385L / 5585 - Laboratory 3 - Introduction to Power Supplies / 20 FEB 2017
Due: 06 MAR 2017

Objectives:
1. Understand the secondary voltage output of a transformer
2. Proper use of diodes for rectification of an AC signal
3. Filtering of rectified AC signals
4. Use of solid state voltage regulators

Equipment and Parts:
1. Digital multimeter and probes
2. Oscilloscope with probes
3. Capacitance meter
4. ELENCO electronics kit
5. Various capacitors, resistors and diodes
6. 12.6 VAC filament transformer
7. 7812 Voltage Regulator

3-0 Note on the Transformers and Connections

Attached to the 12.6 VAC transformers at each station is a gray cord. Within the gray cord are four wires, three of which are insulated (red, clear, black). The red and black wires are (should be) soldered to the opposite ends of the secondary and the clear wire to the center tap (CT). The other end of the wires are soldered to a multipin connector for insertion to the breadboard. When placing this plug on the breadboard be sure the three pins are in sockets which are not attached to any other component on the board. Although the voltage is only 12 VAC the output current can be as much as 1 A. Be extremely careful when handling the bare plug; always be sure the switch is off before disconnecting the plug from the breadboard or the transformer.

3-1 Transformer Output Voltage Measurements

Using an empty breadboard, connect the transformer (via the pin connection) to the breadboard. The red and black wires are attached to the opposite ends of the secondary winding of the transformer and the clear wire is connected to the center tap. The secondary of a transformer has no explicit ground until one is connected to it. Connect either the black or red wire to ground, **but not both. Be sure only one wire is grounded or the transformer will short and be destroyed.** Use both the oscilloscope and the DMM to measure the AC voltage with respect to ground at the other two wires (i.e., measure from the center tap to ground and across the entire secondary winding). Turn the power off and remove the ground lead from one of the end contacts. Now ground the center tap and repeat the AC voltage measurements. How does grounding the transformer in the two configurations influence the output voltage? Are the output voltages influenced in magnitude only or also in their phase relationships?

3-2 Diodes

Connect the function generator, operating at ν=60 Hz and V_{pp}=5 V, to a power diode and 100-ohm resistor in series and then to ground. Connect channel 1 of the oscilloscope to the output of the function generator and channel 2 in between the diode and resistor, measuring the potential with respect to ground. Does the charge flowing in this circuit exhibit an ohmic response? If not, how does the current differ from Ohm's law? Use the DMM in resistance mode and on the proper scale for testing diodes to determine the anode and cathode of the diode (look up what cathode means if unfamiliar). How are the two ends of the diode distinguished with markings? The unique I-V characteristics of a diode make it extremely useful in the construction of DC power supplies.

3-3 Half-wave rectified power supply

Ignoring the center tap of the transformer, wire the circuit shown in the figure below. Figure 2 shows a diagram of the circuit on a breadboard. One end of the transformer is to be grounded while the other is attached to the diode. Be sure the diode is connected in the circuit properly. Draw a sketch of the input voltage and the output voltage. What effect does the diode have on the waveform? If the diode were to be reversed, how would the output voltage be modified?

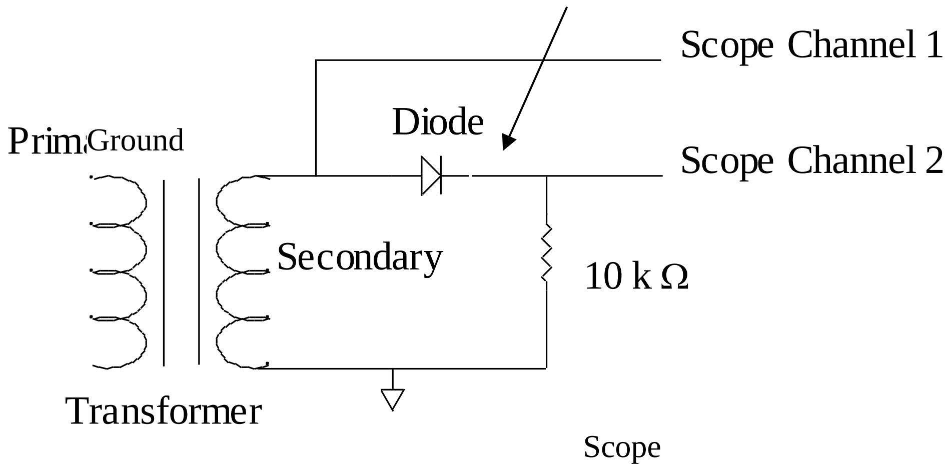

Figure 1. Half-wave rectifier circuit diagram.

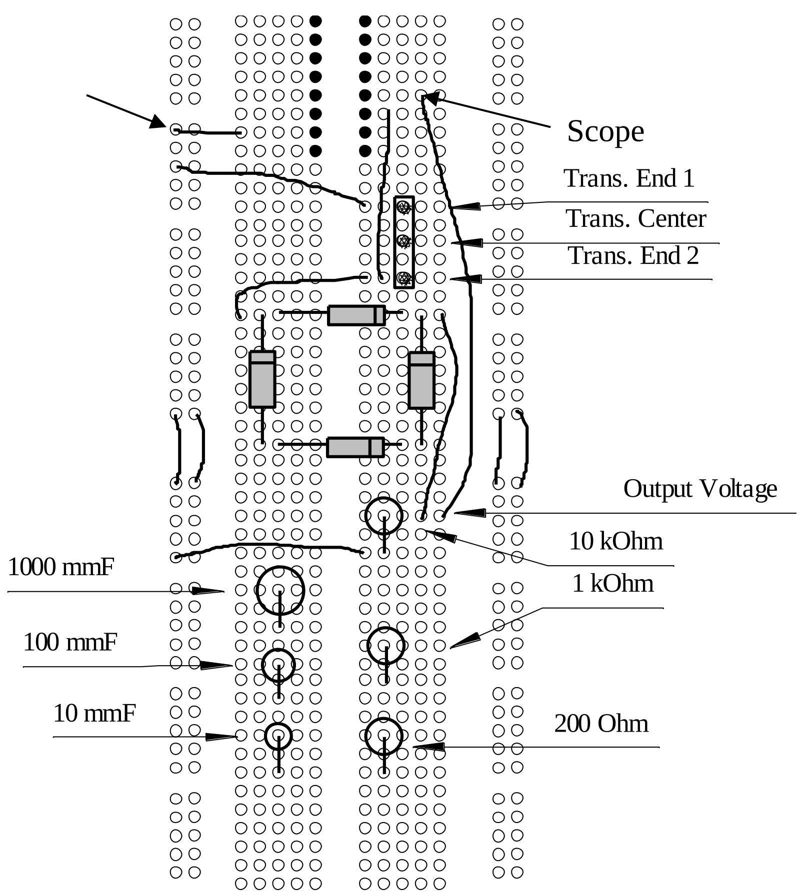

Figure 2. Breadboard diagram of half-wave rectifier.

3-4 Full-wave Rectified

Wire the circuit shown in the figure below. In this circuit the center tap of the transformer is grounded**.** **<u>Be sure to remove the ground from the end of the transformer (from 3-3 configuration).</u>** This circuit uses two diodes to modify the AC waveform. Again compare the voltage across the load resistor to the input voltage. What difference is observed with this circuit as compared to the previous circuit? How does the voltage maximum compare?

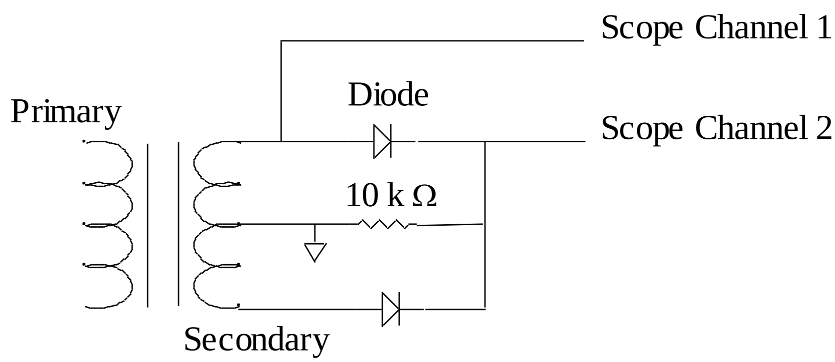

Figure 3. Full-wave rectifier.

<u>3-5 Bridge Rectifier</u>

Wire the following circuit using now four (4) diodes in the bridge configuration (below). Again be cautious with wiring the output of the transformer (**remove the center tap from ground from the previous circuit**). The center tap is ignored in this circuit. Repeat the AC voltage measurements of the input and output voltages. How do these compare to the previous two circuits?

<u>3-6 Filter Capacitors</u>

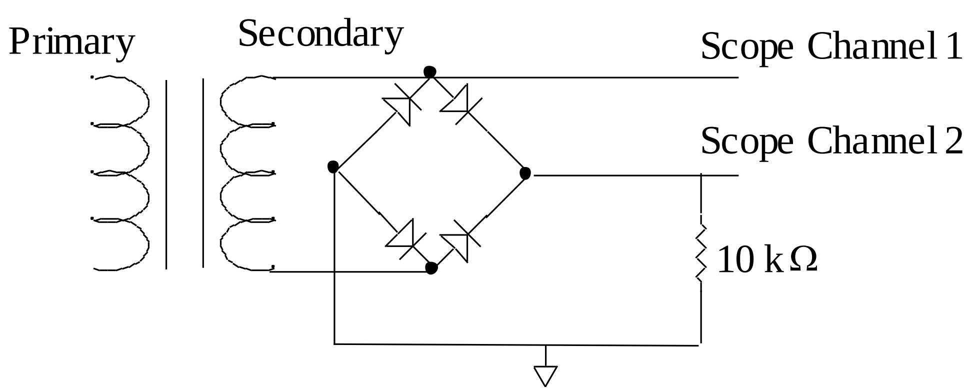

Figure 4. Bridge rectifier.

By filtering the output of the diode array a DC voltage can be approximated. The quality of the filter determines to what extent the DC voltage is obtained. The measure of a filter is the remnant AC signal remaining on the DC signal. This AC signal is called the AC ripple.

One possible filter is a resistor and capacitor connected in parallel. Using the circuit of Figure 4, replace the 10 kΩ resistor with the following capacitor-resistor pairs (Figure 5) and measure the DC output voltage and the AC ripple. The capacitors which are being used are electrolytic and must be connected properly to avoid damage. **<u>The minus lead of the capacitor should always be connected to the lower potential side.</u>** Be sure the power is turned off prior to making any connections. A combination of three capacitors and two load resistors will be used to measure the filtering effects. The lower value of the load resistor will allow a large current and therefore the resistor will become hot quickly. **<u>To minimize heating, make the measurements quickly and turn the power off immediately.</u>** The values for the filter capacitor are 10 μF, 100 μF, and 1000 μF and the resistors to be used are 1 kΩ and 200 Ω.

The theoretical value for the ripple should be $V_{AC} = I_{load} / 2fC$, where f is the frequency and C is the capacitance. The current is the current through the load resistor.

3-7 Voltage Regulators

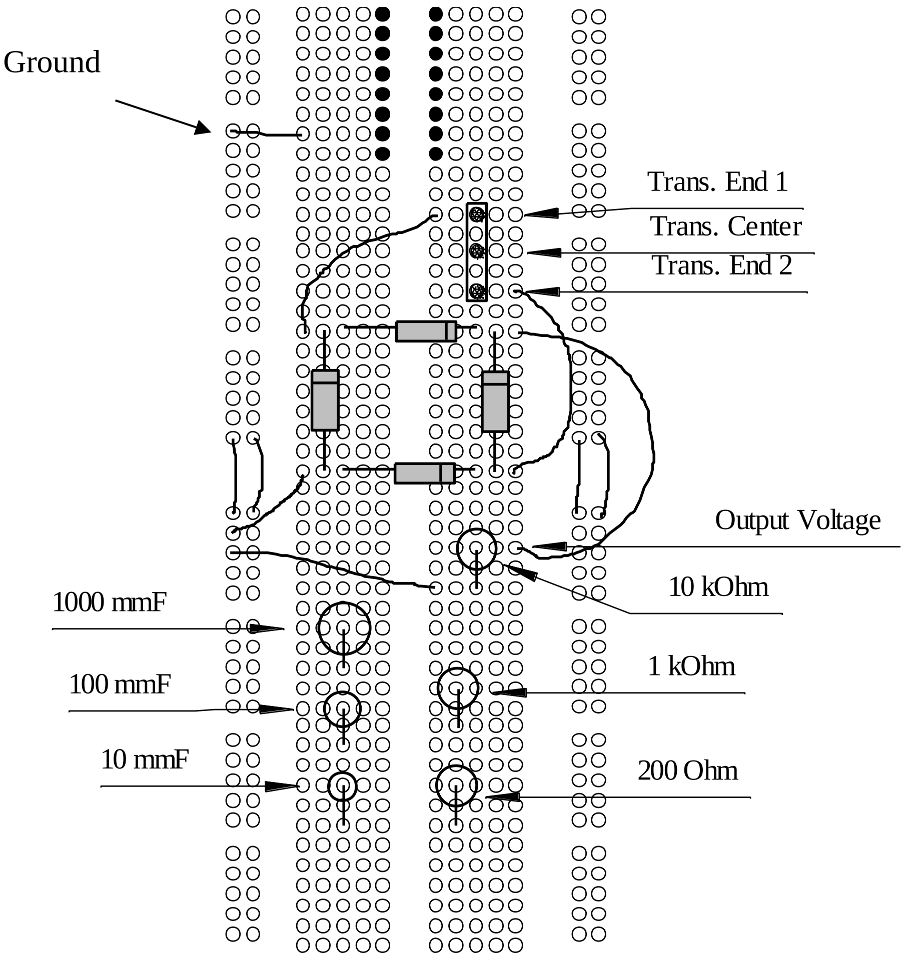

Figure 5. Breadboard layout for the bridge rectifier.

Using the circuit above with C=1000 μF and R=1 kΩ connect the voltage regulator to the circuit as shown below. Compare the voltage input to output of the voltage regulator. What is the ripple on the output of the regulator? What effect does the regulator have on the output voltage?

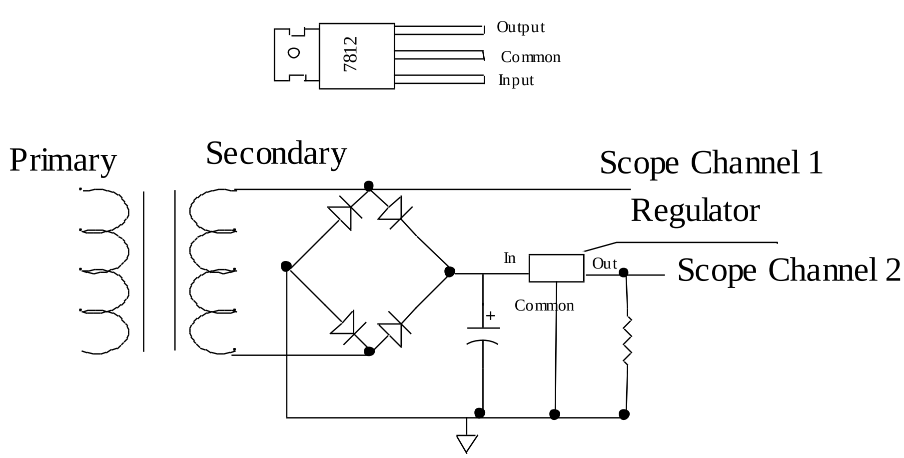

Figure 6. Voltage regulator circuit.