Flying Squirrel

Operation/Assembly Manual

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Spring 2025-Fall 2025

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1 ASSEMBLY/DISASSEMBLY

The assembly and disassembly processes are broken into different sub-assemblies of the Flying Squirrel. The assembly process describes in order how the lower section, handle section, top section, and anchors are put together. The disassembly process is the reverse order of the assembly process. Other processes are discussed outside of assembly and disassembly of the main sub-assemblies.

1.1 Assembly

This section discusses the assembly of the physical model, excluding wiring, which is included in section 1.3.2. The lower assembly is first as it contains the main structural components that hold the top and bottom sections together. The handle assembly is next as it needs to be put together before being connected to the top section. The top section is the final piece of the main body to be constructed as it will be assembled with the handle section and attached to the lower section via lead screw and support bars. After the main body is assembled, the anchors can be assembled and connected to the device.

1.1.1 Lower Section

Prior to assembly, the support bars and linear bearing need to be thermally treated to fit in their designated positions in the robot. Allow support bars and linear bearings to cool in a freezer for a minimum of 30 minutes prior to their installation. The support bars and linear bearings are shown in figures 1 and 2.

Figure 1. Linear Bearing

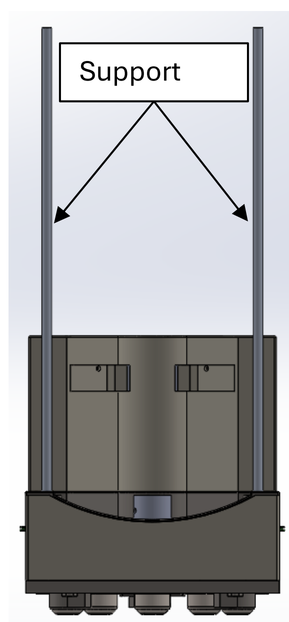


Figure 2. Support Bars

Before beginning assembly, inspect all 3D printed parts for errors or imperfections. After verifying all parts are good, begin with the lower base plate of the lower section shown in figure 3. This component is the mounting point for all components needed in the lower section. The first pieces needed to be attached to this part are the support bars from figure 2. To install the support bars, after the cooling process, place one bar in the support bar mounting hole and press in the support bar. The bars may need light impact from a rubber hammer to be properly mounted. The installed support bars are shown in figure 4.

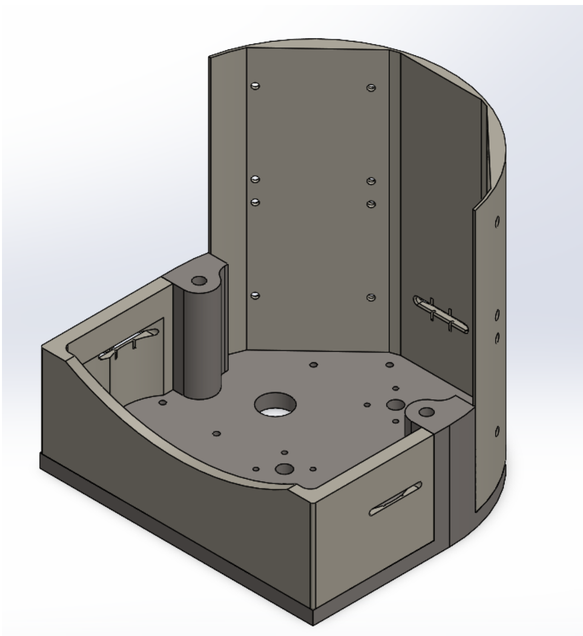


Figure 3. Base Plate

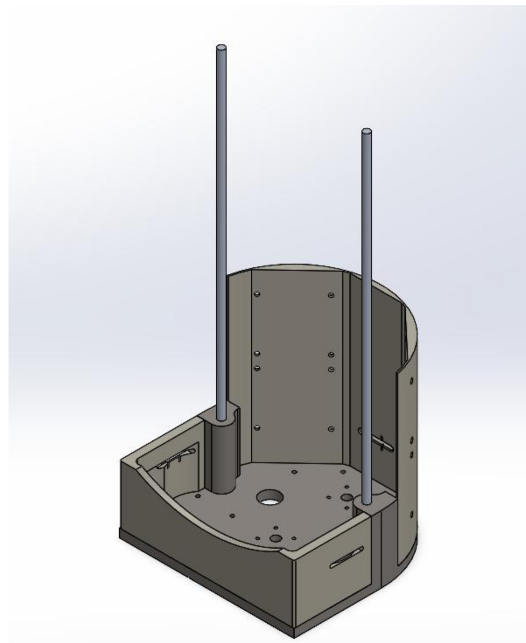


Figure 4. Installed Support Bars

The next step is to install the wheels on the bottom of the base plate using M4 bolts. The installed wheels are shown in figure 5. After the wheels have been installed, the motors can be installed using M3 screws onto the top of the base plate. The wire orientation of the motors is important to follow and is labeled in the figure. The installed motors are shown in figure 6. The wheels are installed before the motors to allow the shaft of the motor to have space during motor installation.

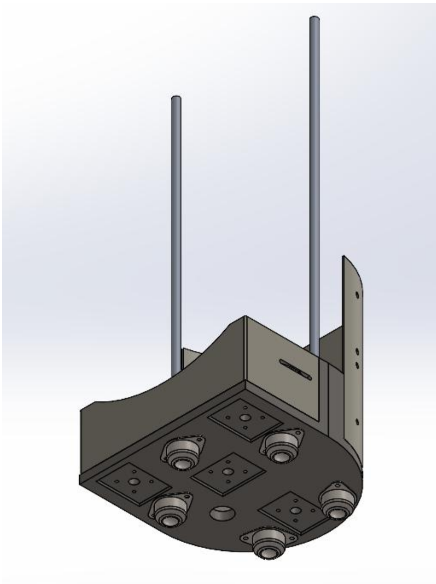


Figure 5. Installed Wheels

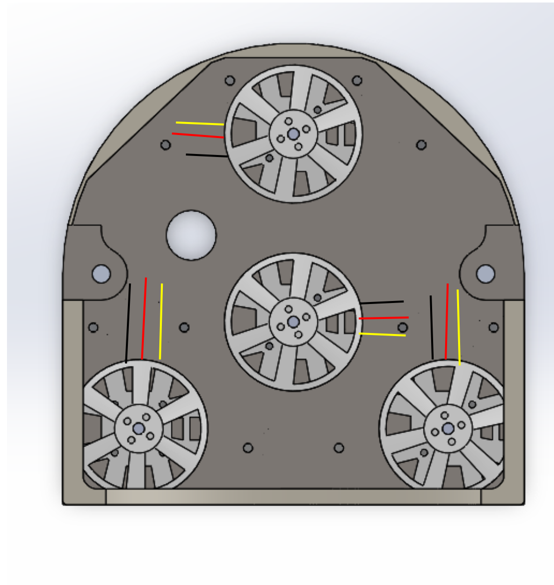


Figure 6. Installed Motors, Proper Orientation

The following steps are to attach the encoder bracket and encoder to the bottom of the base plate using shallow M3 screws as shown in figures 7 and 8. Proper installation of the encoders is described in section 1.3.1.

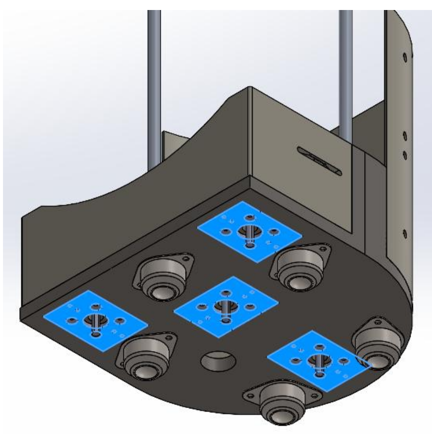


Figure 7. Encoder Brackets

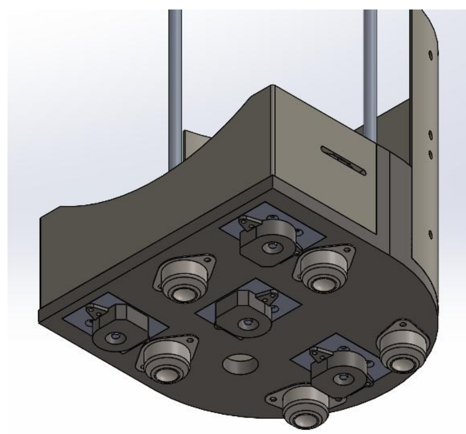


Figure 8. Encoders

The cable guide pulleys are next to be installed. Before installing the pulleys to the base plate, they first need to be assembled. The parts to assemble the pulleys are the guide pulley shaft, guide pulley bearing, and guide pulley. The guide pulley is shown in figure 9. Six guide pulleys are assembled for base plate and three for the anchors that are described in section 1.1.5. After all guide pulleys are assembled, they are attached in their designated locations with epoxy on the left, right, and back sides of the body shown in figures 10-12

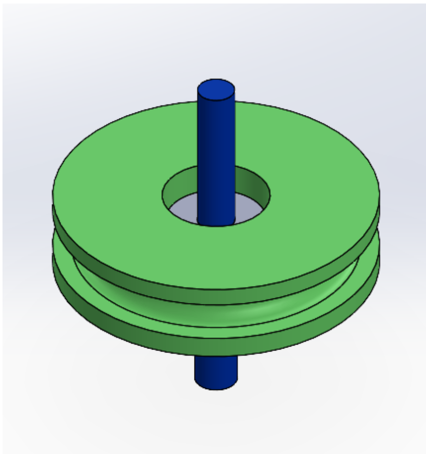


Figure 9. Guide Pulley

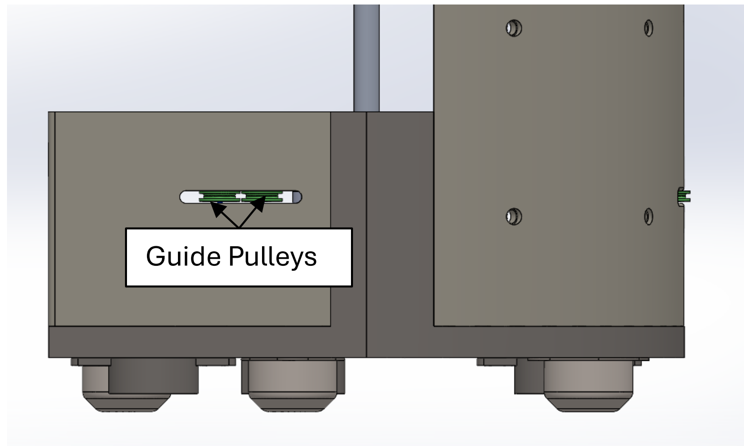


Figure 10. Mounted Guide Pulleys (Left)

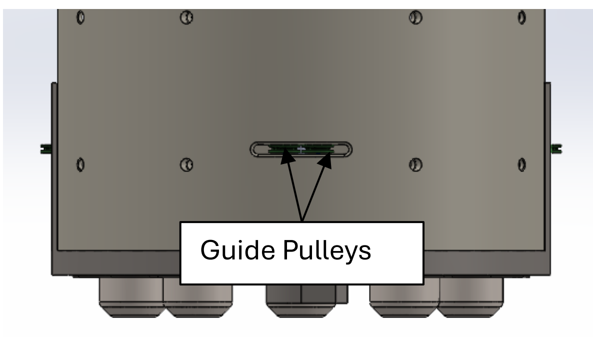


Figure 11. Mounted Guide Pulleys (Back)

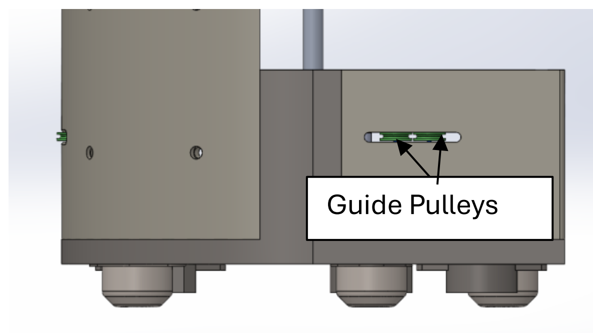


Figure 12. Mounted Guide Pulleys (Right)

After all guide pulleys are set in place, the motor drivers can be mounted using M3 bolts. The upper motor drivers are oriented so the wire connectors are facing upward, and the lower drivers are downward' Figure 11 shows the mounted motor drivers and figure 12 shows the physical model as an example to show orientation. All wiring will be discussed in section 1.3.2.

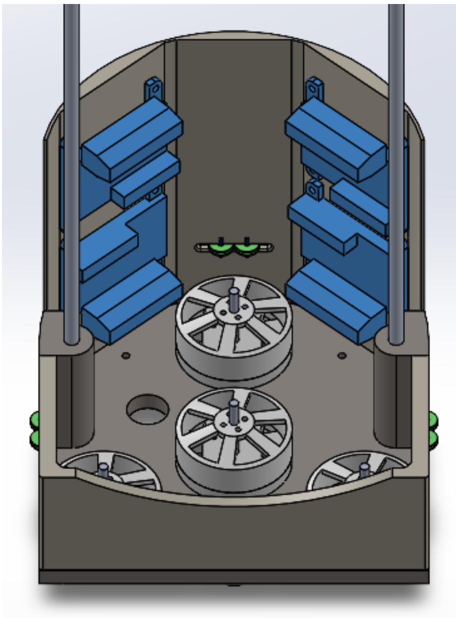


Figure 13. Mounted Motor drivers

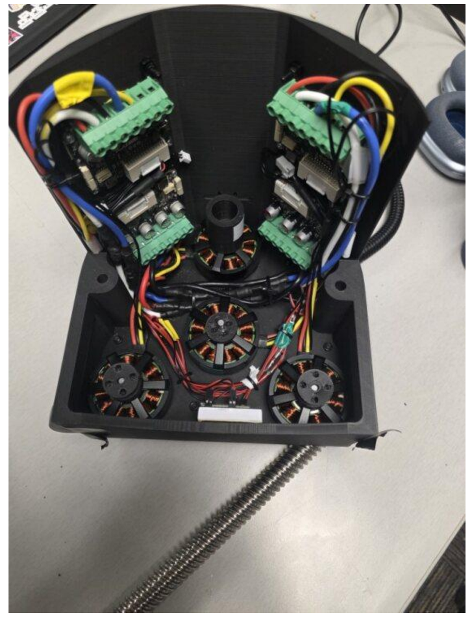


Figure 14. Motor Driver Orientation

After all motor controllers are mounted and wired, the coupler and pulleys can be mounted to the motors. The coupler will be mounted first as it is connected to the rear motor using M3 bolts. The coupler consists of four parts: the coupler, the bearing, the cable guide, and the bearing spacer. Four holes are designed into the coupler for heat sets. The assembled coupler is shown in figure 13 and the attached coupler is shown in figure 14.

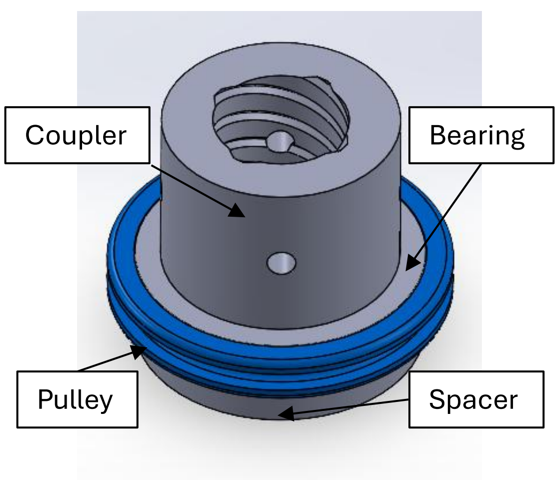


Figure 15. Couple Assembly

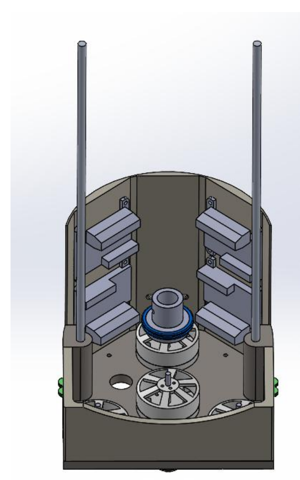


Figure 16. Installed Coupler

The next step is to cable pulleys on the other three motors. The pulleys require a coupler to be mounted to the motor prior to installation. All parts use M3 screws. The couples and pulleys installed are shown in figures 15 and 16. After cable pulley installation, please refer to section 1.3.3 for cable preparation.

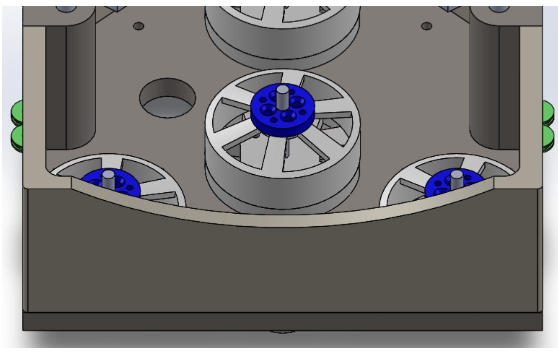


Figure 17. Cable Pulley Couplers

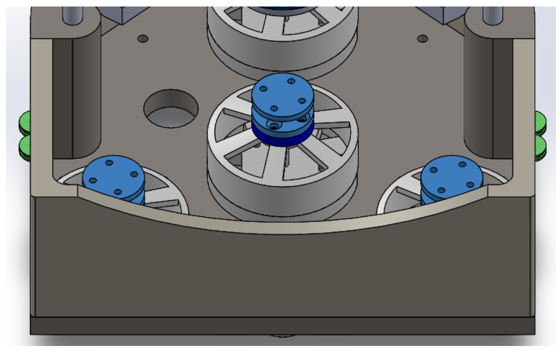


Figure 18. Cable Pulleys

The lead screw and Teensy are the final components to be mounted before the covers of the lower section are installed. The lead screw threads into the coupler on the rear motor and is locked into place with set screws. The lead screw is shown in figure 17. The Teensy is mounted at the front of the base plate between the front two motors as shown in figure 18.

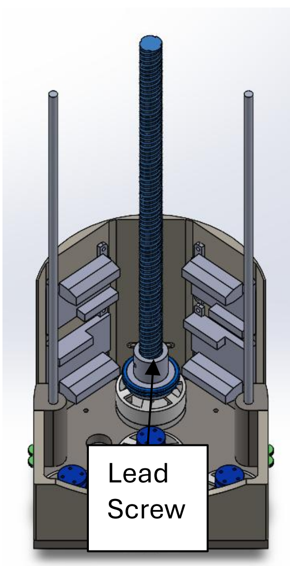


Figure 19. Lead Screw

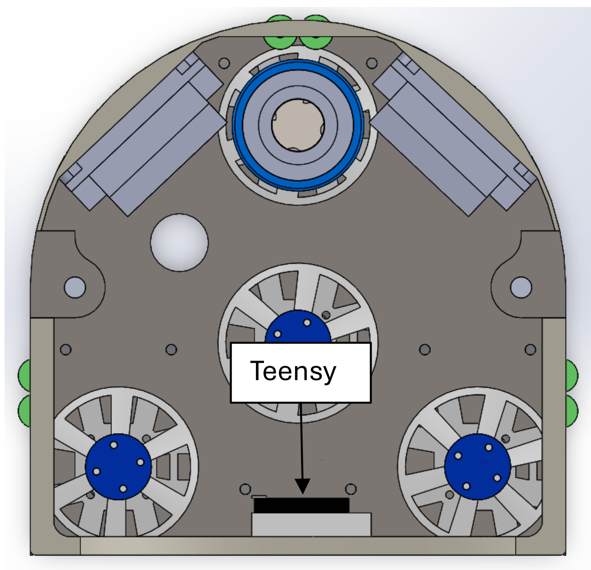


Figure 20. Teensy

The final component to be installed on the lower assembly is the cover. The cover consists of three separate covers called the bottom front ceiling, bottom back ceiling, and back wall. The covers either need to be attached via epoxy or printed as a single part. Figure 19 shows the cover, and figure 20 shows the cover mounted to the body.

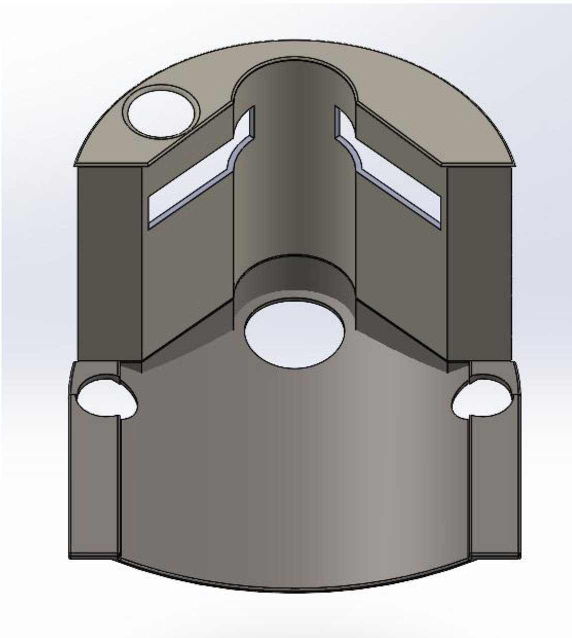


Figure 21. Lower Body Cover

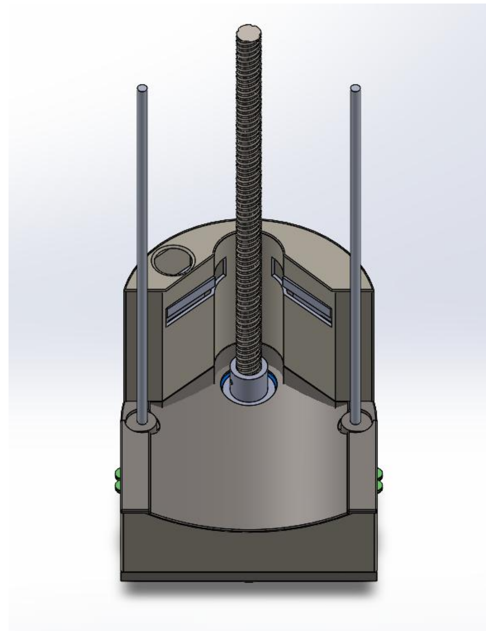


Figure 22. Lower Cover Mounted to Lower Section

The complete lower section is shown in figure 21 and the next sub assembly can be constructed

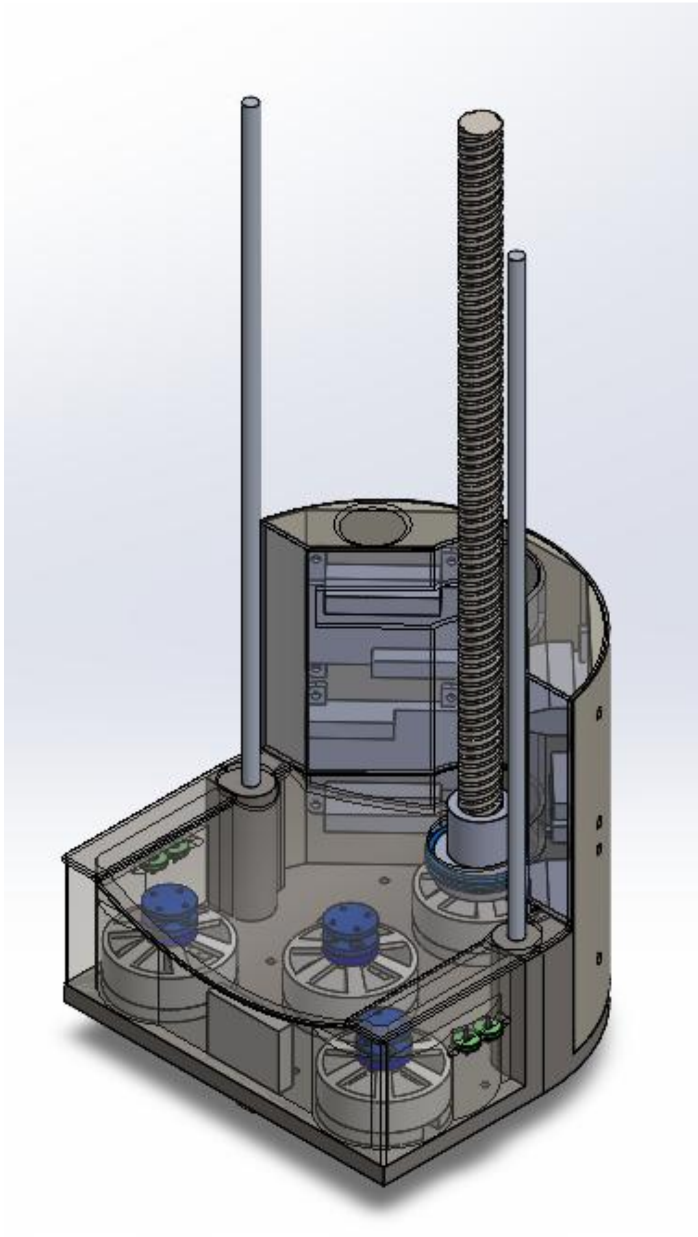


Figure 23. Lower Section

1.1.2 Handle Section

The handle section mainly consists of five parts: the load cell, the handle plate, the handle track, the handle, and the strap. The handle plate attaches to the load cell using M5 screws. The load cell and handle plate are shown in figure 22.

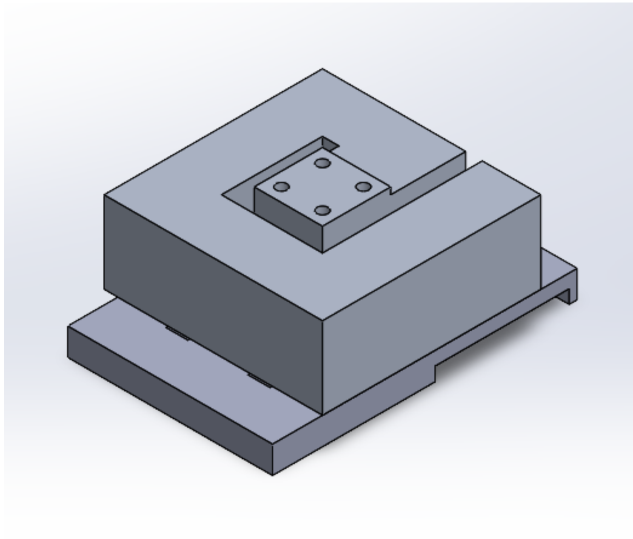


Figure 24. Load Cell Attached to Handle Plate

To connect to the handle plate, the handle tracks need to be slid in and secured by an adhesive. The handle is attached to the two tracks prior to being adhered to the handle plate. Figure 23 shows the handle tracks attached to the handle and figure 24 shows the tracks attached to the handle plate

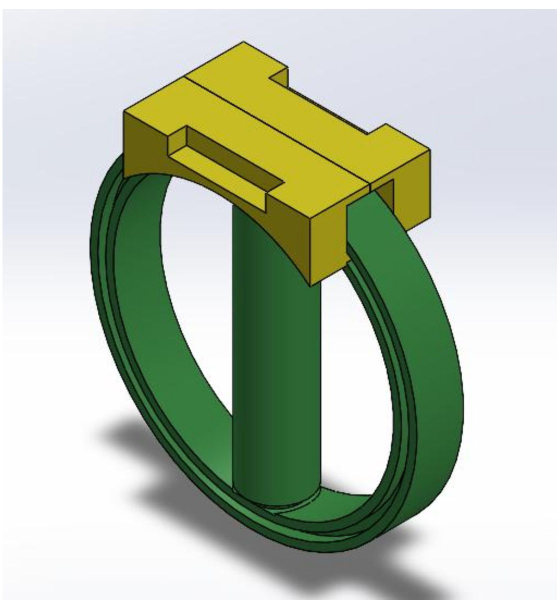


Figure 25. Two Piece Track with Handle

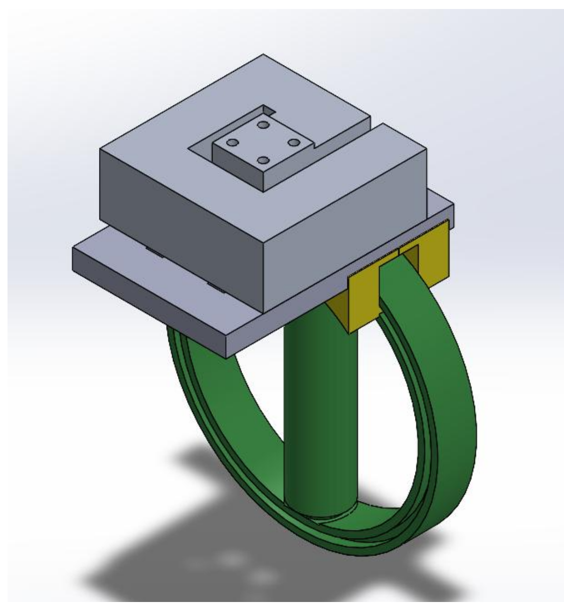


Figure 26. Handle Track attached to Handle Plate

The final part of the handle assembly is to attach the strap. Figure 25 shows the strap attached to the handle assembly.

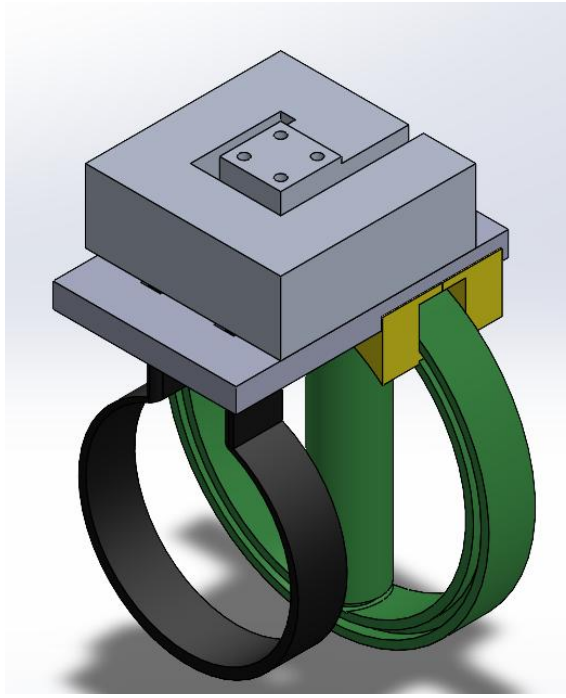


Figure 27. Handle Assembly

1.1.3 Top Section

The top of the section contains multiple 3D printed parts such as the top plate, top mounting plate, raspberry PI mount, lead screw nut and the top shell. In terms of the electrical components housed in the top sections include the load cell, battery, raspberry Pi, screen, and their associated wires.

Begin assembly by inserting the two linear bearings and lead nut into the bottom of the top plate.

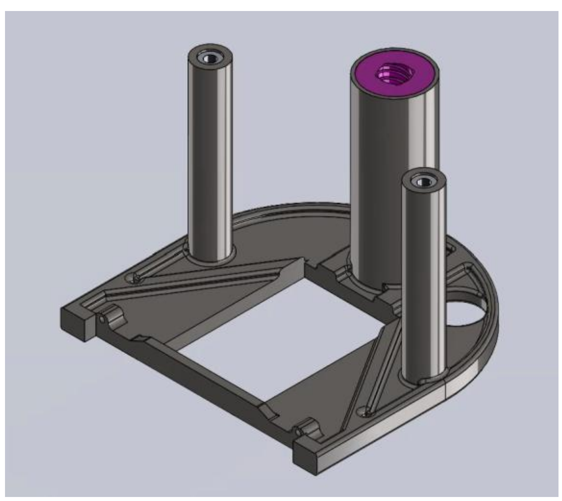


Figure 28: Top Plate Underside View

Add the top mounting plate before screwing in the touch screen.

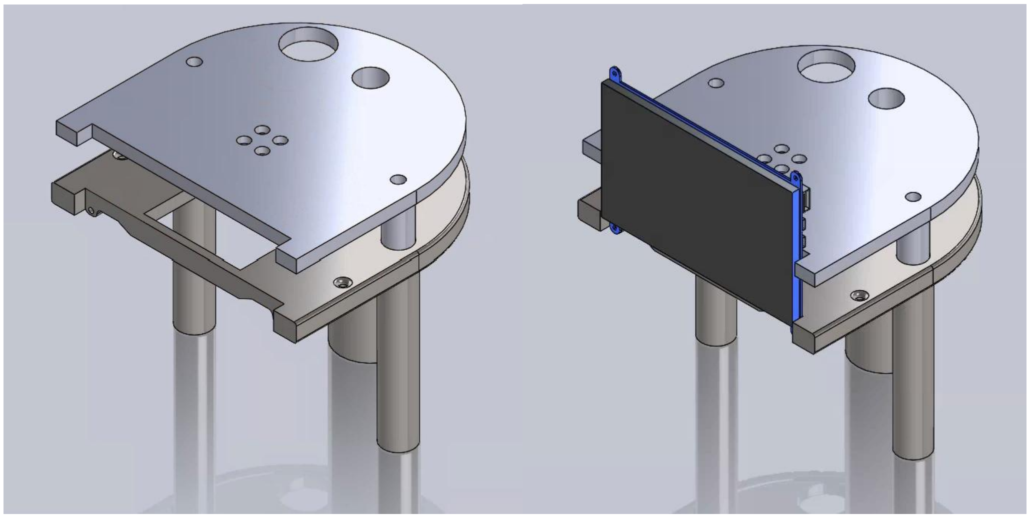


Figure 29: Top Plate and Mounting Plate with and without screen

Now both the battery and the Raspberry Pi, screwed into its angled mount, can be added. The additional space in the top assembly will be needed for wiring all the components together.

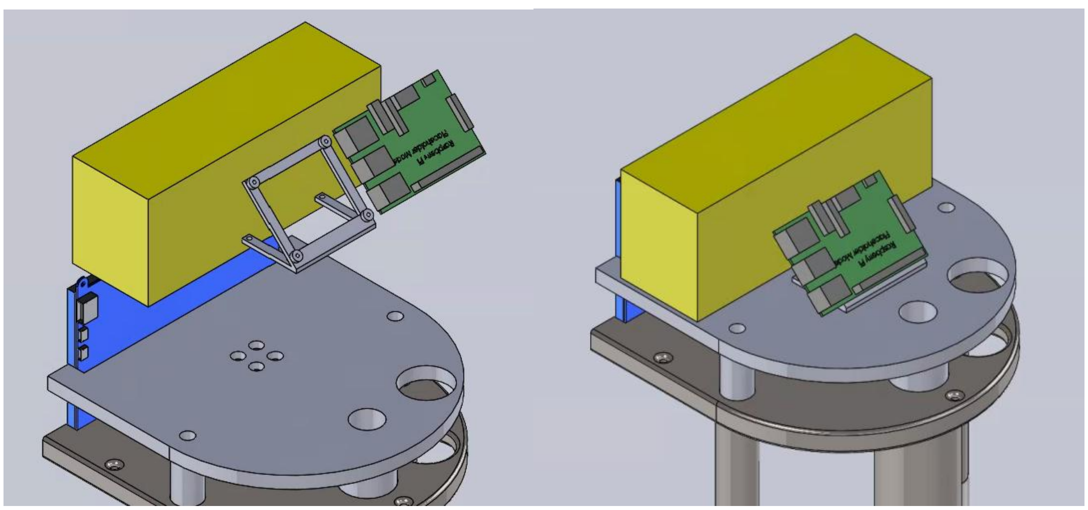


Figure 30: Top Assembly Battery and Raspberry PI configuration

With all the components in place, secure the top shell over the assembly.

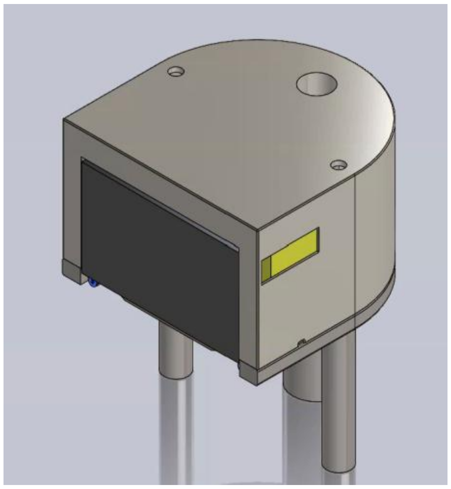


Figure 31: Entire Top Assembly

1.1.4 Full body assembly

For the full body assembly, the top assembly needs to be placed on top through the aluminum rods and the lead screw. Once that is completed, the wires from the bottom need to be run up through the sleeve to the battery and Pi and the force sensor wire needs to be run down from the top.

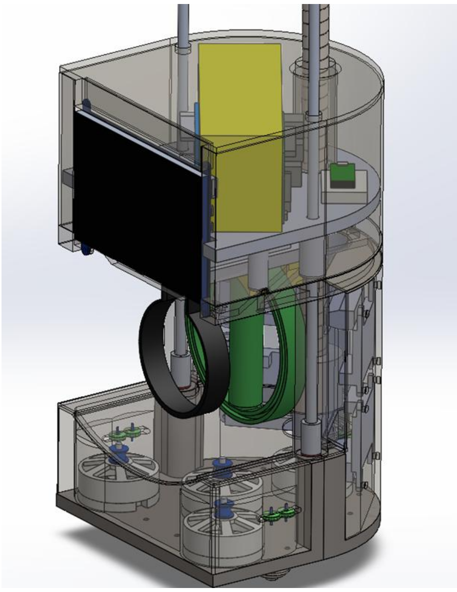


Figure 32: Full Body Assembly

1.1.5 Anchors

To connect the c-clamp and suction cup for each anchor, simply mount the unifying bracket to the side of the suction cup, perpendicular to its axle. Make sure it is on the opposite side of the large knob attached to the axle. Use superglue or another comparable adhesive to secure the bracket in place.

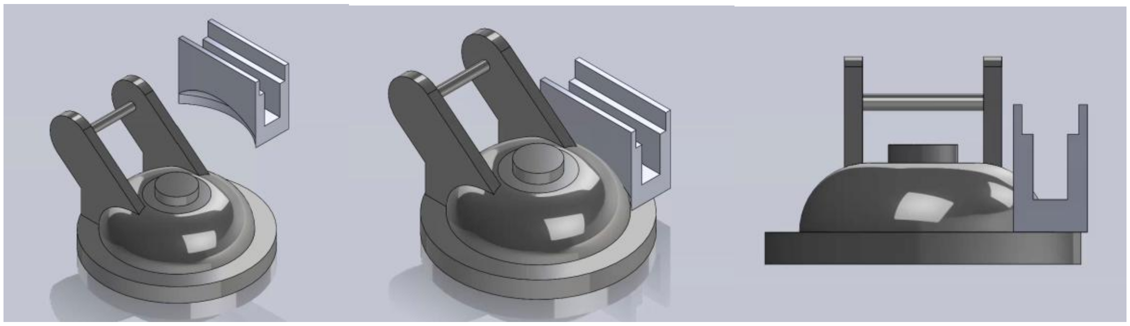


Figure 33: Achor Multiview

Before attaching the clamp to the assembly, remove the suction cup axle to install the first part of the pulley mount.

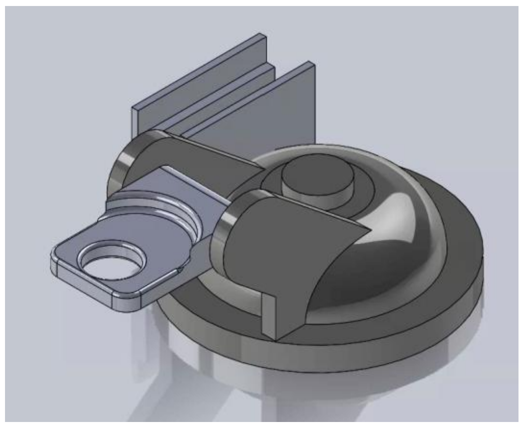


Figure 34: Achor Attachments

With this step done, the c-clamp can be more easily installed. Place it in the bracket so that the end of the suction cup's axle is tucked into the clamp's curvature. Secure the connection with adhesive.

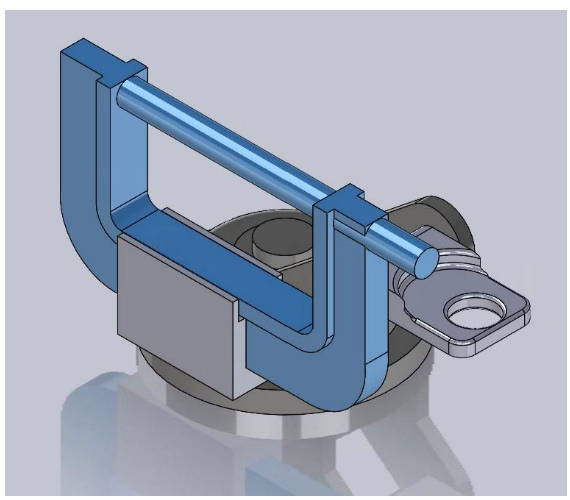


Figure 35: Anchor with the C clamp

To finish installing the idler pulley assembly, attach the pulley mount to the suction cup, then attach the lock using adhesive. Make sure the mount can rotate freely.

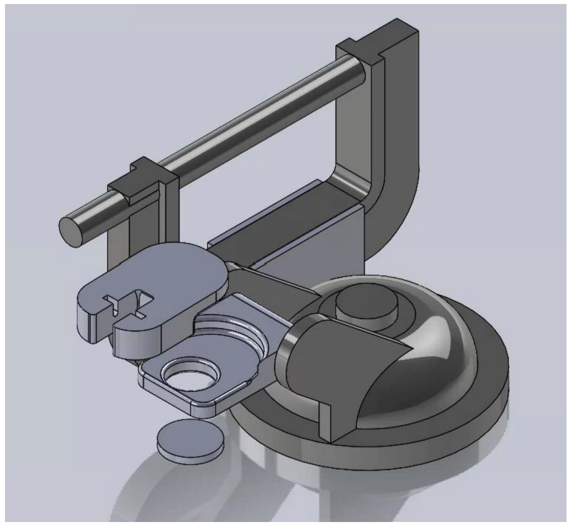


Figure 36: Anchor Idler assembly

Insert the idler axle into the bearing and pulley, then place the axle in the pulley mount. Heat up the mount plastic to seal the axle in place.

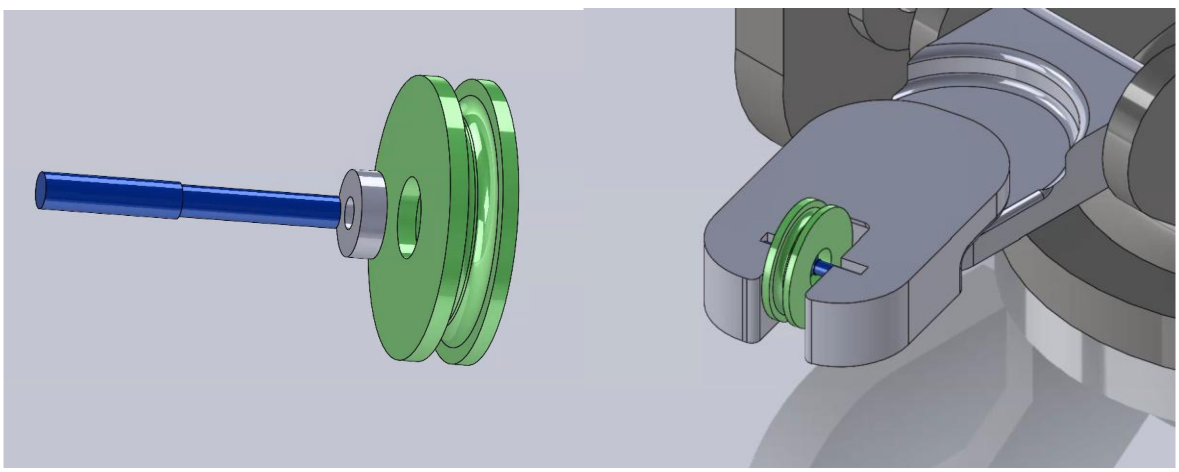


Figure 37: Anchor Idler Pulley Assembly

Repeat these steps twice more to complete the three anchors. When they are ready to be attached to the main assembly, thread the cables from the bottom assembly, through each pulley, and tie the ends to the top assembly.

1.2 Disassembly

1.2.1 Disassembly prep

To prepare the robot for disassembly disconnect the battery from the robot and turn it on to ensure all the wires are not energized to prevent electrical shorting from wires touching during the disassembly process. Remove the top shell to gain access to all of the wiring and the battery and disconnect all of the wires and remove the battery and Raspberry Pi from the robot.

1.2.2 Anchors

To disassemble the anchors from the robot, untie the knots connecting the wires to the top of the robot and pull the wires back through the anchors to free the anchors.

1.2.3 Top Section

To disassemble the top section, first remove the screen by unbolting the two bolts located at the bottom of the screen using a Phillips head screwdriver to reduce the risk of breaking the mounting points on both the screen and top plate. After the screen has been removed, grasp the lead screw and turn clockwise to raise the top section until it is free from the robot.

1.2.4 Handle Section

To disassemble the handle section, the load cell needs to be detached from the top mounting plate. Detach the strap from the handle plate, then remove the handle track from the handle plate by removing the adhesive. This done, the handle can be simply removed from the handle track. Finally, the handle plate can be unscrewed from the load cell.

1.2.5 Lower Section

To disassemble the bottom section, remove the bottom lid to gain access to the electronics located underneath. Disconnect all the wires connected to the motor controllers using a flathead screwdriver then remove the motor controllers from the back of the baseplate using a Phillips head screwdriver. After the motor controllers have been removed, lay the baseplate on its side to gain access to the bottom of the robot. Remove the encoders by carefully lifting the tabs holding them in place and unplug the connectors. After the encoders have been removed, using a Phillips head, remove the bolts holding the encoder bracket on then remove the bolts holding the mounting plate to the motors.

1.3 Miscellaneous

1.3.1 Encoder installation

To install the encoders on the motor output shafts, put the spacing tool on top of the motor mounting plate, then slide the yellow spacer over the output shaft, then the black space over the yellow spacer. Then, using the encoder shaft adapter press, press down on the black space until it touches the spacing tool. Then remove the spacing tool and encoder shaft adapter press and install the encoder mounting bracket onto the motor mounting bracket using M3 bolts, then press the encoder into the bracket and connect the wires.

Figure 38: Spacing Tool

Figure 39: Encoder Shaft Adapter Press

1.3.2 Wiring

Motors and motor drivers

The motors receive power from the motor drivers. They are connected into the drivers with their yellow, black, and red wires into the driver's A, B, and C ports respectively. The motor drivers are connected to the positive and negative straight from the battery to the DC+ and DC- ports. The ports on the motor driver are shown in figure 35 and an example of the wired motor driver is shown in figure 36.

Figure 40: ODrive S1

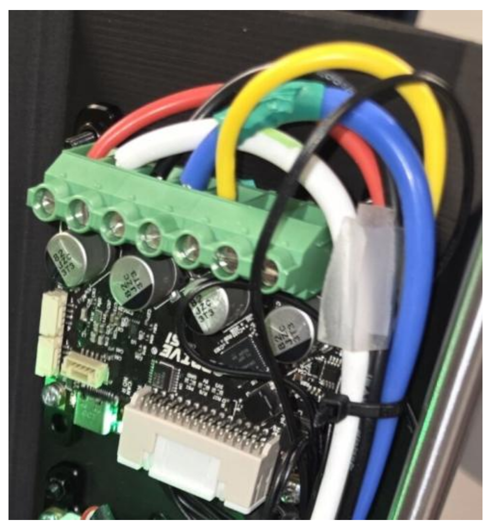


Figure 41: ODrive Configuration

The positive and negative for the motor drivers share common power and ground wires, white and blue wires, respectively. A harness was built to fit specific length for each driver and are labeled with colored tape to indicate their respective driver (white:1, red:2, green:3, and yellow:4). The harness and labelled drivers are shown in figure 42.

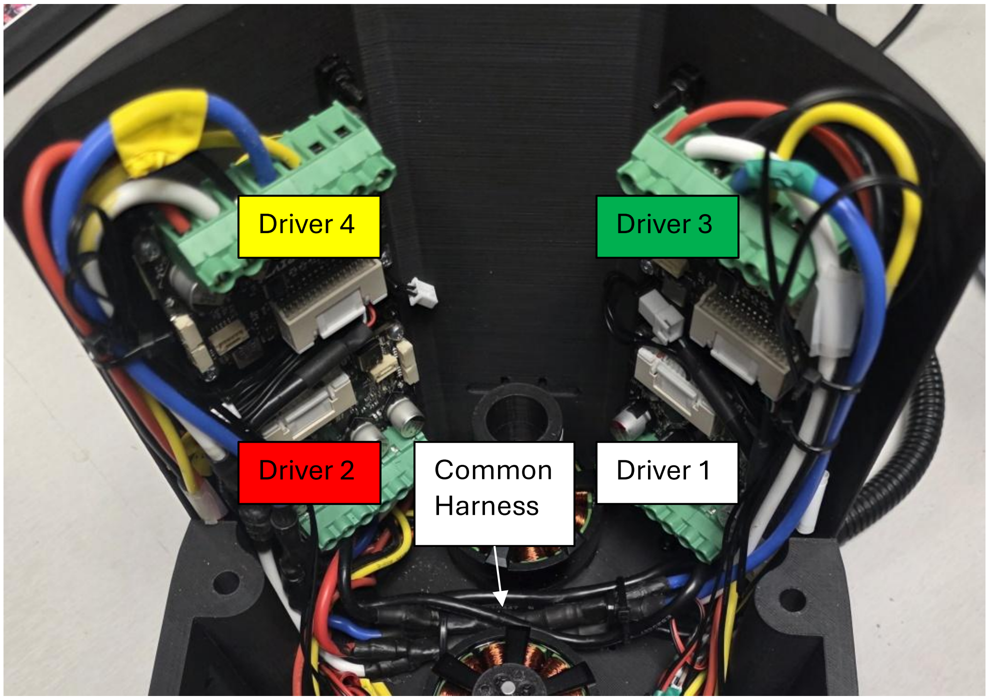


Figure 42. Motor Drivers and Harness

Teensy wiring

The Teensy communicates with the motor drivers and the load cell. The Teensy uses UART to send commands to the motor drivers and analog pins to communicate with the load cell. The pin diagram of the Teensy is shown in figure 43. The motor drivers share the 3.3 V (250 mA max) and GND pin, share the same wires to connect to the board, red wire is power, and black wire is ground. The UART pins are the RX and TX ports for motor controllers 1-4. RX ports use the red wire from the drivers, and TX ports use black wires from the drivers.

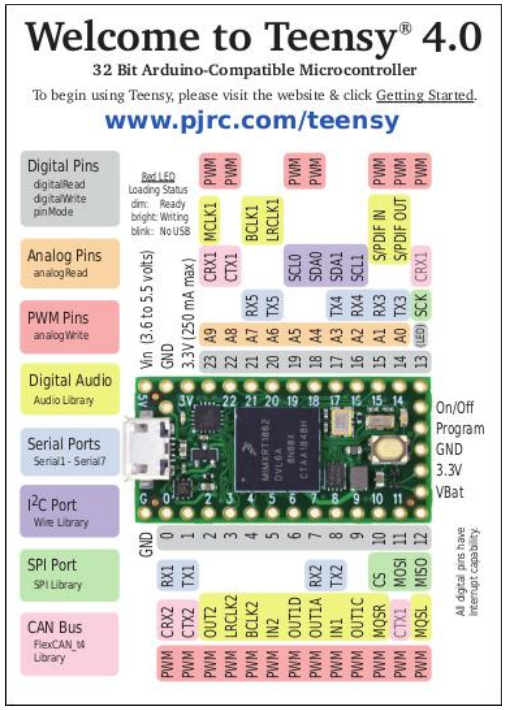


Figure 43. Teensy 4.0 Pin Diagram

The motor drivers are labeled with different colors to indicate what which driver wires to what pin in the Teensy. The colors used are white for driver 1, red for driver 2, green for driver 3, and yellow for driver 4. Near the end of the harness going to the Teensy is a small strip of wire that correlates to the motor driver connecting to the board. An image of this is shown in figure 44.

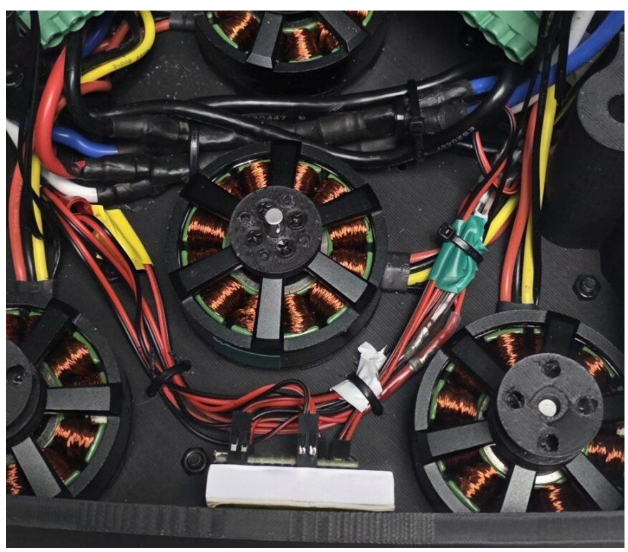


Figure 44:

<u>Raspberry Pi wiring</u>

The Raspberry Pi is powered from a 5V/5A step down converter plugged into the USB-C port. It is then connected to the Teensy via serial USB from the top section to the robot to the lower section. The screen is connected to the Raspberry Pi's Micro HDMI port. The touch screen control is enabled through micro-USB from the screen to any USB port on the Raspberry Pi. The Raspberry Pi is shown in figure 45.

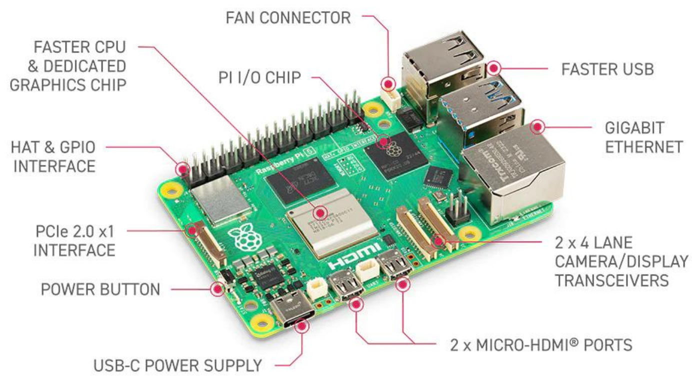


Figure 45. Raspberry Pi

<u>Load Cell Wiring:</u>

The load cell in the flying squirrel has four cables sorted by color. The four wires include the black for X direction, red for the Y direction, yellow for the Z direction, and green for the common positive and ground. For the direction of wires, it splits into two more wires with red representing data and black representing the Clock. X, Y, and Z axis data and clock wires will utilize Teensy ports 18-23, respectively. Figure 46 shows the labeled wires from the load cell.

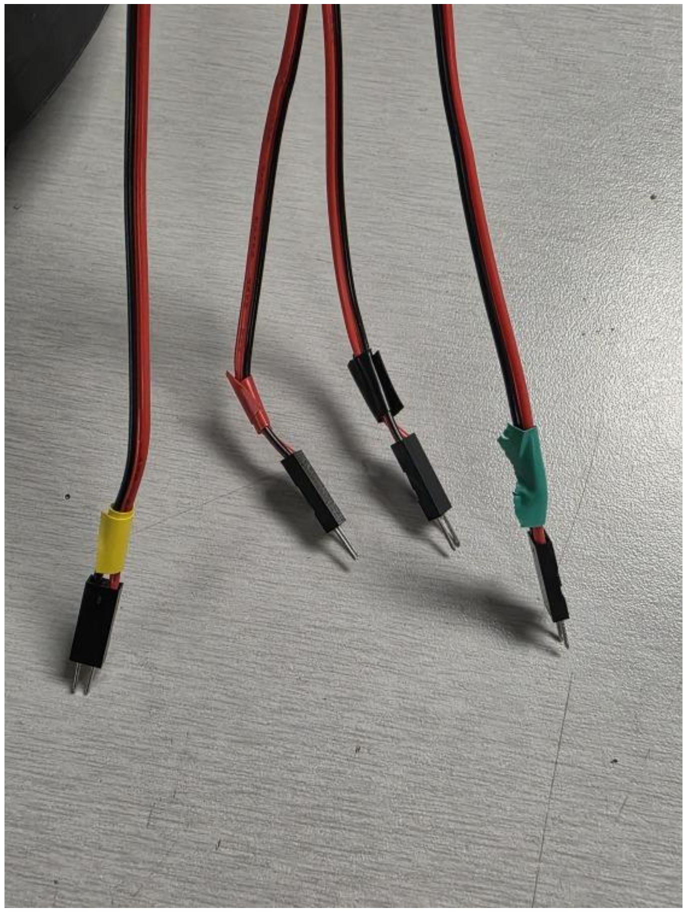


Figure 46. Load Cell Wires

1.3.3 Cable Prep

Before operating the robot, conduct a visual inspection of the device to check for fraying of the wires and that pulleys have the correct orientations and cables are properly attached to those pulleys.

1.3.4 Coding

The Code for functionality should already be installed on the motor drivers, teensy, and Raspberry PI. Though if there is a need to reinstall all the code should be available through the flying squirrel Microsoft teams. The movement code and the force senor code need to be uploaded to the teensy.

2 OPERATION

2.1 Set-Up Procedure

2.1.1 Preparing Robot

To set up the *Flying Squirrel*, the robot needs to be taken out of the stowed position, whether it's being stored in-box or in another location. The ideal table size to use for the *Flying Squirrel's* operation is a table approximately 4 feet wide and 3 feet in depth as the minimum size. The operation of the *Flying Squirrel* on a table smaller than 4 feet by 3 feet may result in a limited range of motion. Place the robot in the middle of the widest side of the table near the edge where the user is sitting.

2.1.2 Securing Anchors

Place the two anchors on either side of the *Flying Squirrel* onto the table at a distance of at least 2-3 feet from either side. Place the anchor on the rear of the *Flying Squirrel* directly behind the robot's starting position at 2-3 feet away from the robot. For ease of use, placing the forward two anchors close to the corners of the table will allow for approximately equal length of the two cables and ensure a proper minimum cable length.

When using the C-clamps on the anchors, unscrew the clamps to the necessary height of the side of the table and place the anchors against the side of the table and securely tighten the clamp to the table as pictured below in figure 47. Ensure the pulleys on the anchors remain above the table surface during this process. The maximum height of a tabletop that the anchors can fit onto is 1.9 inches. If the tabletop height is greater than 1.9 inches, or a side of the table is against a wall or otherwise blocked by another object, use the suction cups on the anchors to secure them to the top of the table.

Figure 47: Anchor Using C-Clamp

When using the suction cups on the anchors, ensure the lever on the top of the anchor is flipped to the upward position. Following this step, remove the plastic cover sheets from the bottom of each anchor. Firmly attach each suction cup onto the table's surface to ensure the adhesive securely holds to the surface. The result should look like the anchor pictured in figure 48 below. Once attached, flip the levers on the top of the anchors downward to engage the suction cup as shown in figure 49.

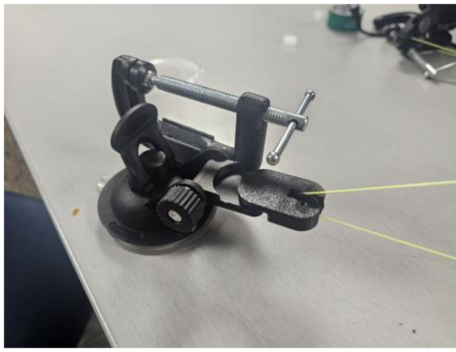
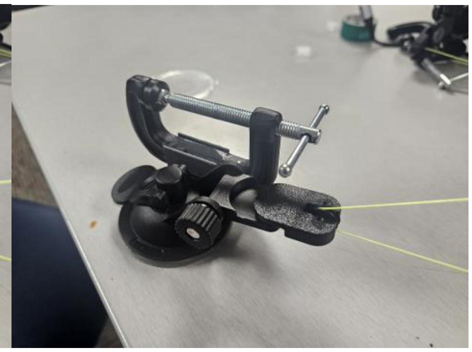
 

Figure 48: Anchor, Suction Cup Unlocked Figure 49: Anchor, Suction Cup Locked

Once the anchors have been properly secured to the table, ensure the cables are properly fed through the anchor pulleys. Also ensure the bar on the end of the C-clamp screws are out of the way of the cables and pulley assembly, so it will not interfere with the robot's operation.

2.1.3 Powering on the Robot

After setting up the *Flying Squirrel* for use, plug the LiPo connector on the battery wires into the LiPo connector on the wires found coming from the rear of the *Flying Squirrel*. These LiPo connectors are included in Figure 50. The screen should turn on shortly after this step, which indicates the robot is powered on and ready to be used.

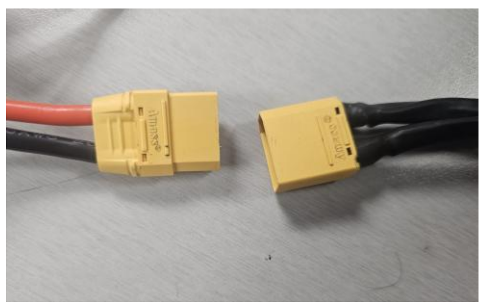


Figure 50: LiPo Connectors for the Battery Wires (Pictured Left) and Power Wires (Pictured Right)

2.2 Operation of Robot

2.2.1 Preparing Operation

Before running the exercise program within the *Flying Squirrel*, ensure that the user has supervision by the physical therapist overseeing the user's recovery, the user's caretaker, or another individual who is knowledgeable on the operation of the *Flying Squirrel* during the duration of the program. This ensures that any injury to the user or damage to the robot can be prevented in case of an emergency or error.

If the movement program for the *Flying Squirrel* is finalized, then the user interface should be brought up on the screen. The user interface is a simple black screen with "Ready" at the top of the screen and a green button underneath it labeled "Start Program."

If the user interface is not brought up once the system is powered, then the user interface needs to be started using the terminal on the screen. In the top left of the screen, select the small black icon, pictured below, that will pull up the terminal. In the terminal, type "python3 touchscreen_control.py @" to initiate the interface program.

Figure 51: Command Window Icon

Pressing the "Start Program" button will initiate the movement program for the *Flying Squirrel*. The screen will change to display the text "Running Program..." and the button will turn red and will be labeled with "End Program." This secondary screen signifies that the program is running, and the "Stop Program" button can shut down the program immediately if pressed by either the user or the individual supervising the use of the *Flying Squirrel.*

2.2.2 Preparing User

When the user is ready to use the *Flying Squirrel*, help guide the hand of their affected arm through the wrist strap. Tighten the strap to be snug against the wrist but ensure it's not too tight on the user. Once the user grasps onto the handle, the user or supervisor can press the "Start Program" button to begin the program.

Instruct the user to push against the direction of movement as the program runs. The robot will compensate for the push and will continue moving until the exercise is complete. This force is what will help the user rebuild their strength.

2.2.3 Alternate Program

If the exercise program in the *Flying Squirrel* is not ready to use, then a simplified motion program will run in its place. Ensure which program is being used before operation. This can be completed by first pulling out the cables to prevent any damage to the motors, followed by powering up the *Flying Squirrel* before finishing the setup procedures. If the motors begin running as soon as the robot powers on, then the secondary program is in use. If the secondary program is in use, follow the procedures below to set up the robot.

Attach the anchors to the table the same was as outlined in section 2.1.2. Next, prepare the user for the operation of the *Flying Squirrel* as outlined in section 2.2.2. Once those steps are complete and the user is ready to begin, plug the wires on the back of the robot into the battery's LiPo connector, and once the robot is powered, the movement program will begin.

2.3 Stowing Procedure

2.3.1 Powering Down

Once the *Flying Squirrel* has completed its exercise/movement program, power off the robot by disconnecting the LiPo connectors (yellow plugs on the wires) for the battery and the wires on the back of the robot. Once powered off, if the top of the robot is not fully lowered, manually spin the lead screw counterclockwise to lower the top section completely.

2.3.2 Removing Anchors

If the anchors were secured using the suction cups, flip the lever on the top of the suction cups upwards. Once the suction cups are disengaged, use the tab on the suction cups to peel them off the table. Replace the plastic cover sheet and stow the anchors into the open space in the middle of the robot. If the anchors were mounted using the C-clamps, loosen the clamps and remove from the table's edge and stow in the open section of the robot by the handle.

2.3.3 Storage

After stowing the anchors, remove the *Flying Squirrel* from the table by carefully lifting the robot from underneath the base and placing it back into its box or in its storage location. Store in a dry, temperature-controlled area and ensure that it is stored on a stable surface to prevent the robot from being damaged.

3 MAINTENANCE INSTRUCTIONS

3.1 Battery

On a full charge and on a healthy battery, battery life should last up to four and a half hours. To preserve the life of the battery, it is recommended that the battery charge never falls below 20% of full capacitance and remains between 40-60% to maximize the overall life of the battery.

3.2 Pulleys

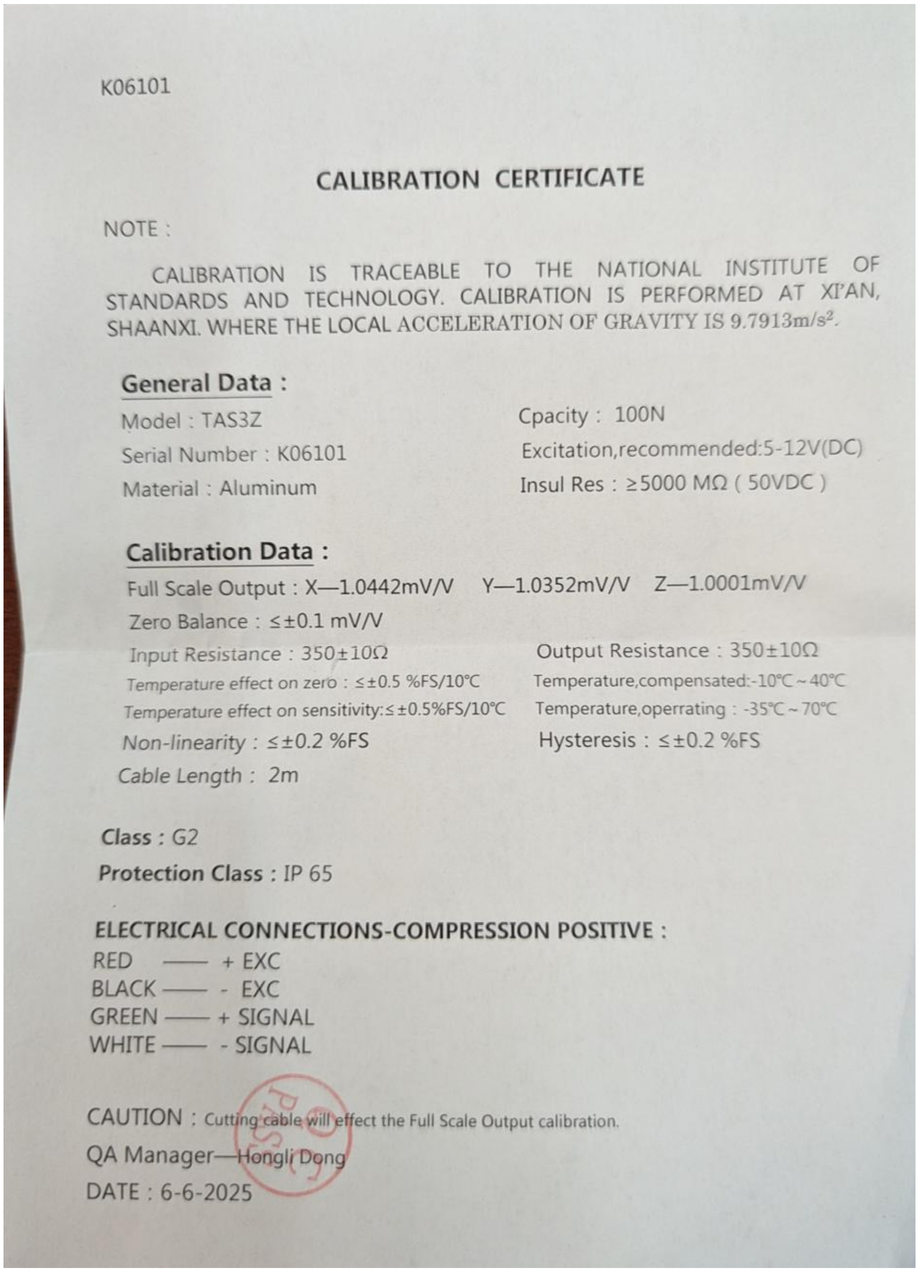
The pulleys at this moment are the most likely component to fail. One way the pulley can fail is that the string can jump over the pulley if the acceleration of a pulley releasing wire is not proportional to the speed of a pulley pulling the robot. Another way the pulley can fail is that the force acting upon it can cause catastrophic failure in the pulley. The two ways this manual would recommend you work around this would be either, A using the CAD files provide with this manual to reprint the broken pulley or B manufacture the pulley using a stronger material than PLA.

3.3 Anchors

When not in use, the suction cup part of the anchors should have its plastic film attached. If the bottom of the suction cup becomes dirty, wipe it down with a wet cloth and leave it to dry before setting it again. When put under enough force, it is possible that the c-clamp attachment of the anchor could be detached. It is recommended that you reapply a suitable adhesive to reattach the two parts.

3.4 Force Transducer

The force transducer/load cell should be recalibrated every 12 months. At the writing of this manual, the last time the load cell was calibrated was November 5^{th}, 2025. To begin the calibration process, see the manufacturer's data sheet and instructions. The calibration sheet is shown in figure 52.



K06101

CALIBRATION CERTIFICATE

NOTE :

CALIBRATION IS TRACEABLE TO THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY. CALIBRATION IS PERFORMED AT XI'AN, SHAANXI. WHERE THE LOCAL ACCELERATION OF GRAVITY IS 9.7913m/s².

General Data :

Model : TAS3Z
Serial Number : K06101
Material : Aluminum
Cpacity : 100N
Excitation,recommended:5-12V(DC)
Insul Res : ≥5000 MΩ (50VDC)

Calibration Data :

Full Scale Output : X—1.0442mV/V Y—1.0352mV/V Z—1.0001mV/V
Zero Balance : ≤±0.1 mV/V
Input Resistance : 350±10Ω
Output Resistance : 350±10Ω
Temperature effect on zero : ≤±0.5 %FS/10℃
Temperature,compensated:-10℃ ~ 40℃
Temperature effect on sensitivity:≤±0.5%FS/10℃
Temperature,operrating : -35℃ ~ 70℃
Non-linearity : ≤±0.2 %FS
Hysteresis : ≤±0.2 %FS
Cable Length : 2m

Class : G2
Protection Class : IP 65

ELECTRICAL CONNECTIONS-COMPRESSION POSITIVE :

RED —— + EXC
BLACK —— - EXC
GREEN —— + SIGNAL
WHITE —— - SIGNAL

CAUTION : Cutting cable will effect the Full Scale Output calibration.
QA Manager—Hongli Dong
DATE : 6-6-2025

Figure 52. Load Cell Spec Calibration Sheet

4 TROUBLE SHOOTING

This section discusses common failures that might occur during normal operation of the robot and what to do when these failures do occur.

4.1 Motors/Motor Controller

If a failure occurs in the D5312s motor, ODrive S1 Motor Controller, or the 16384 CPR Absolute RS485 Encoder then the solid blue light on the motor controller will change to a flashing red light when the movement program is run indicating that an error has occurred. The motor controller should be removed from the backplate and connected to a computer using a usb-c to either usb-c or usb (depending on what ports the computer has) as well as an opto-isolator to not risk back feeding power from the battery directly into the computer port. Then open the ODrive GUI tool using Microsoft Edge and connect to the motor controller. The error message will be displayed at the bottom of the screen.

The most common failure to occur for the motors is the Odrive S1 Motor Controller running into a spinout error with the 16384 CPR Absolute RS485 Encoder. If this occurs, the robot should be disconnected from power then reconnected. This will usually result in the error being remedied. If running the code again results in a solid blue light instead of flashing green or red, this means that the encoder needs to be calibrated again. In the GUI tool, ensure all the settings in the “Power Source” through “Interfaces” pages are correct, then follow the steps in the “Apply and Calibrate” page. If the problem still persists after recalibrating the encoder, then either the cable to the encoder or the encoder is not functioning correctly. Unplug the encoder in question and move it to another motor and run the calibration process again. If the calibration process is a success, then the cable to the encoder is non-functional and needs to be replaced. If the calibration process is not successful, then the encoder is nonfunctional and needs to be replaced.

If the robot runs into an overvoltage error, then too many volts were sent through the motor controller causing it to trip to not damage any of the components, or the DC bus overvoltage trip level is set too low in the GUI and needs to be raised.

4.2 Wiring

While uncommon after assembly, wiring issues can arise from regular use of the robot. Ensure that all connectors are fully connected by unplugging the connector and plugging it back in. If this does not fix the problem, then using a voltmeter check the continuity of the wire by placing one of the leads on the plug end and one at the base where it connects to ensure there is not a break in the wire.

4.3 Coding

If the Arduino IDE is no longer compiling code after it has already been tested to ensure the code works, then copy and paste the code into a new sketch and compile it from there. If the Raspberry Pi is not turning on or failing to run codes, turn it off then turn it back on. If those same issues keep occurring, then there is an error in the microSD card, and it needs to be repaired. With the Raspberry Pi off, remove the microSD card and insert it into a computer running Windows. Repair the drive then reinsert it into the Raspberry Pi.

4.4 Other

If excessive chattering is occurring in the lift screw, then it is not centered in the coupler. Remove the top section and the plate covering the motors. Loosen the four retaining screws holding the lift screw in and using a level tighten two screws at a time making sure they oppose each other on the coupler i.e. the screw facing you and the one directly behind it to not force the screw off level from tightening one side too much.

If one of the pulleys begins to move in the wrong direction, the wire unspooled incorrectly causing it to wrap around the pulley in the opposite direction. Disconnect the robot from power then continually unspool the pulley until you feel it correct itself then respool the pulley.