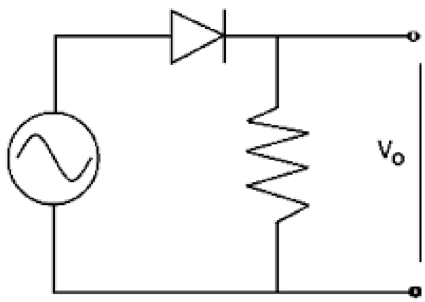
Laboratory 7: AC-DC Conversion

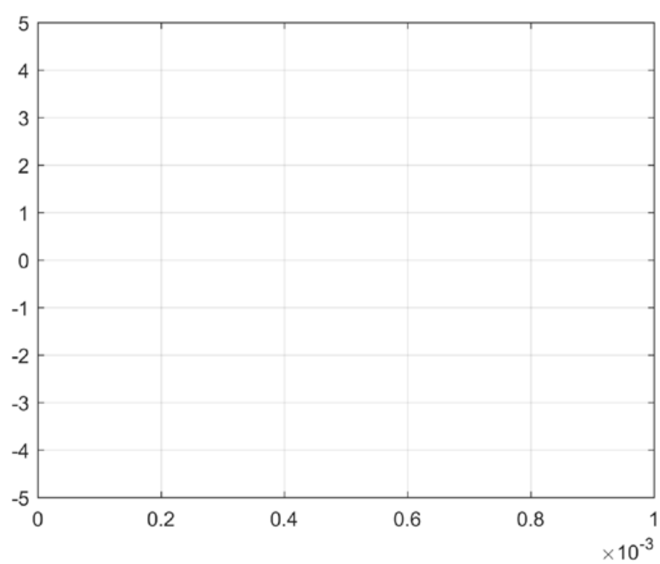
This week we will take the use of diodes one step further to convert an AC waveform to a DC waveform. This is a common circuit in all AC power converters as well as in analog circuits that are used to multiply signals.

This laboratory introduces you to the non-linear behavior of a diode in response to AC signals. In this lab, you are to use a 1 kHz sine wave generated from the Digilent arbitrary waveform generator. Under no circumstance should you use a wall plug to drive your circuit!

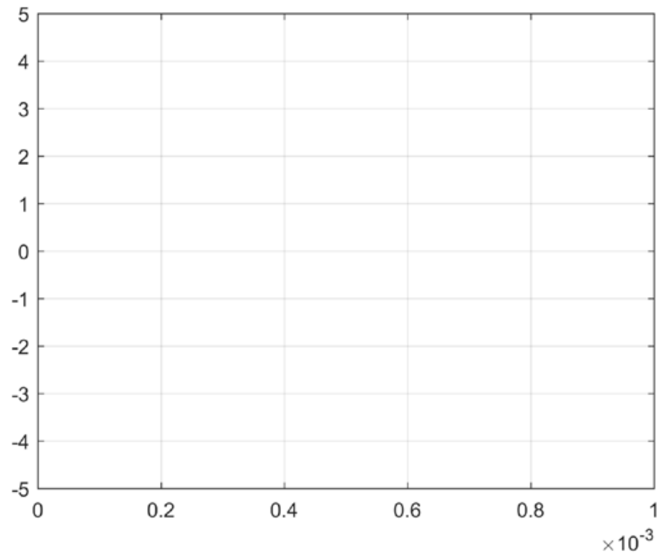
Required Parts: 1 100 Ohm, 1kOhm resistor, 4 diodes (such as 4148), 1 22uF capacitor (TC22) , 1 Transformer (such as XFRA).



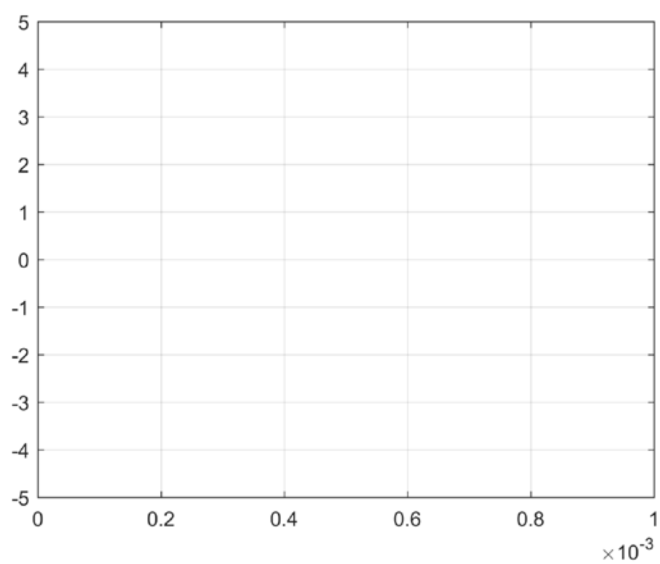
Step 1. Return to the schematic that you created last week with a 1k Ohm resistor. Use a 1kHz sine wave with amplitude of 2.5V at 0 V DC and plot the waveform across the resistor. Does it create a half-wave rectified waveform? Can you find the "peak" and "average" value of the half-wave rectified waveform? (6)



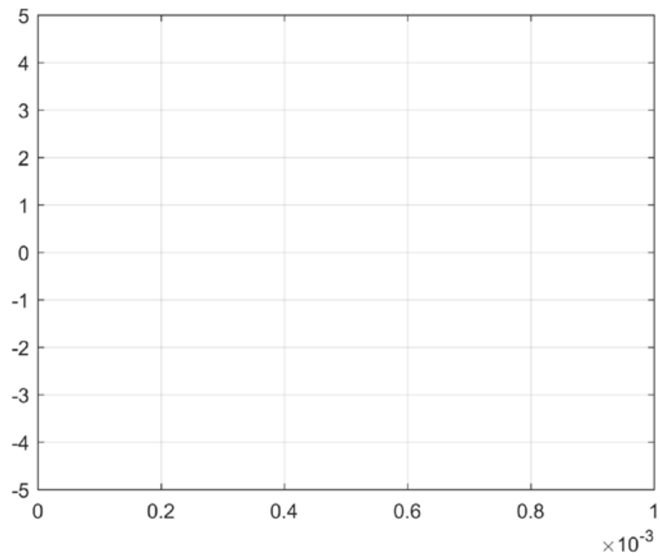
Step 2. Now reduce the AC signal to a 0.5 V, 1kHz sine wave. Plot the waveform. Does it create a half-wave rectified waveform? Can you find the "peak" and "average" value of the half-wave rectified waveform? (5)



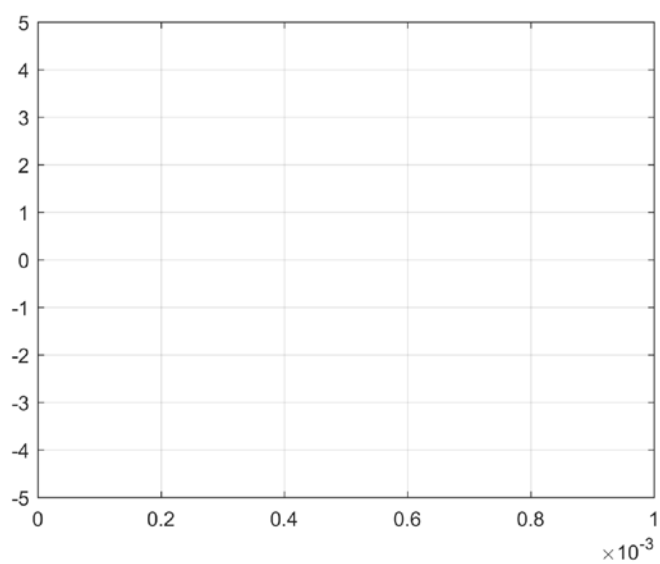
Step 3. Now adjust the DC bias while keeping the AC signal a 2.5V, 1kHz sine wave. Plot the waveform for a DC of 1 V. Does it create a half-wave rectified waveform? Can you find the "peak" and "average" value of the half-wave rectified waveform? (5)



Step 4. Reverse the direction of the diode while keeping the DC at 1 V and AC signal a 2.5V, 1kHz sine wave. Plot the waveform. Does it create a half-wave rectified waveform? Can you find the “peak” and “average” value of the half-wave rectified waveform? (5)



Step 5. Now return the diode to the original direction as shown in the schematic but add the 22 μF capacitor in parallel with a 1k Ohm resistor. Use a sine wave with amplitude of 2.5V at 0 V DC. Plot the waveform across the 1 kOhm resistor with and without the capacitor. What is the average DC voltage across the resistor? What is the DC output voltage ripple (the difference between the maximum and minimum voltage)? (6)



Step 6. Sweep the input AC voltage and measure the DC voltage. Compare this to the expression that we found in class. (5)

$$V_{DC} = \frac{1}{\pi}(V_{AC} - V_D)$$

AC input voltage (V)	Calculated DC output voltage (V)	Measured DC output voltage (V)
0.5		
1		
1.5		
2		
2.5		

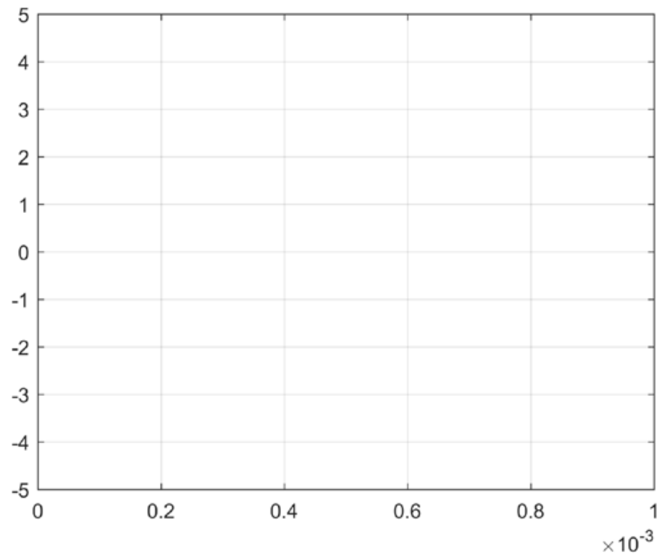
Step 7. Compare the average DC voltage and voltage ripple across the resistor with a 100 Ohm resistor and a 1kOhm resistor? (4)

Resistor Load	DC output voltage	DC output ripple
100 Ohm		
1 kOhm		

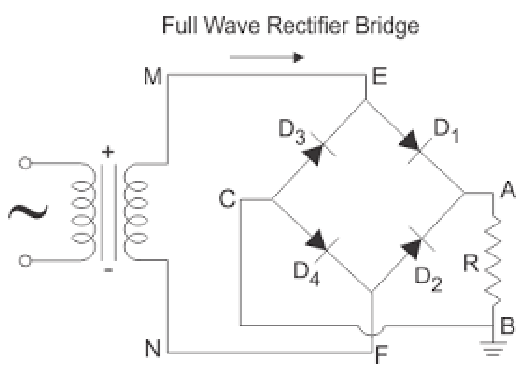
Step 8. Let's look at the small signal response now. Orient the diode so that the diode is forward biased (as in the original schematic) with the 1 kOhm resistor. Apply a 1 kHz sine wave with an amplitude of 25 mV at 0V, 0.5V, 1V, and 1.5V DC. Plot the waveform across the 1 kOhm resistor for the 1.5V case. What is the measured AC voltage across the resistor? How does this compare to the "expected" small signal value? (8)
Hint: Remember that we know have a voltage divider for the small signal.

$$V_{OUT} = V_{IN}\frac{R}{R + R_{ON}} \quad \text{where } R_{ON} = \frac{V_T}{I_{DC}}$$

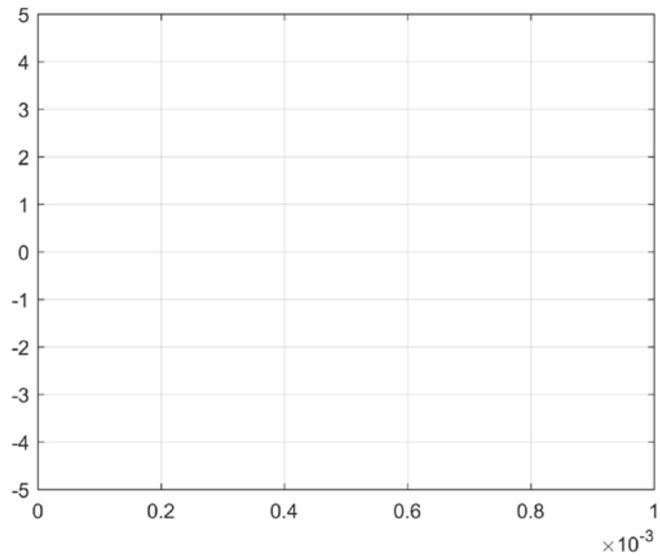
DC input voltage (V)	Measured DC current through R	Calculated AC output voltage (V)	Measured AC output voltage (V)
0			
0.5			
1			
1.5			



Step 9. The full-wave rectifier is an important circuit that is used for AC-DC power transfer as might be found in the power supply of a laptop computer. Notice that the rectifier transfers power when the diodes are forward-biased. Use four diodes to construct a full-wave rectifier as shown in the figure below. You may need a transformer to isolate the AWG from the diode bridge. The transformer available from the stockroom is an audio transformer so use a 1 kHz sine wave in this problem. Also the transformer has an uneven number of turns on the primary and secondary side. Use the configuration that gives you the most voltage swing on the load.



Now, introduce the 2 V, 1 kHz sine wave to the input of the transformer. Plot the waveform across the 1 kOhm (load) resistor and record the average DC voltage across the resistor. Do you see the full wave rectified signal?



Step 10. Now add the 10 uF capacitor to the resistor. Measure the DC output voltage as function of the AC input voltage. What is the difference between the DC output voltage for the half-wave and full-wave rectifier? (5)

AC input voltage (V)	Calculated DC output voltage (V)	Measured DC output voltage (V)
0.5		
1		
1.5		
2		
2.5		