Assignment 04
Diode Rectifier Circuit Simulation

ECEN 222, Spring 2026

University of Nebraska-Lincoln

Overview

This assignment focuses on simulating and analyzing diode rectifier circuits using Multisim. You will build and analyze half-wave and full-wave (bridge) rectifiers, and explore the effects of filter capacitors. These circuits are fundamental to power supply design and demonstrate practical applications of diode behavior.

Submission Requirements

Submit a **single PDF document** containing all requested screenshots, measurements, and analysis. Your PDF should include:

- Clear, legible screenshots showing complete circuits with component values visible
- Oscilloscope waveforms with proper scale settings and measurements
- Brief explanations of observed behavior and comparisons to theoretical values

Software Requirements

- **Multisim:** Available through the NI Academic Site License. Download from `https://www.ni.com/` or use computers in the lab.

Part 1: Half-Wave Rectifier [25 points]

Build and simulate a basic half-wave rectifier circuit.

Circuit Specifications:

- AC voltage source: 12 V_{RMS}, 60 Hz
- Diode: 1N4004 or similar silicon diode
- Load resistor: $R_L = 1\ \mathrm{k}\Omega$

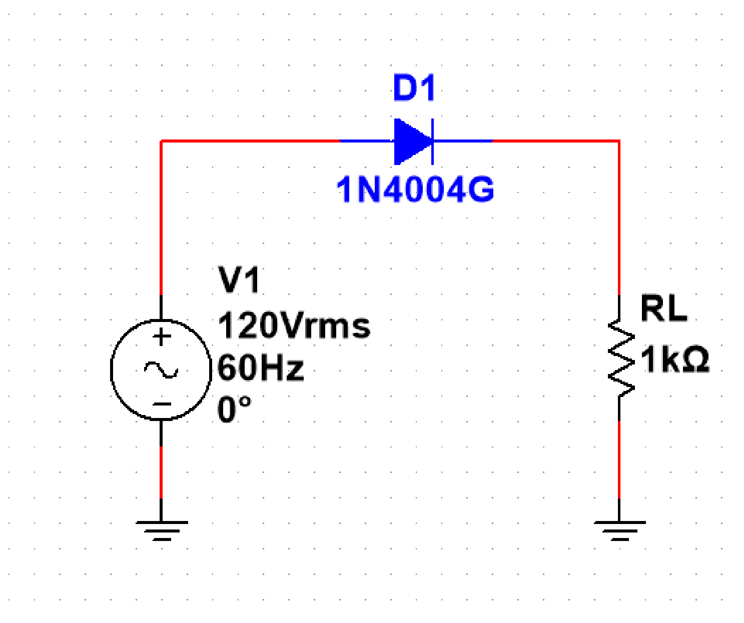

Figure 1: Half-wave rectifier circuit schematic

Analysis Tasks:

1.1 Circuit Screenshot [5 points]: Include a screenshot of your complete half-wave rectifier circuit showing:

- AC voltage source with parameters visible
- Diode (1N4004)
- Load resistor with value visible
- Ground connection
- Oscilloscope probes connected to measure input (AC source) and output (across load)

1.2 Transient Analysis [10 points]: Run a transient analysis and capture oscilloscope waveforms showing:

- Both input voltage (Channel A) and output voltage (Channel B)
- At least 3 complete periods
- Time and voltage scales clearly visible

- Include this screenshot in your submission

1.3 Measurements and Calculations [10 points]: From your simulation, report:

- Peak input voltage V_p (measured from oscilloscope)
- Peak output voltage (measured from oscilloscope)
- Average (DC) output voltage (use a multimeter in Multisim or read from oscilloscope)
- Compare your measured DC voltage to the theoretical value $V_{DC} = \frac{V_p - V_D}{\pi}$ (assume $V_D = 0.7$ V). Calculate percent error.
- Briefly explain why the output only shows positive half-cycles.

Note: Measuring DC Voltage

To measure the average (DC) output voltage, you can place a multimeter set to DC voltage mode across the load resistor. Alternatively, use a measurement function on the oscillorscope that can compute the average value of a waveform.

Part 2: Bridge (Full-Wave) Rectifier [25 points]

Build and simulate a bridge rectifier circuit for improved performance.

Circuit Specifications:

- AC voltage source: 12 V_{RMS}, 60 Hz (same as Part 1)
- Four diodes: 1N4001 or similar (arranged in bridge configuration)
- Load resistor: $R_L = 1$ kΩ

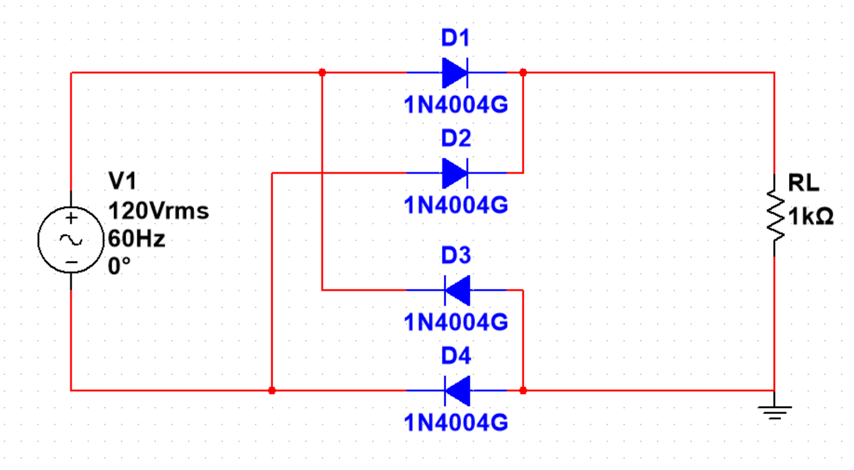

Figure 2: Bridge rectifier circuit schematic

Analysis Tasks:

2.1 Circuit Screenshot [5 points]: Include a screenshot of your bridge rectifier showing:

- AC voltage source
- All four diodes properly arranged in bridge configuration
- Load resistor
- Ground connection
- Oscilloscope probes

2.2 Transient Analysis [10 points]: Run a transient analysis and capture oscilloscope waveforms showing:

- Input and output voltages
- At least 3 complete periods
- Both half-cycles of the AC input producing positive output
- Include this screenshot

2.3 Measurements and Comparison [10 points]: From your simulation, report:

- Peak output voltage

- Average (DC) output voltage
- Compare to theoretical: $V_{DC} = \frac{2(V_p - 2V_D)}{\pi}$ (note: two diode drops)
- Compare the DC output voltage to the half-wave rectifier from Part 1. By what factor did it increase?
- Explain why the bridge rectifier produces a higher DC output voltage.

Part 3: Filtered Rectifier [50 points]

Add a filter capacitor to your bridge rectifier to reduce ripple voltage.

Circuit Specifications:

- Use your bridge rectifier from Part 2
- Add a filter capacitor: $C = 470\ \mu\text{F}$ in parallel with R_L
- Keep $R_L = 1\ \text{k}\Omega$

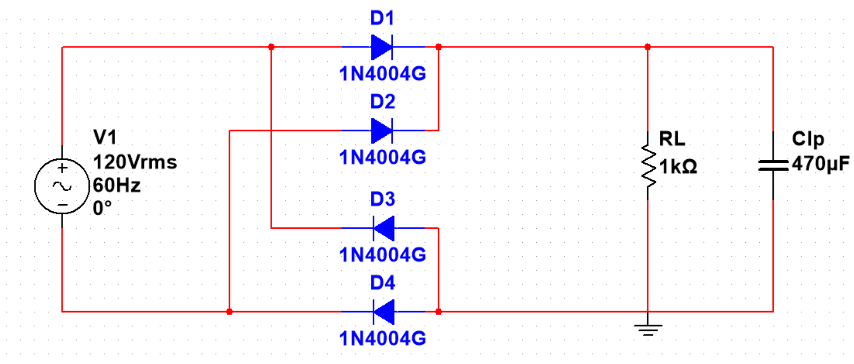

Figure 3: Bridge rectifier with filter capacitor

Analysis Tasks:

3.1 Circuit Screenshot [10 points]: Include a screenshot showing:

- Bridge rectifier with added capacitor
- Capacitor value clearly visible
- Oscilloscope probes measuring output voltage

3.2 Transient Analysis [15 points]: Run a transient analysis showing:

- Output voltage waveform after the circuit reaches steady state
- Zoom in to clearly show the ripple voltage
- Use oscilloscope cursors or measurements to determine peak-to-peak ripple voltage V_r
- Include this screenshot with measurements visible

3.3 Ripple Analysis [15 points]: From your simulation, report:

- Measured ripple voltage V_r (peak-to-peak)
- Measured average DC output voltage
- Compare measured ripple to theoretical: $V_r \approx \frac{V_p}{2fR_LC}$ (note: $2f$ for full-wave)
- Calculate percent error

3.4 Capacitor Effect Study [10 points]:

- Change the capacitor to $C = 100\ \mu\text{F}$ and re-run the simulation

- Capture a screenshot showing the increased ripple
- Briefly discuss how capacitor size affects ripple voltage and DC output voltage

Note: Steady State

When you first run the transient simulation, the capacitor will charge up from zero. Make sure to run the simulation long enough (e.g., 100 ms) to reach steady state, then zoom in on the later portion of the waveform to see the steady-state ripple.

Tips

- **Simulation Settings:** For transient analysis, use appropriate time spans (e.g., 50-100 ms for rectifiers to reach steady state). Set maximum time step small enough to capture waveform details (e.g., 0.1 ms).
- **Measurements:** Use the oscilloscope measurement functions (mean, peak-to-peak, etc.) to get accurate values rather than estimating from the display. This will also help practice for real lab measurements.