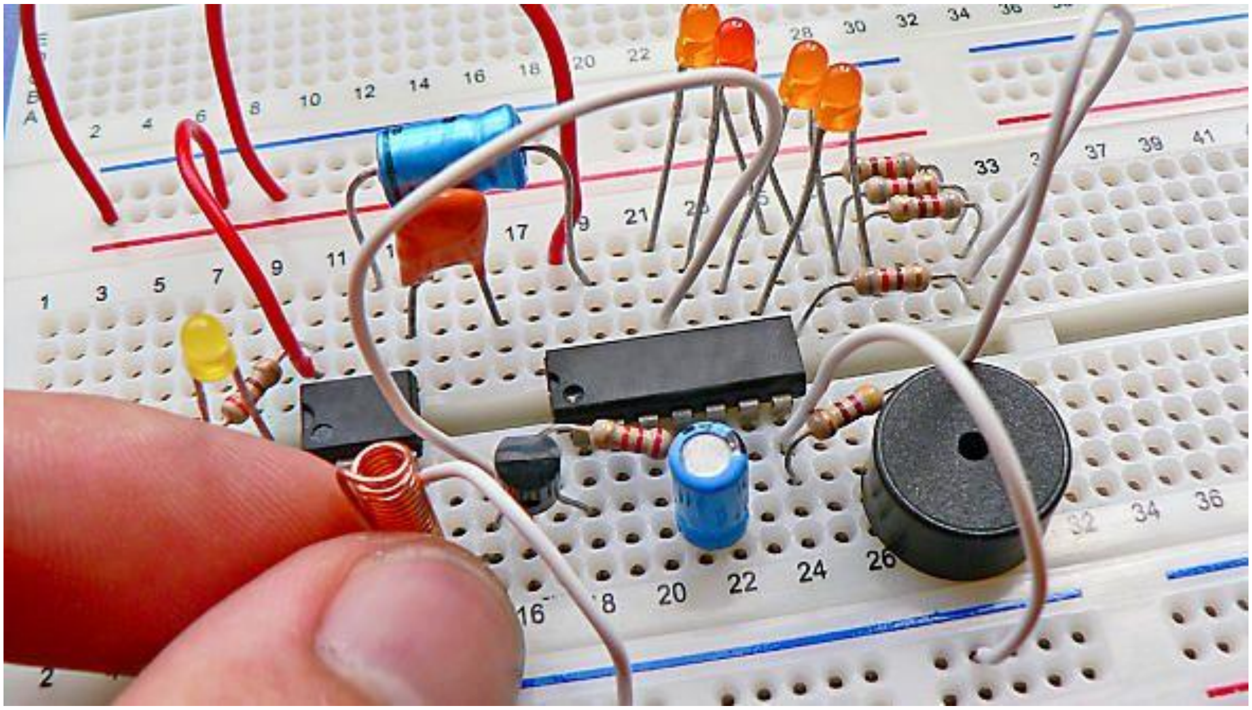
Lab 1: Diodes

EEE109 Electronic Circuits



In Lab 1, there are four sections, ***please read this material before the lab and perform the experiment following with the instructions step by step***.

Required Components and Technology

- **Platform: NI ELVIS III**
- **Components:**

Section 1:

- **(1) 1N4001 diode**
- **(1) 47 Ω resistor**
- **(1) 1 kΩ potentiometer (on Protoboard)**
- **(1) 1 MΩ resistor**

Section 2:

- **(1) 1 MΩ resistor**
- **(1) Red LED**
- **(1) 1N4001 diode**

Section 3:

Only simulation

Section 4: ***(This part is optional, if you have extra time)***

- **(1) 1 kΩ resistor**
- **(1) 10 kΩ potentiometer (on Protoboard)**
- **(1) 1N4735 Zener diode**

Section 1: Diodes

1.1 Observing Diode Behavior

As you have already learned, a diode is an electronic component that conducts current primarily in one direction. It is a two-terminal component and has low resistance in one direction and high resistance in the other.

Instructions

1. Turn on the NI ELVIS III and from the Instruments tab of Measurements Live open the following instruments:

    - IV Analyzer

Note: For more information about accessing Measurements Live and launching instruments, visit http://www.ni.com/documentation/en/ni-elvis-iii/latest/getting-started/launching-soft-front-panels/.

2. Place the diode with the correct polarity between the **DUT+** and **DUT-** terminals in NI ELVIS III. *(Screwdriver is needed to fix the terminals.)*

    - Place the *Anode* in the **DUT+** terminal.
    - Place the *Cathode* in the **DUT-** terminal.

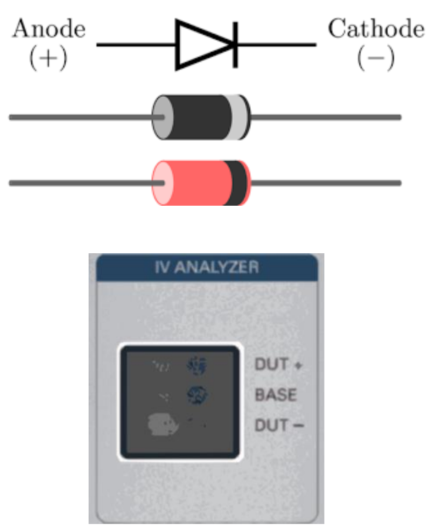


Figure 1-1

Generate the Current vs. Voltage Graph

1. Set the IV Analyzer by following the instructions in the table below:

Table 1-1 IV Analyzer Settings

Analyzer mode	Diode
Voltage Sweep	
Start	0.00 V
Step	0.05 V
Stop	0.70 V
Current range	
Negative	-30.00 mA
Positive	+30.00 mA

Table 1-2

Graph Settings	
Autoscale	On

2. Click **Run** to start measuring. The instrument will provide voltage (x) and then measure current (y). It will increase the voltage and repeat the procedure until it reaches the user-defined voltage limit. The graph clearly displays how the current rises when it reaches a given voltage value.

3. Repeat the previous step, starting the measurement at -10 V (inverse voltage), in 0.1 V steps. Keep the stop value as 0.7 V.

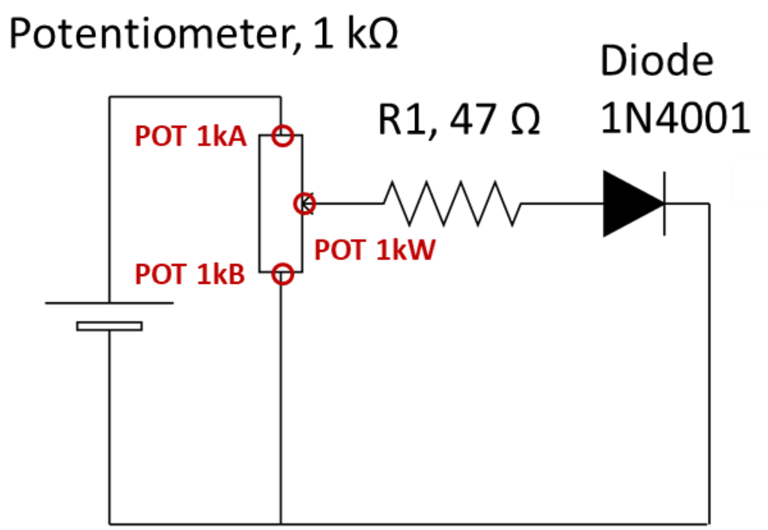
4. **Take a screenshot and include it with your lab report.**

1.2 Diode Measurements

Build a Circuit and Measure the Current Flow Through a Diode

1. Use the NI ELVIS III to set up the following circuit:

Warning: Do not force the DMM probes into the breadboard holes. Instead, create a measurement point by plugging in one end of a wire or a header pin into the breadboard hole.



Circuit 1.2 Diode Measurements

2. Open the following instruments from Measurements Live:

- Digital Multimeter (DMM)
- Variable Power Supply 1-15 V DC (VPS)

Instructions

1. Use the VPS to apply 1 V.
2. Measure the voltage between the resistor and the diodes, that is the **source voltage**.
3. Spin the potentiometer to adjust the source voltage increases from 0-1 V, step 0.1 V.
4. Under each source voltage, measure the total current in the circuit and the voltage of the diode using the DMM.
5. Record your results in the table below:
6. **Graph a plot of Source Voltage (VS) vs. Total Current (I)**. Source Voltage should appear in the x-axis. Current and diode voltage should appear in the y-axis. **Include it with your lab report.**

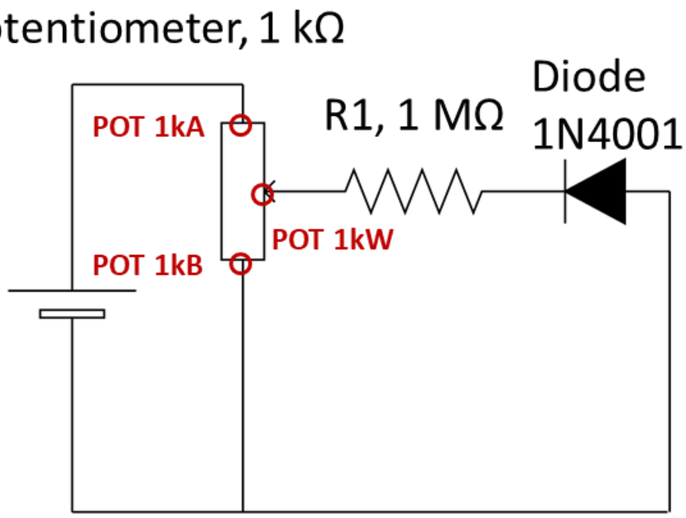
Table 1-3

Source Voltage (VS)	Total Current I (mA)	Diode Voltage (V)
0.0		
0.1		
0.2		
0.3		
0.4		
0.5		
0.6		
0.7		
0.8		
0.9		
1.0		

1-1 Compare the current vs. supply voltage curve with the one obtained from the IV Analyzer. Are they different? If so, why?

Reverse the Polarity of the Diode

1. Change the resistance of the resistor to 1 MΩ.
2. Invert the diode's polarity as shown in the illustration.
3. Use the VPS to apply 10 V to the circuit.



Circuit 1.3 Reverse the Polarity of the Diode

1-2 What is the diode's current?

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1-3 What is the diode's voltage drop?

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1.3 Conclusion

These questions will help you review and interpret the concepts learned in this section of the lab.

1-4 Using the data in the Table 1-3, what is the maximum power dissipated by the diode?

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1-5 How did the diode behave when its polarity was reversed?

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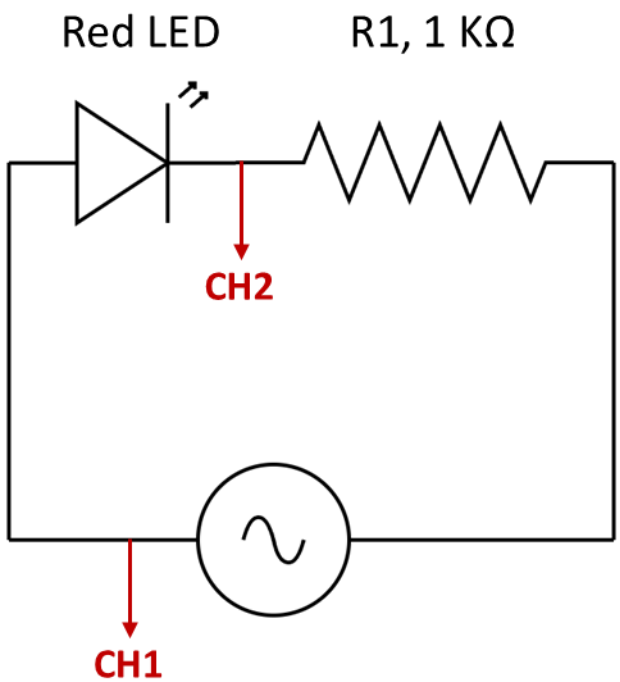
Section 2: Diodes in a Half-Wave Rectifier

2.1 Diodes in Half-Wave Rectifier

Instructions

1. Use the NI ELVIS III to set up the following circuit:



Circuit 2.1 Diodes in Half-Wave Rectifier

2. Open the following instruments from Measurements Live:

 - Function Generator (FGen-Arb)
 - Oscilloscope

3. Configure the Function Generator according to the settings in the table below:

Table 2-1 Function Generator Settings

Frequency	0.5 Hz
Amplitude	10 Vpp

4. **Run** the Function Generator and observe the LED.

2-1 Knowing how a diode (such as an LED) behaves with a negative voltage, hypothesize what is happening through each cycle of the sine wave.

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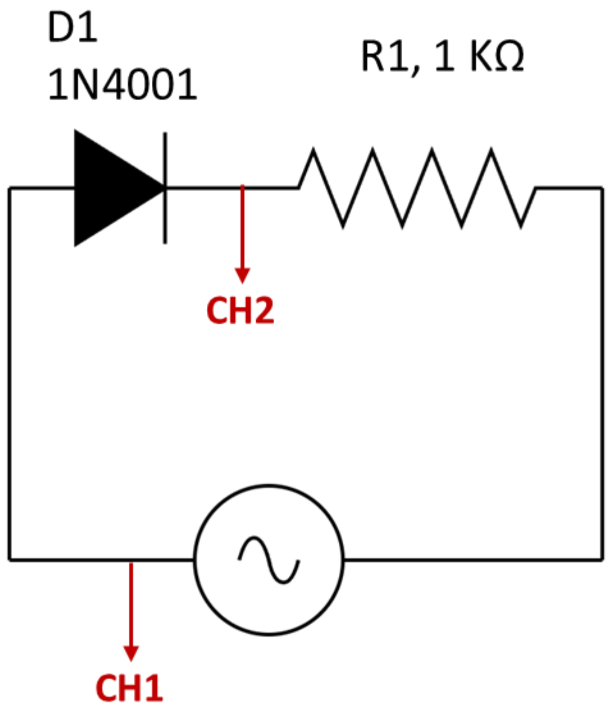
5. When you are finished, click **Stop** on the Function Generator.

2.2 Replace the LED with a Normal Diode

Instructions

1. Next, you will measure the behavior of a diode in a circuit. Replace the LED with a 1N4001 diode:



Circuit 2.2 Replace the LED with a Normal Diode

2.3 Configure the Oscilloscope

Table 2-2 Oscilloscope Settings

Trigger	
Type	Analog Edge
Channels	
Channel 2	Active

1. **Run** the Oscilloscope and Function Generator

2. Observe the graph of the Oscilloscope

3. **Take a screenshot to record your results. Include it with your lab report.**

2.4 Conclusion

These questions will help you review and interpret the concepts learned in this lab.

2-2 Summarize any observations from the lab that haven't been addressed elsewhere.

2-3 In your own words, describe a diode's operation and application.

2-4 In your own words, describe the role of the diode in a half-wave rectifier circuit.

Section 3: Diodes in a Rectifier

3.1 Full-wave Rectifier

In this section, you will simulate the behavior of a full-wave rectifier in Multisim Live. During the lab procedure, you will compare measured results with the simulated results to get an idea of the behavior of the real circuit compared to a simulated circuit.

1. Click the link below to open the Multisim Live circuit.
2. https://www.multisim.com/content/PxWFZubYPw354S96TYYvDX/diodes-in-a-rectifier/
3. Examine the circuit, simulated with Multisim Live.
4. Click **Run** to run the Interactive simulation.
5. Observe the blinking pattern of the LEDs.

3-1 Hypothesize the pathway of current for the *negative* half of the sine wave and the *positive* half of the sine wave.

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Observe the Graph to Confirm Hypothesis

1. Switch the Multisim environment from **Schematic** to **Split** mode.
2. **Run** the simulation and observe the measured voltages.
   - The *source sine wave* is graphed in *green*
   - The *signal* through the resistor is graphed in *blue*

3. **Stop** the simulation, take a screenshot or take a picture of the voltage vs. time. **Include the image in your lab report.**

Note: The resistor's voltage is measured from the right to the left of the resistor.

3-2 Does the signal measured through the resistor confirm your hypothesis about the path of the current for both phases of the sine wave? Explain how the diodes are routing the AC current through the resistor.

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3.2 Conclusion

These questions will help you review and interpret the concepts learned in this lab.

3-3 Summarize any observations from the lab that haven't been addressed elsewhere.

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3-4 In your own words, discuss the operation and application of rectifiers.

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-5 In your own words, identify the pathway of current through a rectifier and describe how diodes control current flow.

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3-6 Explain how you converted an AC signal to DC using a full-wave rectifier with filtering.

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Section 4: Zener Diodes (Optional)

4.1 Observing Zener Diode Behavior

As you have already investigated, a Zener diode is an electronic component that conducts current in both forward and reverse directions. It is a two-terminal component and is used to regulate voltage.

Instructions

1. From the Instruments tab of Measurements Live, open the following instruments:

   - IV Analyzer

Note: For more information about accessing Measurements Live and launching instruments, visit http://www.ni.com/documentation/en/ni-elvis-iii/latest/getting-started/launching-soft-front-panels/.

2. Place the Zener diode in the **DUT+** and **DUT-** terminals in NI ELVIS III.

Note: The *anode* should be placed in the **DUT+** line and the *cathode* should be placed in the **DUT-** line. *(Screwdriver is needed to fix the terminals.)*

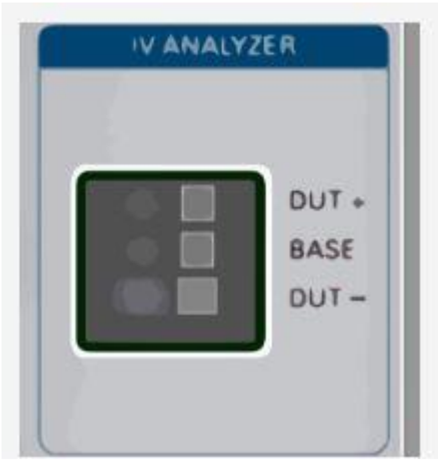


Figure 4-1 IV Analyzer

Use the IV Analyzer

1. In the IV Analyzer window, set the following settings:

Table 4-1 IV Analyzer settings

Voltage Sweep	
Start	-6.00 V
Step	0.25 V
Stop	0.7 V
Current Limits	
Negative	-30.00 mA
Positive	+30.00 mA

Table 4-2

Graph Settings	
Auto Scale	On

- Ensure that the instrument is set to the NI ELVIS III.

2. Click **Run** to run the analysis.
3. Analyze the results.

Note 1: If the IV Analyzer gives a warning for:

4. **"***Negative current limit exceeded***"**- increase the Start voltage.
5. **"***Positive current limit exceeded***"**- decrease the Stop voltage.

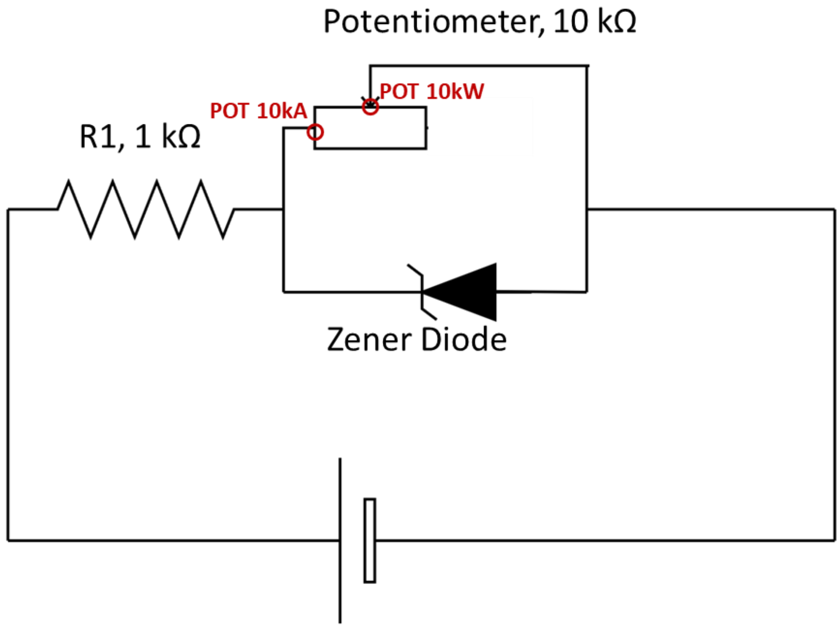
Note 2: At a certain negative voltage, negative current is allowed to flow. This is the *breakdown voltage* of the Zener diode. With positive voltage applied, the Zener diode behaves similarly to the diodes you've seen before.

4.2 Zener Diode in a Voltage Regulator

You will now build a circuit and measure the current flow through a diode.

The next part of the exercise is to generate the curve manually using the power supply and the digital Multimeter.

1. Use the NI ELVIS III to set up the following circuit:



Circuit 4.2 Zener Diode in a Voltage Regulator

2. Open the following instruments from Measurements Live:

- Digital Multimeter (DMM)
- Variable Power Supply 1-15 V DC (VPS)

4.3 Apply Voltage to the Load

Instructions

1. **Run** the Variable Power Supply, set the resistance of the potentiometer to 10 kΩ.
2. Observe the voltage across the potentiometer as the supply voltage changes.
3. Increase the **Supply +** voltage until the voltage measured on the DMM stops increasing.

4-1 At what voltage does the measured voltage level off?

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4. Confirm that this voltage corresponds to the breakdown voltage of the Zener diode, if possible.

Change Load Resistance and Observe the Voltage

1. Set the **Supply+** voltage to 15 V.
2. Modify the resistance of the potentiometer, making sure to stay above the lower 20% of the range (2k-10kΩ).
3. Confirm that the voltage across the potentiometer stays fairly the same as the resistance is changing.

4.4 Conclusion

These questions will help you review and interpret the concepts learned in this lab.

4-2 Summarize any observations from the lab that haven't been addressed elsewhere.

4-3 In your own words, discuss the operation and different applications of a Zener Diode.

4-4 Explain how you implemented a voltage regulating circuit using a Zener diode.

4-5 Describe and explain the specific role of a Zener diode in a regulator.