

Lab Exercise 05 AC-to-DC Conversion via a Diode Full Wave Rectifier

In this lab, we will design and build a full wave bridge rectifier for AC-to-DC conversion. We will capture the time response data with the NI myRIO device, export it to a data file, import that data file into MATLAB, plot the data, derive an analytic prediction, and compare the analytic prediction to the data.

The objectives of this lab exercise are for students:

1. to understand AC-to-DC conversion,
2. to deepen their understanding of diode circuits,
3. to better 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 05.1 Materials

The following materials are required for each lab station:

- 1. a PC with LabVIEW installed,²
- 2. a myRIO configured with LabVIEW,³
- 3. an oscilloscope,
- 4. a multimeter,
- 5. a breadboard,
- 6. jumper wires,
- 7. four 1N914 diodes,
- 8. a 1 k Ω resistor, and
- 9. a 100 μ F capacitor.

Lab 05.2 Build the circuit

The full wave bridge rectifier circuit we are building can be represented by the circuit diagram of [Figure 05.6](#).

²See [Resource 2](#) for more details on the LabVIEW software configuration.

³See [Resource 3](#) for more details on the myRIO software configuration.

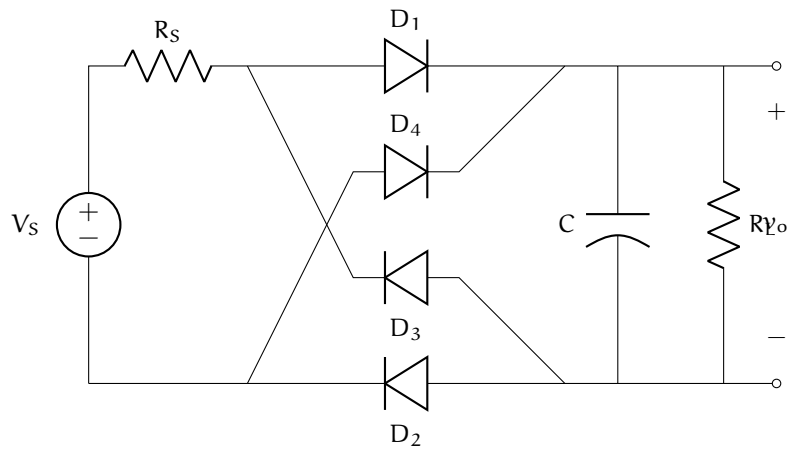


Figure 05.6: full wave bridge rectifier circuit, including the function generator output resistance $R_S = 50 \Omega$.

- 1. Use a function generator as the voltage source. Choose a capacitor of nominal capacitance $C = 100 \mu\text{F}$ and a resistor of nominal resistance $R_L = 1 \text{ k}\Omega$. Select four 1N914 diodes.
- 2. Measure and record the actual resistance R and capacitance C with a multimeter.

	$R_L (\Omega)$	$C (\mu\text{F})$
nominal	1000	100
measured		

- 3. Measure each diode voltage drop using the multimeter. The stripe on the diode corresponds to the cathode (the direction toward which current typically flows). The voltage drops should be around 0.6 V.

	$\tilde{v}_{D_1} (\text{V})$	$\tilde{v}_{D_2} (\text{V})$	$\tilde{v}_{D_3} (\text{V})$	$\tilde{v}_{D_4} (\text{V})$
measured				

- 4. Build the circuit on a breadboard. It should look something like [Figure 05.7](#).

Be cautious with the capacitors—they're polarized! Be sure to connect the $-$ terminal to ground.

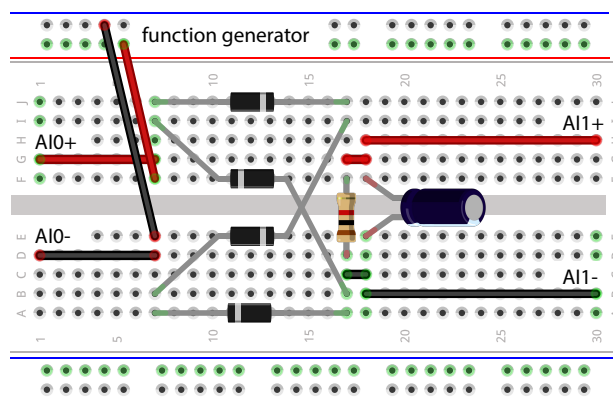


Figure 05.7: an example of how the breadboard circuit might look.

Box 05.1 prepare the myRIO for data collection

Before proceeding, be sure to prepare the myRIO for data collection with the steps of [Resource 5](#).

Lab 05.3 Create Main VI

The Labview VI needed for this lab exercise is very similar to that of [Lab Exercise 03](#). Edit your lab 05 stub downloaded in lab 02 such that it has the following functionality:

- 1. measures the function generator voltage using AI0+, continuously;
- 2. measures the voltage across the capacitor using AI1+, continuously;
- 3. plots the circuit input (scope output) and circuit output (capacitor) voltages on the same chart, continuously;
- timed-loop** 4. uses a *timed-loop* that executes once every 10 ms;
- 5. after (and only after) the user toggles the front-panel button `record data` pressed, stores
 - a. time values (with zero beginning when the button is pressed),
 - b. measured circuit input voltage V_s , and
 - c. measured circuit output voltage \tilde{v}_o in arrays; and
- 6. after the timed loop is exited via a `Stop & Save` button, write the three arrays to a LabVIEW .1vm datafile on the myRIO via the custom VIs

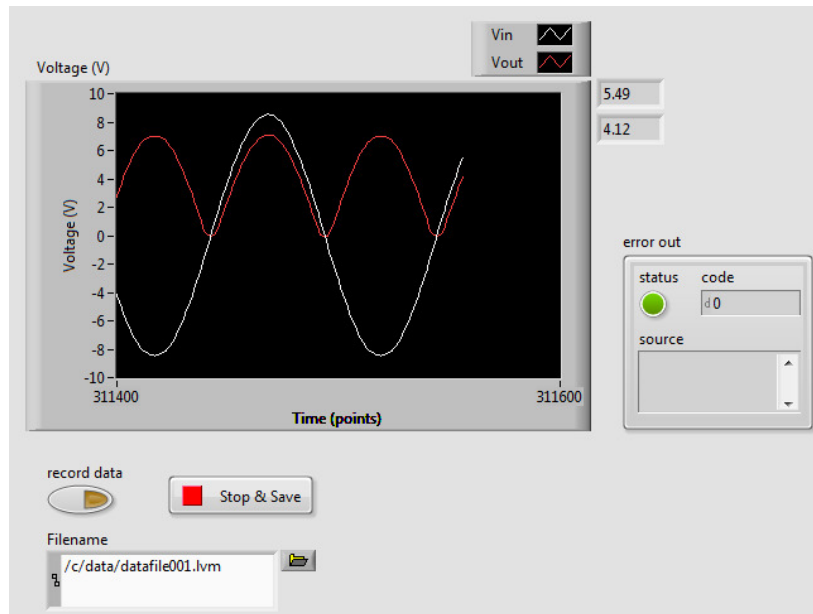


Figure 05.8: how the front panel of your VI might look when the capacitor is disconnected.

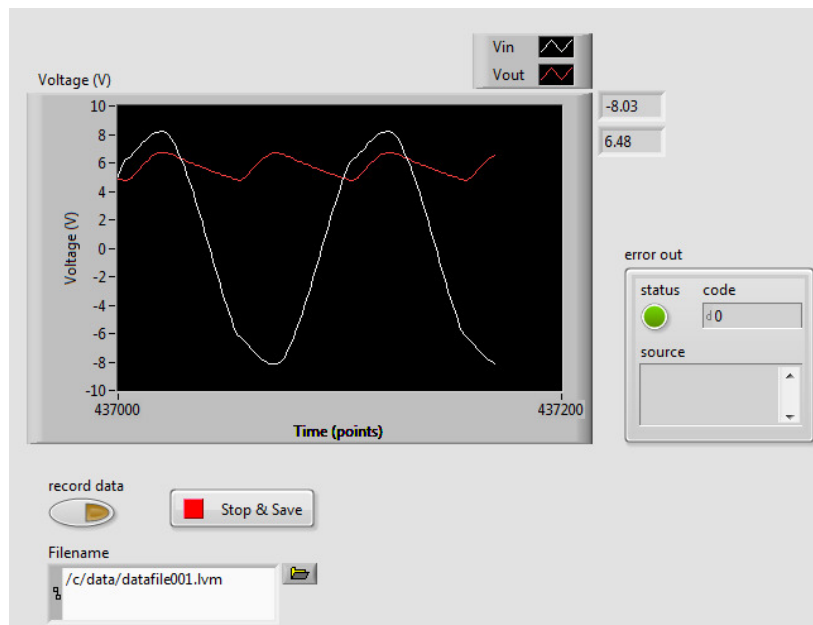


Figure 05.9: how the front panel of your VI might look when the capacitor is connected.

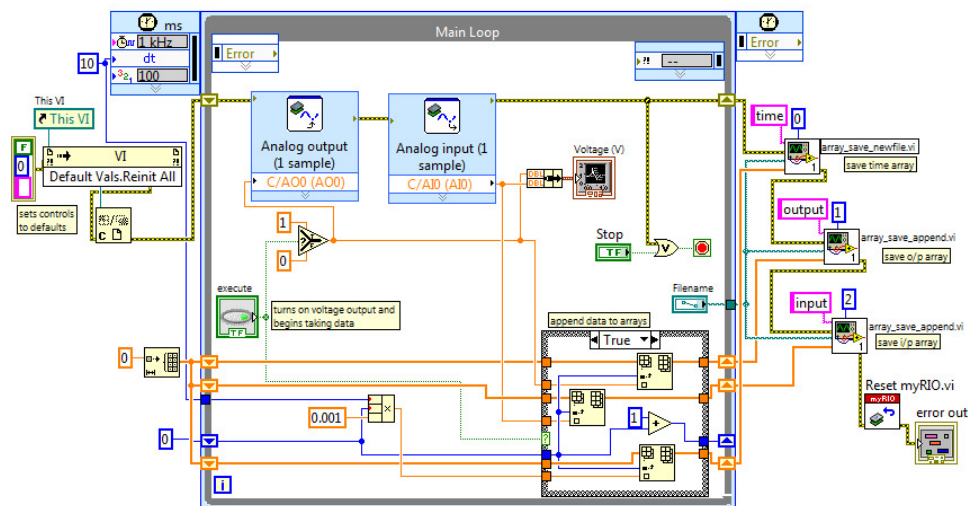


Figure 05.10: how the block diagram of your VI might look. Note that, unlike your VI, this example has an output voltage and does not include a measurement of the source \tilde{V}_s . One should probably use a loop time of 1 ms instead of the 10 shown.

I've written for you `array_save_newfile.vi` and `array_save_append.vi`, which are zipped here:

ricopic.one/resources/array_savers.zip.

(unzip and move them to the same directory as your project);

The front panels of [Figures 05.8](#) and [05.9](#) and corresponding block diagram of [Figure 05.10](#) show a way of realizing a very similar VI. The difference is that the example includes an output voltage and has no measurement of \tilde{V}_s .

Lab 05.4 Measure the signals

Use your VI to measure the source voltage $V_s(t)$ and the output voltage $v_o(t)$ across the load resistor.

included Set your function generator to 8 V.⁴ For two cases, the capacitor *included*
excluded and *excluded* from the circuit, measure and record (save to a data file) each

⁴If you're using a BK Precision function generator, use your VI to hand-tune the function generator voltage to 8 V.

voltage (in and out) over at least three periods of input at 10 Hz.

Repeat for the function generator frequency at the following values:⁵

- 1. 15 Hz,
- 2. 20 Hz, and
- 3. 25 Hz.

Be sure to note which data file is associated with which frequency. Also, be sure to change the filename before each trial is run.

Without the capacitor, the front panel should display something like what is shown in [Figure 05.8](#).

With the capacitor, the front panel should display something like what is shown in [Figure 05.9](#).

Copy your data files to a convenient directory on the computer (e.g. `Documents/me316/lab05`).

Lab 05.5 Report requirements

Write a detailed report of your experimental results, as outlined in the report template. Pay special attention to the following.

- 1. A *thorough* description of the theoretical analysis of the circuit. As part of this analysis, predict ripple and average DC value for each circuit with the capacitor attached. Also predict the current supplied to the load resistor R_L . Use these and the model of [05.01.2](#) to give a predicted DC voltage v_{DC} and ripple Δv_o .
- 2. Four figures that compare each of the capacitor-attached captured data sets (input and output) to its corresponding analytic prediction. It is acceptable to predict only the ripple range and average value of the output, but a full time-analysis is even more fun! In MATLAB, be sure to use `xlim` to scale the x-axis such that around 3–5 periods are visible on each plot (or trim the data). Include somewhere on the plot the approximate measured ripple and DC value. (You can use the plot cursor tool to help with the estimate. “Measure” peak-to-peak and divide by two. Alternatively, use the MATLAB function `cumtrapz` to numerically integrate the voltage and divide it by the time duration, which should be an integer multiple of the signal’s period, to find its average.)

⁵If you’re using a BK Precision function generator, use your VI or the oscilloscope to measure the actual frequency, which you should record.

- 3. Four figures that display the capacitor-detached input and output data sets. Alternatively (preferably), plot these on the corresponding capacitor-attached data set plots. Carefully label and caption these.
- 4. The other parameters measured in the lab (e.g. R_L , C).
- 5. Be sure to comment on how well your predictions matched the theory.