In this laboratory, all the circuits will be set up and functioning. The student will need to focus on taking measurements and understanding what is happening in each of the circuits. There are 4 diode experiments (first 3 better if done in order), and 2 transistor experiments (better if done in order). Helpful hint: It is highly probable that the questions asked will be similar to those on Test 3. The lab provides a good opportunity to find them out beforehand.

**Half-Wave Rectifier (diode)**

![Half-Wave Rectifier Diagram](image)

- Two channels on the oscilloscope should be used. One to view the input waveform and the other to view the output across the diode.
- The signal generator should be used for the input and should be set for a 1 kHz 10 volt peak-to-peak sinusoidal waveform.
- Sketch (or print) the output waveform.
- Measure the voltage where the output waveform is flat (near zero). Why is it not zero as the ideal diode model would predict?
- Sketch both the ideal and real (simple version) diode voltage/current graphs.
Half-Wave Rectifier with LED

![Half-Wave Rectifier with a Light Emitting Diode (LED)](image)

Figure 2: Half-Wave Rectifier with a Light Emitting Diode (LED)

- Two channels on the oscilloscope should be used. One to view the input waveform and the other to view the output across the diode.
- The signal generator should be used for the input and should be set for a 15 Hz 10 volt peak-to-peak sinusoidal waveform. This should cause the LED to come on intermittently. Recall that the LED is on when it is forward biased.
- Verify that the output waveform is similar to the regular diode.
- Measure the voltage where the output waveform is flat (near zero). Why is it not zero as the ideal diode model would predict? Why is it different from the regular diode?

- Lower the voltage on the input. What happens to the LED?

- Raise the voltage on the input. What happens to the LED?

- Increase the frequency. What is the highest frequency that your eye can distinguish that the LED is flashing. (This is the bandwidth of your sight system)

- Either print or sketch the input and output waveforms. Make sure the scaling is the same.
Full-Wave Rectifier Constructed with LED’s

![Full-Wave Rectifier Diagram](image)

Figure 3: Full-Wave Rectifier with Light Emitting Diodes (LEDs)

It may be helpful to read the section in your text on “The Bridge Rectifier” pages 484-486.

- Two channels on the oscilloscope must be used to measure $V_o$. One channel should be used to read between the plus side of $V_o$ and ground and the other should be used to measure between the minus side of $V_o$ and ground. To read the output you will need to use the subtract function on the math channel.
- The signal generator should be used for the input and should be set for a 15 Hz 10 volt peak-to-peak **square** waveform. This should cause the LED to come on alternately in pairs. Recall that the LED is on when it is forward biased.
- Is your circuit converting the waveform to DC? Is it perfect?
- Sketch the input, $V_i$ and rectified output, $V_o$. (Ideally – not what is seen on the scope.)
An interesting application for diodes is their use in extracting an audio signal that we can hear from an AM (amplitude modulated) radio signal being broadcast. When a radio station broadcasts, they modulate the audio signal with a much higher “carrier” frequency. This allows the signals traveling around to be at a frequency above that which can be heard. When the signal reaches your radio, a bandpass filter will get rid of all the signals except for the frequency of the station you have “tuned in.” Then the signal is demodulated and brought back down to the audio frequency. The secret to a good design is really the time constant, \( \tau = RC \). (WOW!!! Isn’t this really cool how all these ideas are coming together.) You need the signal to decay/grow enough so that it can follow the audio signal, but not so much that it decays/grows too fast. The output voltage is then shifted and amplified before it is sent to the speakers.
In the real world, the carrier frequency is much higher than the 1000 Hz signal shown in the plots. The experiment that you will be doing uses a carrier frequency of 5 MHz and an “audio” signal of 1000 Hz. The resistor is 3kΩ and the capacitor is 10nF.

- What is the time constant?
- Is this less than the period of the audio signal?
- Is this greater than the period of the carrier?
- Does the output signal (sine waveform) have a frequency of 1000 Hz?
- What would happen if the resistor were removed?
Transistor (NPN 2N2222 BJT)

Figure 9: Common Emitter Transistor Circuit

- The voltage to the load, $R_C$, is a fixed 5 volts. $R_B$ is 1000 $\Omega$ and $R_C$ is 2000 $\Omega$.
- A DC power supply will be used for $V_s$.
- The input voltage will be set according to Table 1. The voltages across $R_B$ and $R_C$ are to be measured and recorded in Table 1.
- Calculate the currents $I_B$ and $I_C$ and record them in Table 1. (Post Lab)
- While the voltage drop across $R_C$ is near 5 volts (i.e., in saturation) measure and record the voltage on the transistor between the base and emitter and between the collector and emitter. Do your values match theoretical?
- Plot $I_B$ on the x-axis and $I_C$ on the y-axis. Identify where the transistor is in cut-off, active (amplifying) and saturation.

Table 1: Transistor Data

<table>
<thead>
<tr>
<th>$V_s$ (volts)</th>
<th>$V_{RB}$</th>
<th>$V_{RC}$</th>
<th>$I_B$</th>
<th>$I_C$</th>
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Five volts from a DC source should be applied continuously to the motor. This will need to be on a separate supply from Vi.

The input voltage should be set to ensure saturation. See Table 1 or default to 5 volts.

Switch the Input Voltage, Vi, on and off and observe that it controls whether the motor is on or off.

What purpose is the diode serving in this circuit? What part would fail if it were not there? Hint: It is NOT the motor.

What function (amplification, switching) of the transistor is being used in this circuit?