University of Colorado Boulder

Electrical and Computer Engineering

ECEN3730 Practical PCB Design Manufacture

LABORATORY REPORT

Board 1 Report

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1 Introduction

In this lab report, we will explore the design and assembly of a simple functional circuit board, referred to as BOARD 1. This circuit board project serves as an opportunity to gain hands-on experience in the entire board design process, emphasizing best design practices as outlined in the Skill Building Video series. Additionally, it provides practice in manual SMT assembly, with the use of 1206 size parts.

2 Objectives

1. To gain experience in the manual SMT assembly process using 1206 size parts.
2. To design a functional circuit board resembling a business card with a QR code link to a portfolio page.
3. To implement a 555 timer in an astable vibrator circuit, driving four LEDs with different series resistors.
4. To add isolation switches, indicator LEDs, and test points to facilitate debugging.
5. To adhere to five critical design habits outlined in the lab instructions.
6. To practice using Altium Designer.
7. To gain experience in the PCB design process.

3 Plan of Record

The POR outlines the specific requirements and expectations for BOARD 1. These include:

1. The oscillator should operate at around 500 Hz with a 60% duty cycle.
2. Four LEDs of the same color should exhibit different brightness levels, achieved through different series resistors.
3. The board should draw an average current of 110 mA and a peak current of 190 mA.
4. The board must include measurement points for the oscillator output and current through one LED.
5. Use a decoupling capacitor for 555 IC to reduce switching noise.
6. Measure the current draw thru the 555 timer.
7. Use info from solder less breadboard prototype to design board 1.

4 Methodology

4.1 What it means to work

- Working means the board should perform as outlined in the POR. The board should have a roughly 50% duty cycle at 500Hz. The board should light up 4 LEDs each with different current limiting resistors.

4.2 Initial sketch (BON and Block Diagram)

- We were given a board with three closed-loop configurations: Common return for the victim line, Separate return for the victim line, and Ground plain return. (Figure 1)

4.3 Schematic and PCB layout

- The schematic was designed with the block diagram in mind. Using some shapes we can outline each block diagram and make it easier to read. (Figure 2)
- The PCB was designed with debug in mind. (Figure 3 & 4)
  - Isolation switches to disconnect power or isolate specific sections.
  - Test points at critical locations for easy signal measurement.
  - Indicator LEDs for power rails to quickly identify operational areas.
- Components Used
  - 555 Timer IC (Part Number – NE555DR)
  - $10K\Omega, 1K\Omega, 300\Omega, 47\Omega$Resistors
  - 1 uF and 22 uF Capacitors
  - Power jack, Red LEDs, Isolation Switches and Test points.

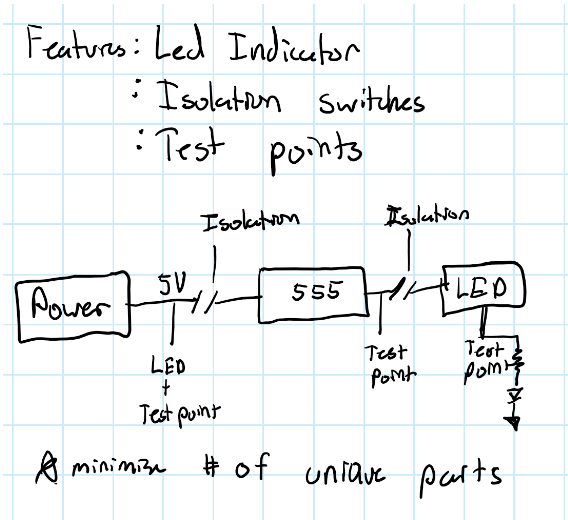

Figure 1: Block Diagram for Board 1

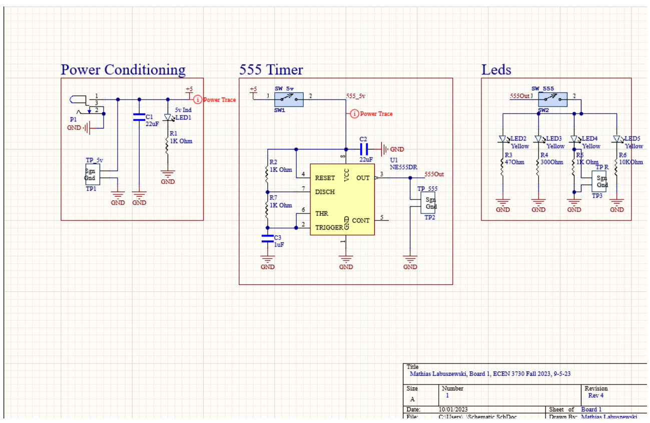

Figure 2: Schematic of Board 1

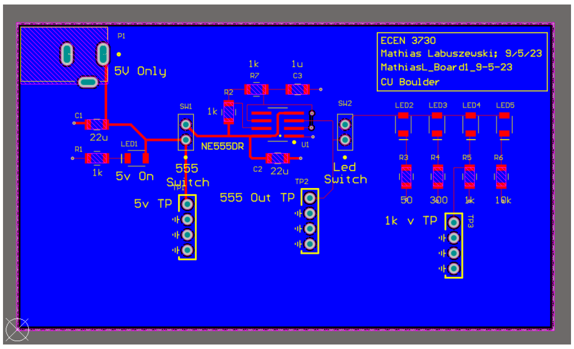

Figure 3: PCB layout of Board 1

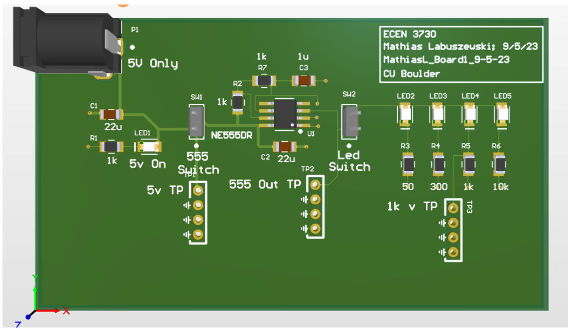

Figure 4: PCB layout of Board 1
in 3d

4.4 Board 1 Bring up

- Board 1 was assembled by hand.
- Board 1 assembly went very well, as all the values of components were clearly listed on the PCB.
- All footprints of SMD components matched up.
- All components functioned as expected.

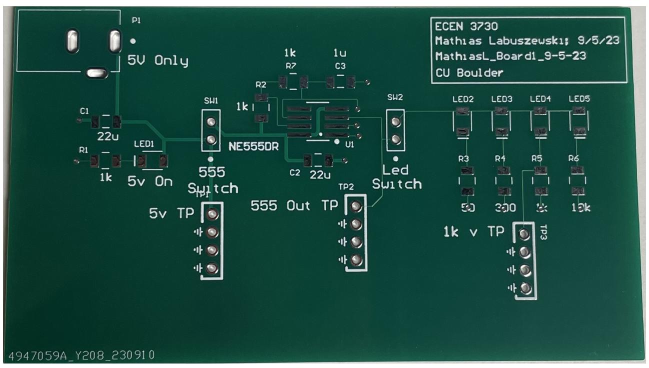

Figure 5: Unassembled PCB from
JLC PCB

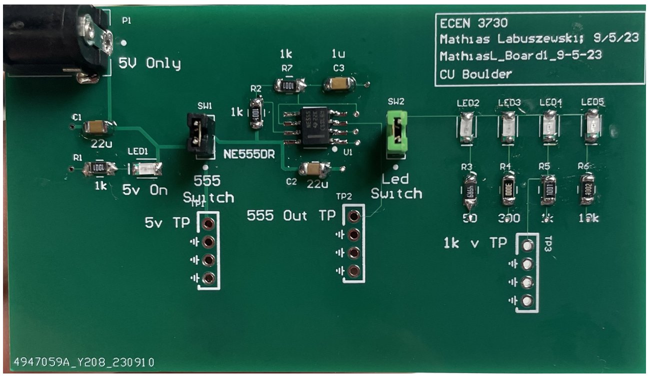

Figure 6: Assembled Board 1

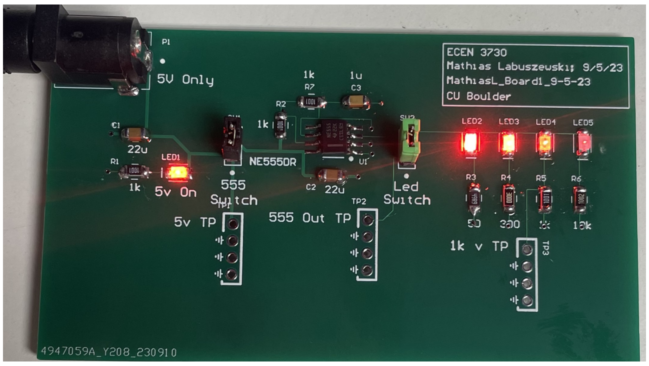

Figure 7: Working Board 1

4.5 Measurements

- To verify the correct working of Board 1, we take measurements of key signals.

4.5.1 Initial Measurements

- The initial measurements were taken with the load switch disconnected.

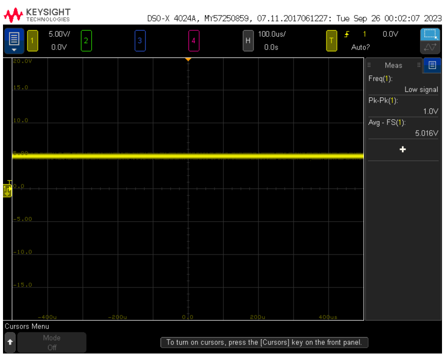

Figure 8: 5v line with no load - 5v

Figure 9: 555 output line with no load - 487Hz

Figure 10: 555 timer output rise with no load (Yellow - 5v line, Green - 555 out)

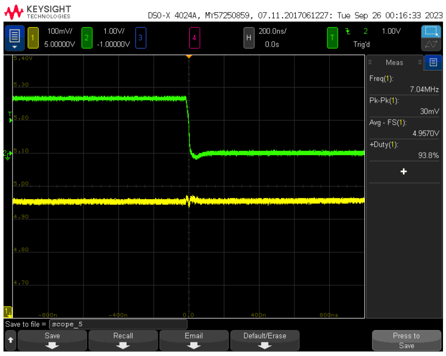

Figure 11: 555 timer output fall with no load(Yellow - 5v line, Green - 555 out)

- We can see initially all the components are working correctly.

4.5.2 Secondary Measurements

- The secondary measurements were taken with the load switch connected.

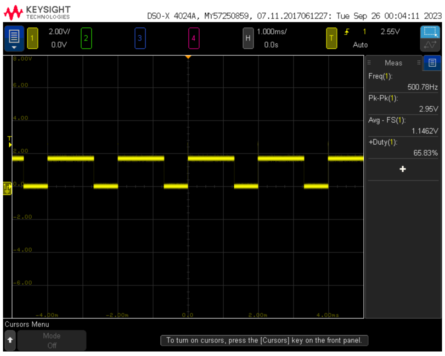

Figure 12: 5v line with load - 500Hz

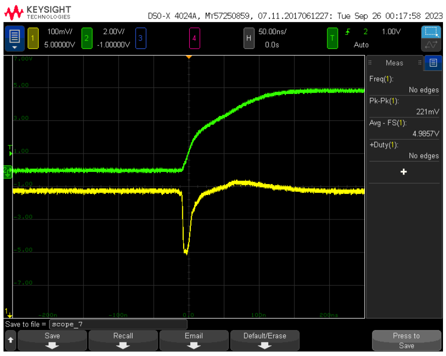

Figure 13: 555 timer output rise with load (Yellow - 5v line, Green - 555 out)

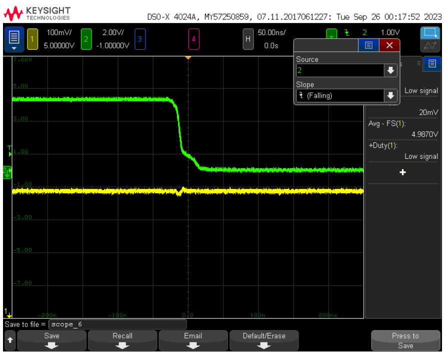

Figure 14: 555 timer output fall with load (Yellow - 5v line, Green - 555 out)

Figure 15: 555 output rise, and 1kΩ resistor. (Yellow - resistor voltage, Green - 555 out)

4.6 Measurement Analysis

- 555 timer current measurement
  - Voltage at 555 output - $3.8v$
  - Load resistance - $10k\Omega||1k\Omega||300\Omega||47\Omega = 39\Omega$
  - 555 Output Current $= 97mA$

- 555 Thevenin resistance
  - 555 output Voltage with no load: $Vth - 4.9v$
  - 555 output Voltage with load: $Vl - 3.8v$
  - Thevenin resistance: Rth - 87Ω
- These measurements are important. We found out our output current is 97mA, which is within the spec of the data sheet of the 555 timer. The output resistance also falls within the range listed on the data sheet.

5 Results

5.1 What worked

- There were no hard errors on the board.
- The 555-timer output was at 500Hz under load, which is right on the target value.
- Indicator leds allowed us to visually see the board working.
- Test points with spring probe grounds allowed us to get accurate measurements of the board's key signals.
- Isolation switches allowed us to measure and test each block of the board.

5.2 What didn't work

- My biggest issue was a 5v power supply for the board. Unfortunately, the kits purchased intended for this class do not come with a 5v wall adapter to plug into our boards. During bring up I used probes to power the board from a lab bench power supply. I later purchased a 5v power adapter.
- In the future board I would like to minimise white space on the board. In my opinion, it is a waste of space and may add manufacturing costs, and should be avoided.

5.3 Learning Outcomes

- Developed the ability to design a functional circuit board following best practices.
- Gained experience in evaluating components for suitability in a given application.
- Improved documentation skills by creating a detailed schematic, layout, and comprehensive lab report.
- Understood the importance of designing for ease of debugging and testing, leading to efficient troubleshooting processes.

5.4 Takeaways

- Design Iteration: Building a solderless breadboard version of the circuit before the board design significantly reduces the risk of errors and helps verify the design's functionality.
- Component Selection: Choosing appropriate components based on factors like availability, performance, and footprint size is crucial for successful board design.
- Design Validation: Thoroughly validating the design, including datasheet reviews and evaluation boards if necessary, helps identify and rectify potential issues early in the design process.
- Engineering Judgment: Blindly following reference designs or online information can be risky. Always exercise engineering judgment and understand the rationale behind design decisions.
- Cost vs. Performance: Balancing performance objectives with cost considerations is a critical aspect of design. Consider factors like dollars, schedule, and risk when making design decisions.

- Design for Debug: Incorporating features like test points, isolation switches, and indicator LEDs can significantly ease the debugging process and reduce downtime in case of issues.

5.5 Conclusion

Board 1 has provided invaluable hands-on experience in the entire board design process, emphasizing best practices and critical design habits. It has allowed us to learn, apply, and reflect on these practices and principles. Through this project, we've not only gained practical knowledge but also identified areas for improvement in future designs.