EE 320 L ELECTRONICS I

LABORATORY 4: DIODES AND RECTIFIERS

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
UNIVERSITY OF NEVADA, LAS VEGAS

1. OBJECTIVE

Get familiar with diodes, and apply knowledge learned in lecture to practical applications. Understand how regular diodes, rectifiers and Zener diodes work, and their functions in the circuits.

2. COMPONENTS & EQUIPMENT

Power Supply	Breadboard
Function Generator	Jump wires
Multimeter	Resistors & Capacitors
Oscilloscope	Diodes (LED, 1N4001, 1N4148, 1N4375)

3. BACKGROUND

A diode is a two-terminal electronic component that conducts current primarily in **one direction** (asymmetric conductance); it has low (ideally zero) resistance in one direction, and high (ideally infinite) resistance in the other. This unidirectional behavior is called **rectification**, and is used to convert alternating current (AC) to direct current (DC). Forms of rectifiers, diodes can be used for such tasks as extracting modulation from radio signals in radio receivers.

Special-purpose diodes can perform many different functions. For example, diodes are used to regulate voltage (Zener diodes), to protect circuits from high voltage surges (avalanche diodes), to electronically tune radio and TV receivers (varactor diodes), to produce light (light-emitting diodes), and etc.

Key knowledges and formulas regarding to RC circuits and frequency response.

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I-V curve of a diode (i.e. PN junction):

$$I = I_s\left(e^{\frac{V_D}{V_T}} - 1\right)$$

$$V_T = \frac{kT}{q}$$

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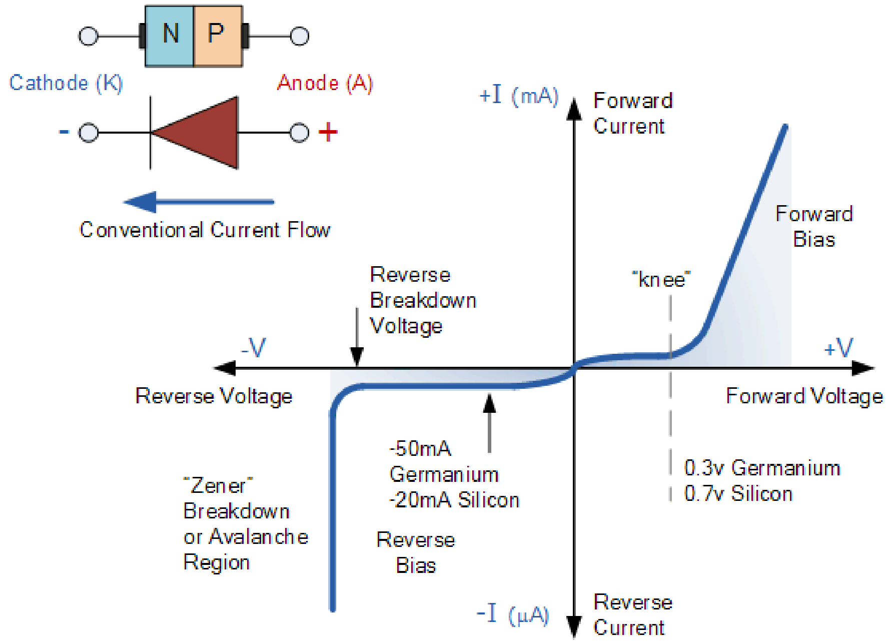

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An ideal diode model in electrical circuits:

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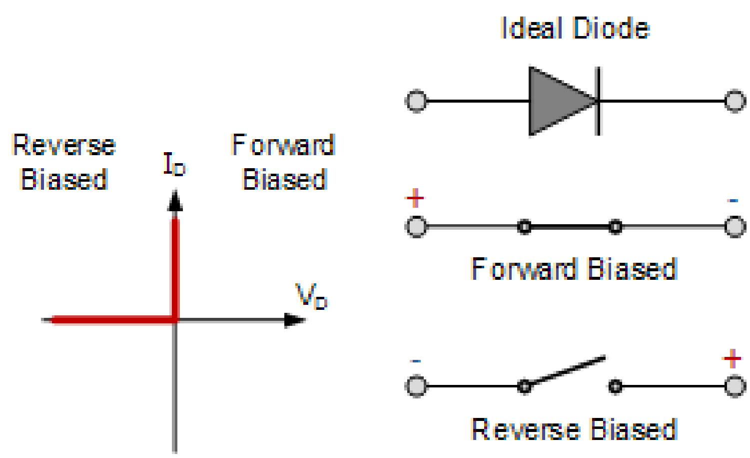

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A real (linear) diode model in electrical circuits:

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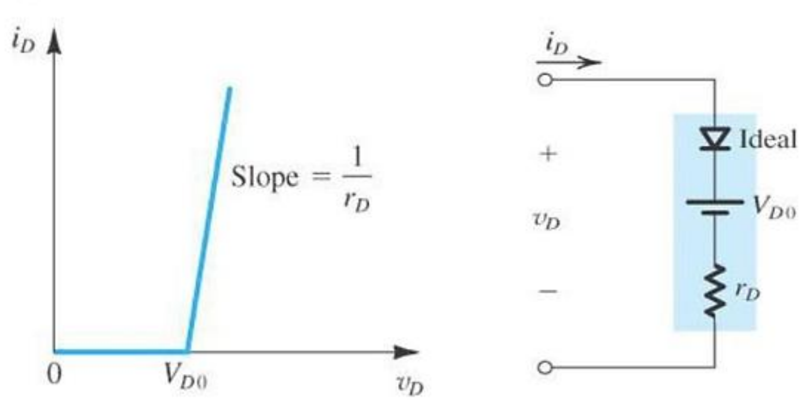

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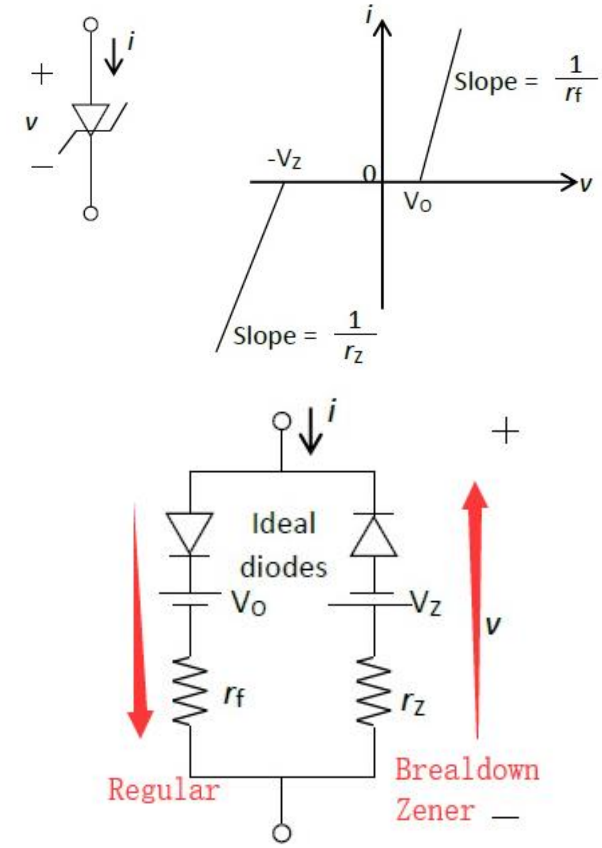
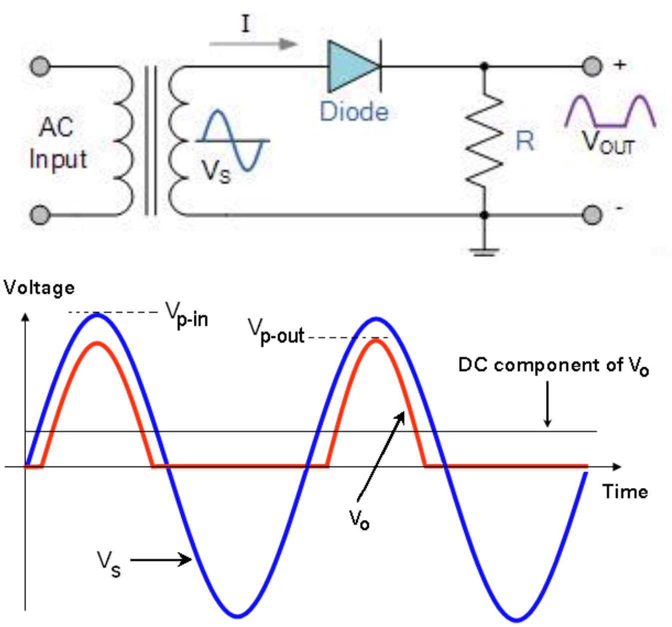
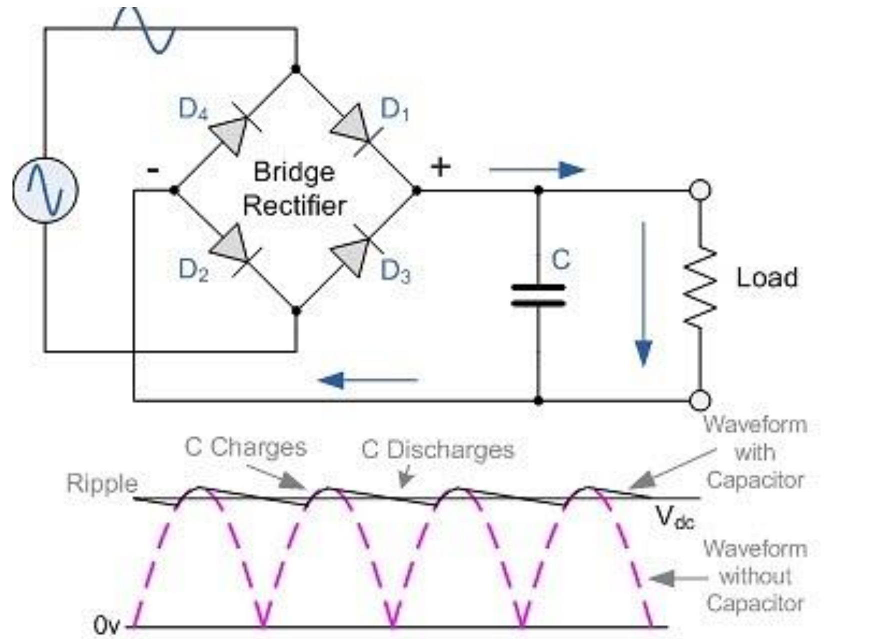
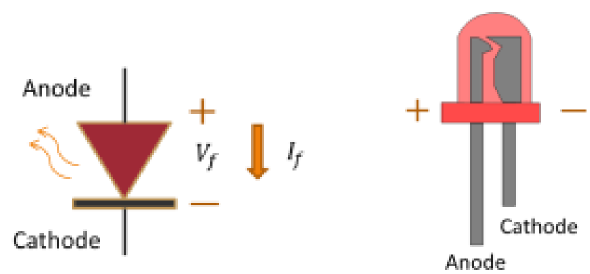
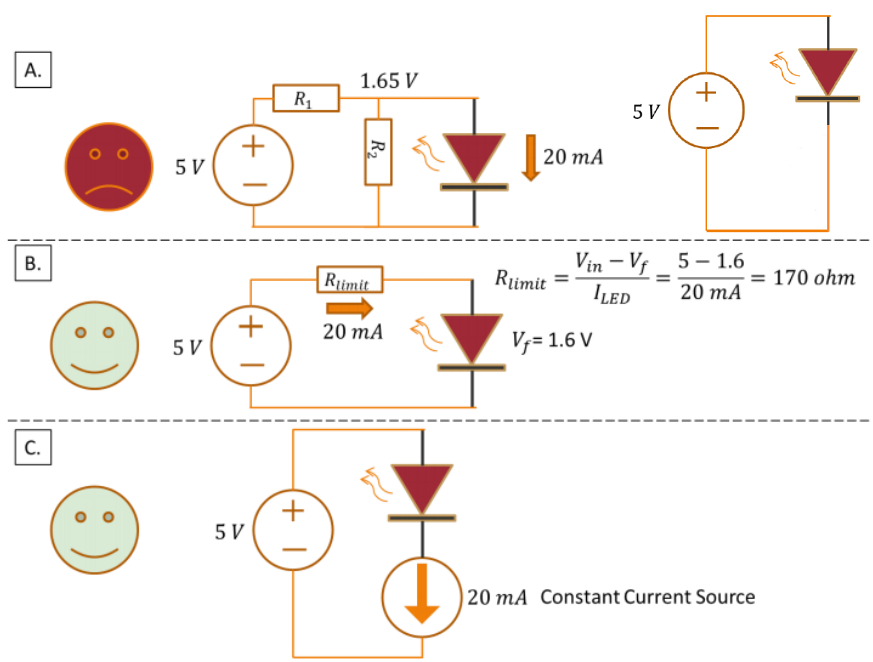
A Zener diode model:	
A half wave rectifier:	

A full wave bridge rectifier:



LED Diode:





4. LAB DELIVERIES

PRELAB:

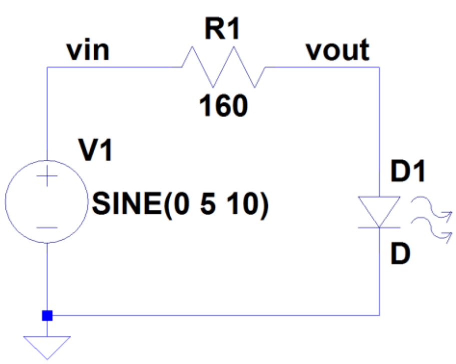
1. **Review the knowledge of regular diodes, rectifiers and Zener diodes, part of which are listed in the previous section.**

2. **Overview the key character of diodes in their datasheets.**

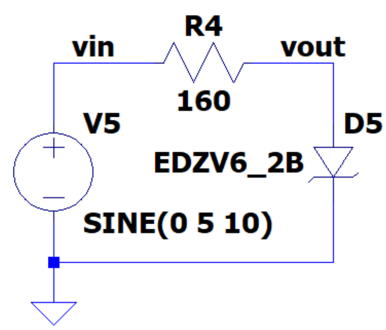
LED:	https://www.vishay.com/docs/83171/tlur640.pdf
1N4001:	https://www.vishay.com/docs/88503/1n4001.pdf
1N4148:	http://www.onsemi.com/pub/Collateral/1N914-D.PDF
1N4735:	https://www.mouser.com/datasheet/2/427/1n4728a-104110.pdf

3. **Use LTspice to simulate Circuit 1 & Circuit 2.**

   1) Observe the voltage at "vin" and "vout". Write down the peak voltage of "vout".
   2) Repeat 1) but replace the LED diode with a regular diode.
   3) Repeat 1) but replace the diode with a Zener diode (Circuit 2).
   4) Repeat 3) but increase the input voltage V_p to 10V. Observe the waveform change and why?
   5) What if reverse the Anode and Cathode of the Zener diode in Circuit 2. Explain the changes.



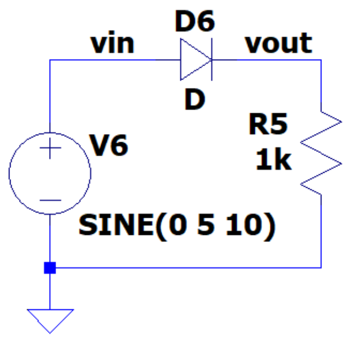
Circuit 1.



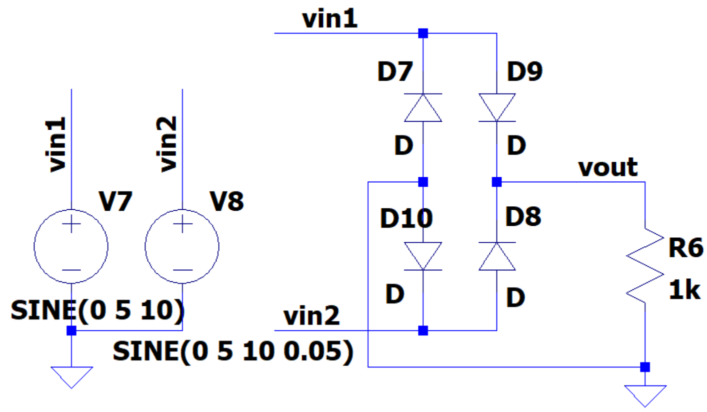
Circuit 2

4. **Use LTspice to simulate half-wave rectifier (Circuit 3).**

   1) Observe the voltage at "vin" and "vout". Write down the peak voltage of "vout".
   2) Repeat 1) but replace the regular diode with a Zener diode (forward bias). Observe "vout".
   3) Reverse the orientation of Zener diode in 2), i.e. reversed bias. Observe "vout".
   4) Increase the input voltage V_p to 10V. Observe "vout". Explain the changes.
   5) Add a $\mathbf{1}\mu$F capacitor in parallel with the load resistor R5. Observe "vout" again and explain.



Circuit 3



Circuit 4

5. **Use LTspice to simulate full-wave rectifier (Circuit 4).**
   1) Observe the voltages and waveforms of "vin1-vin2" and "vout". "vin1" and "vin2" should share the same amplitude and frequency, but with a 180 ° phase difference (i.e. "vin1" = -"vin2"), and the same common ground of the circuit. Explain.
   2) Repeat 1) with a 0.22μF capacitor connected at load in parallel. Explain the changes.
   3) Increase the resistance to 100kΩ and capacitance to 10 μF (or the largest you can find in lab).
   4) Repeat 2) but use Zener diode in reverse orientation, with $R = 10k\Omega, C = 0.22\mu F$.
   5) Repeat 4) with $R = 100k\Omega, C = 10\mu F$.

LAB EXPERIMENTS:

1. **Implement and measure Circuit 1 & 2 in Prelab Experiment 3 on breadboard, and compare the hand-calculation and LTspice results.**

2. **Implement and measure Circuit 3 in Prelab Experiment 4 on breadboard, and compare the hand-calculation and LTspice results.**

3. **Implement and measure Circuit 4 in Prelab Experiment 5 on breadboard, and compare the hand-calculation and LTspice results. (Careful with the ground setup.)**

POSTLAB REPORT:

Include the following elements in the report document:

<table>
<tr><th>Section</th><th colspan="2">Element</th></tr>
<tr><td>1</td><td colspan="2">Theory of operation
Include a brief description of every element and phenomenon that appear during the experiments.</td></tr>
<tr><td>2</td><td colspan="2">Prelab report
1. Hand calculation results of Prelab Experiment 3~5.
2. LTspice schematics and simulation results of Prelab Experiment 3~5.</td></tr>
<tr><td rowspan="5">3</td><td colspan="2">Results of the experiments</td></tr>
<tr><th>Experiments</th><th>Experiment Results</th></tr>
<tr><td>1</td><td>Screenshots of LTspice simulations and oscilloscope waveforms, and V_p, V_{pp} values.</td></tr>
<tr><td>2</td><td>Screenshots of LTspice simulations and oscilloscope waveforms, and V_p, V_{pp} values.</td></tr>
<tr><td>3</td><td>Screenshots of LTspice simulations and oscilloscope waveforms, and V_p, V_{pp} values.</td></tr>
<tr><td rowspan="3">4</td><td colspan="2">Answer the questions</td></tr>
<tr><th>Questions</th><th>Questions</th></tr>
<tr><td>1</td><td>Why add a capacitor at load in Experiment 2 and 3?</td></tr>
<tr><td>5</td><td colspan="2">Conclusions
Write down your conclusions, things learned, problems encountered during the lab and how they were solved, etc.</td></tr>
<tr><td>6</td><td colspan="2">Images
Paste images (e.g. scratches, drafts, screenshots, photos, etc.) in Postlab report document (only .docx, .doc or .pdf format is accepted). If the sizes of images are too large, convert them to jpg/jpeg format first, and then paste them in the document.

Attachments (If needed)
Zip your projects. Send through WebCampus as attachments, or provide link to the zip file on Google Drive / Dropbox, etc.</td></tr>
</table>

5. REFERENCES & ACKNOWLEDGEMENT

1. Adel S. Sedra & Kenneth C. Smith, "Microelectronic Circuit", 6th Ed.
2. https://en.wikipedia.org/wiki/Diode
3. Related diode datasheets.

I appreciate the help from faculty members and TAs during the composing of this instruction manual. I would also thank students who provide valuable feedback so that we can offer better higher education to the students.