

EXPERIMENT 8: DIODE CHARACTERISTICS AND CIRCUITS

5/9/06

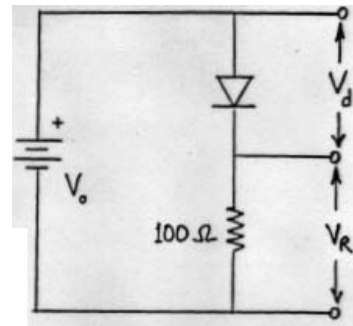
In this experiment we will measure the I vs V characteristics of Si, Ge, and Zener p-n junction diodes, and investigate the use of diodes in a variety of circuits, including DC power supplies.

The properties of a p-n junction are very dependable. All forward biased Si p-n junctions have a voltage drop of about 0.6 V across the junction when a current of about 5 mA is flowing through the junction. Similarly all forward biased Ge p-n junctions have a voltage drop of about 0.25 V at 1 mA. If an ordinary diode is reverse biased, only a very small current (10^{-6} - 10^{-10} A) flows until the peak inverse voltage (PIV) is exceeded, at which point the diode conducts a large current and is usually permanently damaged. Zener diodes have a well defined reverse avalanche breakdown voltage (available between 3 V and 200 V) and are often used as voltage regulators.

1. (a) Use the circuit shown at the right to measure the voltage vs current (V_d vs I_d) characteristics of a forward-biased Si diode. Start by adjusting V_0 to get $I_d = 50 \mu\text{A}$ and then work up to $I_d = 50 \text{ mA}$, increasing I_d by a factor of 2 or 3 at each step.

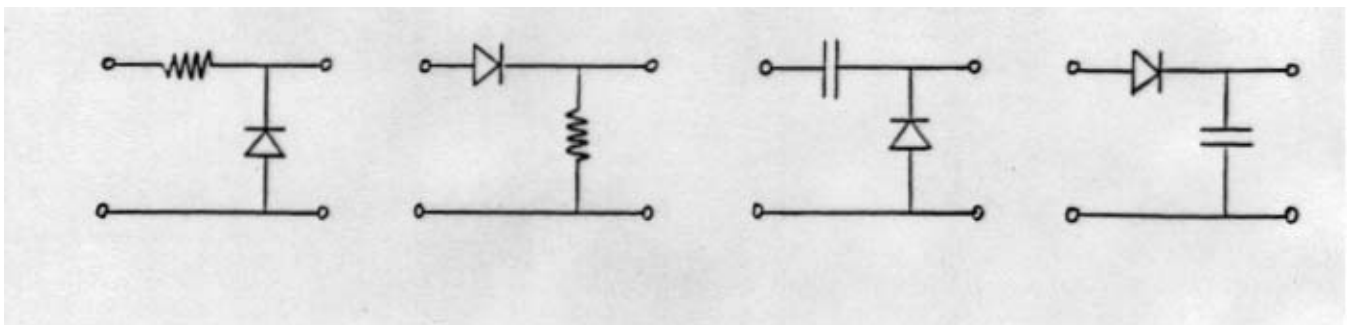
Take a corresponding set of measurements for a Ge diode, and then make a graph (on linear paper) of V_d vs I_d for the two cases.

- (b) For the Zener, measure just enough points to decide whether the diode is made of Si or Ge. Then turn the Zener around and determine the voltages required to produce reverse currents of 10 mA, 20 mA, and 30 mA.



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2. The four circuits shown below are diode-resistor and diode-capacitor combinations that demonstrate clipping, rectification, level shifting and filtering. Use the sine wave output from the function generator with $f = 1 \text{ kHz}$ as the AC voltage source, and adjust the amplitude for about 4 volts peak-to-peak. Use $R = 1 \text{ k}\Omega$ and $C = 0.1 \text{ }\mu\text{F}$. For each circuit make a sketch showing both the input voltage and the output voltage for the Si diode. Write a sentence or two explaining what the circuit does. Observe what happens (no sketches required) when you reverse the diode and when you use the Ge diode instead of the Si diode.



#1

#2

#3

#4

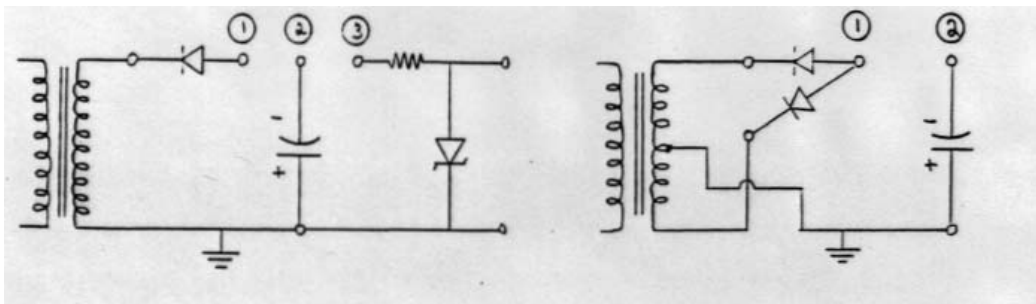
In the remaining parts of the lab we will study the properties of some diode rectifier circuits and their use in D.C. voltage sources.

3. Circuit #4 above can be thought of as a simple DC voltage supply. Observe what happens when you attach a $50 \text{ k}\Omega$ load resistor across the output. Sketch the resulting output wave form, and measure the ripple (i.e. the peak-to-peak variation of the output voltage). Try to estimate the ripple based on what you know about RC circuits, and compare your estimate with the measured ripple.

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The following steps involve using a pre-wired “rectifier board” and a 6.3 volt center-tapped transformer.. The transformer can provide either a single $V_{RMS} = 6.3\text{ V}$ output (by grounding one yellow terminal and taking the output from the other) or a pair of $V_{RMS} = 3.5\text{ V}$ outputs 180° out of phase with each other (by grounding the black center-tap terminal and taking the outputs from the two yellow terminals).

4. Set up the half-wave rectifier circuit shown below, using the $V_{RMS} = 6.3\text{ V}$ output from the transformer.
 - (a) Sketch the circuit and label all of the component values. Make a sketch of the wave form at point 1 (if your results look funny, try connecting a $100\text{ k}\Omega$ load resistor between 1 and ground).
 - (b) Connect points 1 and 2 and observe the voltage at 2.
 - (c) Finally connect points 2 and 3 (leaving points 1 and 2 connected) to make a complete DC power supply with voltage regulation provided by a Zener diode. Observe the output voltage with the scope. See if you can find a way to determine the current through the Zener diode as a function of time. Make a sketch of the output voltage and the Zener current.
 - (d) Use a DMM to measure the magnitude of the output voltage (meter on DC) and the ripple (meter on AC) with no load attached at the output. Then repeat the measurements with load resistors of 2000Ω , 500Ω , and 100Ω .



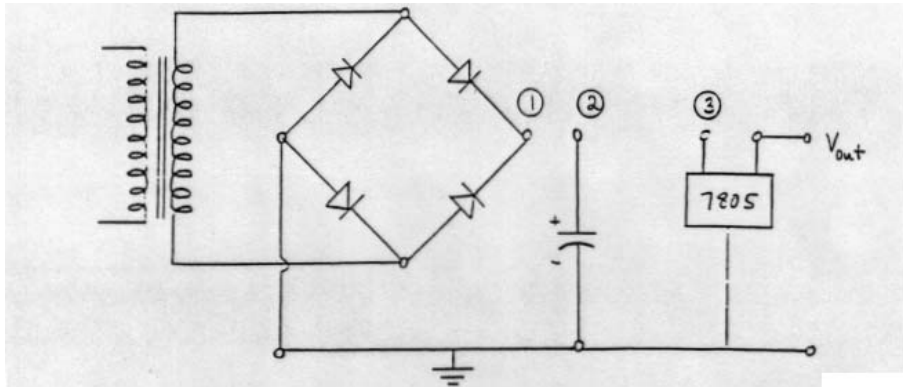
HALF-WAVE RECTIFIER

FULL-WAVE RECTIFIER

5. Remove the wires connecting points 1,2 and 3. Use the 3.5 V center tapped transformer outputs to construct the full-wave rectifier shown above.

Make a sketch of the wave form at point 1. In what ways does the result differ from what you saw for the half-wave rectifier circuit of part 4?

6. Use the rectifier board and the $V_{RMS} = 7\text{ V}$ transformer output to construct the DC voltage supply shown below. This circuit makes use of a full-wave bridge rectifier, and the voltage regulation is provided by a 7805 solid state voltage regulator. Repeat steps (a)—(d) of part 4 for this circuit.



APPENDIX: PROPERTIES OP SOLID STATE DEVICES USED IN THIS EXPERIMENT

DIODES	MATERIAL	TYPE	$I_{F,max}$	DISSIPATION	I_R	PIV
1N4005	Silicon	Rectifier	1.0 A	1 W	10 mA	600 V
1N100	Germanium	Signal	0.2 A	80 mW	50 mA	80 V
1N4731A	Silicon	Zener	1.0 A	1 W	230 mA	4.3 V

7805 VOLTAGE REGULATOR

$V_{out} = 5.0V \pm 4\%$
 $I_{out} = 1\text{ A max}$
 $(V_{in} - V_{out}) \geq 2.0\text{ V}$

Ripple Rejection = $-75\text{dB @ } 120\text{Hz}$
 Line Regulation = $\pm 2\text{mV } 7V_{DC} \leq V_{in} \leq 25V_{DC}$
 Load Regulation = $\pm 25\text{mV } 5\text{ mA} \leq I_{out} \leq 1.5\text{ A}$