LABORATORY 4

Taking measurements with the Oscilloscope and building a Linear Power Supply

OBJECTIVE:

By using a transformer, the student will learn how to measure the amplitude and period of a common AC signal. Students will build a linear power supply. The linear power supply is a simple yet powerful device that can convert and regulate voltage needed in certain circuitry. At the end of Lab 4, the student should have a basic understanding of the components that make up the power supply as well as what each of these components do.

EQUIPMENT REQUIRED:

- Center Tapped Transformer
- 1N4001 Diode(s)
- 2200 µF Capacitor
- MCC 7805CT Voltage Regulator
- Load Resistor (resistance will vary)
- Oscilloscope
- Digital Multimeter (DMM)
- Banana Jumper Cables

PRE-LAB:

Please review again the documents on the course web site that describe the laboratory instructions for this course. You are to follow these instructions for each of your assigned labs.

1. One component of the linear power supply is the transformer. We are using a center tapped transformer that takes the 120V AC voltage from the wall outlet and steps it down to a lower voltage of roughly 16V AC. This enables the voltage to be used for powering lower voltage equipment, and in our case, for use in a power supply.

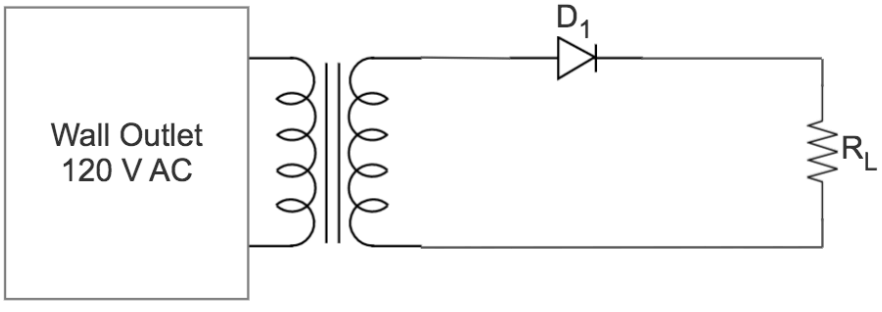
    a) What is a turns ratio in a Transformer and what does this tell you about the output voltage with respect to the input voltage?

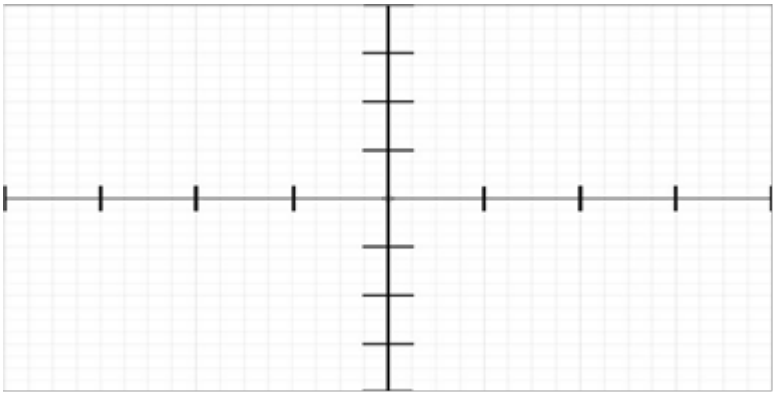
    b) What is meant by a “Center Tapped” Transformer?

2. Diodes are commonly used as one-way valves in circuits. They allow current to flow in one direction, but typically not in the reverse direction. Thus, they can be used in various configurations to convert a bipolar (both positive and negative) sine wave to a unipolar (all positive) waveform. This unipolar waveform can then be “filtered” to produce a DC voltage. This process (called rectification) is done using one of three configurations of diodes. Two configurations are called Half-Wave Rectifier circuits and a Full-Wave Rectifier circuits. When a center tap on the transformer is unavailable, a Full-Wave Rectifier is built as a Bridge Rectifier. This allows the negative peaks of the AC wave to flip to positive. With a center tap,

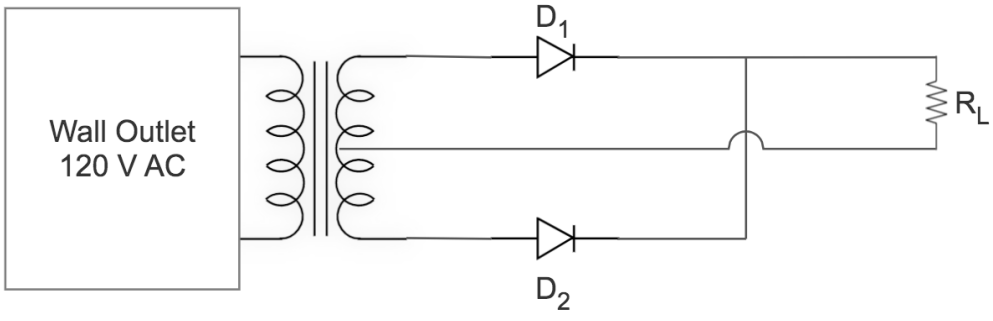
only two diodes are needed to maintain all peaks of the wave. For each of the rectifier circuits pictured below, the voltage between the center tap and either the top or bottom lead of the transformer is 8 V AC. This means, ignoring the center tap, the voltage from the top lead to the bottom lead is 16 V AC. This is your input into the rectifiers. Draw the predicted output measured across the load resistor:

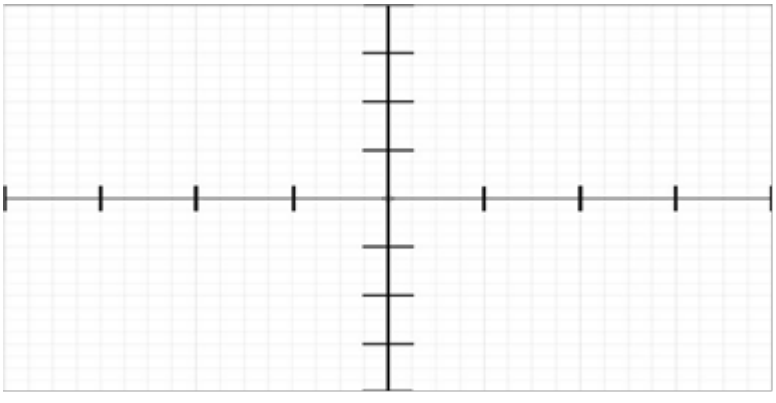
a) Half-Wave Rectifier



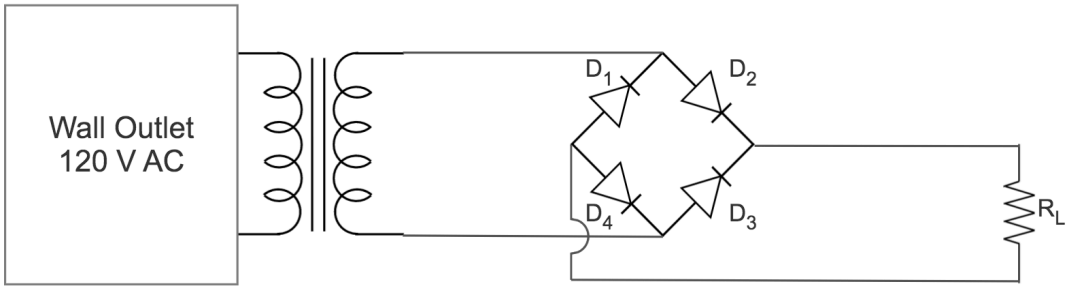


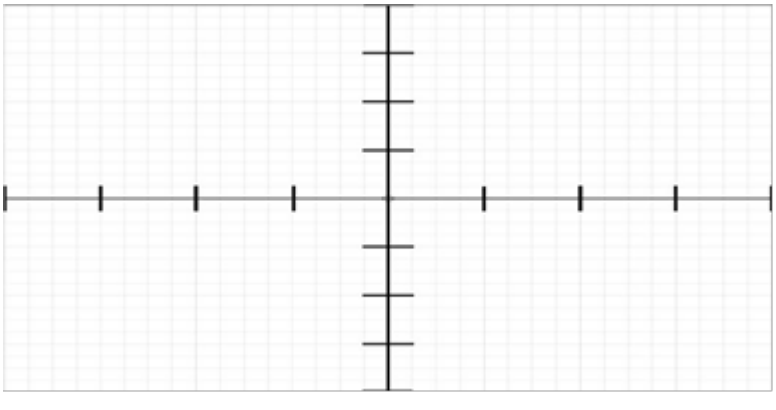
b) Full-Wave Rectifier:





c) Bridge Rectifier:





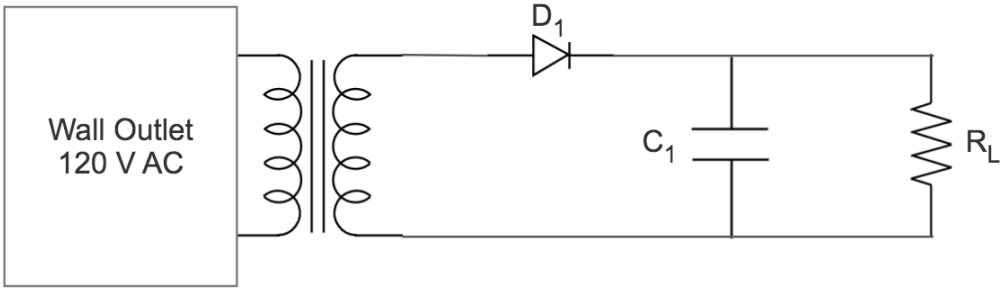
3. Since the rectified sine wave periodically drops to zero, it is not a DC level signal that may be needed to power certain circuits. A capacitor on the output can be used to help maintain a certain voltage level. The capacitor will charge up and hold the charge for the time between the unipolar peaks, providing a DC level.

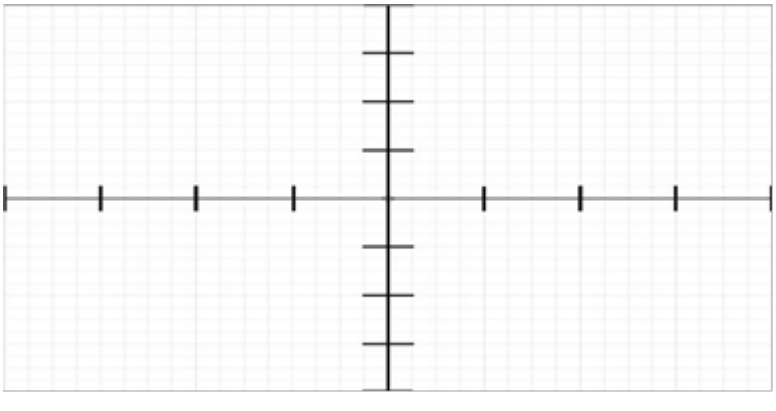
    a) The electrolytic capacitor that we are using in Lab 4 has a polarity. This means one side is positive and one side is negative. How can one tell which lead is which? Hint: Look at axial lead electrolytic capacitors as well as radial lead electrolytic capacitors.

    b) What will happen if the capacitor is put in the circuit the wrong way?

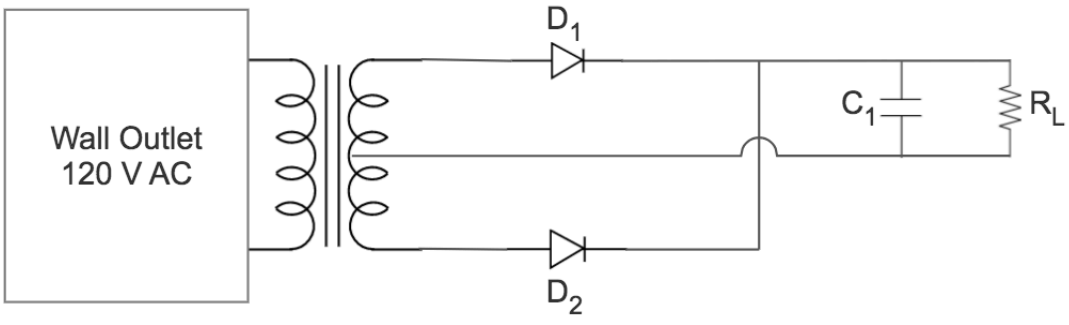
Draw the predicted output measured across the load resistor:

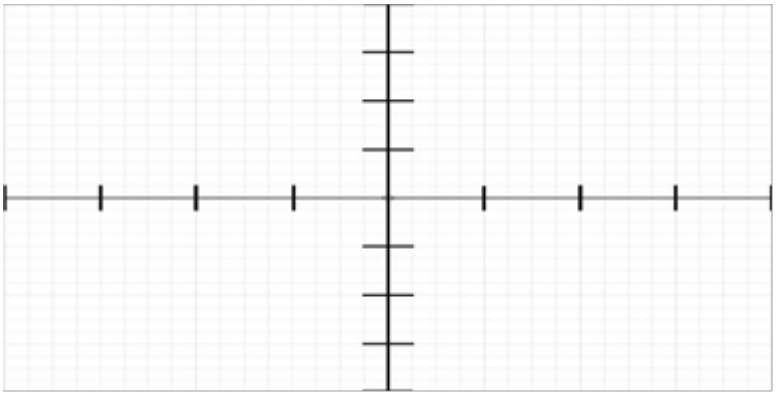
Half-Wave Rectifier with Smoothing Capacitor:



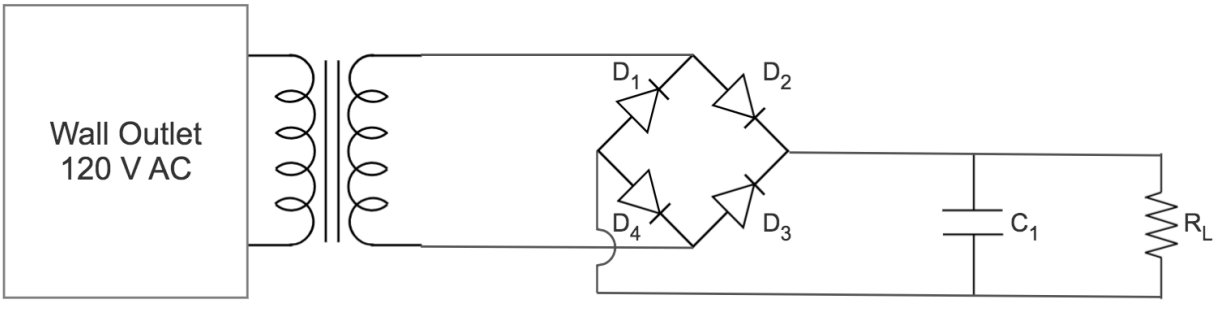


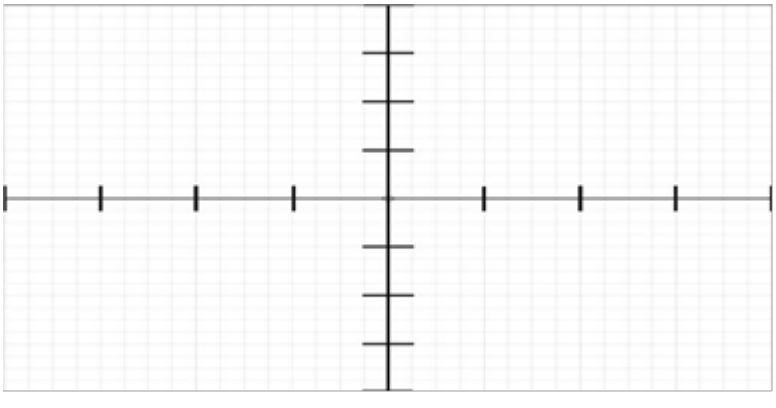
Full-Wave Rectifier with Smoothing Capacitor:





Bridge Rectifier with Smoothing Capacitor:



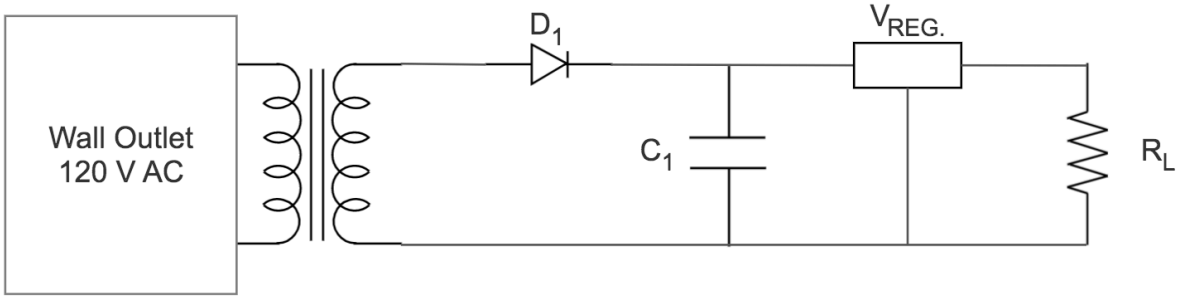


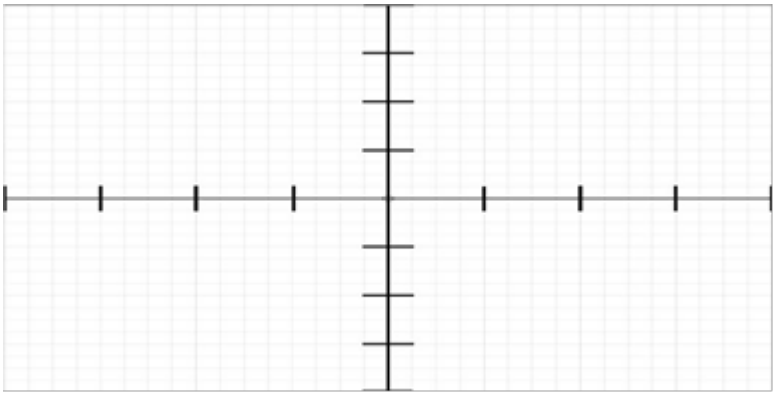
4. Become familiar with reading a data sheet. These documents give valuable information to the performance and function of certain chips and components. You should find the data sheet for the MCC 7805CT Voltage Regulator and answer the following:

    a) What is the maximum input voltage?

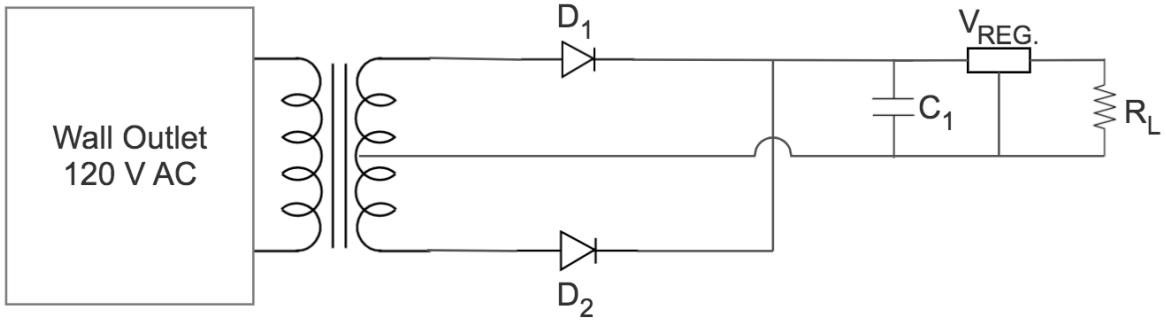
    b) What is the expected output voltage range for an input voltage range of 7V≤Vin≤20V?

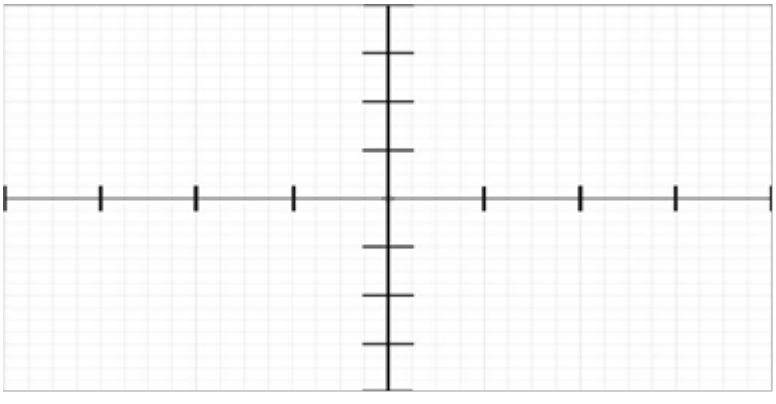
Half-Wave Rectifier with Smoothing Capacitor and Voltage Regulator:



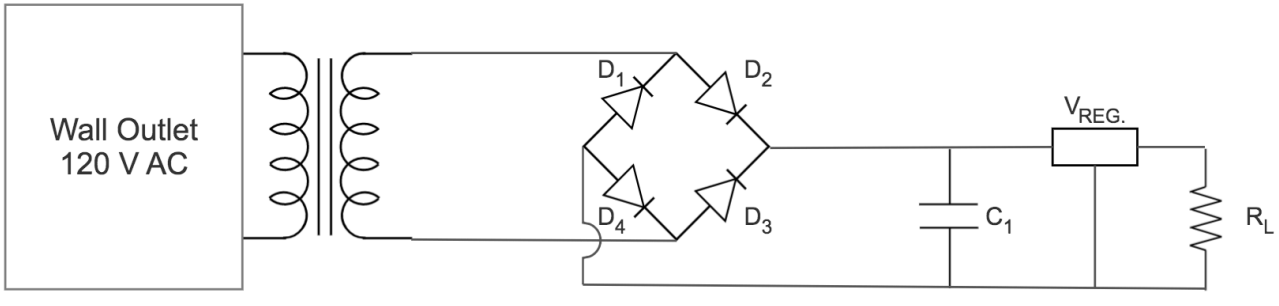


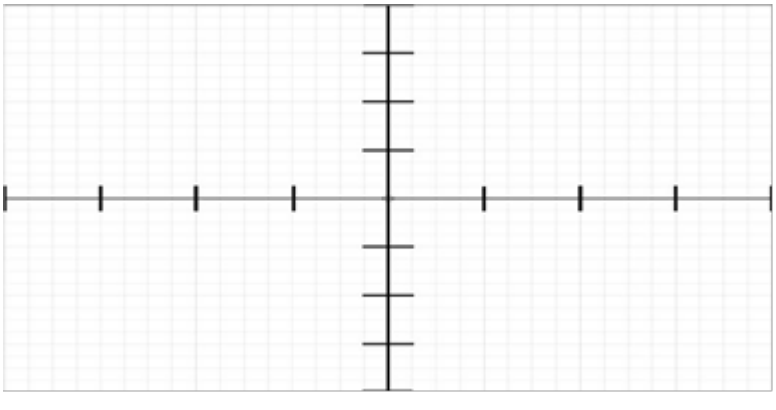
Full-Wave Rectifier with Smoothing Capacitor and Voltage Regulator:





Bridge Rectifier with Smoothing Capacitor and Voltage Regulator:





5. Create a lab procedure that will allow you, using both the oscilloscope and the DMM, to measure the voltage output of the three rectifier circuits:

    - Without smoothing capacitors (2)
    - With smoothing capacitors (3)
    - With smoothing capacitors and voltage regulator (4)

Include predicted results for what you expect to see from each circuit.

LAB:

In Lab you will be working with the components listed to build a linear power supply. This will involve using the transformer to step down the voltage from the 120VAC from the wall outlet to the 8V AC or 16 V AC on the output side of the transformer. This will then enter the half-wave, full wave, and bridge rectifiers (separately) to give a unipolar wave. A smoothing capacitor applied on the output will give a DC like signal. Zooming in on the oscilloscope will show that this is not the case and adding a voltage regulator will give a steady 5 Volt DC output. Students should follow their developed procedure, as well as instructor suggestions to complete these tasks over the three lab periods. The lab TAs will give more instruction on when certain tasks are to be accomplished in lab. Using the oscilloscope and DMM, the output of the transformer, rectifier circuits, and voltage regulator should be sketched and measured.

NOTE: Since the transformer will be plugged into the wall, 120VAC will be present on the transformer. Because of this, great care needs to be taken with the transformer and components attached to it. Before the transformer is ever plugged in, verify your circuit with one of the Lab TAs or Instructor.