EECE72545-24W DELIVERABLE

HW Testing Report

Project 2 – Hardware Testing Report

EECE72545-24W: Engineering Projects IV

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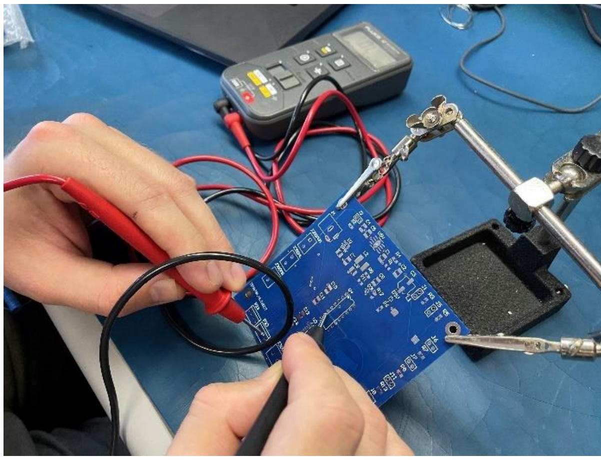
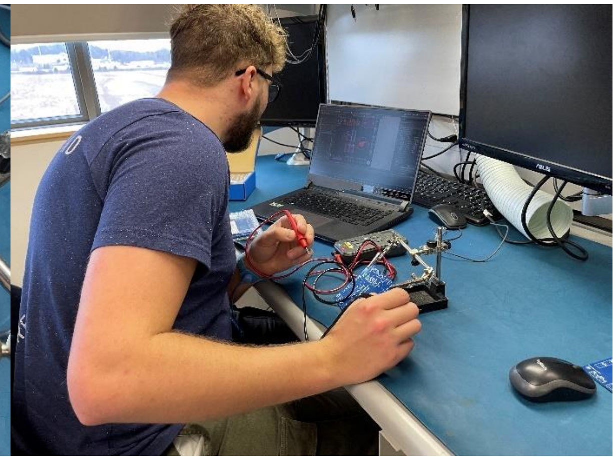
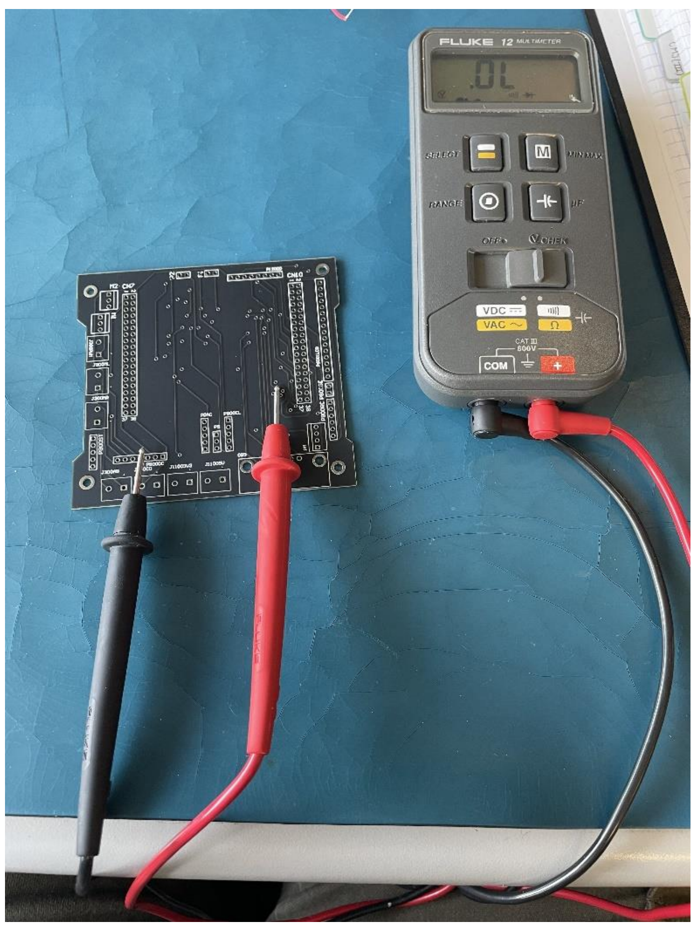
Date Submitted: 1/04/2024

ED3 – Bare Board Inspection: PCB Continuity Test





The continuity of both boards was recorded in W9, using a Fluke 12 Multimeter. PCB1 behaved as expected with continuity breaks between jumpers and shorts across 0-ohm resistors and OL across the motor driver's IC footprints. It was later revealed that the signal path from 5V output to the 3V3 regulator at the 3rd pin was not continuous which would later have to be mitigated.



Continuity from the 5V input to output was measured along the expected signal paths along the designated power planes of PCB2 continuity to ground was also measured from relevant points including the RS232 IC, CANBUS, encoder and limit switch footprints. It was later determined that the signal path from MCU5V to the 5V pin of the MCU not continuous, this would later be remediated with a jumper wire.

ED3 – PCB1 Test Plan for Verification and Validation:

Test Objectives and Scope:

The main purpose of this testing is to verify the functionality of the 5V and 3.3V Regulators. The scope of the testing is for the two main regulators on the power and motor driver PCB (in blue). Additionally, continuity across the inputs and output of the motor driver ICs will be tested. Finally continuity at the power and motor driver terminal connectors will be measured.

One way you can test the reliability of the 5V regulator is if it operates within the stated range that it was designed to handle. For example, will the 5V regulator reliably convert a 14.8-30V input to 5V at 3A consistently or does the 3.3V regulator convert a 5V input to a 3.3V input at 300mA (see below for the regulators used).

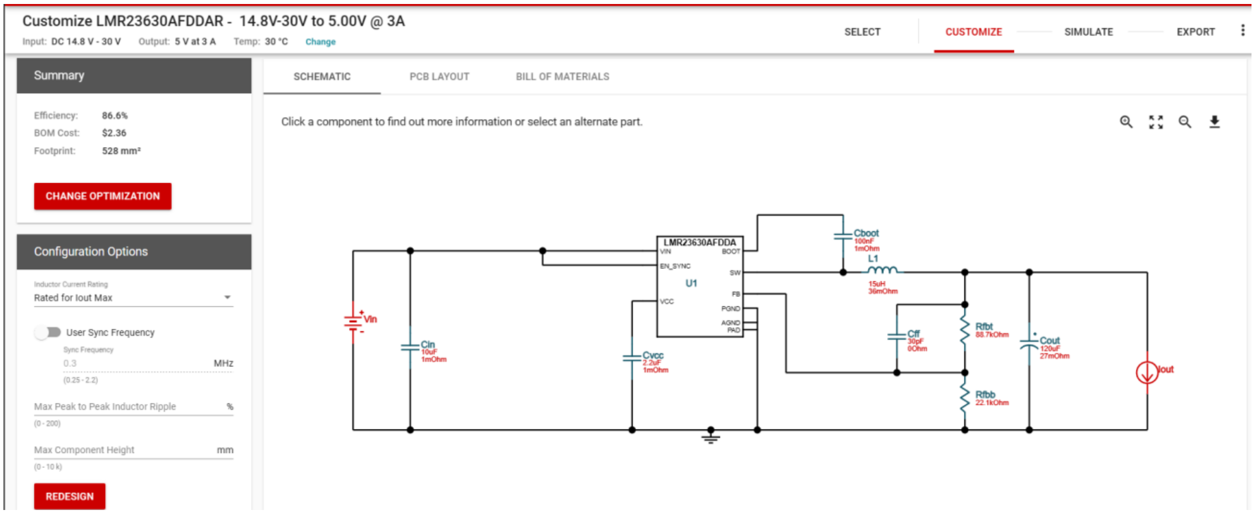


Figure 1: 5V Regulator

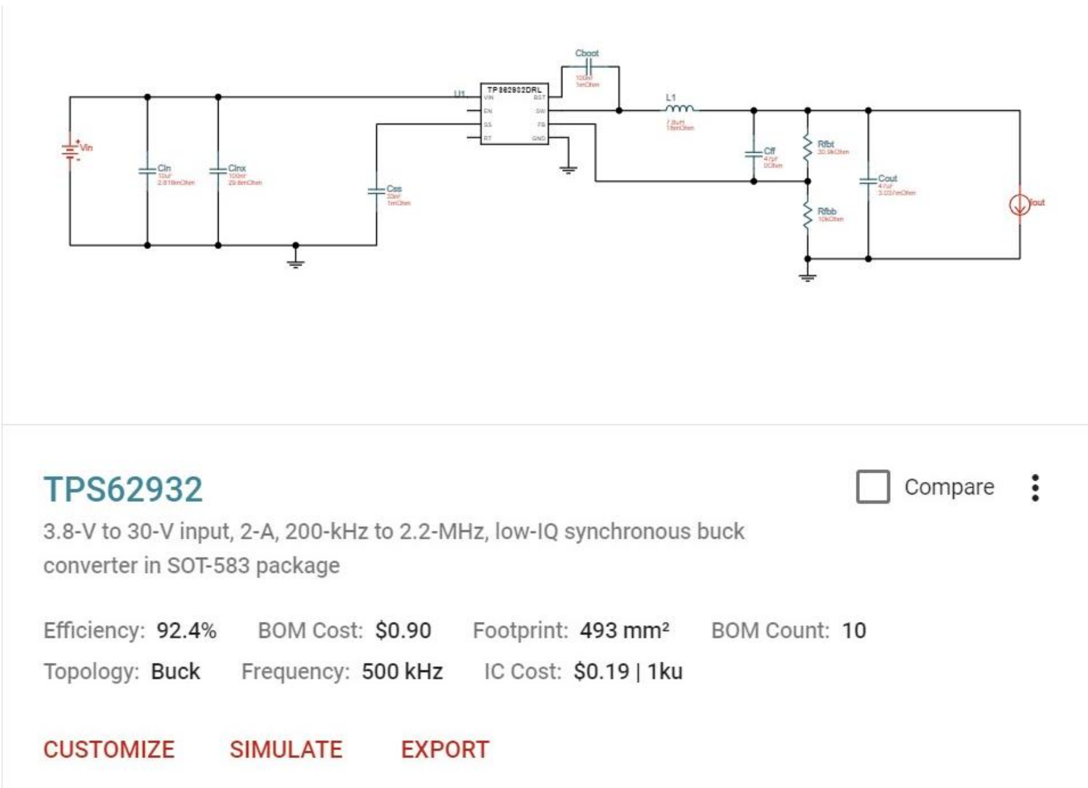


Figure 2: 3.3V Regulator

It's **important** to **test the stability of the output voltage** of both regulators, that the voltage remains consistent within the specified limits under varying loads either 14.8V or 30V.

Another critical thing to consider is the **temperature performance** of the regulator ICs, this may be more challenging to test in the lab as there is limited access to the temperature camera.

It's critical that all of the jumpers' points get tested before they are connected to the rest of the circuit with 0 ohm resistors.

Test Environment and Equipment:

The chosen test environment is the 2nd year ESE classroom / labs at one of the lab benches. The primary tools which will be used are the lab bench power supply the helping hands and a fluke 12 multimeter owned by Kyle Dick.

To mimic real world conditions, an anti-static mat and arm bracelet will be required to perform all testing in addition to safety glasses.

Test Types and Levels:

Functional Testing:

Follow the previous testing methodology to verify that the PCB performs as intended. Refer to the testing procedure for a more detailed process to follow. Measure the input voltage and the output voltages of both regulators. Test the continuity of the stepper input and output signals, and the corresponding signals of the DC motor as well as the continuity of the power and motor connectors.

Test Procedures:

Functional Testing for Power Systems:

Set V Batt and R5VT3V3R input using the lab bench power supply, measure output using personal multimeter from output source to ground.

5V Voltage Regulator (14.8V 1mA IN to 5V @ 3A OUT)			
Circle Pass if 5V is measured at the output	Set input at J2 V Batt to 14.8V 1mA (max)	Measure MCU5V Output: _________ @ **J1**	Pass / Fail
		Measure R5VT3V3R Output: _________ @ **J5**	Pass / Fail
		Measure MCU5V Output: _________ @ **J6**	Pass / Fail
		Measure MD5V Output: _________ @ **J7**	Pass / Fail
5V Voltage Regulator (30V 1mA IN to 5V @ 3A OUT)			
Circle Pass if 5V at the output	Set input at J2 V Batt to 30V 1mA (max)	Measure MCU5V Output: _________ @ **J1**	Pass / Fail
		Measure R5VT3V3R Output: _________ @ **J5**	Pass / Fail
		Measure MCU5V Output: _________ @ **J6**	Pass / Fail
		Measure MD5V Output:	Pass / Fail

		_________ @ **J7**	
3V3 Voltage Regulator (5V to 3V @ 0.3A)			
Circle Pass if 3.3V at the output	Set input at **J5** R5VT3V3R to 5V, 1mA	Measure IC3V3A Output: _________ @ **J8**	Pass / Fail
		Measure IC3V3B Output: _________ @ **J12**	Pass / Fail

Functional Testing for Motor Drivers:

Perform continuity tests on the inputs to the outputs of the motor driver ICs using personal multimeter at a lab bench with proper ESD equipment:

Stepper Motor Driver: U3 SMD		
Signal continuity between	**pin 2 & 3**	Pass / Fail
	pin 9 & 8	Pass / Fail
	pin 12 & 13	Pass / Fail
	pin 1 & 18	Pass / Fail
DC Motor Driver: U4 TH		
Signal continuity between	**pin 1 & 3**	Pass / Fail
	pin 9 & 6	Pass / Fail
	pin 7 & 11	Pass / Fail
	pin 10 & 14	Pass / Fail

Functional Testing for Motor and Power Connectors:

Perform continuity tests on the power and signal terminal connectors using personal multimeter at a lab bench with proper ESD equipment:

Continuity to Power Screw Type Terminal Connectors		
Circle Pass if continuity exists between specified tests points	J1 (MCU5V) & pin1 of J3005V	Pass / Fail
	J6 (IC5V) & pin2 of J3005V	Pass / Fail
	J12 (IC3V3B) & pin1 of J3003V3	Pass / Fail
	Pin 14 (U3) & pin2 of J3003V3 (GND)	Pass / Fail
Continuity to Stepper Motor Outputs Screw Type Terminal Connectors		
Circle Pass if continuity exists between specified tests points	From U3 L293DD SMD to P23 Terminal Connector	
	pin 3 U3 to pin 1 P23	Pass / Fail

	pin 8 U3 to pin 2 P23	Pass / Fail
	pin 13 U3 to pin 3 P23	Pass / Fail
	Pin 18 U3 to pin 4 P23	Pass / Fail
Continuity to Stepper Motor Outputs Screw Type Terminal Connectors		
Circle Pass if continuity exists between specified tests points	From U4 L293D TH to P33 Terminal Connector	
	pin 3 U4 to pin 1 P33	Pass / Fail
	pin 6 U4 to pin 2 P33	Pass / Fail
	pin 11 U4 to pin 3 P33	Pass / Fail
	Pin 14 U4 to pin 4 P33	Pass / Fail

Test Data and Metrics:

Expected outcomes:

- Voltage logged in the test procedure for both regulators.
- Continuity between selected pins, recorded as pass or fail in the test procedure.
- Images taken where voltage is outside of the expected range (acceptable criteria), indicating the input and output pins for the voltage regulators and the pair of pins where measuring continuity.

Acceptance Criteria: +/- 5% when calculating voltages.

Defect Reporting and Resolution:

- Report defective solder joints with a photo and a note of where it's located in the Traceability and Documentation section.
- Where there is no continuity between pins, a note with its location will be made for later inspection.
- Defective traces, vias or stenciling can also be addressed with a note or an image posted to the Traceability and Documentation section.

Addressing Issues:

- All rework and debugging will be performed by the owner of the board.
- Any design changes will be addressed in the next revision.
- Where there are issues with soldering, rework will be performed, and new components used where necessary.
- Key issues will be documented in lessons learned section of MBSE.

Traceability and Documentation:

Test results will be documented in test procedures. Any deviations from expected results can be recorded in the Notes Section below:

NOTES:

Risk Assessment:

Addressing Potential Risks:

- There could be a possible problem with U2 and may require additional testing to confirm continuity between pin 1 and 3 and OL everywhere else.
- R9 is not soldered to the board yet as it did not arrive with the rest of the shipment of parts.
- Ensure there is no continuity between any of the remaining resistor pads on the PCB, once proper operation has been confirmed, these will be populated by 0-ohm resistors.

Approval and Sign-Off:

Reviewed and approved by a second year ESE student. Testing may begin once sign-off is completed.

Name: ________________

Date____________________

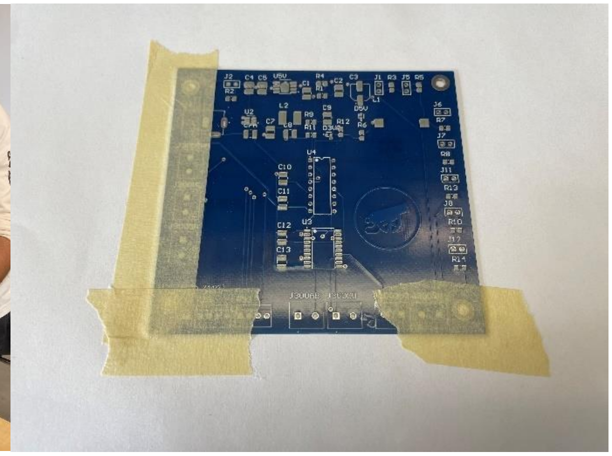
ED3 – PCB2 Test Plan for Verification and Validation:

<table>
<tr><th colspan="4">MCU5V</th></tr>
<tr><td>Circle Pass if 5V is measured</td><td>Set pin 1 of J11005V to 5V 600mA</td><td>Measurement at pin 6 of CN7: _________ V</td><td>Pass / Fail</td></tr>
<tr><th colspan="4">IC5V</th></tr>
<tr><td rowspan="4">Circle Pass if 5V is measured</td><td rowspan="4">Set pin 2 of J11005V to 5V 600mA</td><td>Measure IC5V at pin 2 of PDAC: _________V</td><td>Pass / Fail</td></tr>
<tr><td>Measure IC5V at pin 2 of PS: _________ V</td><td>Pass / Fail</td></tr>
<tr><td>Measure IC5V at pin 4 of PM: _________ V</td><td>Pass / Fail</td></tr>
<tr><td>Measure IC5V at pin 16 of U232: _________ V</td><td>Pass / Fail</td></tr>
<tr><th colspan="4">IC3V3B</th></tr>
<tr><td rowspan="2">Circle Pass if 3.3V is measured</td><td rowspan="2">Set pin 1 of J11003V3 to 3.3V 600mA</td><td>Measure IC3V3B at pin 5 of PDAC: _________V</td><td>Pass / Fail</td></tr>
<tr><td>Measure various points to confirm 3.3V plane works</td><td>Pass / Fail</td></tr>
<tr><th colspan="4">GND</th></tr>
<tr><td>Circle Pass if GND continuity is measured</td><td>Measure GND from pin 2 of J11003V3</td><td colspan="2">Measure various points to confirm GND plane works</td></tr>
</table>

ET2 – Measurement Tools

Instrumentation	**Measurement Techniques and Uses**
Digital Multimeter	Measuring voltages, resistances, diode direction and continuity
Lab Bench Power Supply	Simulating power source, controllable, up to two channels active at once
Helping Hands	Holds Circuit board or solder and holds it still to make soldering and measuring easier.
Soldering Iron	Heats up solder
Solder	Binding agent to create a connection between pads and components
Clothing Pin	Used to apply solder or separate shorts on pads
Oscilloscope	Used for measuring various characteristics of electronic signals and help to diagnose and troubleshoot issues.

ET2 – Paste

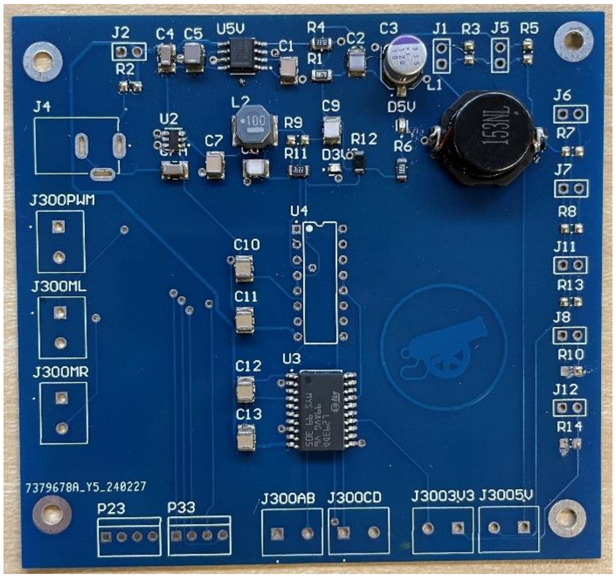


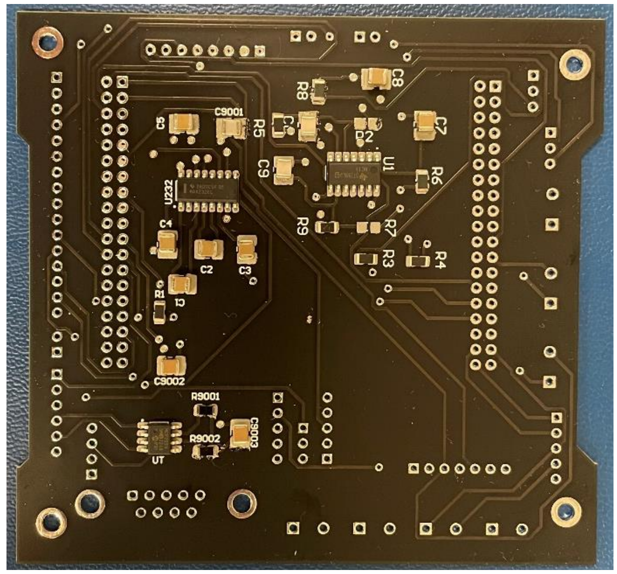
In the first image above, the student and their classmate are learning how to apply solder paste to PCB1 the traditional way where the stencil is positioned, aligned, and placed on top without the use of a jig other than some pieces of tape (image on the right). The reason he was doing it this way is due to the thickness of their PCB1. When he tried to apply solder paste to it using the jig they found that their board flexed and resulted in an inaccurate placement of paste to the pads. The second image above shows the result before placing SMD components and baking them.

The image to the left shows the student applying solder paste with the jig to PCB1. PCB1 was not expected to fail with on the jig the way it did. It helped to have another classmate who couldn't use the jig, to learn the more traditional way of applying solder paste.

ET2 – Populate

The main lesson learned from this section was to choose a larger 3V3 regulator (U2 in the image below). This would have saved many more headaches later when it discovered to be misaligned in the X-Ray machine.





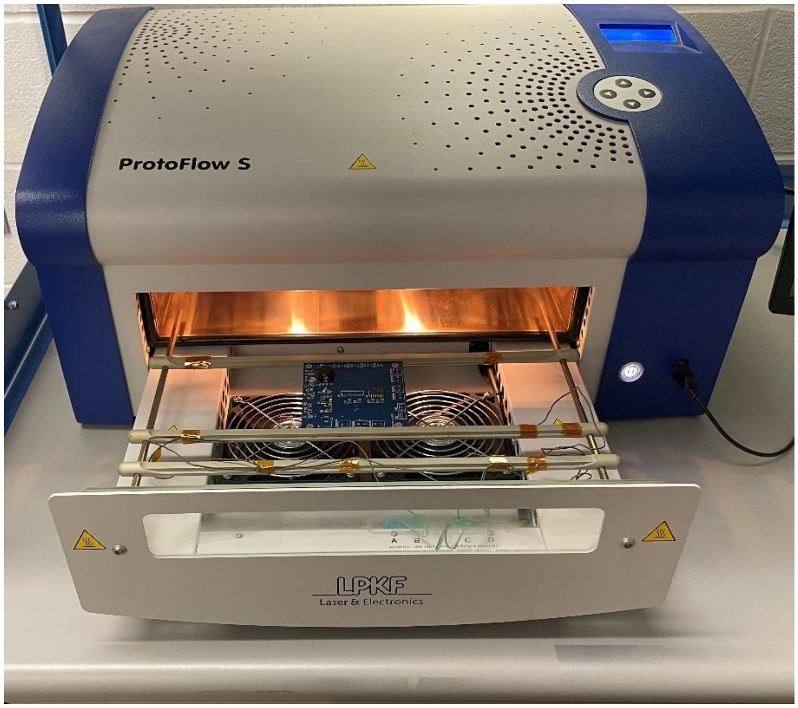
If the board were to be redesigned, I would have been wise to use two of the same motor driver ICs in the TH configuration instead of one TH and one SMD. In future iterations of the mobile robot, more time will be spent selecting the components for purchase according to the recommendations of the regulator datasheets instead of only following the WEBench configurations.

Details of the solder paste used on PCB1 and 2:

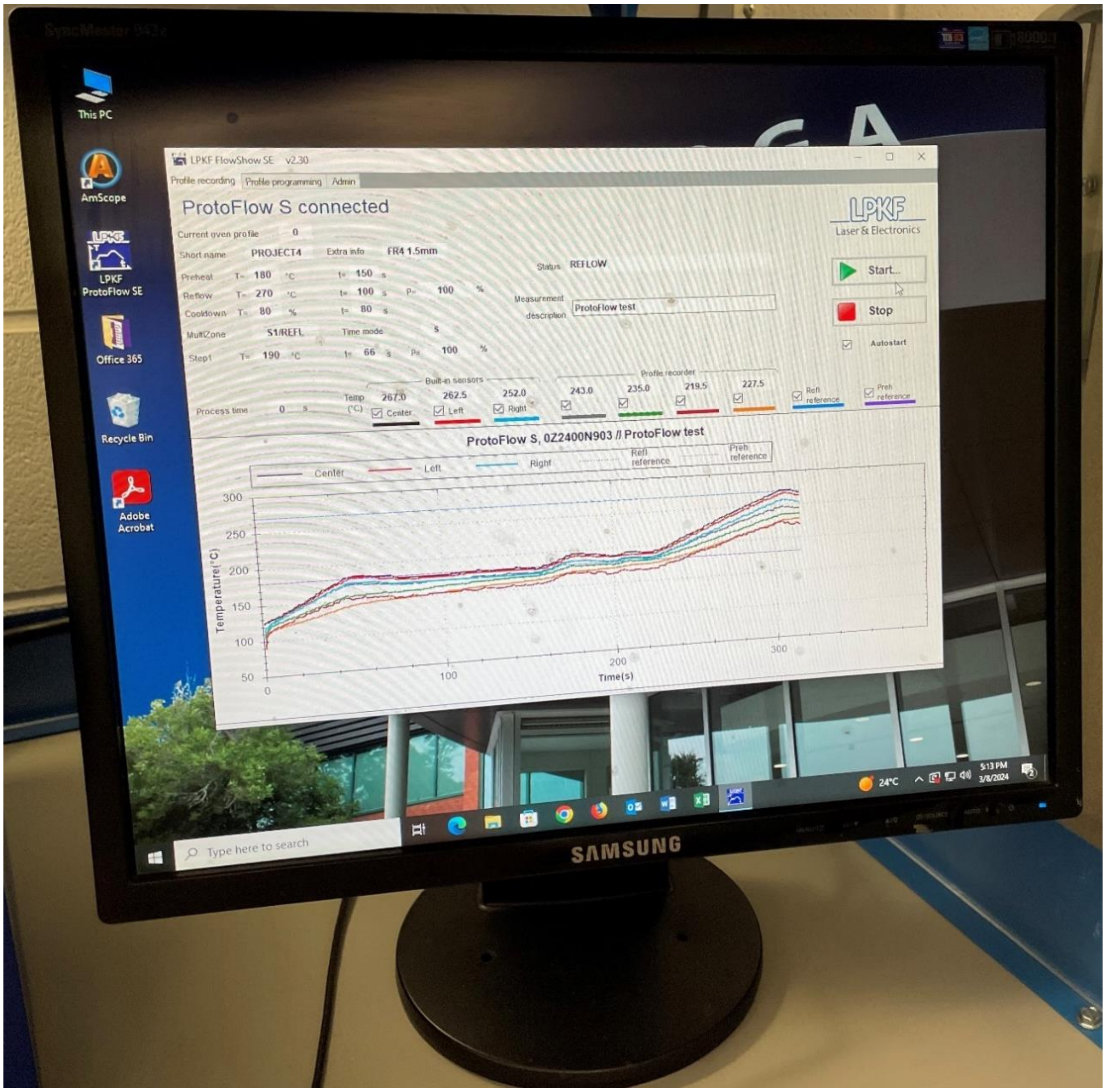
Brand: Chipquik.
Type: TS991SnL500T4, Sn96.5/Ag3.0/Cu0.5 synthetic NO-Clean T4.
MFG date: 231005.

ET2 – Reflow

The image below is of thePCB1 exiting the Protoflow S after the reflow process.

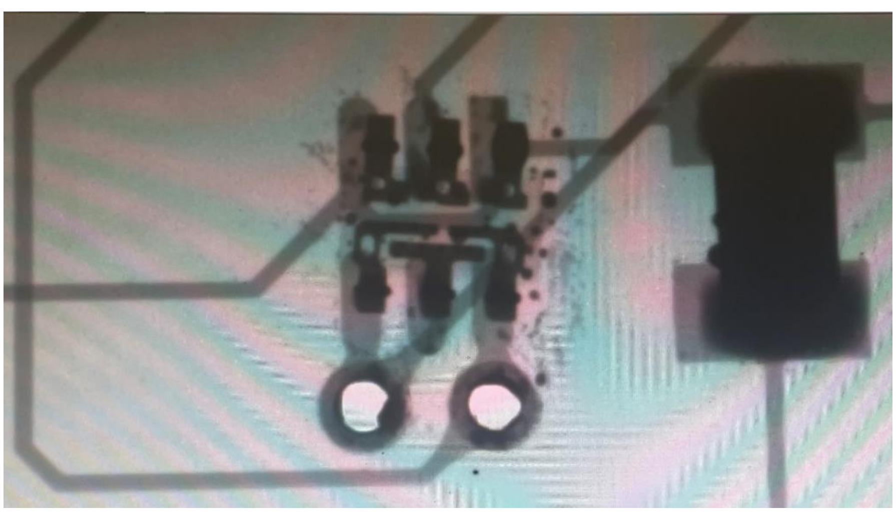


The following image shows the temperature profile of the Protoflow S, showing the temperature on the y-axis and the time on x-axis. At the top left, it shows the settings for each of the stages of the baking process, each with a target temperature and time spent in that stage. This profile was preset for FR4 1.5mm boards. It should be noted that extra care was made with PCB1 as it was .5 mm thinner than the specified FR4 dimension. I made sure to talk with Dave Sulivan about this before baking it. He said that I did not need to change anything for the components and solder to reflow properly in fact, he said it might turn out better at this dimension.

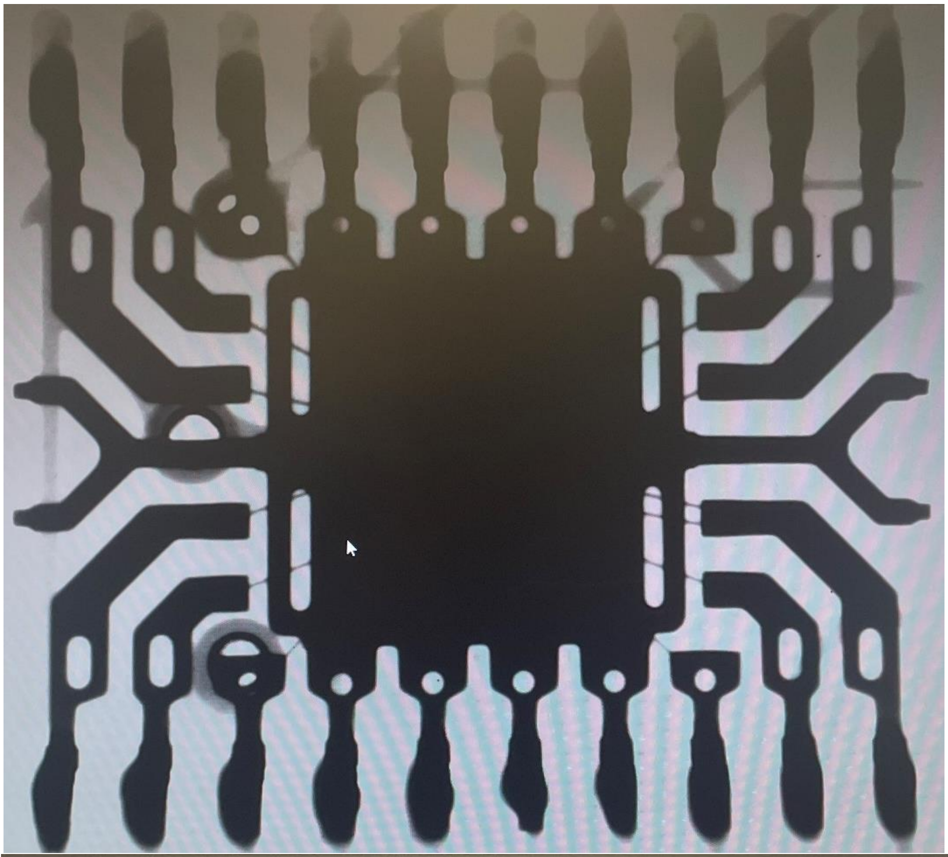


The same process was repeated for PCB2, but unfortunately the profile recording and the .CSV file was not captured due to user error. I have since learned more about how to use the Protoflow oven for future boards.

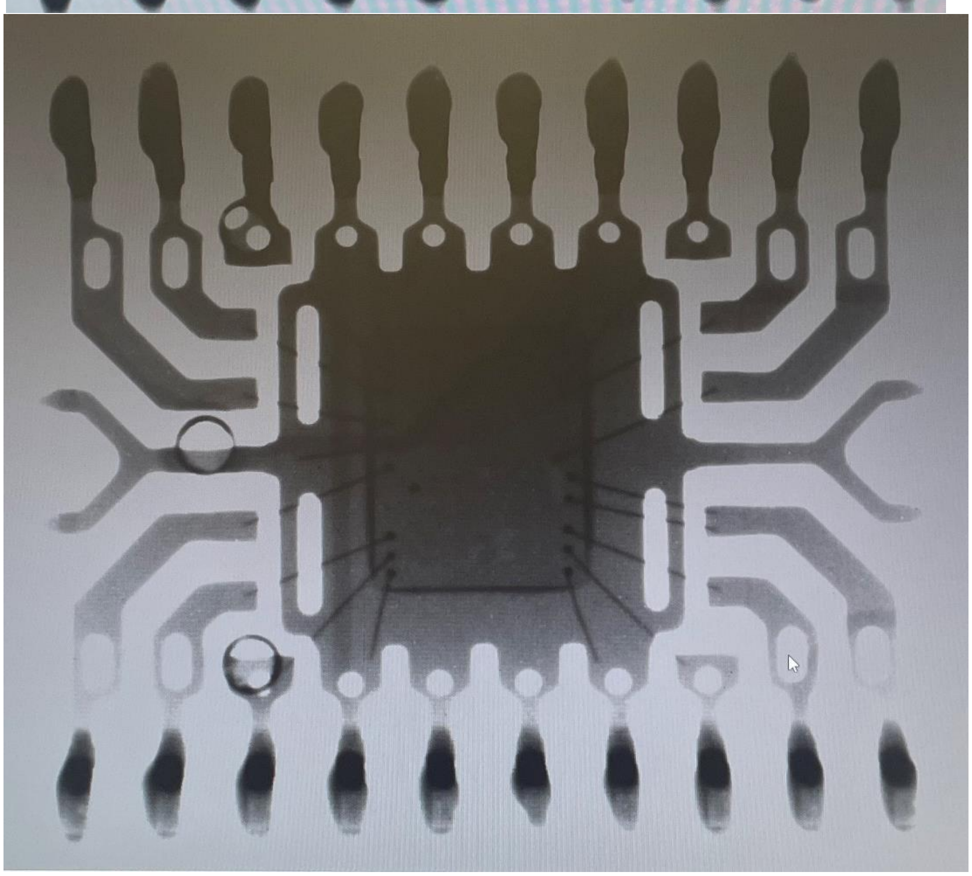
ET2 – X-Ray Inspection



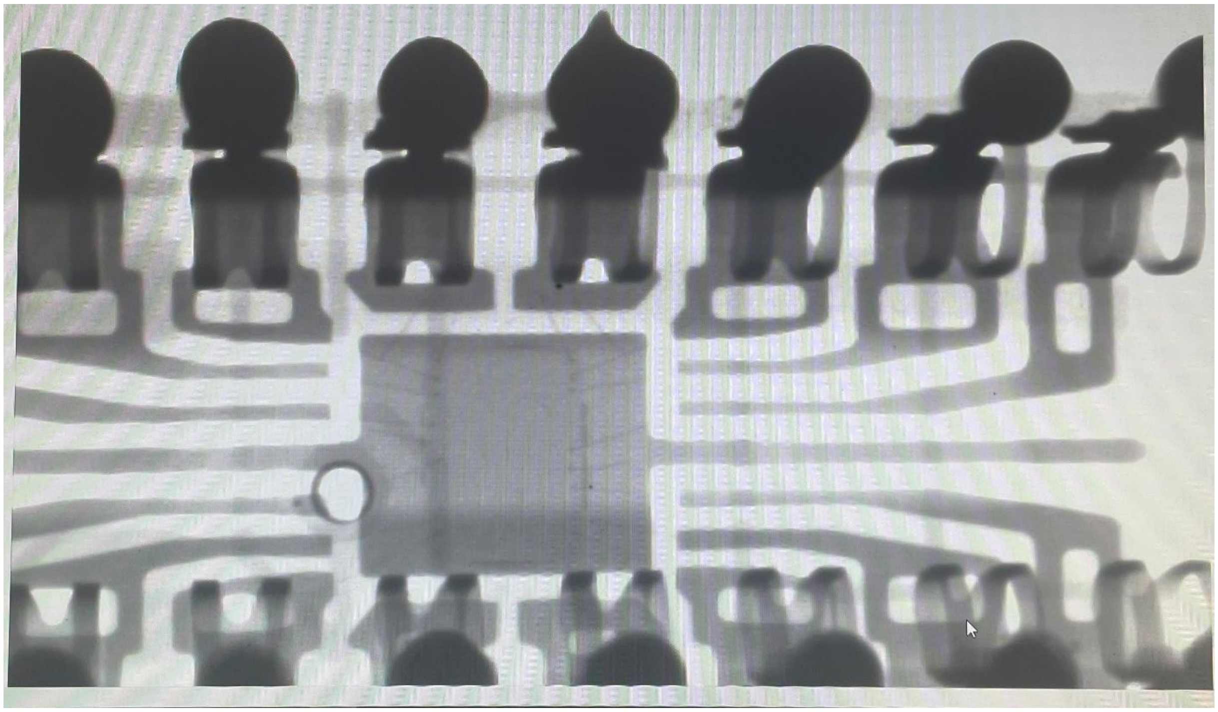
Above is an image of the 3V3 regulator; in this image it's clear to see that the fitment of the chip is off causing it to misbehave in the circuit. This chip was later replaced with a fresh IC with help from Dave Sulivan.



This is an X-Ray image of U3, the circular bubbles were revealed to be vias. It's clear by this image that their placement should be changed in future iterations as there is a high potential for shorts when they are placed this way.



This is a similar image to the one above, the main difference is in the penetration level of the X-Ray; this image looks deeper into U3 compared to the one above.



The above image shows U4 from PCB1, the dark circles at the top of the image show solder errors which occurred when the IC container lifted of the board during fitment.

TM1 – Personal Contribution: Completed Test Plan for PCB1

testing procedure for a more detailed process to follow. Measure the input voltage and the output voltages of both regulators. Test the continuity of the stepper input and output signals, and the corresponding signals of the DC motor as well as the continuity of the power and motor connectors.

Test Procedures:

Functional Testing for Power Systems:

Set V Batt and R5VT3V3R input using the lab bench power supply, measure output using personal multimeter from output source to ground.

5V Voltage Regulator (14.8V 1mA IN to 5V @ 3A OUT)			
Circle Pass if 5V is measured at the output	Set input at J2 V Batt to 14.8V 1mA (max)	Measure MCU5V Output: 5.08 @ J1	Pass / Fail
		Measure R5VT3V3R Output: 5.08 @ J5	Pass / Fail
		Measure MCU5V Output: 5.8 @ J6	Pass / Fail
		Measure MD5V Output: 5.08 @ J7	Pass / Fail
5V Voltage Regulator (30V 1mA IN to 5V @ 3A OUT)			
Circle Pass if 5V at the output	Set input at J2 V Batt to 30V 1mA (max)	Measure MCU5V Output: 5.08 @ J1	Pass / Fail
		Measure R5VT3V3R Output: 5.08 @ J5	Pass / Fail
		Measure MCU5V Output: 5.08 @ J6	Pass / Fail
		Measure MD5V Output: 5.06 @ J7	Pass / Fail
3V3 Voltage Regulator (5V to 3V @ 0.3A)			
Circle Pass if 3.3V at the output	Set input at J5 R5VT3V3R to 5V, 1mA	Measure IC3V3A Output: 0 @ J8	Pass / Fail
		Measure IC3V3B Output: 0 @ J12	Pass / Fail

Functional Testing for Motor Drivers:

Perform continuity tests on the inputs to the outputs of the motor driver ICs using personal multimeter at a lab bench with proper ESD equipment:

Stepper Motor Driver: U3 SMD			

ZM

Signal continuity between	pin 2 & 3		Pass / Fail *
	pin 9 & 8		Pass / Fail *
	pin 12 & 13		Pass / Fail *
	pin 1 & 18		Pass / Fail *
DC Motor Driver: U4 TH			
Signal continuity between	pin 1 & 3		Pass / Fail *
	pin 9 & 6		Pass / Fail *
	pin 7 & 11		Pass / Fail *
	pin 10 & 14		Pass / Fail *

Traceability and Documentation:

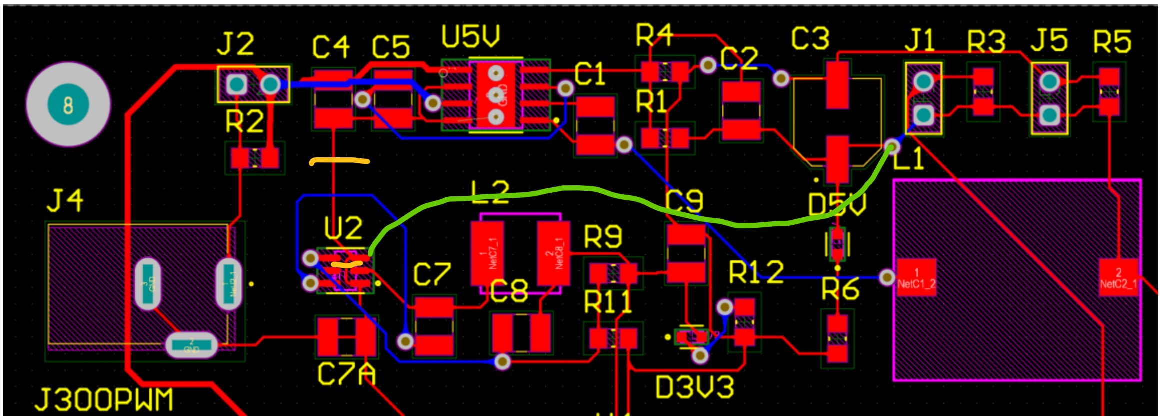
Test results will be documented in test procedures. Any deviations from expected results can be recorded in the Notes Section below:

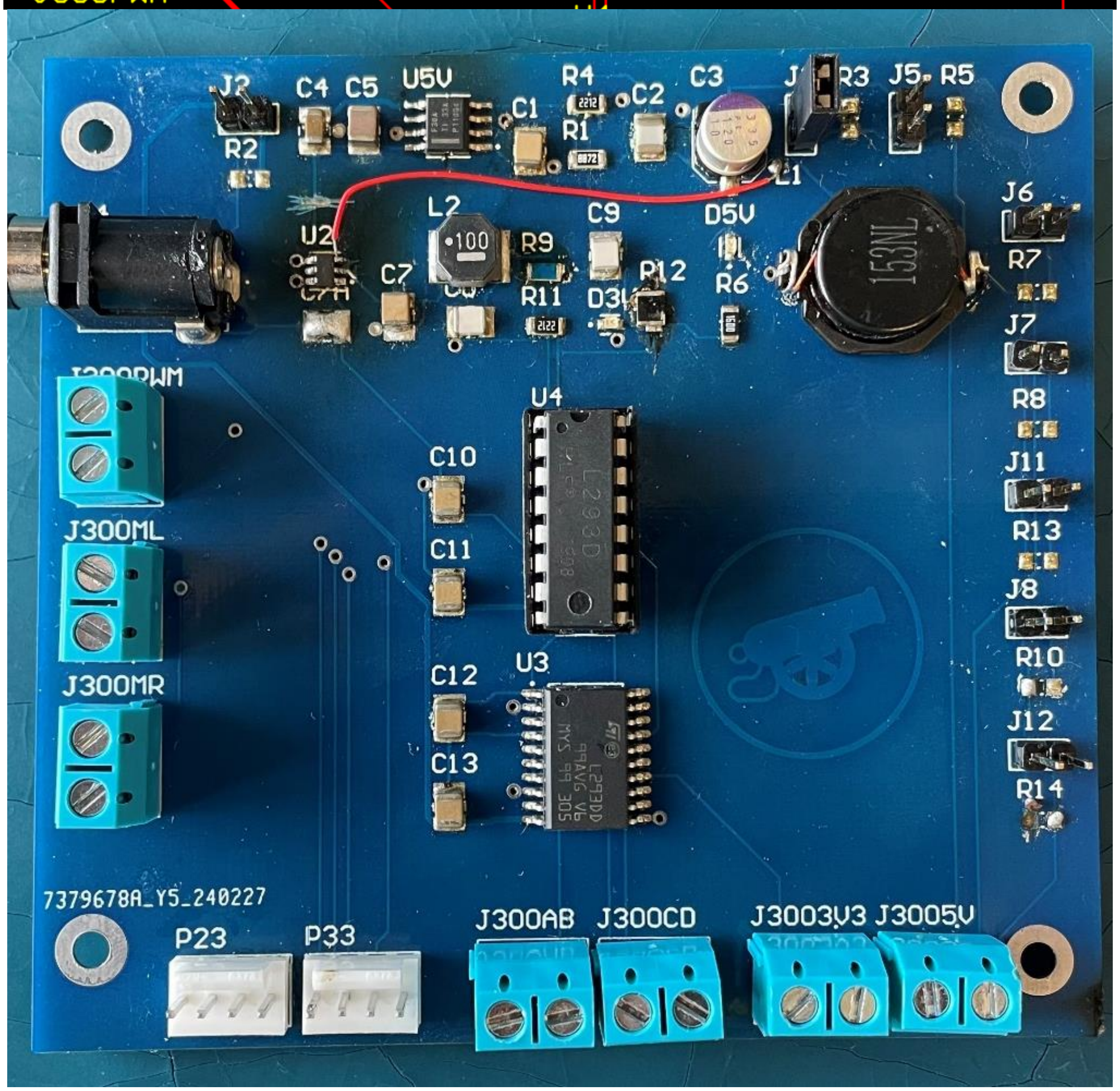
NOTES:

- D5V, D3V Backward
- MC need power to read continuity
- U3 1,11 Enable is reading 0.5V
- No continuity between
- 1.09, 2.09 at 1,9 respectivly
- Refer to M.C datasheet for IC internal circuit

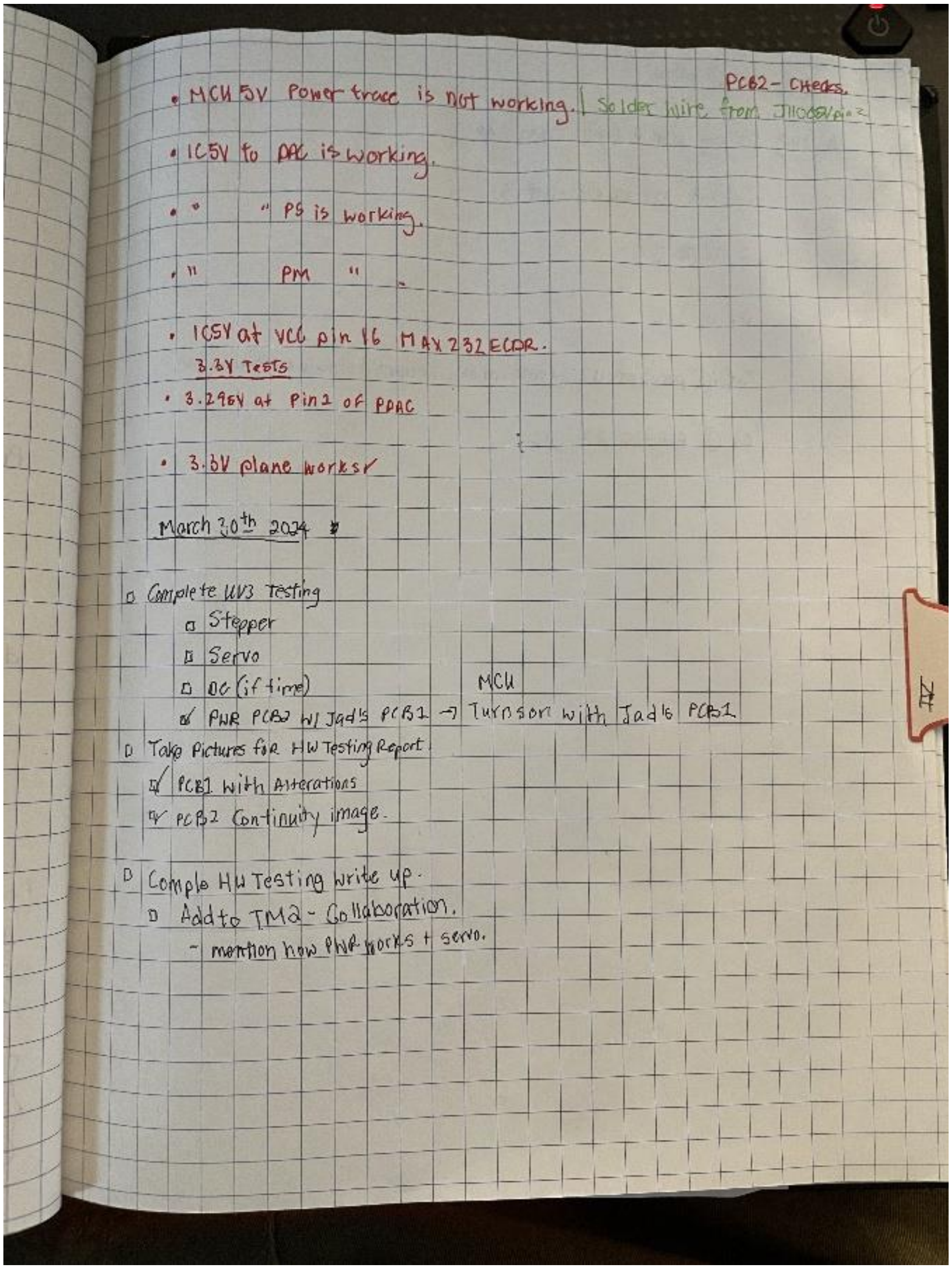
TM1 – Collaboration

While debugging PCB1, it was determined with help from a classmate that to make the 3V3 (U2) regulator work, multiple trace would need to be cut. The trace above U2 was cut along with the trace connecting pin 1 to pin 3 of the same IC. In addition to that, it was discovered that capacitor C7A was unnecessary as it was shorted across its pads to ground having no affect . Finally, it was discovered that the 3V3 regulator wasn't getting power from the 5V regulator, as such, a wire was jumped to the 3rd pin of the 3V3 regulator to power it. Below are two images showing where the changes were made (cuts in orange and added trace in green) in Altium as well as the final PCB:


J2
C4
C5
U5V
R4
C2
C3
J1
R3
J5
R5
C1
R1
R2
L1
J4
L2
C9
D5V
U2
R9
R12
R6
C7
C8
R11
C7A
D3V3
J300PWM


J2
C4
C5
U5V
R4
C2
C3
R3
J5
R5
C1
R1
R2
L1
L2
C9
D5V
U2
R9
R12
R6
C7
R11
J6
R7
J7
R8
J11
R13
J8
R10
J12
R14
U4
C10
C11
C12
C13
U3
J300ML
J300MR
7379678A_Y5_240227
P23
P33
J300AB
J300CD
J3003V3
J3005V
153NL
100
L293D
L293DD

CM1 – Log Engineering Info



PCB2 - Checks.

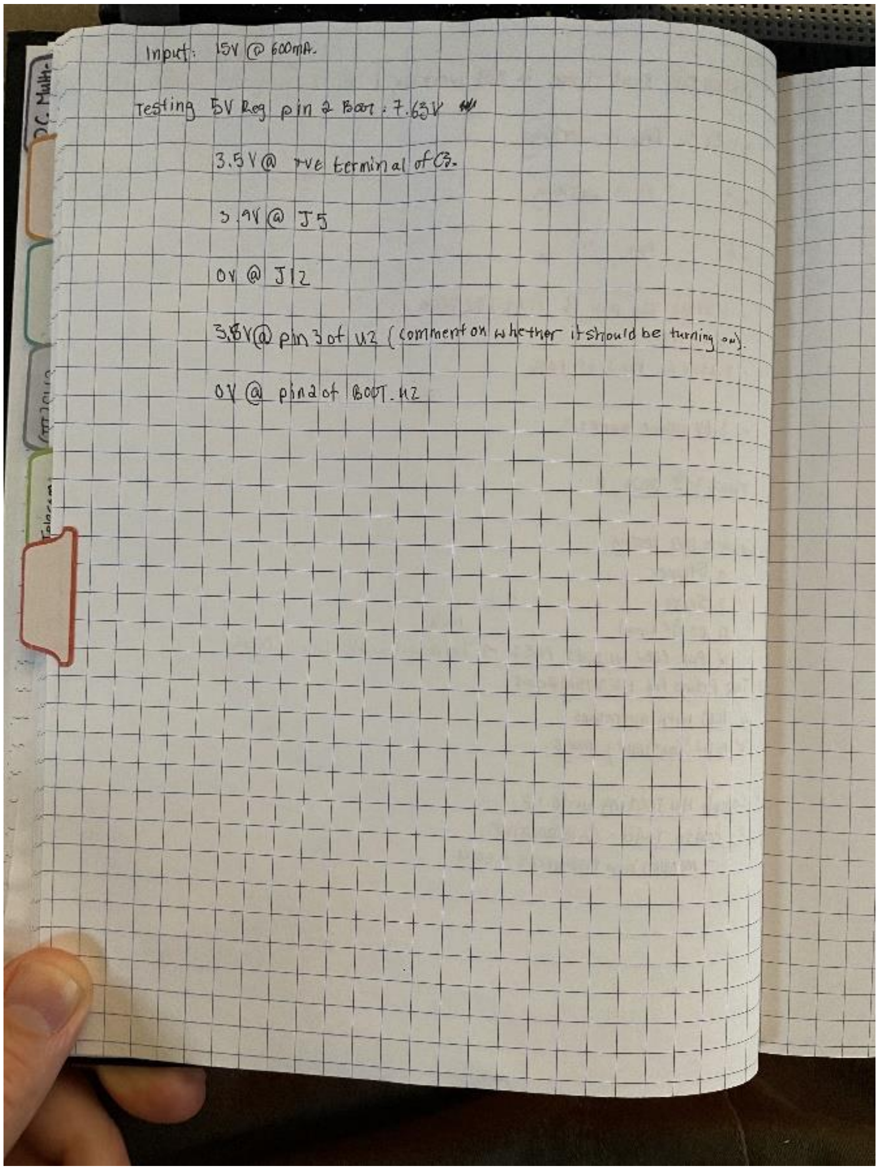
- MCU 5V Power trace is not working. | Solder wire from J1106 5V pin 2
- IC5V to DAC is working.
- " " PS is working.
- " PM " .
- IC5V at VCC pin 16 MAX232ECDR.

3.3V Tests

- 3.295V at Pin 2 of PDAC
- 3.3V plane works ✓

March 30th 2024

- ☐ Complete UV3 Testing
  - ☐ Stepper
  - ☐ Servo
  - ☐ DC (if time)
  - ☑ PWR PCB2 w/ Jad's PCB1 → Turns on MCU with Jad's PCB1
- ☐ Take Pictures for HW Testing Report.
  - ☑ PCB1 with Alterations
  - ☑ PCB2 Continuity image.
- ☐ Complete HW Testing write up.
  - ☐ Add to TM2 - Collaboration.
    - mention how PWR works + servo.



CM2 – Convey Engineering Info

For future iterations of this design, PCB1 will be reprinted with the proper thickness with improved component placement and routing. Alternatively, it would be possible another functional design as a replacement for PCB1. Section IV2 shows how another student's design was used to power PCB2 and interface with the STM32 to cause the motors to function as intended.

In the previous section PCB1 did not perform as expected with the 5V regulator outputting 3.5V and the 3V3 regulator outputting 0V after alterations were made. In the future, more time will be allotted to completing the routing without the auto feature. Additionally, the future design will have place vias further from the IC to minimize the possibility for shorts. Even after calculated modifications were made with others' support, PCB1 still does not function as it was intended to, at this point, an alternative approach will be taken to ensure the rest of testing can be completed.

For PCB2, there is still more debugging to do, mainly with testing the DC motors, the LCD display, the Limit Switches and Encoders as well as the Keypad. Additionally, there is other functionality like with RS232 and CAN Bus, DAC which won't get tested until semester 5.

So far, with the exception of the DC motors, all required functionality for PCB2 has been met. The DC motors will be tested once the code has been completed.

LL1 - Autonomous Learning

Recent evidence for a commitment to autonomous learning has been seen with staying late on campus on multiple occasions to complete the soldering of the boards. Over the easter weekend, testing was completed on PCB2 to see if it would interface with a classmates PCB1. Effort was also made to consult Dave Sullivan to get the info on solder paste we used this semester as well as enlist his support to complete the modifications made to PCB1. These efforts show a commitment to effective time management, consistent study habits by taking notes and communicating with profs and creating task list to complete to work towards the eventual goal of complete the course and producing quality deliverables.

LL2 – Applying Knowledge and Skills

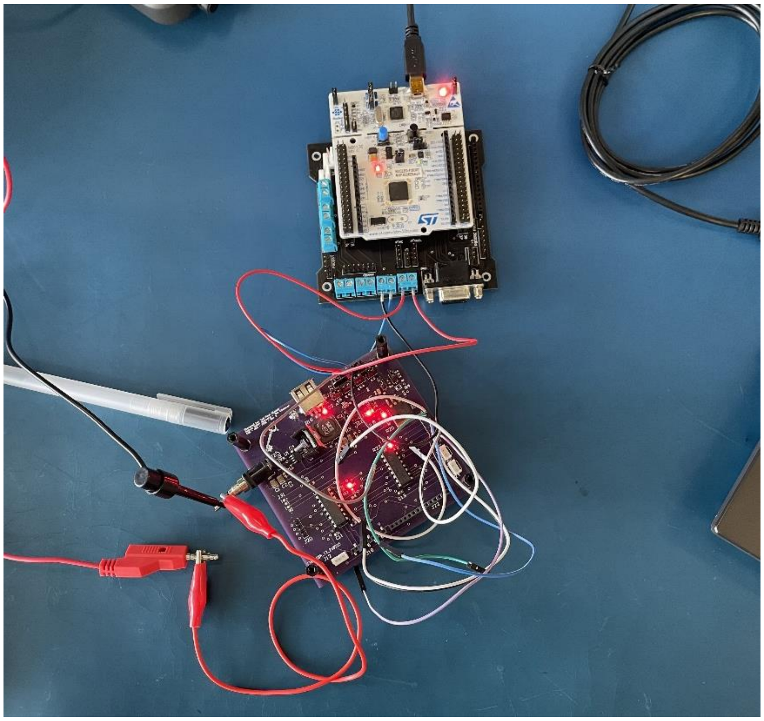
This course has caused students to develop an ownership over their own work. Due to the open-ended nature of this project, students will be encouraged to think differently about how to approach tasks than in past projects. Before with the Amplifier Project or with CMS, there were always concrete tasks to do every week with the potential for above and beyond laid out as well. Conversely this project has more of an open sided component to it. Although this style of learning can be more challenging for an analytical mind who likes to follow within the lines. It has overall been a rich learning experience which has both been taxing and rewarding at the same time.

LL3 – Self Direction & Reflection (Meta-Learning)

See section TM1 and IV2 for evidence of extra debugging and trouble shooting. **See section CM2** for a discussion on future recommendations.

IV2 – Measure

Below is an image showing evidence that PCB2 can receive MCU5V from a classmates PCB1.



See lab notes in section CM1 for evidence that PCB2 can supply 5V and 3.3V to the necessary output pins.

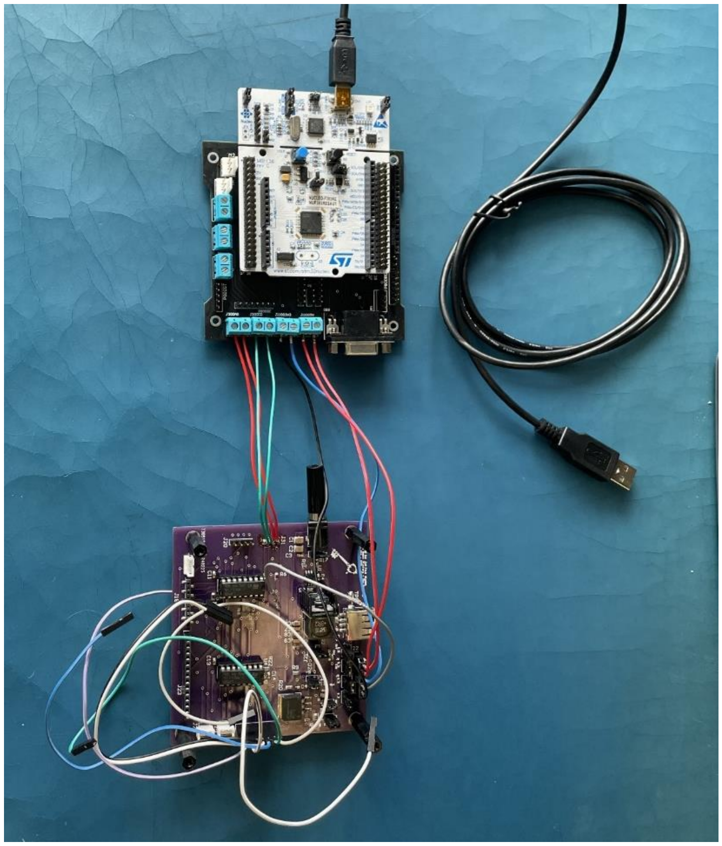
IV3 – Experiment: Isolated 5V Regulator

The 5V regulator no longer works as expected it does not provide 5V to the 3.3V regulator when supplied with an input signal of 14.8-30V instead it was measured to output 3.5V. See CM1 for evidence of notes taken and TM1 for an image of the modifications made. Before the modifications were made, this regulator reliably outputted 5V, the reason the output voltage was reduced is unknown. Further research is needed to determine how to improve this in future iterations. For one it's possible that a trace was broken internally due to the reduced thickness of the board. The problems with this board were solved by enlisting the support of another classmate's board.

IV3 – Experiment: Isolated 3.3V Regulator

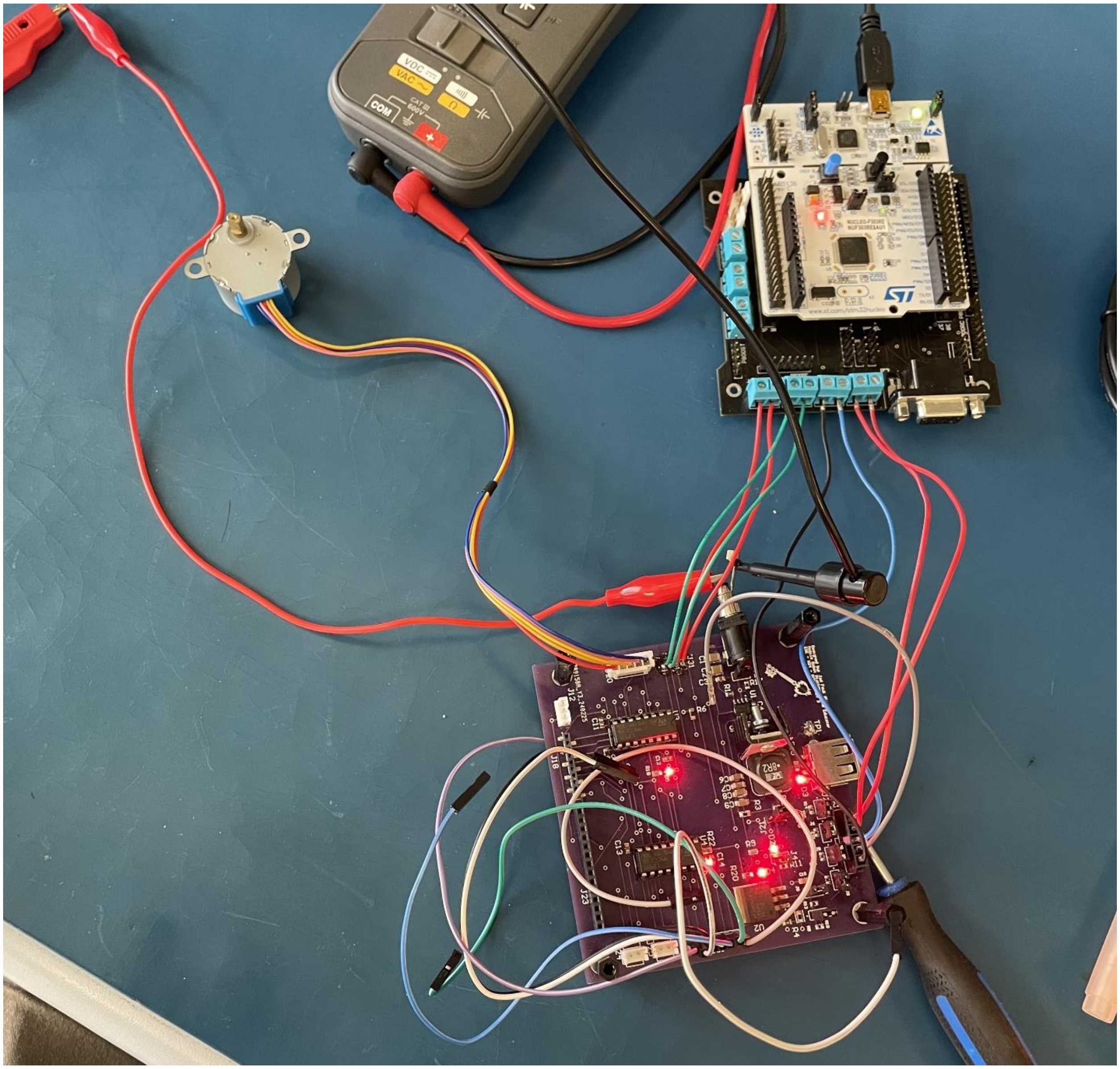
My 3.3V regulator no longer works as expected it cannot output 3.3V even after fixes were made to the circuit. Instead, it was measured to output 0V. See CM1 for evidence of notes taken. Overall, it can be concluded that this part of the circuit never worked due to improper routing, it's possible that the regulator was under powered by the other regulator, further research and testing is needed to determine the root cause of the issue.

Below is an image of a classmates PCB1 connected to my PCB2 with the STM32 on top of it.



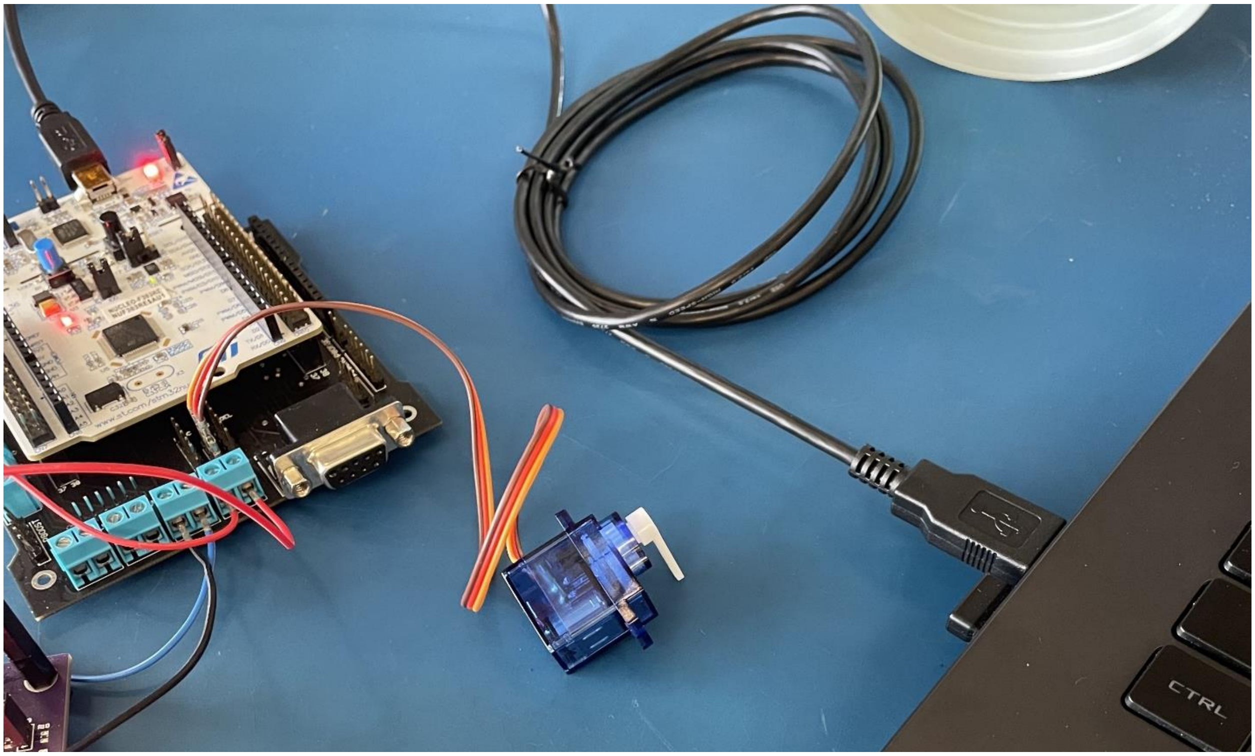
IV3 – Experiment Stepper Motor

Once the stepper motor was connected to the classmate's PCB1, it was found that it did not turn as expected, instead the shaft of the motor twitched. I've concluded that the issue is not with the code but with the way the motor was connected to the pins. To fix this issue, the motor will be disconnected the pin housing then reconnected in the correct order.



IV3 – Experiment Servo Motor

Testing the servo motor went along smoothly without any hitches, the motor shaft rotated the correct number of degrees showing that PCB2 interfaced properly with the STM32. In future, I will add the option of changing the angle of the motor based on user input rather than having it cycle between -45 and 45 degrees on repeat. Below is an image of the servo motor functioning as expected.



IV3 – Experiment DC Motors and Encoder

At the time of this document being written, the code for the DC motors and Encoder hadn't been written. Based on the successes had with this current configuration of PCBs, it's very likely that the DC motors and Encoders would operate as expected. More time spent developing the code for these components is still required.

CC0 – Concluding Thoughts

In conclusion, testing both PCB1 and PCB2 has provided valuable insights into the performance and reliability of the circuit boards for the mobile robot platform. From the assessment of PCB1's power supply capabilities and motor control functions to the evaluation of PCB2's management of various systems and seamless interaction with the MCU, these findings have demonstrated a robust foundation for the robot's operation. This analysis has identified areas of strength and areas for potential improvement, encouraging a refined and optimized design for future iterations. By addressing the testing outcomes and implementing necessary enhancements, the aim is to enhance the overall functionality and durability of the robot platform, to contribute to its efficiency and efficacy in real-world applications.