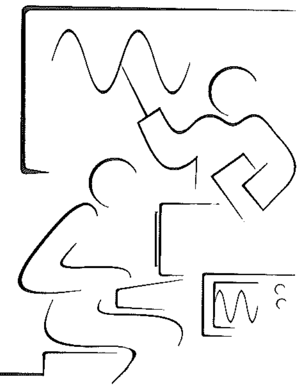
Lab 3
Diodes and Rectification



In this exercise you will become familiar with diodes and their use in simple rectifier circuits. You will use an oscilloscope and learn some fundamentals of AC circuits. You will also learn a useful technique called "breadboarding" that will allow you to construct prototype circuits without soldering components together.

Reading Assignment

Building Scientific Apparatus by J. H. Moore, C. C. Davis, and M. A. Coplan (Addison-Wesley, NY 1989). Sections 6.2-6.2.2 *Passive components* (pages 363-367 including Tables 6.6-6.7 and Figures 6.25-6.26 on pages 367-372); Section 6.3.1 *Diodes* (pages 382-385); Section 6.9 *Grounds and grounding* (pages 463-466); Section 6.10 *Hardware and construction* (pages 471-490); Section 6.11 *Trouble shooting* (pages 490-501).

Materials Required

Heathkit ET-1000 Circuit Design Trainer (1); Resistors @1/4 W: 430 Ω (1), 1 kΩ (1), 5.1 kΩ (1); Diodes: 1N4002 (4), Zener: 1N5242B (1), LED: LN21RPHL (1); Capacitor: Electrolytic: 100 μF @ 50 V (1); Hookup wire (solid); Wire stripper (1); Multimeter: 4 1/2 digit (1); Oscilloscope: Dual-channel (1).

I. Introduction

In this exercise you will "breadboard" circuit components using the Heathkit Circuit Design Trainer. This device contains a "breadboard" (shown in Figure 3-1). The breadboard will allow you to interconnect circuit components without soldering or twisting their leads together. Familiarize yourself with its layout. Some of the breadboard sockets are "common" (connected to each other). Use an ohmmeter to check the continuity between different sockets on the breadboard.

Know how the breadboard sockets are interconnected before you continue!

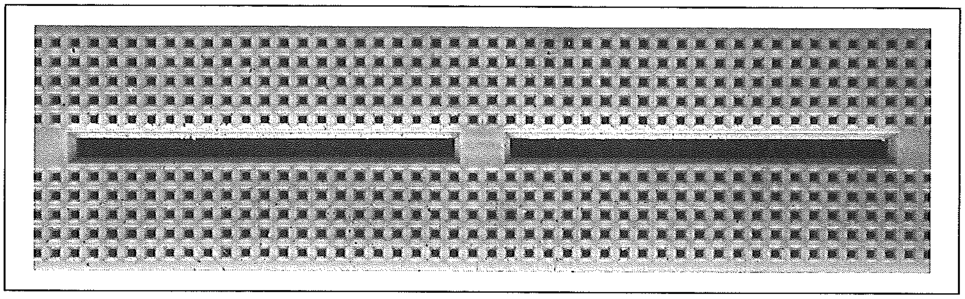


Figure 3-1. Circuit Breadboard

You will need to prepare short lengths of hookup wire to interconnect the various components of a circuit together. Use a wire-stripper (or similar tool) to cut the hookup wire to length and to bare each end for proper insertion into a breadboard socket. Component leads (resistors, capacitors, diodes, etc.) are inserted directly into a socket on the breadboard. *Do not cut the components leads*. If necessary, insulate the leads from each other with "spaghetti" (the insulation stripped from a length of hookup wire). Cut the insulation to length and slip the "spaghetti" over a bare wire as required. Always use insulated wire when you connect a circuit to a power supply, the transformer, or other elements in the Trainer.

II. Transformer Characteristics

The Heathkit Circuit Design Trainer contains a transformer with secondary leads attached to sockets as shown schematically in Figure 3-2. Use a multimeter to measure the AC voltage across the secondary windings of the transformer and between each secondary lead and the center tap (CT). Record the results in your lab report.

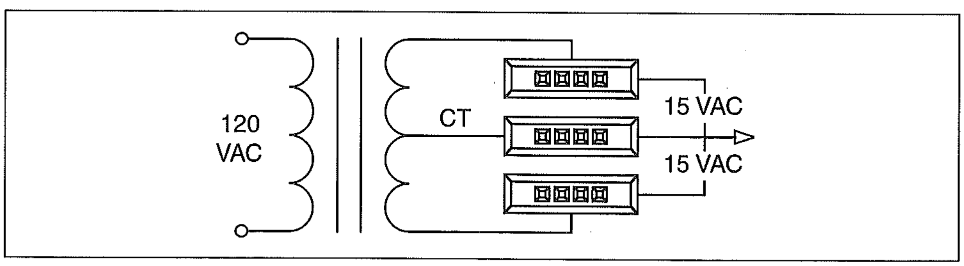


Figure 3-2. Transformer Connections

Connect the Transformer's center tap (CT) to oscilloscope ground. Set both inputs to AC coupling. Display the AC waveforms between each secondary lead and the center tap. Use both vertical amplifier inputs of the oscilloscope to display the waveforms simultaneously. Set both inputs to DC coupling and look at the amplitude and the phase of each waveform. Compare and discuss your AC and DC measurements. Notice that the amplitude of each AC waveform does not agree with its corresponding multimeter reading. Why?

III. Half Wave Rectification

Wire the half-wave rectifier circuit as shown in Figure 3-3. Maintain the correct diode polarity! Observe the output AC waveform across the 1 kΩ resistor with the oscilloscope. Set the vertical amplifier input to "DC", and then to "AC". Discuss your observations.

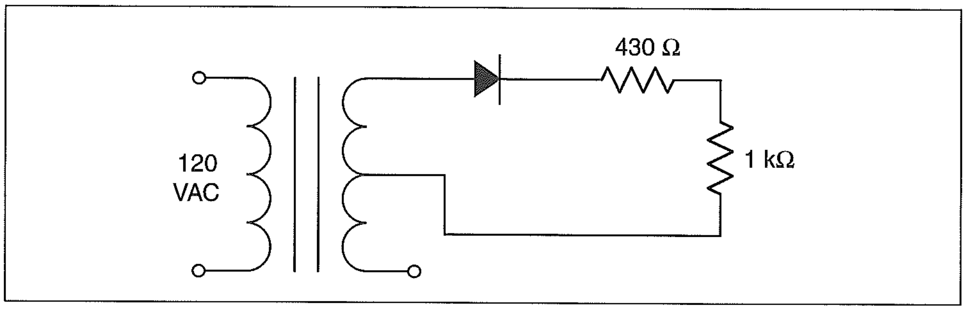


Figure 3-3. A Half Wave Rectifier

IV. Full Wave Rectification

Wire the full-wave rectifier circuit shown in Figure 3-4. Do the polarities of the diodes shown in the schematic make sense? Observe the output AC waveform across the 1 kΩ resistor with an oscilloscope. Set the vertical amplifier input to "DC", and then to "AC". Compare your waveform amplitudes with the voltages read on a multimeter. Discuss and compare your observations with those of the half-wave rectifier circuit in Part III.

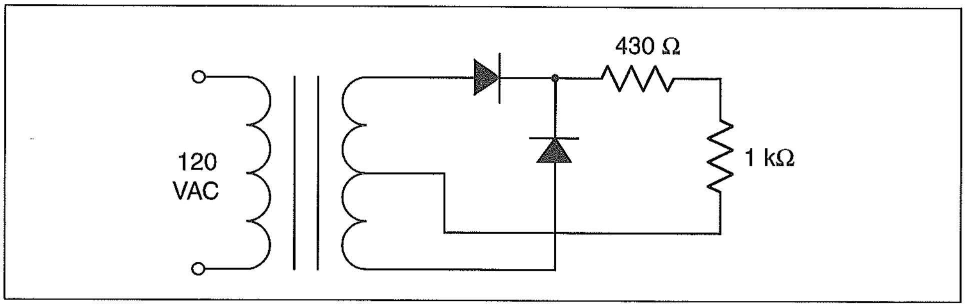


Figure 3-4. A Full Wave Rectifier

V. Filtering

Add the electrolytic capacitor to the circuit as shown in Figure 3-5. Observe the polarity of the capacitor. Electrolytic capacitors can be damaged if the polarity is not correct. In some cases an incorrect connection can be visually spectacular, and loud!

Observe the waveform across the capacitor and across the 1 kΩ resistor with an oscilloscope. Measure the corresponding voltages with a multimeter.

Note The voltage across the capacitor is greater than the voltage you measured with the digital multimeter across the transformer secondary.

Is Conservation of Energy violated? Discuss the "filtering" effect of the capacitor.

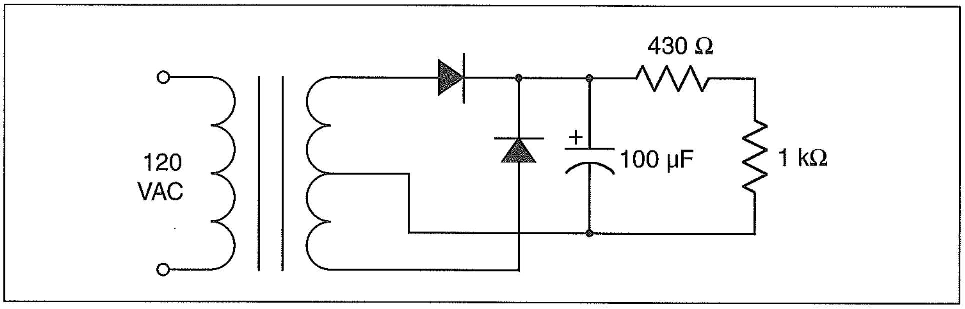


Figure 3-5. A Filtered Full Wave Rectifier

VI. Zener Diode

Add the zener diode to the circuit as shown in the schematic diagram below. Measure the output voltage with a multimeter, and observe the corresponding waveform with an oscilloscope. What function does the zener diode serve in this circuit? (**Hint:** It may help to temporarily remove the capacitor from the circuit.)

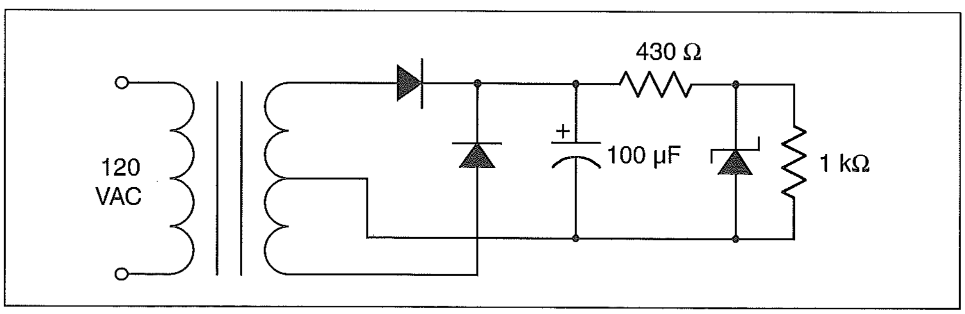


Figure 3-6. A Zener Diode Voltage Regulator

VII. Light Emitting Diode

Add a light emitting diode (LED) to your circuit as shown below. Substitute a 5.1 kΩ resistor for the 1 kΩ load resistor. Note the change in the luminous intensity of the LED.

Check all voltages and record their values before and after the change of load resistor. Does a change in voltage or current (or both) produce the change in the luminous intensity of the LED?

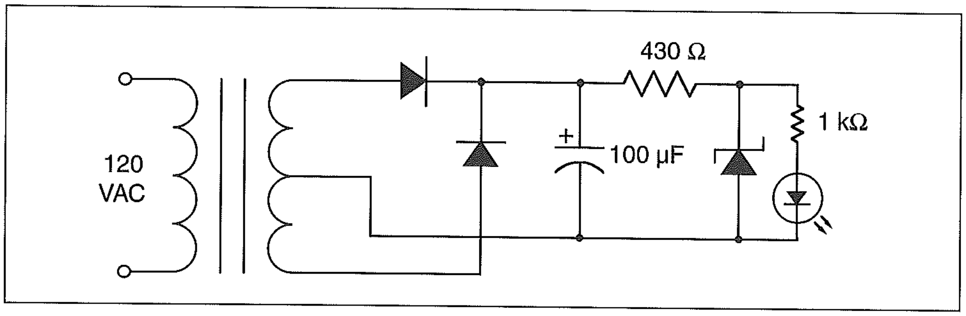


Figure 3-7. An LED Indicator

VIII. Full Wave Bridge

A common type of rectifier circuit is called a "full wave bridge". Wire the full-wave bridge rectifier circuit shown in Figure 3-8. Observe the output AC waveform across the 1 kΩ resistor with an oscilloscope. Set the vertical amplifier input to "DC", and then to "AC". Compare your waveform amplitudes with the voltages read on a multimeter and discuss your observations. Explain the operation of the bridge rectifier and compare your observations with those of the full wave rectifier in Part IV.

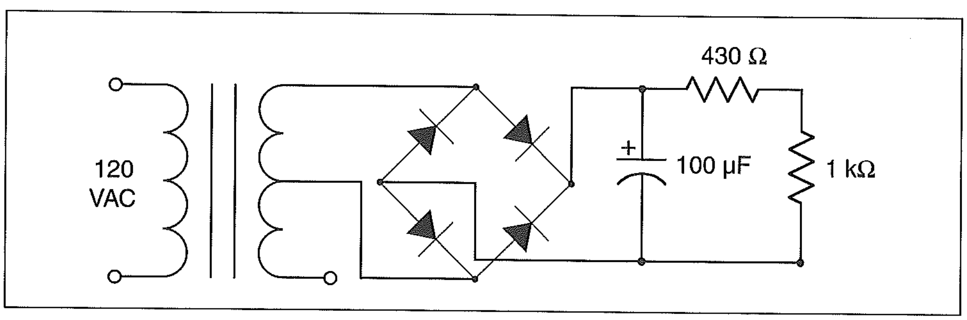


Figure 3-8. A Full Wave Bridge Rectifier