RC circuit (sans source) on a breadboard. The capacitor is **polarized**; that is, it has a positive and a negative terminal. We must take care to connect such capacitors such that the voltage always drops from the positive terminal to the negative terminal. Sometimes this is indicated by a shorter lead and/or a "−" symbol on the negative side. (In our case "−" should connect to the ground node.)

☐ 3. Connect the myRIO to power and to your workstation computer via USB. It will be both the voltage source V_s and measurement of v_o.

☐ 4. We will be using the MSP connector named `C` on the side of the myRIO shown in Figure 03.2.

☐ 5. With jumper wires, connect the analog output ground channel `AGND` (`3`) to the ground of your circuit (ensure this is conected to the "−" capacitor terminal).

☐ 6. Connect the analog output channel `AO0` (`4`) to the resistor such that the analog voltage supplied via `AO1` and `AGND` is applied across both the resistor and capacitor. You now have V_s supplied by analog output `AO0`.

☐ 7. Connect `AI0-` (`8`) to the circuit's ground.

☐ 8. Connect `AI0+` (`7`) to the node shared by the resistor and capacitor. You now have a measurement of v_o on analog input `AI0`.

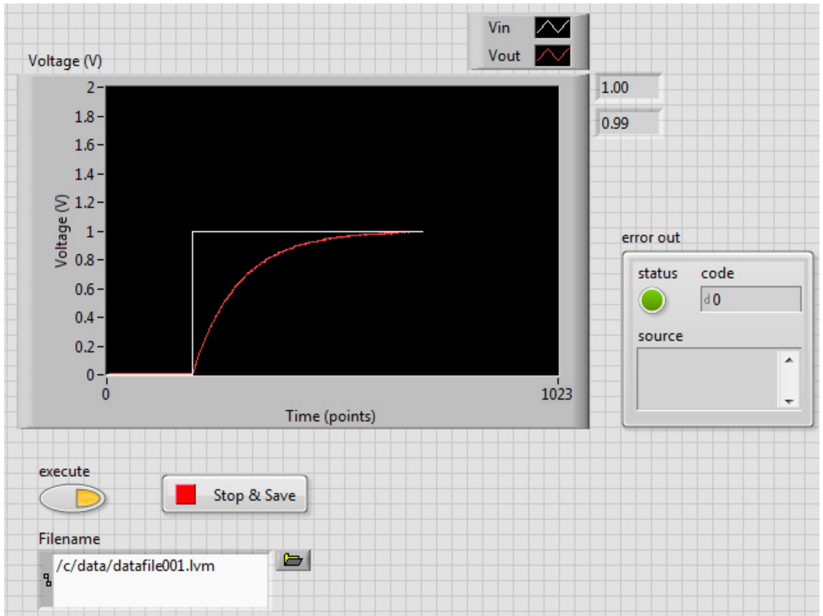

Figure 03.3: how the front panel of your VI might look.

Lab 03.3 Create Main VI

Edit the lab stub for lab 03 downloaded during lab 02 such that it has the following functionality:

☐ 1. outputs an analog voltage of 1 V from `AO0` when the user toggles a button named execute;

☐ 2. measures the voltage across the capacitor using `AI0+`, continuously;

☐ 3. plots the command, output, and input voltages on the same chart, continuously;

☐ 4. displays digital readouts of the current command, voltage output, and input, continuously;

timed-loop

☐ 5. uses a *timed-loop* that executes once every 10 ms;

☐ 6. after (and only after) the execute button is pressed, store time values (with zero beginning when the button is pressed), measured circuit input voltage $\widetilde{V}_s$, and measured circuit output voltage $\tilde{v}_o$ in arrays; and

☐ 7. after the timed loop is exited via a Stop & Save button, write the three arrays to a LabVIEW `.lvm` datafile on the myRIO via the `array_save_newfile.vi` and `array_save_append.vi` functions.

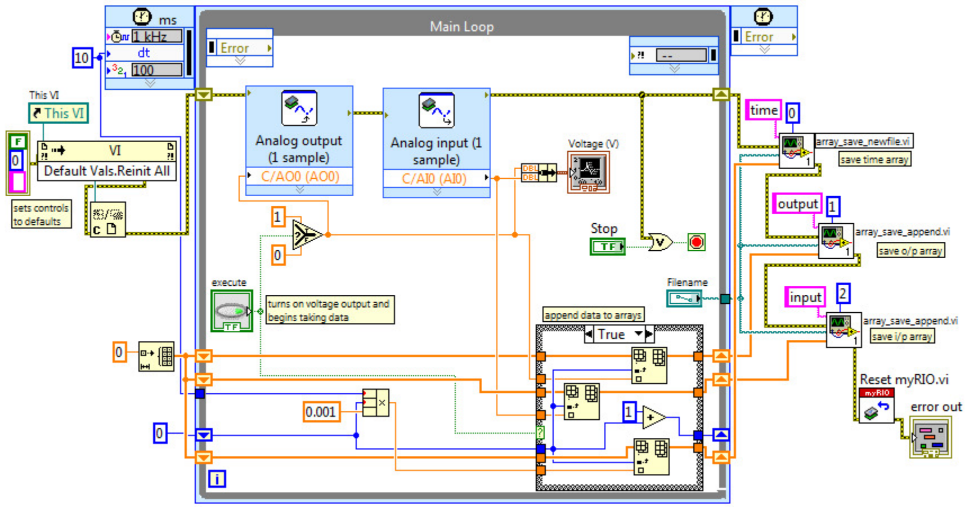

Figure 03.4: how the block diagram of your VI might look. Note that this example does not include a measurement of the source $\widetilde{V}_s$.

The front panel of Figure 03.3 and corresponding block diagram of Figure 03.4 show a way of realizing a very similar VI. The difference is that the example has no measurement of $\widetilde{V}_s$ (it assumes the circuit doesn't load the source).

The code that *preceeds* the Main Loop in Figure 03.4 resets the controls on the front panel to their default values. The block labeled This VI is the VI Server Reference VI and is found in the Functions › Application Control palette. The block labeled `Defaults Vals.Reinit All` is the Invoke Node VI and is found in the Functions › Application Control palette. After wiring the VI Server Reference to the input of Invoke Node, right-click on the word `Method` on the Invoke Node VI and select Method for VI Class › Default Values › Reinitialize All to Default. Finally, the block labeled `C` is the Close Reference VI and is found in the Functions › Application Control palette.

The Case Structure labeled `append data to arrays` has a `False` panel that simply passes through arrays instead of appending to them.

Box 03.1 See Resource before proceeding

See Resource 5 before proceeding. It will help you prepare the myRIO so you can download data from it to the desktop computer.

Lab 03.4 Capture the capacitor voltage response

The following procedure can be used to capture the charging of the capacitor.

1. Name your data file on the front panel something like `/c/data/datafile001.lvm`.
2. Run your `Main.vi`. You should see a zero voltage V_s and v_0 reading on the chart.
3. Click the execute button to begin application of V_s and data acquisition of v_o.
4. Observe the voltage response on the chart. You should observe an exponentially decaying approach of $\tilde{v}_o$ to 1 V.
5. Once the voltage has leveled off (at least about $6\tau = 6RC$), click the Stop & Save button on the front panel of the VI.
6. Check to see if the data file was saved to the myRIO flash memory. Use Windows Explorer to navigate to the mapped network drive `http://172.22.11.2/files`. Navigate to `/c/data`. Each run, a data file is created (or over-written) here with a name specified on your front panel. Old data files may be present. Be sure that you identify your data file.
7. Copy your data file to a convenient directory on the computer (e.g. `~/Documents/me316/lab03`).

Lab 03.5 Report requirements

Write a report on your laboratory activities using the template given.

- ☐ 1. Include the following plots (use MATLAB to make the plots):
  - ☐ a. The measured $\widetilde{V}_s$ and $\tilde{v}_o$ as functions of time and
  - ☐ b. The measured $\tilde{v}_o$ as a function of time overlayed with your theoretical prediction for v_o.
  - ☐ c. A log-linear plot of the measured $\tilde{v}_o$ as a function of time overlayed with your theoretical prediction for v_o and your linear regression of the data.

☐ 2. Include all measurements made by hand (e.g. resistance).
☐ 3. Include an analysis of a voltage RC circuit that can be used to produce the theoretical predictions in the plots.
☐ 4. Compute your measured time constant $\tau = \mathtt{RC}$ by performing a linear regression on your measured $\tilde{v}_o$ data. The data must be processed before a linear regression can be performed! (It's not linear yet, it's exponential.)
☐ 5. Include, as always, an abstract, introduction, materials and methods, results, and discussion.

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