Board 1 Report
ECEN 3730 - PCB Design and Manufacturing

Completed by:
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Introduction

The primary objective of this lab was to gain practical experience in circuit design, component selection, and assembly while addressing real-world engineering challenges such as minimizing noise and ensuring consistent circuit performance. Building on the concepts learned in Lab 5, which covered the SBB PDN and slammer circuit, we designed a printed circuit board schematic featuring a 555 timer circuit. The timer was configured to operate at a frequency of 500 Hz with a 60% duty cycle and used to drive four LEDs. By observing the changes in switching noise and LED brightness, we analyzed how circuit design choices impact performance and signal integrity.

What does it mean to work?

To determine whether the board "works," we first look for clear physical indicators of proper operation. The LEDs should turn-on as expected, voltage readings at the designated test points should align with the design specifications, and the power rail should exhibit minimal switching noise. After confirming these basic checks, we use an oscilloscope to take more precise measurements of the circuit's frequency and duty cycle. If these readings are close to the target values of 500 Hz and 60% duty cycle, we can confidently conclude that the board functions as intended. Together, these qualitative and quantitative observations verify that the circuit performs correctly.

Board 1 Plan of Record (POR)

1. Power plug to use an external 5V AC to DC charger to power the board
2. A 555 timer chip and circuitry designed for about 500 Hz and 60% duty cycle
3. Using parts in the JLC integrated library we provide for you.
4. Add 4 LEDs of all the same color and series resistors of: 10k, 1k, 300, and 50 Ohms.
5. Use indicator lights, test points and isolation switches as appropriate.
6. Design to measure the 5 V input rail, the 555 output voltage and the current through the 50 Ohm LED.
7. Note: will the 555 IC you select support driving all the current through all the LEDs? How much current is this?

Schematics and Design

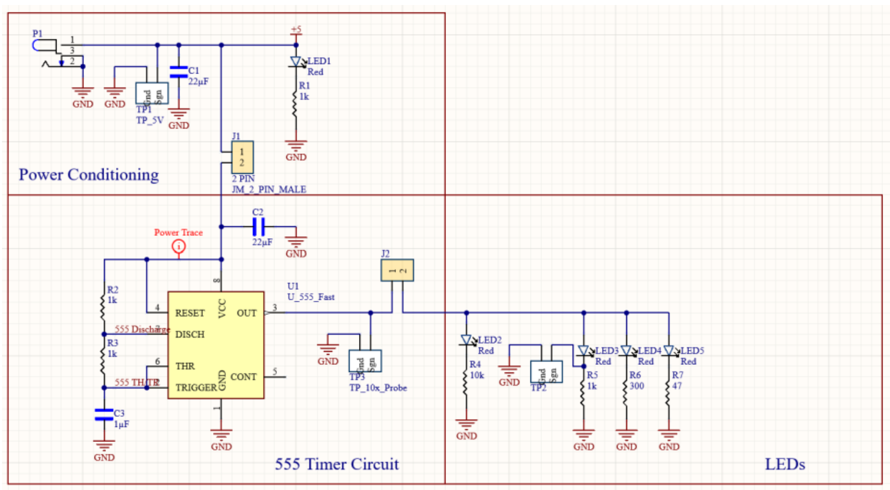

Figure 1: Altium schematic of 555 Timer circuit

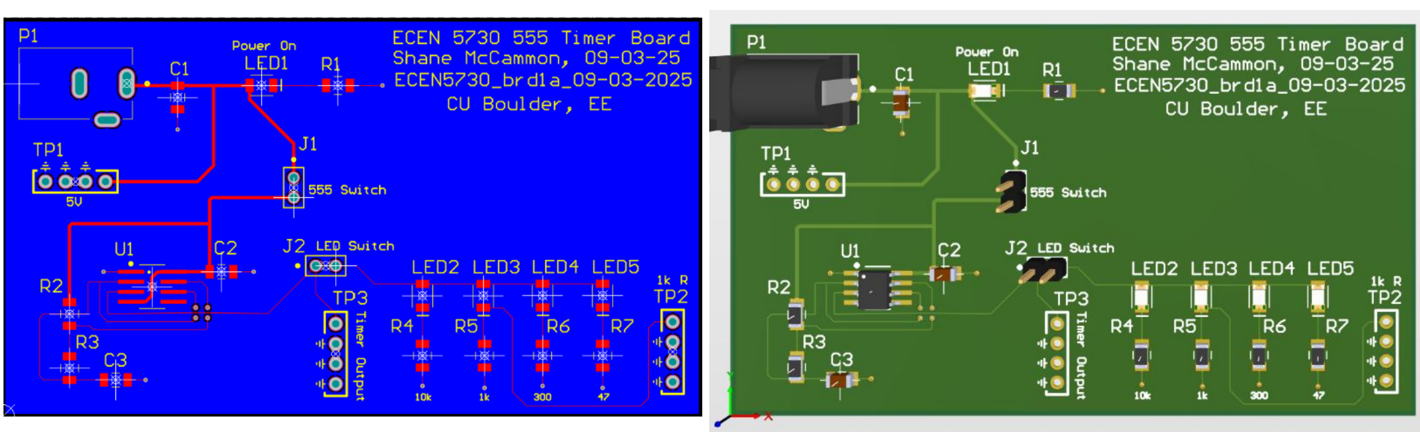

Figure 2: Altium board assembly and 3D view

Figure 3: Printed and Assembled Board 1

Output Waveforms & Analysis

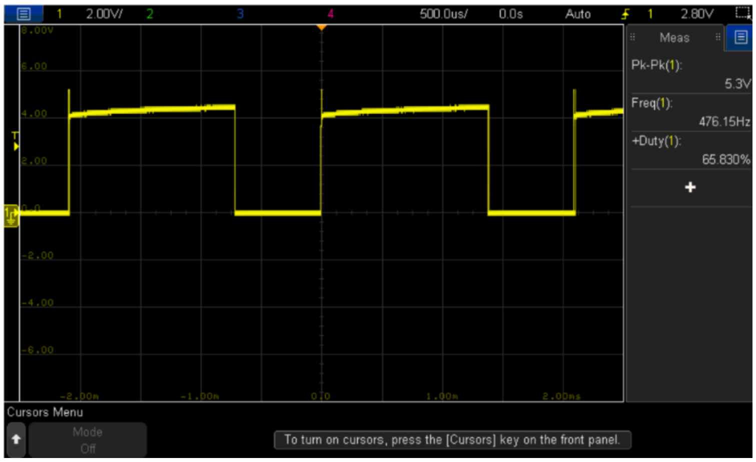

Figure 4: 555 Timer Output [No Load]

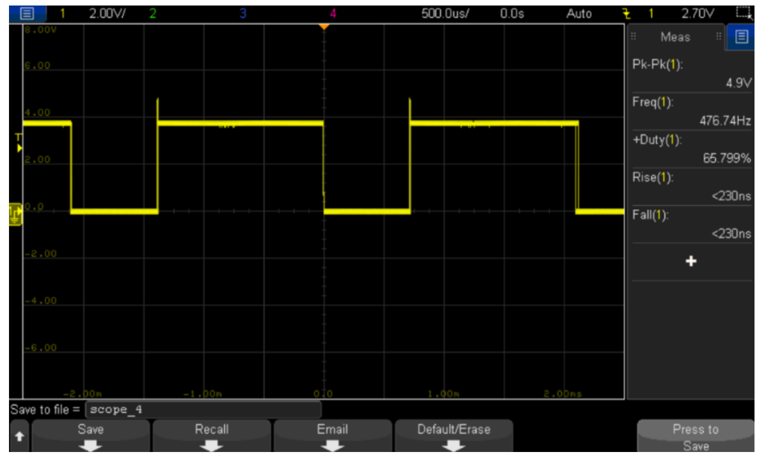

Figure 5: 555 Timer Output [With LED Load]

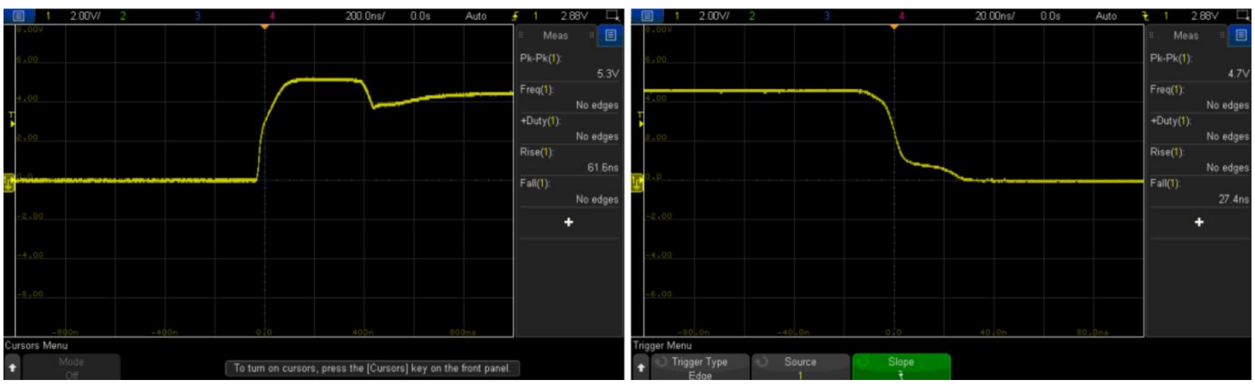

Figure 6: Output Rise Time and Fall Time [No Load]

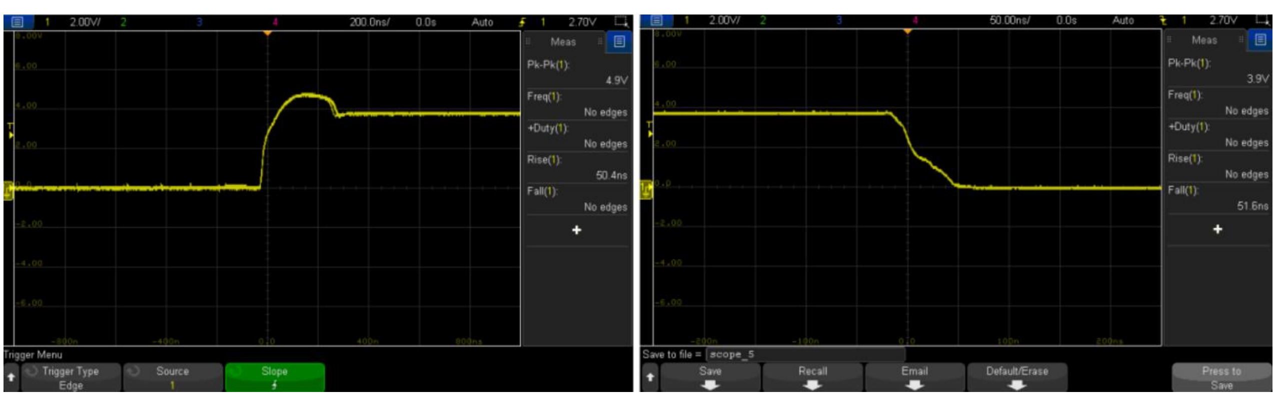

Figure 7: Output Rise and Fall Time [Loaded]

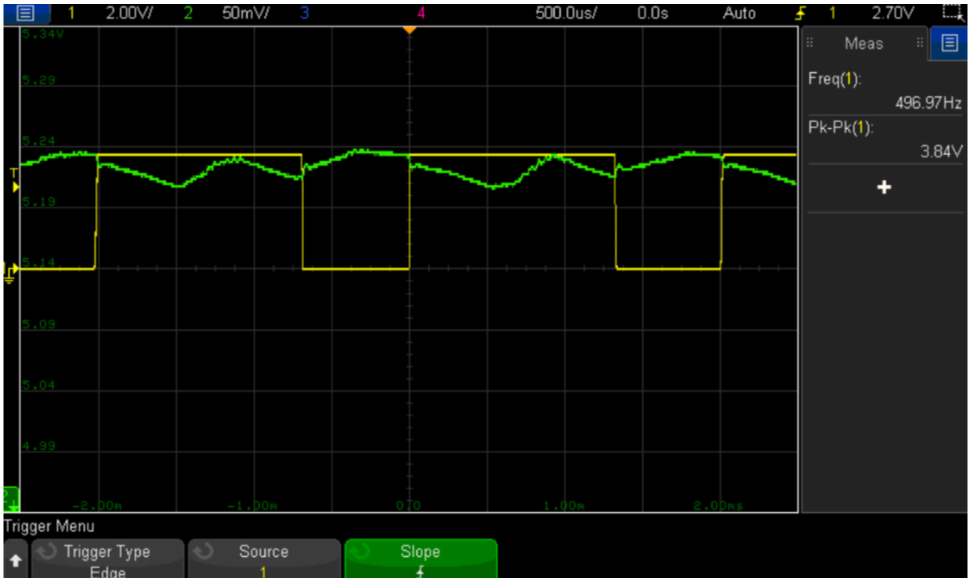

Figure 8: 5V Power Rail Noise [50mV/unit]

After assembling and testing the circuit, the output signal measured a stable frequency of 480 Hz with a 65% duty cycle. These small deviations from specification are typical and can be attributed to component tolerances, as resistors and capacitors often vary slightly from their nominal values. Oscilloscope measurements also revealed consistent waveform behavior. The rise and fall times of the signal were measured both with and without the LED load connected. Without the LEDs, the signal transitioned rapidly between states. When the LEDs were added, a small delay was observed, which aligns with expectations since the additional current demand slightly affects the switching response of the circuit. Current measurements for each LED were determined by calculating the voltage drop across their respective resistors. The results showed varying current levels, with the 47 Ω resistor drawing the highest current at approximately 40 mA. This confirmed that the circuit operated correctly under different load conditions and that the LED brightness differences were consistent with the expected current distribution. Overall, the data indicates that the circuit performed as intended. The minor variations in frequency, duty cycle, and switching speed are within acceptable limits and highlight the impact of component tolerances and load effects in practical circuit design.

Calculations

Total Resistance:

$$R_{tot} = \frac{1}{\frac{1}{47} + \frac{1}{300} + \frac{1}{1000} + \frac{1}{10000}} = 40\ \Omega$$

Thevinin Resistance:

$$R_{Thev} = \frac{V_{th} - V_{load}}{V_{load}} R_{tot} = 7\ \Omega$$

Current:

$$I_{1k} = \frac{V}{R} = \frac{1.85}{1k} = 1.85\,mA$$

$$I_{10k} = \frac{1.85}{10k} = 0.185\,mA$$

$$I_{47} = \frac{1.85}{47} = 40\ mA$$

$$I_{300} = \frac{1.85}{300} = 6.17\,mA$$

Conclusion

This project ultimately demonstrated the effective use of a 555 timer to generate signals and drive LEDs. If I were to repeat the project, I would place greater emphasis on precise soldering from the beginning by using flux and being more careful placing components. The red LED indicator light is a through-hole LED as the original SMD LED fell out of my pliers and could not be found.