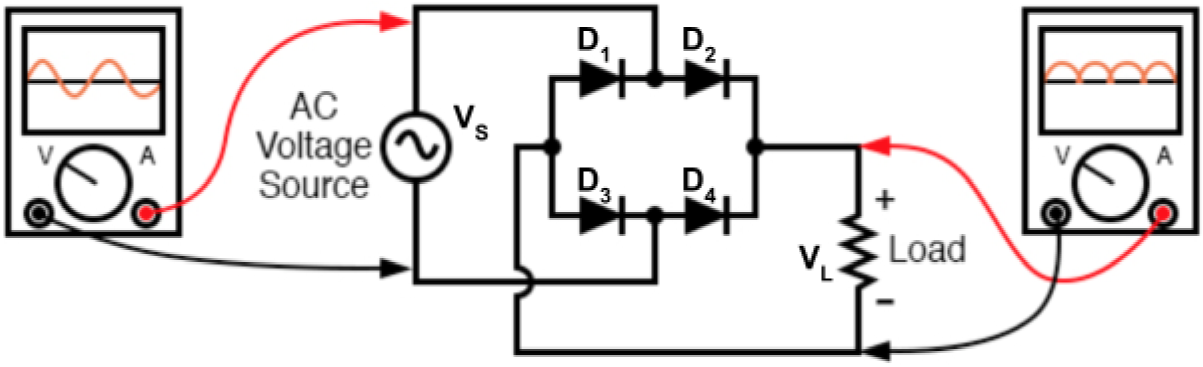
Julia Frothingham

Lab 13

Figure 1. Full-wave bridge rectifier circuit diagram



V_S = 5sin(500*2pi*t) V
Load = 328Ω
$D_{1\text{-}4}$ = Western Electric 712-429 Si switching diode

Figure 2. Built full-wave bridge rectifier circuit.

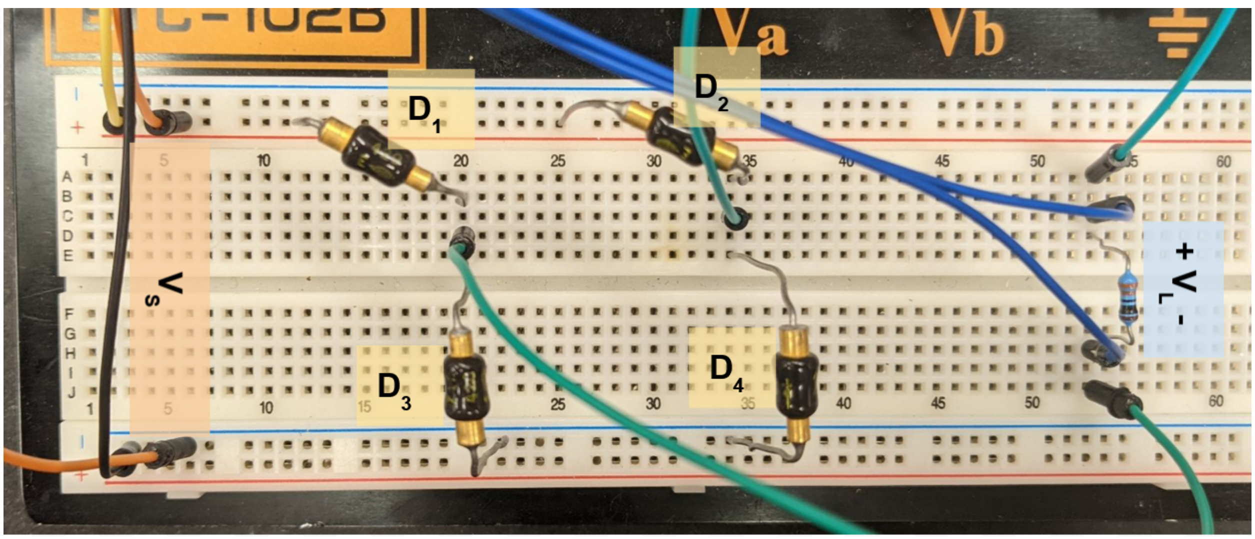


Figure 3. Source voltage in Scopy wave generator.

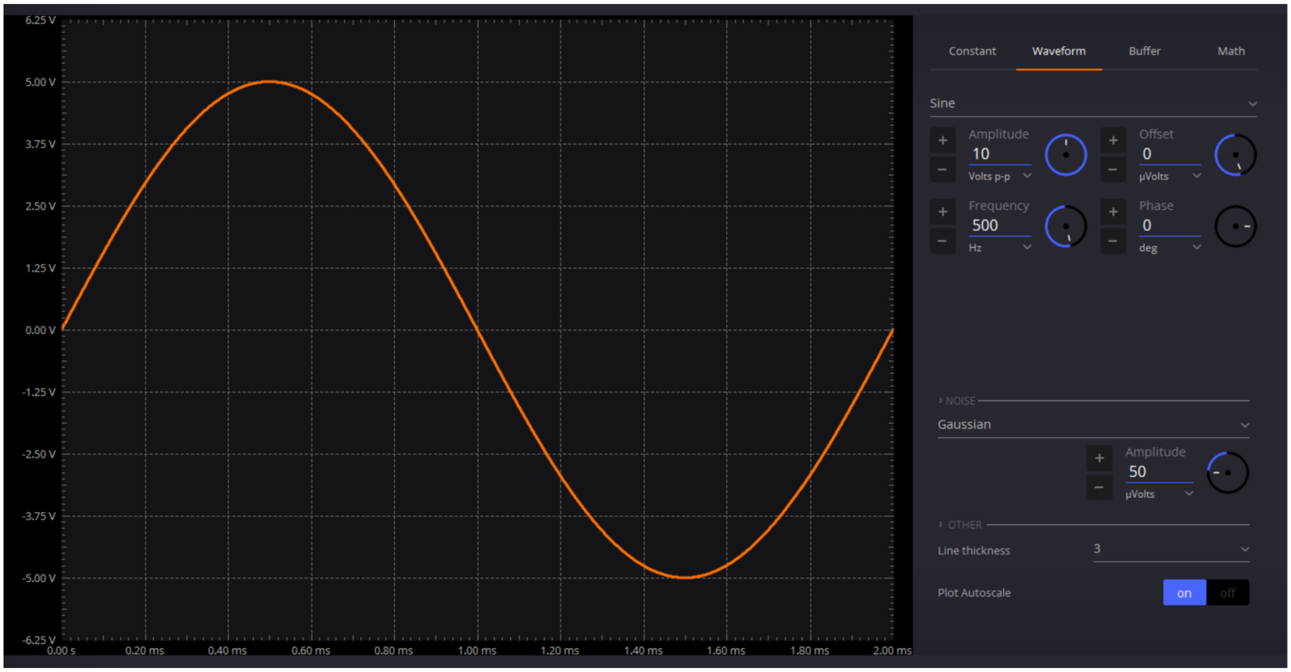
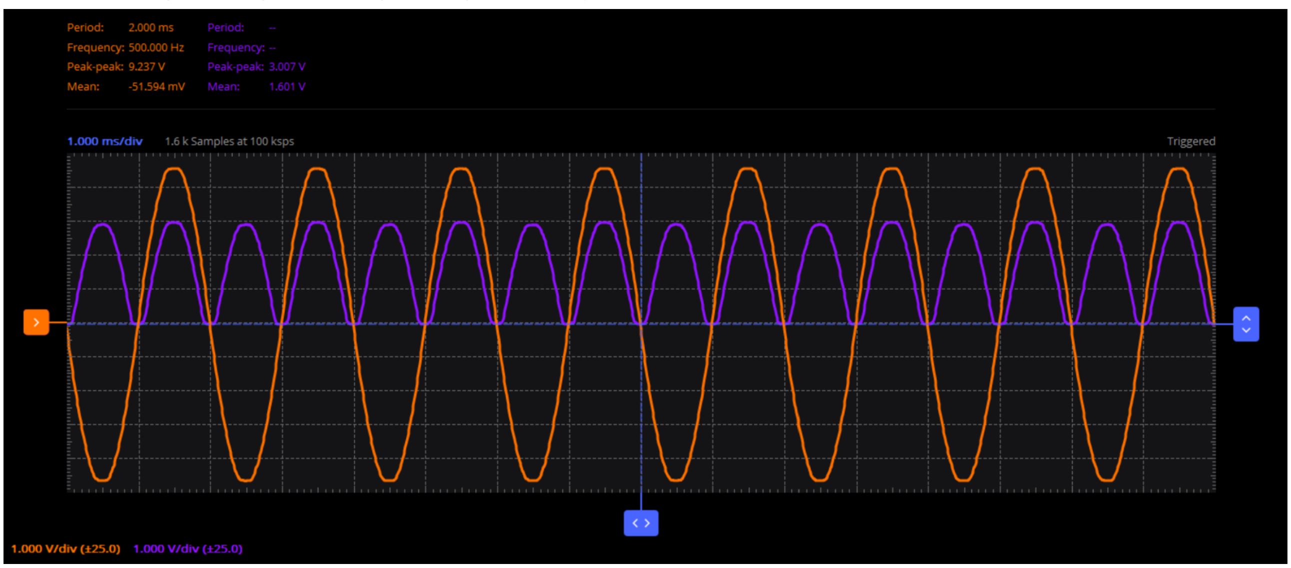


Figure 4. V_S (orange) and V_L (purple) in Scopy oscilloscope.

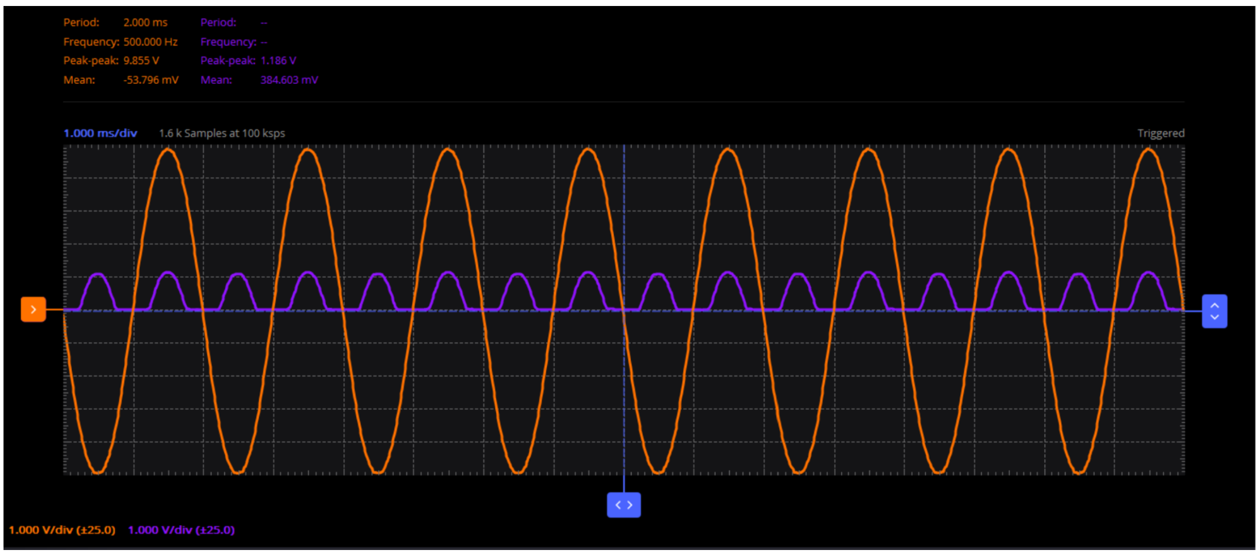


This qualitatively looks like the expected output of a full-wave bridge rectifier. The negative half-cycles in the input AC source voltage are converted to positive half-cycles in the output load voltage.

However, it is not quite what would be expected for ideal diodes. The output voltage is about 1.5V lower than the input voltage. For an ideal diode, I would expect the input and output voltages to be the same. Also, at places where the input voltage approaches or is equal to zero, the output voltage is constant at 0V for about 0.2ms. This delay, and the decrease in output voltage, is because the diodes used are not ideal. For ideal diodes, as soon as the threshold voltage is reached, the current instantly goes to infinity and the resistance goes to zero. However, because these diodes are not ideal, there is a delay between the threshold voltage being reached and the current increasing. That's why the output voltage is steady at zero for a longer period than expected. Additionally, current can't actually go to infinity, so the diodes have a resistance. This means that less current flows through the load resistor, which decreases the output voltage across the load resistor.

Replacing the silicon diodes with red LEDs still produces a positive, full-wave output voltage. However, LEDs are much further from ideal diodes than the silicon diodes. So the output voltage is much more dramatically reduced, and the transition time where the output voltage is 0V is much longer.

Figure 5. V_S (orange) and V_L (purple) in Scopy oscilloscope for LEDs used as circuit diodes.



When running this circuit at 500Hz, all four LEDs appear to be lit at once. Because of the high frequency at which the LEDs are blinking, it is not possible to visually determine if the circuit is working as expected. This is documented here: https://youtu.be/Vrs8hKVfG2w

However, when running this circuit at 1Hz, it becomes clear that the bridge rectifier circuit really does only allow current to flow through half of the diodes at a time. During the positive half-cycles, two of the LEDs are lit and two are unlit. During the negative half-cycles, the previously unlit LEDs light up and the previously lit LEDs go out. At a low frequency, this effect is perceptible, so it is easy to tell if the circuit is working as expected by visual inspection. This is documented here: https://youtu.be/cpHE5pnpvpI

NOTE: We are exploring these rectifier circuits using a fairly weak but easy to use AC source voltage. This is fine for understanding the basics of rectifier circuits, but the real applications of these circuits would usually involve using the 120V rms wall outlet as V_S and converting that to a steady DC voltage needed to operate a device that requires a fairly constant voltage.

Some devices just need a positive input voltage, and can tolerate a lot of “ripple” in the output, like a DC motor or an incandescent lamp. For the DC motor, because it's a mechanical system, its response is slow enough that it reacts mainly to the average voltage, and the ripple does no harm. For the incandescent lamp, as long as the frequency is higher than about 60Hz, the filament can’t cool very quickly and the lamp also effectively responds to the average voltage. However, you could not use the circuit you build in class to run even a small DC motor or a small lamp, since they take much more current than our scopy power supply can provide.

Other devices, like a power supply for a lighting panel, are more sensitive to ripple, and the output of the rectifier needs to be smoothed if it were to be used as a power supply for that kind of device. (The smoothing can be done with capacitors, in a fairly straightforward way, if you have a target amount of ripple that can be tolerated, and also have a maximum value of current that the device will need.)

We will not pursue those kinds of circuits at this time in this class, but if you are interested in pursuing this, you might consider a project involving designing a power supply with a diode rectifier that has a small enough ripple and can deliver enough current to operate a device that demands both DC voltage and a large amount of current.