PROBLEMS ENCOUNTERED

- Initially had difficulties importing LM393 model into Ltspice
- Had to troubleshoot the bridge rectifier circuit due to node naming and measurement issues
- Had a bit of difficulty wiring the TLV272 and LM393 because of the custom pin numbering • Completing the breadboard implementation took a long time to verify

INTRODUCTION

This lab explored several practical diode and comparator applications including half-wave rectifiers, RC peak detectors, bridge rectifiers, and clipping detection circuits. The Ltspice simulations and breadboards were used to analyze diode conduction, capacitor charging behavior, comparator switching, and LED indication circuits. This lab also introduced the LM393 comparator and operational amplifiers in practical signal processing applications.

DISCUSSION

8.5 Pre-lab

8.5.1 LTspice Simulations

This section introduces the operation of a diode in various situations like in a half-wave rectifier. The input and output waveforms are compared to demonstrate the diodes functions during various input signals.

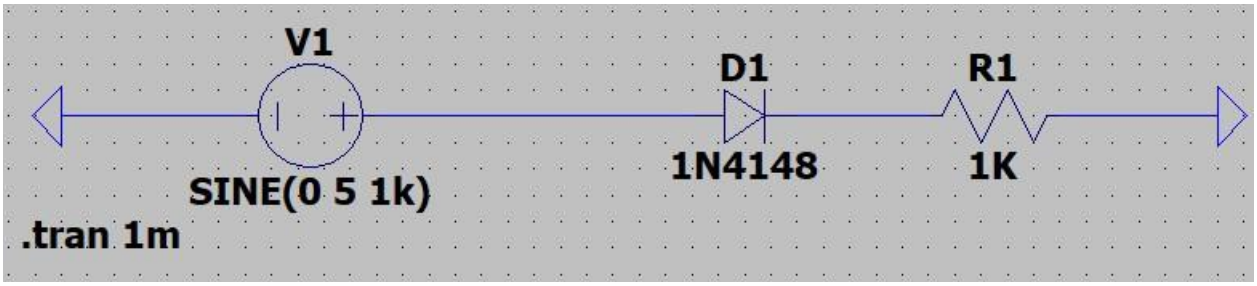


Figure 1: Half-wave rectifier circuit using a 1N4148 diode and a 1 kΩ load resistor.

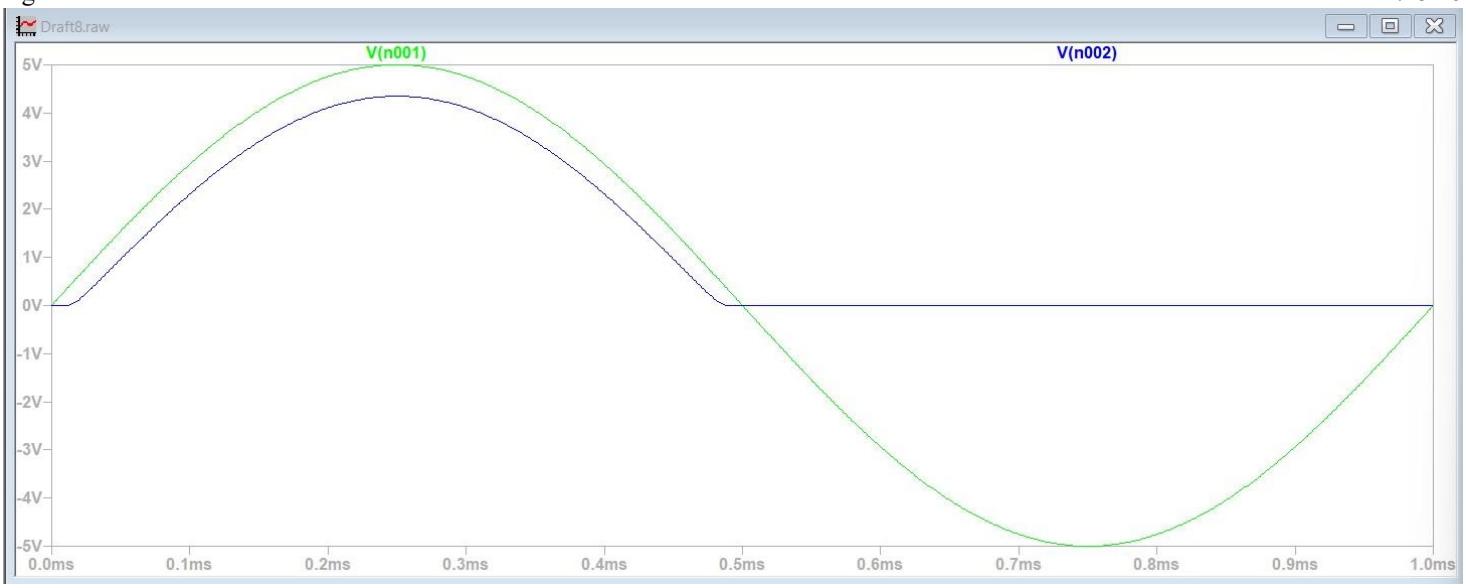


Figure 2: Simulated input and output voltages of the half-wave rectifier showing removal of the negative half-cycle

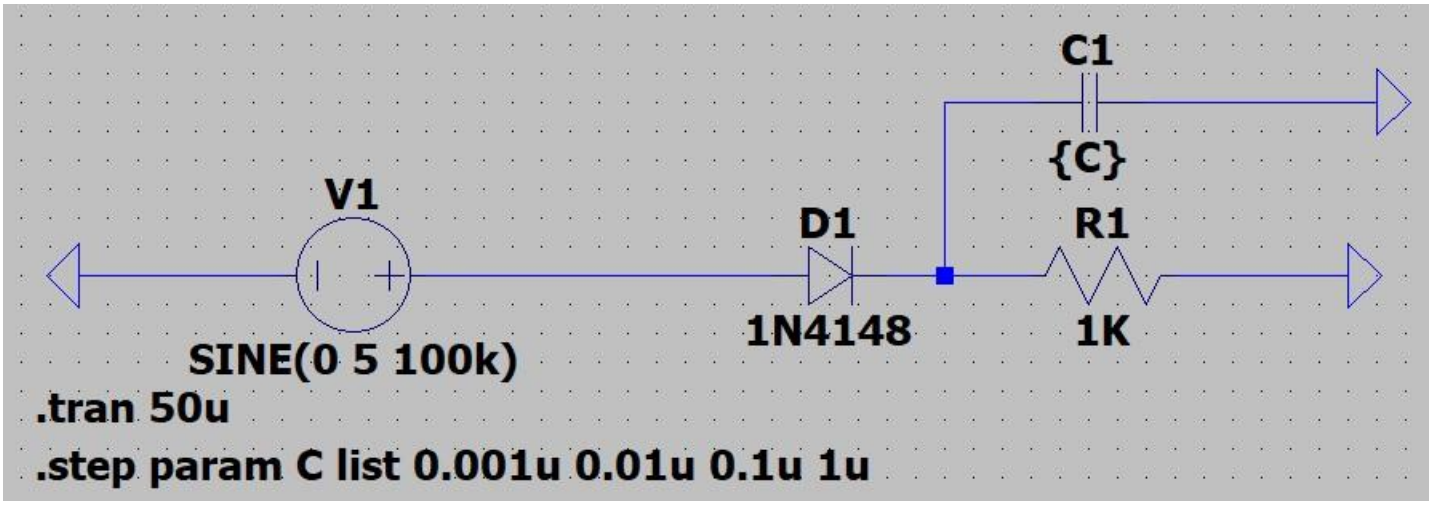


Figure 3: Peak detector circuit with capacitor values stepped in LTspice

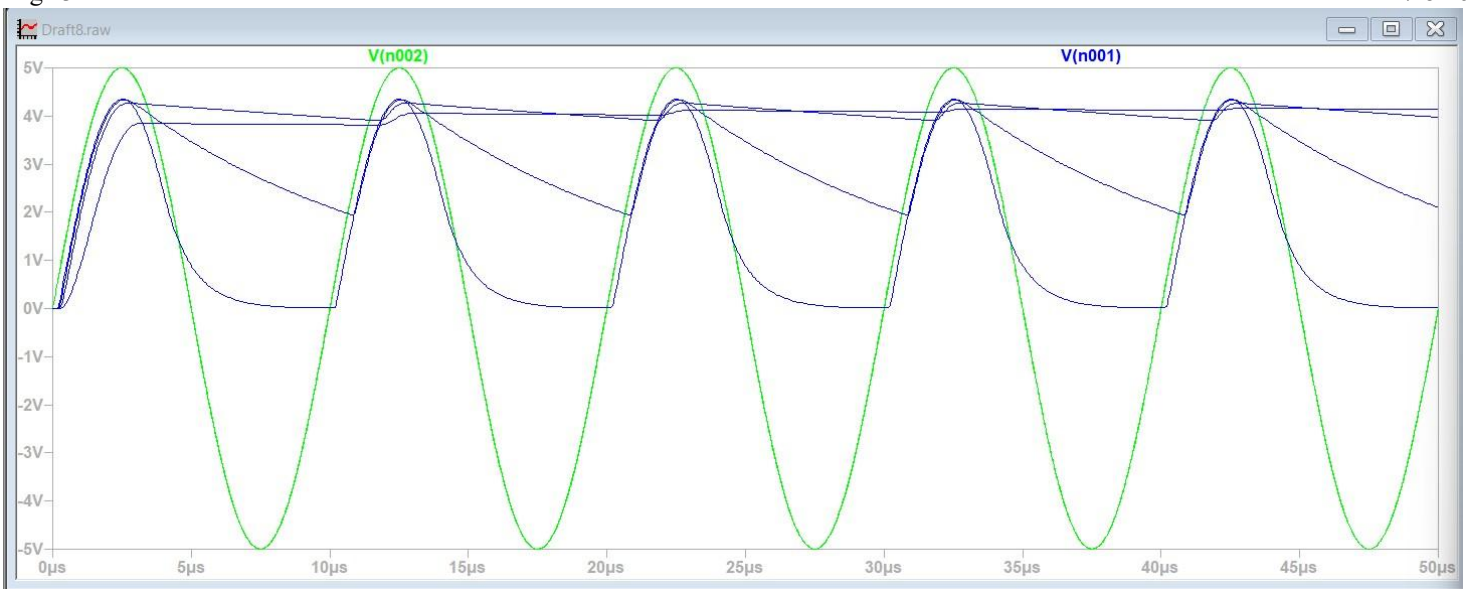


Figure 4: Peak detector output for multiple capacitor values demonstrating decreasing ripple as capacitance increases

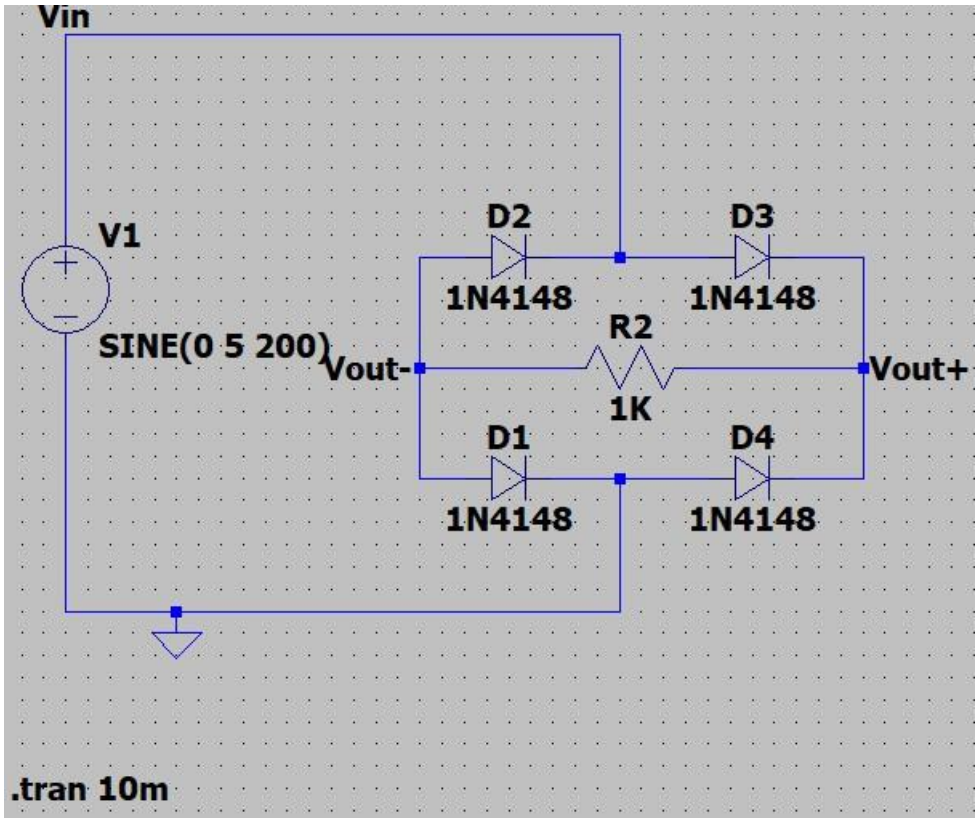


Figure 5: Full-wave bridge rectifier constructed with four 1N4148 diodes

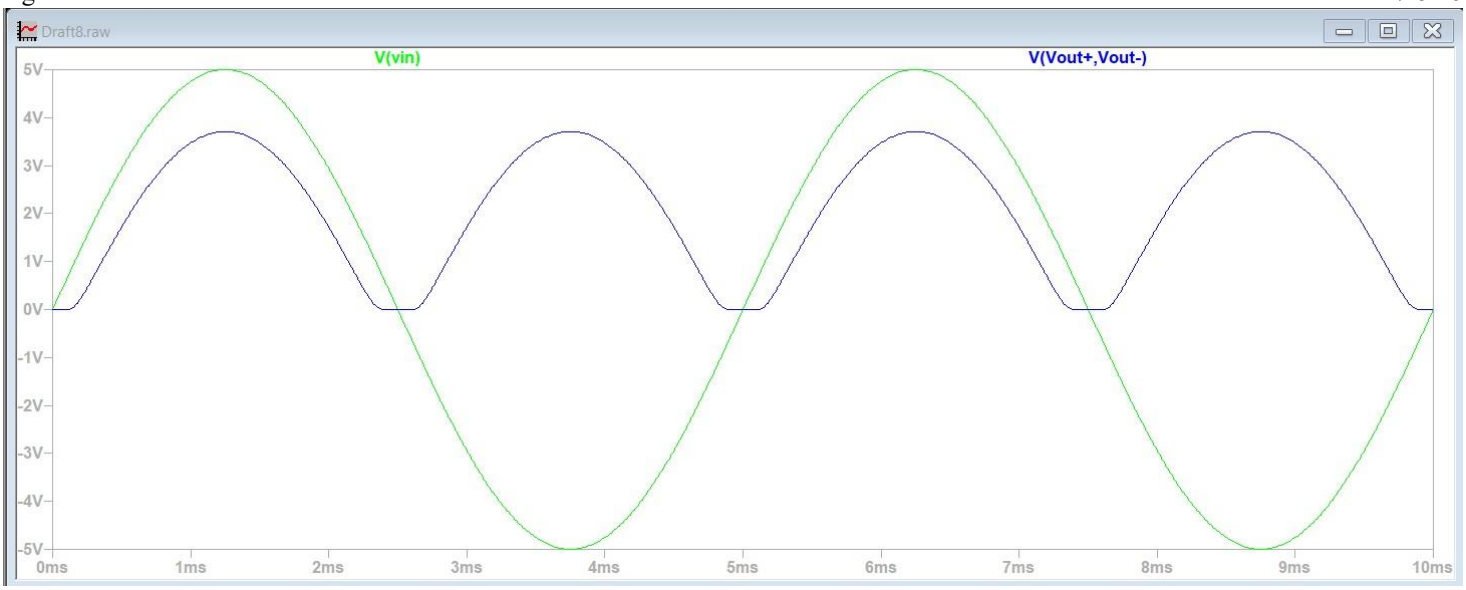


Figure 6: Simulated input and load voltage demonstrating full-wave rectification

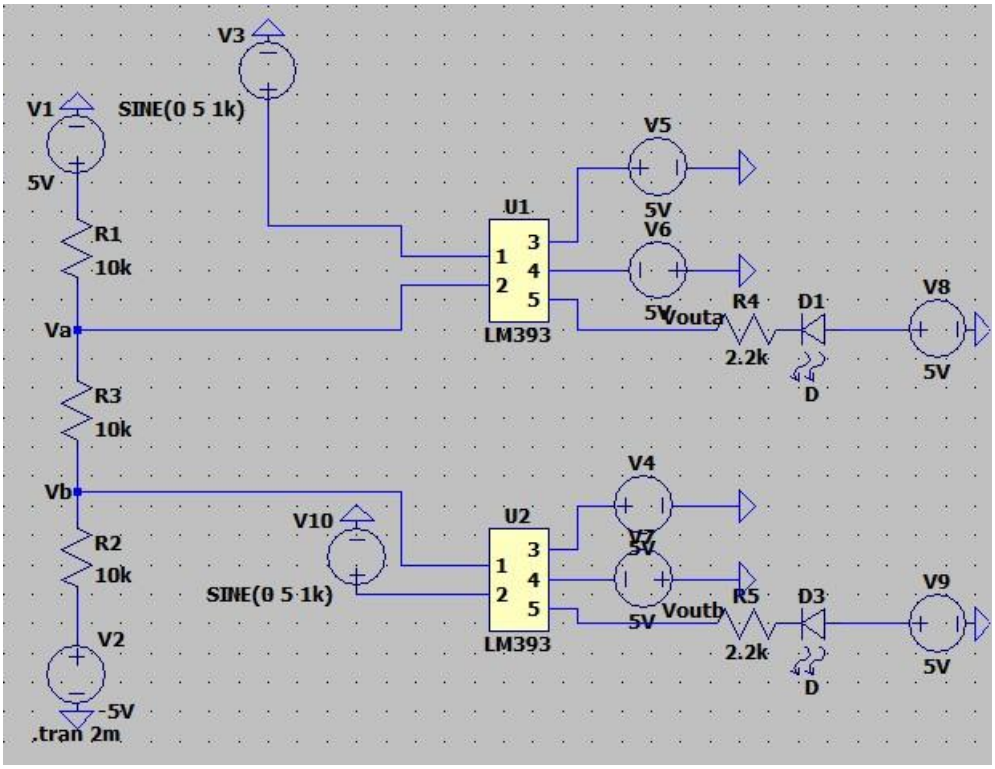


Figure 7: LM393 clipping detector circuit using two comparators and LED indicators

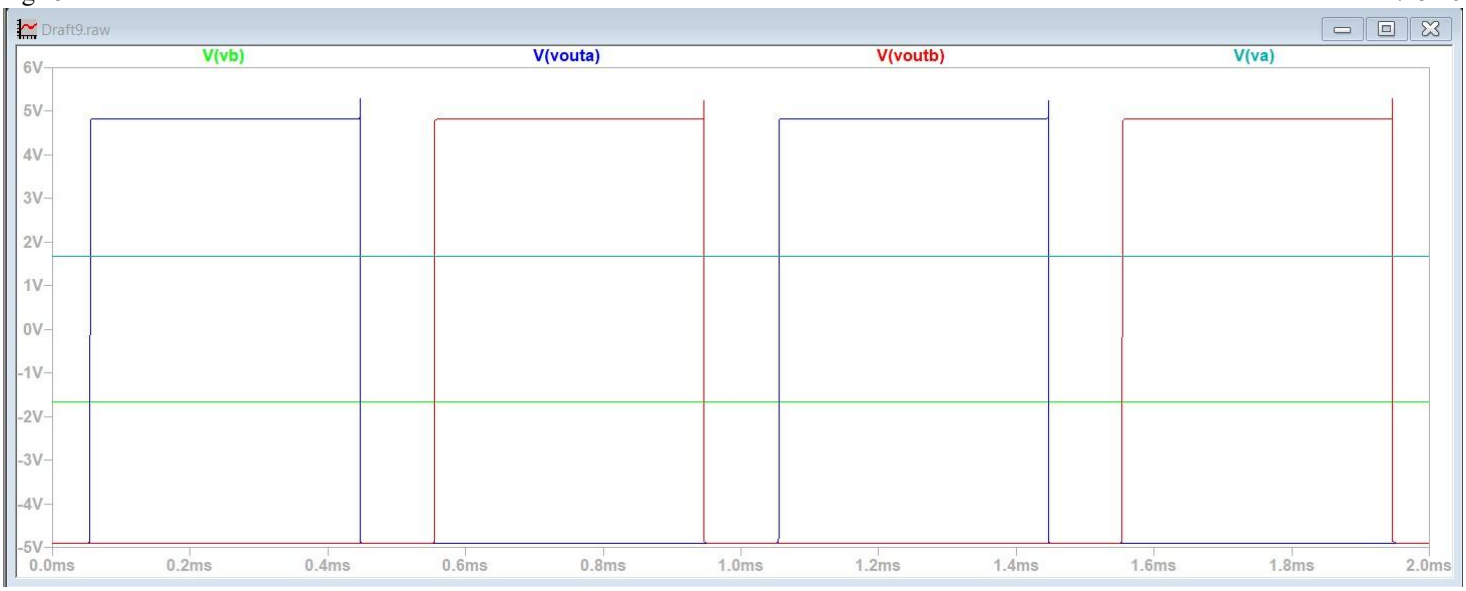


Figure 8: Comparator simulation showing reference voltages and digital output transitions

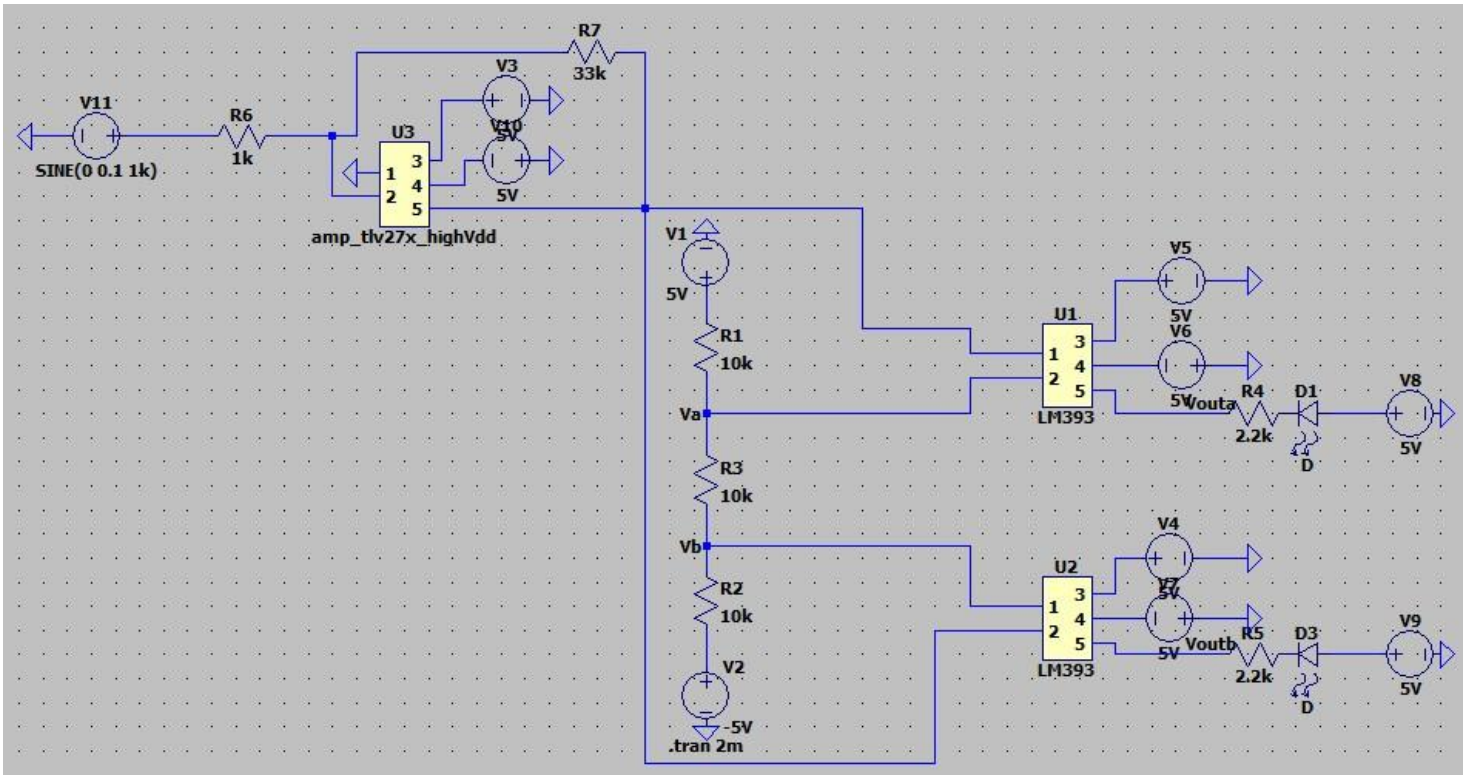


Figure 9: TLV272 amplifier and LM393 clipping detector circuit

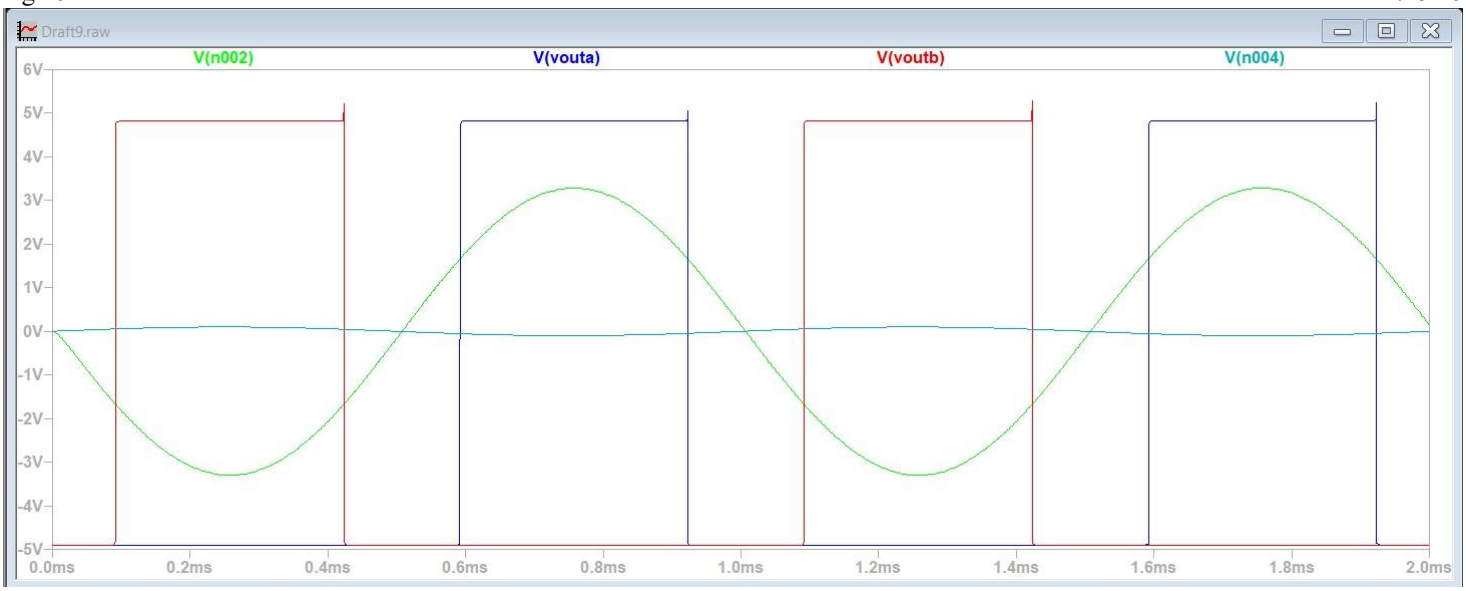


Figure 10: Simulated op-amp output, comparator outputs, and reference voltages used for clipping detection

8.5.2 Breadboard Implementation

This section verifies the comparator circuit using physical hardware. The oscilloscope measurements confirm that the comparator outputs switch between high and low levels as the input crosses the reference voltages.

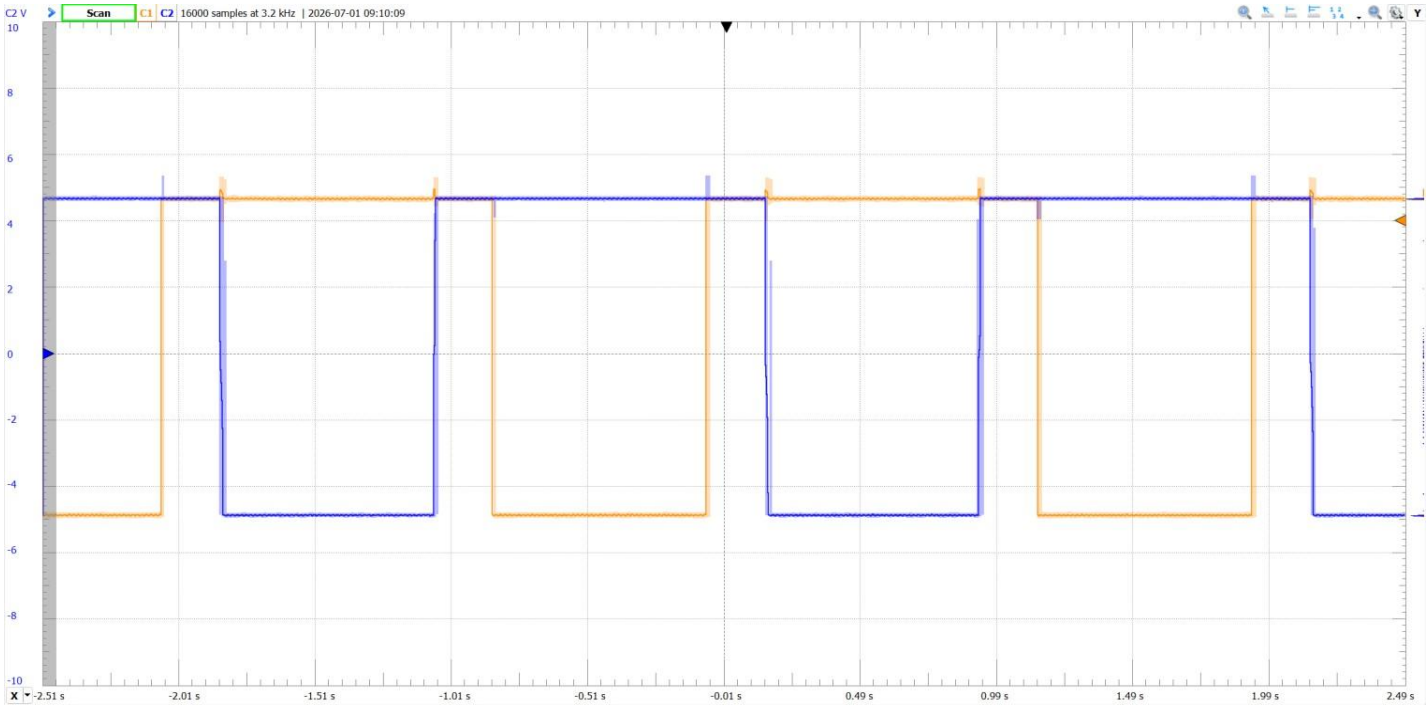


Figure 11: Breadboard implementation of the LM393 clipping detector circuit

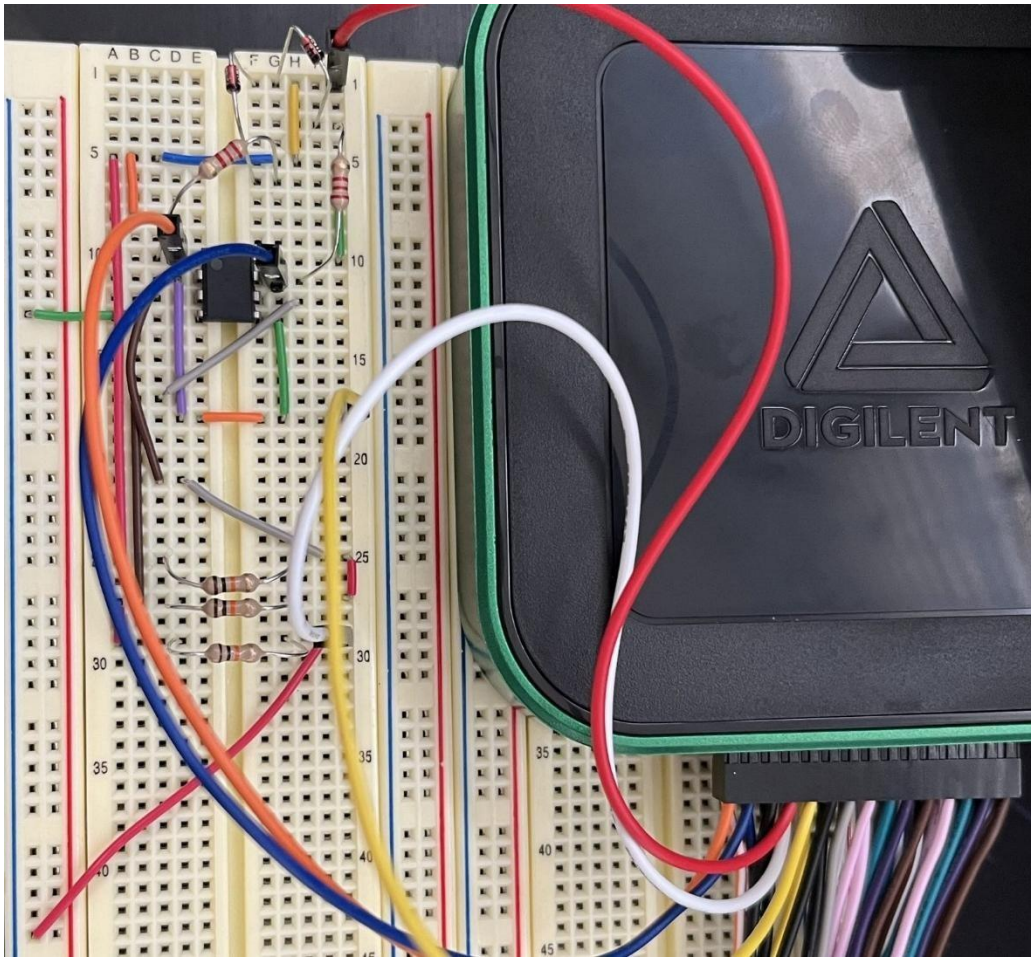


Figure 12: Oscilloscope capture of the comparator outputs during hardware testing.

8.6 In-Lab

This section verifies the diode rectifier and comparator circuits using physical hardware. The oscilloscope measurements were collected to compare the experimental inputs and outputs with the Ltspice simulations.

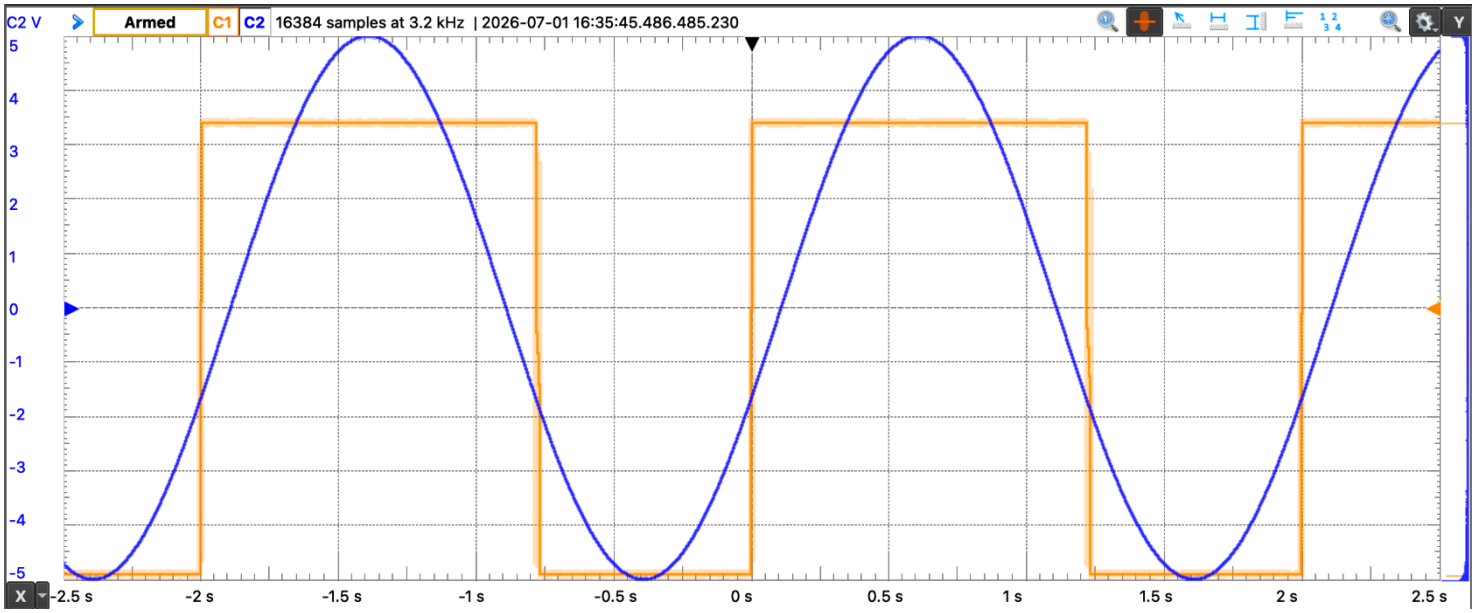


Figure 12: Oscilloscope capture of the LM393 comparator showing output switching as the input crosses the reference voltage.

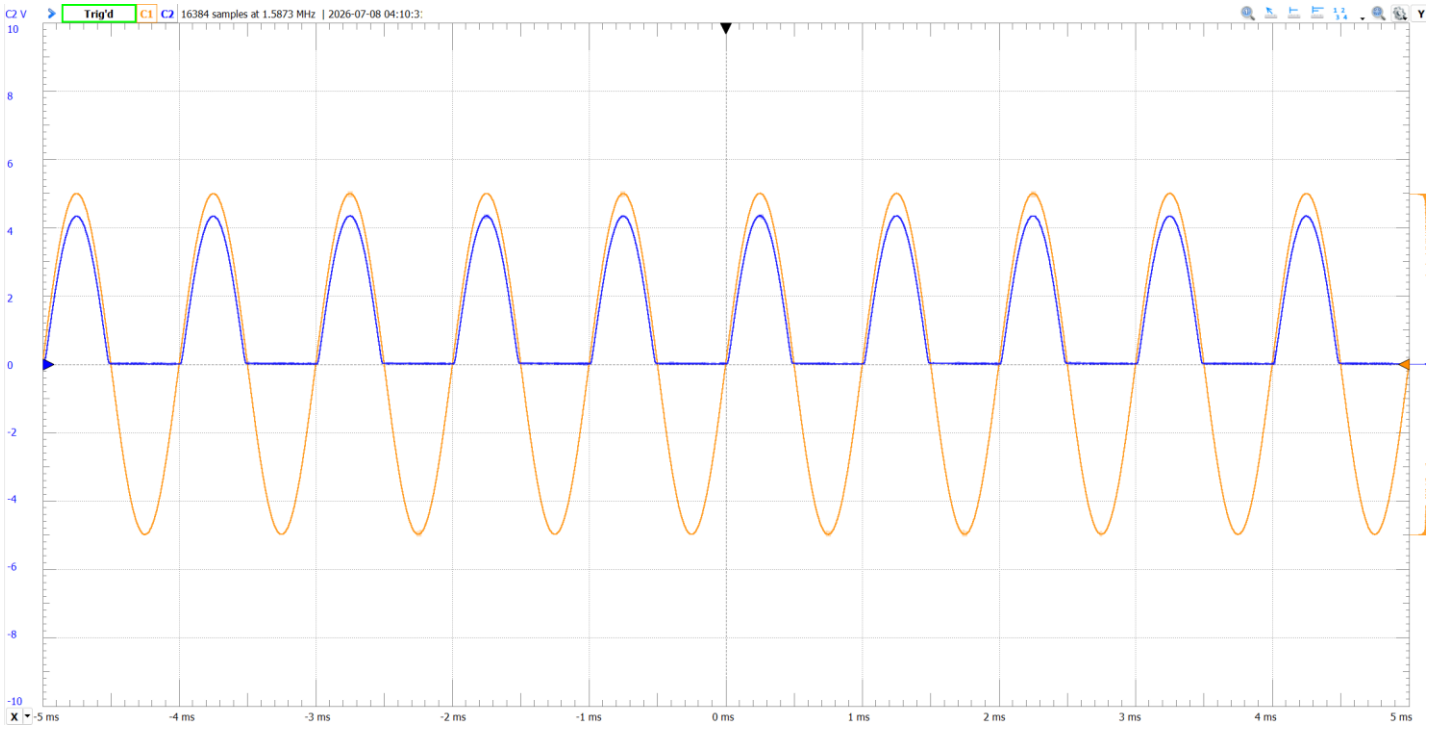


Figure 13: Breadboard half-wave rectifier showing the measured input sine wave and rectified output waveform.

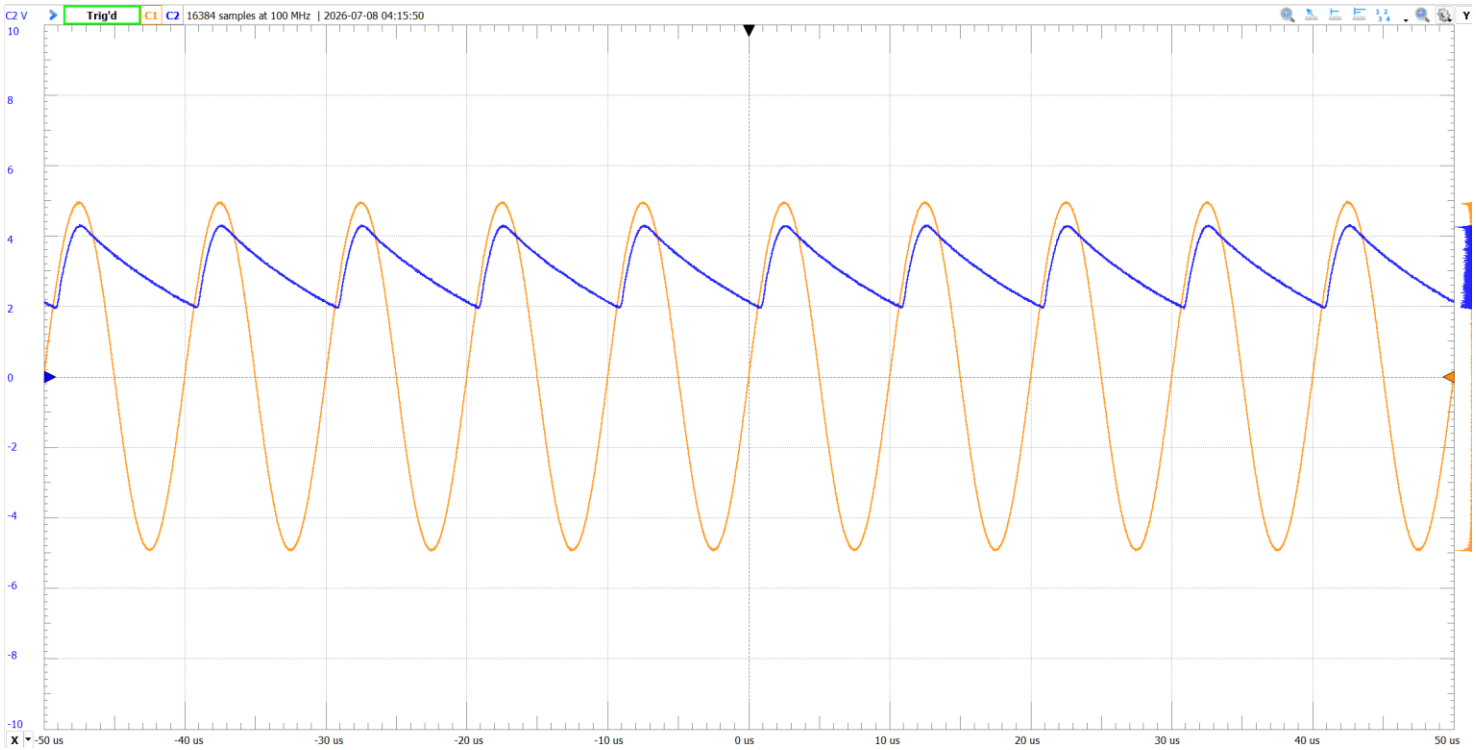


Figure 14: Breadboard peak detector using a 0.01 µF capacitor demonstrating noticeable ripple caused by rapid capacitor discharge.

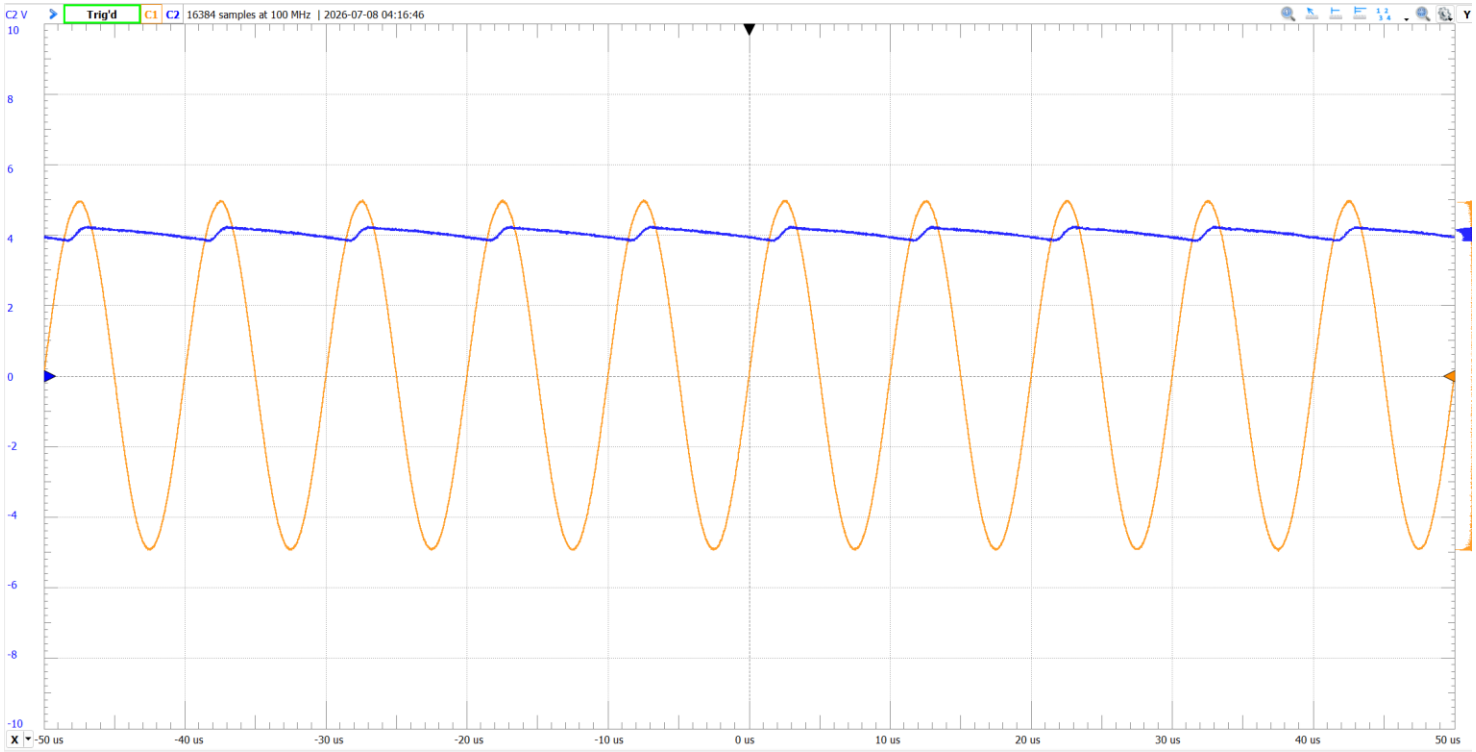


Figure 15: Breadboard peak detector using a 0.1 µF capacitor demonstrating reduced ripple and improved filtering due to the larger capacitance.

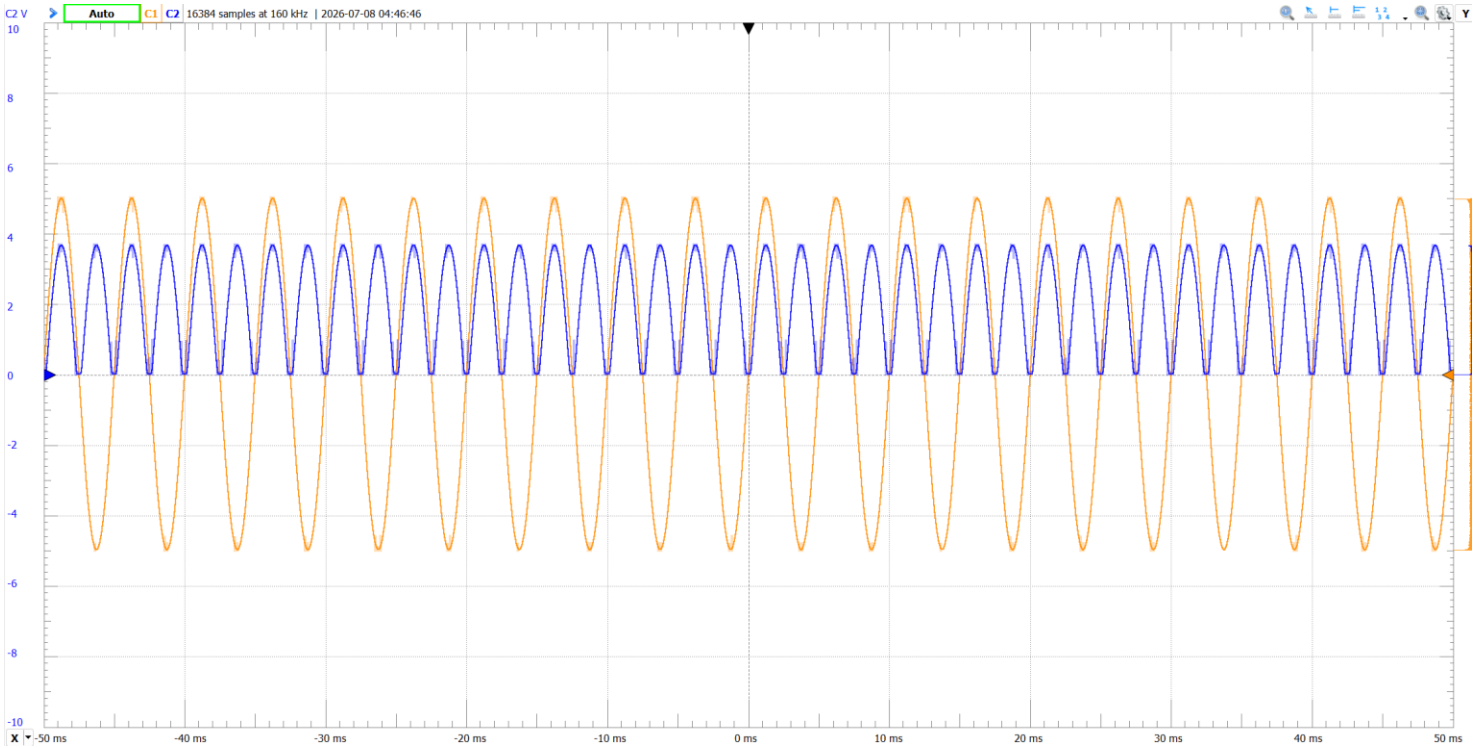


Figure 16: Breadboard full-wave bridge rectifier showing full-wave rectification with reduced output amplitude caused by the two conducting diode drops.

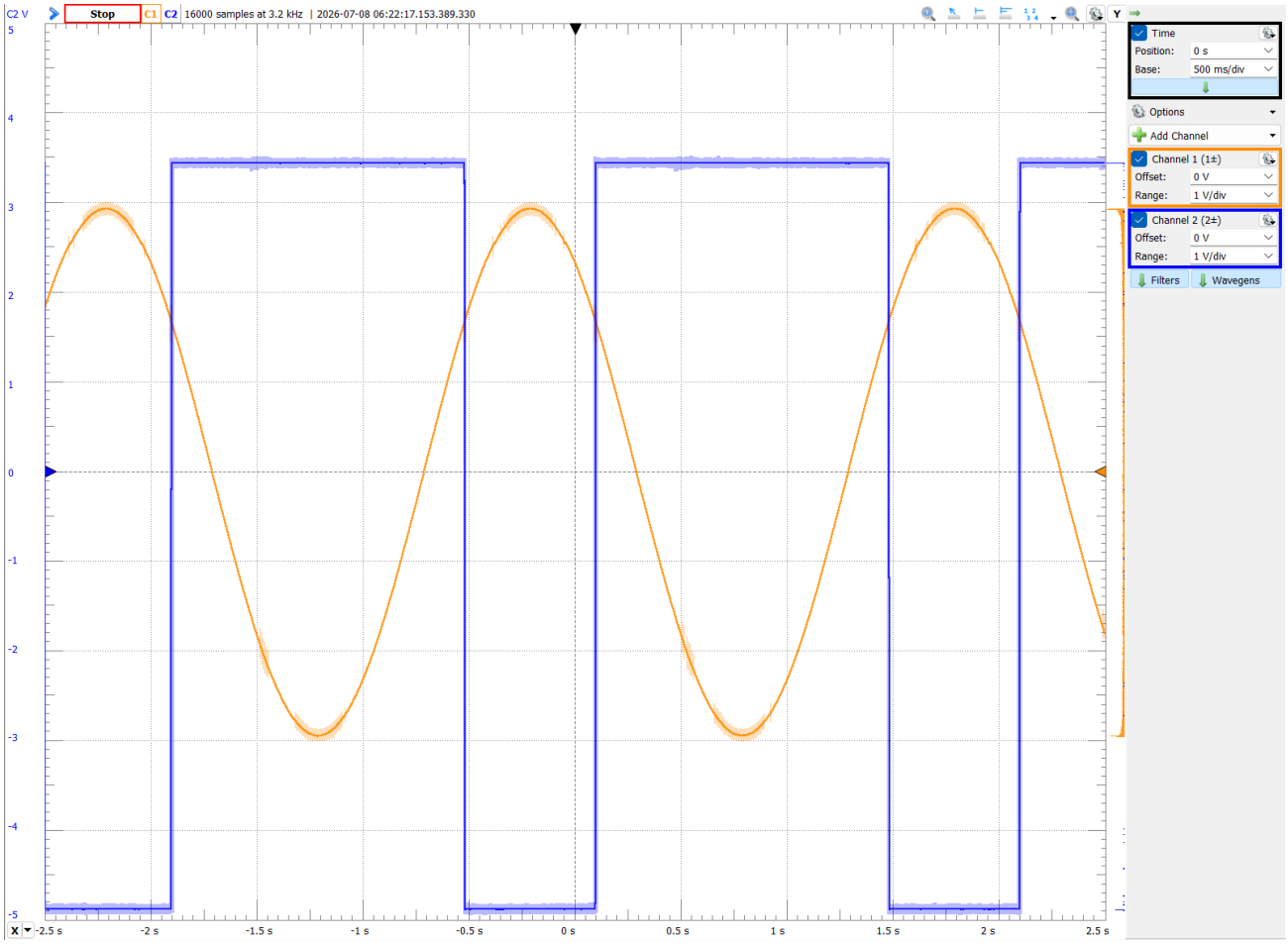


Figure 17: Oscilloscope capture of the TLV272 amplifier output (orange) and LM393 comparator output (blue). The amplified sine wave is compared against a fixed reference voltage, causing the comparator to switch between high and low output states as the signal crosses the threshold.

Discussion Question: The experimental waveforms closely matched the LTspice simulations. Both the half-wave rectifier and the bridge rectifiers properly produced their waves and desired output results. Operational amplifiers and comparators both compare voltages applied to their inputs, but they are designed for different purposes. Operational amplifiers are intended to operate with negative feedback and provide linear amplification and buffering while comparators operate on an open loop to switch between high and low output states. Thus, comparators are better suited for threshold detection and digital switching scenarios while operational amplifiers are preferred for analog signal conditioning and amplification.

CONCLUSION

In this lab, diode rectifier circuits, peak detector circuits, bridge rectifiers, and comparator circuits were simulated and implemented utilizing both LTspice and physical hardware. The oscilloscope measurements verified the expected diode conductivity, comparator switching behavior, and capacitor filtering. Overall, the experimental results showed very similar results to the simulations and demonstrated the practical applications of diodes and operational amplifiers in signal processing circuits.