AC to DC Converter

Objective: To gain experience with

- Full wave rectifier circuits with light emitting diodes (LEDs)
- Smoothing Capacitor (Capacitive filter)

Table of Contents:

Pre-Lab Assignment

1) Read the background and lab procedures before coming to lab.

Parts Needed

1) 1 x 1kΩ resistor
2) 1 x 0.22uF capacitor
3) 1 x op amp
4) 4 x LEDs

Background

Diodes are nonlinear passive components that are used in many different applications such as switches, power regulators, and rectifiers. There are different types of diodes, such as photodiodes, light emitting diodes, and zener diodes.

In this lab, light emitting diodes (LEDs) will be used to build a full-wave rectifier circuit to rectify an AC input signal. The positive half of the sinusoidal input current flows through diode A, the load resistor (R_L), diode B, and back to the source. The negative half of the sinusoidal input current flows through diode C, is rectified through the load resistor, flows through diode D and back to the source. The circuit diagram and the rectified output voltage is shown below.

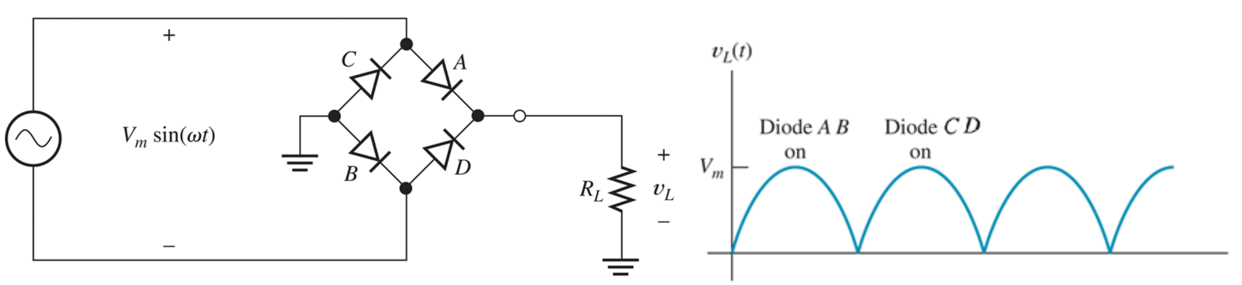


Figure 1. (a) Circuit diagram of full wave rectifier. (b) Output voltage.

If the frequency of the input voltage is low enough, it is possible to see which LEDs turn on during the positive half of the input cycle and which ones turn on during the negative half of the input cycle.

A smoothing capacitor can be added in parallel with the load resistor to convert the rectified signal into a DC signal with ripples. The larger the smoothing capacitor, the larger the time constant, and therefore the smaller the ripples on the DC signal. V_{rms}

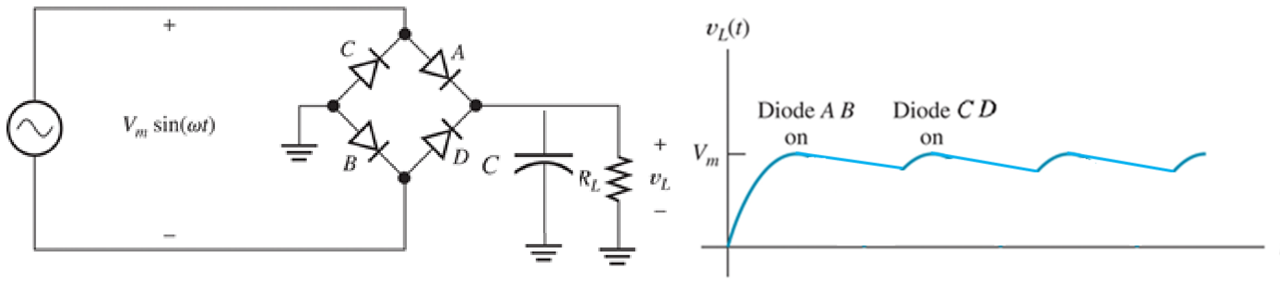


Figure 2. (a) Circuit diagram of full wave rectifier with smoothing capacitor. (b) Output voltage.

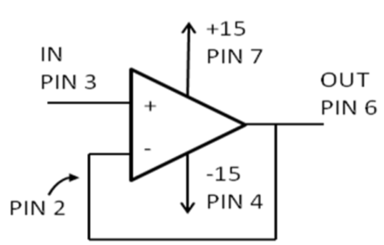
The relationship between the capacitor and ripple voltage is defined by the following equation:

$$C = \frac{I_L}{2fV_r}$$

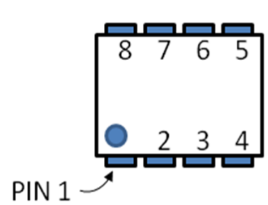
where, C is capacitance, I_L is current through the load, f is the frequency of the original AC signal, and V_r is the height of the ripple voltage.

Note: Diodes A through D of the full wave rectifier shown in figures 1 and 2 are assumed to be ideal diodes with zero turn on voltage. The LEDs used in the lab have a finite turn on voltage.

Op Amp Buffer Circuit



Schematic of unity gain buffer



PIN diagram for LF351 Op Amp IC

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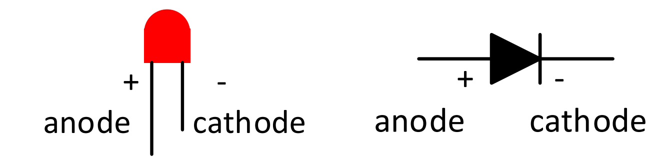
All diodes have a direction, and the direction in LEDs is indicated by the length of the wires as shown below.



Lab Procedure

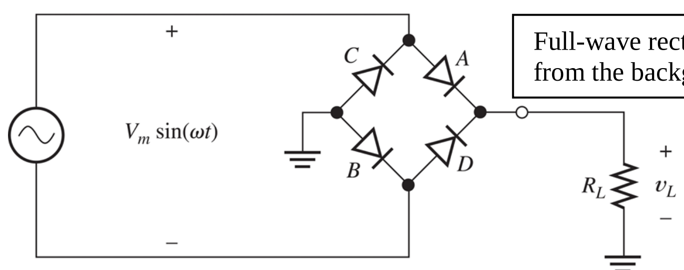
You must get an Instructor sign off for Part A) OR Part B)

Setup

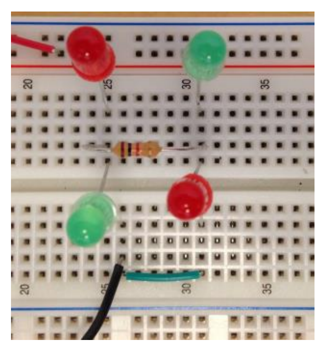
- Connect the myDAQ to your computer using the USB connector.
- Start up the NI ELVISmx Instrument Launcher software.
- Start up the function generator FGEN and the SCOPE by clicking on their icons.

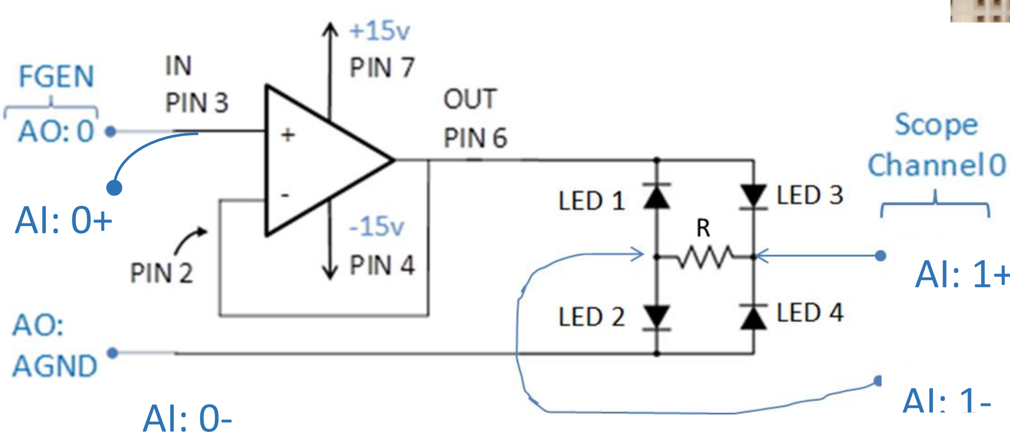
Part A) Measure output of full wave rectifier

1. Build the full-wave rectifier circuit shown below. **NOTE: Use the appropriate pins for the op amp that you own. It may be different than the one in the figure.**
2. Connect Channel 0 of the scope across the input terminals and Channel 1 of the scope across the load resistor as shown in the figure.
3. Set the function generator and oscilloscope settings to the values shown in the screen capture on the next page.
4. Run the function generator and oscilloscope.



Full-wave rectifier schematic from the background section





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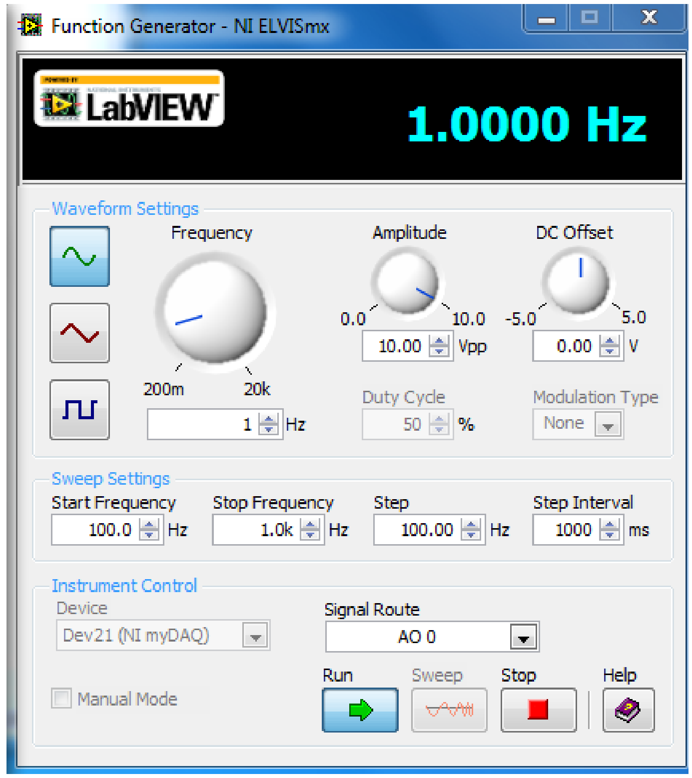
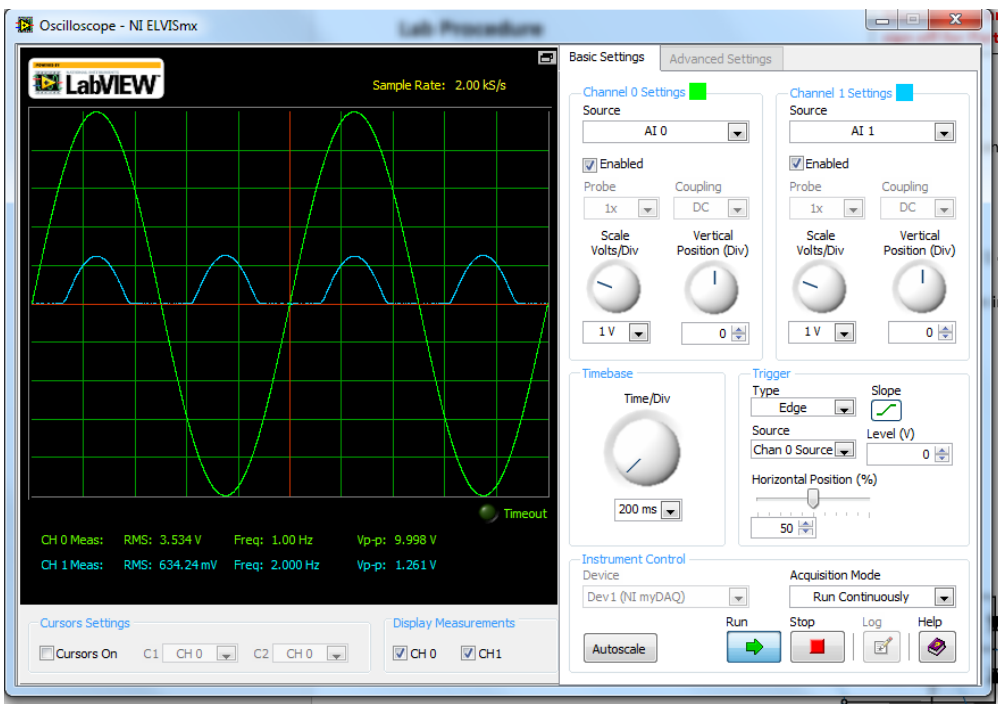


Function Generator

1. Waveform: Sinusoidal
2. Frequency: 1 Hz
3. Amplitude: 10 Vpp
4. DC offset: 0 V

Oscilloscope

1. Volts/Div: 1 V/div
2. Time/Div: 200 ms/div
3. Trigger: CH 0



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5. Determine rms: The rms voltage for a waveform is the square root of the average of the squared signal. For a positive signal, the rms is just the average value of the signal. For a sinusoidal signal with amplitude A and zero DC offset, the rms is $A/\sqrt{2}$.

   From the oscilloscope plots, calculate the rms of the input voltage waveform from the amplitude, and estimate the average of the output waveform to get the rms of the output voltage:

Estimated	V_{rms}
Input voltage (from function generator)	
Output voltage (across R_L)	

6. Measure the rms voltage, peak-to-peak voltage, and frequency of the rectified output voltage and compare the rms values to the estimated values from Part 5 (to make sure that you know how to estimate the rms). (You can read these values directly below the scope).

Measured	V_{rms}	V_{p-p}	Frequency
Input voltage (from function generator)			
Output voltage (across R_L)			

7. Is there a difference in the peak-to-peak voltages and frequencies between the input and output voltages? If so, why?

8. Is there a difference in the shape of the measured rectified output voltage and the theoretical rectified output voltage (background section, page 1.). If so, why?

Name: ____

9. If a 100 ohm resistor was used for the load instead of the 1k ohm resistor, what would happen to the LEDs?

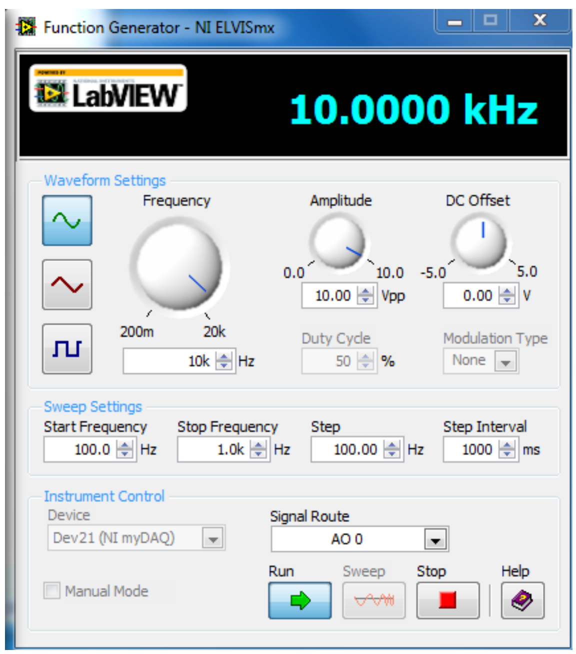
Part B) Add smoothing capacitor to full wave rectifier

This section allows you to see the effect of the smoothing capacitor to the output of a full wave rectifier.

1. Turn off the function generator and oscilloscope.
2. Add the capacitor in parallel with the resistor.
3. Set the function generator and oscilloscope settings to the values shown in the screen captures shown below.
4. Run the function generator and oscilloscope.

Function Generator
1. Waveform: Sinusoidal
2. Frequency: 10 kHz
3. Amplitude: 10 Vpp
4. DC offset: 0 V

Oscilloscope
1. Volts/Div: 1 V/div
2. Time/Div: 50 µs/div
3. Trigger: CH 0



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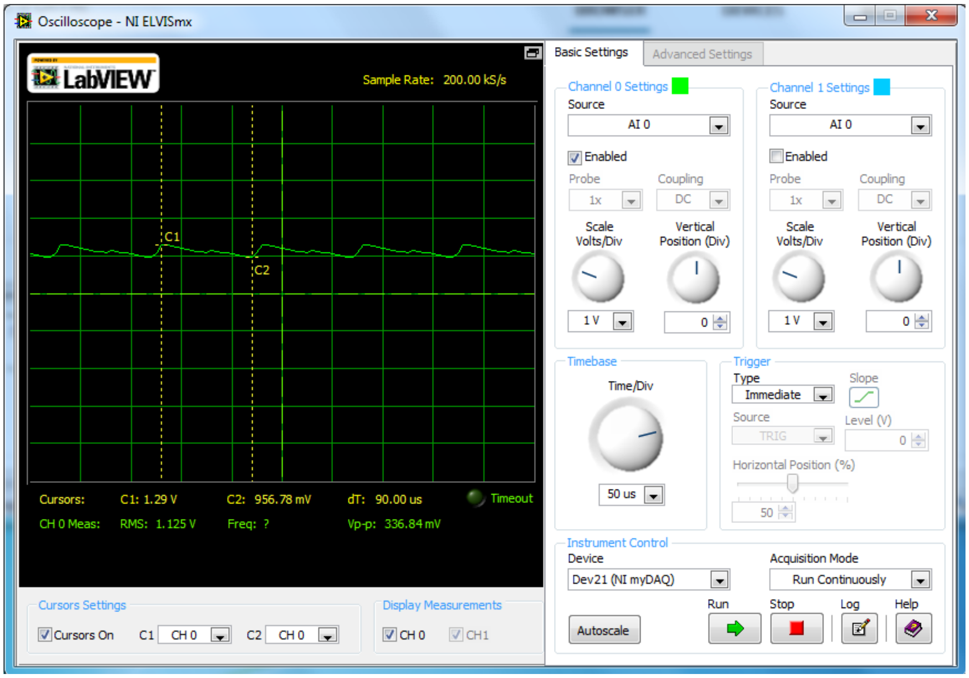

5. Measure the filtered rectified output ripple voltage from the oscilloscope, this is displayed as the Vp-p of the signal.

   Vp-p = ___________________

6. Measure the rectified output RMS voltage:

   V_{RMS} = ___________________

7. How can the smoothing capacitor be changed so that the output voltage looks more like a DC voltage?

8. Compare the measured output Vp-p and V_{RMS} to the output values measured in Part A. Are the values different? If so, why?