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ECE 401

Section 5

10/26

Laboratory #4 (Pre-Lab)

Objective:

The objective of this lab is for a student to learn how to measure the amplitude and period of a common AC signal. Students will also build a linear power supply. 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
  - A variation of a classic transformer that varies by adding a third wire to the output that always will have a negative charge. Used in AC to DC applications such as full-wave rectifier.
- 1N4001 Diode(s)
  - A diode commonly found in AC to DC adaptors.
- 2200 µF Capacitor
  - A small electrolytic capacitor that temporarily store voltage in an electrical circuit.
- MCC 7805CT Voltage Regulator
  - A three-lead voltage regulator that allows only a certain voltage to pass through a circuit.
- Load Resistor (resistance will vary)
  - A simple resistor that will be measured to output a signal on an oscilloscope.
- Oscilloscope
  - An oscilloscope provides a graph of voltage in relation to time. This allows the observer to see how the voltage changes over time. This is most useful when dealing with periodic waveforms
- Digital Multimeter (DMM)
  - An electronic instrument used to measure electric voltage, current and resistivity. Multimeters provide the ability to measure different electrical signals as opposed to using individual meters.
- Banana Jumper Cables
  - A pair of wires connected to conductive clips to temporarily join electrical equipment. They are used in conjunction with an oscilloscope and DMM to measure electrical signals.

Pre-Lab:

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?

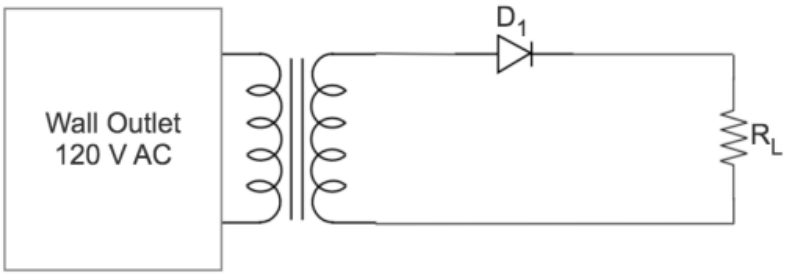
A turns ratio is how many turns the primary has around the core divided by the number of turns of secondary around the same core. If the number of turns in the primary coil is larger than the number of turns in the secondary coil, the secondary voltage will be smaller than the primary voltage. If the number of turns in the primary coil is less than the number of turns in the secondary, the secondary voltage will be larger than the primary.

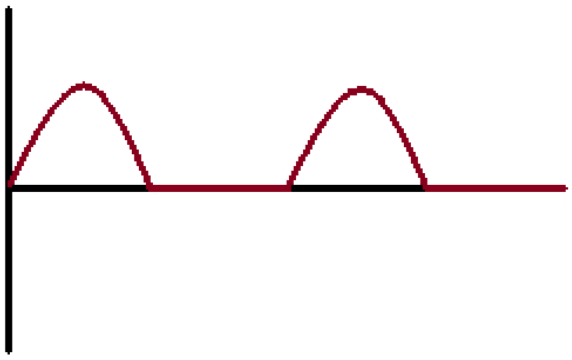
b) What is meant by a "Center Tapped" Transformer?

Because in the real world, rarely do commercial transformers have only four leads, thus a center taped transformer is used. A center tap is an electrical connection between the two ends of a transformer winding. By using a center tap, it is possible to utilize only a fraction of the winding voltage.

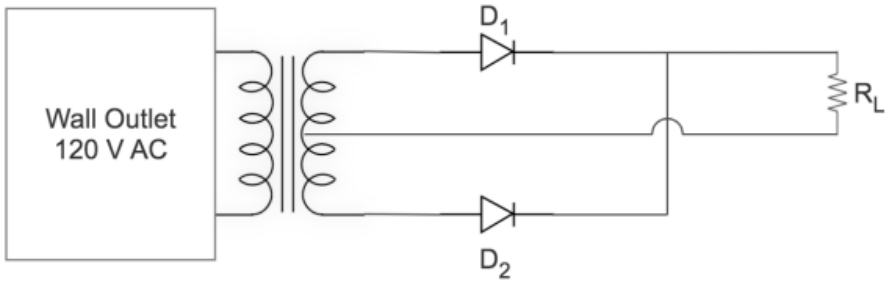
2. Diodes are commonly used as one-way valves in circuits. They allow current to flow in one direction, but typically not in the reverse direction. Thus, they can be used in various configurations to convert a bipolar (both positive and negative) sine wave to a unipolar (all positive) waveform. This 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:

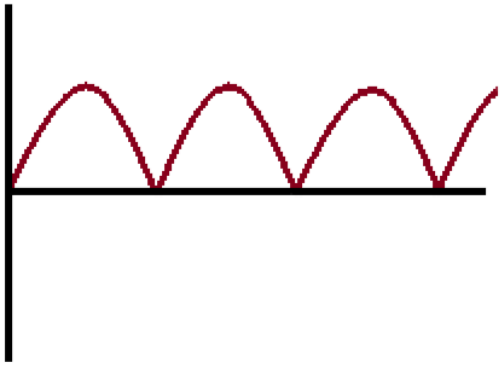
a) Half-Wave Rectifier



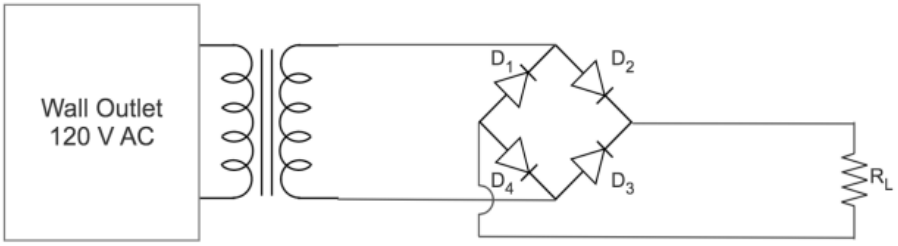


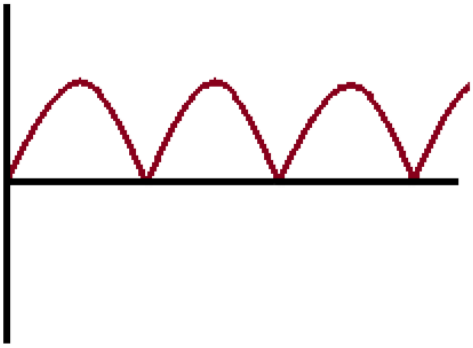
b) Full-Wave Rectifier:





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.

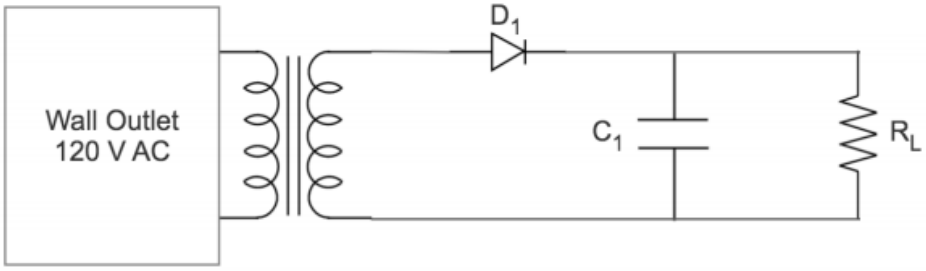
Axial lead electrolytic capacitors and radial lead electrolytic capacitors are usually marked with a stripe or arrows pointing to the negative lead.

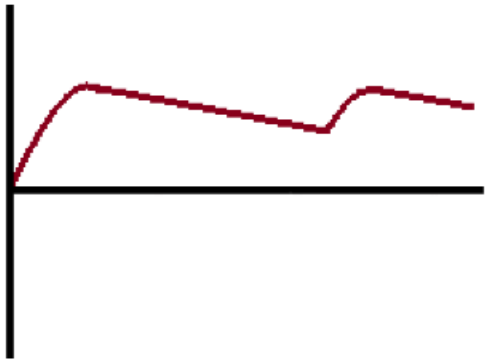
b) What will happen if the capacitor is put in the circuit the wrong way?

Dielectric breakdown can occur when the capacitor is placed with the wrong polarity in a circuit. This can result in a low-resistance current path between the two plates of the capacitor.

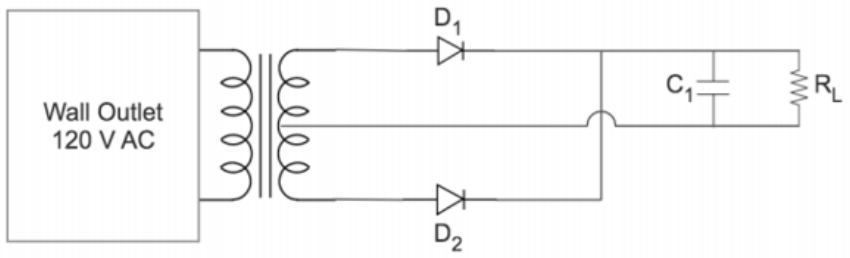
Draw the predicted output measured across the load resistor:

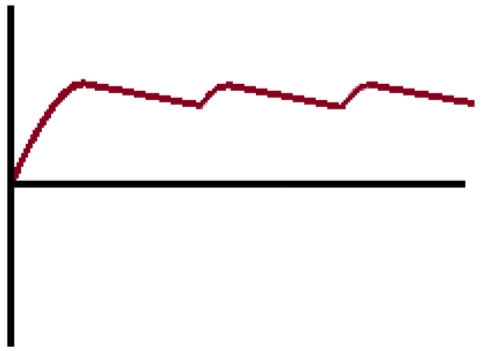
Half-Wave Rectifier with Smoothing Capacitor:



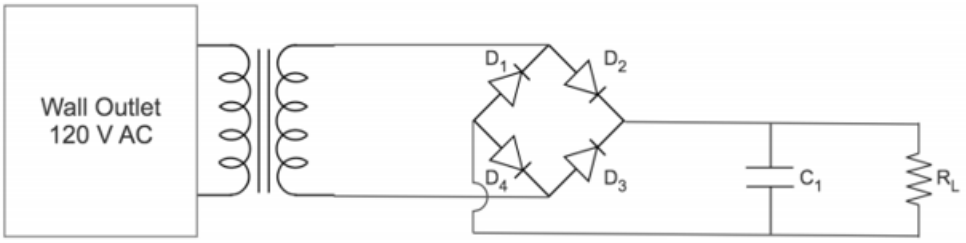


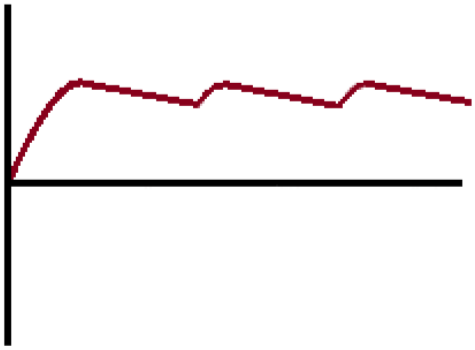
Full-Wave Rectifier with Smoothing Capacitor:





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:

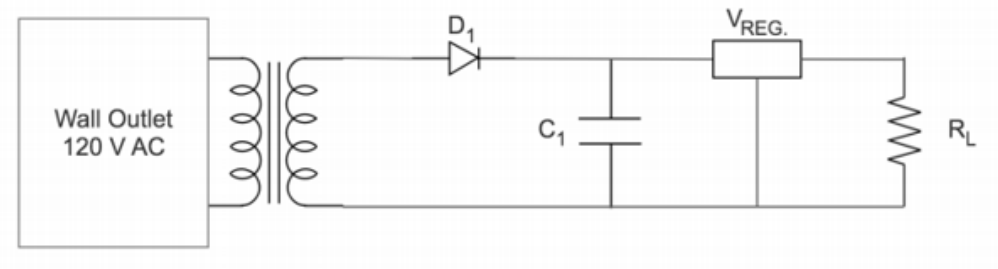
a) What is the maximum input voltage?

30V

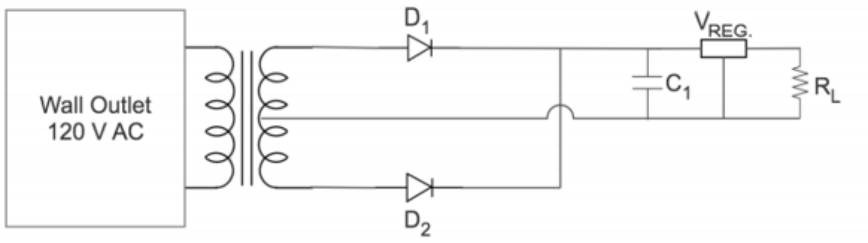
b) What is the expected output voltage range for an input voltage range of $7V \leq V_{in} \leq 20V$?

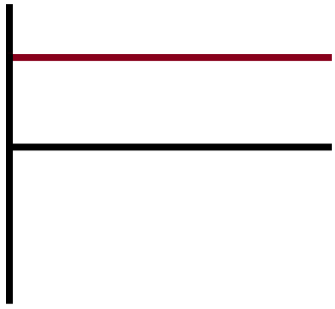
5V

Half-Wave Rectifier with Smoothing Capacitor and Voltage Regulator:

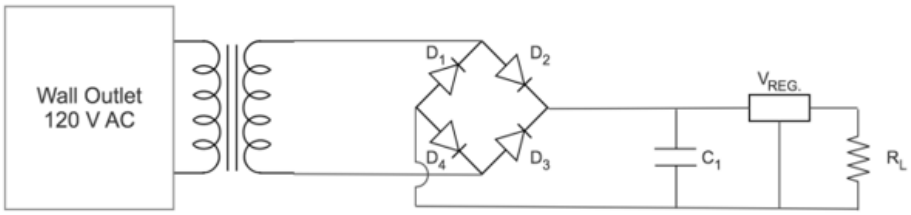


Full-Wave Rectifier with Smoothing Capacitor and Voltage Regulator:



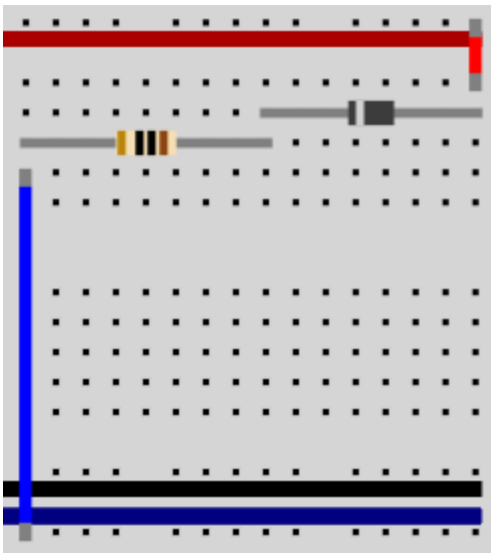


Bridge Rectifier with Smoothing Capacitor and Voltage Regulator:



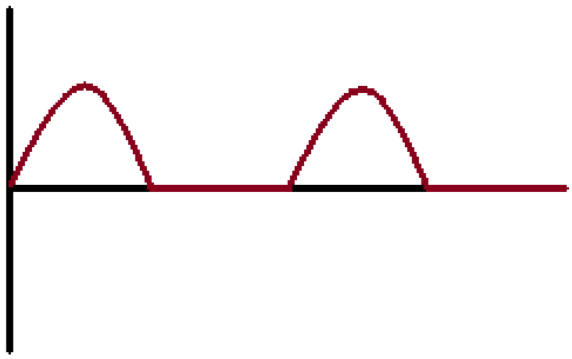
5. Create a lab procedure that will allow you, using both the oscilloscope and the DMM, to measure the voltage output of the three rectifier circuits:

- Without smoothing capacitors (2)
    1. Configure components on a breadboard like this:

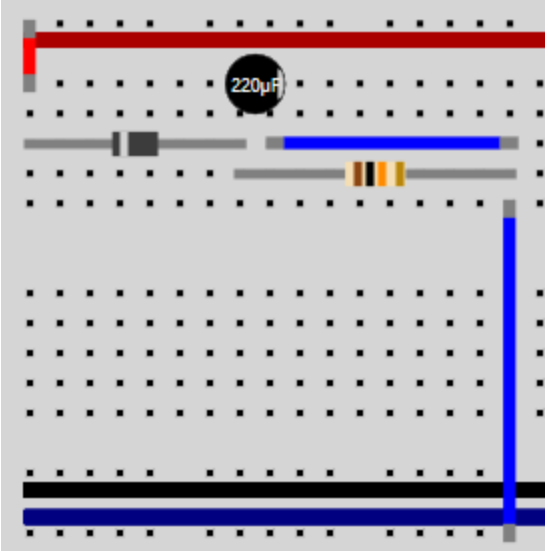


2. Place test leads in the place of the resistor (do for DMM first, then oscilloscope)
3. Record DMM and oscilloscope output

Expected Results:

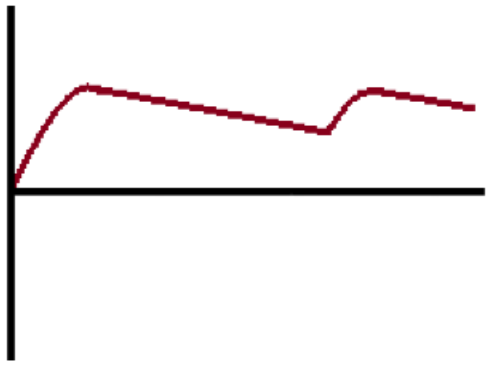


- With smoothing capacitors (3)
  1. Configure components on a breadboard like this:

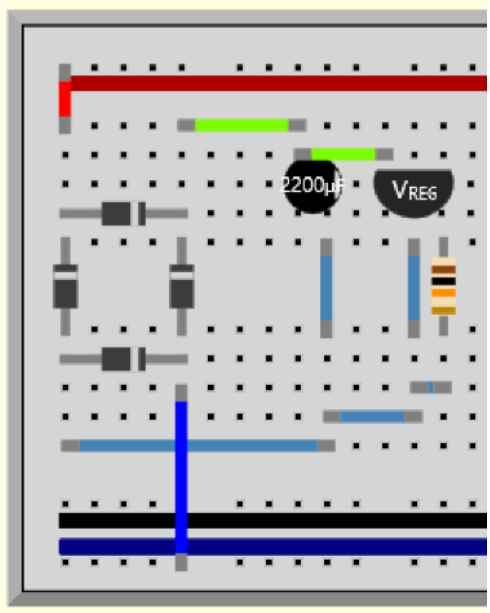


2. Place test leads in the place of the resistor (do for DMM first, then oscilloscope)
3. Record DMM and oscilloscope output

Expected Results:



- With smoothing capacitors and voltage regulator (4)
  1. Configure components on a breadboard like this:



2. Place test leads in the place of the resistor (do for DMM first, then oscilloscope)
3. Record DMM and oscilloscope output

Expected Results: