Project Salico

Final Design Presentation

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Review: Background and Motivation

Background

Sea Asparagus (Salicornia) is a salt tolerant crop which grows in seawater.
It has a variety of environmental and dietary benefits.

We connected with **Dr. Wenhao Sun**, the President and Co-Founder of **Olakai Hawaii**, a hydroponics company focused on cultivating sea asparagus.

Needs Assessment

The current harvesting process relies on **manual labour**.

All existing harvesting machines hinder **plant health** and **harvest quality**.

Our Goals

After visiting the farm we have updated our basic goals:

- Traverse each column of the farm and harvest the sea asparagus crop.
- Harvest only newly grown tips at nodes to maintain high quality standards.
- Lay the groundwork for automation as the farm scales.

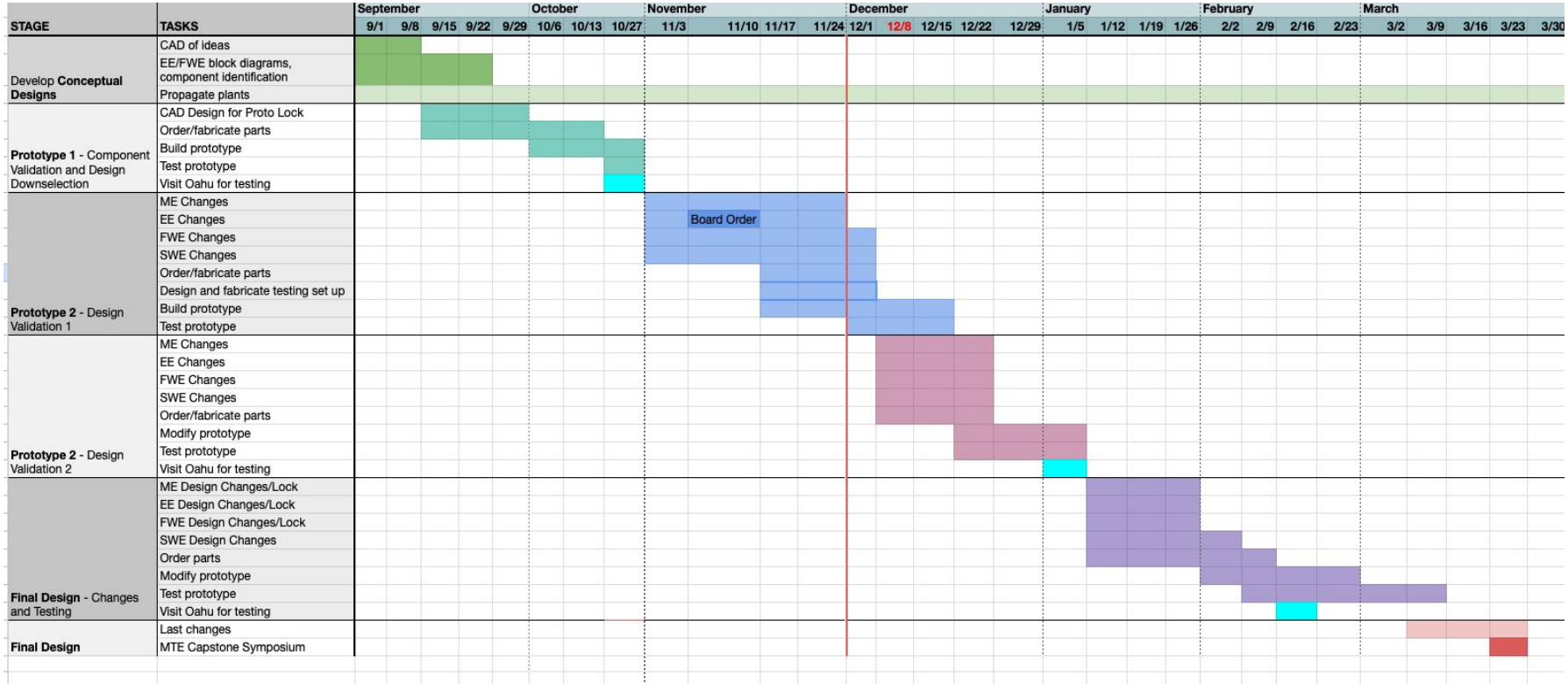
Constraints

- Total cost of the device and engineering must be within the budget of ~$4000
- Be waterproof and corrosion resistant
- Collect the harvested crop in a closed container until manually retrieved
- Do not up-root any plants during the harvesting process

Criteria

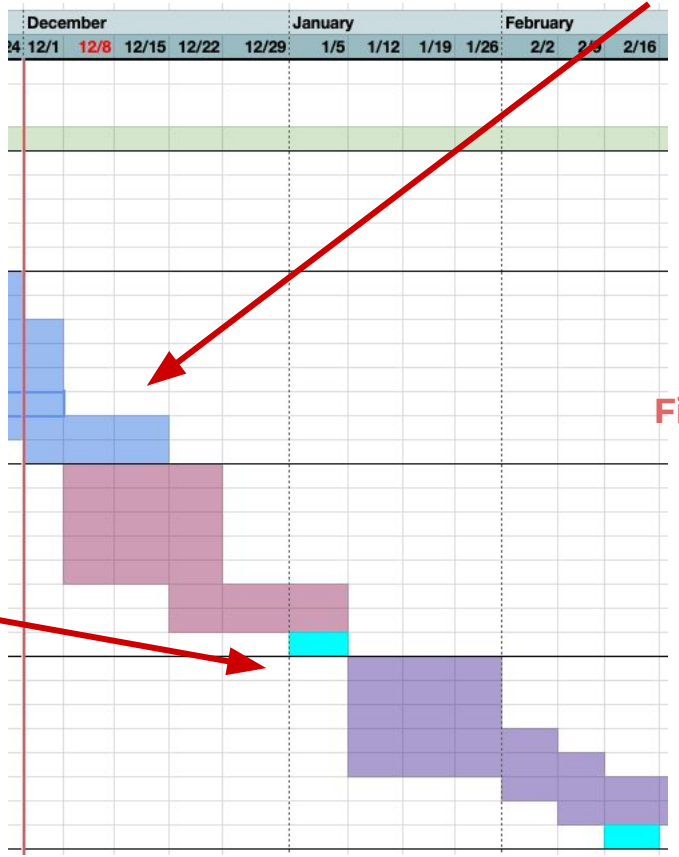
- Harvest Rate
- Harvest Yield
- Harvest Reliability
- Design Complexity
- Environmental Tolerance

Schedule


STAGE
TASKS
September
9/1
9/8
9/15
9/22
9/29
October
10/6
10/13
10/27
November
11/3
11/10
11/17
11/24
December
12/1
12/8
12/15
12/22
12/29
January
1/5
1/12
1/19
1/26
February
2/2
2/9
2/16
2/23
March
3/2
3/9
3/16
3/23
3/30
Develop Conceptual Designs
CAD of ideas
EE/FWE block diagrams, component identification
Propagate plants
Prototype 1 - Component Validation and Design Downselection
CAD Design for Proto Lock
Order/fabricate parts
Build prototype
Test prototype
Visit Oahu for testing
Prototype 2 - Design Validation 1
ME Changes
EE Changes
Board Order
FWE Changes
SWE Changes
Order/fabricate parts
Design and fabricate testing set up
Build prototype
Test prototype
Prototype 2 - Design Validation 2
ME Changes
EE Changes
FWE Changes
SWE Changes
Order/fabricate parts
Modify prototype
Test prototype
Visit Oahu for testing
Final Design - Changes and Testing
ME Design Changes/Lock
EE Design Changes/Lock
FWE Design Changes/Lock
SWE Design Changes
Order parts
Modify prototype
Test prototype
Visit Oahu for testing
Final Design
Last changes
MTE Capstone Symposium

Schedule

Prototyping and one round of testing before the winter break



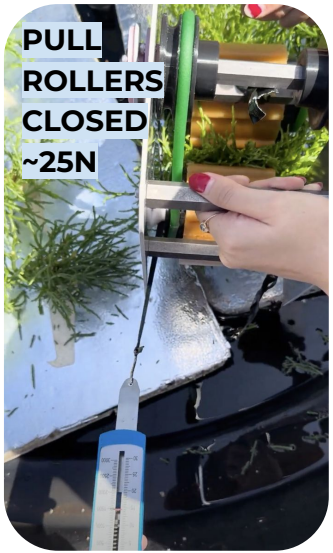
Final testing: Everyone

Third round of testing: Joyce and Daniel, can we come to Oahu the end of the first week of January

Simulating and Testing

Testing - Forces

PINCHING: Should have an adjustable spring for the pinching force since a slight adjustment can change whether woody or tender parts will be picked.



Force to pull medium out: ~15-25N minimum, depends on root growth

Force to pull cone out of platform: from ~25N to well above 30N

Density of plants (sparse case): approximately 70 tips for 100x110x85mm box.

Force (N)	# of Tips	N/tip
20	30	0.67
2.5	5	0.50
15	50	0.30
10	32	0.31
17	45	0.38
12	40	0.30
15	35	0.43
10	40	0.25
20	35	0.57
20	40	0.50

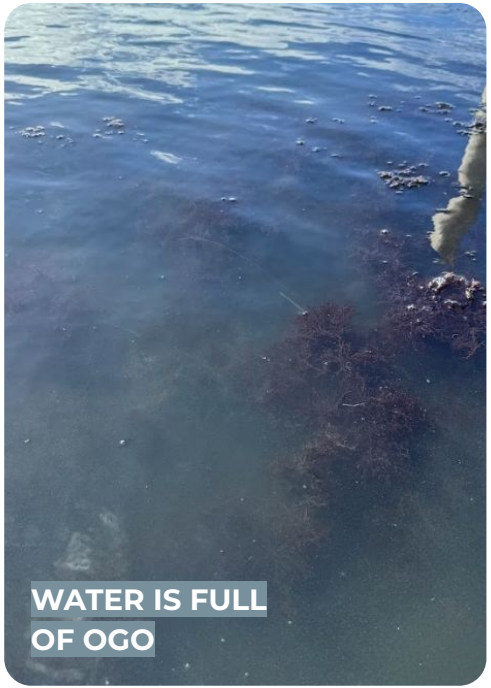
Testing - Spacing and Pond Observations

Spacing between cones is always 6 in, however space between growth is different. Measurements of 5 spaces:

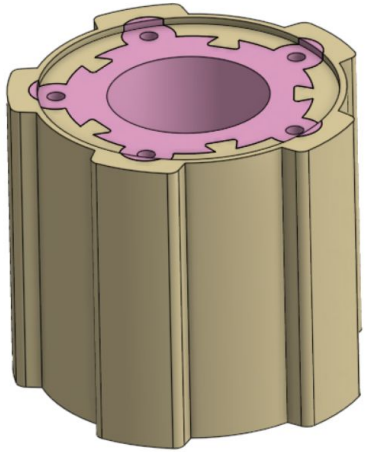
X Distance (mm)	Y Distance (mm)
0	0
35	20
60	30
75	30
100	35
120	55

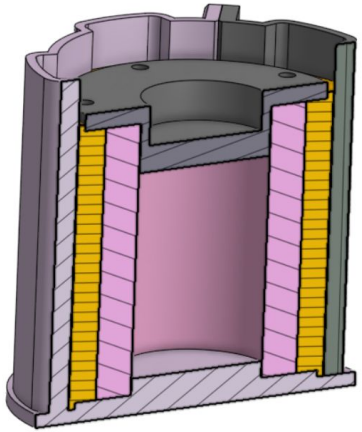
Testing - Water Quality

Ogo is a type of Hawaiian seaweed and actually one of their main crops, it's all over the pond floors and cleans the water (black ish seaweed). They float around the water (no roots). No propellers for traversal.

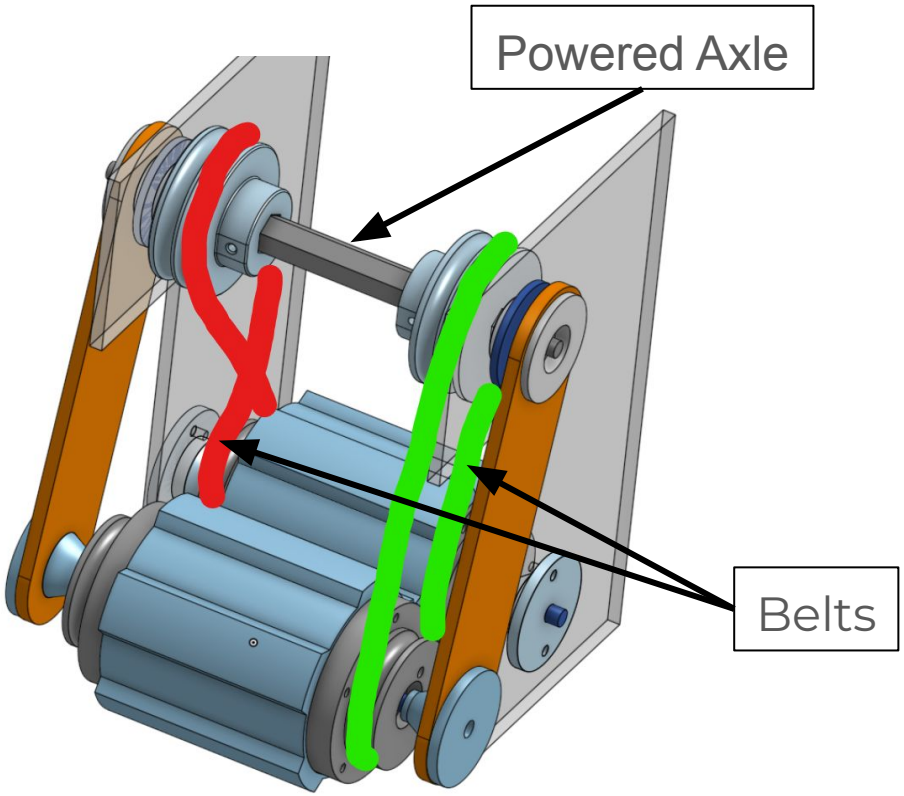


Urethane Casting





Hawaii Picker Test Rig



Motor Sizing

Empirically measured:

Average force per tip = 2.6 N

Tips/mm of roller = 0.46 tips

Calculations:

Full roller length = 610 mm

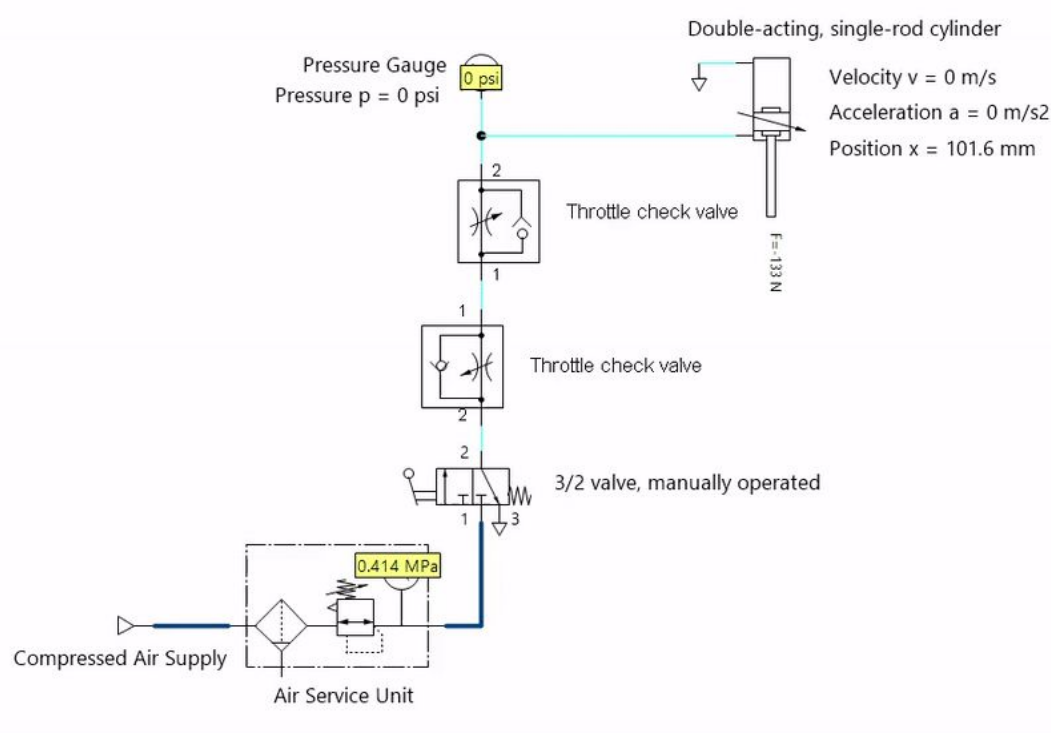
Peak tip number = 610 * 0.46 = 284 tips

Peak pick force = 284 * 2.6 = 740 N

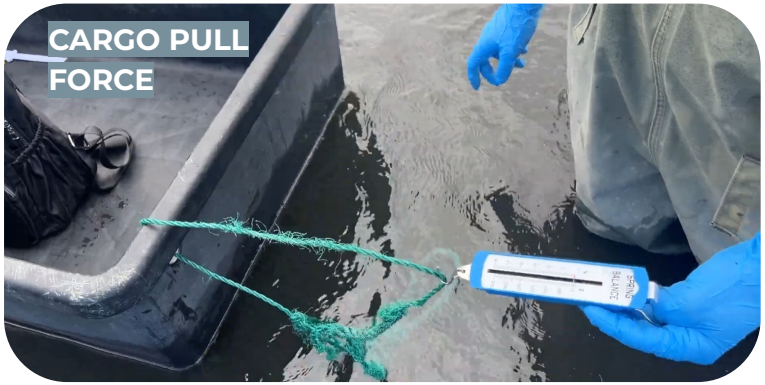
Peak picking torque = 33.3 Nm, split between 2 rollers. Gearbox required.

Pick Forces using spring scale

Pneumatics Testing



Miscellaneous Testing



Detailed Design Overview

Overview

#1 Top-down picking approach with multiple passes (most similar to our tests in Hawaii)

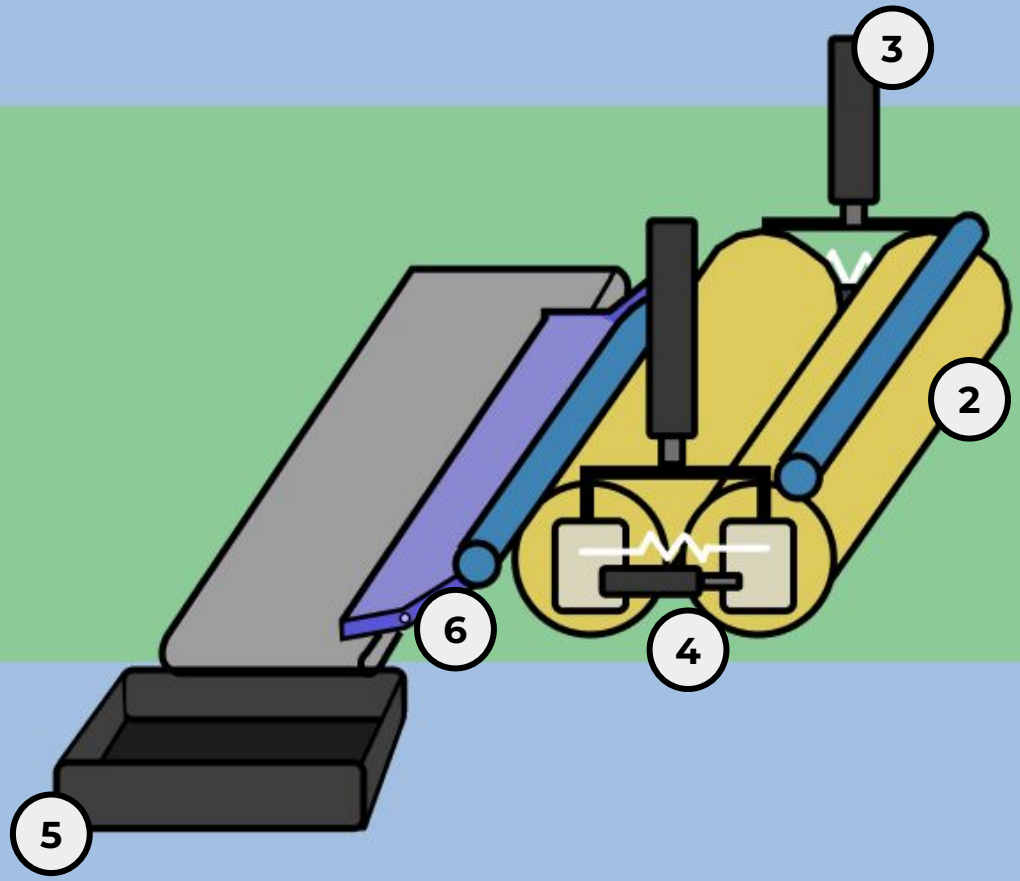
#2 Roller material will be urethane with a texture latex sleeve

#3 Pistons and springs for up down and in out motions

#4 One motor for each roller, direct drive

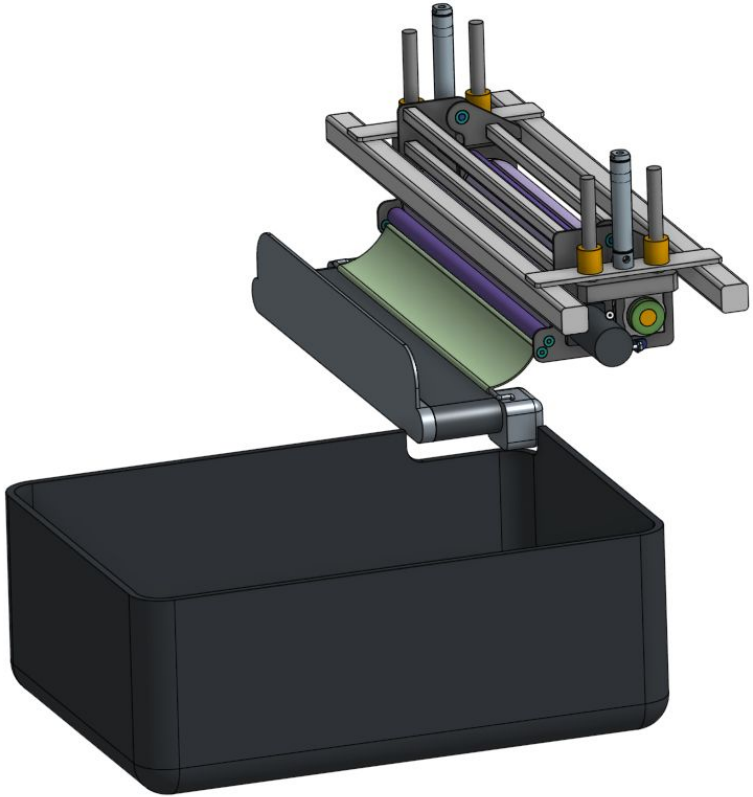
#5 One sided collection bin, tips pushed in using brushes and air

#6 “Hinged” ramp for temporary storage in lower position

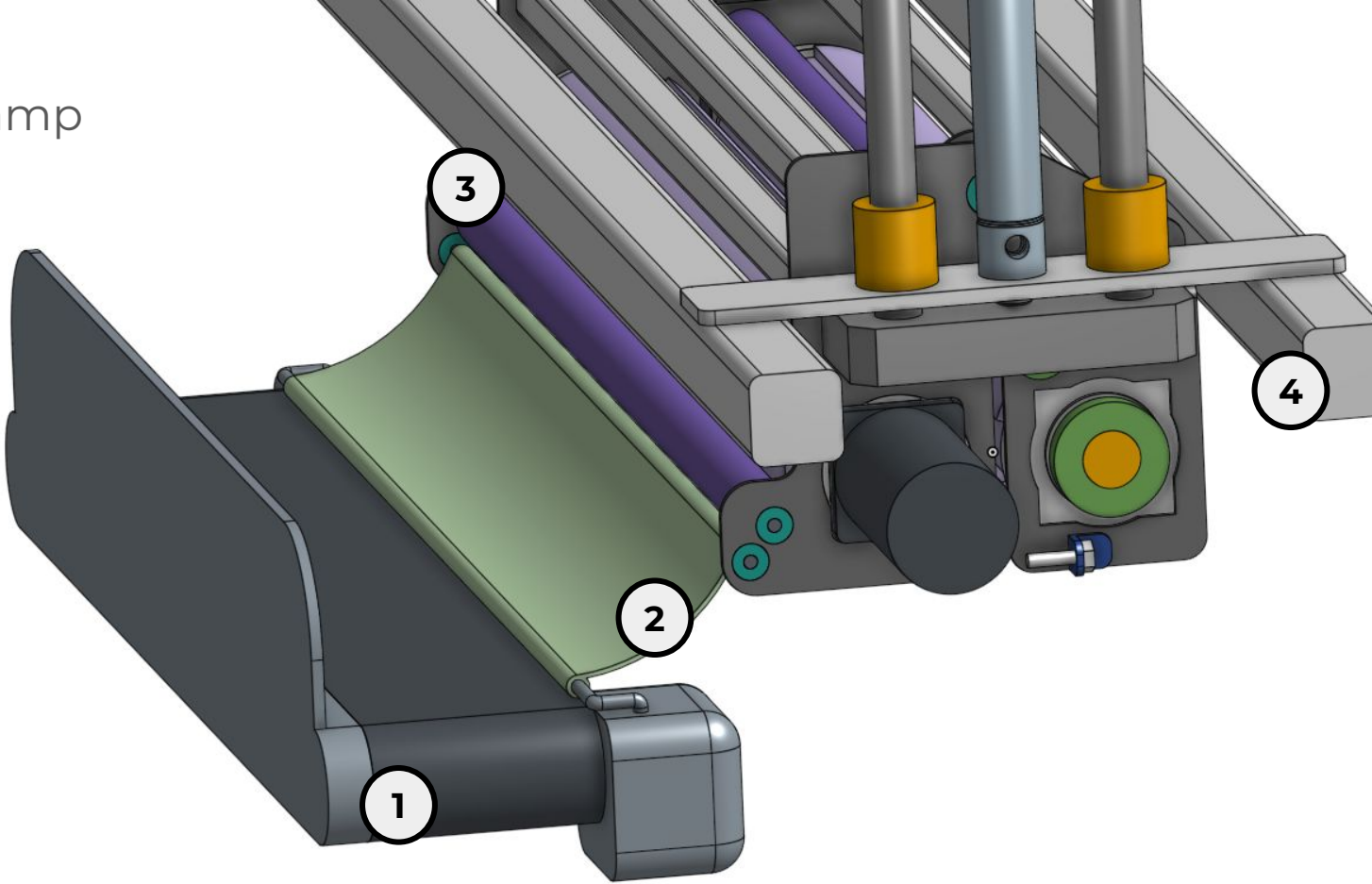


Mechanical

Detailed Design - Picker Mechanism



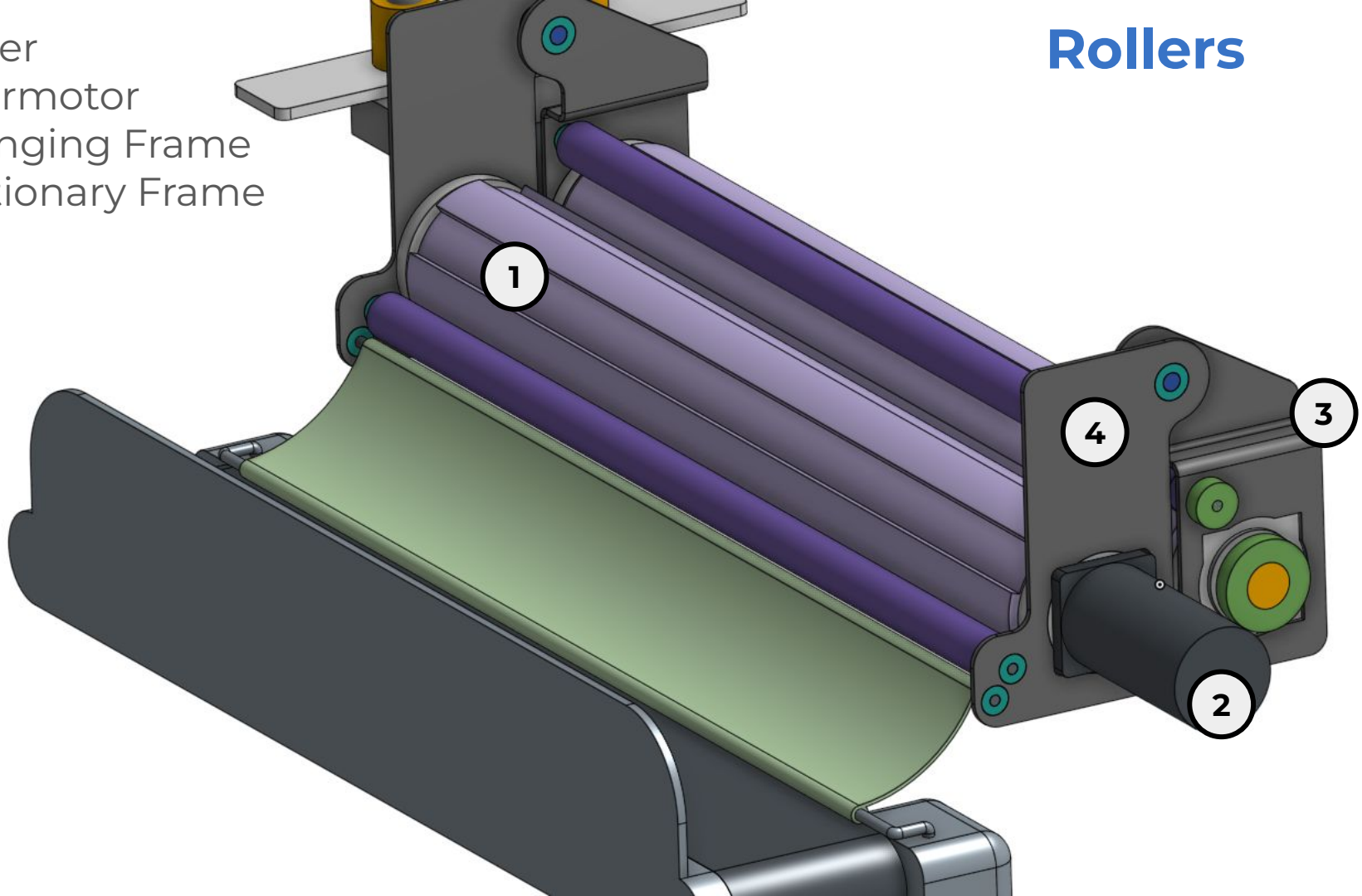
1. Conveyor
2. Collection ramp
3. Brush
4. Frame



Collection

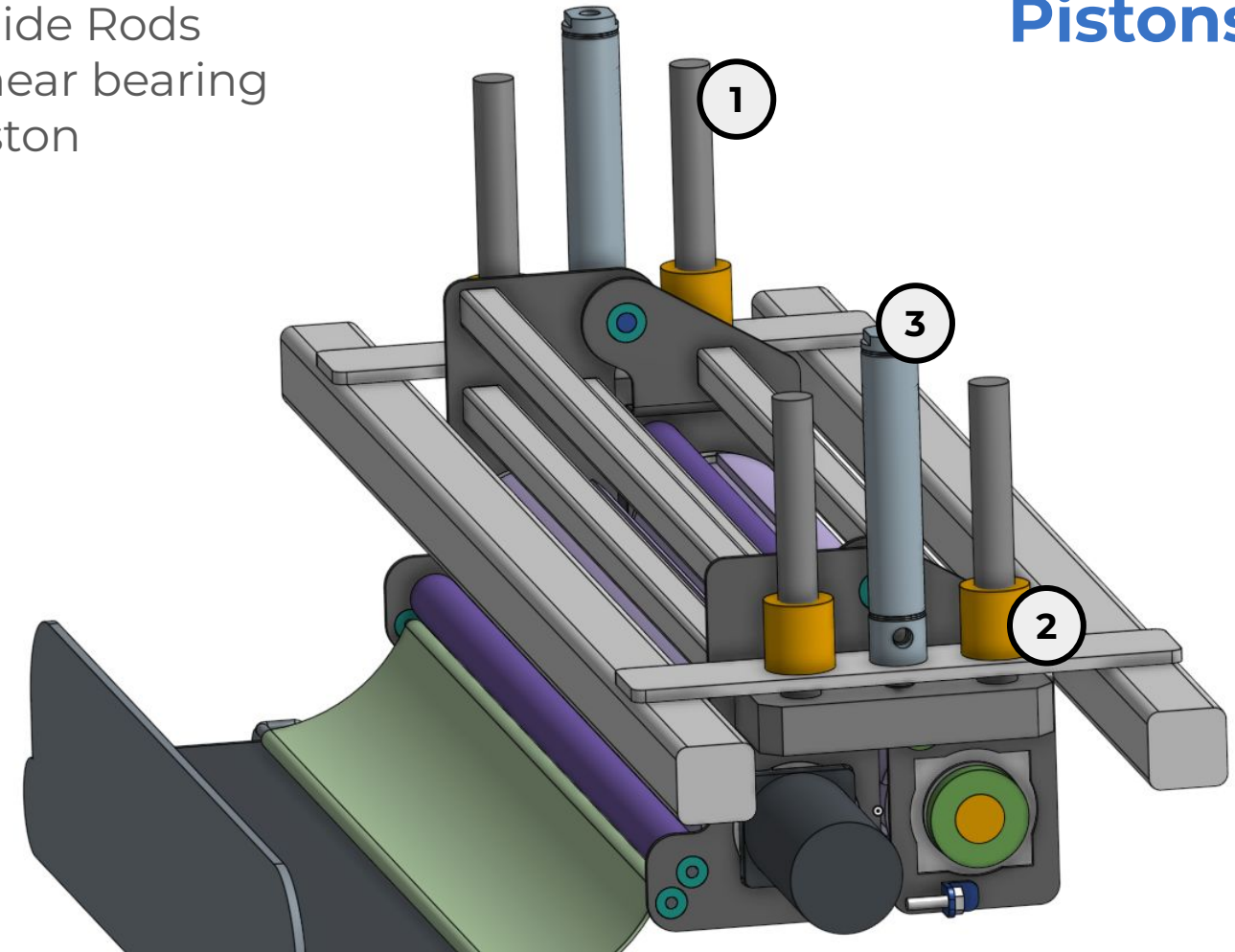
Rollers

1. Roller
2. Gearmotor
3. Swinging Frame
4. Stationary Frame



Pistons

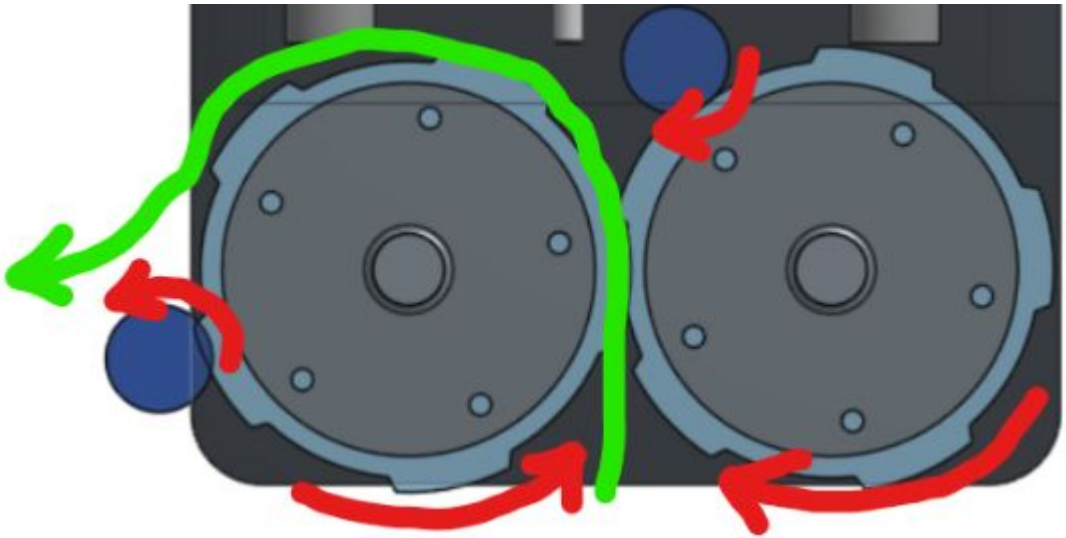
1. Guide Rods
2. Linear bearing
3. Piston



Roller Motor

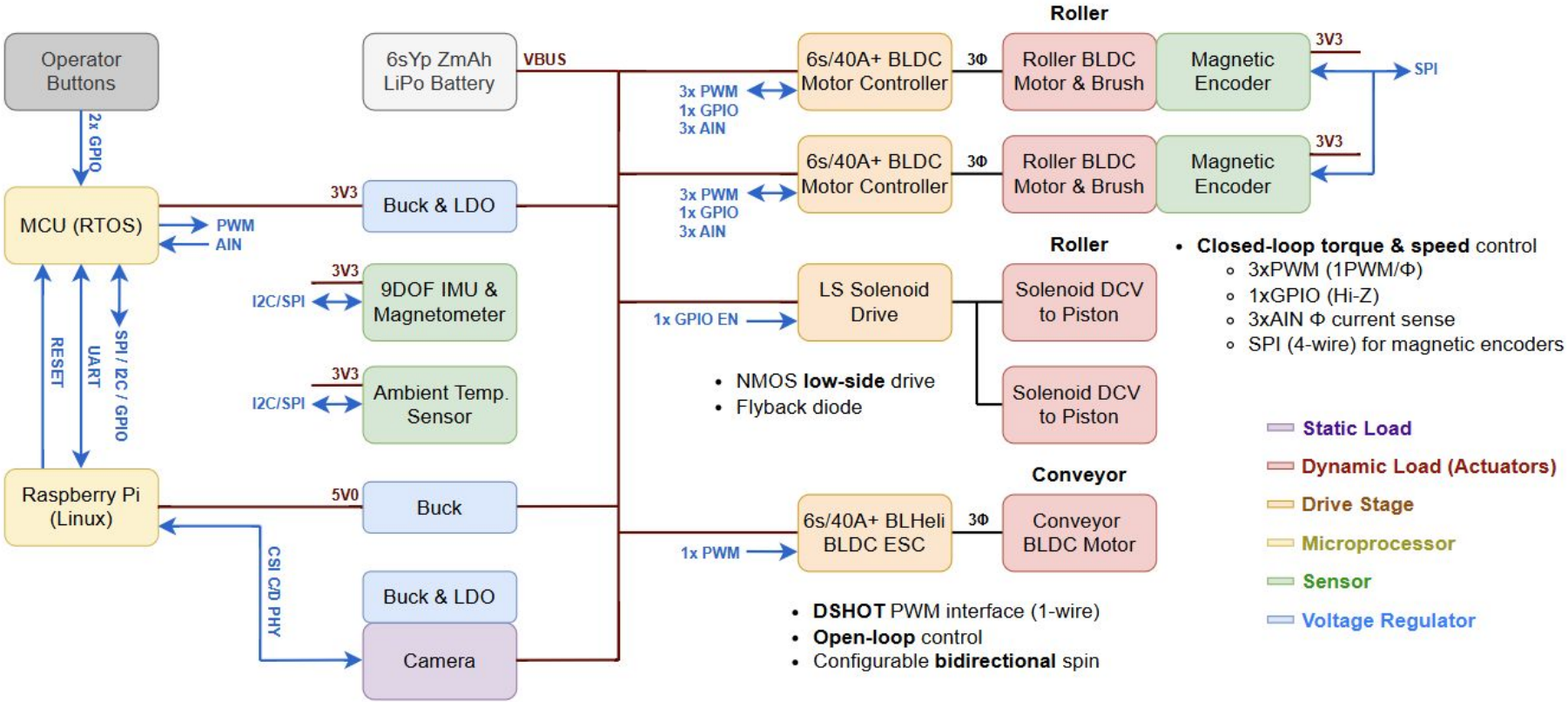
Detailed Design - Tip Transportation

Green: Tip Movement
Red: Rolling Direction



Firmware/Software

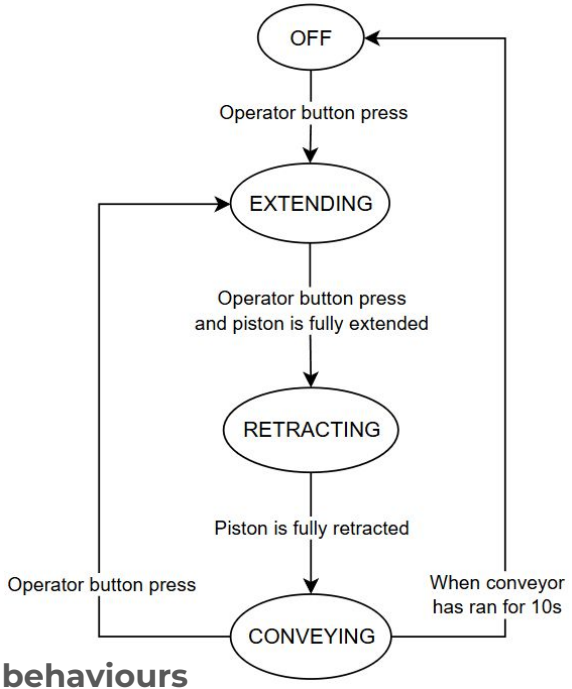
System Architecture Diagram



Firmware Design

Picker MCU

Thread	Period (ms)	Priority (1-highest to 10-lowest)
State machine	10	1
Rpi UART handler (tx/rx)	10	2
Roller motor(s): closed-loop speed control	1	1
Roller motor monitors	100	1
Conveyor motor	100	2
Picker raiser (trigger detection and solenoid actuation)	100	3
Claw actuator	100	2



State behaviours

OFF:

- Idle state, no system movement

EXTENDING:

- Piston extends and rollers begin intaking

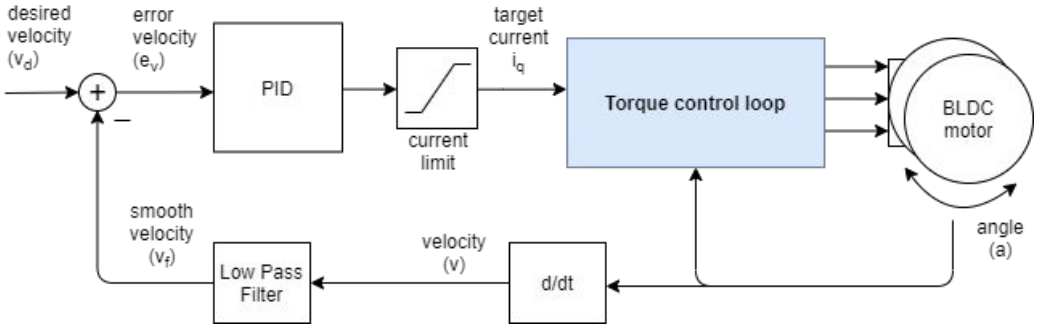
RETRACTING:

- Piston retracts and rollers spin freely

CONVEYING:

- Run conveyor for 10s (max) to move tips to cargo

Motor Speed/Torque Control

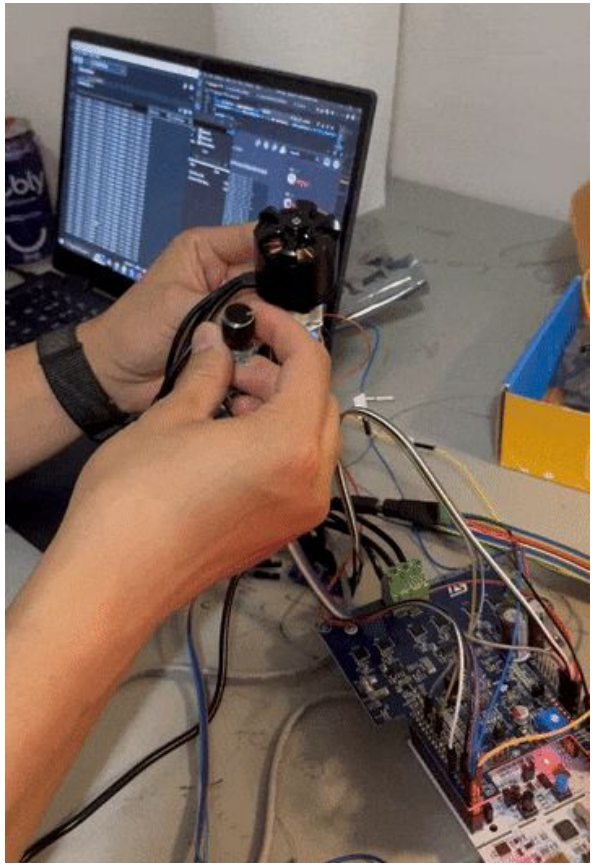


https://docs.simplefoc.com/velocity_loop

- Based on recorded data, each roller spins at 20rpm, and exerts a max of 15Nm
- Closed loop velocity control using magnetic angle sensor
- Torque limiting using phase currents
- 1ms RTOS motor thread validated

Additional Sensing

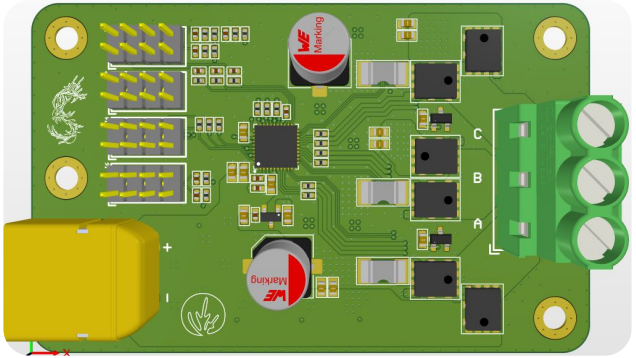
- Buttons for operator input
- Limit switches for triggering conveyor

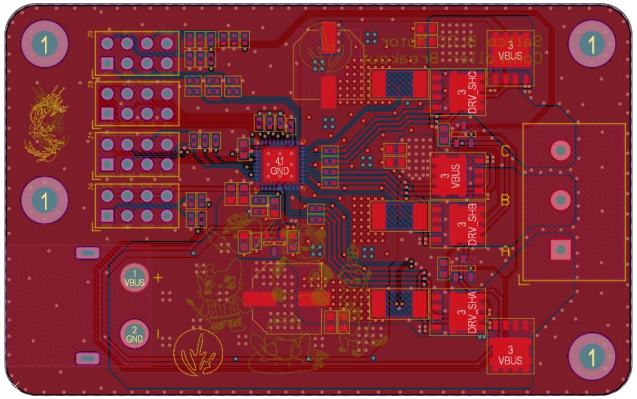


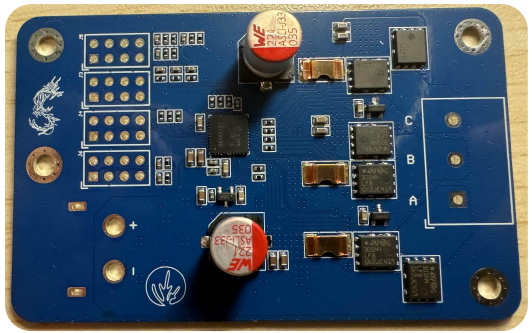
Electrical

6S/50A BLDC Motor Controller Breakout

- Semi form-factored 6S & 50A 3-phase BLDC motor controller breakout (80mm x 50mm)
- Features:
  - Integrated 3-phase gate driver (DRV8323)
  - External NMOS half-bridges
  - Phase current & voltage sense
  - Temperature sense
- Mode of commutation & current sense amplifier parameters configurable via SPI







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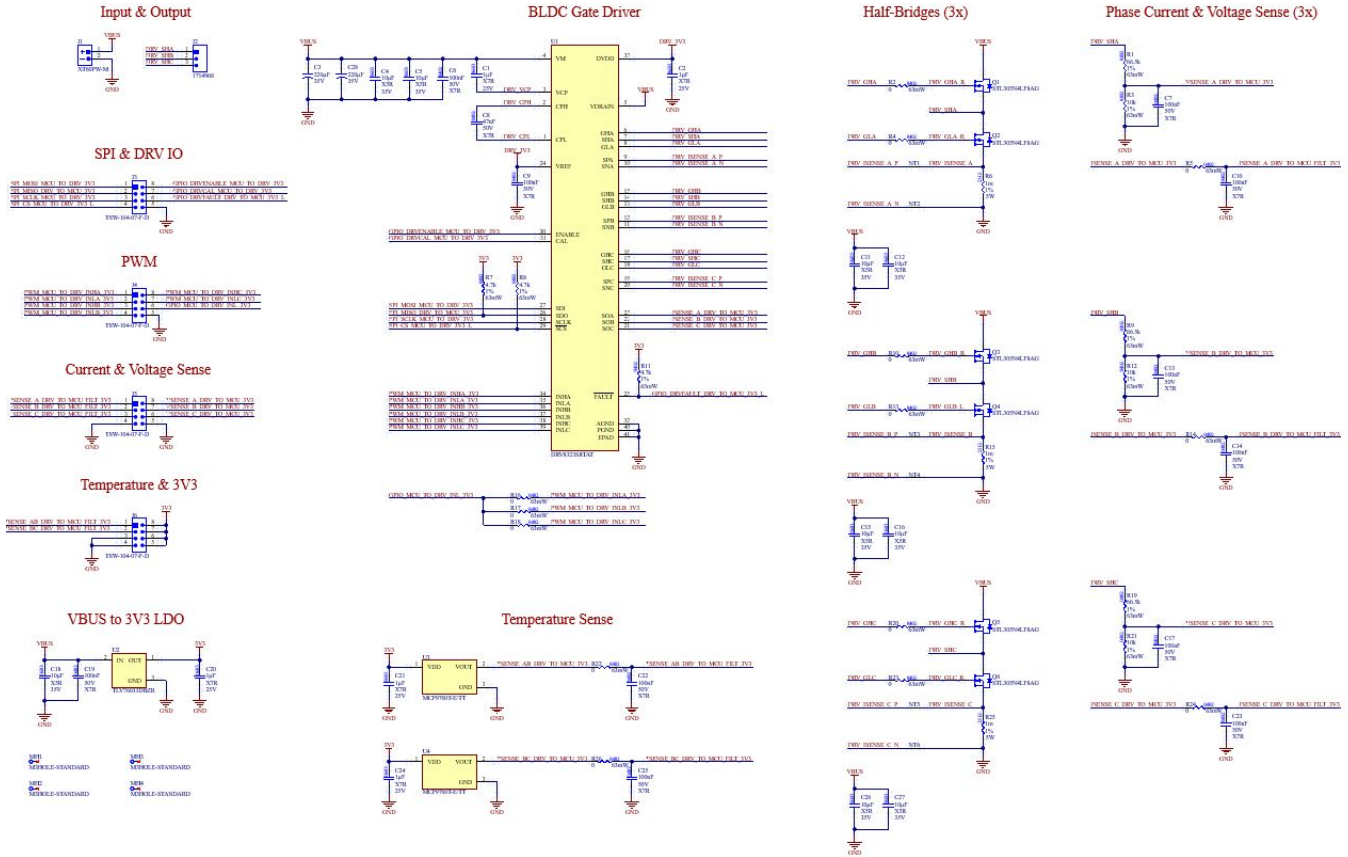

Thanks! <3