Electronic Design Lab

Exoskeleton Glove

Milestone-3

Review of Milestone - 2

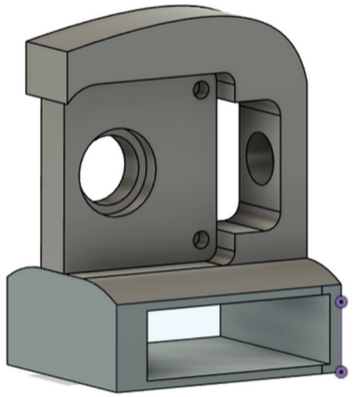
- After the discussion, we were suggested that we had to focus on the crucial parts first and then focus on the non-error prone parts of the task
- We were also criticized for sloppy documentation
- Moreover, there were still some potential problems that we were yet to test out - whether the raspberry pico W, will be able to drive the analog multiplexer(The datasheet said it should, but we were yet to confirm) and our hand model was yet to work properly.

Work since Milestone 2

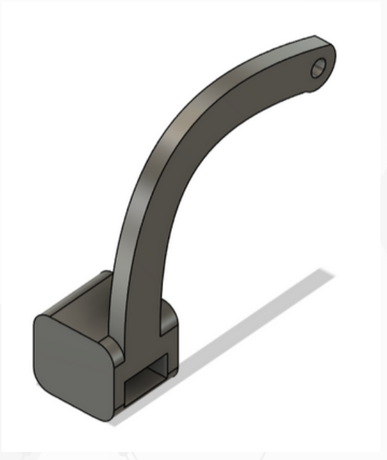
We started working on testing the circuit ASAP, and that lead to clarifying a lot of issues

1. We verified that the pico can drive the analog multiplexer, with 3.33 volts, which has cleared one of the milestone 2 unknowns
2. We made our documentation proper again kept adding any sort of progress we made, alongside code and pcb designs and figured out the wifi pipeline, hand model, hand movement and also made a small message diary, nothing too complex, but it works.
3. We were able to bread board test the fingers motion, and were pleasantly surprised, the ciruit was indeed responding fast and accurately via, serial communication
4. To be precise, the analog multiplexer is fast enough to around a (1/100)th of a second, and knowing that we have 3 ADC channels, well will be able to sample as fast as 13 times a second (approximate calculation, to be confirmed, when we test on all the sensors concurrently)

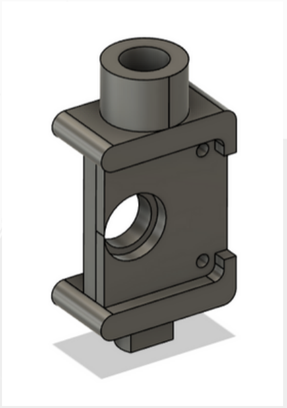
Our CAD Models :



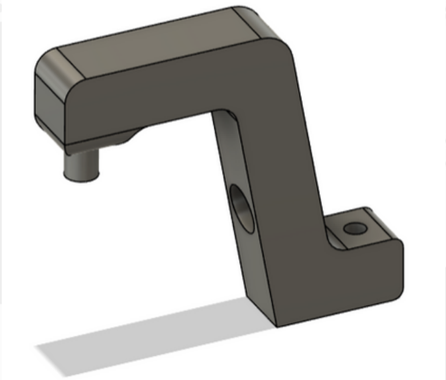
Sensor casing (Other Joints)



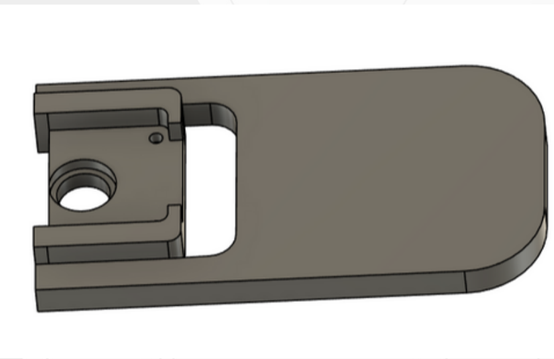
Finger attachment (Other Joints)



2DOF sensor casing
(Finger Palm Joint)

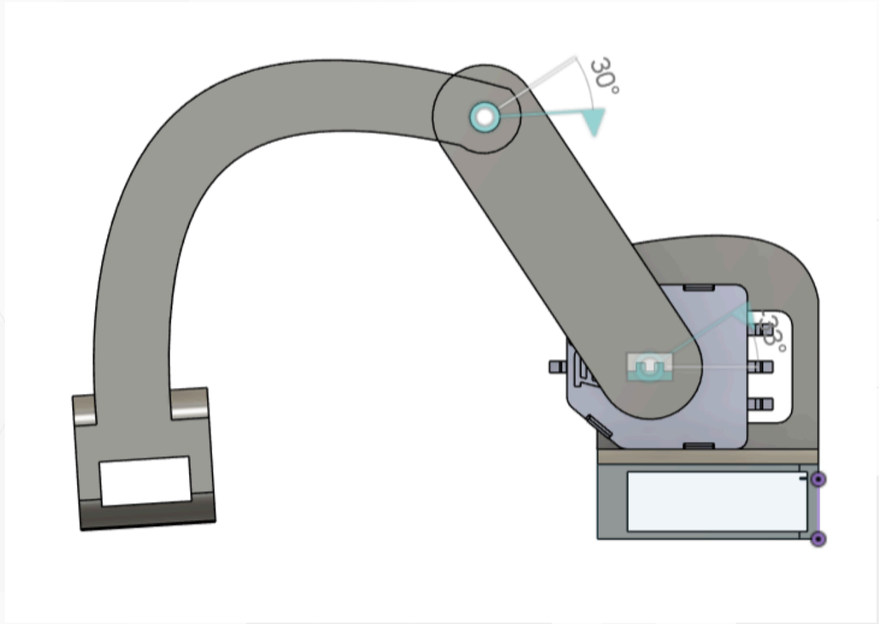


Rotation Limitter
(Finger Palm Joint)

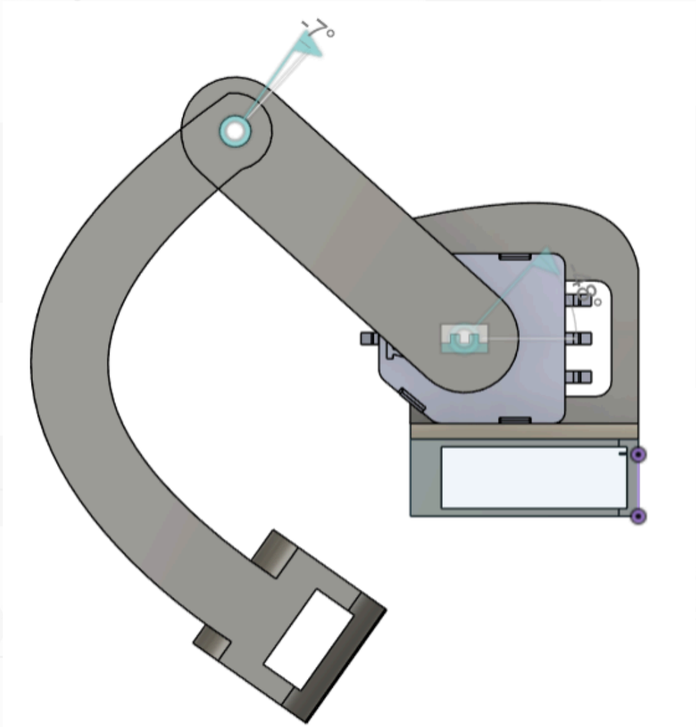


Base
(Finger Palm Joint)

Assembly (Other Joints) :

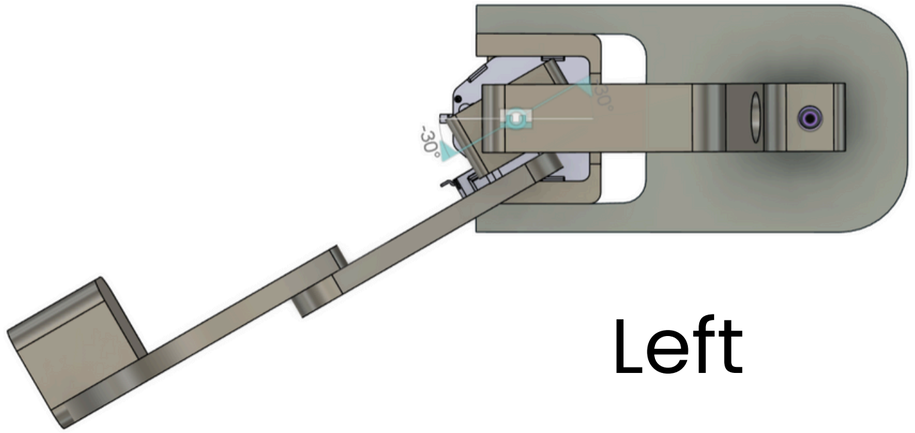


Straight

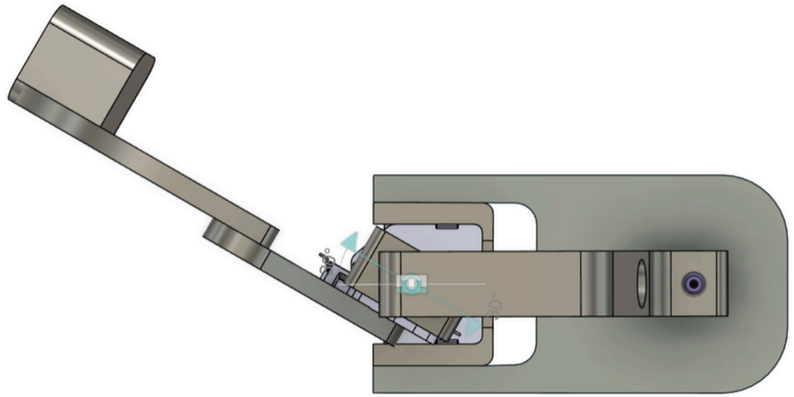


Flexion

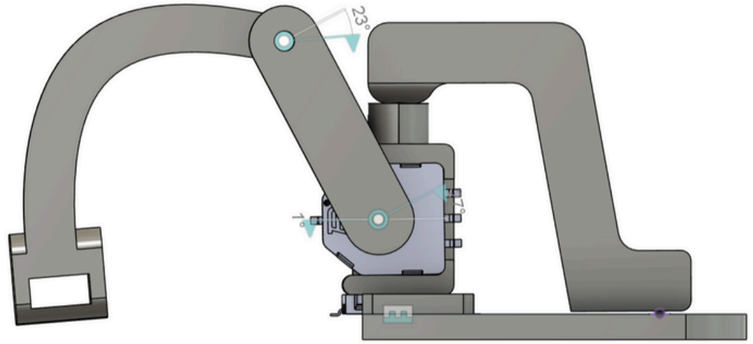
Assembly (Finger Palm Joint) :



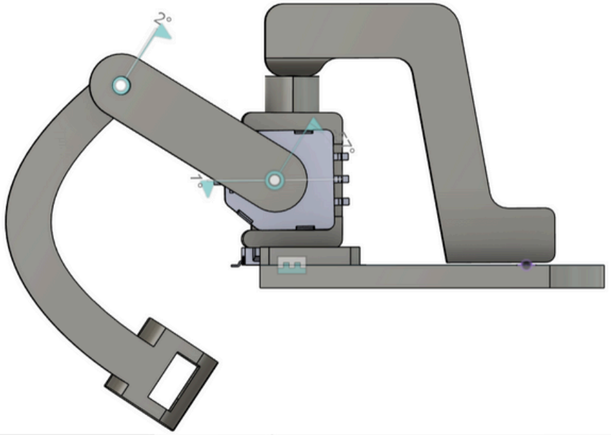
Left



Right

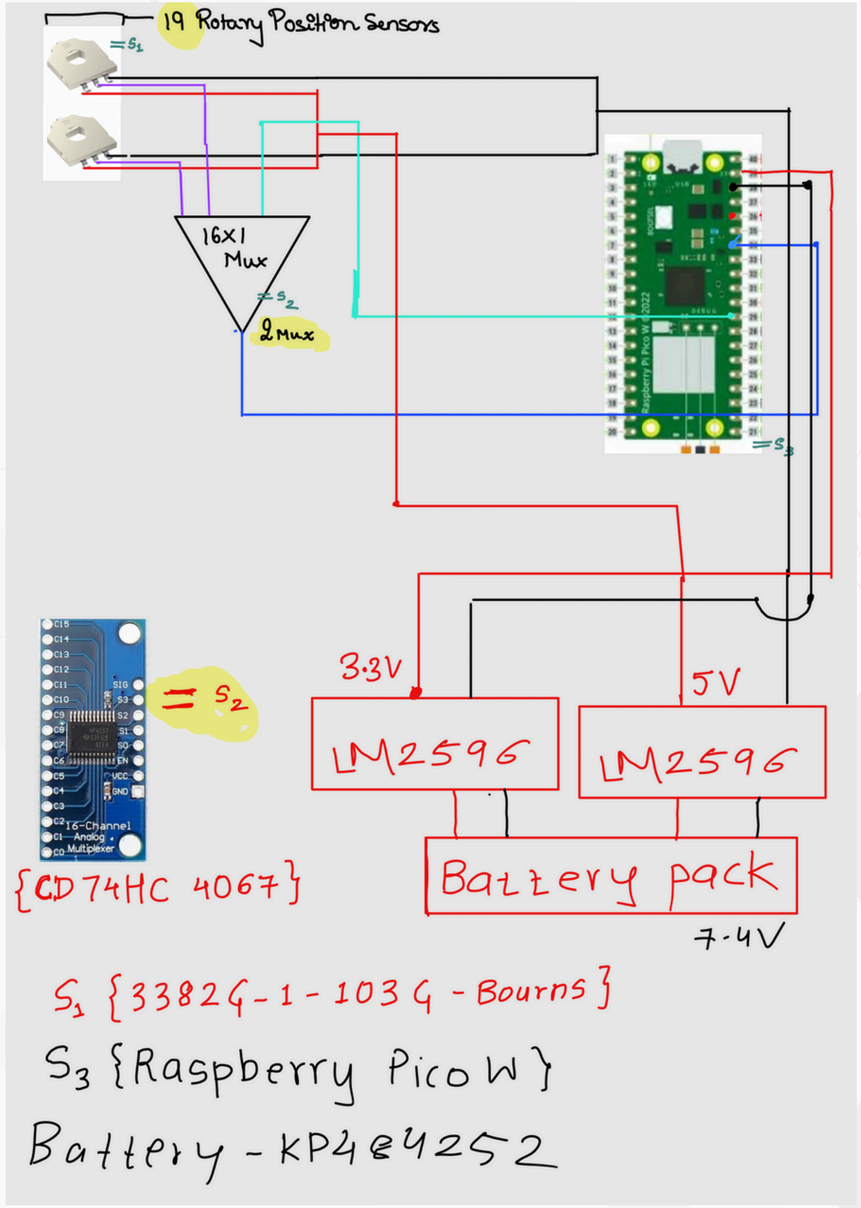


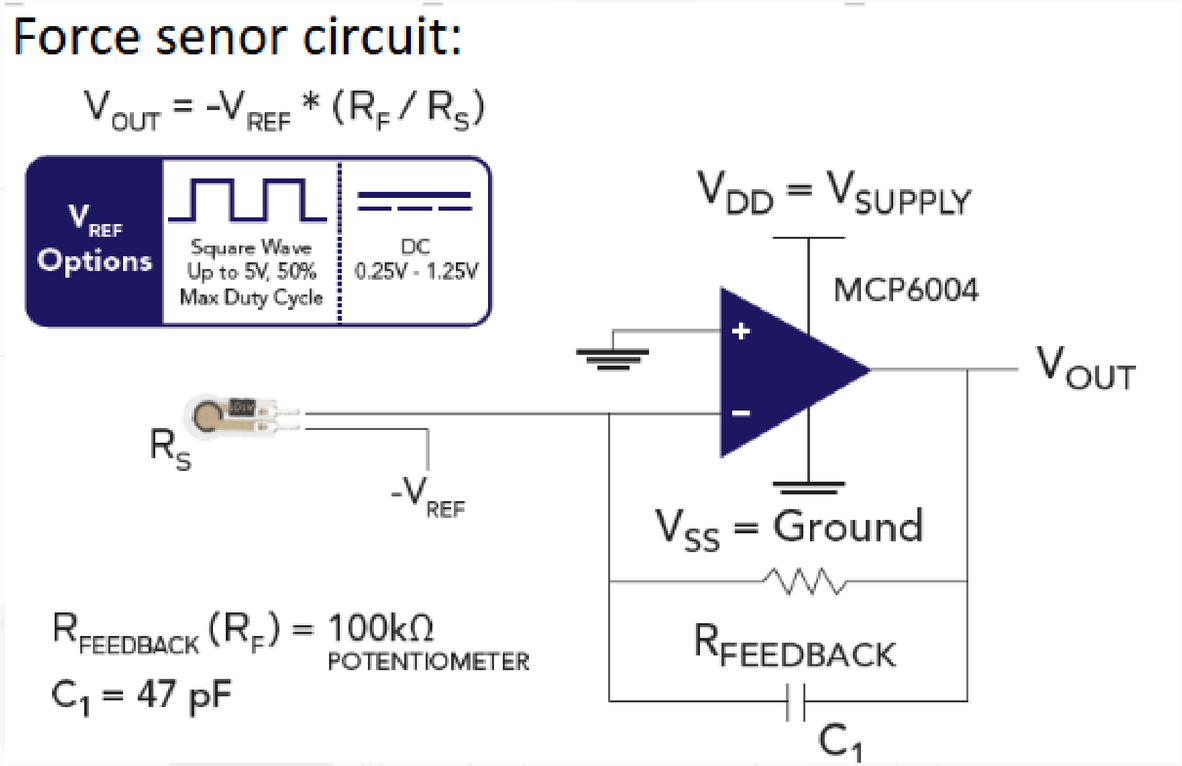
Straight



Flexion

PCB Design(went through 5 iterations)





Electronics and Connection to Software model on PC

Protocol : We chose the UDP (User Datagram protocol) for transmission of the data from the pico to out host pc ; The reasoning behind this was, UDP was known to be the faster alternative over TCP

Coding Scheme : A simple scheme has been setup for testing, maybe we will optimize this later on ; the current scheme is :
“{Sensor id} ; {Sensor reading}”

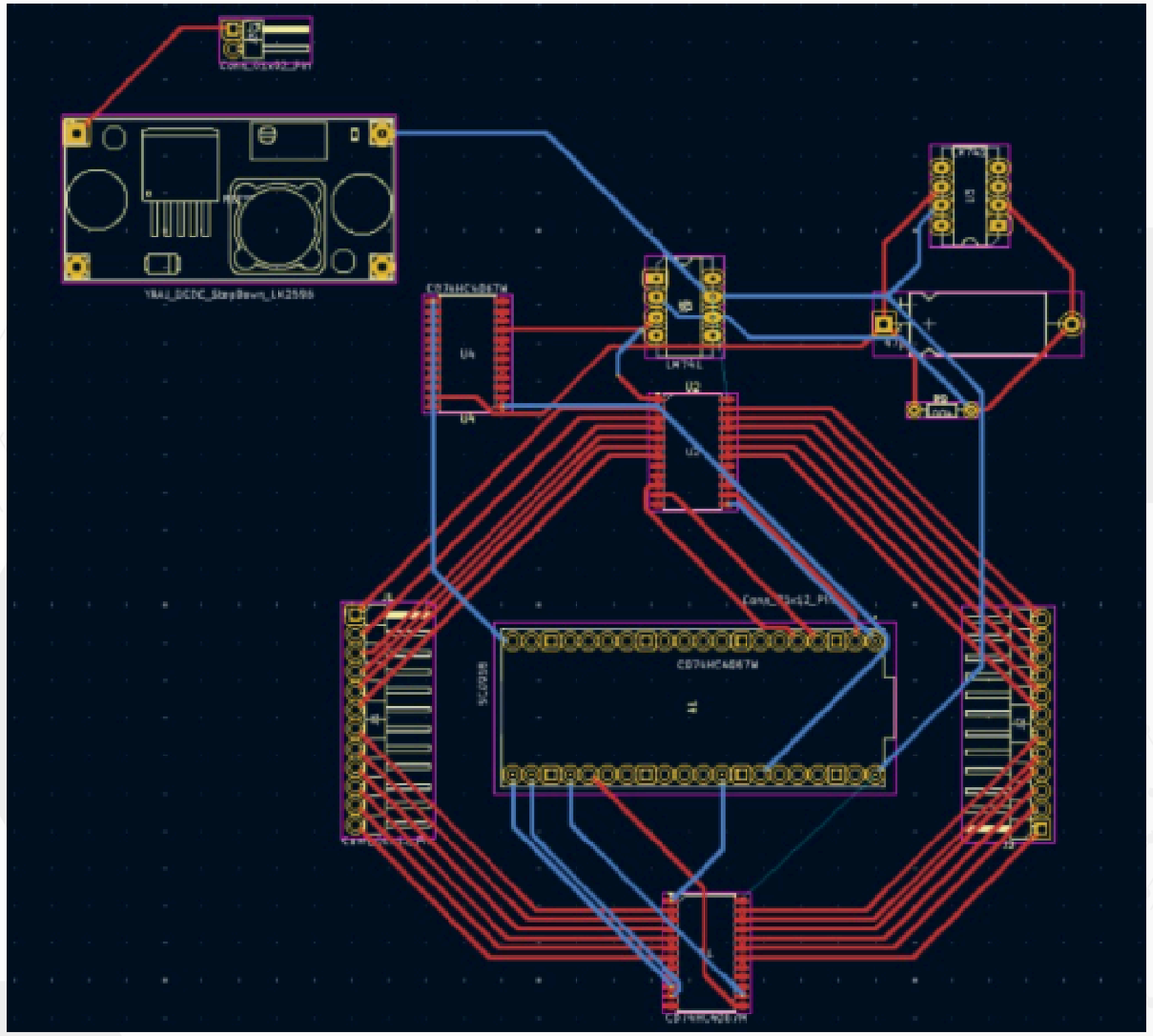
Electronics and Connection to Software model on PC

Talking with Unity for over wifi :

- We setup a websocket from out host PC, and relayed the content over to our local host ip or 127.0.0.1
- After which we were able fetch this info from unity, which in turn calls the finger movement helper function
- This , as one would expect moves the finger, according to data sent
- We were to make a bread board demonstration for this, simulating 2 fingers to move according to the angles we gave from sensors ; creating a concrete proof of concept, that this can work

PCB Design(went through 5 iterations)

This yielded us our first PCB iteration , but we realised that the circuit is to cumbersome to fit on a persons hand and we had to optimise it o



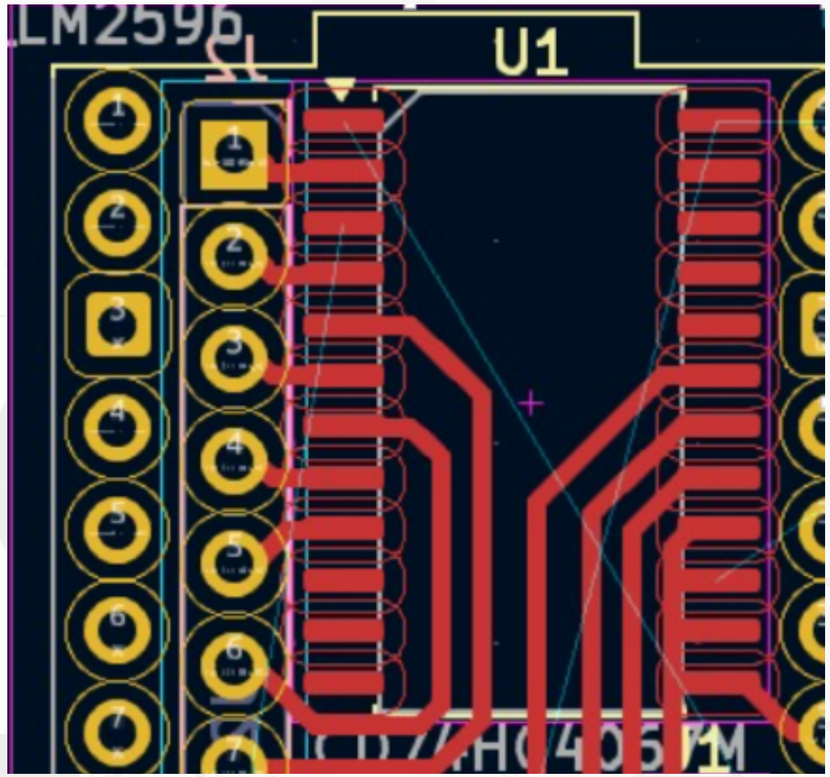
PCB Design – 2nd and 3rd Iterations

2nd Iteration: Attempted to fit all three multiplexers within the Raspberry Pi Pico for space optimization, but tracing connections became impractical.

Challenge: No provision for ±15V required for op-amps in force sensor filtering.

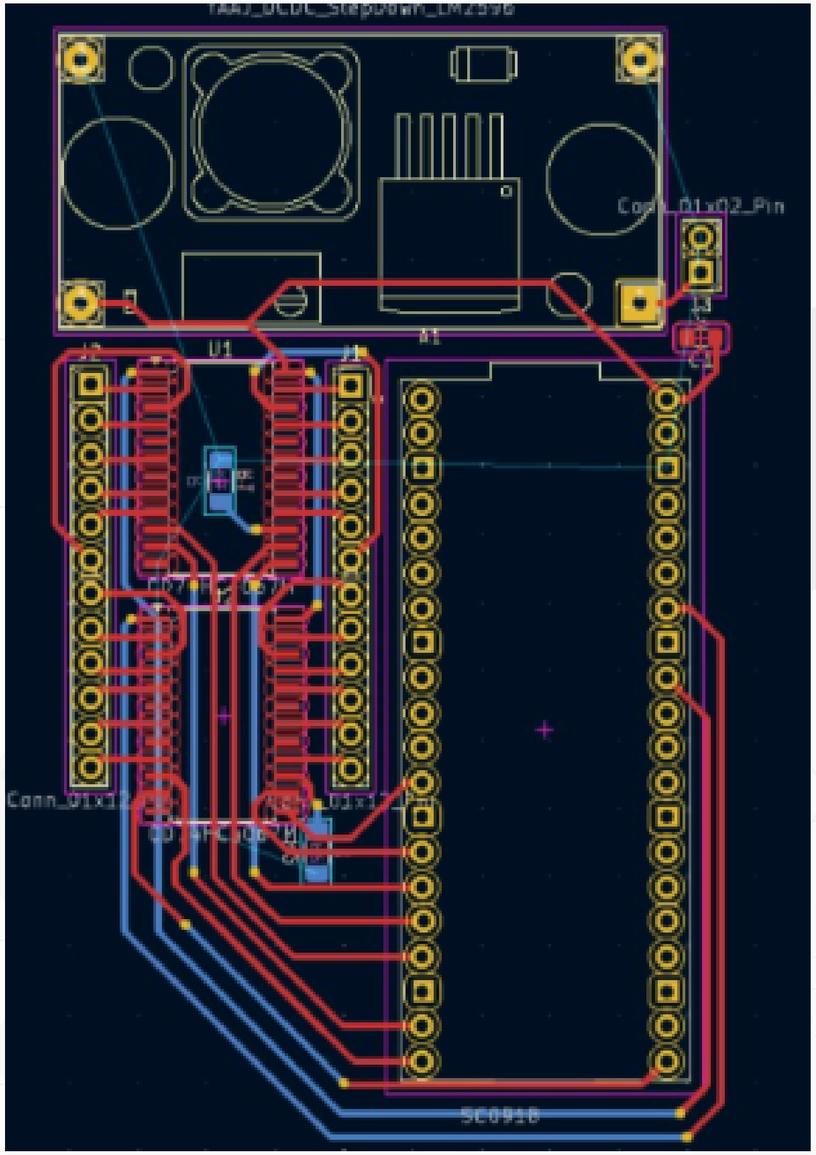
Solution: Switched to a digital filter, making it adjustable and eliminating the need for two op-amps and one multiplexer.

3rd Iteration: Optimized layout with reduced components and improved filtering approach.



PCB Design - 4th Iterations

Here we wanted to minimize PCB size for compact design but unknowingly we had many boundary violations which made the layout impractical but this pcb design laid the ground for the final PCB



PCB Design – 5th Iterations(After review)

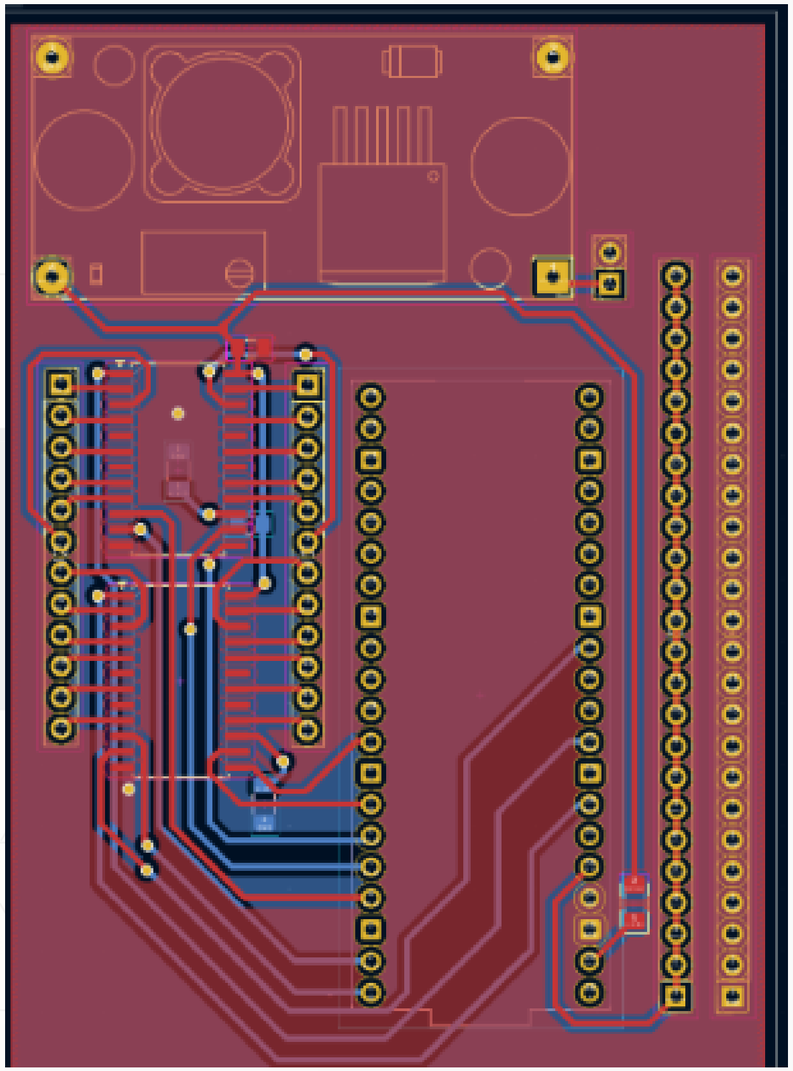
Review Process: After adding the ground plane, we consulted for feedback.

Major Issues Identified:

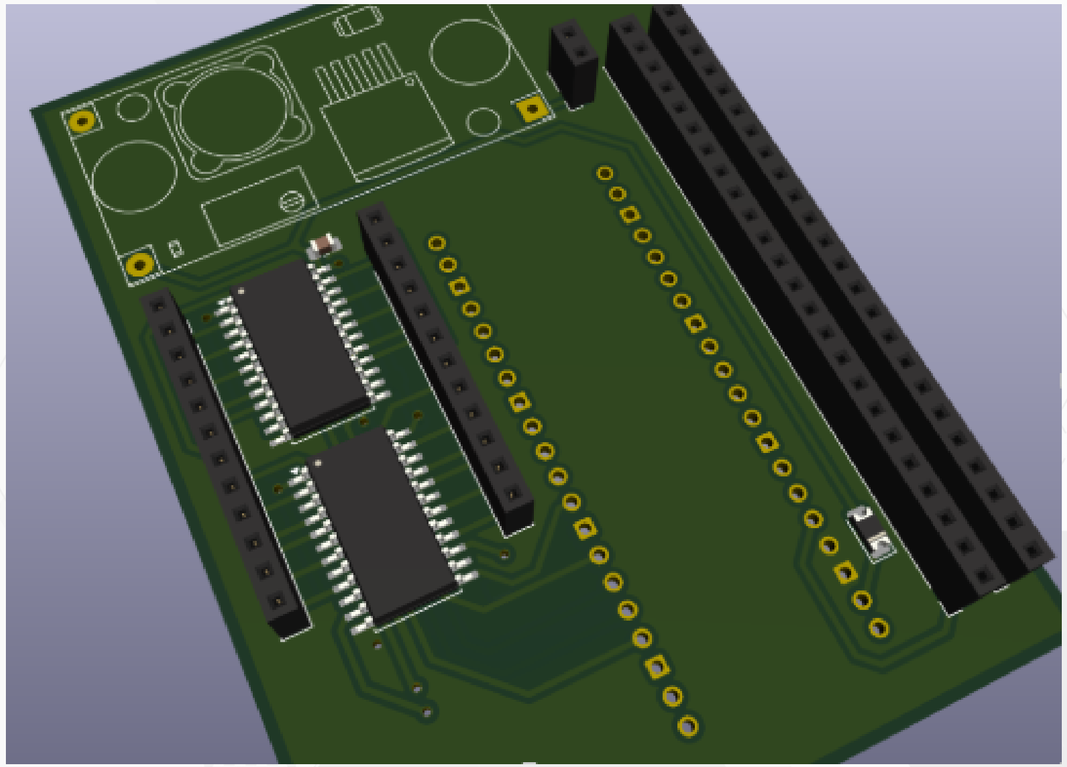
- Incorrect placement and usage of decoupling capacitors.
- Improper power connections to the Raspberry Pi Pico W.

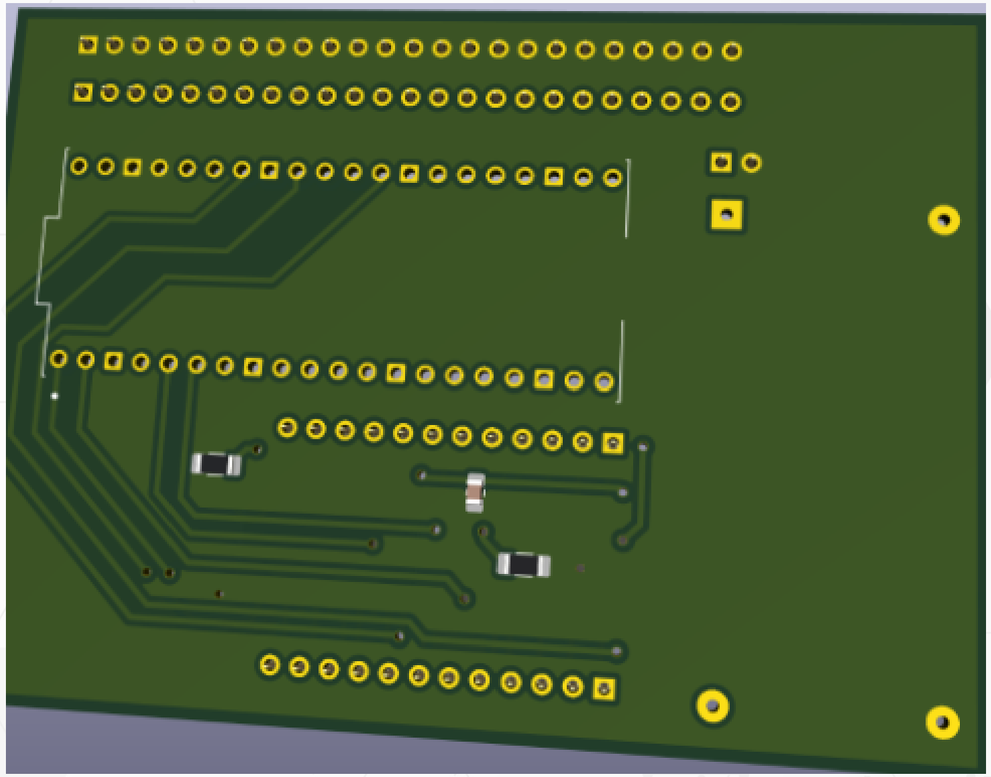
Additional Requirement:

- Integrated 48 extra sockets:
  - 24 for GND connections
  - 24 for VCC (3.3V) connections



PCB Design – 5th Iterations(After review)





Previous Design: 20 cm × 20 cm PCB.
Optimized Design: 8.7 cm × 6.3 cm.
Significant reduction in size, enhancing compactness and efficiency.

We are to add stitching vias between the ground planes between the front and back planes which we will do so after final review

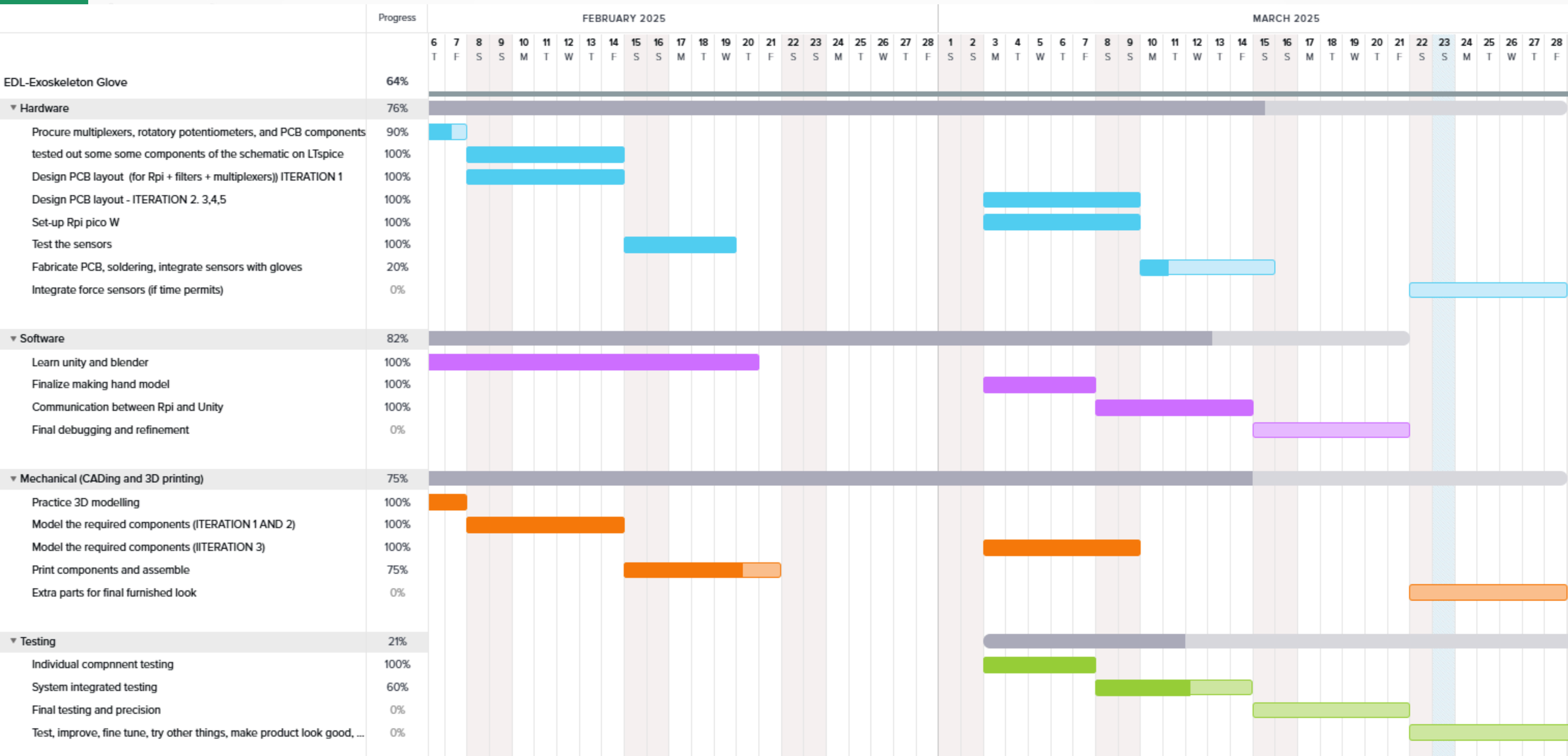
Critical Tasks in Progress

- Integrating sensors with the 3d printed assembly and testing
- PCB fabrication and testing
- Software optimization and better visualization

Key Risks

- Integrated working of all 18 sensors in parallel might overload the circuit (We have made calculations about the net current drawn but testing is required)
- Sensor noise and fluctuations when all sensors work together
- Never power the Raspberry Pi Pico W externally while it is connected to USB, as this would create a parallel combination of both power sources, potentially burning the IC.

Gantt Chart


Progress
FEBRUARY 2025
MARCH 2025
6 T 7 F 8 S 9 S 10 M 11 T 12 W 13 T 14 F 15 S 16 S 17 M 18 T 19 W 20 T 21 F 22 S 23 S 24 M 25 T 26 W 27 T 28 F 1 S 2 S 3 M 4 T 5 W 6 T 7 F 8 S 9 S 10 M 11 T 12 W 13 T 14 F 15 S 16 S 17 M 18 T 19 W 20 T 21 F 22 S 23 S 24 M 25 T 26 W 27 T 28 F
EDL-Exoskeleton Glove 64%
Hardware 76%
Procure multiplexers, rotatory potentiometers, and PCB components 90%
tested out some some components of the schematic on LTspice 100%
Design PCB layout (for Rpi + filters + multiplexers)) ITERATION 1 100%
Design PCB layout - ITERATION 2. 3,4,5 100%
Set-up Rpi pico W 100%
Test the sensors 100%
Fabricate PCB, soldering, integrate sensors with gloves 20%
Integrate force sensors (if time permits) 0%
Software 82%
Learn unity and blender 100%
Finalize making hand model 100%
Communication between Rpi and Unity 100%
Final debugging and refinement 0%
Mechanical (CADing and 3D printing) 75%
Practice 3D modelling 100%
Model the required components (ITERATION 1 AND 2) 100%
Model the required components (ITERATION 3) 100%
Print components and assemble 75%
Extra parts for final furnished look 0%
Testing 21%
Individual compnnent testing 100%
System integrated testing 60%
Final testing and precision 0%
Test, improve, fine tune, try other things, make product look good, ... 0%

Gantt Chart (Justification for Deviation)

- **Hardware:** Went through multiple iterations and learning to make a PCB while accounting for all necessary precautions took time.
- **Software:** Integration with unity is completed and tested. Entire testing can be done after glove assembly.
- **CAD:** Unavailability of printers and printing issues lead us to do multiple iterations but we completed the final model and testing has begun

Work Distribution

Nishant Bhave:

- CAD modeling and 3D printing of the exoskeleton glove.
- Ideation on the Mechanism and Iterative Prototyping.
- Testing circuit with multiplexers, ADC, and Raspberry Pi Pico to test multiple rotary encoders

Prajwal Nayak

- Developed a 3D hand simulation in Unity and integrated it with Raspberry Pi Pico W for real-time data input.
- Debugged and refined the Unity simulation based on Unity Simulation.

Work Distribution

Reeyansh Shah

- Rigged the 3D hand in Blender and contributed to its simulation in Unity and integration with Raspberry Pi Pico W.
- Assisted in refining the PCB design and verifying its functionality.
- Tested rotary encoders by simulating the setup on a laptop to ensure proper functionality.

Shikhar Moondra

- 3D printed CAD models and assembled them to identify and debug design flaws.
- Designed and built a circuit integrating multiplexers, ADC, and Raspberry Pi Pico to test multiple rotary encoders with laptop simulation.

Work Distribution

Siddick Khatri

- Designed a compact PCB integrating 24 sensors, multiplexers, Raspberry Pi Pico, and a buck converter and iteratively change the design based on feedback received
- Developed and tested the circuit with multiplexers and ADC to interface multiple rotary encoders, simulating the setup on a laptop demonstrating workability