University of Colorado Boulder

Electrical and Computer Engineering

University of Colorado Boulder

ECEN3730 Practical PCB Design Manufacture

LABORATORY REPORT

Board 4 Report

Student Name: Mathias Labuszewski

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1 Introduction

Board 4 is the final board we will make in the class. This board is different as it will be our first 4-layer board. Board 4 is the finalized version of the instrument droid made in previous labs on an SBB. This board will be an Arduino shield, and its purpose is to gather information about power sources, and measure their thevenin resistance and voltage.

2 Objectives

This section delves deeper into the specific outcomes of Board 4. The focus is on:

1. Validate system functionality by introducing a known resistor as a preliminary test.
2. Measure Thevenin voltage, Thevenin resistance, and loaded voltage.
3. Design and test a 4-layer board.

3 Plan of Record

Board 4's design process. The design plan involves several key steps:

1. Creating a schematic and defining parts
    - 1206 size SMD parts
2. Determining power requirements
    - Powered off the Arduino's 5v pins. Termina block for VRM
3. Selecting components such as the ADC, DAC, LEDs, and resistors
    - Use red LEDs and 1k ohm resistors as the indicators
4. Planning signal routing and the layout
    - Two Copper poured return plane and single return path
    - Place signal layers on the top and bottom layers. Use the bottom side for 5v traces.
    - Each via needs a ground via close for impedance matching.
5. Designing an isolation switch for the circuit
    - Switches at 5v in
6. Test points for each of the key signals
    - I2C SDA, SCL lines
    - DAC test point
    - Mosfet Gate test point
    - Opamp test point
    - Buzzer test point
7. Items on board
    - Buzzer
    - Smart LED's
    - Droid circuit
8. Functionality of new items
    - Buzzer should beep for every measurement
    - Smart LED's will indicate measurements and final results
9. Engineering the layout to best fit all components
    - Signals close to IC's
    - Decoupling capacitors close to IC's

4 What it means to work

- Power Rail Stability: The board must deliver have a stable power rail voltage of approximately 5 V.
- Board should communicate via I2C to Arduino.
- Board Performance: The board should be able to take measurements of VRM's.
- Measurement Accuracy: All measurements taken during the experiment should align with expectations based on design specifications.
- Other items, buzzer and smart LED's will work according to design decisions.

5 Risk Management

- Placing test points and labeling them appropriately
- Switches are used at each stage for isolation and debugging purposes
- All power lines are 20 mils in width for easy detection.
- All signal lines are 6 mils width

6 Board Design, Assembly, Bring-Up Testing

6.1 Initial Block Diagram:

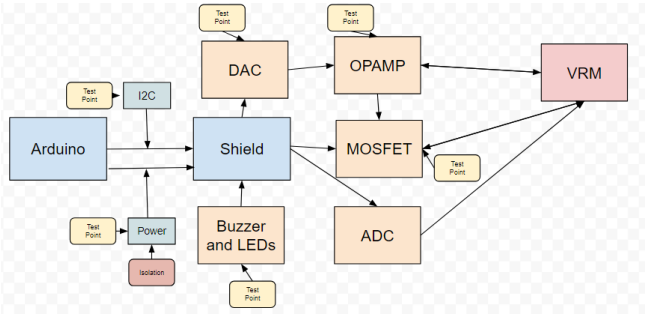

Figure 1: Block Diagram for Board 4

6.2 Schematic of board

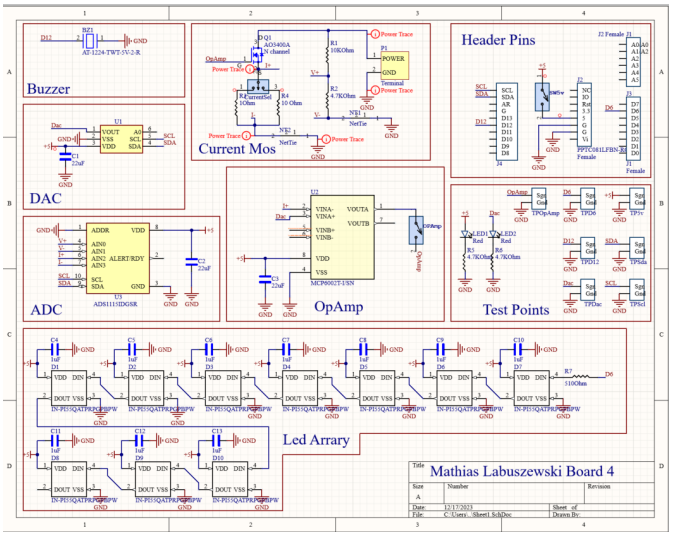

Figure 2: Schematic for Board 4

6.3 Altium designer Board 4 layout

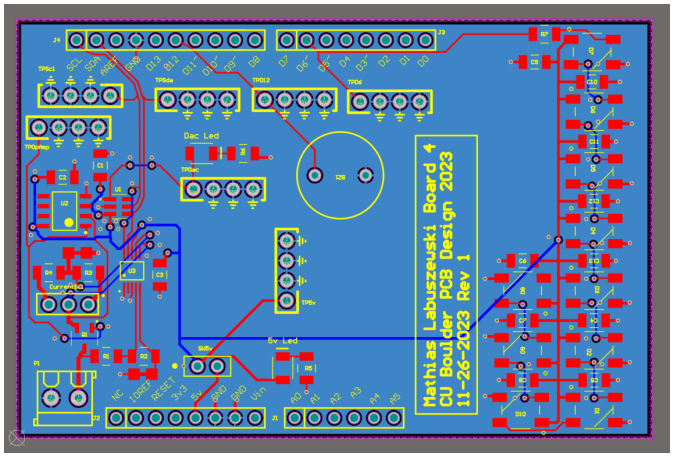

Figure 3: Board layout

6.4 Altium designer 3d view

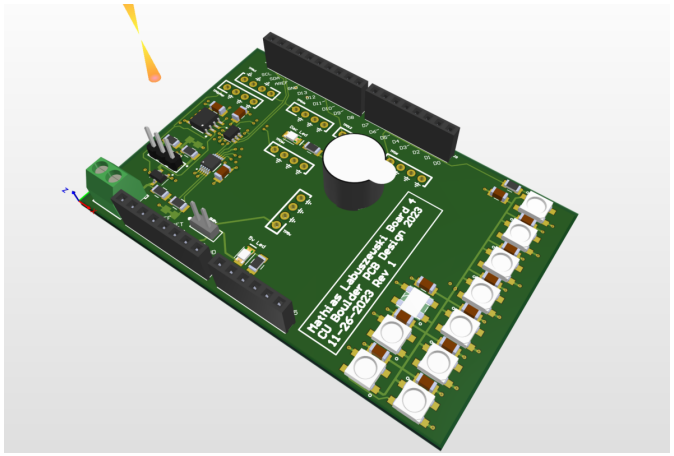

Figure 4: 3d Board layout

6.5 Manufactured board

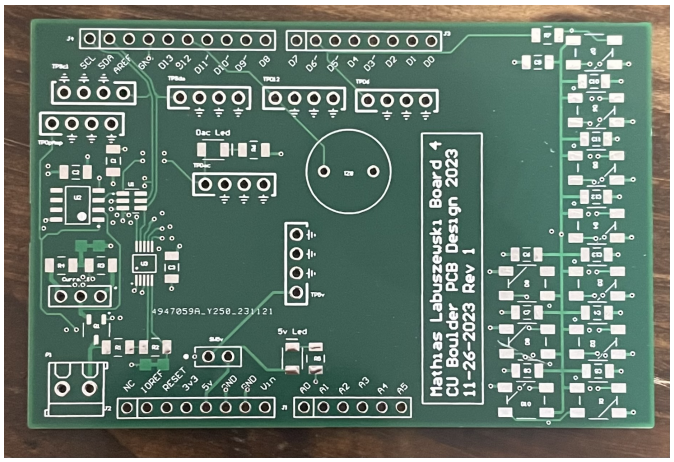

Figure 5: Physical Board 3

6.6 Assembled board

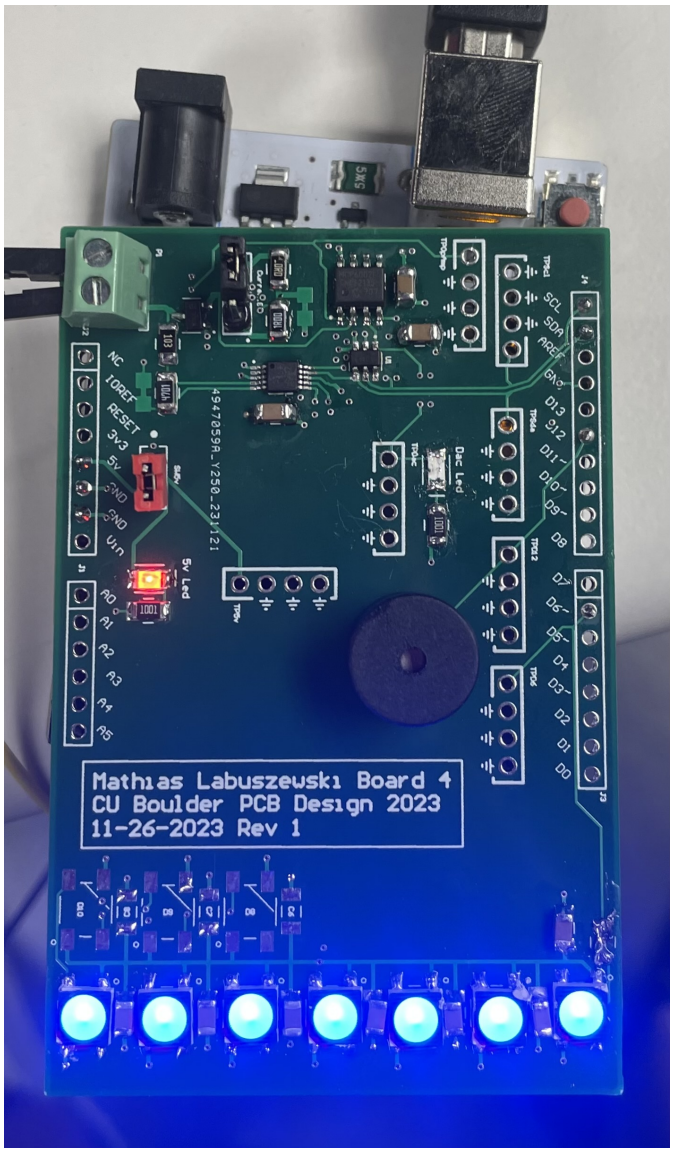

Figure 6: Assembled and working board 3

7 Board Layout

Lab 22 contains information about the working principle behind Board 4.

7.1 Things that went well

My board layout was very compact. It fits over the Arduino very well, I designed the dimensions to be that way. The components were easy to solder and I had no issues.

7.2 Things that went bad

My biggest mistake was in my placement of the header pins. I aligned my header pins from the middle gaps where the arduino is missing them. On the arduino, the gaps on the top and bottom rows are not the same, so we need to account for that in the design. I did account for it, however in doing so I shifted the bottom row of header pins one pin left. This is why Board 4 looks crooked in the assembled picture.

8 Assembly and Bring up

8.1 Things that went well

The board assembly did not pose any difficulties to me. I soldered everything relatively quickly.

8.2 Things that went bad

The assembly proved no issues, and the board worked right away.

9 Measurements

9.1 Initial measurements and Bing up

First I will take some measurements to make sure my board is working.

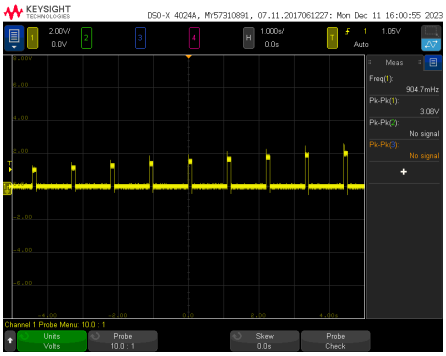

Figure 7: DAC output

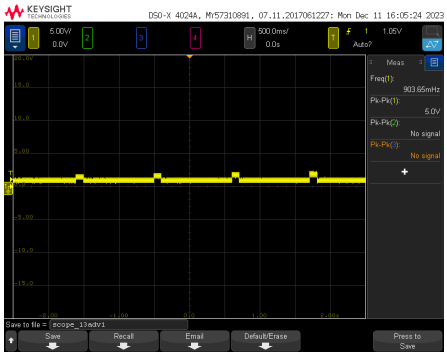

Figure 8: Gate of Mosfet (output of opamp)

Both the MOSFET gate and the DAC output are receiving voltage. This means the DAC is communicating with the Arduino. Test code was used to test the DAC and find the I2C address.

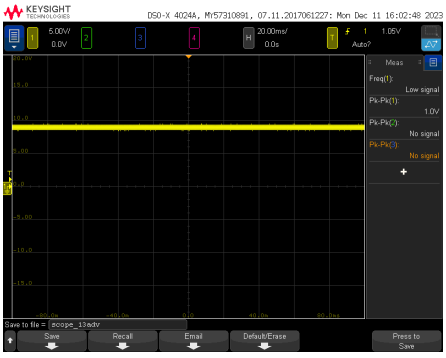

Figure 9: Sense resistor voltage

Figure 10: Serial Monitor data (VS Code)

Voltage across the sense resistor and a serial output from the Arduino prove the ADC is accurately measuring. Test code was used to find the I2C address and verify functonality.

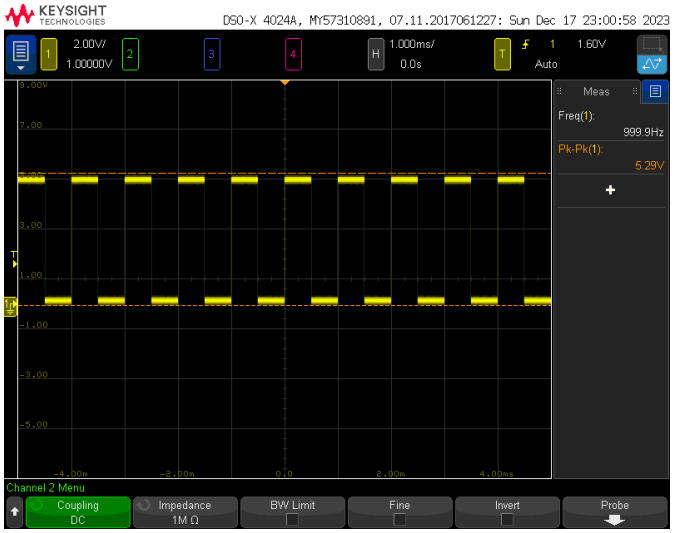

Figure 11: Buzzer Pin

The Buzzer works according to the POR. The Buzzer works when a new measurement is taken, and when the measurement is finished.

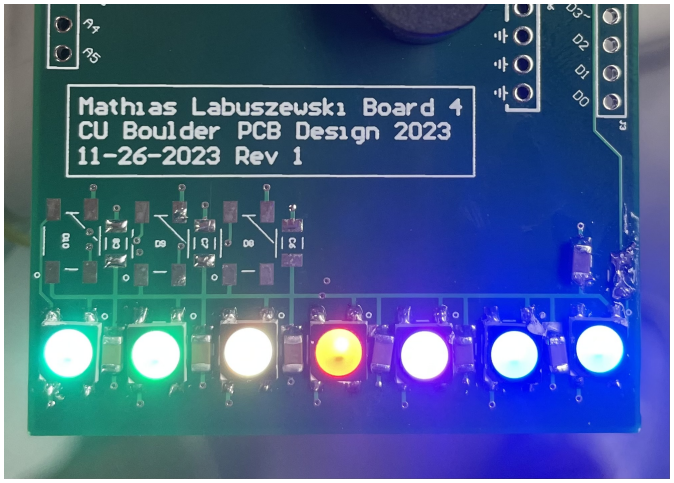

Figure 12: Smart LED's

The Smart leds work. They change color according to the measurements taken and the final measurements calculated.

My Board 4 work. Functionality was verified and we can now get on to testing.

9.2 Measuring VRMs

9.2.1 Testing

To verify the correct output, I connected a test resistance to a DC power bench power supply. The power supply should ideally have 0 Thevenin resistance, but in practice, it is very low. This however is fine, as my test resistance is much larger. Using a 10ohm rest resistance I connected the circuit. The power supply was set in CV mode at 8v with a max current of 2A. The sense resistor I used was a 10ohm. The max current we should see is 0.8A, less than the max current of the DC supply

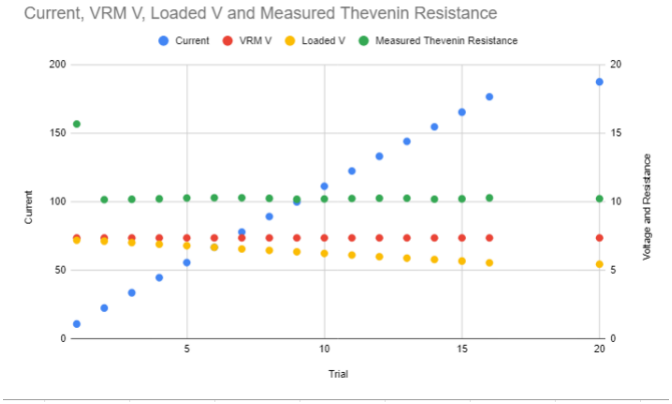

Figure 13: Measurements of Board 4 Test

The plots show us the current, VRM V, loaded V and measured thevenin resistance. We can see the measured thevenin resistance is 10ohms. This is correct. This means the functionality of Board 4 is verified.

9.2.2 5v Rail of Arduino

Measuring the 5v rail can provide insight into the efficiency and reliability of the design. I used the 10ohm resistor.

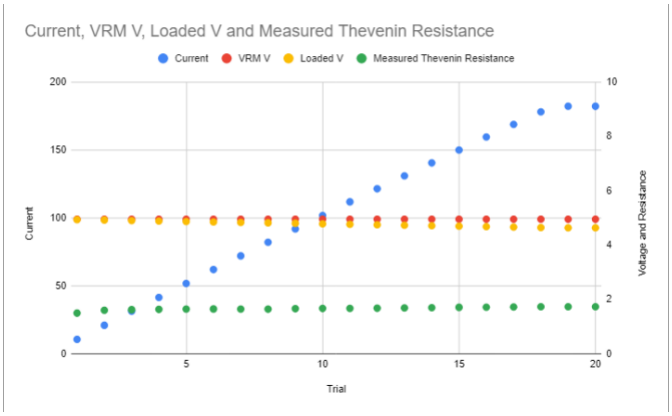

Figure 14: Measurements of 5v Rail of Arduino

We can see the thevenin resistance is around 1.65 ohms.

9.2.3 4 AAAA batteries in series

Measuring the AAAA batteries can provide insight into standalone power supplies for all types of embedded circuits. 4 AAAA batteries in series should be around 6v.

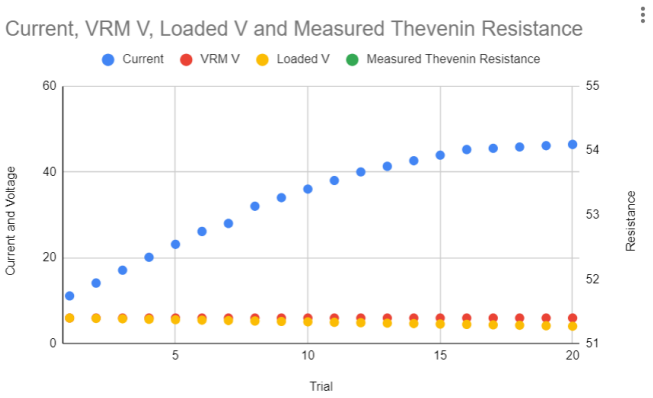

Figure 15: Measurements of 4 AAAA batteries

We can see the thevenin resistance is around 4.1 ohms.

10 Final Remarks

With the above results, I can conclude my board did work and function close to correctly as outlined in the POR. The only thing that did not work well was the placement of the header pins on the board. I was able to remove some unused pins and twist the shield to fit on the Arduino.

I had no soft errors, a big improvement when compared to my last board, with multiple soft errors.

11 Summary of Findings

- Board Functionality: The board was able to communicate to the Arduino.
- Board Performance: The board accurately measured VRM characteristics.
- Board Addons: The Buzzer and Smart leds worked properly and in unison with the measurements.
- Board Layout: The layout of the board helps achieve a good function circuit.
- Measurement Accuracy: All measurements aligned closely with the initial design. All signals were measured using a 10x probe with a spring tip.

12 Conclusion

This lab provided an outline of constructing our board 4, an instrument droid for characterizing voltage sources and VRM's. The board was a 4 layer board where we used our best practices learned to make the best possible board. We used new components that were explored in other labs. We were able to test our board and interface it with an Arduino.