ANNIN ROBOTICS

AR4 Robot Manual

Version 1.6

FREE DESIGN 6 AXIS ROBOT

Contents:

Electrical Safety

- ELECTRIC SHOCK HAZARD. The construction of this control enclosure poses potential exposure to alternating current and direct current which has the potential to cause injury or death. This equipment should be constructed and serviced by trained or qualified persons.
- Keep the area around the device clear and free from dust before, during, and after installation.
- Wear safety glasses if you are working under any conditions that could be hazardous to your eyes.
- Do not perform any actions that create a potential hazard to people or make the equipment unsafe.
- Never install or manipulate wiring during electrical storms.
- Never install electrical jacks in wet locations unless the jacks are specifically designed for wet environments.
- Operate the device only when it is properly grounded.
- Ensure that the separate protective earthing terminal provided on this device is permanently connected to earth.
- Replace fuses only with fuses of the same type and rating.
- Do not open or remove chassis covers or sheet-metal parts unless instructions are provided in the hardware documentation for this device. Such an action could cause severe electrical shock.
- Do not push or force any objects through any opening in the chassis frame. Such an action could result in electrical shock or fire.
- Avoid spilling liquid onto the chassis or onto any device component. Such an action could cause electrical shock or damage the device.
- Avoid touching uninsulated electrical wires or terminals that have not been disconnected from their power source. Such an action could cause electrical shock.
- Always ensure that all modules, power supplies, and cover panels are fully inserted and that the installation screws are fully tightened.

OVERVIEW

About building this robot:

The AR4 is an open design 6 axis robot that anyone can build. All software, print files and manuals are available for download on the Annin Robotics website downloads page. All the components you need to build this robot are outlined in Chapter 1. The assembly of the robot arm is outlined in Chapter 2. The assembly of the electrical enclosure is outlined in Chapter 3..

Components Needed to Build this Robot:

The following is an overview of the 5 component groups needed:

- **3D covers and spacers** (you must print these yourself) see chapter one "spacers and covers" section.

- **Structural components** - You can print these yourself to build a 3D printed robot or you can purchase an aluminum parts kit from the robot kits page to build your robot from aluminum https://www.anninrobotics.com/robot-kits. There are 27 structural components – see chapter one "structural components" section.

- **Hardware components** – this includes the bearings, belts, pulleys, sprockets, chain, shafts, pins, machine screws and set screws. These can be purchased from multiple sources – see chapter one "hardware components" section. If you have difficulty finding these component or wish to buy them all in one place I buy them all in bulk and have made a hardware components kit available on the robot kits page: https://www.anninrobotics.com/robot-kits.

- **Stepper Motors and Drivers** – the 6 motors, drivers and power supply are available directly from Stepperonline, there is a link to this package on the robot kits page: https://www.anninrobotics.com/robot-kits.

- **Electrical components** – The primary electrical components can be purchased on the robot kits page or can be sources separately – all parts are listed in the bill of materials.

- **Misc. components** – The miscellaneous components needed include items such as solder, heat shrink tubing and ethernet cables. You will also need to choose what type of gripper or end effector your robot will need and you will also need to identify what type of enclosure or panel you want to use for installing or mounting the power supply and drivers. All of the miscellaneous components are outlined in the Misc. components section of the bill of materials chapter

General Robot Assembly notes:

- Use medium strength thread locker on all screws.
- All belts should be tensioned using moderate tension (do not over tighten or stress belts or components).

Tools Needed:

- General hand tools including metric hex key set, locking pliers, wire cutters, wire strippers.
- Wire ferrule crimpers and wire ferrules.
- Soldering Iron and flux core silver bearing solder.
- Heat gun or lighter for shrink tubing
- 3D printer and printer filament.
- Various size drill bits for clearing holes in 3D printed components.
- M3, M4, M6 and M8 taps for threading plastic components.
- Epoxy is used for the J6 limit switch tip. Epoxy is also used in some areas of the robot assembly when using 3D printed components.
- A digital level is recommended to assist in fine tuning the robots auto calibration.
- A general angle gauge is used to set the position of Joint #5.
- An oscillating multi tool is used to cut panel access panels when wiring the electrical enclosure.
- Stepped drill bit is used to create panel access holes when wiring the electrical enclosure.

Bearing Fit:

The CAD models for the AR4 robot are sized for a slight press fit on all bearing and race diameters. The assembly steps in this manual also reference pressing the bearings and races in place. I have tried to make sure the aluminum kits offered are closer to a slip or light press fit. If bearings get improperly wedged or tilted and then attempt to press, severe damage can occur – use a quality bearing or arbor press and be very careful that bearing races are pressed or inserted square and true to the housing body. If the tolerance stack up on your components results in a race that is slightly loose, please use bearing retaining compound to alleviate any movement. If the tolerance stack up of your components result in a shaft that is slight too tight shafts can be carefully polished until a slip fit is achieved - bearings can also be warmed up with a hair dryer or placed on a mug warmer to slightly increase size and make insertion onto aluminum shafts a little easier.

The bearing oil that comes on bearings should be sufficient lubrication given the low speed and pressure of the robot joints. If additional lubrication is desired, a small about of standard bearing grease is recommended.

3D Printing Your Robot:

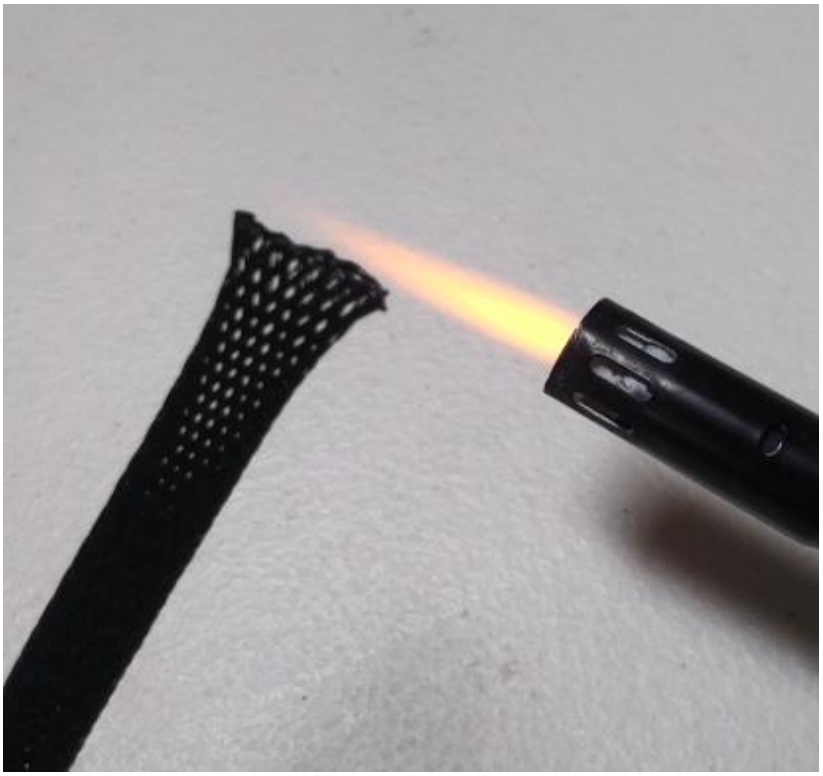
This manual shows the construction of the robot using aluminum for the main structural components but the robot can also be constructed using all 3D printed components. The .stl print files for all components are here: **https://www.anninrobotics.com/downloads** The construction illustrated in this manual is the same using either aluminum or 3D printed components - note the following details if using 3D printed components:

- 3D printed components require all threaded holes to be cleared with appropriate drill size and then tapped.
- All printed structural components were printed at minimum 50% infill with the exception of the J2 and J3 drive spindles and tension rings which were printed at 90%+ solid. Parts were printed at 2mm layer height and 5 layer thick shells.
- All printed covers and spacers were printed at 20% infill at .2mm layer height and 5 layer thick shells.
- The robots I have 3D printed were made using ABS at 220° nozzle temperature. I have not personally tried using other materials but I have received feedback from numerous people who have used PLA, PETG and carbon fiber reinforced filaments without issues.
- The J1 baseplate, J1 baseplate spacer and J2 arm larger than most 3D printer beds and therefore are printed in 2 pieces and require being epoxied together.
- The J1 spindle is printed in 2 pieces and requires the center alignment plug be epoxied into the end of the spindle – this is the center hub that centers the 60T timing pulley.
- The printed design calls for additional reinforcements to be epoxide in place around the J1 base and at the base of the J2 arm (see details at the end of this manual)
- The J4 tube cannot be 3D printed; if building a fully 3D printed robot you will need to cut and drill aluminum tubing as shown in structural components BOM section of chapter 1.
- 2 spools of filament are needed for printing the primary structural components. A 3rd spool is needed if you wish to print your covers and spacers in a different color.

7th AXIS

Please note there are several steps that refer to an optional 7th axis travel track. The robot itself only requires 6 drivers and 6 motor plugs/cables. If you would like to build your enclosure to accommodate a 7th axis you can add a 7th driver as well as a 7th plug and cable but it is optional.

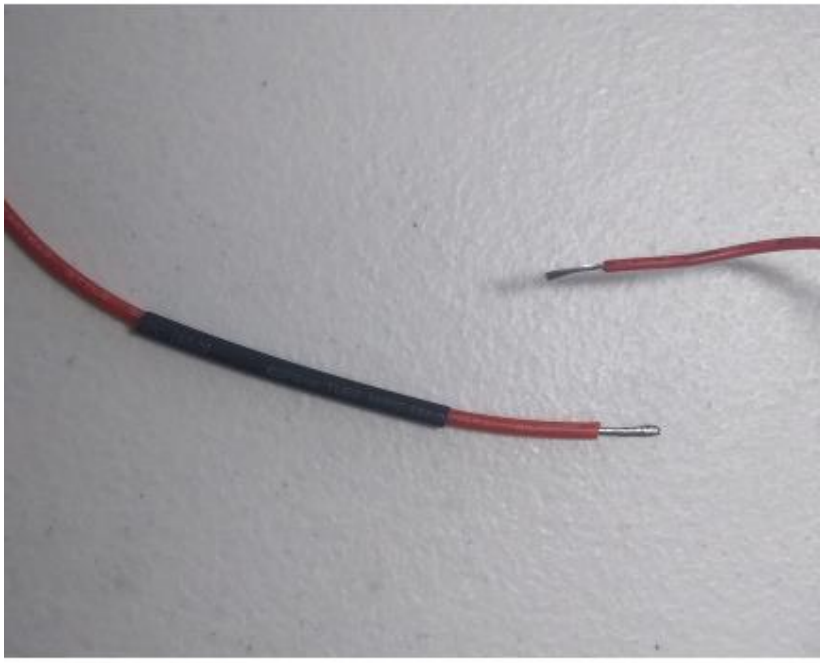
Using Braided Sleeve



Several Steps in this manual will call for braided sleeve to be placed over electrical wires. Make sure that as soon as you cut any braided sleeve you use a lighter or flame to carefully melt the ends of the sleeve as shown.

If you do not melt the ends the sleeve will un-braid and not hold the wires together.

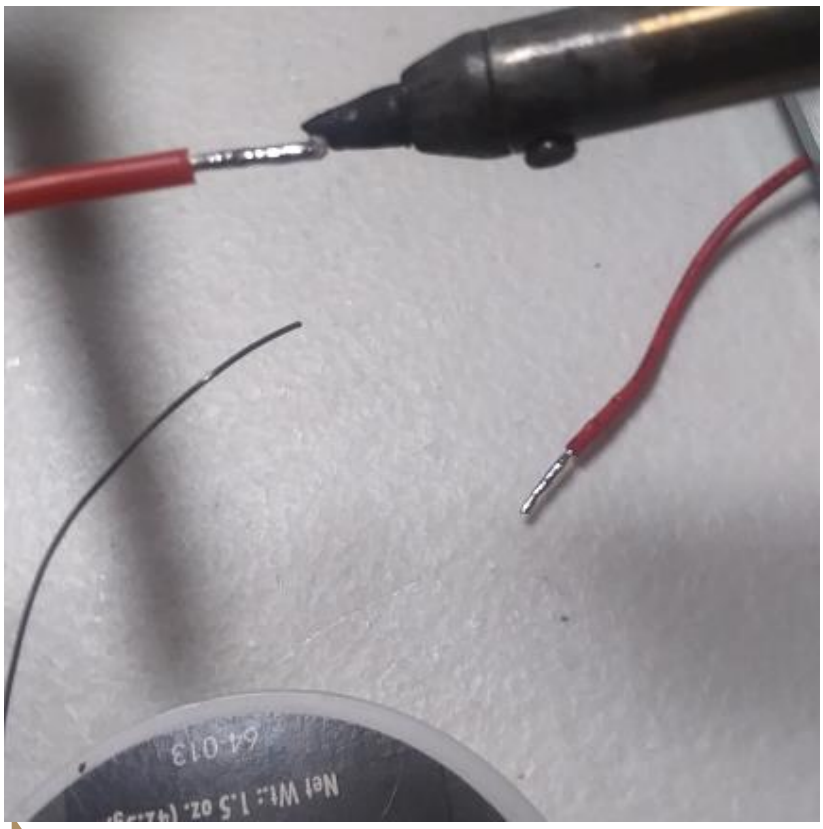
Soldering Wire Connections



Several steps in this manual will call for soldering and heat shrinking wire connections together.

Strip wire ends of both wires and twist wire strands.

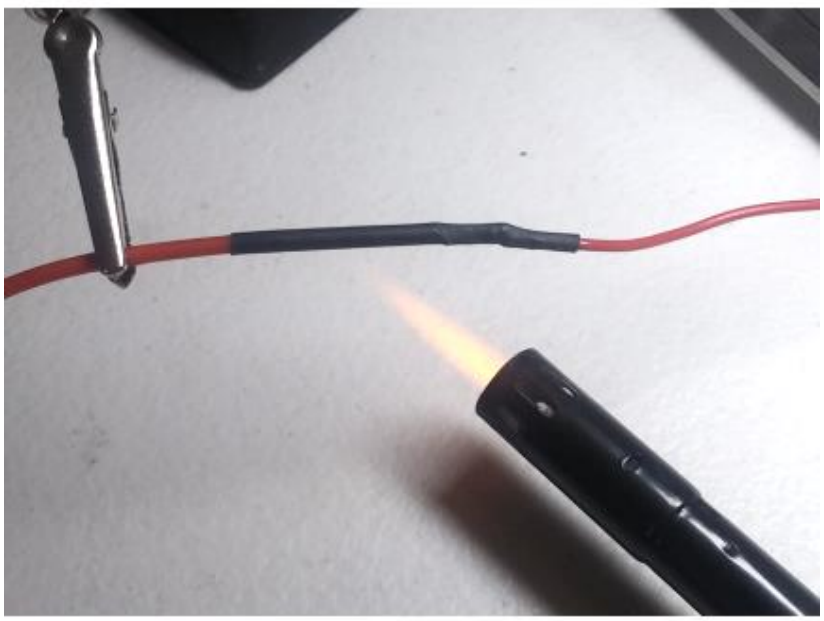
Insert length of heat shrink tube over one of the wire ends.



Use soldering iron and rosin core electrical solder to pre apply solder to the ends of each wire.

This is also known as “tinning” the wire end.

Use soldering iron to melt solder on both wire ends so that wire ends are overlapping and solder forms a complete bond between the two wire ends.

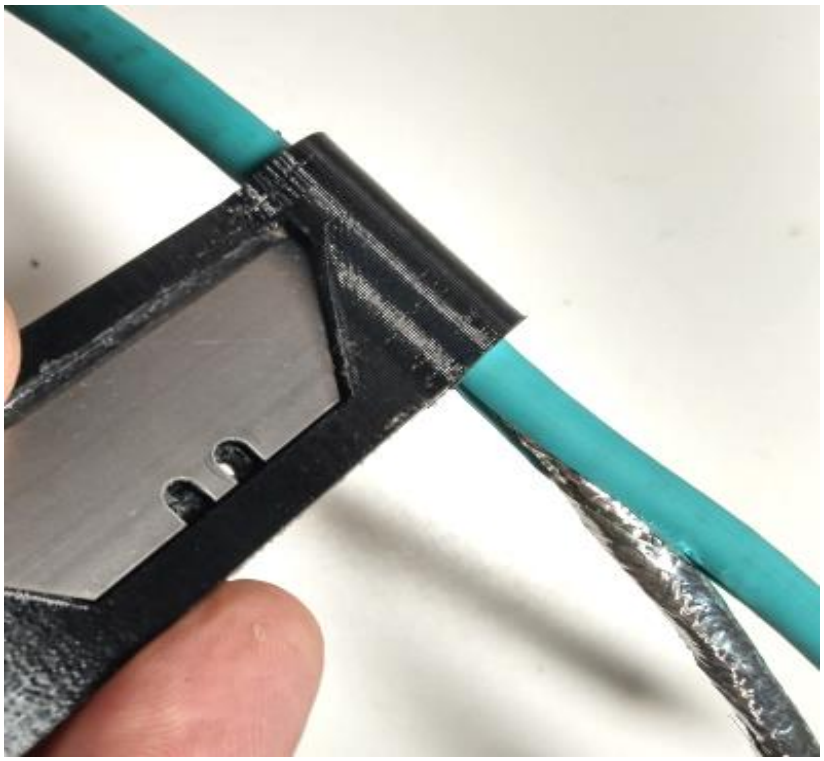


Slide the heat shrink tube over the solder joint and then use a lighter flame to shrink the tubing over the joint.

Gently sweep the flame back and forth over the heat shrink tubing taking care not to apply too much heat.

Do not use open flame around any combustible materials and be careful not to inadvertently melt any of your plastic components or braided sleeve.

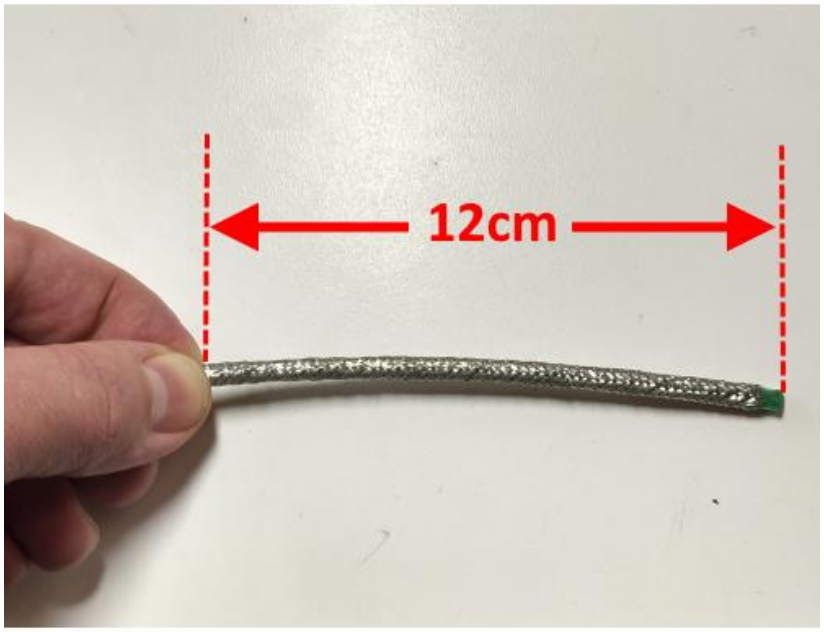
Removing jacket and shielding from continuous flex Cat6 cable



Install razor blade into 3D printed CF Cat6 Jacket Stripper and then feed cable through the round passage in tool.

The jacket will be split as it passes through and you can then peel off the jacket.

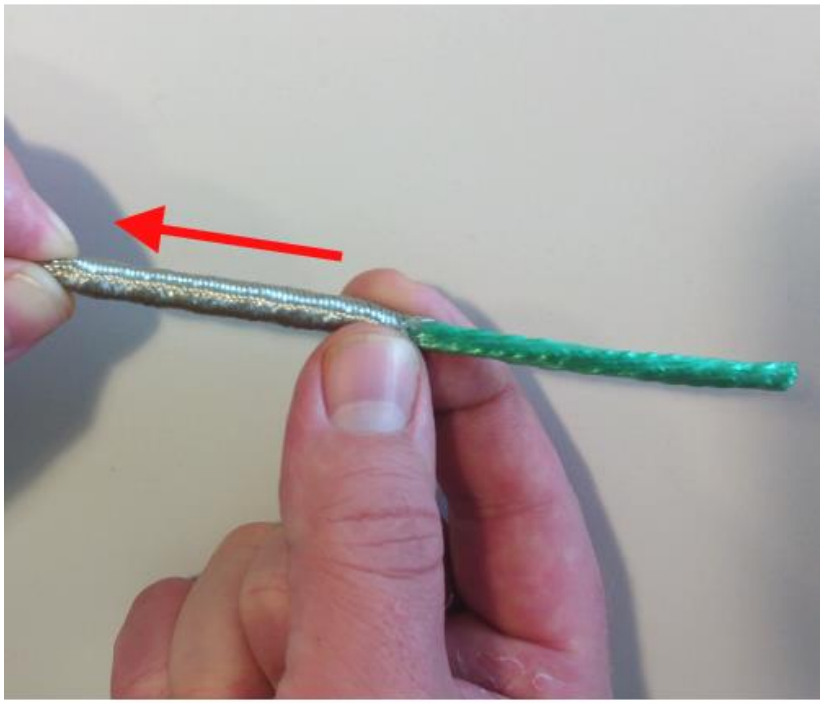
Remove foil wrap from around cable shielding.



Several steps in the manual will call for removing a length of shielding from the end of Cat6 cable.

In this example I will remove 12cm of shielding.

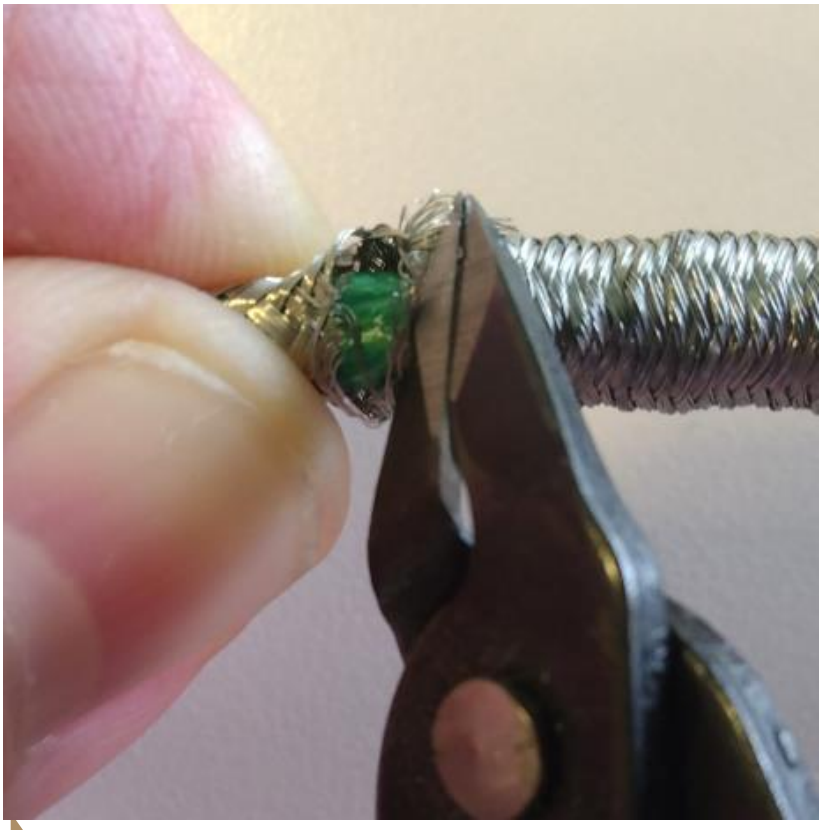
In one hand pinch the cable at the position you want to remove the shielding from.



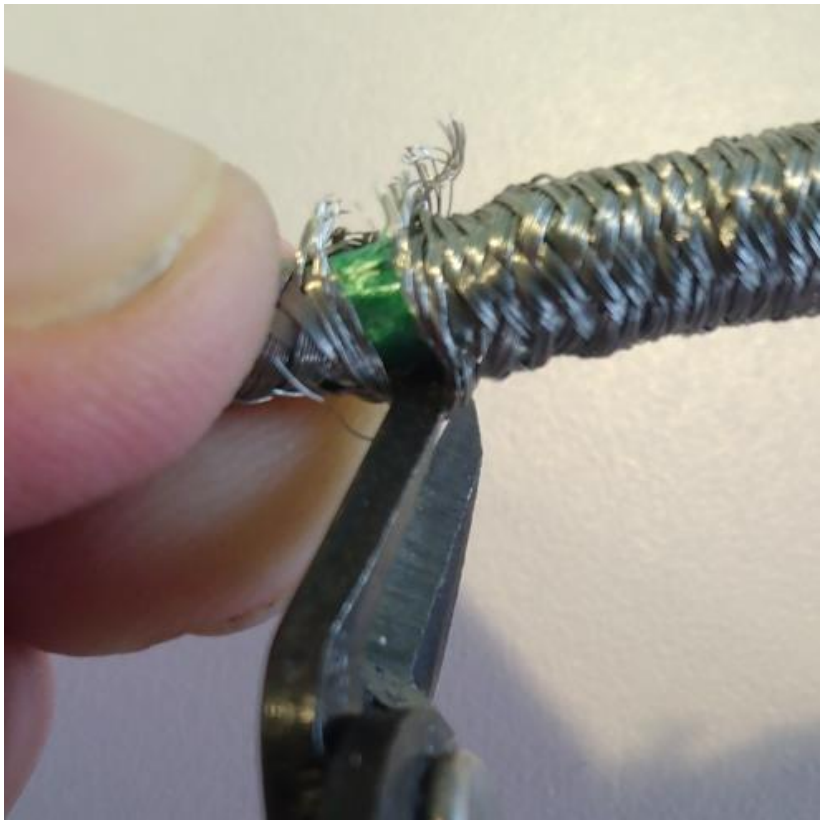
Keep the cable pinched at the 12cm point and then push or bunch up the shielding to be removed toward the pinch point.

At the 12cm pinch point use a pair of sharp point cutters to get under the bunched up shielding.

CAUTION: be extremely careful to only get cutter blade under the shielding, it is very easy to accidentally snag and cut one of the wires.

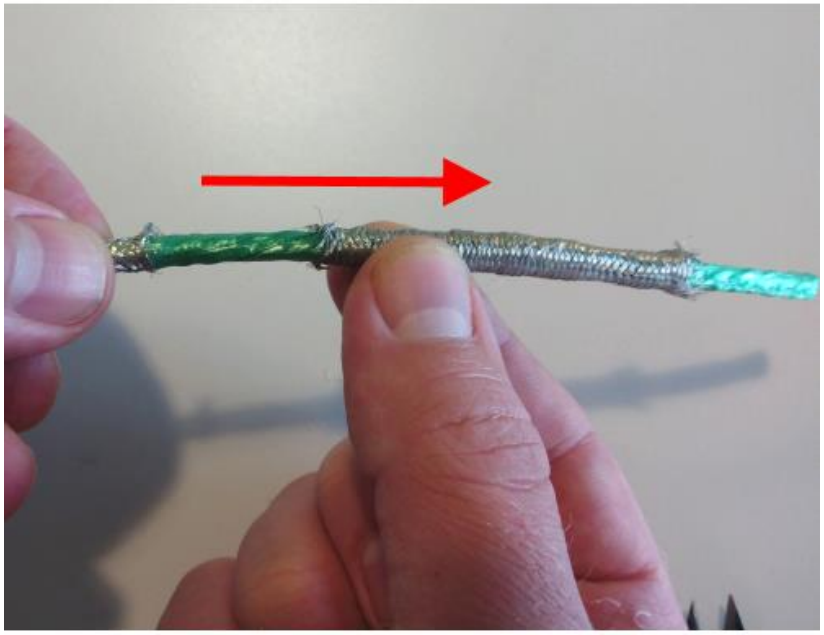


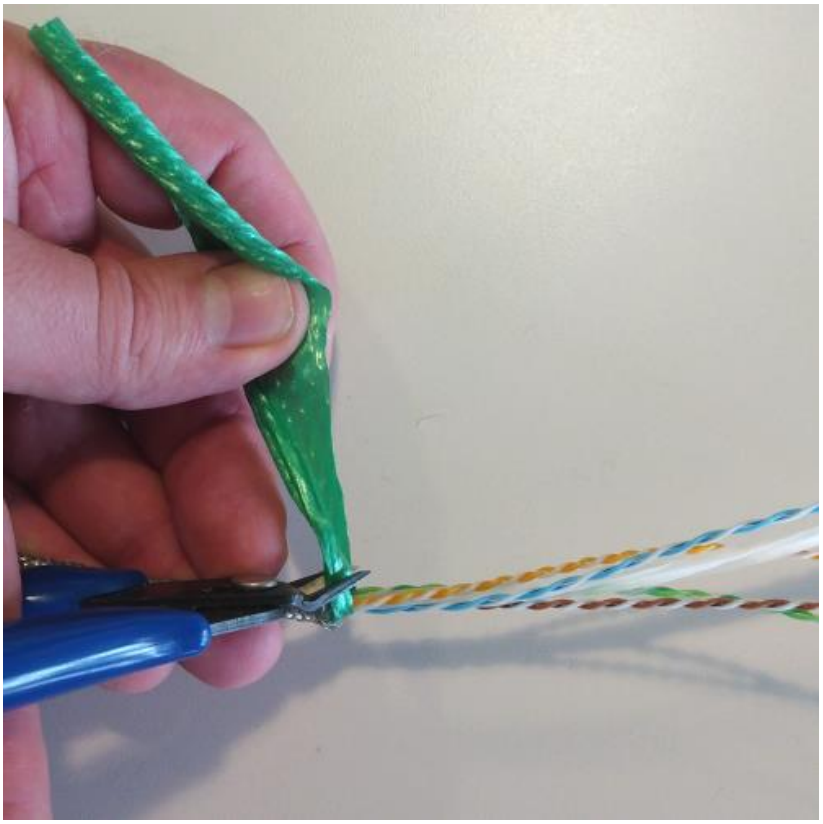
Carefully cut a portion of the shielding as shown. Be very careful to only cut shielding.



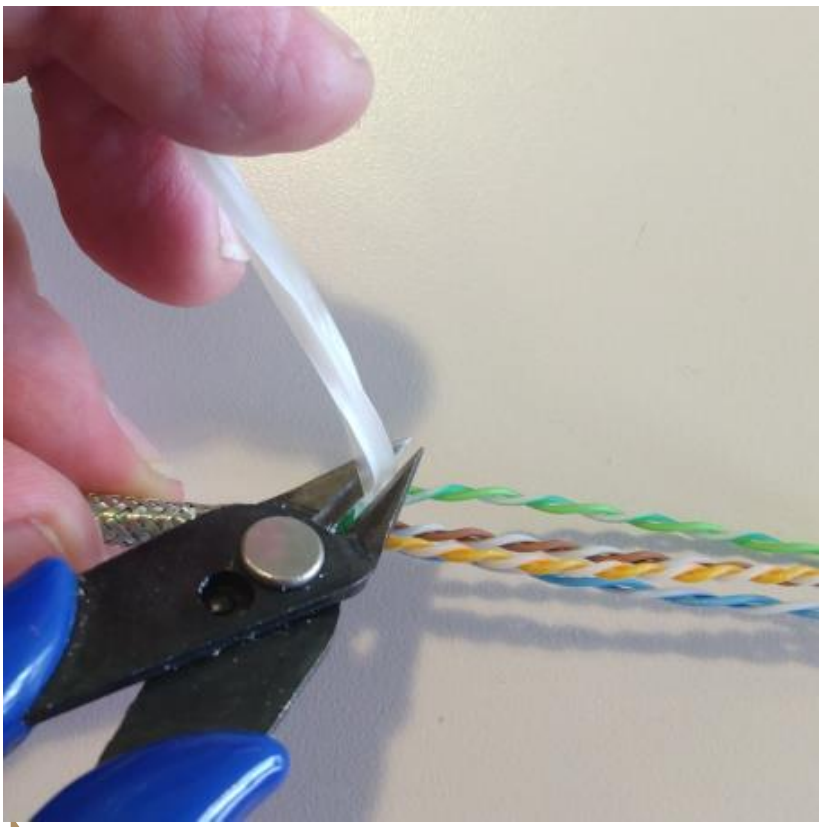
Carefully cut remaining shielding around perimeter of cable.

Remove shielding as shown.





Remove and cut green wrap as shown.



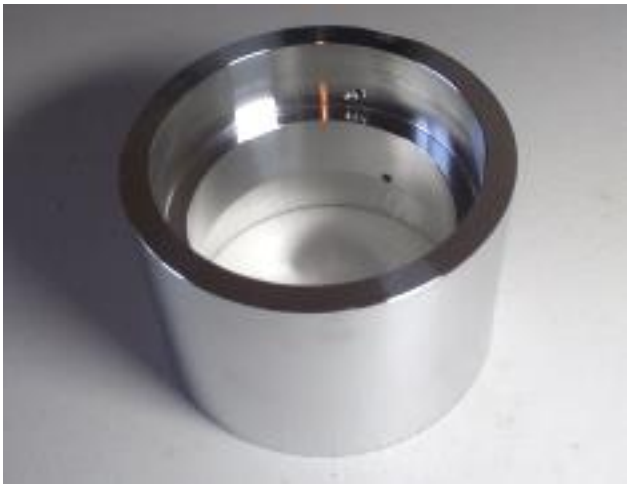
Separate plastic center core and carefully cut and remove.

CHAPTER 1
BILL OF MATERIALS

- **STRUCTRUAL COMPONENTS KIT**
  - These components are part of the AR4 build kit at https://www.anninrobotics.com/robot-kits
- **HARDWARE COMPONENTS KIT**
  - These components are part of the AR4 build kit at https://www.anninrobotics.com/robot-kits
- **ELECTRICAL COMPONENTS KIT**
  - These components are part of the AR4 build kit at https://www.anninrobotics.com/robot-kits
- **MOTORS AND DRIVERS PACKAGE FROM STEPPERONLINE**
  - These parts are available factory direct from Stepperonline as a discount package. There is a link to this package on the robot kits page.
- **3D PRINTED COMPONENTS**
  - These parts you need to print on your 3D printer (please see the overview section on 3D printed parts).
- **MISC. COMPONENTS**
  - These are the miscellaneous components you must source yourself; this includes choosing what type of enclosure fits your needs, what type of robot gripper you would like and minor components such as solder and heat shrink tube.

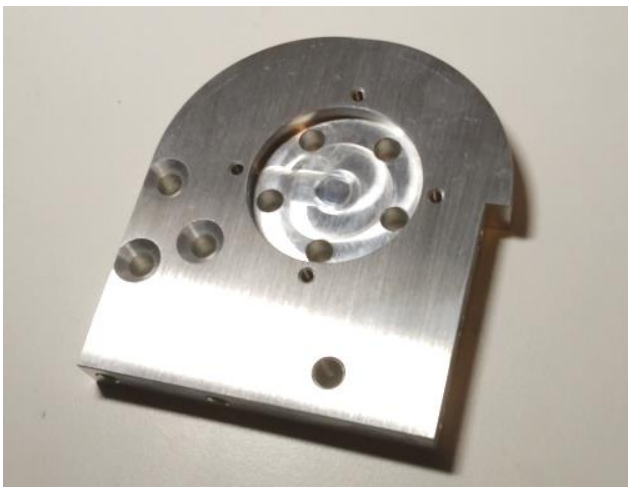
Structural Components

J1 BASE PLATE



J1 TURRET HOUSING

J1 SPINDLE



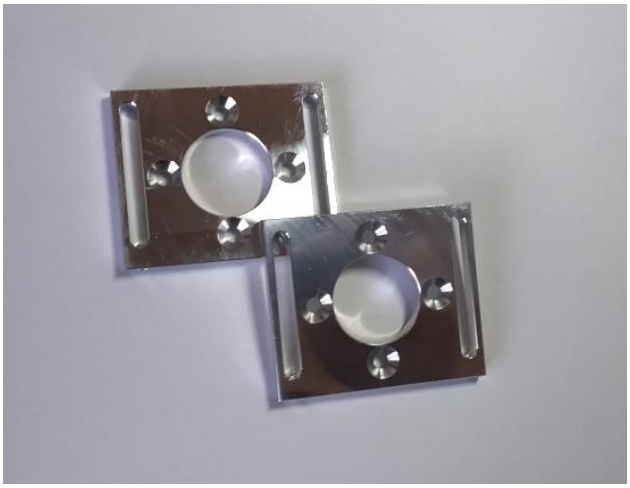
J1 PLATFORM

J2 TURRET HOUSING

J2 ARM

J2 DRIVE SPINDE

J2 TENSION RING



J1 & J3 MOTOR MOUNTS

J2 MOTOR SUPPORT

J3 BEARING CUP

J3 SPINDLE

J3 SPINDLE RETAINER

J4 TURRET HOUSING

J4 MAIN SHAFT

(see note below on making your own J4 main shaft if you are not using aluminum parts kit and are 3D printing your robot)

J5 MOTOR MOUNT

J4 MOTOR MOUNT

J5 BELT CARRIER & J5 BELT CARRIER CLAMP

J5 HOUSING

J5 BEARING POST

J5 IDLER TENSION BLOCK

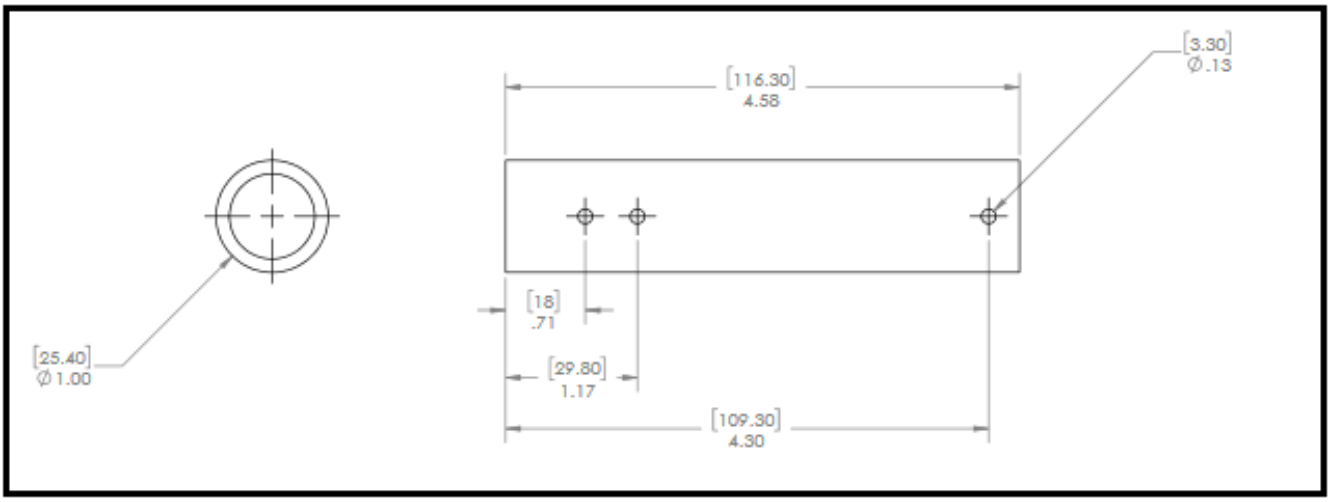
J6 MAIN BEARING ARM

J6 HOUSING

J6 BEARING CAP

J6 GRIPPER MOUNT

- Note on **J4 Main Shaft**: If you are building a 3D printed robot and do not have aluminum parts you will need to purchase a length of aluminum tubing, cut and drill as shown in this drawing. 1" OD .035" wall thickness tubing is available from McMaster Carr #1968T17 or can be sourced from other online metal supply retailers.



- Qty.(1) 1" OD aluminum tube (you need a length that is 116.3mm long) - *Sourced from McMaster Carr*
- You will need to purchase this part only if building a fully 3D printed robot – the aluminum parts kit comes with this tube

Hardware Components

Qty. (2) 32009 (45x75x20mm) taper roller bearing.

Qty. (2) 30206 (30x62x17.25mm) taper roller bearing.

Qty. (1) 30204 (20x47x15.25mm) taper roller bearing.

Qty. (1) AXK3552/AS3552 (35x52x4mm) thrust bearing with washers.

Qty.(3) NTA1625 (1.00x1.5625x0.0781 inch) thrust bearing.

Qty.(4) TRA1625 (1.000x1.5625x0.0312 inch) thrust washers.

Qty.(2) TRD1625 (1.000x1.5625x0.125 inch) thrust washers.

Qty.(2) B1616 (1x1-1/4x1 inch) needle roller bearing.

Qty. (1) HK1612 (16x22x12mm) needle roller bearing.

Qty.(2) 3mm x 85mm shaft.

(If sourcing the parts yourself these are typically sold in lengths of 100mm so you would need to cut them down to 85mm)

Qty.(4) LM3UU 3mm linear rod bearing.

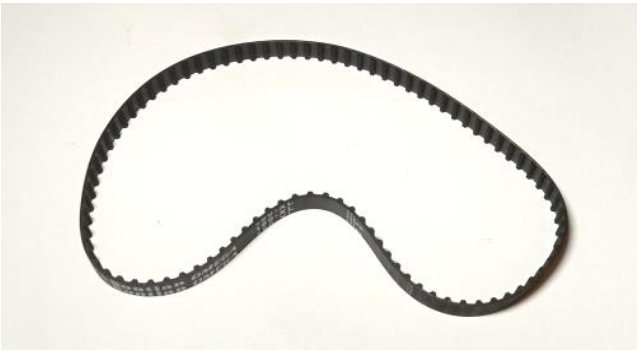
Qty.(1) 688Z (8x16x5mm) groove ball bearing.

Qty.(1) 30203 (17x40x13.25mm) taper roller bearing.

Qty.(1) 60T XL pulley.

(If sourcing your own parts this can be purchased from Amazon or Servo City as a black phenolic material which works fine - there is also a 3D print file for this part)

Qty.(1) 214-L Timing Belt



Qty. (1) 180XL037 belt.

Qty.(1) 150XL037 belt.

Qty.(1) 84XL037 belt.

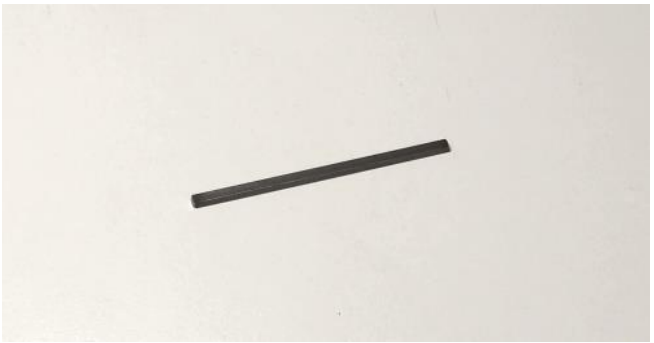
Qty (2) L10 Pulleys (long and short)

Qty.(2) XL 15 tooth 8mm bore.

(*one of them needs a 3mm key broach, the Annin Robotics hardware kit comes with a broached pulley but if you are sourcing your own parts they are not commonly broached for a key shaft*)

Qty.(1) XL 10 tooth 6mm bore pulley

Qty.(1) 8mm keyed rotary shaft (you will need a length that is 50mm long)



Qty.(1) – 2mm x 2mm keystock (you need a length 50mm long)

Machine Screws / Fasteners

#6 x .375 Thread Form Screw	6
M3x10 Flat Head Screw	13
M3x10 Set Screw Screw	4
M3x14 Pan Head Screw	10
M3x14 Socket Head Screw	6
M3x18 Socket Head Screw	4
M3x20 Flat Head Screw	6
M3x20 Pan Head Screw	6
M3x25 Pan Head Screw	24
M3x3 Set Screw	4
M3x4 Set Screw	10
M3x5 Socket Head Screw	1
M3x6 Set Screw	7
M3x8 Socket Head Screw	9
M4 Nuts	4
M4 Washers	12
M4x10 Flat Head Screw	16
M4x10 Set Screw	12
M4x10 Socket Head Screw	16
M4x14 Flat Head Screw	2
M4x14 Socket Head Screw	1
M4x18 Flat Head Screw	3
M4x20 Pan Head Screw	2
M4x20 Socket Head Screw	8
M4x45 Pan Head Screw	4
M4x5 Set Screw	20
M6x14 Socket Head Screw	13
M6x18 Flat Head Screw	9
M6x20 Socket Head Screw	3
M8 x 14 Socket Head	1

J3 DRIVE OPTIONS:

When designing the AR4 I tried to make as many of the components as simple as possible and out of standard thickness plate material where possible. Keeping the J2 arm and J3 motor mount as simple as possible meant the J3 motor shaft would not be exposed very far. I wanted the design to use all low cost off the shelf parts, but I had trouble finding an off the shelf belt / pulley combination that would work with the limited shaft exposure so in the original design I chose to use a 6mm roller chain and sprocket as this would fit the shaft length and handle the needed torque.

More recently I have designed a custom pulley and belt combination for the robot.

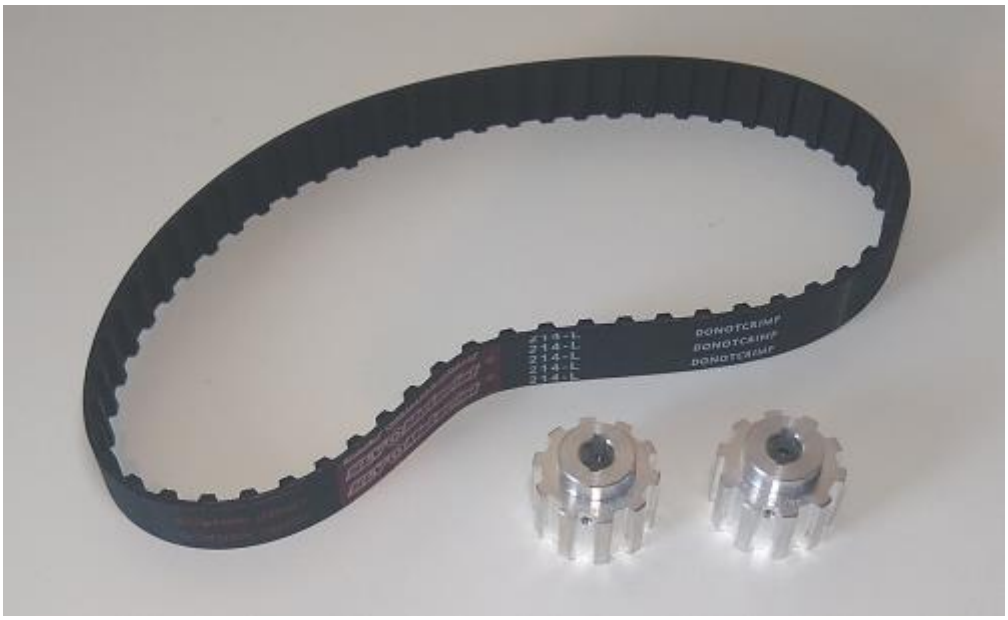
The Annin Robotics hardware kit comes with the newer belt and pulleys, but I wanted to leave the chain and sprocket in the manual as an option for those building their own robot and wanting to use off the shelf components without having to purchase a hardware kit.

The following will show Option 1 using the newer custom pulley and belt, and then It will show option 2 using the off the shelf roller chain and sprocket.

OPTION 1 – BELT AND PULLEY

THIS IS WHAT COMES WITH THE ANNIN ROBOTICS HARDWARE KIT

(L10 pulleys and 214L belt)



- **<u>OPTION 2 – CHAIN & SPROCKET</u>**
- **(YOU WOULD PURCHASE THESE IF YOU DID NOT WANT TO PURCHASE A HARDWARE KIT AND WANTED AN OFF THE SHELF OPTION)**

- (2’ length) 04B 6mm roller chain for J3 – *Sourced from McMaster Carr*

- Qty.(1) 04B link for 6mm chain for J3 – *Sourced from McMaster Carr*

- Qty.(2) 04B 13 tooth 8mm bore 6mm pitch sprocket for J3 chain – *Sourced from McMaster Carr*

Electrical Components

20awg flexible silicone wire in the following colors:

- Black
- Red
- Blue
- Green

3.2 meters of each color.

Continuous flex Cat6 cable 26awg shielded.

(This needs to be stranded flex wire)

6.6 meters

Standard flex Cat6 cable.

(solid core wire is fine)

2 meters

18awg 4 conductor cable.

9.15 meters

NOTE: Wire colors are red, white, black and green

¼” braided sleeve.

3 meters

¾” braided sleeve.

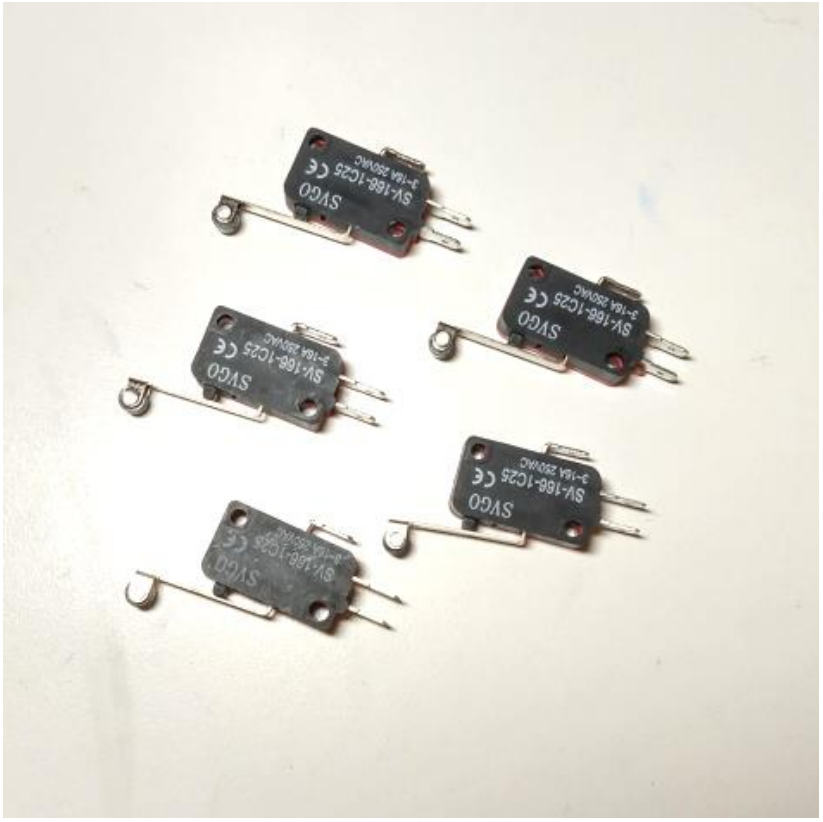
1.65 meters

PG-21 gland nut.

Qty (2)

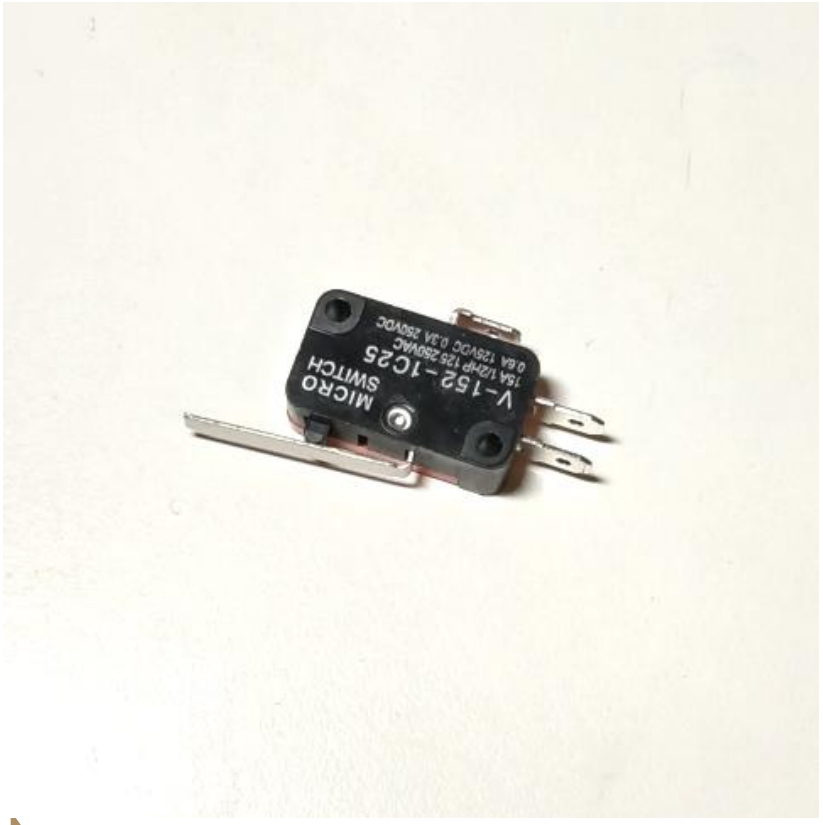
RJ-45 Keystone Jack.

Qty (6)



SV-166-1C25 Limit Switch.

Qty (5)



XV-152-1C25 Limit Switch

Qty (1)

GX16-4 aviation plugs.

Qty (12)

AC Rocker Switch 3 Pin IEC320 C14 Inlet Module Plug Fuse.

Qty (1)

Emergency Stop Switch
Push Button Switch
NO/NC.

Qty (1)

3 Position Double Row
Terminal Block.

Qty (1).

Teensy 4.1 (with pins)

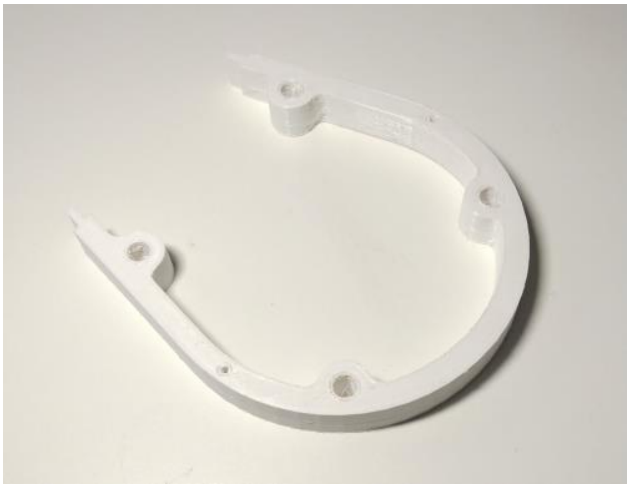
Qty (1)

Terminal Block Breakout Board Module - Teensy 4.1

Qty (1)

3D Printed Components

You will need to 3D print the robots covers and spacers. See downloads page **https://www.anninrobotics.com/downloads** for .stl print files. Covers and spacers can be printed in any color of your choosing – in this robot build I have chosen white covers and blue logos.

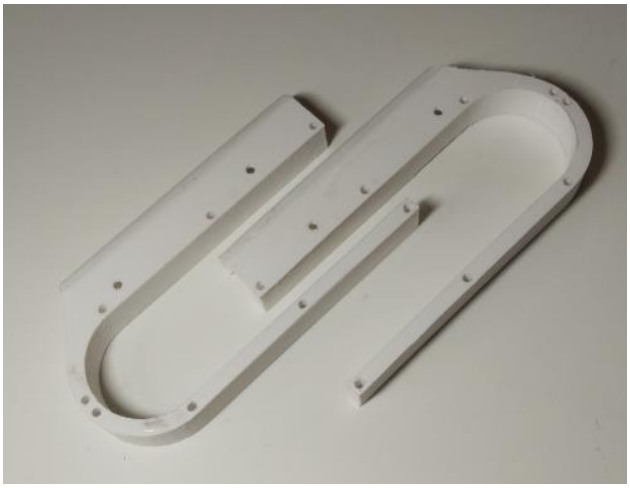


J1 BASE ENCLOSURE PART 1

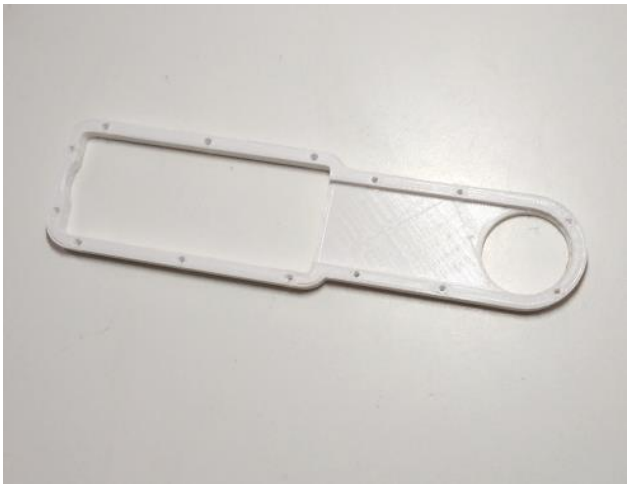
J1 BASE ENCLOSURE PART 2

J1 BASE ENCLOSURE LID

J2 UPPER AND LOWER SIDE COVERS

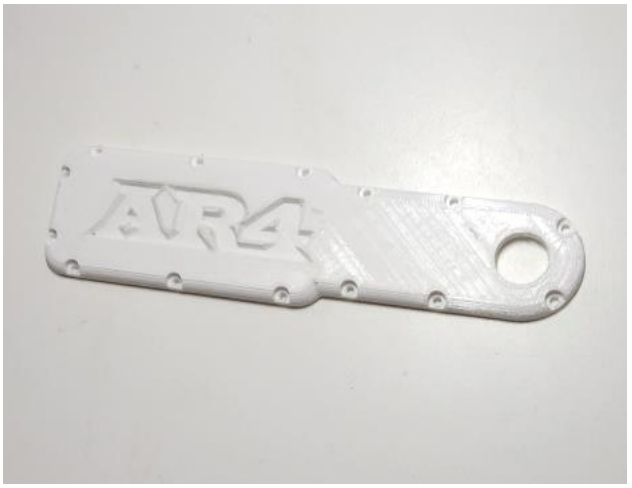


J2 UPPER AND LOWER ARM COVER SPACERS



J5 SIDE PLATE

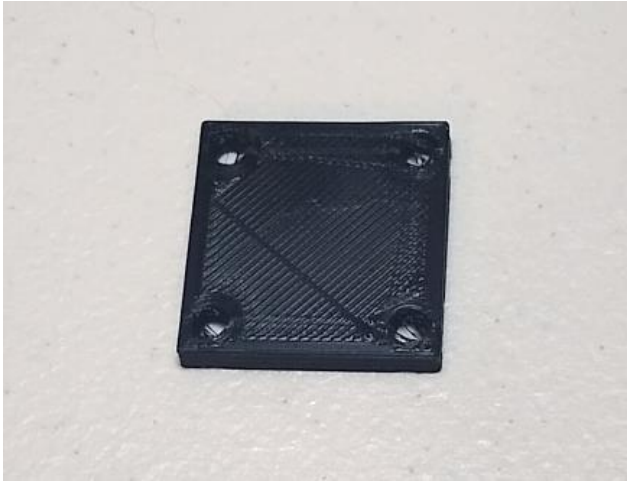
J5 SIDE SPACER



J5 SIDE CAP

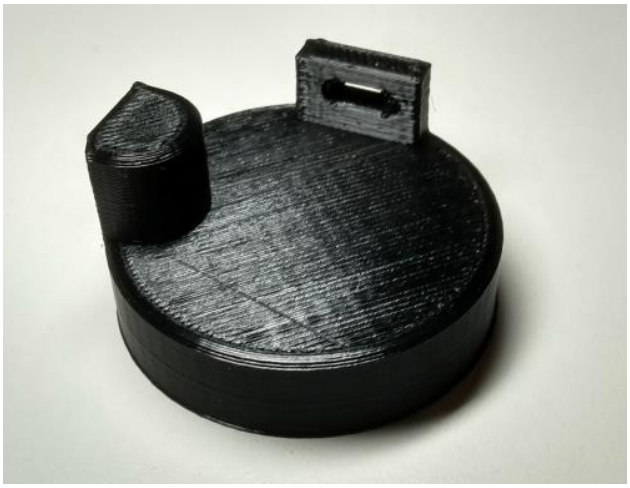
J6 LIMIT SWITCH TIP

J2 & J5 ARM COVER LOGOS

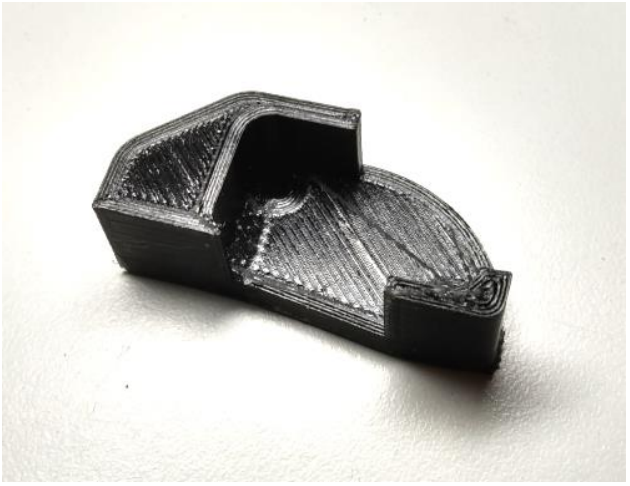


J4 MOTOR SPACER – 4mm

J2 SPACER YGS



J2 Stop



J3 Stop

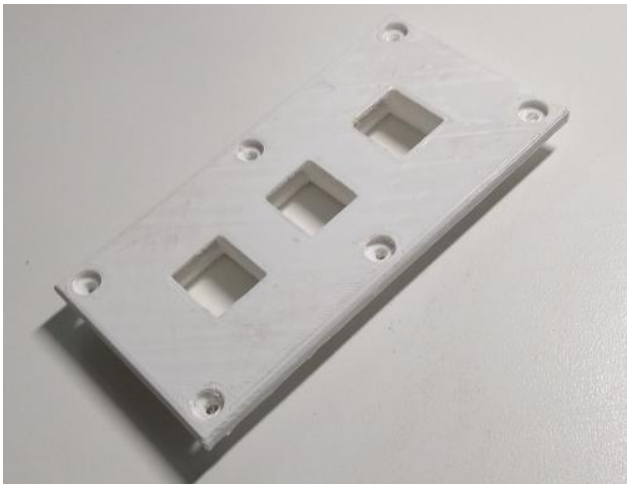
J5 Bearing Post Spacer

J5 Timing Hub

CF Cat6 Jacket Stripper

This is a tool you can print to assist in removing the outer jacket of the continuous flex Cat6 cable.

J5 Motor bracket



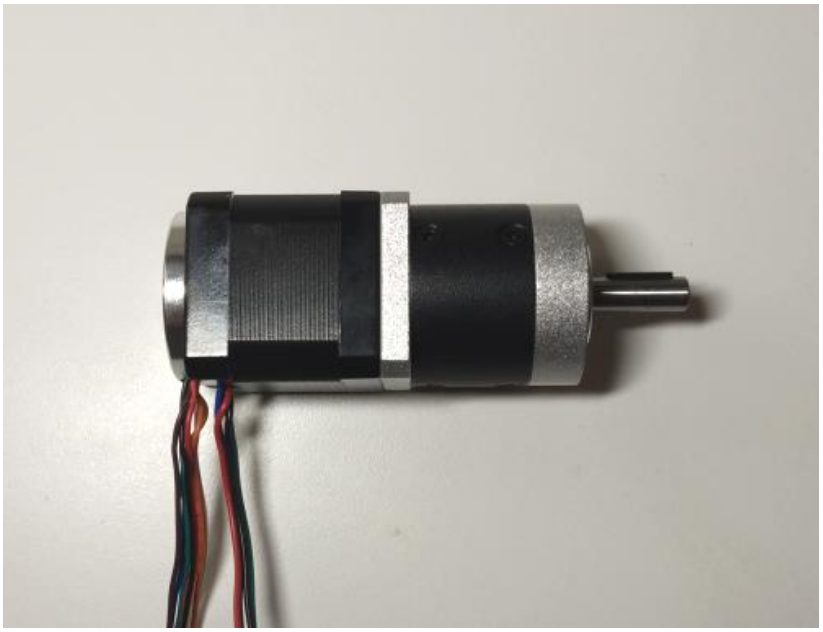
PANEL FACE KEYSTONE SOCKETS

PANEL FACE - GX16 PLUGS

Stepper Motors & Drivers

All motors are available from Stepperonline. There is a link on the robot kits page to a complete discounted motor, driver and power supply kit from Stepperonline.

https://www.omc-stepperonline.com/



J1 gear head motor

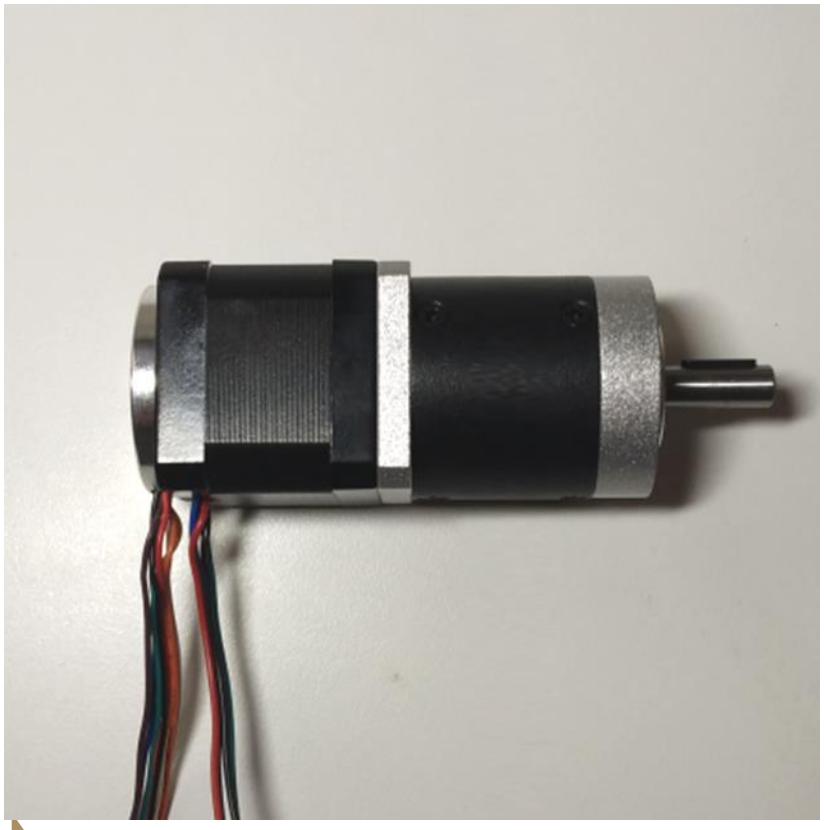
SKU: 17HS15-1684D-HG10-AR4

J2 motor

SKU: 23HS22-2804D-AR4

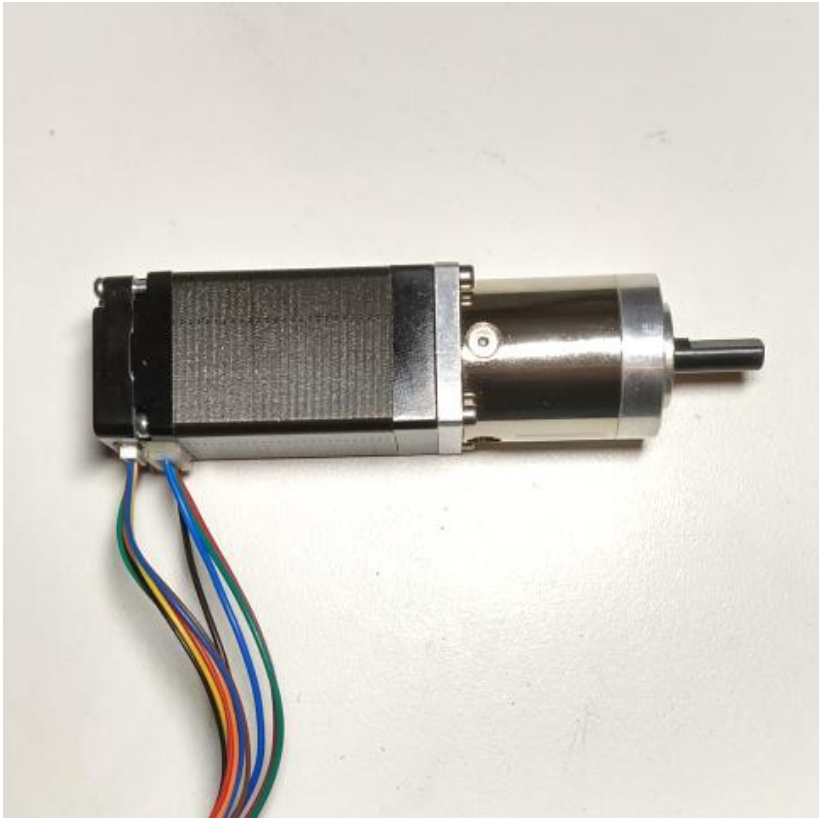
J2 gearbox

SKU: 23HS22-2804D-YGS50-AR4



J3 gear head motor

SKU: 17HS15-1684D-HG50-AR4

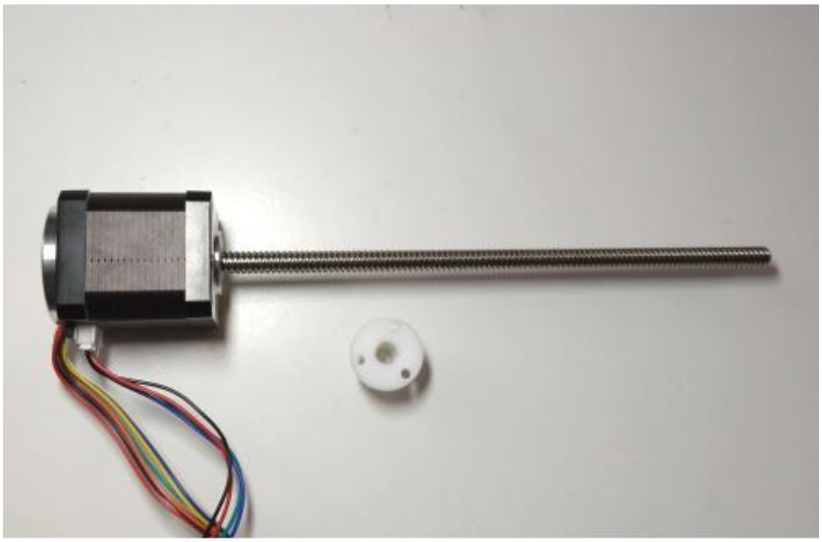


J4 gear head motor

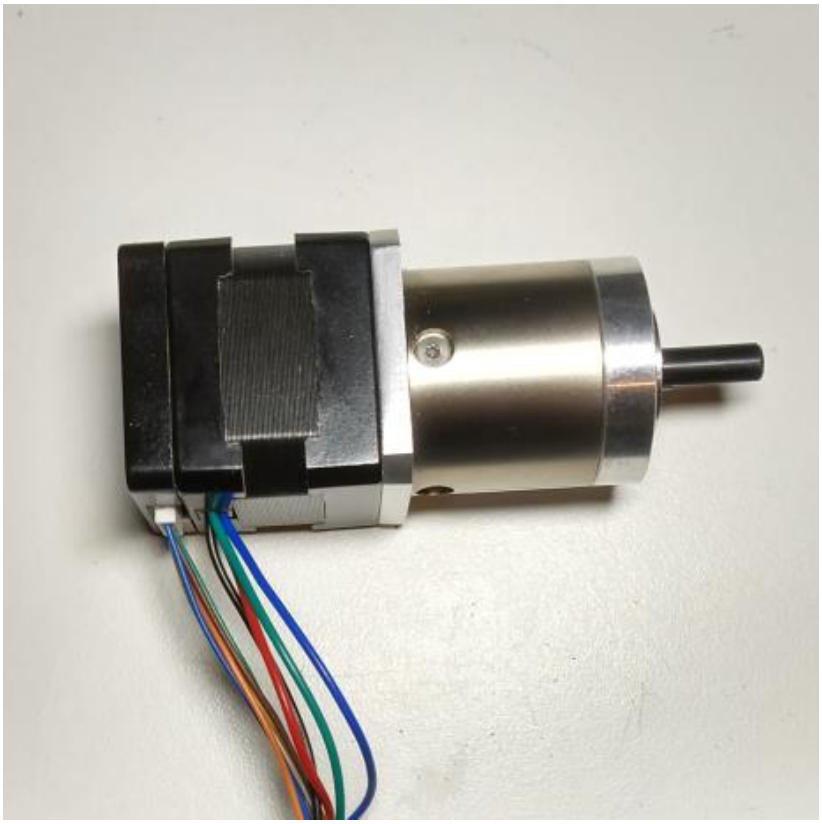
SKU: 11HS20-0674D-PG14-AR4

J5 linear drive motor

17LS19-1684E-200G-AR4



Note: the motor lead screw comes with a POM nut which can be black or white depending on production.



J6 gear head motor

SKU: 14HS11-1004D-PG19-AR4

250W 24V 10A 115/230V Switching Power Supply

Power Supply as well as stepper motors package for the AR4 robot is available from Stepperonline

https://www.omc-stepperonline.com/

STEPPERONLINE

Digital Stepper Driver 1.0-4.2A 20-50VDC 23, 24 Stepper Motor

★★★★★ 13 reviews | Write a review

SKU: DM542T

$30.25

DM542T digital stepper driver.

You will need (5) of these drivers for axis 1,2,3,5 & 6 of the robot. You will need one additional driver if you would like to build a travel track.

Stepper drivers as well as stepper motors package for the AR4 robot is available from Stepperonline

NOTE: the drivers shown in some of the pictures in this manual are blue – however the DM542T is typically black.

DM320T digital stepper driver.

STEPPERONLINE

Digital Stepper Driver 0.3-2.2A 18-30VDC for Nema 8, 11, 14, 16, 17 Stepper Motor

★★★★★ 3 reviews

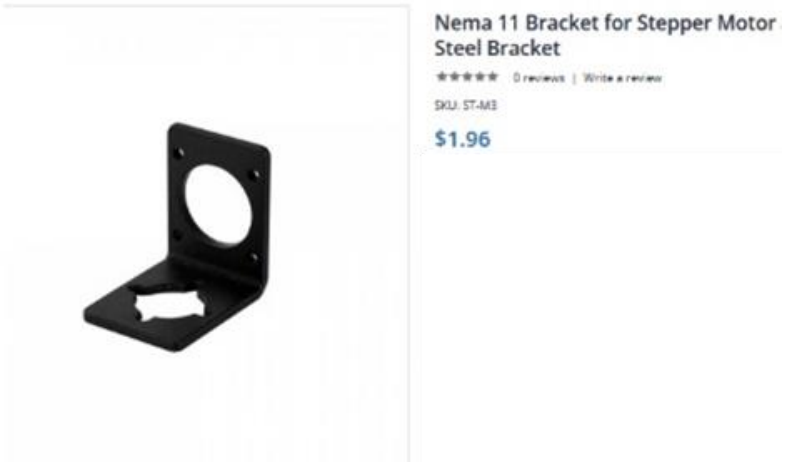
SKU: DM320T

$19.25

You will need (1) of these drivers for axis 4 of the robot.

Stepper drivers as well as stepper motors package for the AR4 robot is available from Stepperonline

https://www.omc-stepperonline.com/



(1) Bracket for the J4 motor

#SKU: ST-M3

https://www.omc-stepperonline.com/

Misc. Components

Many people building the robot have an electrical panel or enclosure they prefer or are already using. It is up to you to determine which enclosure or panel best suits your needs. This is the most economical enclosure I have found and is the one I show in this manual.

BUD Industries NBF-32026 Plastic ABS NEMA Economy Box.

This item is available from Amazon or can be purchased from multiple online sources or the manufacture.
https://www.budind.com/

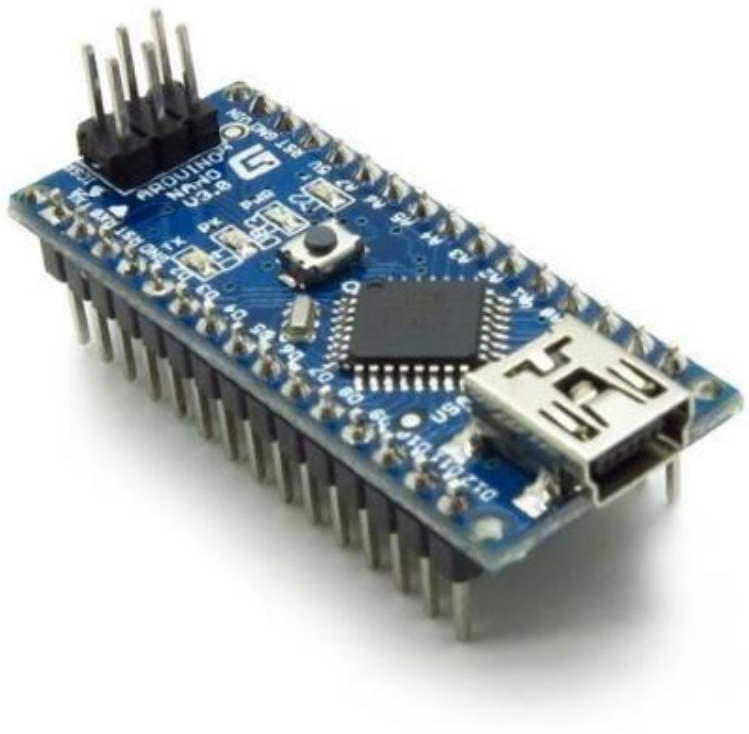
BUD Industries NBX-32926-PL ABS Plastic Internal Panel

This item is available from Amazon or can be purchased from multiple online sources or the manufacture.
https://www.budind.com/

***Note:** you will also need to source #6 x 3/8 thread forming screws or equivalent size screws are needed for securing components to the backplane*

BUD Industries IPV-1115 IP32 Air Vent, 3.2" x 3.2“

This item is available from Amazon or can be purchased from multiple online sources or the manufacture.
https://www.budind.com/



Arduino Nano development board is an optional component.

If installing a pneumatic gripper, you will need this to control a relay and solenoid valve. If installing a servo gripper this device can be used to control the servo.

NOTE: *the Teensy board operates at 3.3v and has limited pins available therefore I wrote the software to use this Nano board for controlling peripheral devices – also this board operates at 5v and 5v relays and servos are much more common and reliable than 3.3 which is why the teensy is only used for control of the robot arm.*

This choice of gripper or end effector will vary based on application of the robot, you are free to use any gripper you like, this SMC pneumatic gripper is the gripper shown in this manual.

Qty. (1) SMC MHF2-8D1 pneumatic gripper.

This is the recommended gripper for the robot however you can use any gripper you like. Please review chapter in this manual on grippers.

This gripper can be found for the best price on Ebay or Ali Express

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If using a pneumatic gripper you will need a 5v relay and a 24v 5 way 2 position solenoid valve.

NOTE: please review chapter on robot grippers.

Please also see the tutorial video on grippers and IO connections: https://youtu.be/76F6dS4ar8Y

uxcell Silicone Tube 1.5mm ID X 3mm OD 32.8' Flexible Silicone Rubber Tubing

Price: $8.89 ✓prime

If using a pneumatic gripper on your robot:

You will need 3mm OD flexible pneumatic.

This item is available from Amazon or multiple online electrical supply vendors.

---

uxcell M3 Male Thread to 3mm 3/25" Pneumatic Tube Hose Mini Barb Fittings 5 Pcs

by uxcell

Be the first to review this item

Price: $3.75 & **FREE Shipping**

If using a pneumatic gripper on your robot:

(2) M3 thread x 3mm tube fitting.

This item is available from Amazon or multiple online electrical supply vendors.

An alternative push connect fitting can be found here: (QSML-M3-3) https://www.alliedelec.com/product/festo/qsml-m3-3/70990969/

If you want to use a servo gripper on your robot there are numerous options on Amazon and other online sites. Make sure the gripper you select uses a 5v servo.

NOTE: please review chapter on robot grippers.

Please also see the tutorial video on grippers and IO connections: https://youtu.be/76F6dS4ar8Y

Ethernet Cables.

Shielded cables are recommended, they can be any length but 5’ or 1.5m is recommended.

Qty (3)

Heat Shrink Tubing

2mm and 1.5mm size tubing is recommended.

62/36/2 Silver Bearing Solder.

Liquid electrical tape is recommended to reinforce motor wires.

Medium and small cable ties are recommended for securing ends of braided sleeve.

Bearing retaining compound can be useful to have on hand – see notes in overview section on bearing fit.

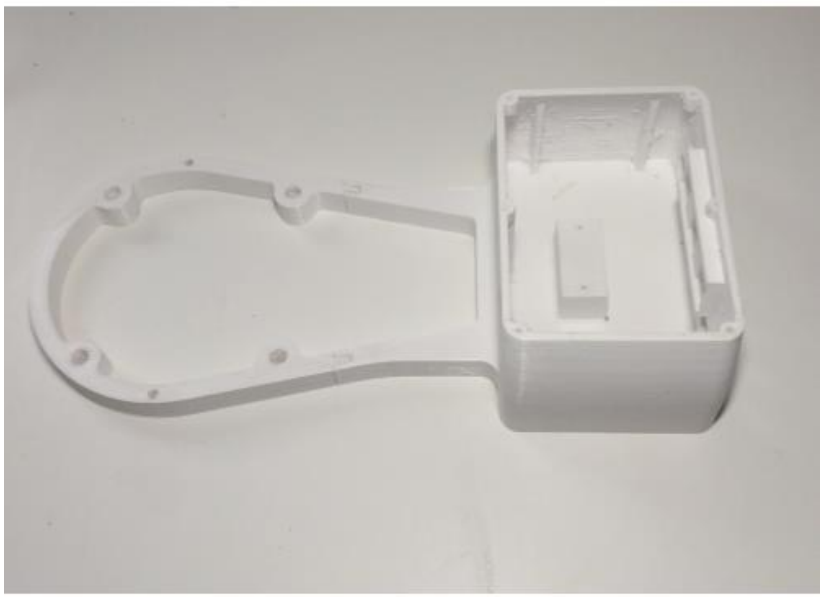
Medium strength thread locker.

Any brand of medium strength will suffice.

CHAPTER 2

ROBOT ASSEMBLY INSTRUCTIONS

Use M4 tap to thread (2) holes as shown in J1 base enclosure part 1

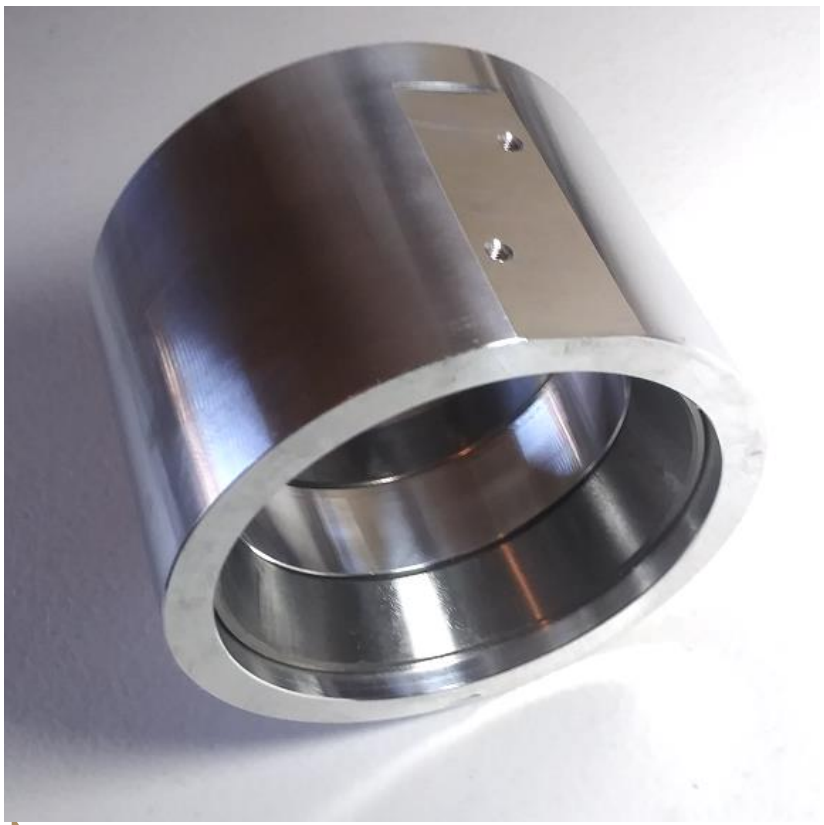


Epoxy J1 enclosure part 1 and part 2 together as shown.

It is recommended that you place both enclosure pieces on flat surface such as a glass table top while epoxy cures.

Secure J1 base plate to J1 enclosure assembly using (2) M4x20 pan head machine screws.

NOTE: these screws are meant to hold base plate to enclosure for assembly and transport purposes only – when assembly is complete and you are ready to use your robot you will need to secure robot to table or work surface using 8mm fasteners through (4) mounting holes.



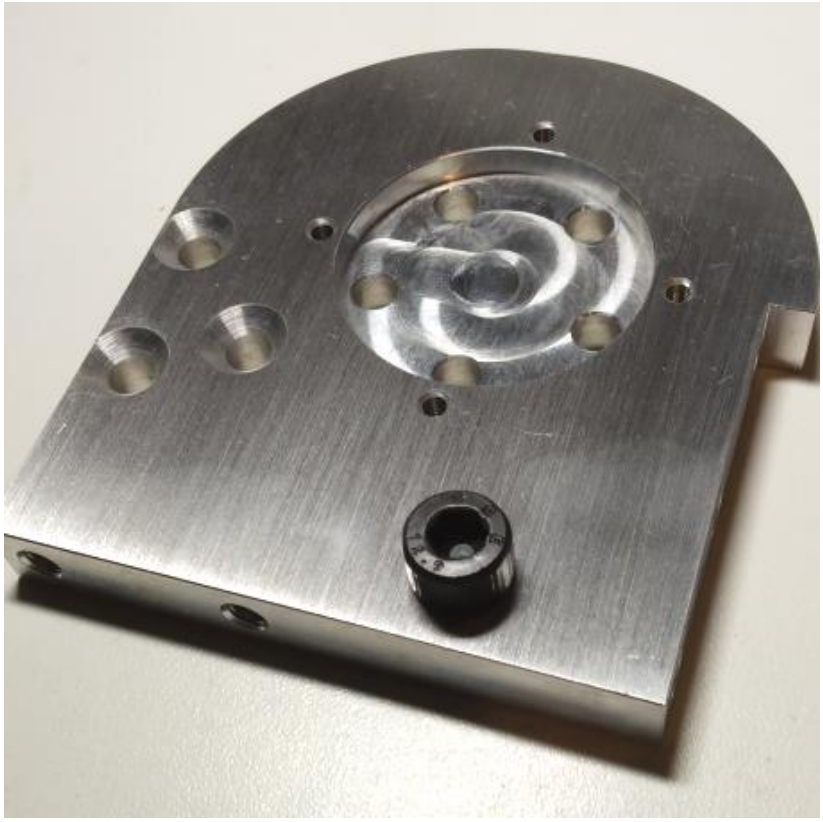
Press (x2) #32009 bearing races into the J1 turret housing. (you will need to do this for both races one at a time)

(See notes on bearing fit in overview section)

Install #32009 bearing on J1 spindle as shown.

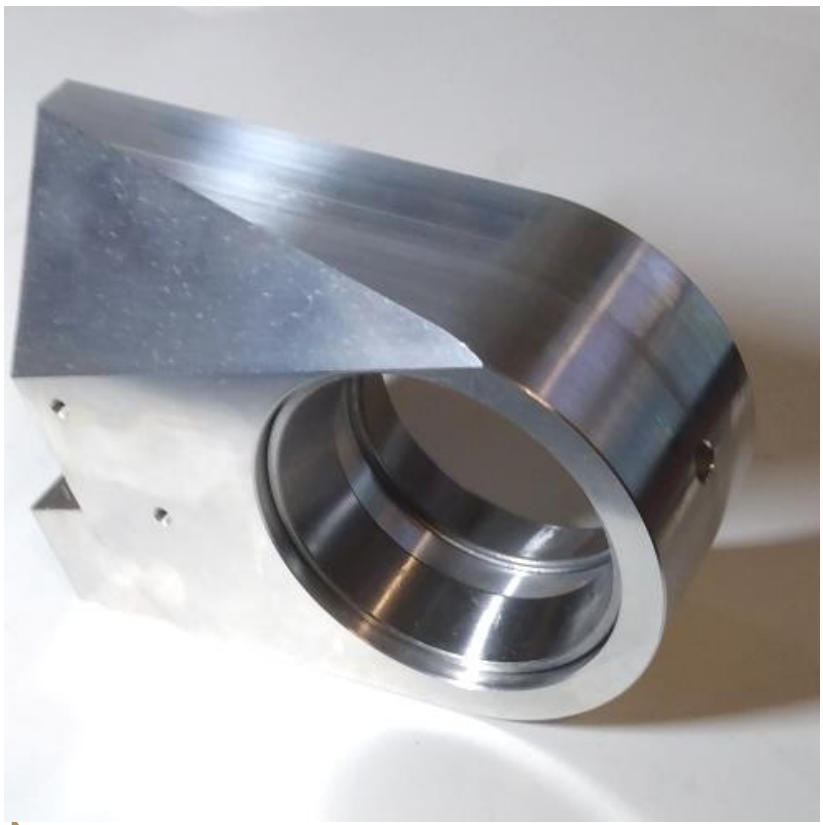
(See notes on bearing fit in overview section)

Insert J1 spindle into turret housing then install the other #32009 bearing on top side of spindle.



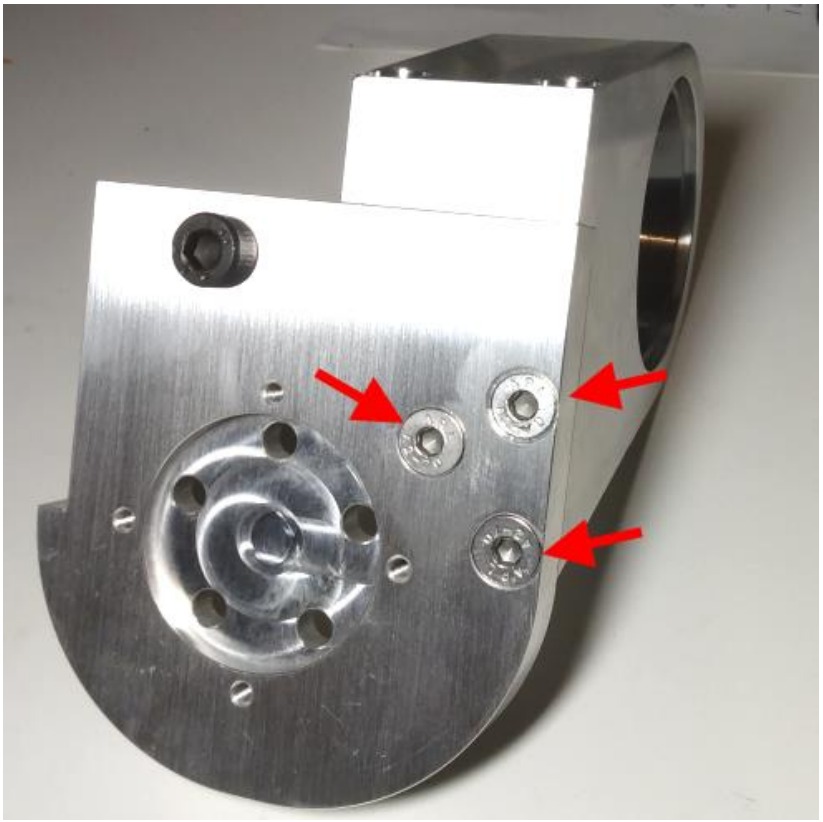
Install M8 x 10 cap screw into J1 platform as shown.

The head of this is screw will contact the J1 limit switch.



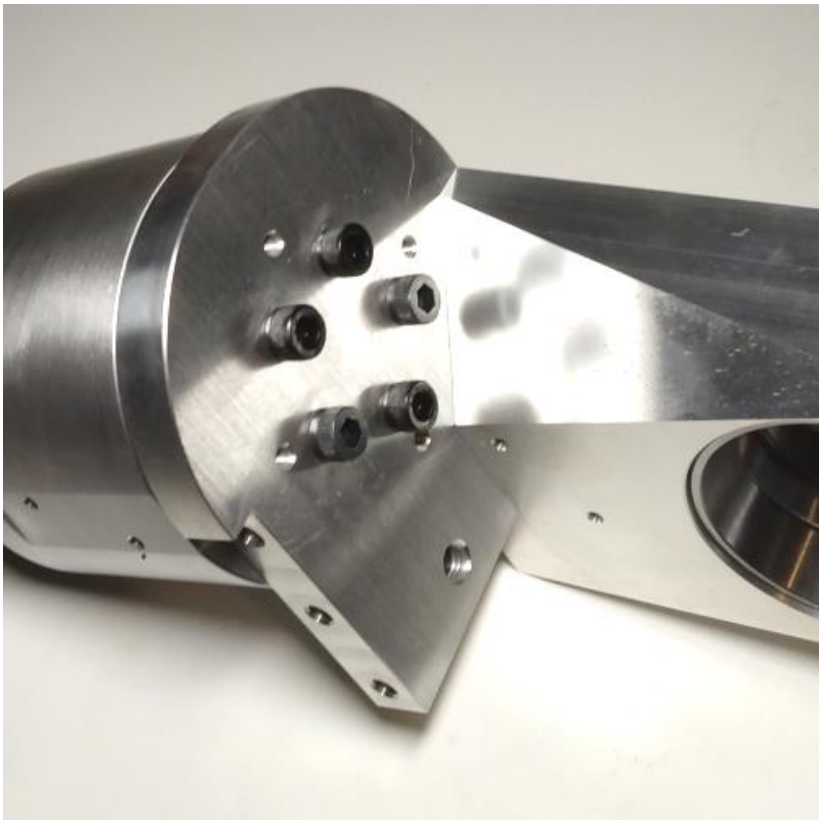
Press (x2) #30206 bearing races into the J2 turret housing. (you will need to do this for both races on each side)

(See notes on bearing fit in overview section)

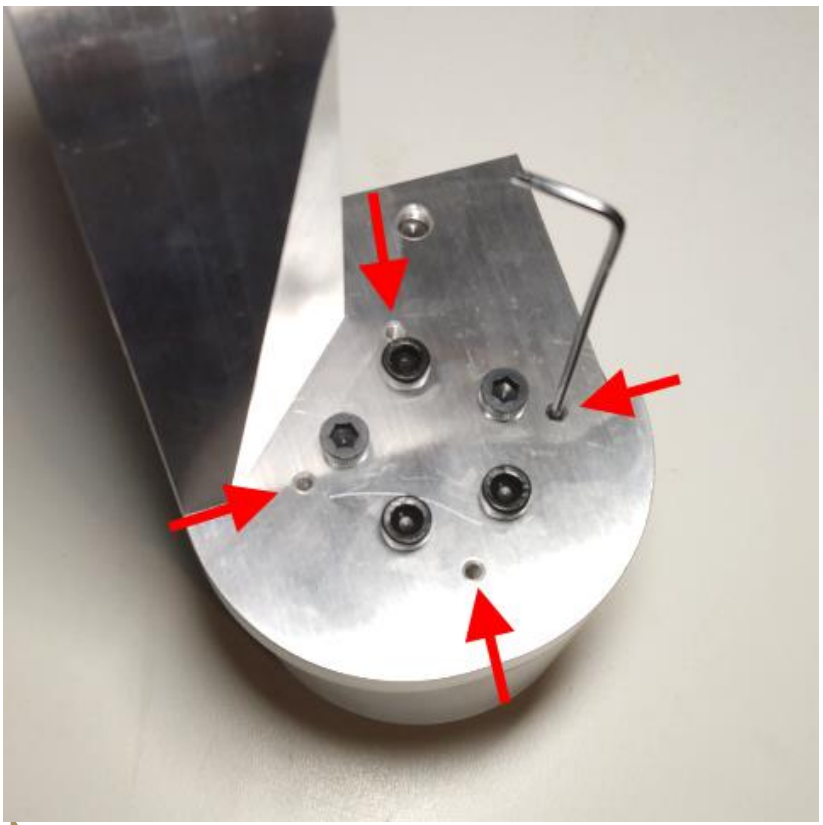


Secure J2 turret housing to J1 platform using (3) M6x18 flat head screws.

Install (2) M6 x 20 socket head screws in front of J2 turret housing going into the J1 platform.



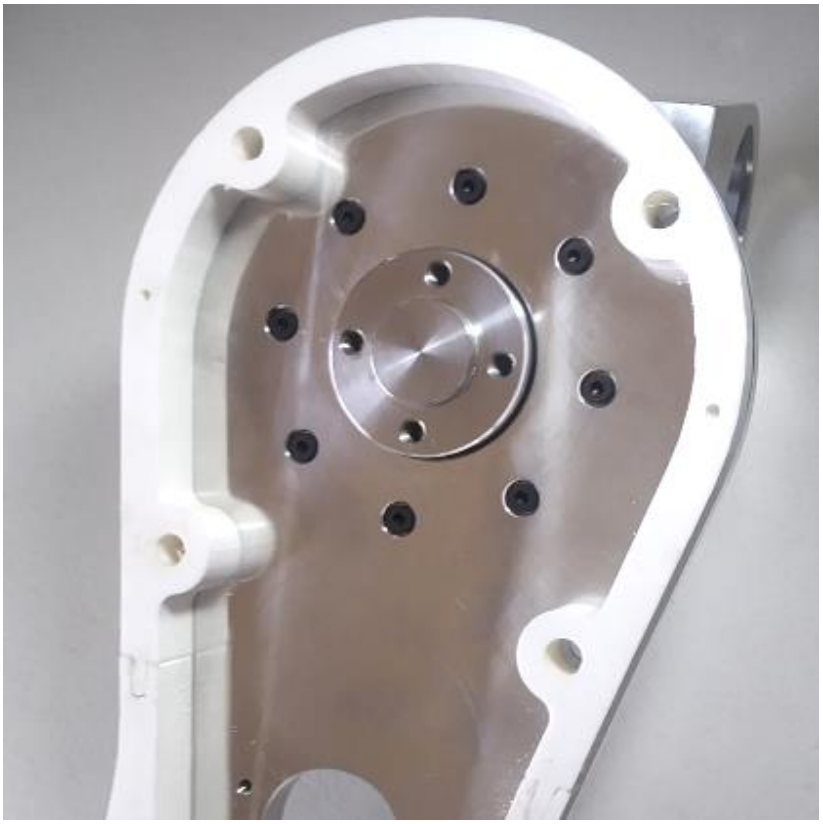
Install platform assembly onto J1 spindle assembly and secure with (5) M6 X 14 socket head cap screws.



Install (4) M4 x 10 set screws in the 4 perimeter holes in the platform.

These place tension on the upper bearing.

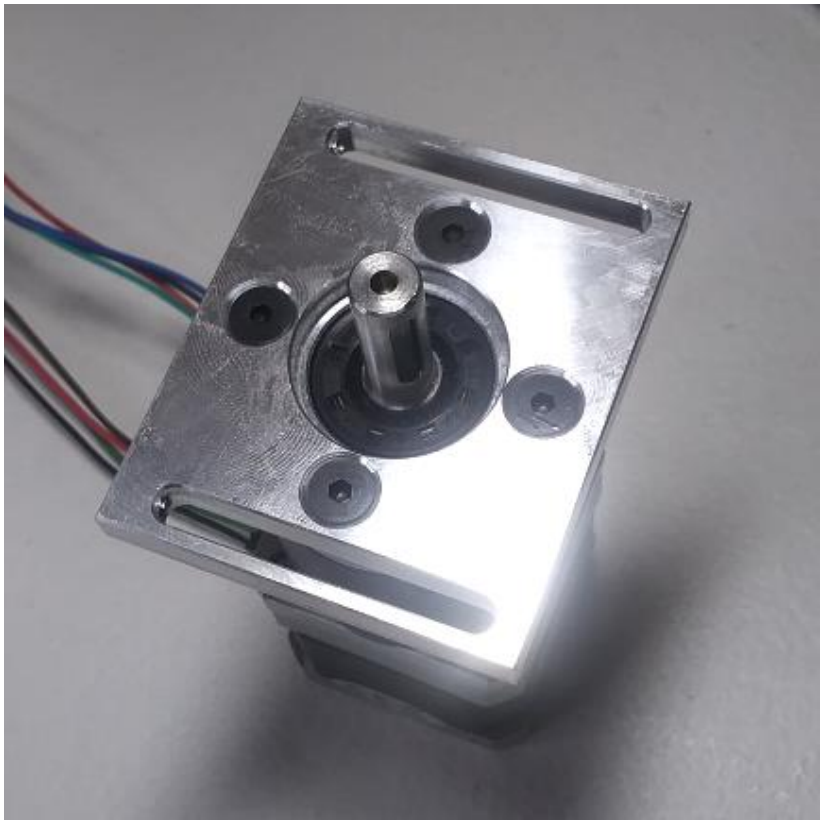
Snug the 4 set screws down evenly until there is no play in the bearings.



Secure J1 turret assembly to J1 base from the bottom using (8) M4x10 socket head cap screws.

Note orientation of limit switch flat in next step prior to installing.

Make sure limit switch flat is facing toward rear as indicated by red lines in this image.



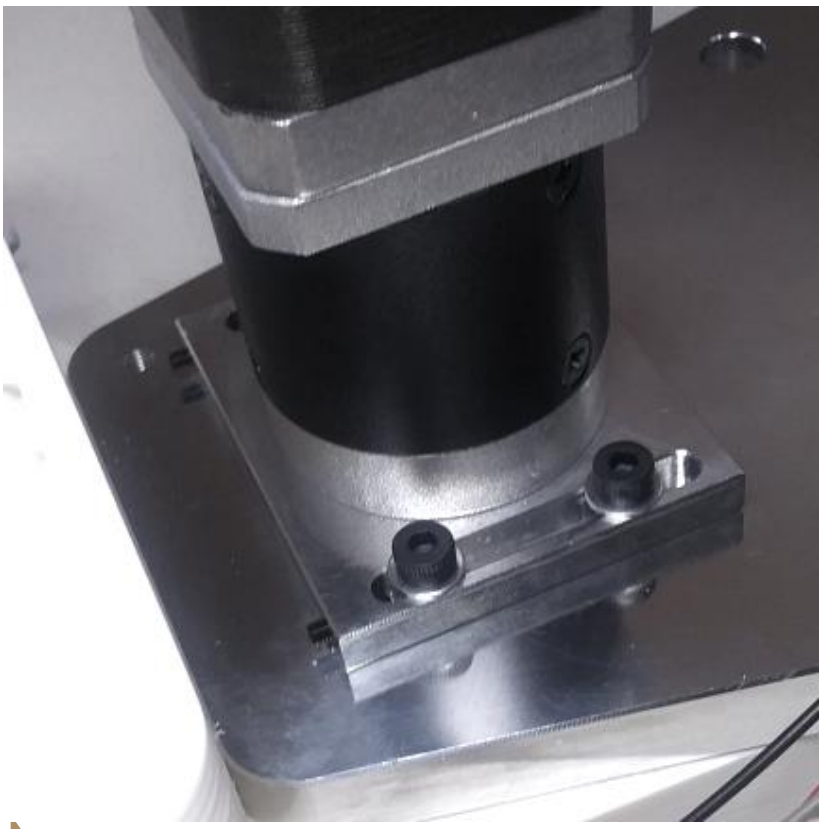
Install J1 motor mount to J1 motor using (4) M4x10 flat head screws.

MAKE SURE YOU ARE INSTALLING THE J1 MOTOR AND NOT THE J3 MOTOR. IT HAS BEEN A COMMON MISTAKE GETTING THESE 2 MOTORS SWAPPED AS THEY ARE NEARLY IDENTICAL IN APPEARANCE.

Install XL15 tooth 8mm bore drive sprocket on J1 gear motor shaft, make sure key is aligned in pulley slot and secure with M3x4 set screws.

The Annin Robotics hardware kit comes with a broached (keyed pulley) but if you are using a blank or un-broached pulley you can remove the key from motor shaft and drive the set screw into the slot but having the pulley keyed is best.

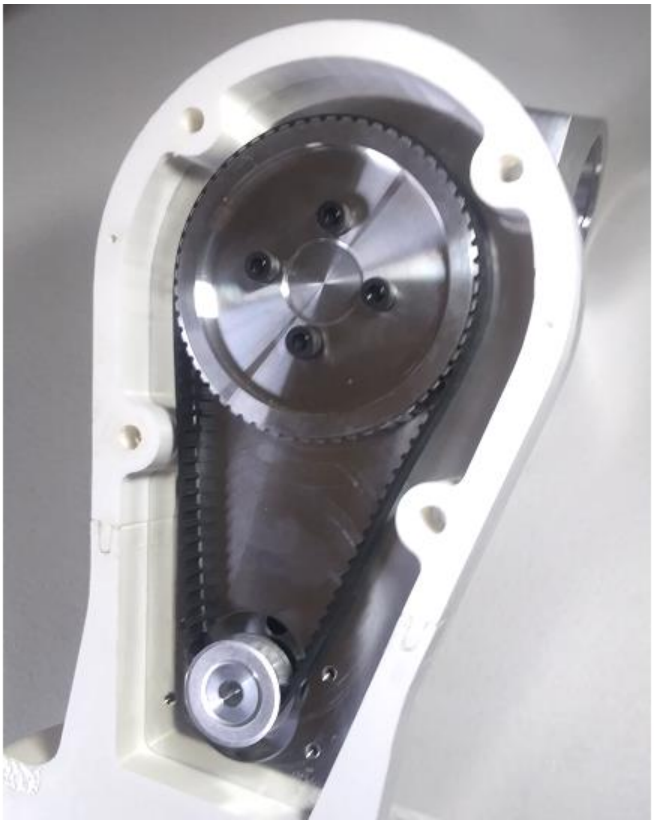
Install (2) M3x10 set screws in rear of motor mount slots.



Install motor assembly onto base and

secure with (4) M4 X 20 socket head cap screws and (4) washers but do not fully tighten until after belt is tensioned.

NOTE: Make sure (2) 3mm tension holes located on ends of slots are facing toward back.



Install 60T timing hub pulley onto J1 spindle and secure with (4) M6x14 socket head cap screws, then install 180XL037 belt as shown.

Make sure the (4) 4mm X 20 socket head cap screws securing the motor to the baseplate are slightly loose so that motor can slide to apply belt tension.

Tension J1 belt using (x2) M3x10 set screws in rear of motor mount slots.

NOTE: when belt is at good moderate tension the set screws will be fully threaded into the motor base plate and no longer be visible.

Once belt has moderate tension tighten the (4) 4mm X 20 socket head cap screws securing the motor to the baseplate.

Install (2) PG-21 gland nuts into base enclosure as shown.

There are 8 wires coming from the encoder (silver disc) Cut the J1 encoder wires to a length of 4cm.

Be sure to keep the black, green, red and blue motor wires separate – these are the wires coming from black motor body below the encoder.

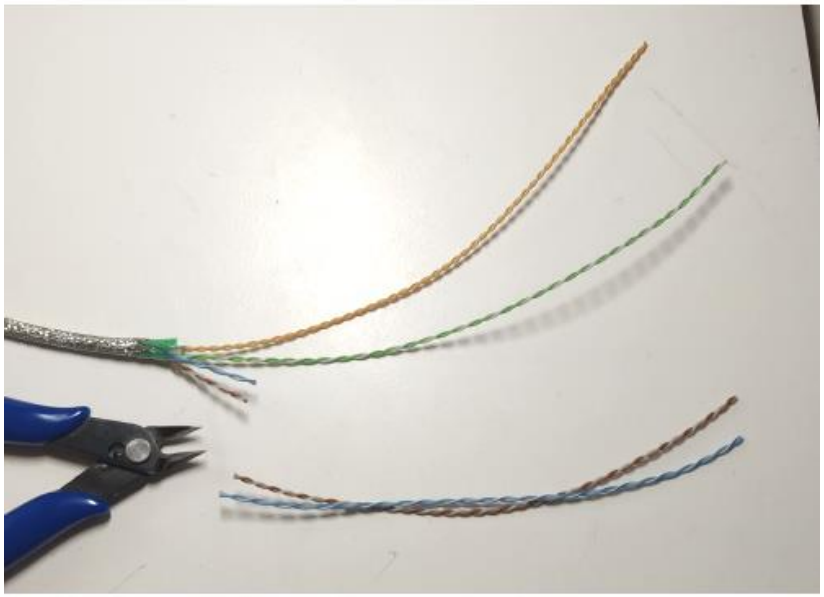
Use wire strippers to strip end of the red, black, brown and blue J1 encoder wires.

Note: only these 4 encoder wires will be used.

For joint 1 cut length of continuous flex Cat6 cable to a length of 53cm long and remove outer jacket. (see overview section on jacket removal)

Remove 12cm of shielding from one end of cable and remove 23cm of shielding from the other end. (see overview section on removing shielding)

The end with 12cm of shielding removed will be the end of the cable that is routed to the base enclosure.



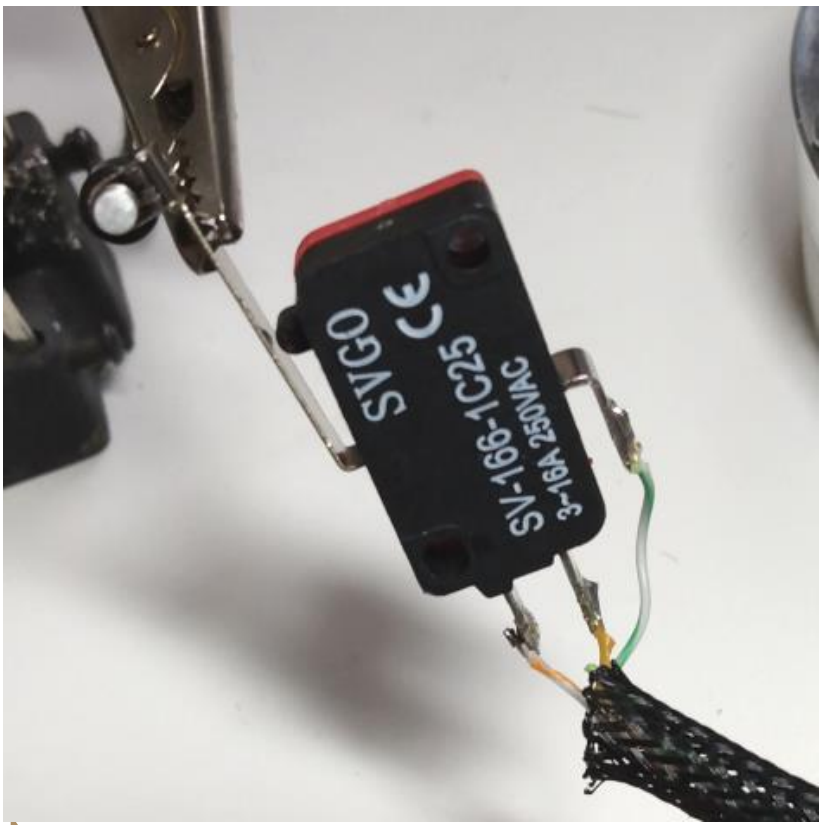
From the end of cable that has 23cm of shielding removed - cut and remove 20cm of the brown and blue twisted pairs leaving 3cm of wire exposed.

Cut length of ¼” braided sleeve to a length of 21cm long then route green and orange twisted pairs through sleeve as shown.

Use cutters to remove 2cm of the orange white twisted pair.

Untwist and remove 2cm of the green wire but do not cut the white with green stripe wire.

Strip ends of wires as shown.



Solder orange wire to “NO” terminal of SV-156-1C25 roller tip limit switch.

Solder white with orange stripe wire to the “NC” terminal.

Solder the white with green stripe wire to the “COM” terminal.

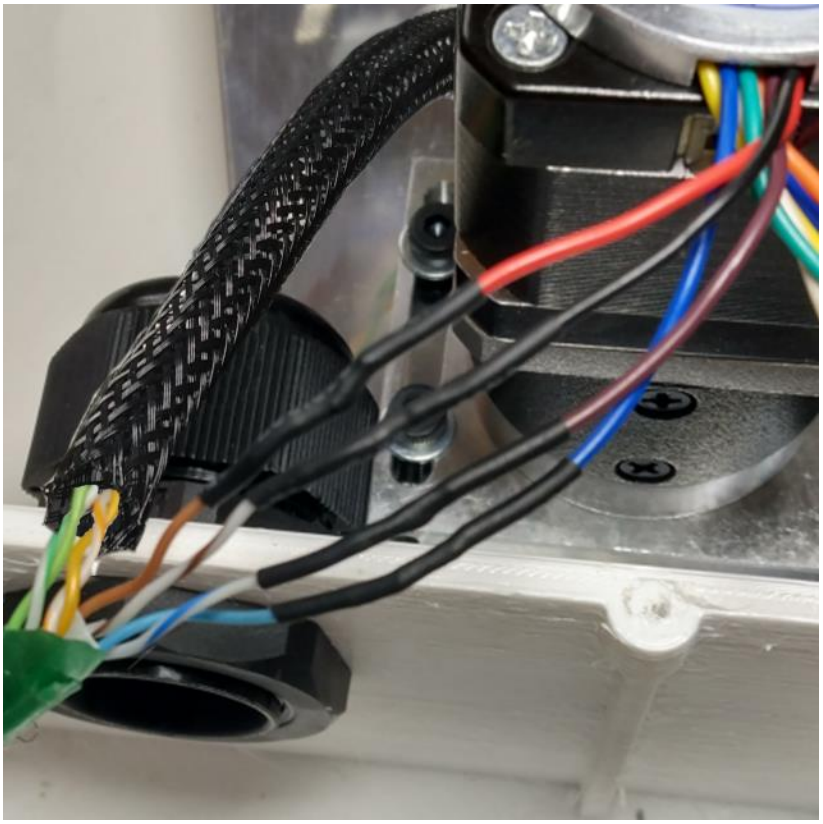
Note: the green wire is not used.

(also see wiring diagrams in chapter 4)

It is recommended to use liquid electrical tape to insulate terminals on limit switch.

You could alternatively use quick disconnects on the limit switch connections but J1 in particular has a tight clearance that makes this difficult – quick disconnect also present connection issues in crimping such small wires.

Use (2) M3x14 Philips pan head screws to secure switch to J1 housing as shown in photo.



Locate the 8 wires coming from the encoder (silver disc) only 4 of the 8 wires will be used - solder and heat shrink the connection from the encoder to the Cat6 cable as follows:

Encoder red wire to the cable brown wire.

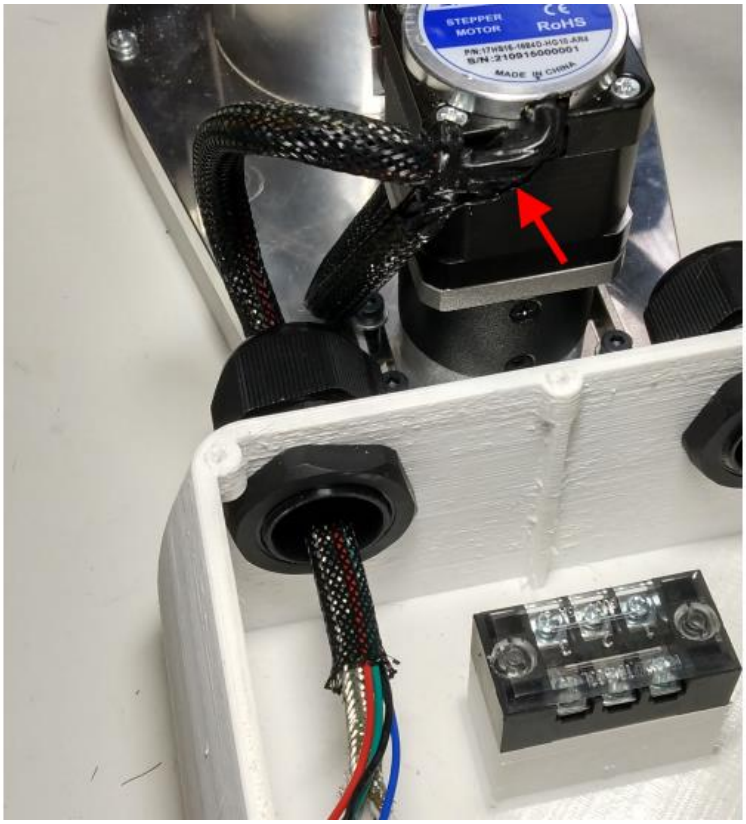
Encoder black wire to the cable white – brown stripe wire.

Encoder brown wire to the cable white – blue stripe wire.

Encoder blue wire to the cable blue wire.

Cut length of ¼” braided sleeve to a length of 23cm long then route J1 motor and encoder wires through the sleeve.

Attach small cable tie as shown near motor(red arrow).



Route J1 wires through gland nut on left side as shown. It is recommended to coat the exposed encoder and motor wires with liquid electrical tape. (red arrow)

Applying the liquid electrical tape can also be done later after fully testing the robot electrically.

Install J2 spindle into J2 arm as shown using (8) M4x10 flat head screws. (green arrow).

Make sure J2 spindle keyway is oriented up as shown (red arrow).

Make sure J3 limit swtich mounting holes are oriented to right side as shown (blue arrow).

Install #30206 bearing onto J2 spindle as shown.

(See notes on bearing fit in overview section)

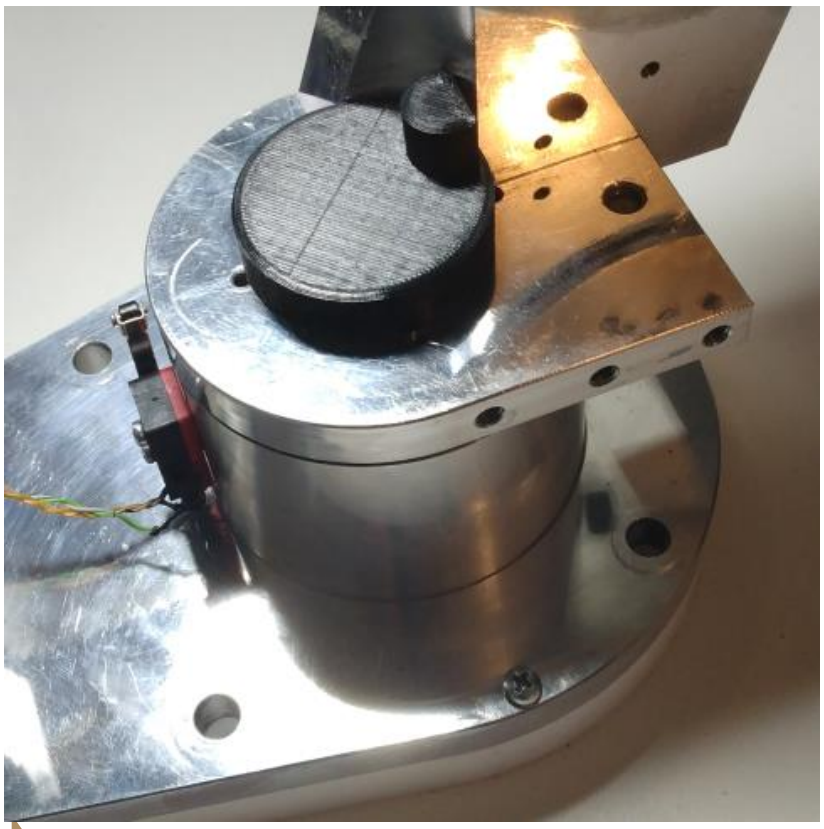
Install M3x10 set screw into J2 spindle as shown but do not thread through to keyway yet.

Install J2 arm assembly into J2 turret housing and then install the other #30206 bearing from opposite side as shown.

Install J2 tension ring and secure with (6) M3x10 flat head screws.

Make sure tension ring is 90° to the J2 arm and that the keyway slot in tension ring aligns with keyway slot in J2 spindle.

Install (4) M4x5 set screws and tighten until there is no play in J2 bearings. These set screws set the bearing tension – remember to apply loctite to set screw threads.



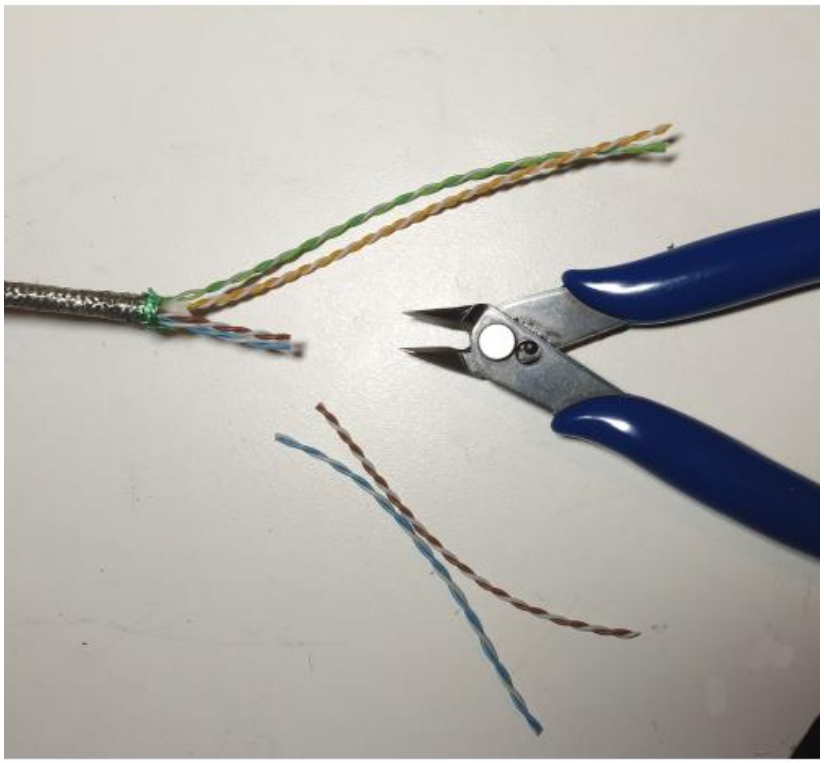
Install the 3D printed J2 Stop as shown. This part is a press fit onto the J1 platform cap screw heads.

This part prevents the J2 arm from collapsing too far.

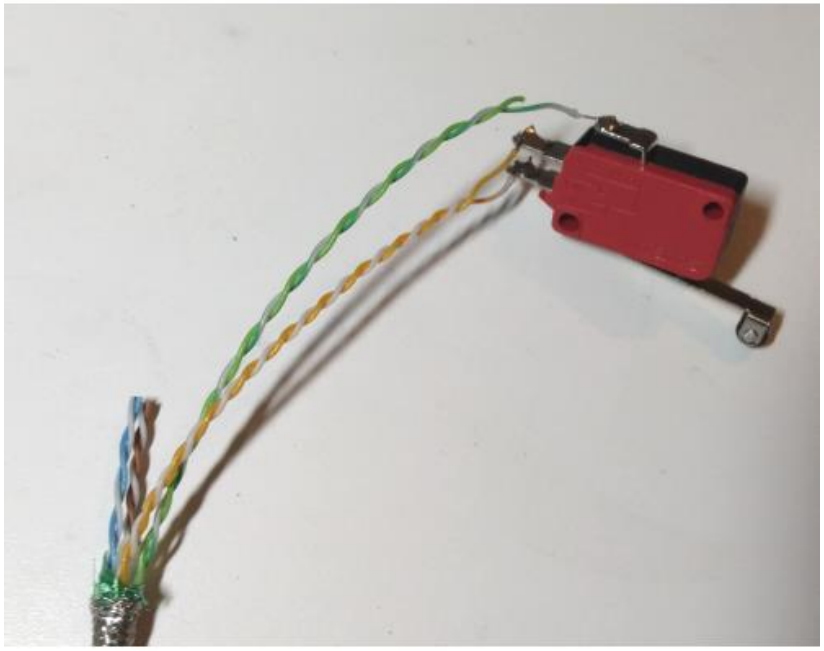
For joint 2 cut length of continuous flex Cat6 cable to a length of 75cm long and remove outer jacket. (see overview section on jacket removal)

Remove 12cm of shielding from one end of the cable and remove 10cm of shielding from the other end. (see overview section on removing shielding)

The end with 12cm of shielding removed will be the end of the cable that is routed to the base enclosure.



From the end of cable that has 10cm of shielding removed - cut and remove 7cm of the brown and blue twisted pairs leaving 3cm of wire exposed.



Solder orange wire to “NO” terminal of SV-166-1C25 roller tip limit switch.

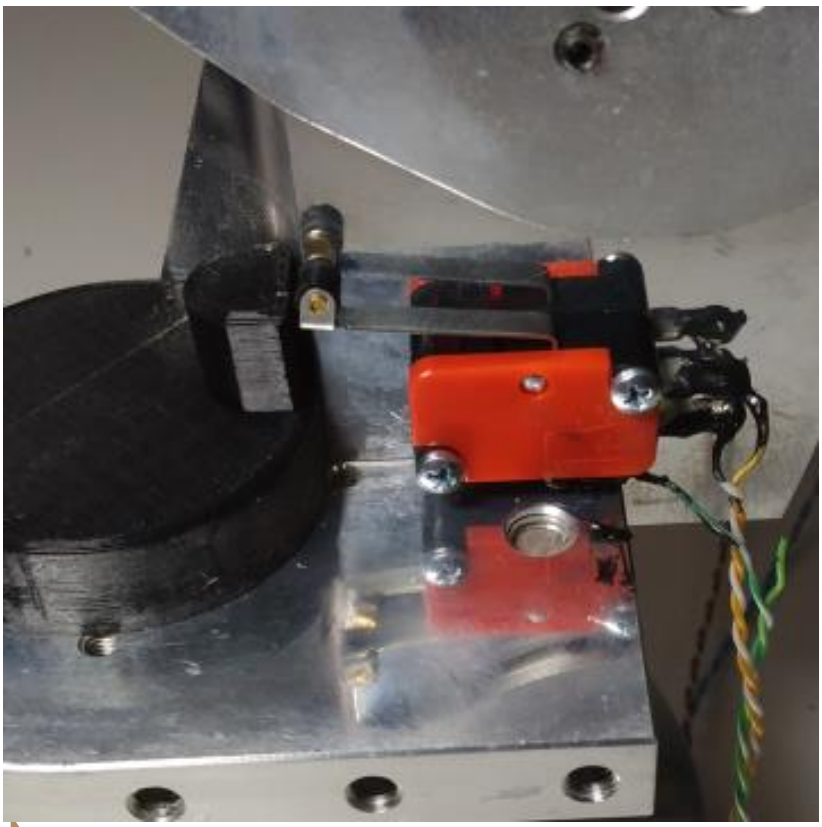
Solder white with orange stripe wire to the “NC” terminal.

Solder the white with green stripe wire to the “COM” terminal.

Note: the green wire is not used.

(also see wiring diagrams in chapter 4)

It is recommended to use liquid electrical tape to insulate terminals on limit switch.



Use (2) M3x14 Philips pan head screws to secure switch to J2 housing as shown in photo.

Remove the (4) M4 cap screws from the motor side flange on the 23HS22-2804D-YGS50-AR4 gear box

Carefully remove the gearbox motor side flange as shown.

Install J2 motor mount over J2 motor gear box housing as shown.

Make sure the countersunk holes at the bottom of the motor (blue arrows) are facing out as shown in the photo.

Install the 3D printed “J2 spacer YGS” onto the gearbox as shown.

Make sure the recessed side of the spacer is facing out as shown.

Carefully re-install the motor side flange on to the 23HS22-2804D-YGS50-AR4 gear box as shown.

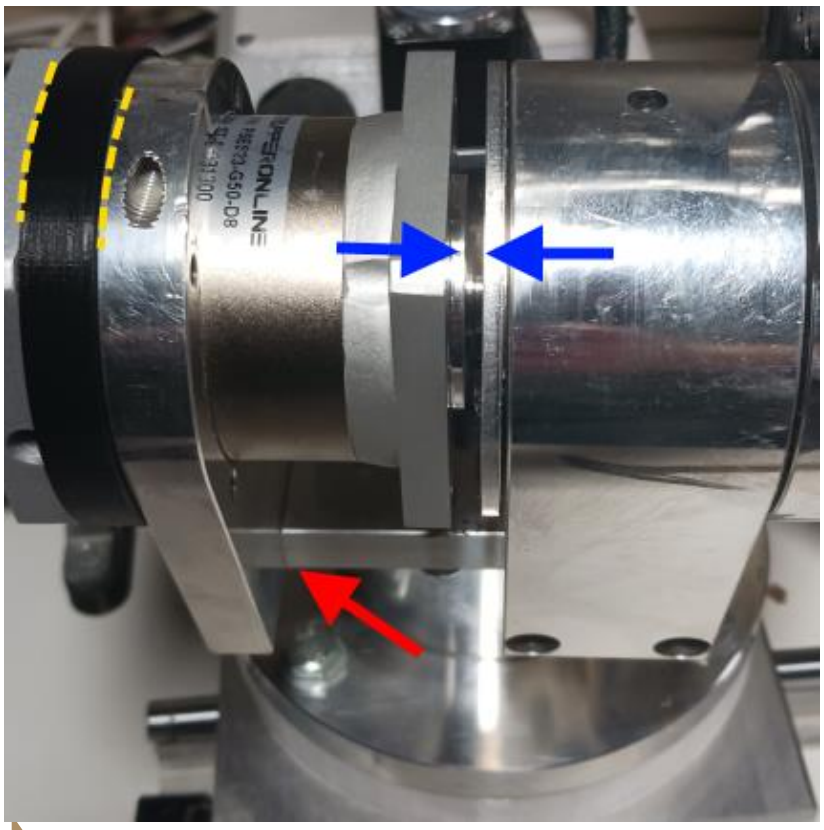
Be very careful to make sure the gears align correctly putting it back on.

Re-install and tighten the (4) M4 cap screws.

Install 23HS22-2804D-YGS50-AR4 gear box into J2 arm assembly as shown.

The 14mm gearbox shaft with key needs to be inserted into the J2 spindle.

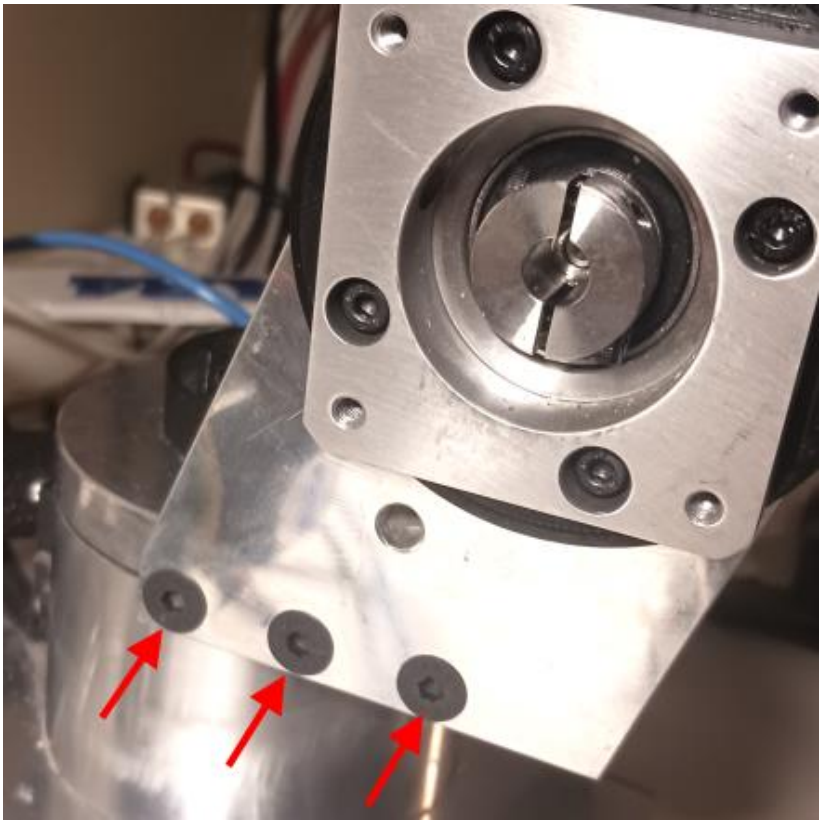
You may need to use a soft rubber mallet to carefully and slowly tap the gear box into the J2 spindle.



Once the gearbox is fully tapped into place there should be an approx. 1mm gap between the J2 gearbox motor housing and the J2 tension ring as indicated by the blue arrows.

The J2 motor mount should be flush to the J1 platform as indicated by the red arrow.

The 3D printed “J2 spacer YGS” should be tight between the gearbox flange and motor mount plate as indicated by the yellow dashed lines.



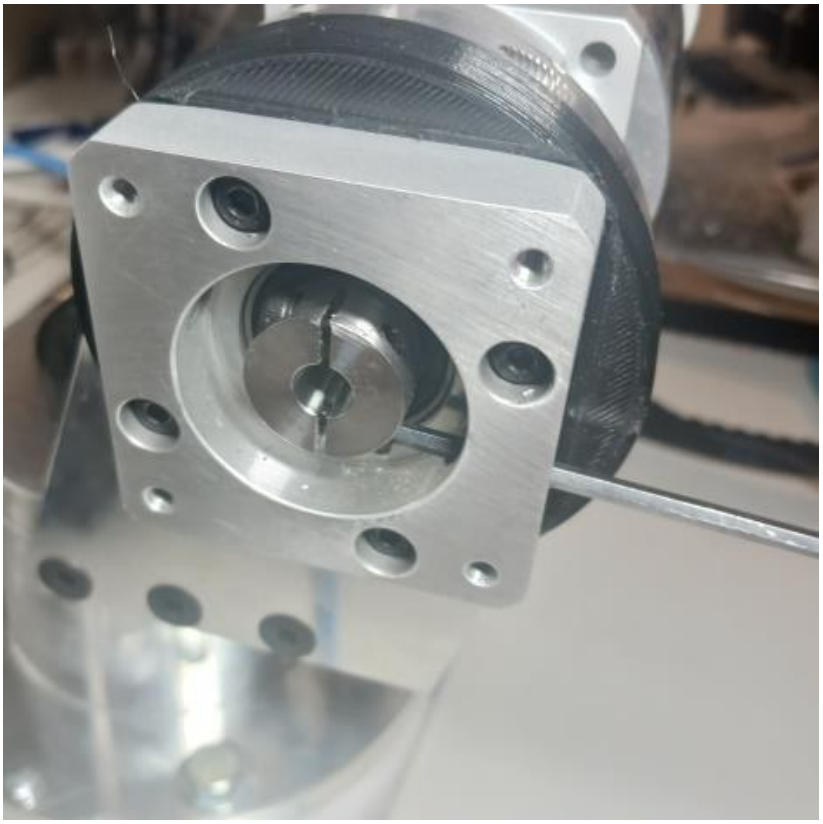
Install and tighten (3) M6x18 flat head screws securing the J2 motor mount plate to the J1 base platform.

Be sure to use medium strength thread locker.

Tighten the M3 set screw for the J2 spindle.

With the J2 arm in a vertical position you can access the set screw through the access hole in top of J2 housing.

You may need to gently move the arm by hand to get it into alignment.

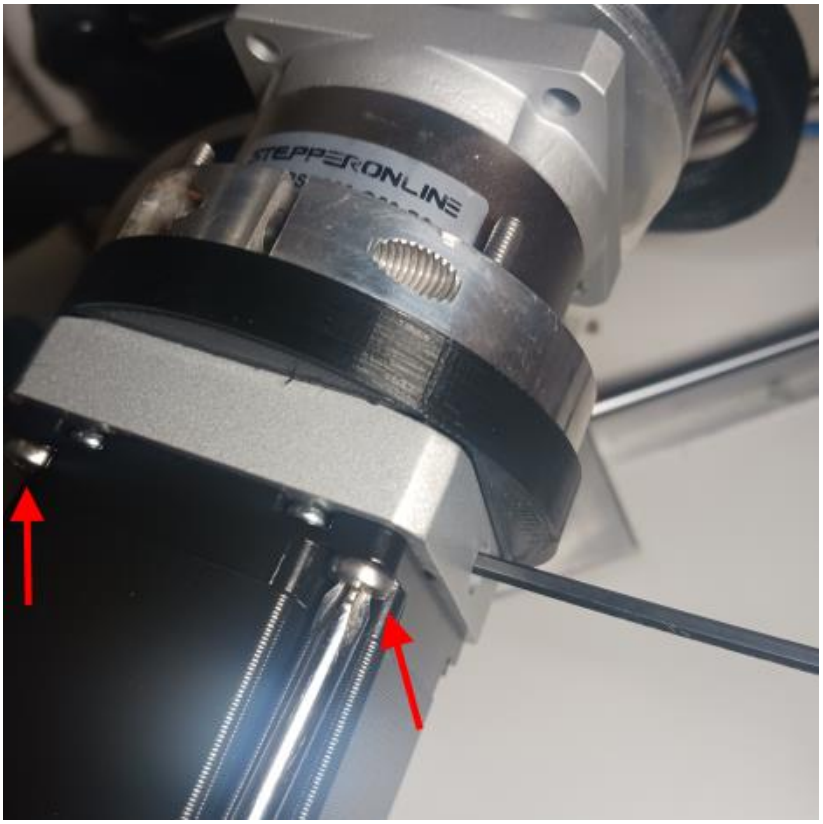


Insert hex key wrench through access hole in side of gear box flange and into the gearbox collar set screw as shown in photo.

You may need to move the J2 arm to get the collar set screw into alignment with the hole.

Do not tighten the screw yet, but leave the hex key wrench in place.

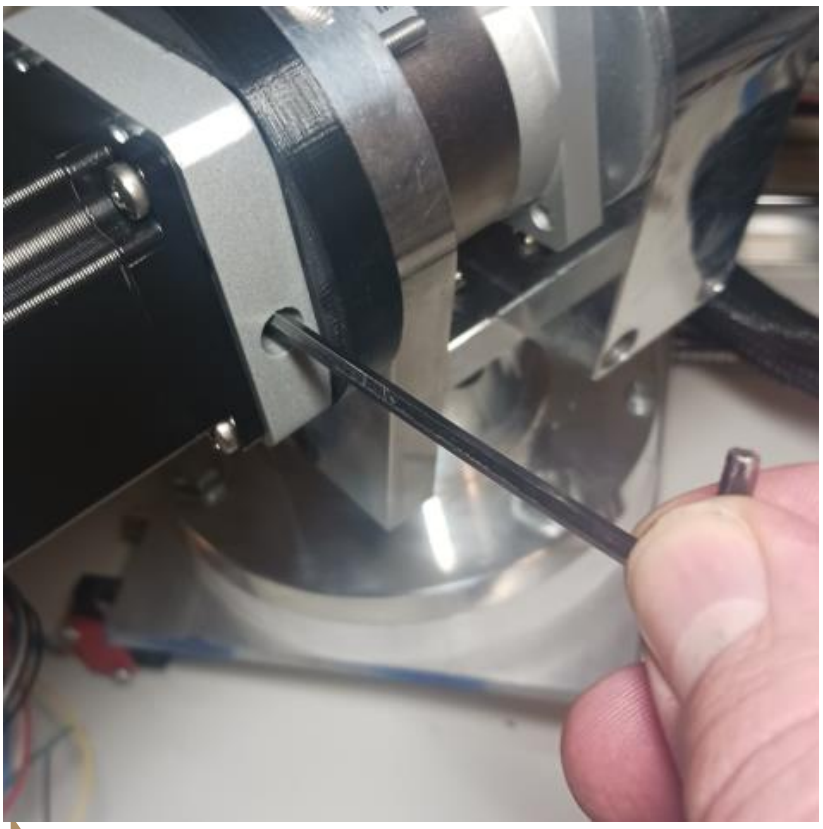
Install the J2 motor onto the gearbox as shown. Make sure the motor and encoder wires are oriented to the left as shown in the photo.



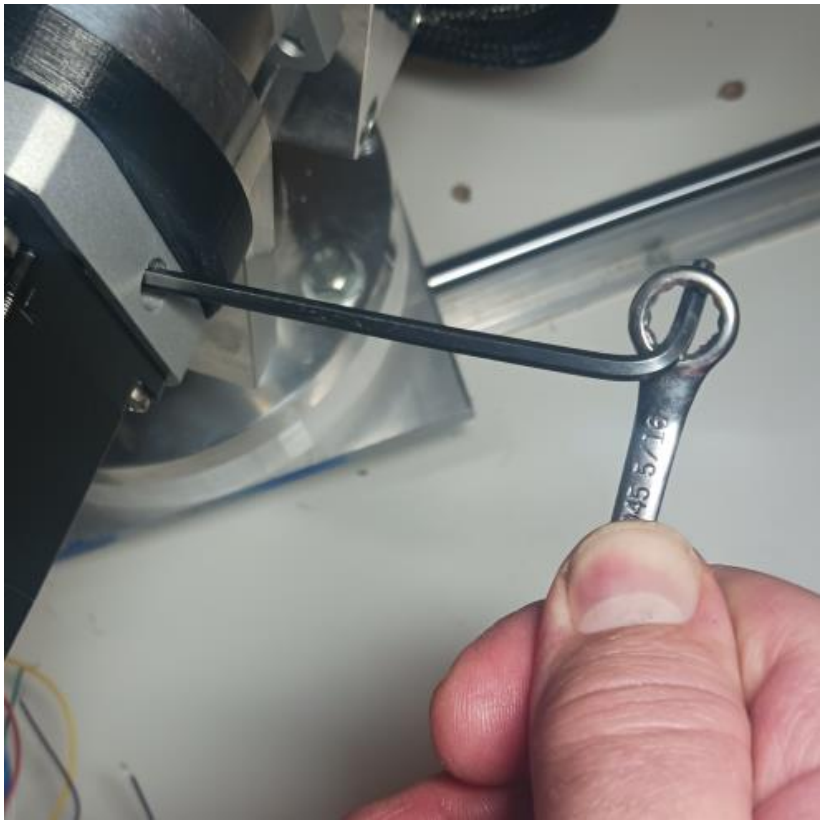
Secure the motor to the gearbox using (4) M4x45 or M4x50 fully threaded pan head screws.

The 45mm or 50mm long fully threaded screws should protrude all the way through the J2 3D printed spacer and the J2 motor mount plate.

NOTE: *we are not using the factory screws that came with the gearbox but do save one of the factory screws as we will utilize it in a future step.*



Once the motor is secured to the gearbox tighten the screw on the gearbox motor collar so that the motor shaft is secured to the gearbox.



You may need to use a pliers or a box end wrench to get leverage on the short end of the hex key wrench when tightening the motor collar screws.

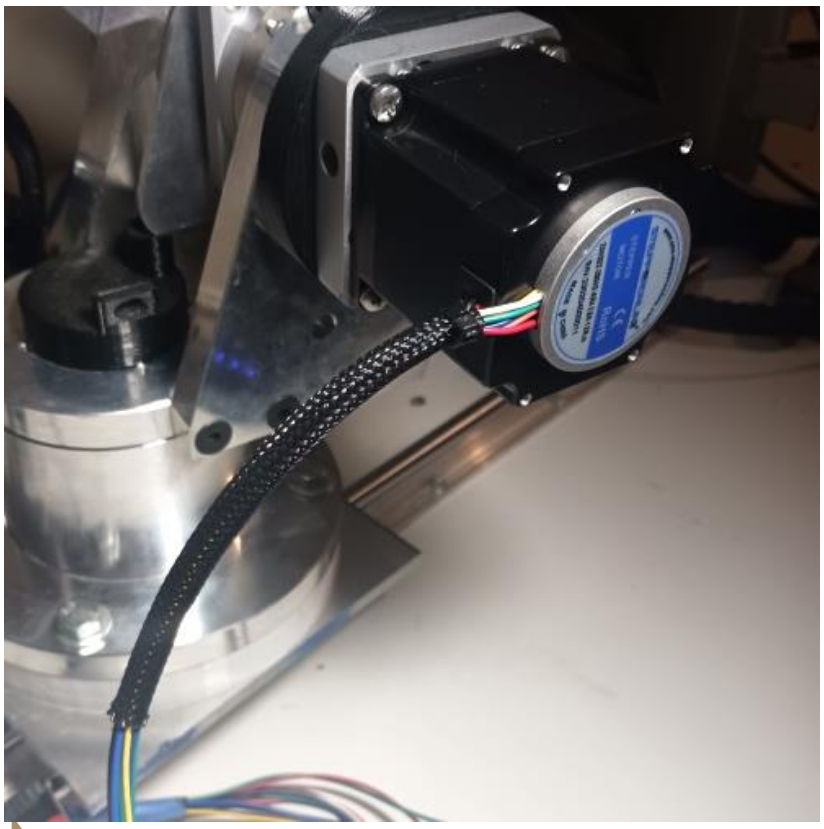
Next tighten the screw on the gearbox motor collar on the opposite side of the motor. There are 2 screws on the collar.

Install and tighten (4) M4 washers and nuts to secure motor gear box assembly to the J2 motor mount plate.

Install and tighten M6x20 cap screw in J2 motor support plate as shown.

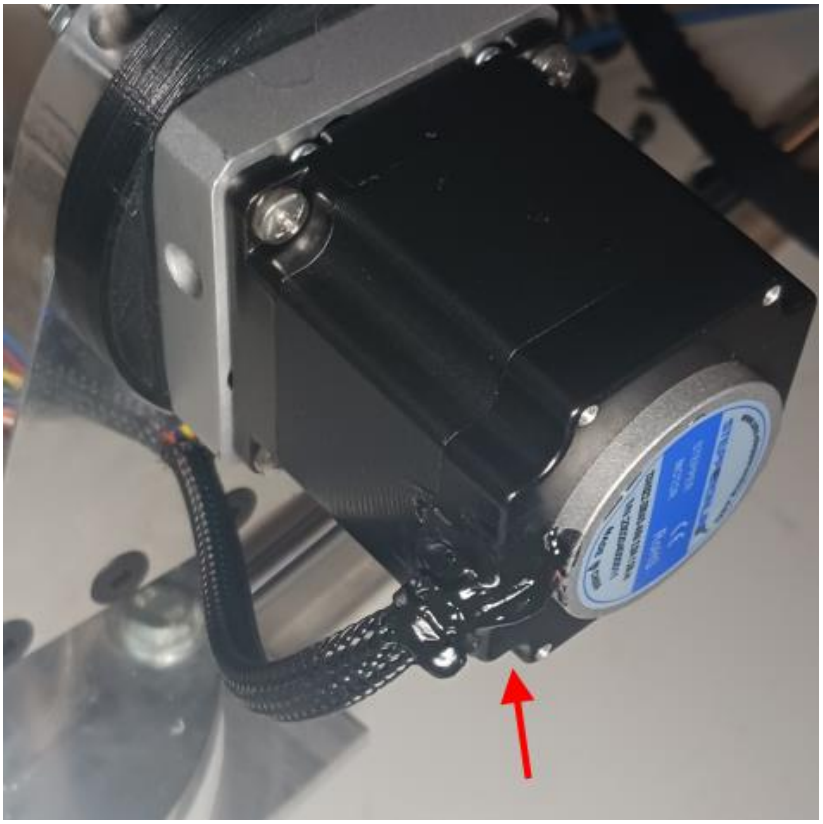
Wrap a piece of tape around ends of motor wires.

This tape is just to keep the motor wires separate and help avoid any confusion after routing the wires through sheathing in next steps.



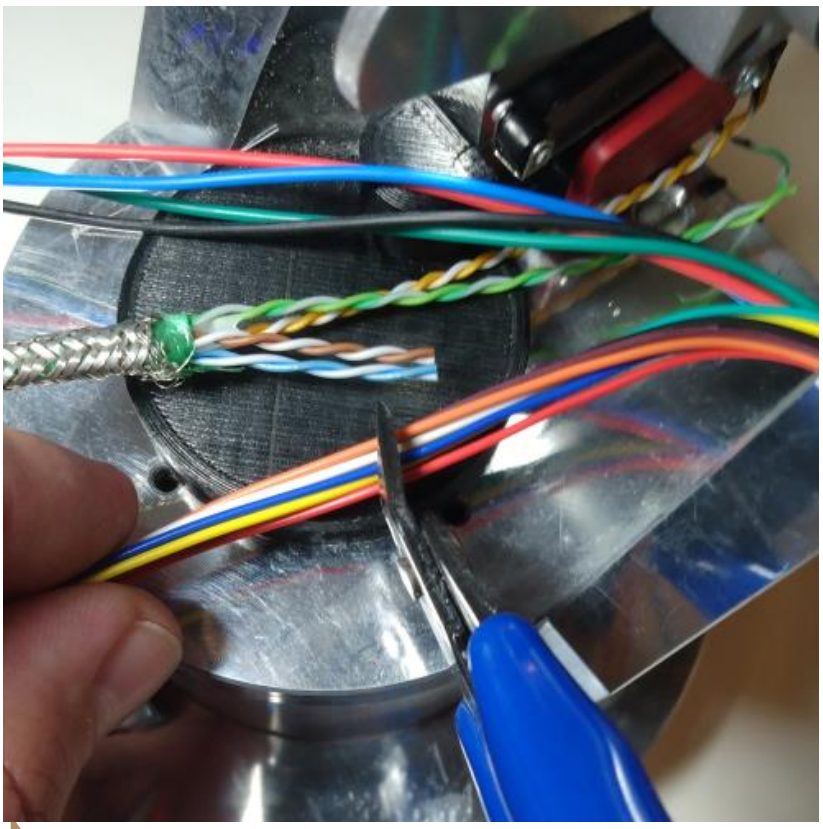
Cut length of ¼” braided sleeve to a length of 15cm long then route J2 motor and encoder wires through the sleeve.

Attach small cable tie as shown near motor (red arrow).

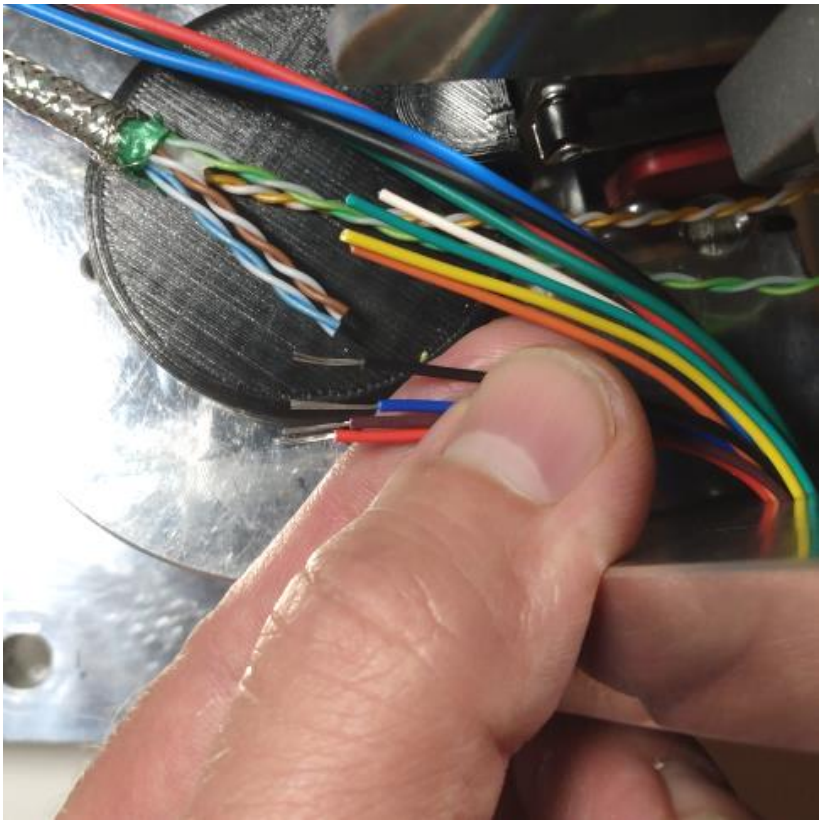


Route J2 wires through J2 motor mount plate as shown. It is recommended to coat the exposed encoder and motor wires with liquid electrical tape. (red arrow)

Applying the liquid electrical tape can also be done later after fully testing the robot electrically.

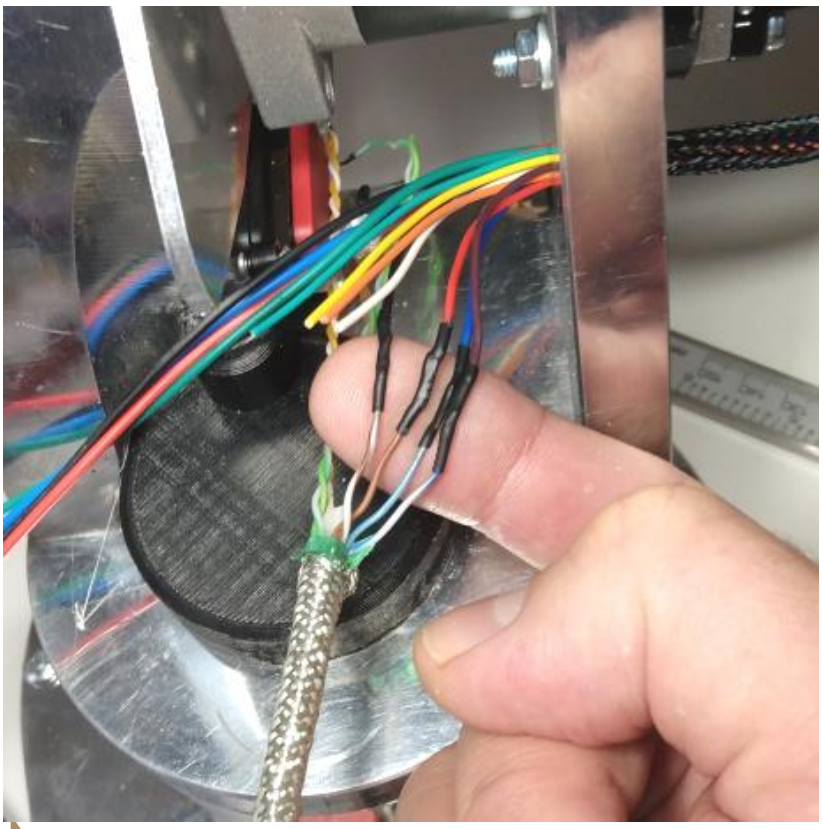


After routing J2 wires through the motor mount plate separate the J2 motor wires from J2 encoder wires then cut the encoder wires to a length where they slightly overlap the brown and blue twisted pairs as shown in the photo.



Use wire strippers to strip end of the red, black, brown and blue encoder wires.

Note: only these 4 encoder wires will be used.



Solder and heat shrink the connection from the J2 encoder to the Cat6 cable as follows:

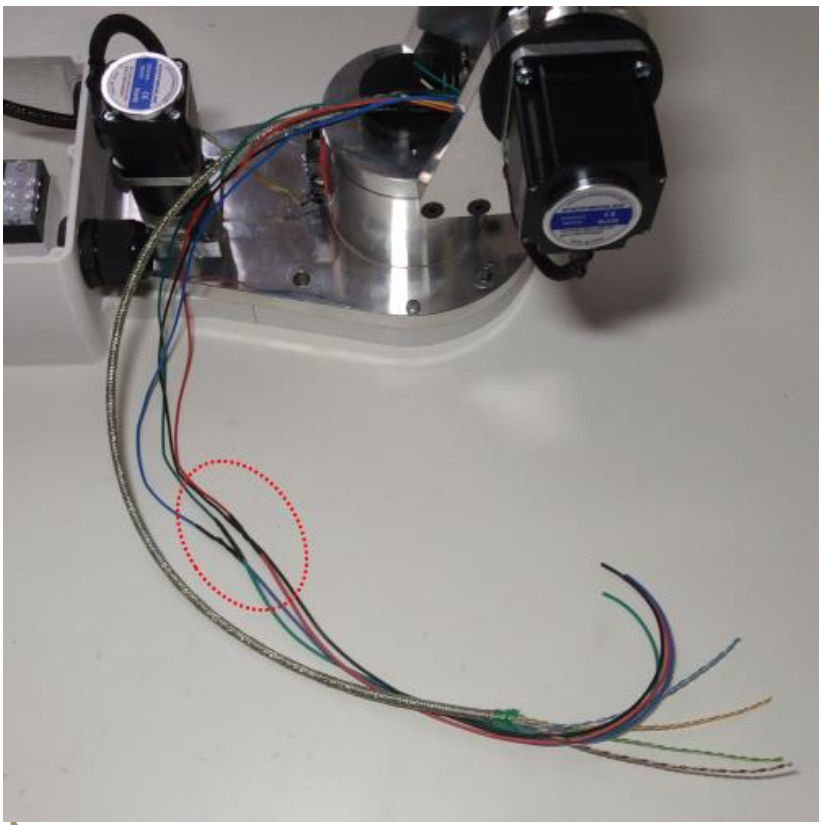
Encoder red wire to the cable brown wire.

Encoder black wire to the cable white – brown stripe wire.

Encoder brown wire to the cable white – blue stripe wire.

Encoder blue wire to the cable blue wire.

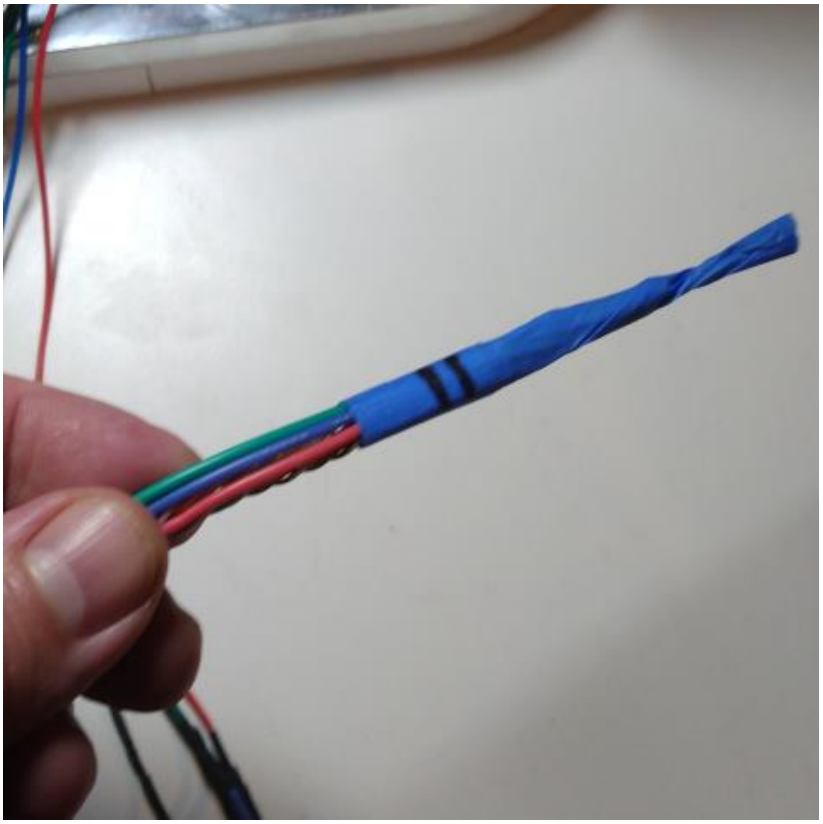
Cut Red, Black, Blue & Green 20awg wires to a length of 33cm long.



Solder and heat shrink 33cm long extension wires to the J2 motor wires as shown.

Be sure to match colors so that red goes to red and so on.

With the J2 motor wires extended the motor wires and Cat6 cable for J2 should now be the same length.



Wrap ends of J2 wires and Cat6 cable with tape and then use a marker to put (2) stripes on so that you will know these are for J2 when wires have been routed inside enclosure.

Press (1) #30204 bearing race into the J3 bearing cup.

(See notes on bearing fit in overview section)

Secure J3 bearing cup and race to end of J2 arm using (6) M3x20 flat head screws.

Install 8mm keyed shaft with 2x2mm keystock into J3 spindle.

- 8mm shaft should be 50mm long.
- 2x2mm keystock should be 25mm long if using a chain and sprocket. (shown)
- 2x2mm keystock should be 50mm long if using a belt and pulley.

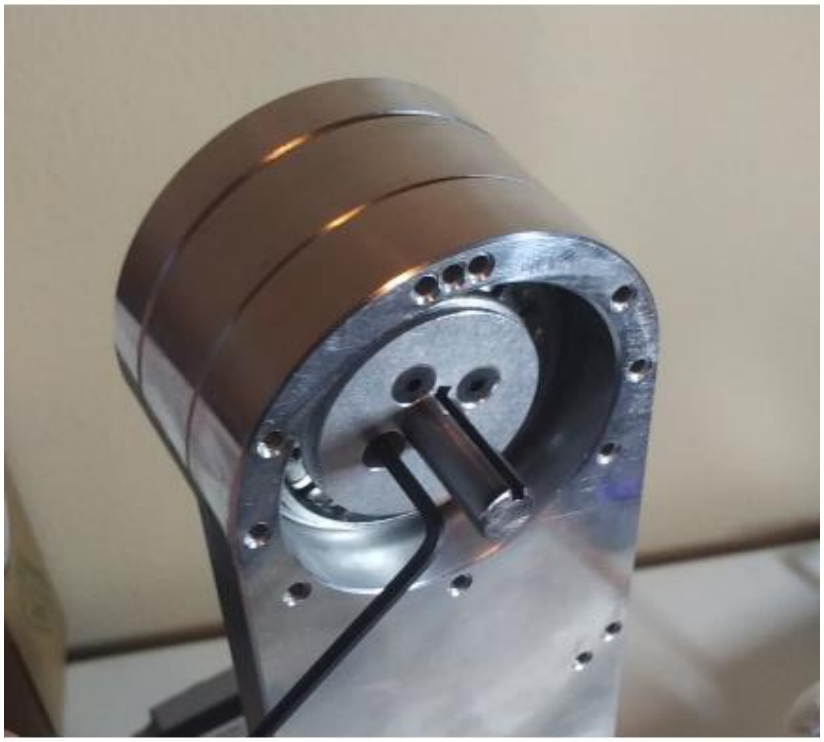
Secure shaft and key in position with M3x4 set screw

Install 35x52x4 thrust bearing and washers onto J3 spindle as shown.

Insert J3 spindle and bearing assembly into J2 arm as shown.

While holding the J3 spindle and bearing in place insert #30204 bearing over J3 spindle shaft as shown.

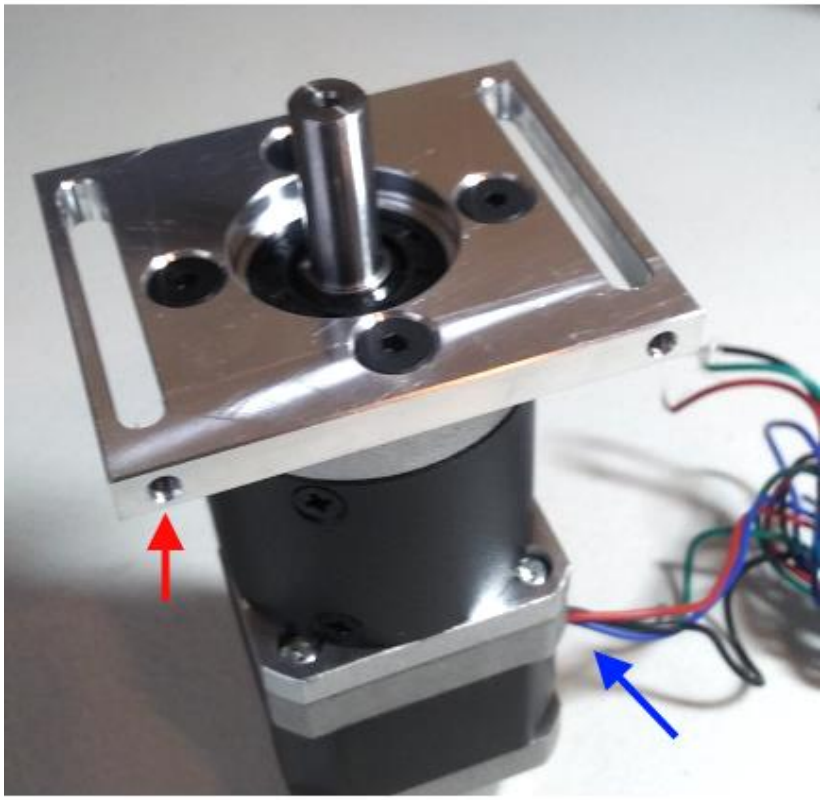
(See notes on bearing fit in overview section)



Install J3 spindle retainer and secure with (4) M3x10 flat head screws.

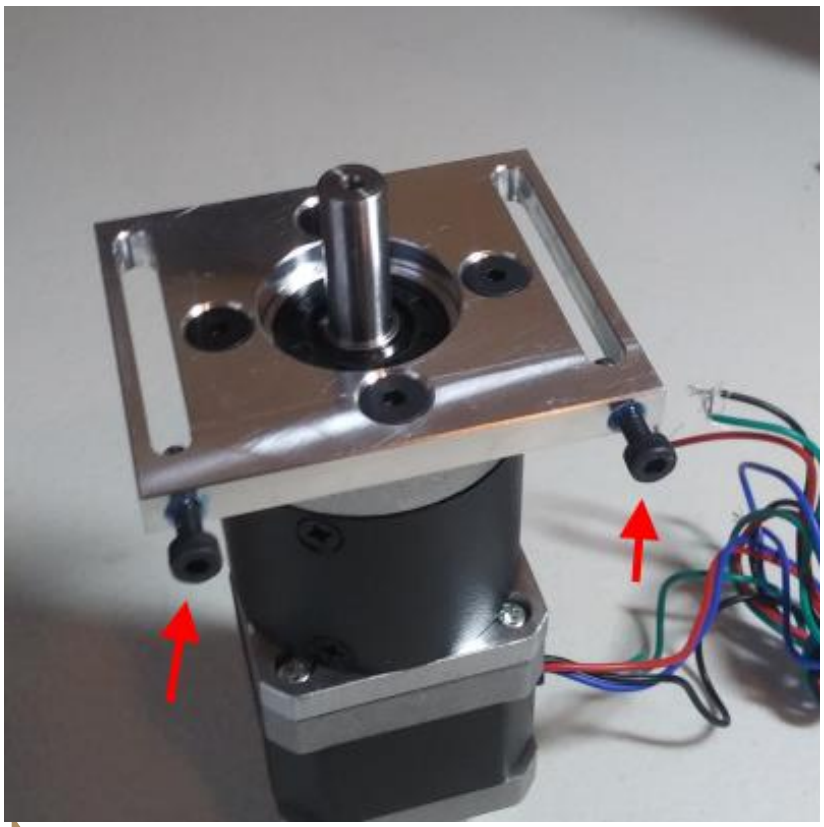
Tension screws so that there is no play in bearing but not too tight that the J3 shaft does not rotate smoothly.

NOTE: don’t forget to use small amount of medium strength loctite on screw threads.



Install J3 motor mount to J3 motor using (4) M4x10 flat head screws.

Make sure that the tension holes (red arrows) are 90° to the motor wires (blue arrows) in the orientation shown in the photo.

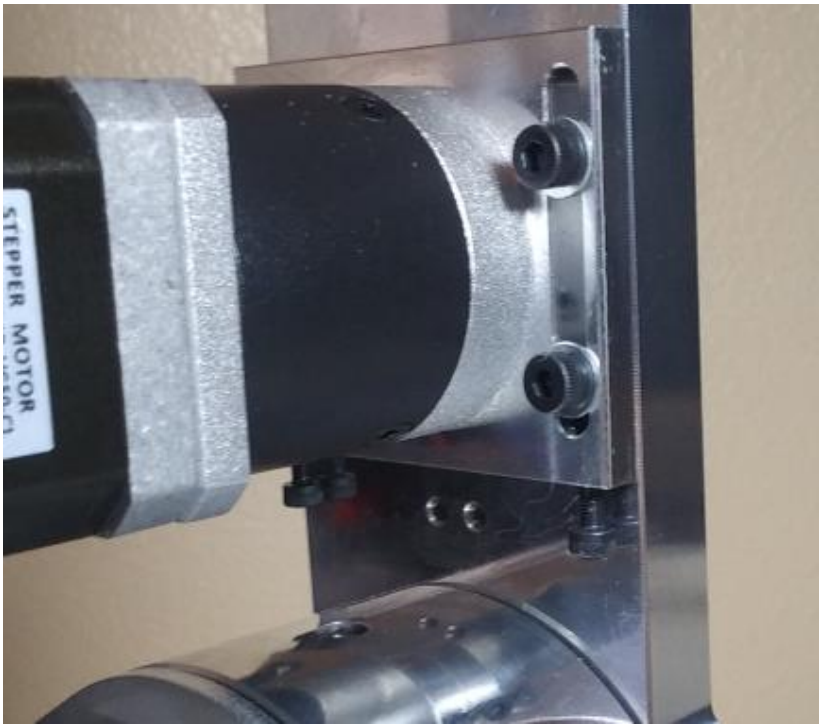


Install (2) M3x14 cap head screws into tension slot holes on J3 motor mount.

J3 BELT AND PULLEY OPTIONS

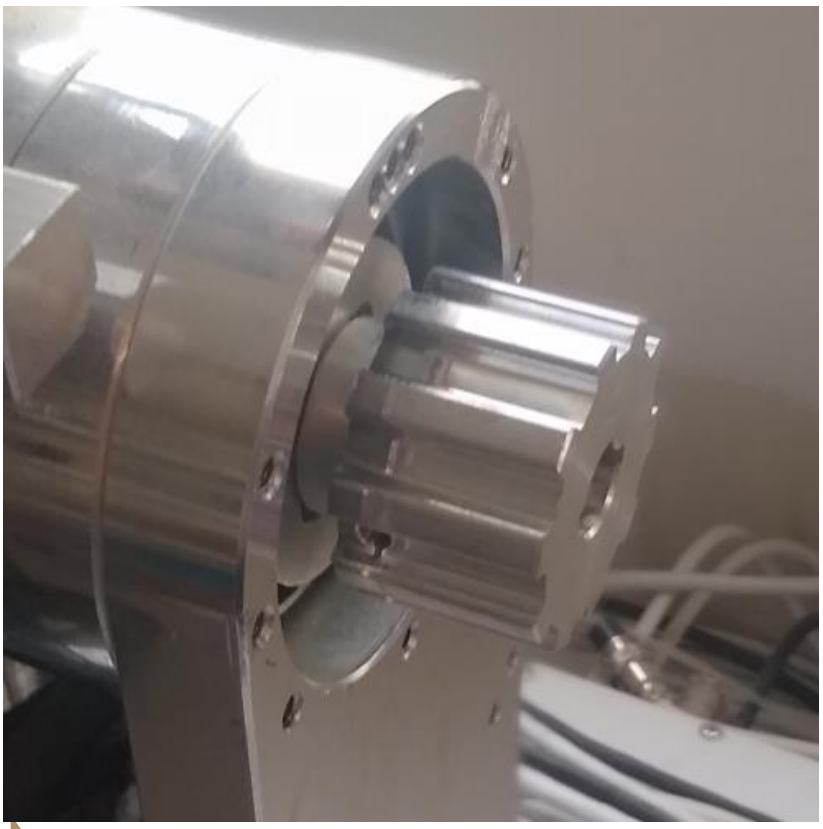
- In the following steps we are going to install the J3 drive belt (or chain).
- When designing the AR3 I tried to make as many of the components as simple as possible and out of standard thickness plate material where possible. Keeping the J2 arm and J3 motor mount as simple as possible meant the J3 motor shaft would not be exposed very far. I wanted the design to use all low cost off the shelf parts but I had trouble finding an off the shelf belt / pulley combination that would work with the limited shaft exposure so in the original design I chose to use a 6mm roller chain and sprocket as this would fit the shaft length and handle the needed torque.
- More recently I have designed a custom pulley and belt combination for the robot.
- The Annin Robotics hardware kit comes with the newer belt and pulleys but I wanted to leave the chain and sprocket in the manual as an option for those building their own robot and wanting to use off the shelf components without having to purchase a hardware kit.
- In the following pages the manual will show Option 1 using the newer custom pulley and belt, and then It will show option 2 using the off the shelf roller chain and sprocket.

OPTION 1 – J3 BELT AND PULLEY

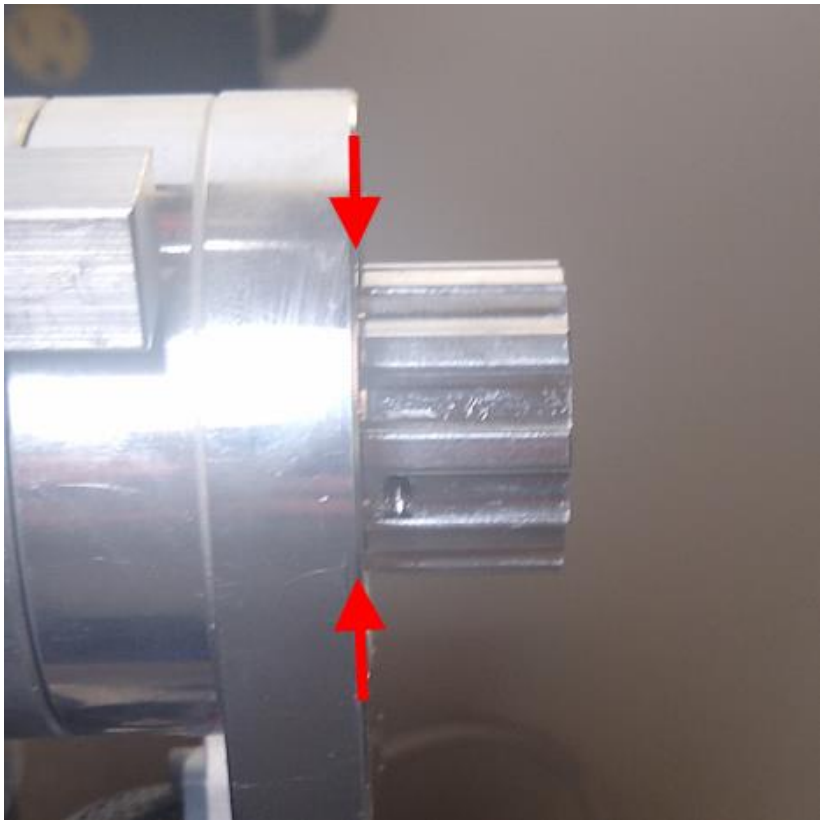


Secure J3 motor assembly to J2 arm using (4) M4x20 socket head cap screws and (4) washers.

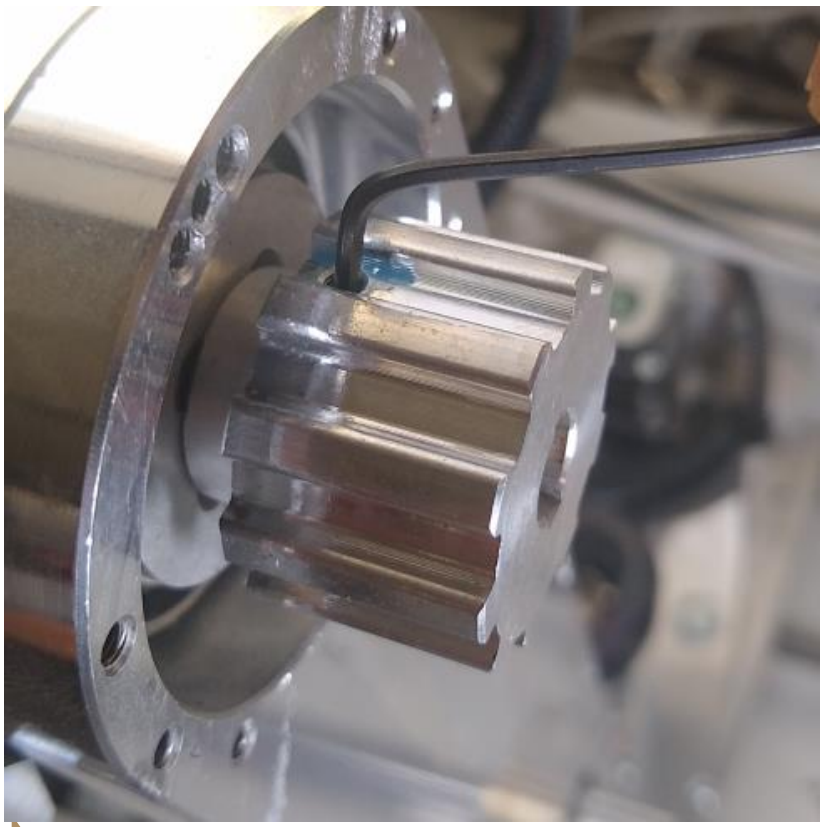
Make sure the socket head cap screws securing the motor to the arm are slightly loose so that motor can slide to apply tension in a later step.



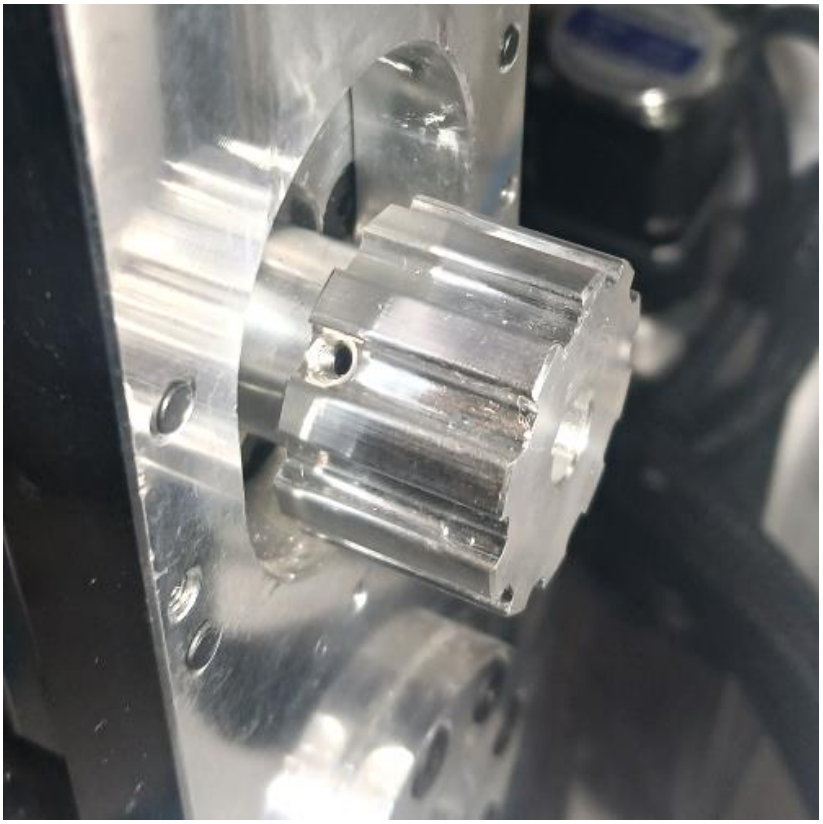
Install the L10 pulley with the short shoulder onto the J3 8mm shaft.



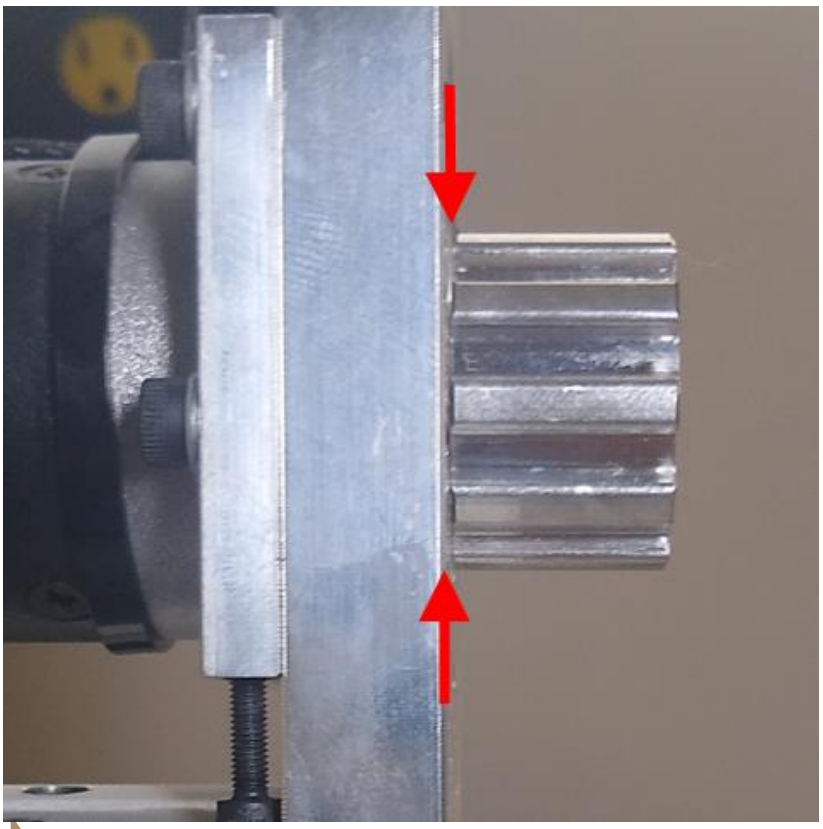
Note that the left or inside edge of pulley should be flush with J2 plate as indicated by the red arrows.



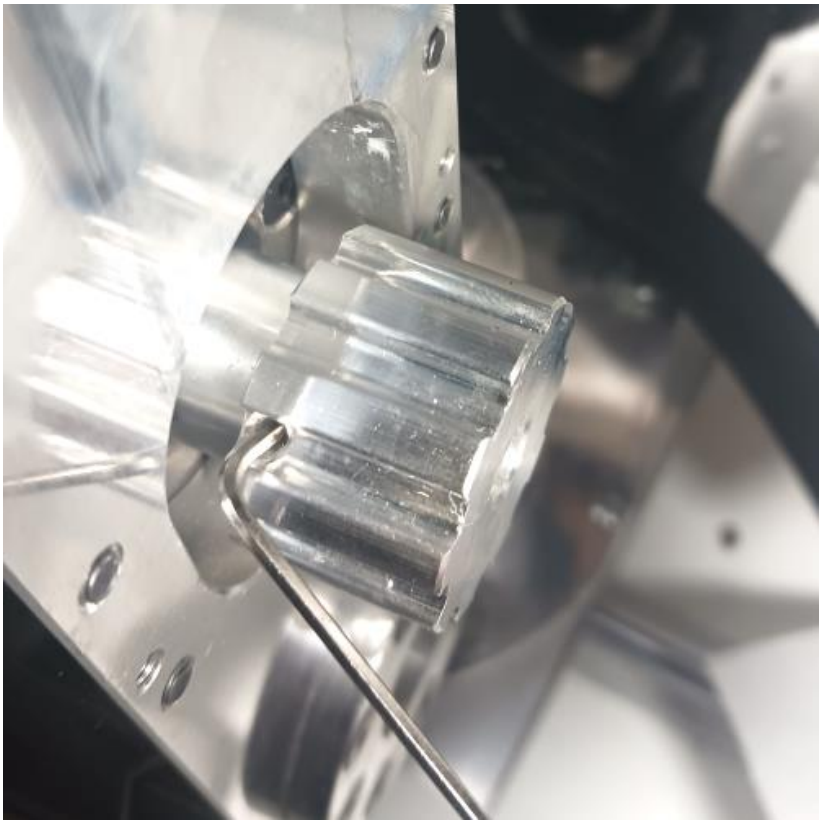
Install and tighten M3x4 set screw in threaded hole on 2mm key side of pulley.



Install the long shoulder L10 pulley onto J3 motor shaft.



Note that the left or inside edge of pulley should be flush or just slightly negative with J2 plate as indicated by the red arrows.



Install and tighten M3x4 set screw in threaded hole on 3mm key side of pulley.

The set screw should contact the very tip of key on the motor shaft.

Install 214L belt as shown over both L10 pulleys.

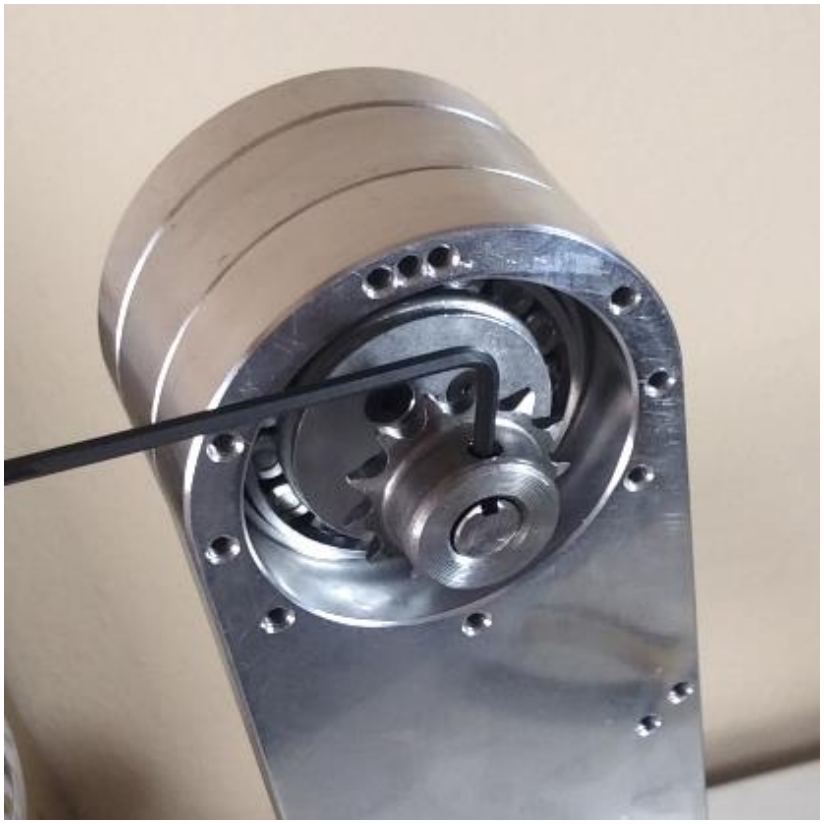
END OF OPTION 1 (belt and pulley)

OPTION 2 – ROLLER CHAIN AND SPROCKET

Standard low cost 13 tooth 8mm bore sprockets are typically blank and will need to be drilled and tapped to accept a 4mm set screw. Use a 3.3mm (#29) drill to drill (2) holed in each sprocket.

(holes should be 90° from each other)

Use 4mm tap to thread (2) holes in each sprocket.



Install 13 tooth sprocket on the J3 spindle shaft and secure with (2) M4x5 set screws as shown.

Blank low cost sprockets are not slotted for the 2mm keyway. If you have access to the proper broach tooling it is recommended that you broach the pulley for a 2mm slot.

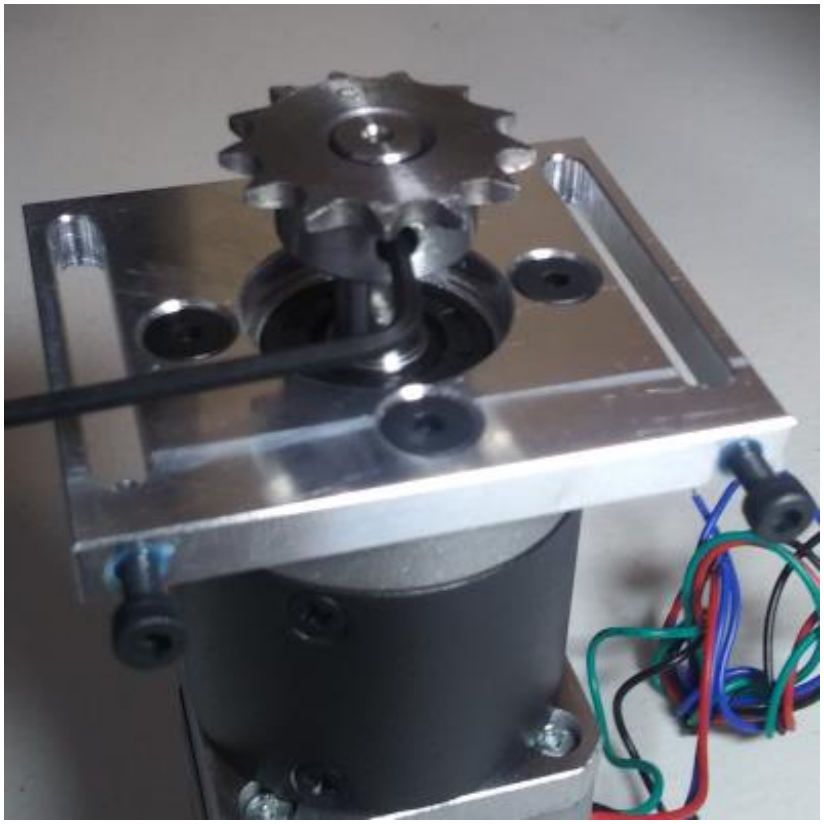
If using un-broached sprocket make sure one of the set screws is seated into J3 shaft slot.

Make sure to use Loctite and be sure both of the set screws are tight and secure.

In the following steps we will install the J3 Motor.

Standard blank sprockets are not slotted for the 3mm keyway. If you have access to the proper broach tooling it is recommended that you broach the pulley for a 3mm slot.

Alternatively you can use a pair of locking pliers to remove the key stock from the motor shaft and then seat the pulley set screw into the key slot when installing.



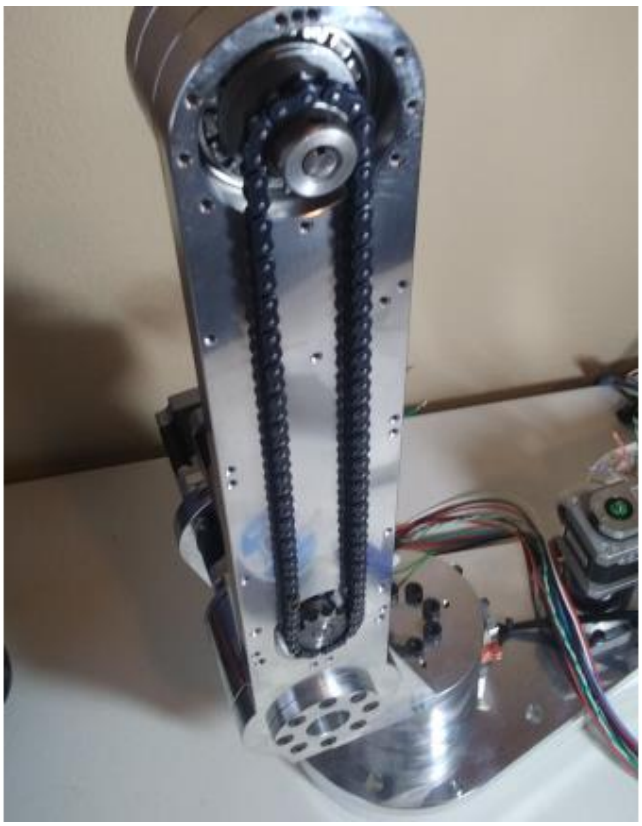
Install 13 tooth 8mm bore drive sprocket on J3 gear motor shaft as shown and tighten set screws.

If using un-broached pulley make sure one of the set screws is seated into motor shaft slot.

Make sure to use Loctite and be sure both of the set screws are tight and secure.

Cut length of 04B - 6mm chain down to length of 20-3/4” long (52.7cm). It should have 43 links.

Install master link in 04B roller chain as shown.



Install chain over top sprocket then insert J3 motor assembly and drop J3 motor sprocket into chain.

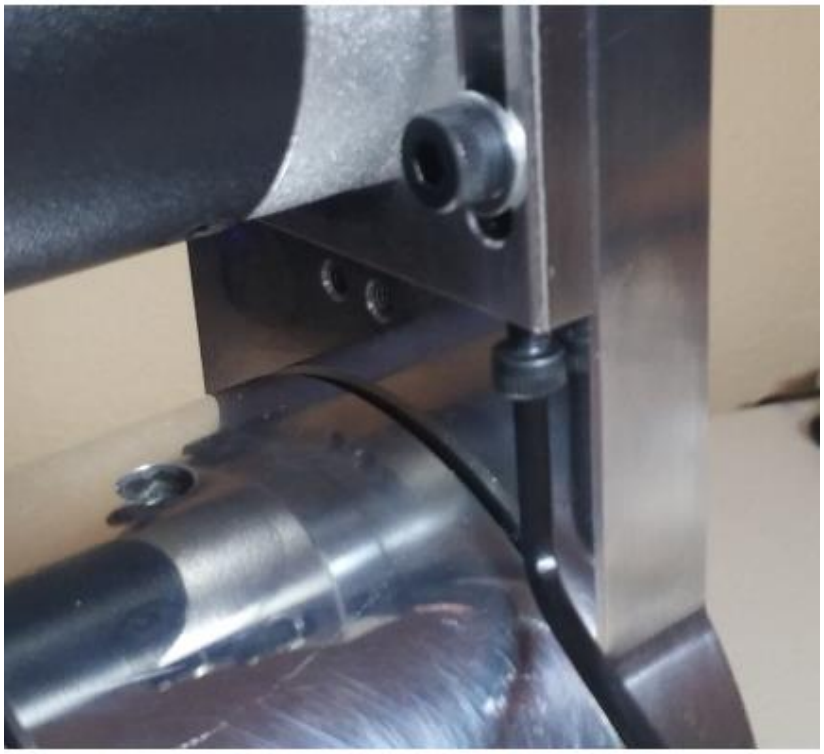
J3 motor assembly will be hanging from chain – motor will be secured in few steps.

Apply grease to chain and sprockets as shown.

Secure J3 motor assembly to J2 arm using (4) M4x20 socket head cap screws and (4) washers.

Make sure the socket head cap screws securing the motor to the arm are slightly loose so that motor can slide to apply chain tension.

END OF OPTION 2 (chain installation)



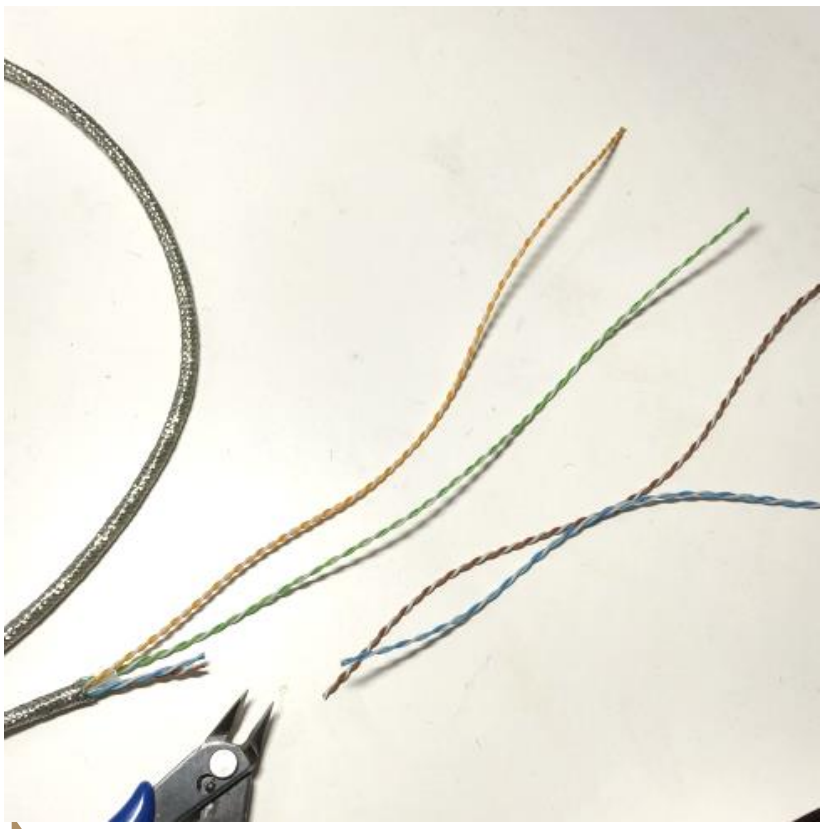
Tighten M3 tension screws until there is moderate tension on belt (or chain).

After belt is tensioned tightened finish securing the J3 motor mount by tightening the (4) M4x20 motor mount screws.

For joint 3 cut length of continuous flex Cat6 cable to a length of 120cm long and remove outer jacket. (see overview section on jacket removal)

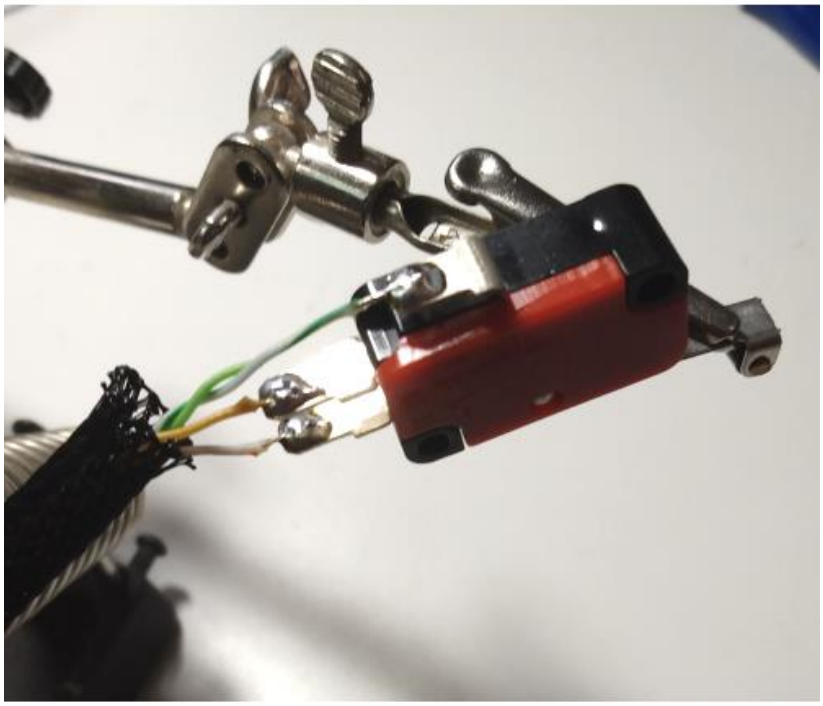
Remove 12cm of shielding from one end of the cable and remove 25cm of shielding from the other end. (see overview section on removing shielding)

The end with 12cm of shielding removed will be the end of the cable that is routed to the base enclosure.



From the end of cable that has 25cm of shielding removed - cut and remove 22cm of the brown and blue twisted pairs leaving 3cm of wire exposed.

Cut length of ¼” braided sleeve to a length of 23cm long then route green and orange twisted pairs through sleeve as shown.



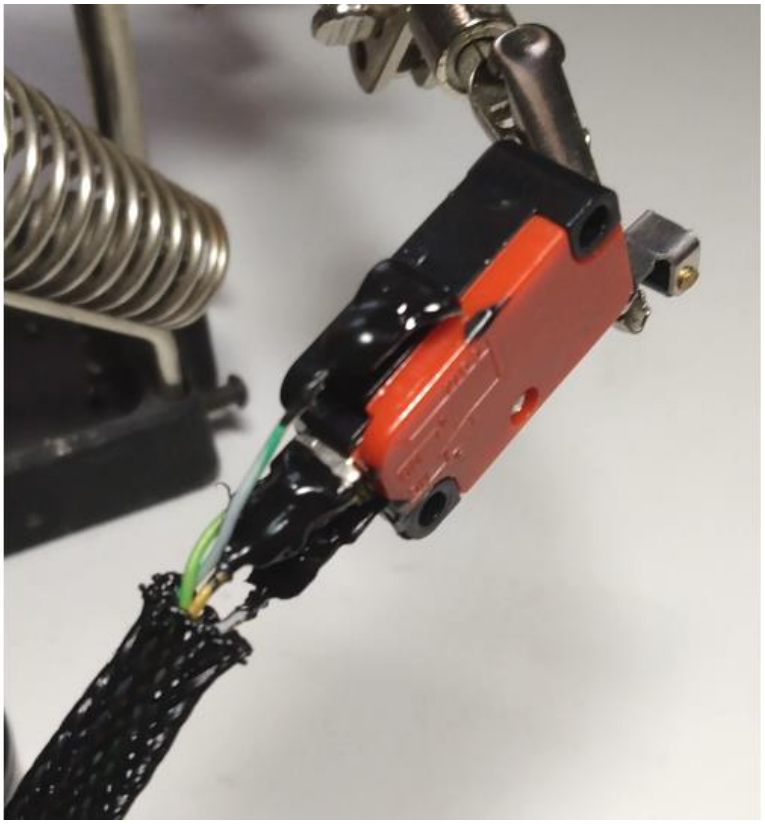
Solder orange wire to “NO” terminal of SV-156-1C25 roller tip limit switch.

Solder white with orange stripe wire to the “NC” terminal.

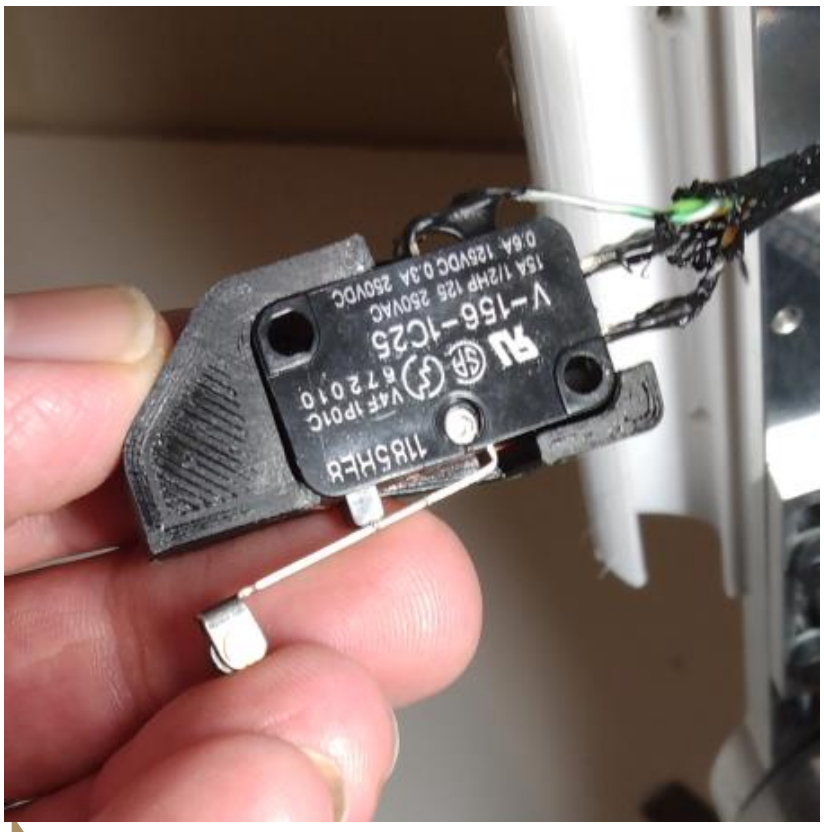
Solder the white with green stripe wire to the “COM” terminal.

Note: the green wire is not used.

(also see wiring diagrams in chapter 4)

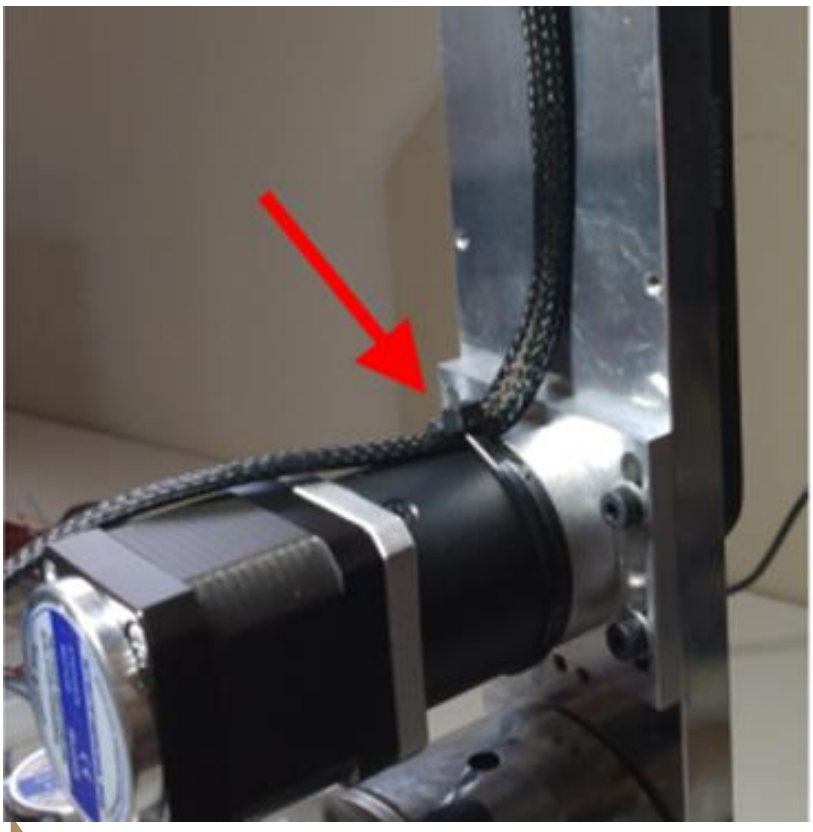


It is recommended to use liquid electrical tape to insulate terminals on limit switch.

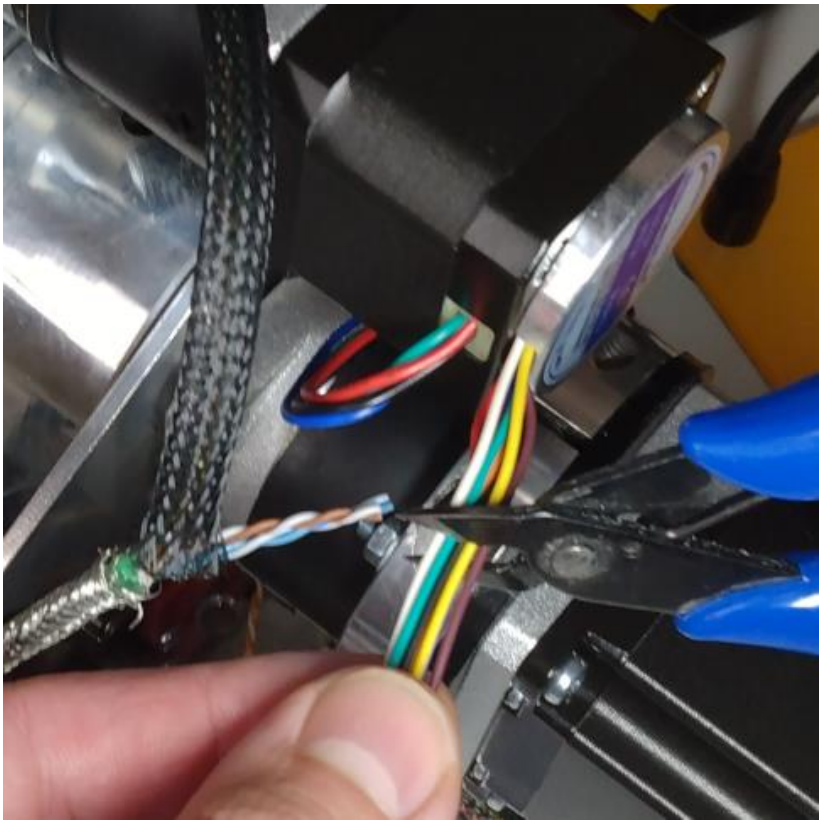


Insert the J3 limit switch into the 3D printed J3 Stop as shown in the photo.

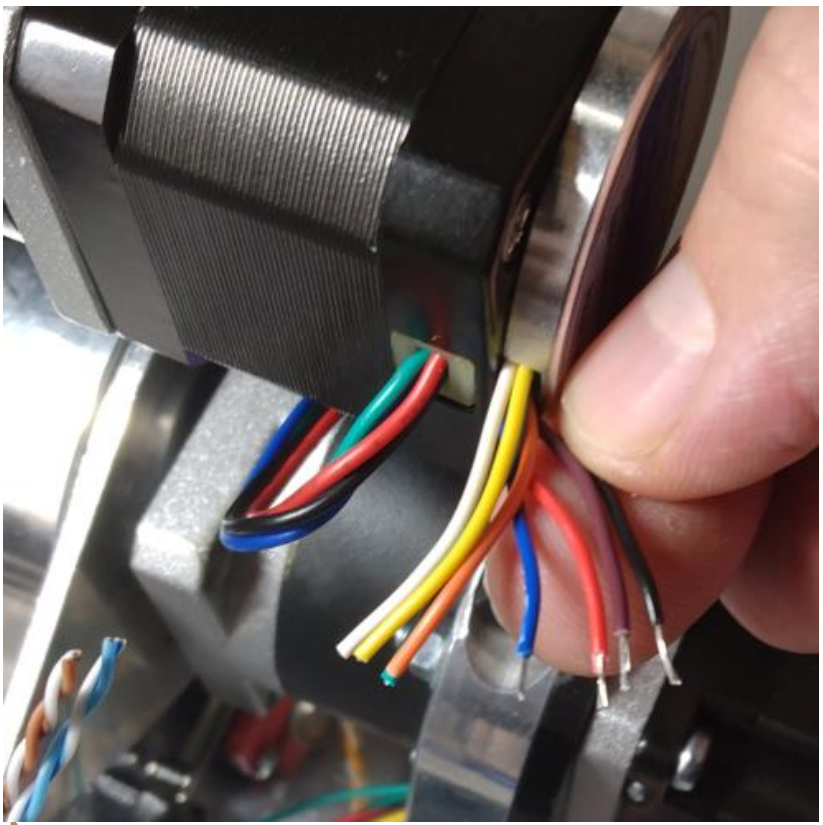
Use (2) M3x14 Philips pan head screws to secure J3 limit switch with J3 Stop onto J2 arm as shown.



Use cable tie to secure J3 limit switch wire and braided sleeve to J3 gear box (red arrow).

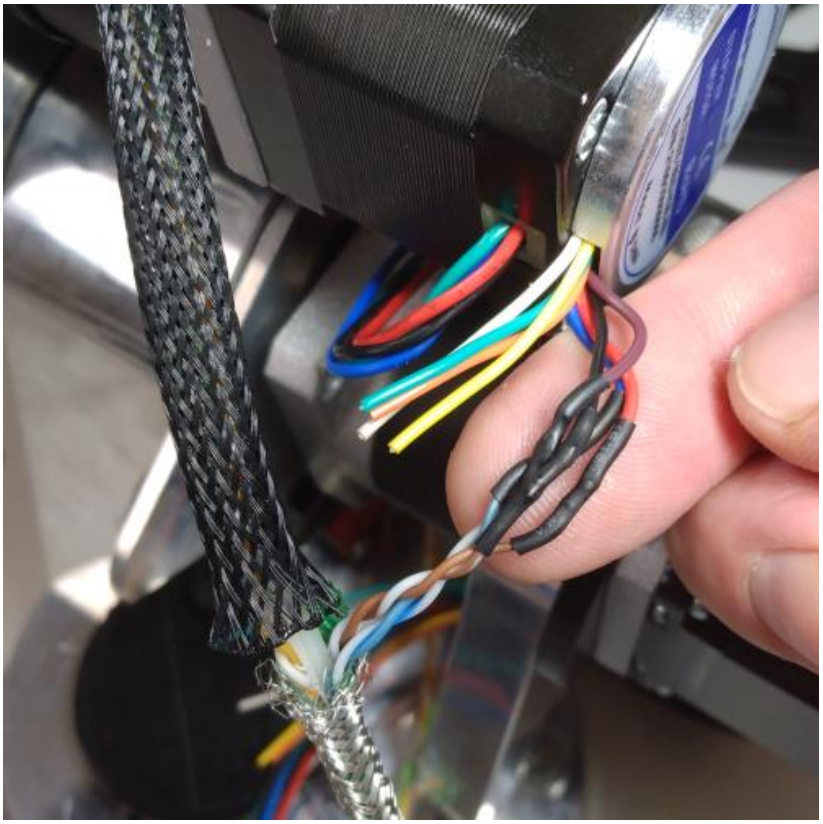


Cut the J3 encoder wires to a length of 4cm.



Use wire strippers to strip end of the red, black, brown and blue J3 encoder wires.

Note: only these 4 encoder wires will be used.



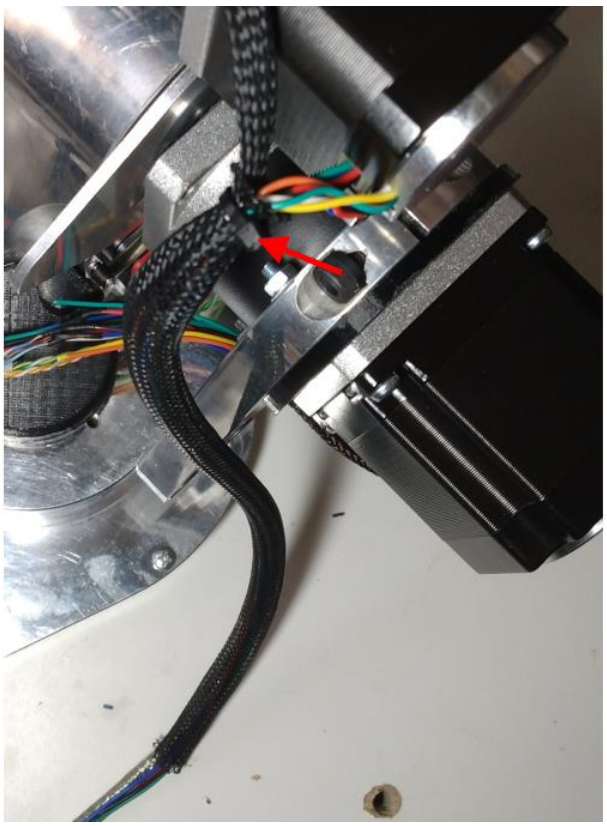
Solder and heat shrink the connection from the J3 encoder to the Cat6 cable as follows:

Encoder red wire to the cable brown wire.

Encoder black wire to the cable white – brown stripe wire.

Encoder brown wire to the cable white – blue stripe wire.

Encoder blue wire to the cable blue wire.



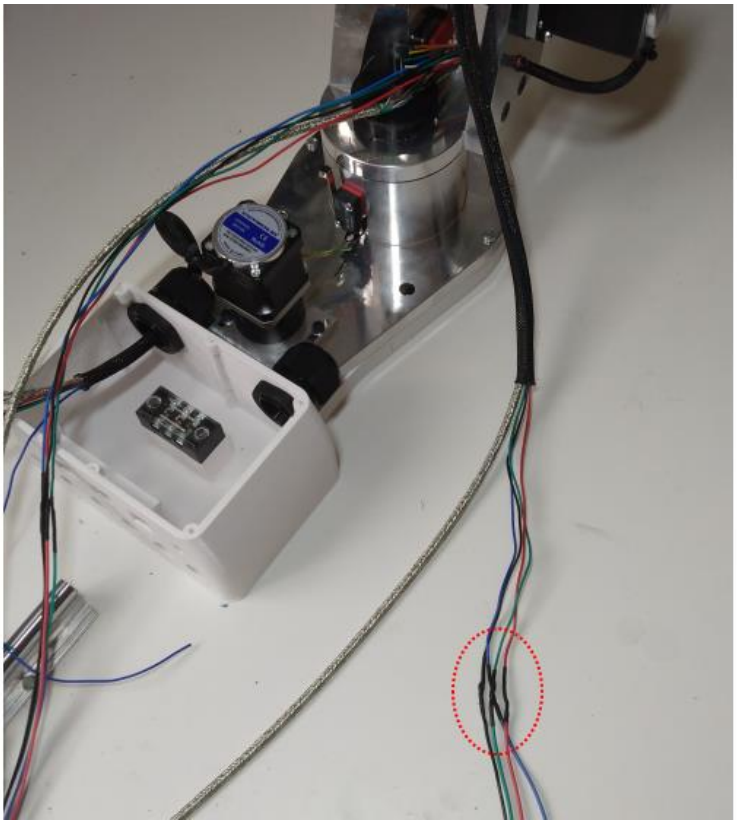
Cut length of 3/4” braided sleeve to a length of 35cm long then route J3 motor wires and J3 Cat6 cable through sleeve as shown.

Secure end of sleeve with cable tie (red arrow).

It is recommended to coat the exposed encoder and motor wires with liquid electrical tape.

Applying the liquid electrical tape can also be done later after fully testing the robot electrically.

Cut Red, Black, Blue & Green 20awg wires to a length of 50cm long.

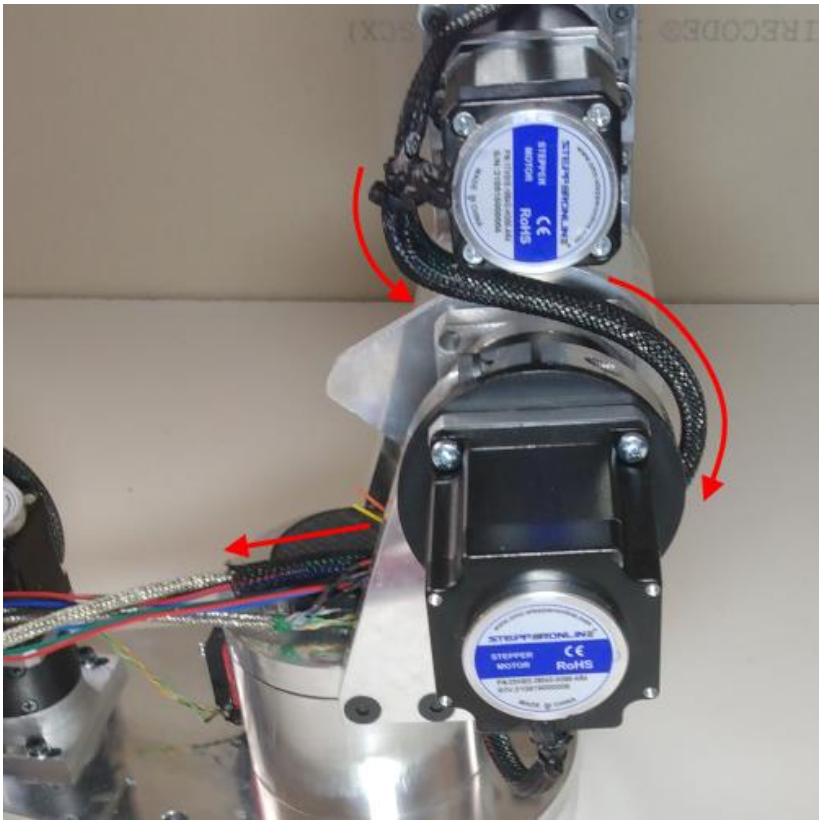


Solder and heat shrink 50cm long extension wires to the J3 motor wires as shown.

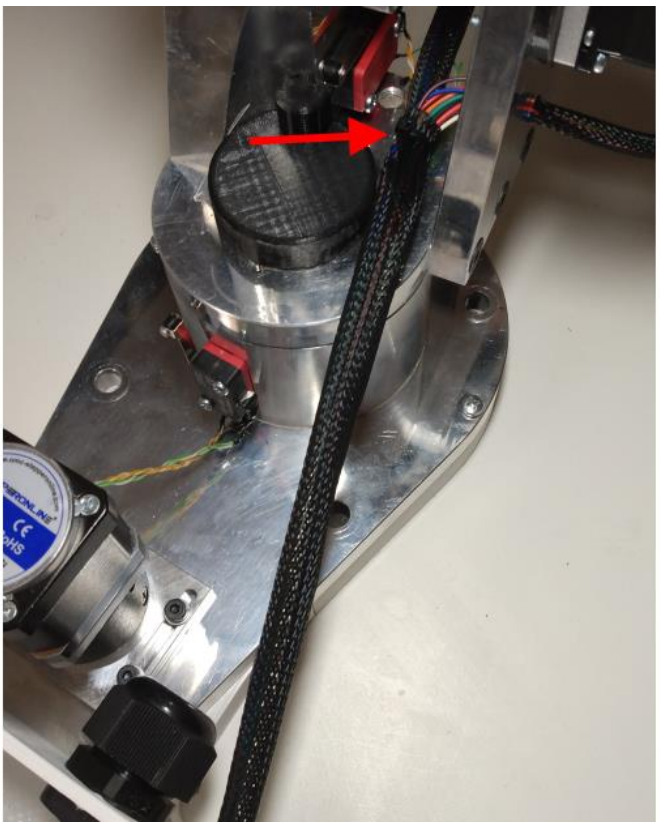
Be sure to match colors so that red goes to red and so on.

With the J3 motor wires extended the motor wires and Cat6 cable for J3 should now be the same length.

Wrap ends of J3 wires and Cat6 cable with tape and then use a marker to put (3) stripes on so that you will know these are for J3 when wires have been routed inside enclosure.



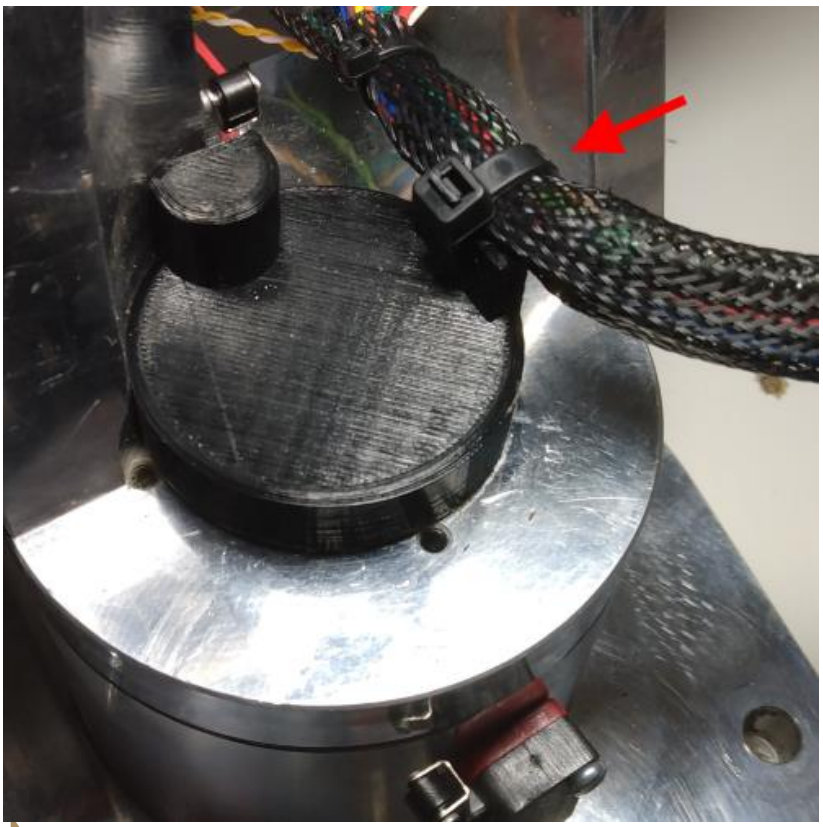
Route J3 motor and Cat6 wires over and then under the J2 gearbox and through center of robot as shown.



Cut length of 3/4” braided sleeve to a length of 60cm long then route all of the J2 and J3 wires and cables through sleeve.

Use cable tie to secure end of sleeve to bundle of wires and cables (red arrow).

Route the J2 / J3 wire loom along with the J1 wires into the left enclosure gland nut as shown.



Secure J2 / J3 wire loom to J1 stop with cable tie as shown (red arrow).

Install J2 upper side cover and upper side cover spacer as shown.

Secure with (2) M3x25 Philips head pan screws.

Install J2 lower side cover and side cover spacer as shown.

Install remaining M3x25 Philips head pan screws.

There are a total of (16) screws.

Secure AR4 logo into recess in J2 side cover using epoxy.

Press (2) B-1616 needle roller bearings into the J3 turret housing (install one on each side).

(See notes on bearing fit in overview section)

Secure J4 turret housing to J3 spindle using (2) M4x14 flat head screws (center) and (4) M4x10 cap screws (outer).

Use an M4 tap to thread each of the (4) holes around the perimeter of the J4 Timing Pulley.

Use an M4 tap to thread each of the (4) holes on the face of the J4 Timing Pulley as shown.

Secure J4 timing hub to J4 main shaft and make sure one of the perimeter threaded holes aligns with the 2nd hold in J4 main shaft (yellow arrow)

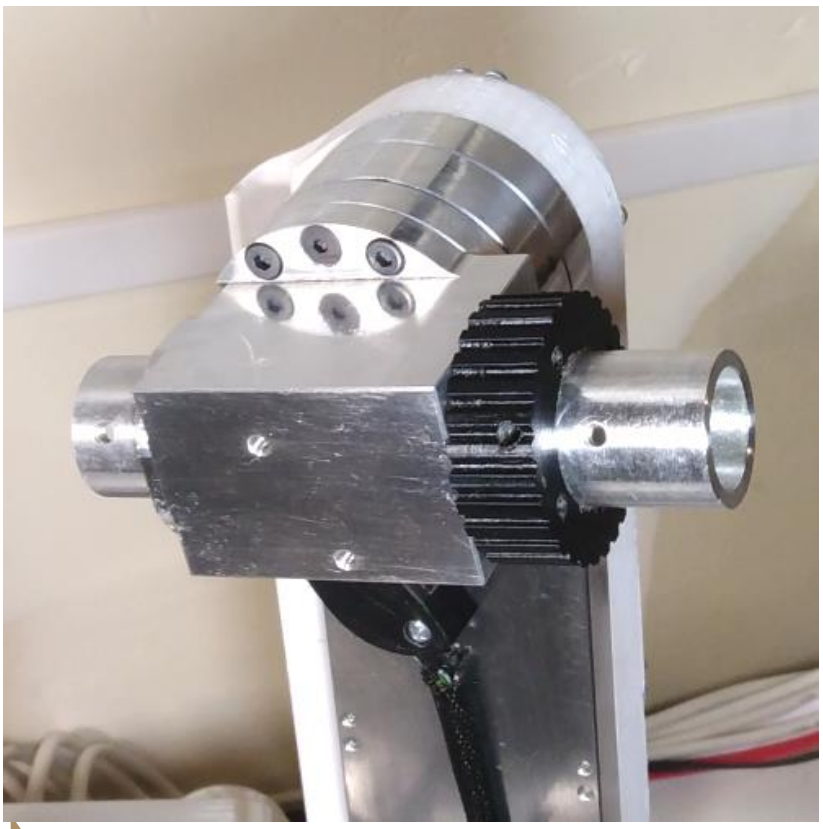
Install (1) M4x10 set screw into the threaded hole that aligns with the 2nd hole in J4 main shaft (yellow arrow) – make sure set screw threads into J4 main shaft approx. 3 turns. This screw locks the alignment of the pulley and shaft.

Install and snug (3) M4x5 set screws in the remaining perimeter holes.

Install (1) TRD1625 (.126” thick) bearing washer over J4 main shaft and into J4 timing hub recess as shown.

Install (1) NTA1625 (1” ID) need roller bearing over J4 main shaft and into J4 timing hub recess as shown.

Install (1) TRA1625 (.032” thick) bearing washer over J4 main shaft and into J4 timing hub recess as shown.

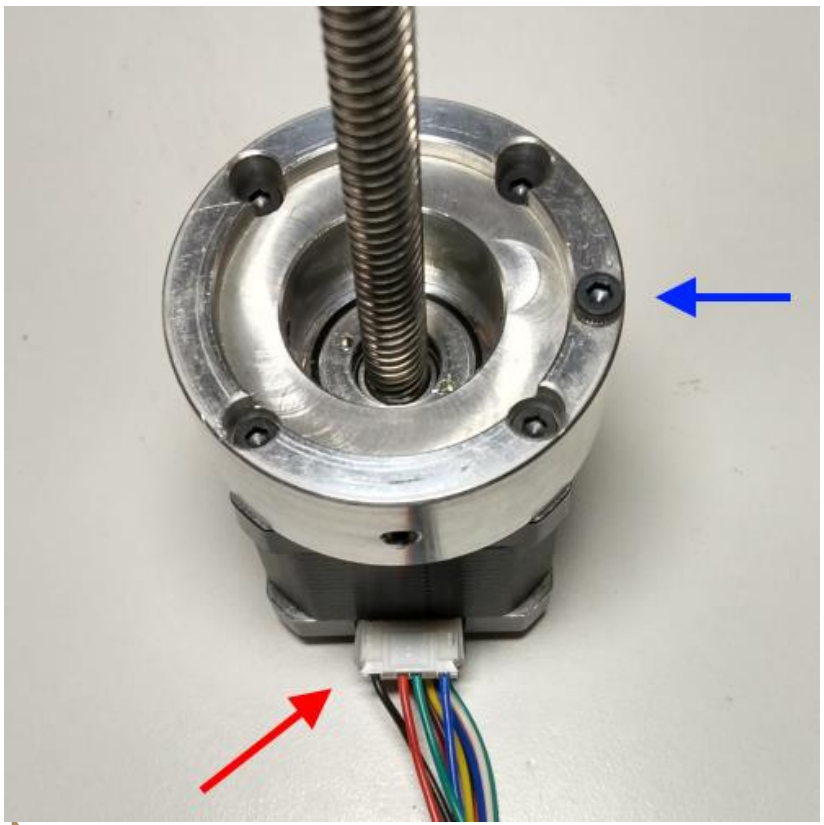


Install J4 tube / timing hub assembly into the J4 turret as shown.

Make sure bearings are fully seated in timing hub recess and flush to J4 turret housing.

Install (1) M3x5 socket head cap screw into J5 motor housing as shown.

This screw serves as a timing lug for the J4 limit switch.



Secure J5 motor mount using (4) M3x18 socket head cap screws.

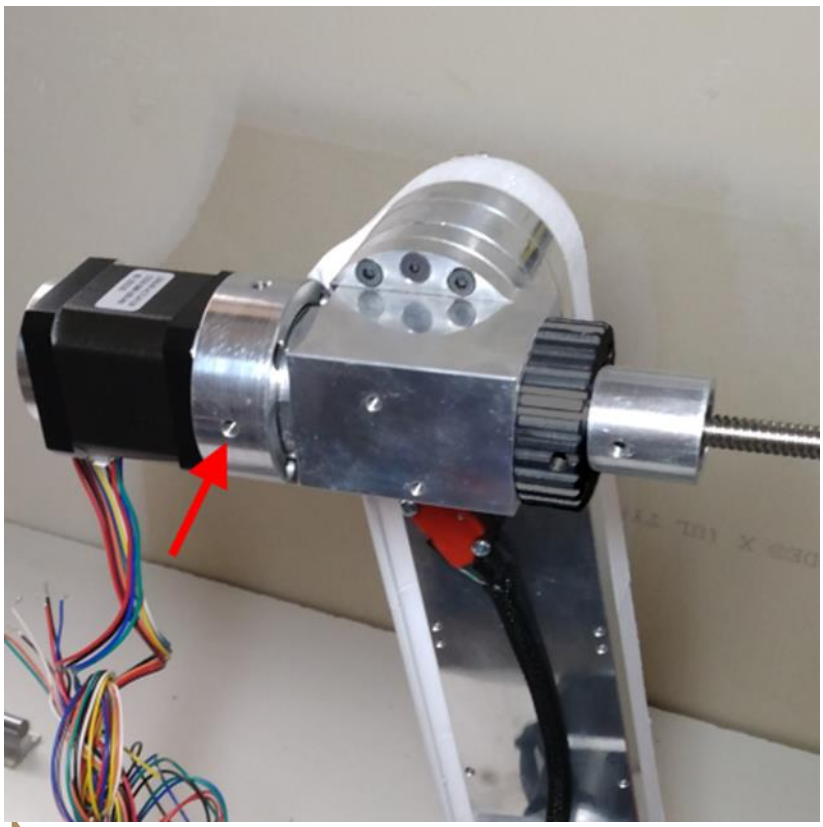
Note the motor connector is facing downward (red arrow) and the timing lug screw is 90° to the right (blue arrow).

NOTE: the M3 threaded holes in motor can be shallow, if you find that the motor mount is not tight you may need to grind one or two threads from end of M3x18 cap screws.

Install (1) TRA1625 (.032” thick) bearing washer over J5 motor shaft and into J5 motor mount recess as shown.

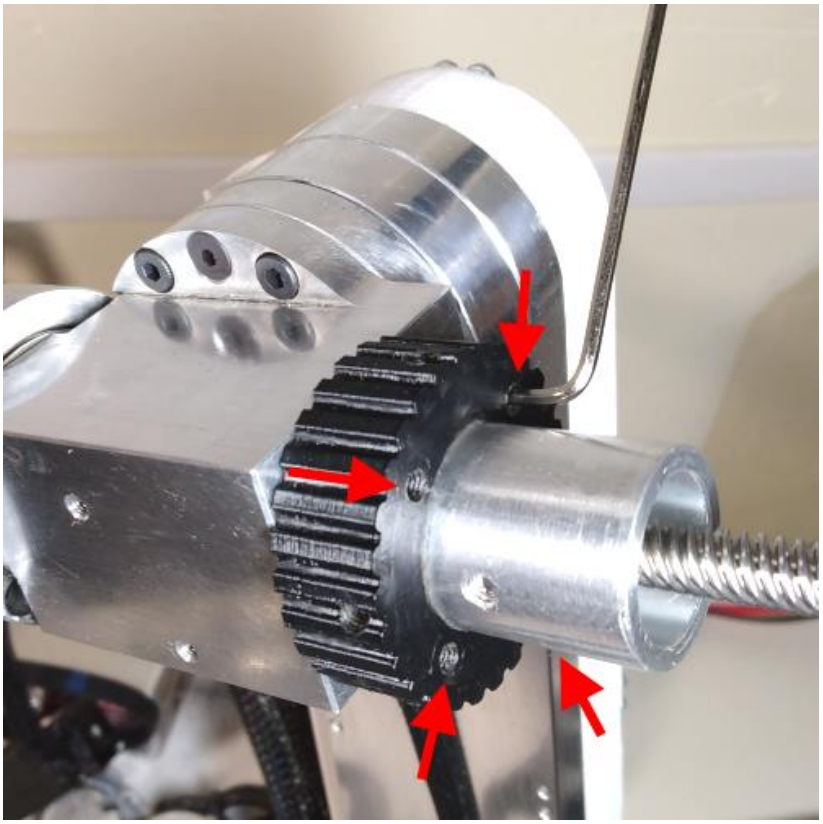
Install (1) NTA1625 (1” ID) need roller bearing over J5 motor shaft and into J5 motor mount recess as shown.

Install (1) TRA1625 (.032” thick) bearing washer over J5 motor shaft and into J5 motor mount recess as shown.



Install J5 motor assembly into J4 main tube as shown.

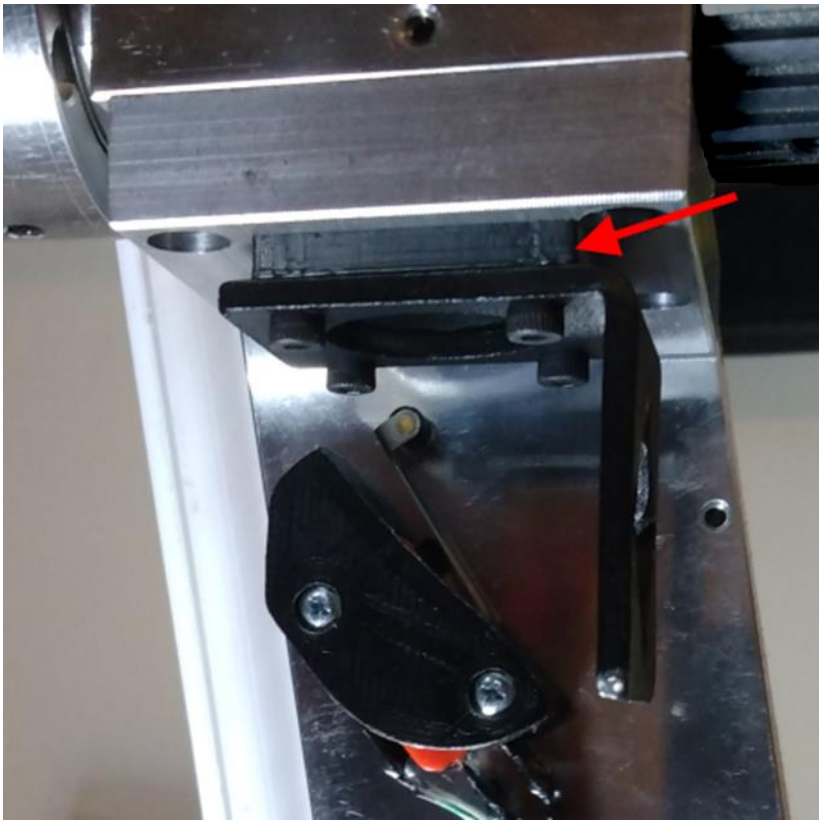
Be careful that bearings stay in place in J5 motor mount and slide over the end of the J4 main tube. When J5 motor mount is fully seated over J4 main tube and bearings are flush to J4 housing secure J5 motor mount to J4 tube using (4) M4x10 set screws. With motor connector facing down the set screw facing out (red arrow) should seat into hole in J4 main shaft.



Install (4) M4x5 set screws into J4 timing hub in locations shown with red arrows.

Don’t forget to apply loctite to set screws and then apply light tension to each screw, these screws will apply tension on all of the J4 bearings. Make sure screws are tensioned such that there is no play in bearing but not too much tension so that the motor and shaft still spin freely in housing.

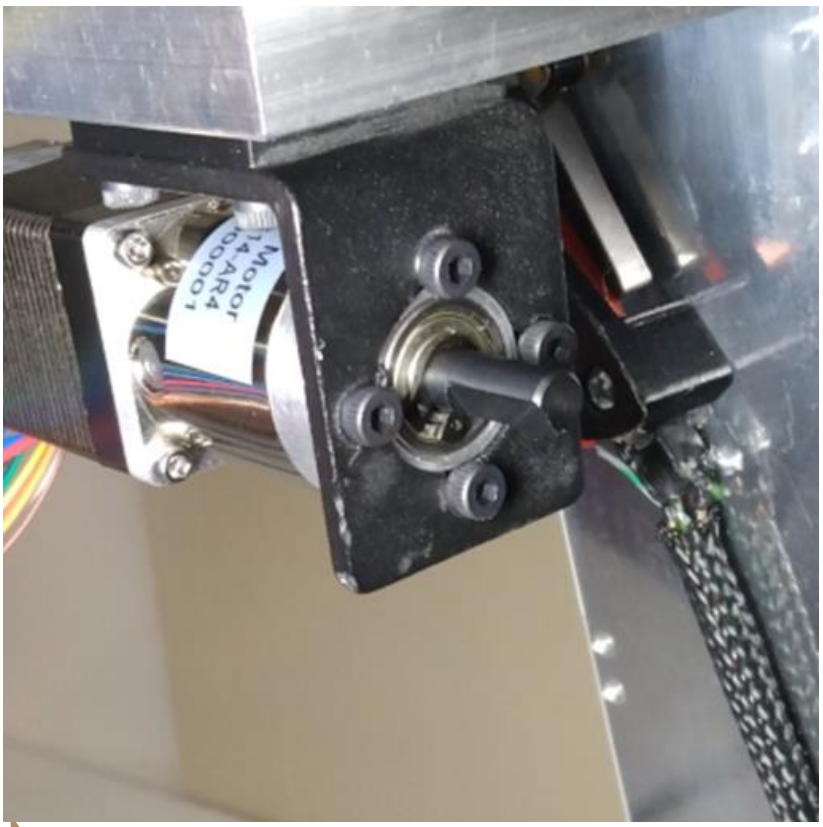
Install J4 motor mount / limit switch contact block as shown and secure with (3) M4x10 socket head cap screws.



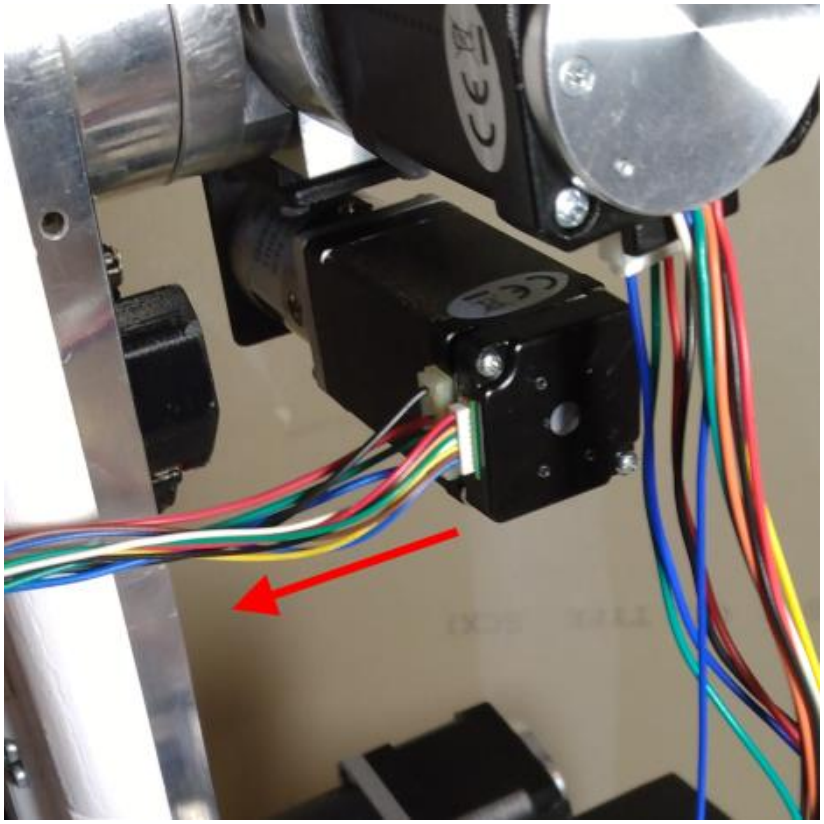
Install Nema 11 motor mount bracket as shown, place the 3D printed part “J4 motor spacer – 4mm” between the bracket and the aluminum (red arrow).

Secure with (4) M3x14 socket head cap screws.

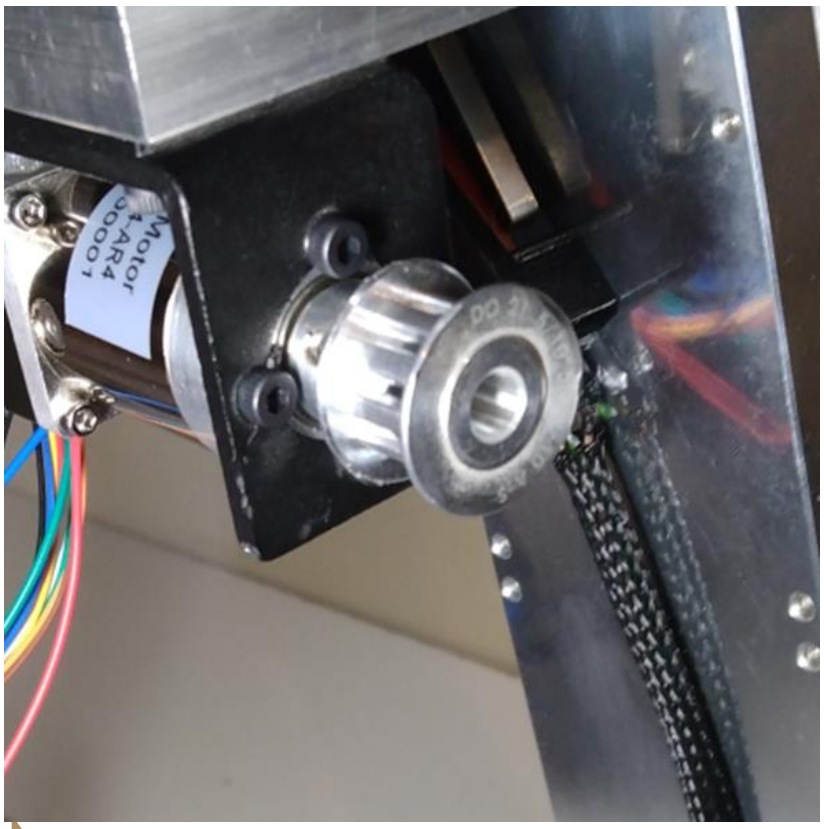
The covers and spacers print files comes with 2mm, 3mm, 4mm and 5mm thicknesses of the “J4 motor spacer” so that you have some options to tension the belt given variation in the belt. If you are printing a 3D printed version I have found the 2mm spacer may fit best depending on your printer and filament material used.



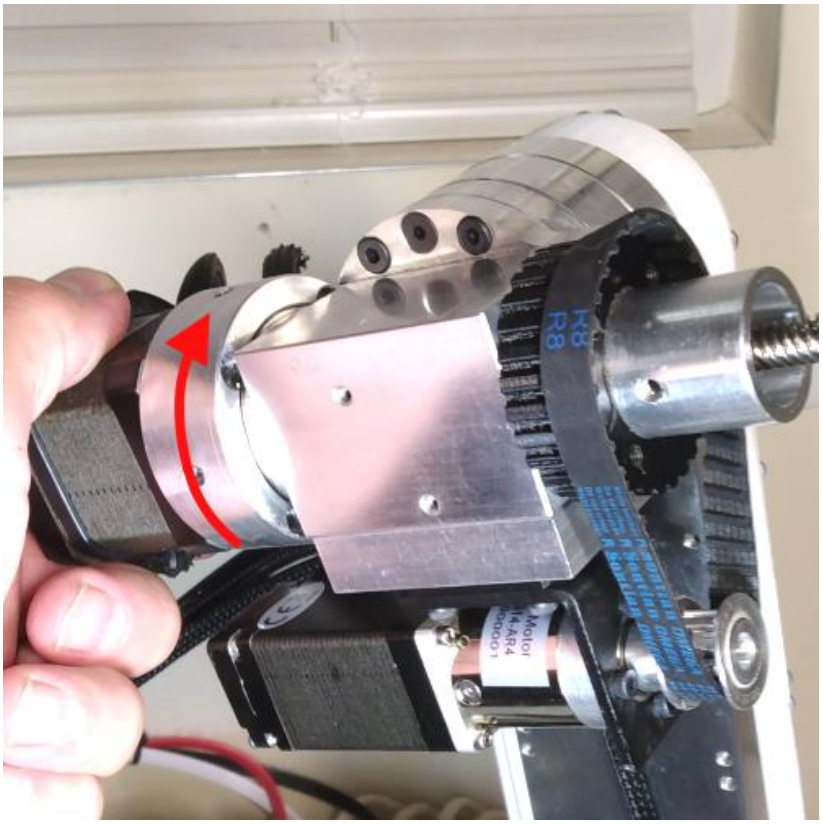
Install J4 motor and secure with (4) M3x8 socket head cap screws.



When installing the J4 motor make sure the motor and encoder wires are facing in toward the J2 arm as shown.



Install XL 10 tooth 6mm bore drive pulley onto J4 motor shaft and secure with (2) M3x4 set screws.



Install 84XL037 timing belt.

Place belt over the 10 tooth J4 motor pulley and then up over the main shaft sprocket – rotate the J5 / J4 assembly as belt rolls onto sprocket.

Countersink the (3) holes in POM nut that came with the J5 linear screw motor.

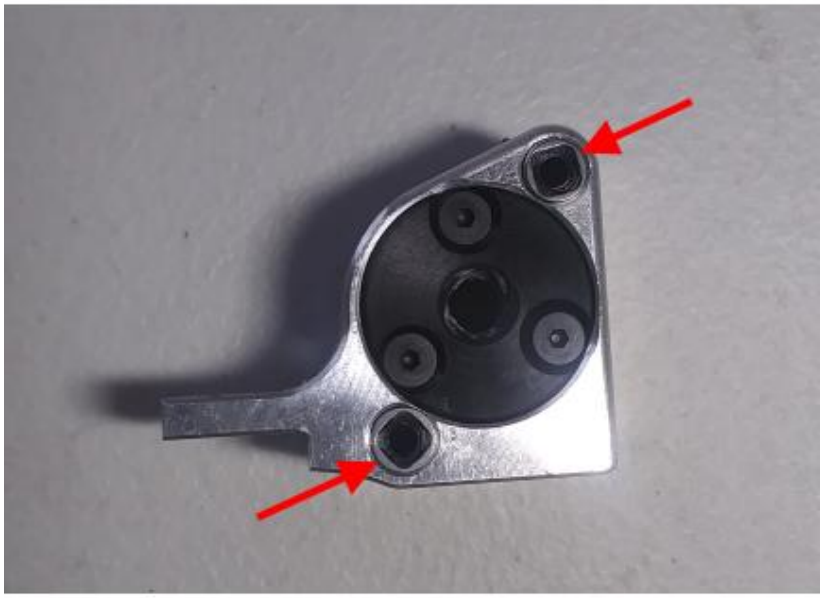
Install POM nut into the J5 carrier as shown and secure with (3) M3x10 flat head screws.

Before installing the 3mm shaft bearings into the J5 carrier check to see that they slide easily and smoothly over the 3mm rods.

DO NOT FORCE BEARINGS OVER RODS

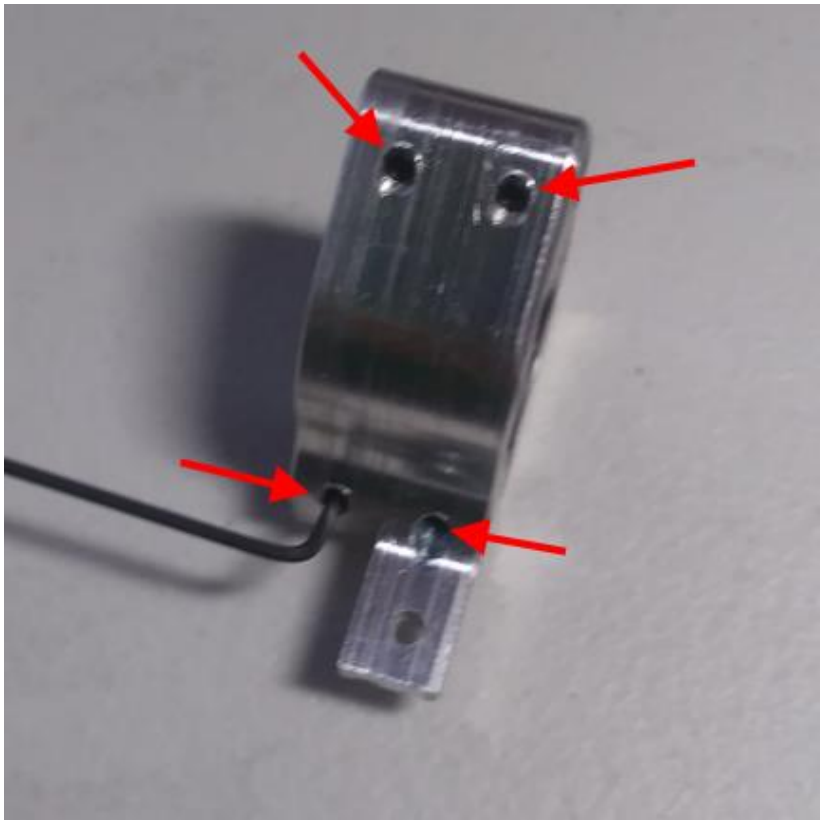
- the inner ball bearings can be dislodged if forced.

- If variation / tolerance in either bearings, rods or rod surface finish result in a slightly tight fit or a rough fit use a drill and scotch-brite or fine steel wool to polish rods – make sure rods slide into bearings easily and smoothly.



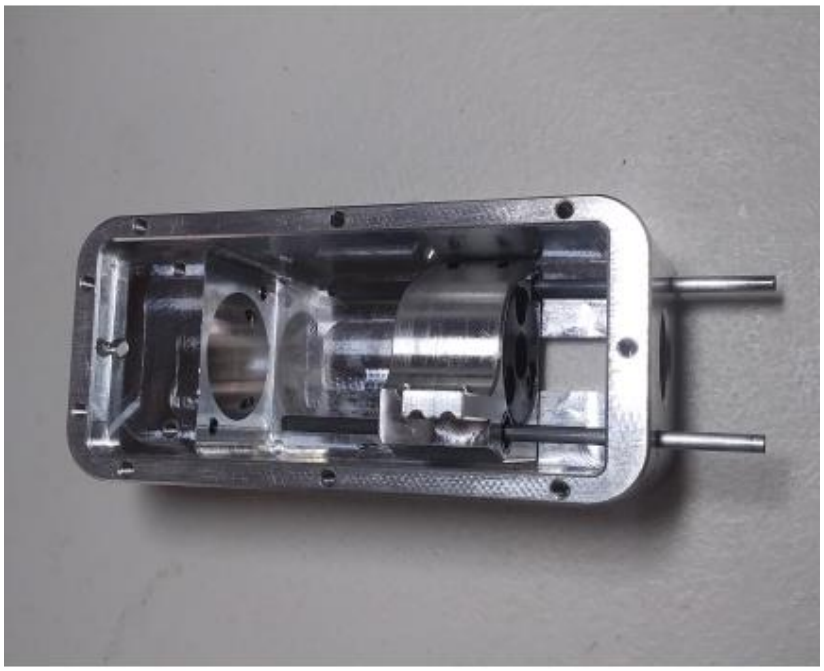
Install (4) LM3UU 3mm shaft bearings into J5 carrier.

Install 2 bearings per side – pictures shown 2 installed on front side of carrier, also install 2 on back side.

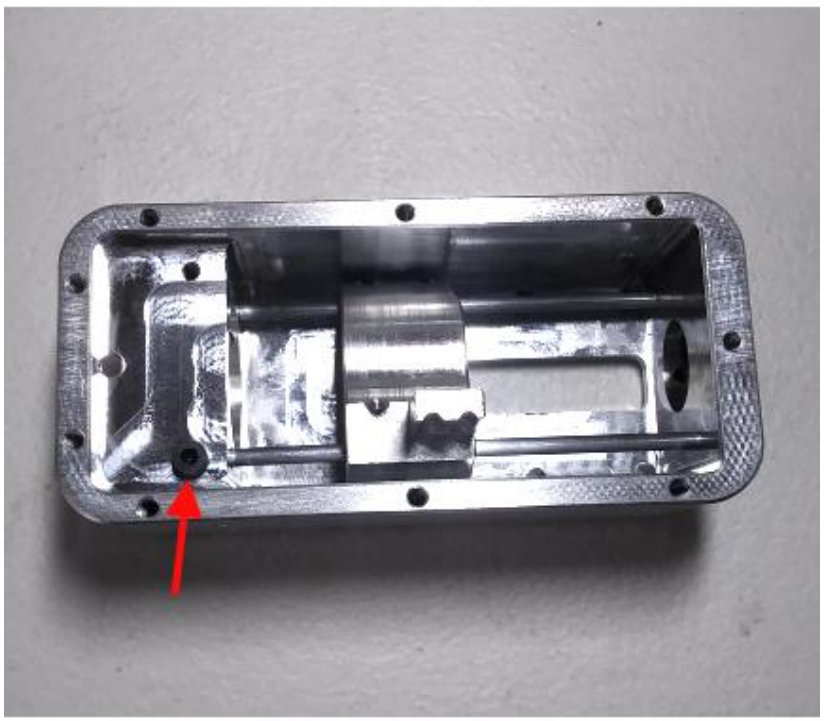


Secure bearings in carrier using (4) M3x4 set screws.

The rods that come with the hardware kit are already 85mm long but if you have sourced your own rods they typically come in lengths of 100mm and you would need to use an abrasive saw to cut (2) 3mm linear rods down to 85mm in length.

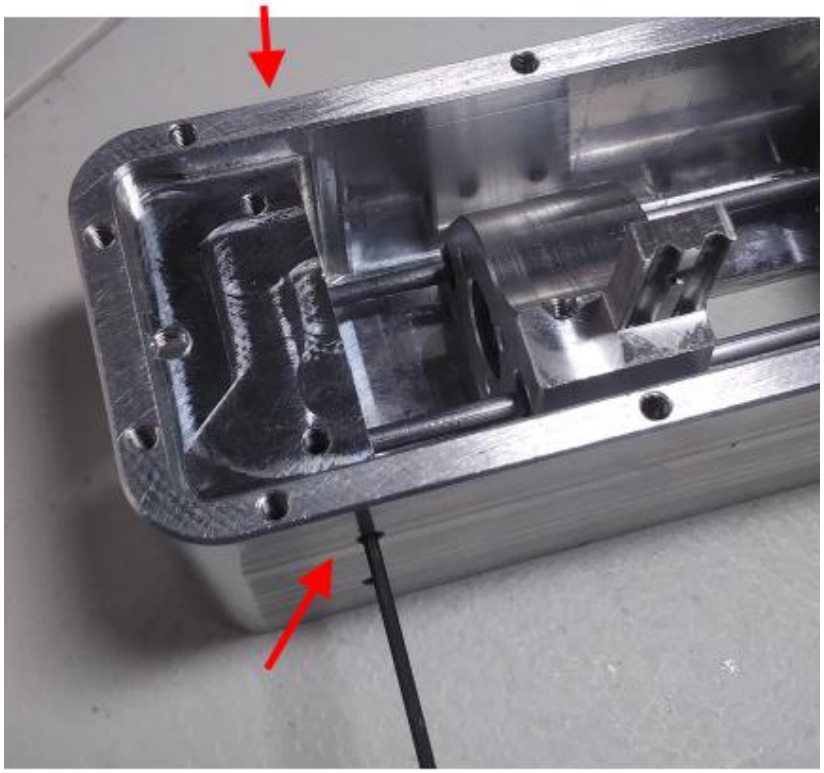


Place J5 carrier inside of the J5 housing, then install (2) 3mm linear rods through the J5 carrier bearings as shown.



Temporarily install M3x8 socket head cap screw fully threaded into hole as shown (red arrow) – this will prevent the 3mm rod from going too deep and blocking the hole.

Finish sliding the 3mm rods into place as shown.



Secure both 3mm rods in place using (2) M3x6 set screws – one from the top and one from the bottom (red arrows).

Then remove the M4 cap screw that was placed temporarily to prevent the rod from inserting too far.

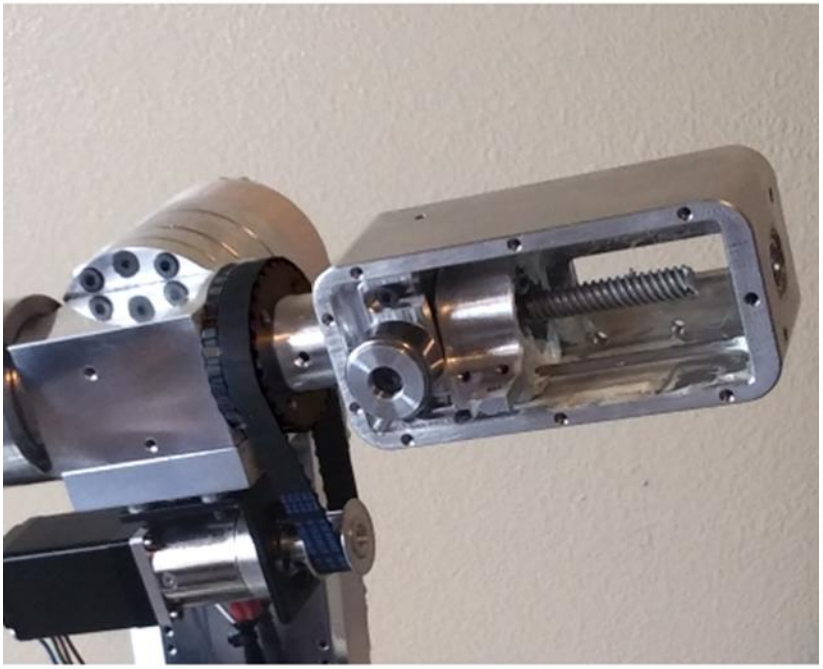
Install the J5 idler tension block and secure with (2) M3x8 socket head cap screws.

Install HK1612 bearing over the J5 bearing post as shown.

Install 3D printed bearing post spacer over the J5 bearing post as shown.

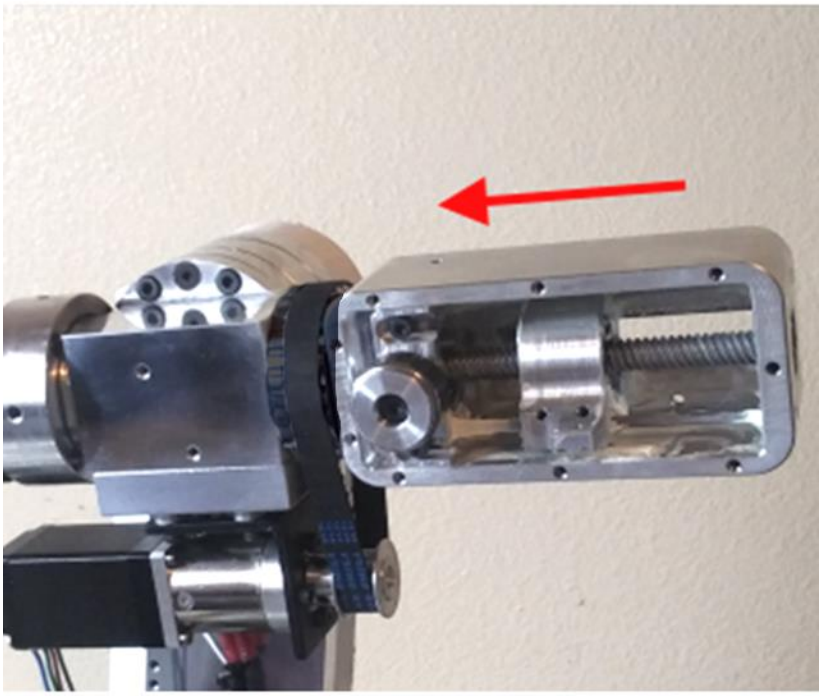
Secure the bearing post and bearing to the J5 tension block using (1) M4x14 socket head cap screw as shown.

Install 688Z bearing in end of J5 housing as shown and then secure with (2) M3x6 set screws from each side.



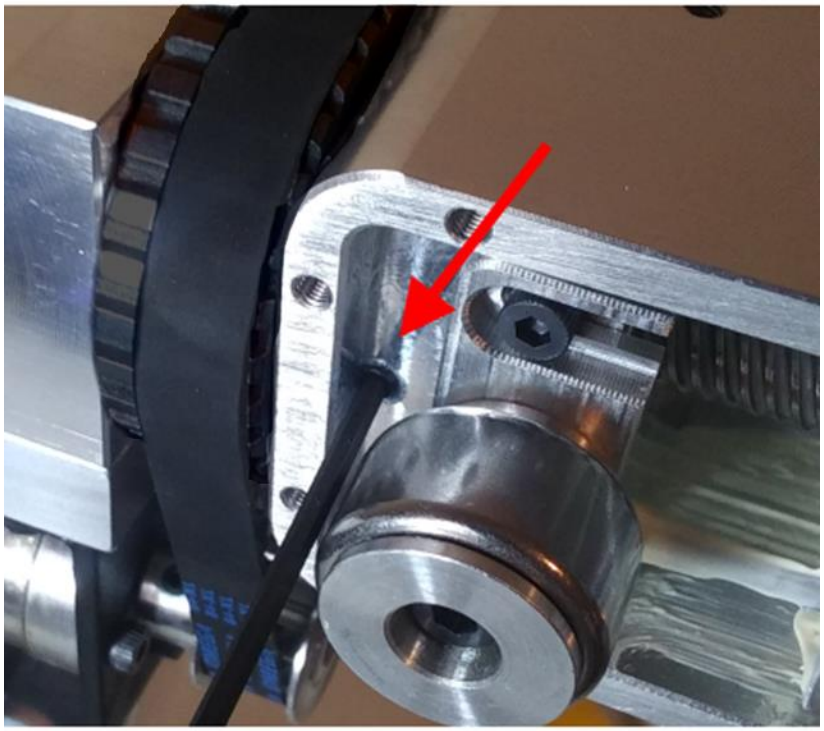
Spin J5 housing assembly onto J5 motor lead screw as shown.

Before proceeding to the next step of inserting the J5 housing onto the J4 shaft apply a liberal amount of retaining compound around the entire perimeter of the end of the J4 shaft to ensure any play between the shaft and housing are alleviated once the compound has set.



Slide J5 housing assembly forward onto J4 main tube until fully seated against J4 timing hub.

Note on robot weight: from this point forward as we add more components to the upper robot arm the J3 motor will at some point start to sag or drift downward and not support the weight of the arm. This is normal, once the robot is fired up and motors are powered the robot will be rigid and support its own weight, for now with no power you may need to put something under the arm to support it or rotate the arm to the vertical rest position for some of the future assembly steps.



Install M4x10 set screw (red arrow) to secure J5 housing to J4 main tube, make sure screw fully threads into hole in J4 main shaft to ensure clocking is correct and housing is secured to main shaft.

Allow retaining compound to set for 1 to 2 hours before proceeding with any further work on the J5 housing or disturbing the J5 housing in any way.

Press #30203 taper roller bearing race into J6 main bearing support arm.

(See notes on bearing fit in overview section)

Secure J6 main bearing arm to J5 housing using (6) M4x18 flat head screws.

Install #30203 taper roller bearing onto J6 housing side post.

(See notes on bearing fit in overview section)

Install (1) TRD1625 (.126” thick) bearing washer into J6 bearing cap recess as shown.

Install (1) NTA1625 (1” ID) need roller bearing into J6 bearing cap recess as shown.

Install (1) TRA1625 (.032” thick) bearing washer into J6 bearing cap recess as shown.

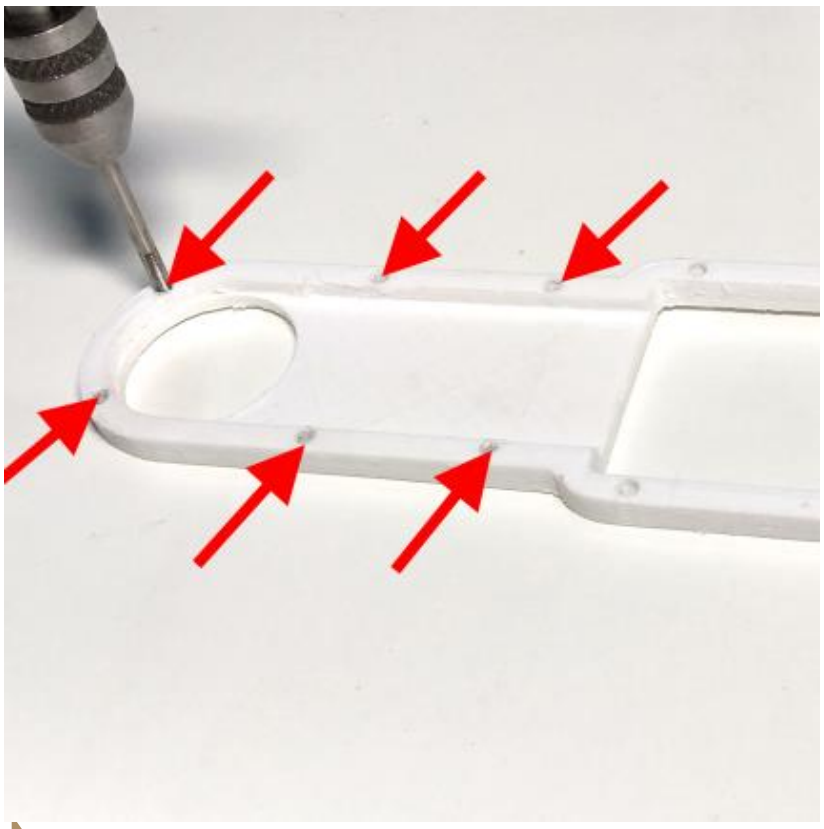
Install J6 housing from left side as shown and then install the J6 bearing cap (with bearings) from the right. Secure bearing Cap to J6 housing using (1) M6x14 socket head cap screw.

Don’t forget to use loctite on screw threads.

Install (6) M4x5 set screws in perimeter of bearing cap.

These set screws will apply tension on J6 bearings.

Set tension evenly on all set screws so there is no play J6 housing rotation but also that it rotates smoothly.



Use M3 tap to thread the front (6) holes in J5 side plate (red arrows).

Use #30 (.128” or 3.25mm) drill bit to clear the rear (8) holes on J5 side cover spacer.

Install J5 side plate as shown, temporarily install (2) M3x25 philips head pan screws to hold side cover in place.

Use countersink to add chamfer to ID of XL15 pulley as shown (red arrow).

The OD of the pullies supplied with the Annin Robotics kit are 28mm in diameter – if you are sourcing your own parts; depending on manufacturer or supplier stock availability the OD of XL15 flange may vary.

Make sure your XL15 sprockets flange OD is between 28mm and 30mm.

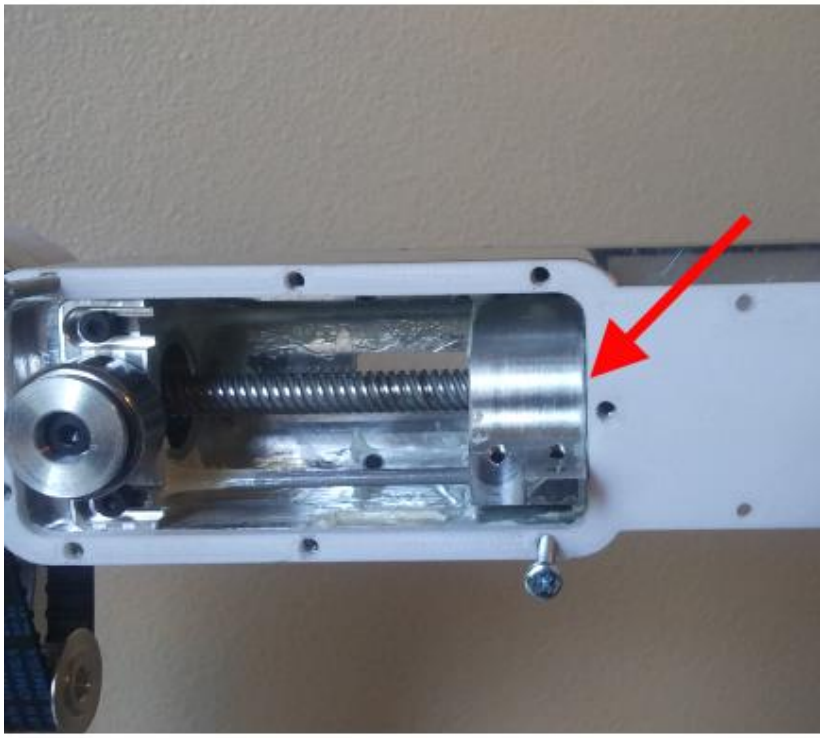
If you have sourced your own pulley and the XL15 pulleys flanges are larger than the ID of the J5 side spacer you can use belt sander or hand file to reduce the flange diameter.

This is a non-critical dimension, it just needs to fit inside the J5 spacer.

Install XL15 pulley onto J6 housing post as shown.

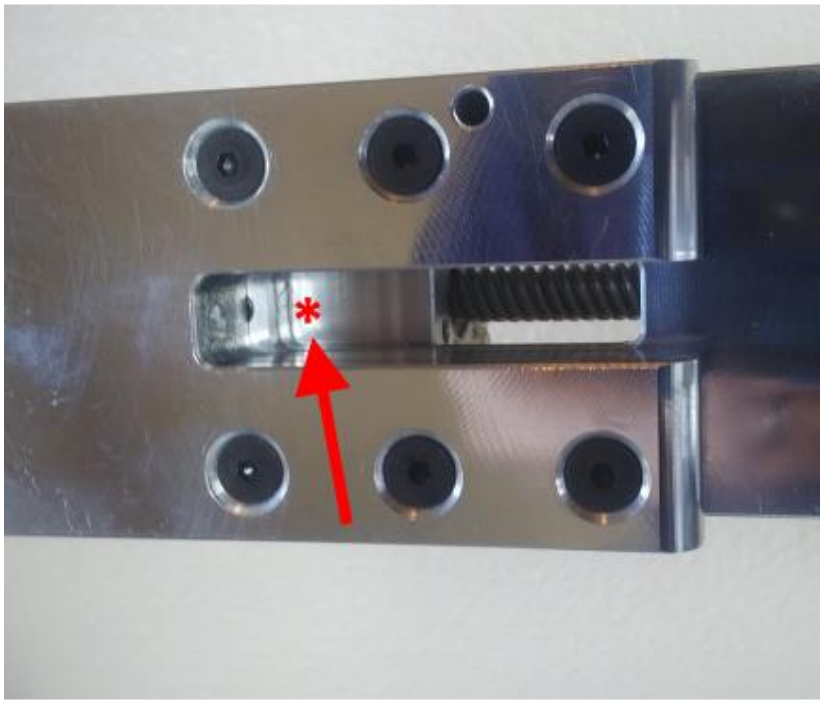
If the pulley does not slide onto the J6 housing shaft easily do not force it. Pulley manufactures and tolerances vary – polish the shaft or pulley bore to achieve a slip fit if necessary.

Do not tighten set screws at this time.



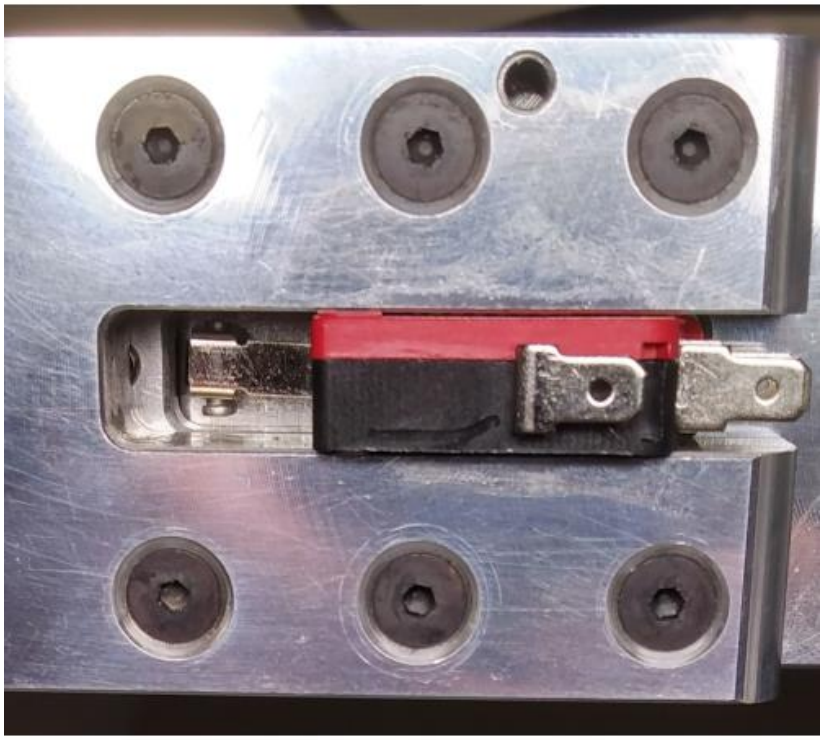
Manually rotate the J5 motor lead screw until J5 carrier is all the way forward as shown.

Apply a small amount of grease on the screw threads and rod shafts. I have used white lithium grease but any standard bearing grease can be used.



In the next steps we are going to install the J5 limit switch, when installed we want the roller tip of the limit switch to make contact with the leading edge of the J5 carrier.

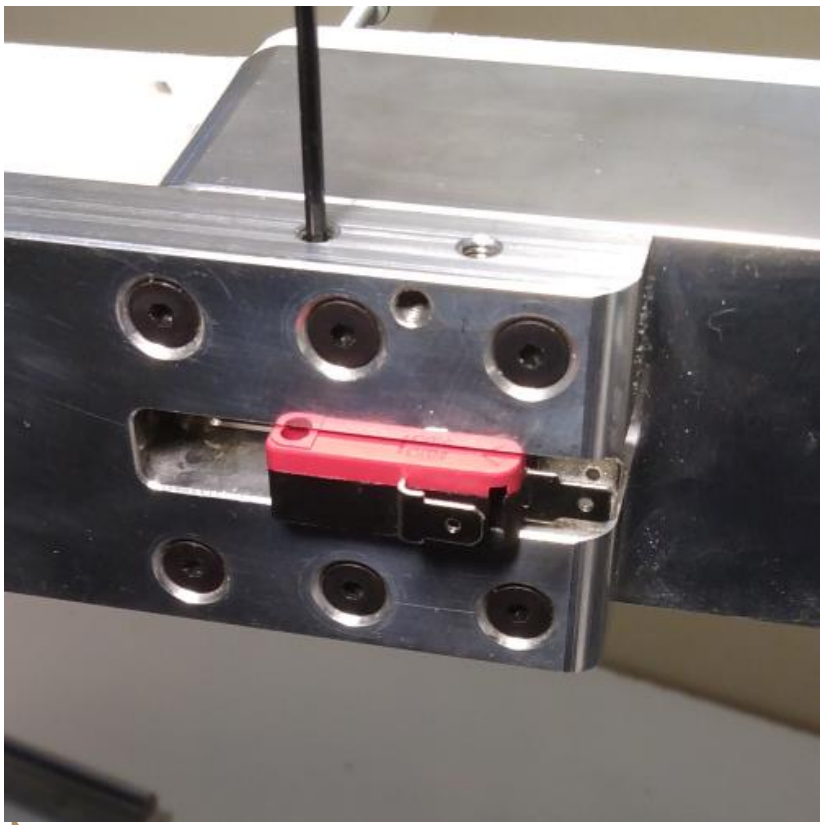
The red star in this photo shows the location in which we want the roller tip to make contact with the carrier.



Install J5 limit switch in J6 bearing arm slot as shown.

Make sure roller tip contacts J5 carrier in position shown.

Insert switch just until you hear and feel the limit switch click and make contact.



With limit switch installed such that switch clicks or makes contact just as J5 carrier makes the forward position install (2) M4x10 set screws (red arrows) to secure limit switch into position.

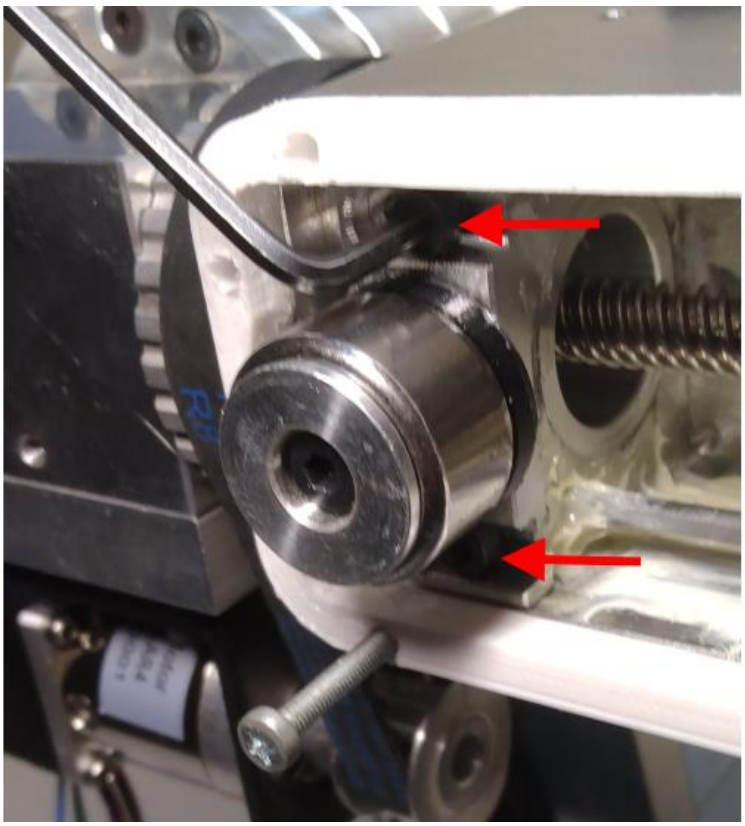
Set screws should be snug and keep limit switch secured but not too tight – do not over-tighten and damage switch.

Do not forget to use loctite on set screws.

Manually rotate J5 motor lead screw back and forth and verify that you can hear and feel the J5 limit switch click closed each time the J5 carrier is all the way forward.

Use #30 (.128” or 3.25mm) drill bit to drill a hole in 150XL belt as shown.

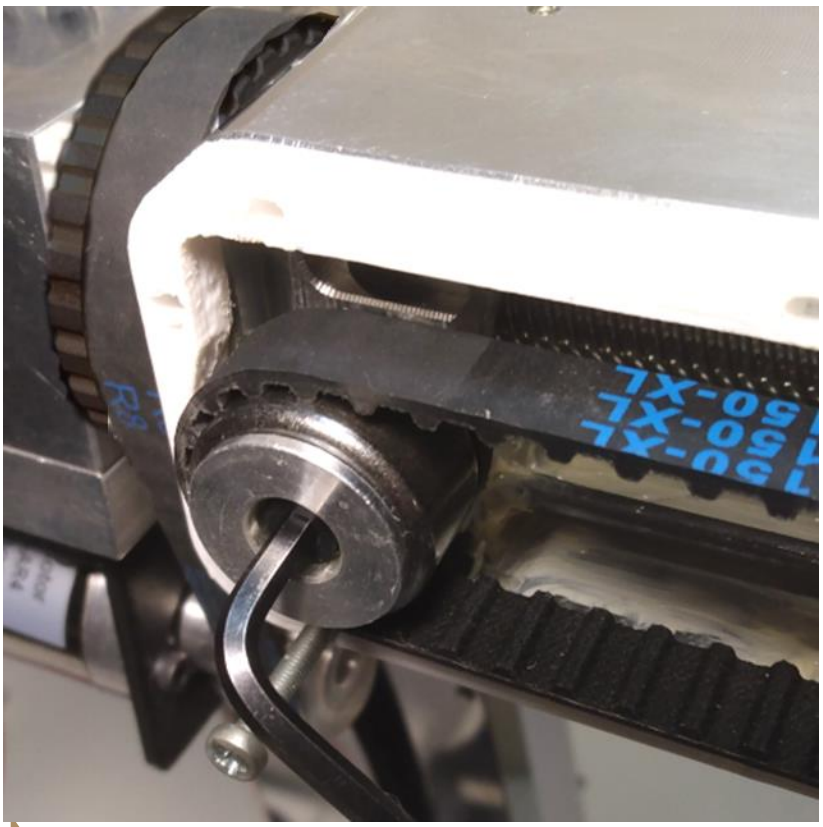
Hole should be directly between 2 of the ribs.



Adjust J5 idler tension block so that when you try to install the belt it is just barely too tight or is very difficult to slip over the idler bearing.

150XL belt should be just barely too tight so that it is very difficult to slip it over the idler bearing.

Note: when using 3D printed components you may not be able to get the belt this tight.



When installing the 150XL belt loosen bearing post mounting screw so that post tips back slightly making it easier to slide belt onto idler bearing.

Next tighten post mounting screw – this will result in a very tight belt adjustment.

When using 3D printed components the M4 screws do not have the holding force to keep tension on the belt under load.

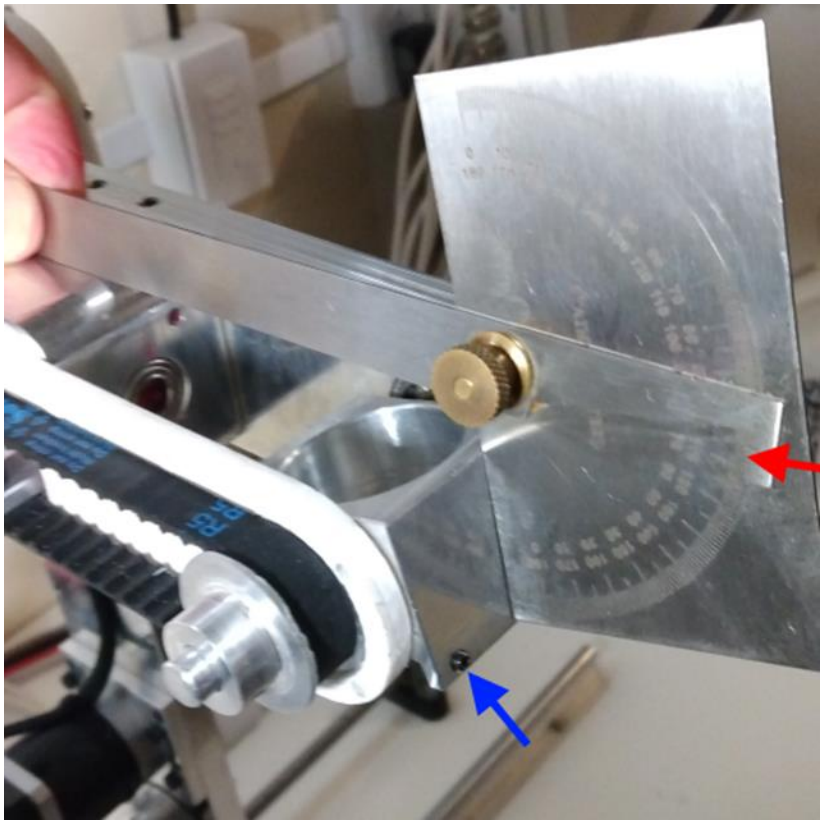
Place a small drop of super glue around the heads of the M4 screws securing the head of the screw to the tension block.

(if disassembled or tension needs to be reset, bond will need to be broken and a new tension block will need to be printed and installed)

Install 150XL belt over J6 pulley and J5 idler bearing.

Make sure the hole drilled in belt is aligned with the J5 carrier and install (1) M3x8 cap screw through belt and threaded into J5 carrier clamp as shown (red arrow).

Make sure screw is tight and belt is secured to J5 carrier.



Make sure set screws in J6 XL15 pulley are still loose.

Make sure the J5 carrier is in the forward position and that the limit switch has just clicked.

Rotate J6 housing to an up angle so that the motor side is down. *(note blue arrow – motor mount screw hole is down)*

Use angle gauge and set J6 housing angle to **105°** (red arrow).

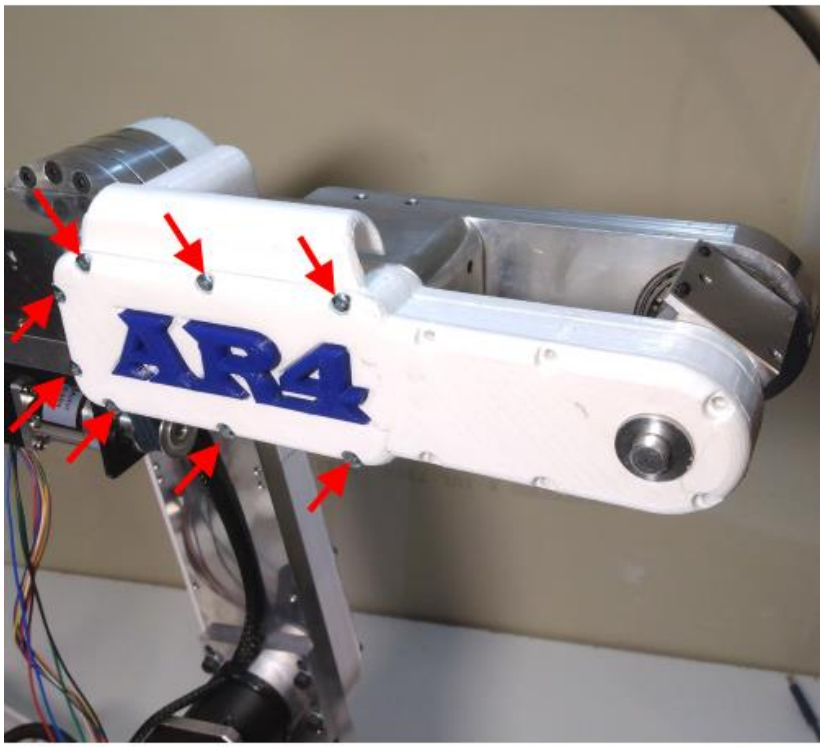
With J5 carrier in the forward position (switch clicked) and the J6 carrier at 105˚ tighten the XL15 pulley set screws.

The J5 angle is now mechanically calibrated.

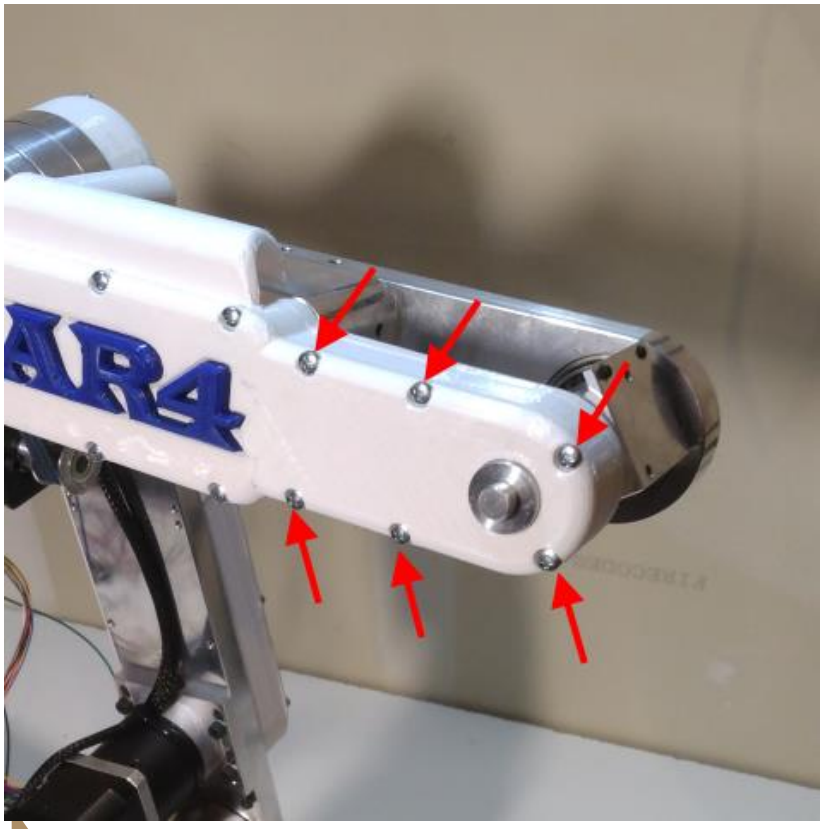
This calibration can be refined further after the robot has been started up.

Manually rotate the J5 motor lead screw until the J6 housing is at approx. a 45° down angle – this will make installation of the J6 motor easier in a future step.

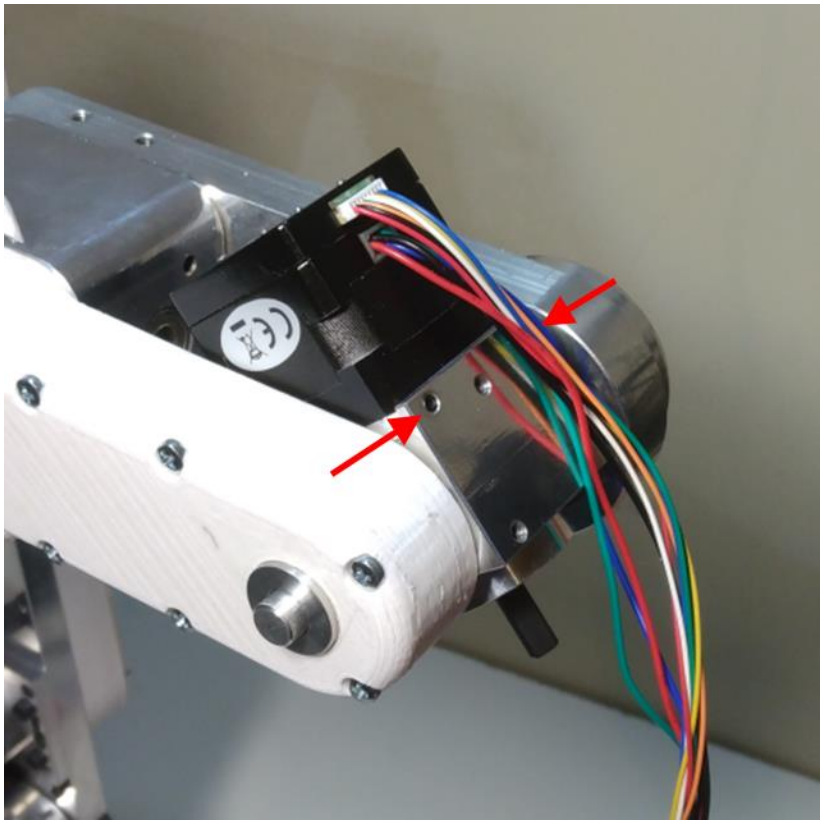
Install AR4 logo into recess in J5 side cap and secure with epoxy.



Install J5 side spacer and J5 side cap as shown and secure to J5 housing using (8) M3x25 Philips head pan screws (red arrows).



Install (6) M3x20 Philips pan head screws in front section of cap (red arrows) securing the side cover cap and side spacer to the side plate.

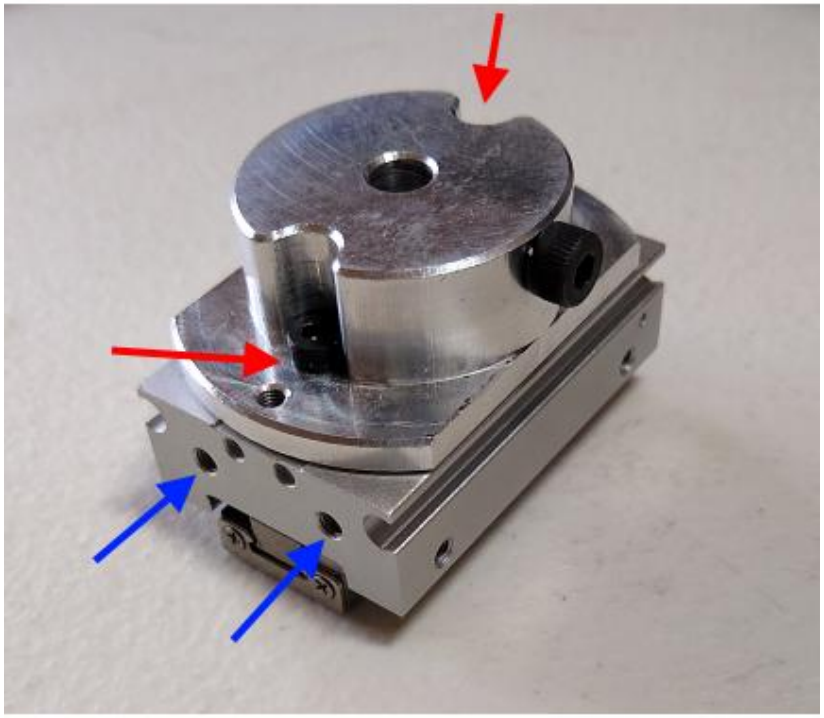


Install J6 motor into J6 housing as shown with wires facing upward.

Secure motor to housing using (4) M3x3 set screws. There are (2) in the front (red arrows) and (2) on the backside.

Install (1) M4x10 socket head cap screw in lower threaded hole in J6 gripper mount as shown.

(This will be the contact for the J6 limit switch)

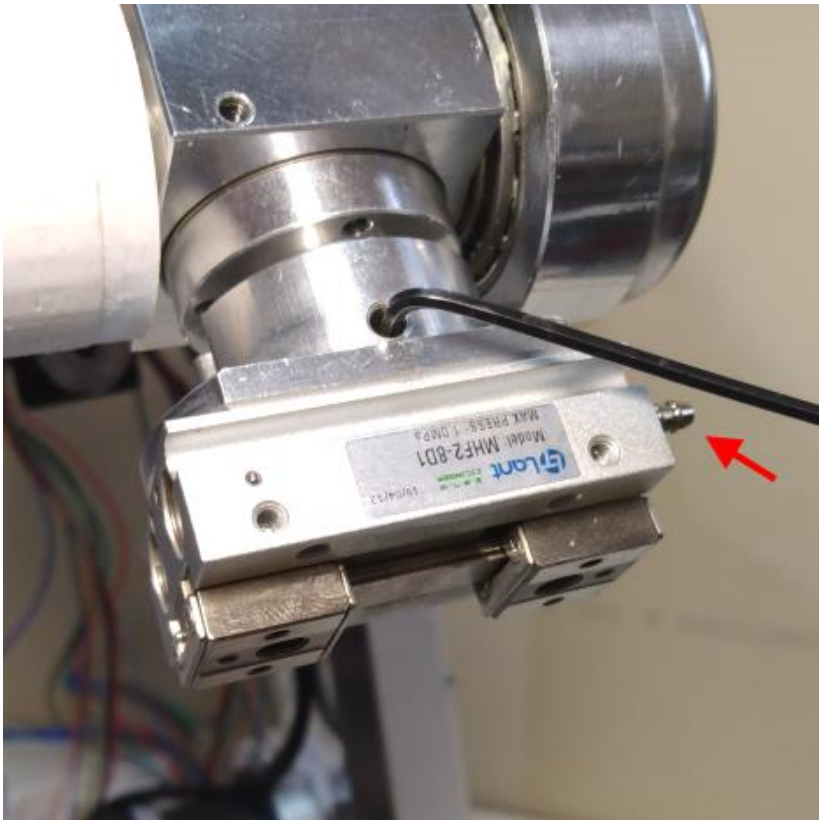


NOTE: *There are many different types of pneumatic grippers, servo grippers or tool holders that can be used on the AR4 robot. In this manual I will be showing the installation of the SMC MHF2-8D1 which is the gripper I recommend.*

Secure J6 gripper mount to MHF2-8D1 gripper using (2) M3x8 socket head cap screws (red arrows).

Make sure pneumatic inlet ports are oriented on left side as shown in photo (blue arrows).

Install (2) M3x3 pneumatic barb fittings into gripper pneumatic inlet ports as shown.



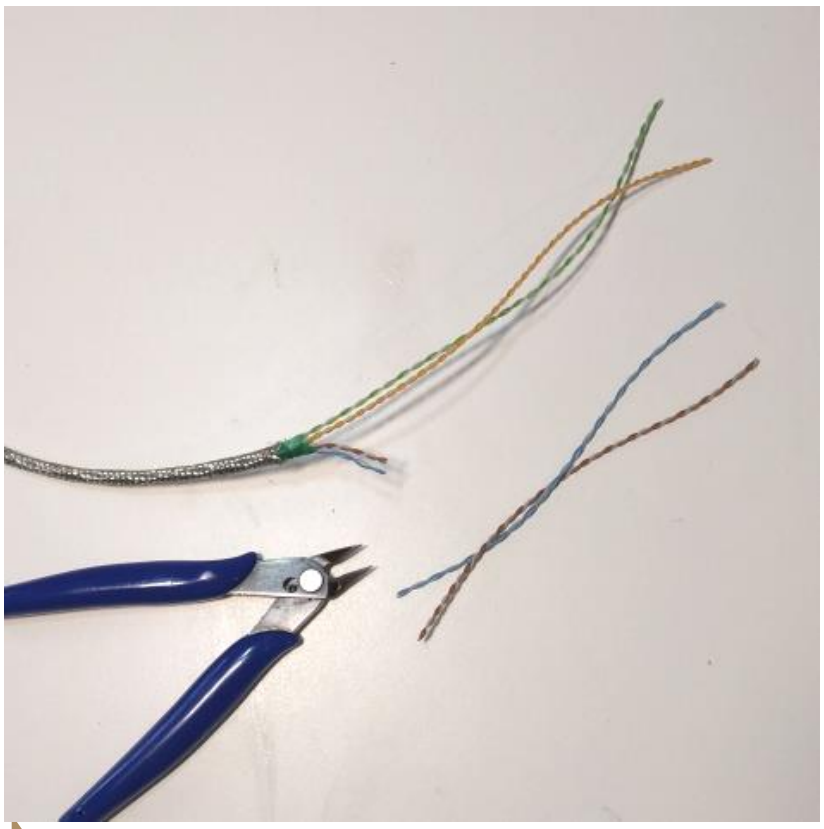
Install J6 gripper mount assembly onto the J6 shaft as shown and secure with (1) M4x10 set screw.

Timing lug set screw should be facing down and pneumatic barb fittings should be on the right side (red arrow).

For joint 4 cut length of continuous flex Cat6 cable to a length of 123cm long and remove outer jacket. (see overview section on jacket removal)

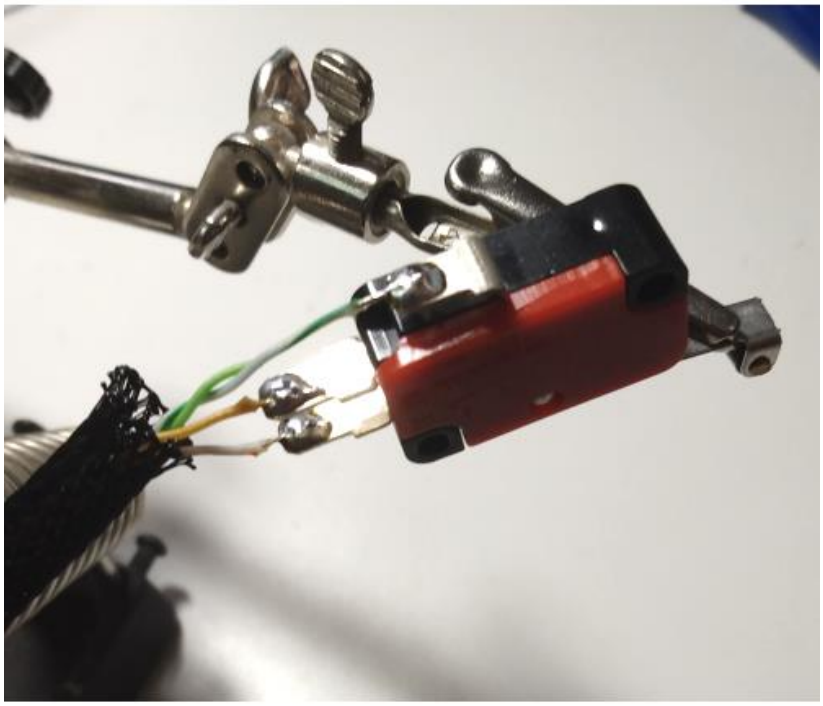
Remove 12cm of shielding from one end of the cable and remove 17cm of shielding from the other end. (see overview section on removing shielding)

The end with 12cm of shielding removed will be the end of the cable that is routed to the base enclosure.



From the end of cable that has 17cm of shielding removed - cut and remove 14cm of the brown and blue twisted pairs leaving 3cm of wire exposed.

Cut length of ¼” braided sleeve to a length of 15cm long then route green and orange twisted pairs through sleeve as shown.



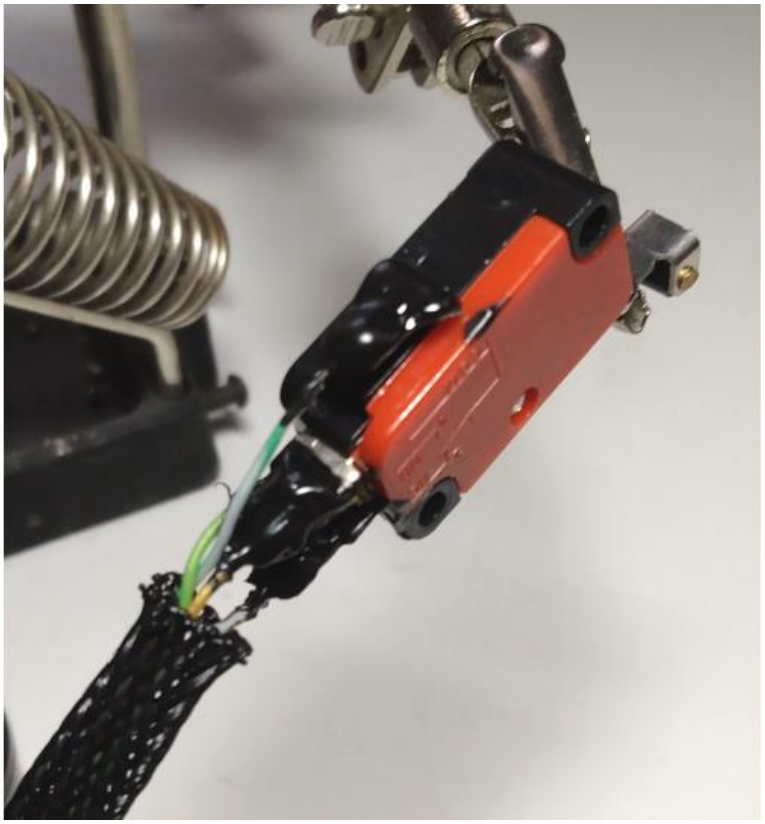
Solder orange wire to “NO” terminal of SV-156-1C25 roller tip limit switch.

Solder white with orange stripe wire to the “NC” terminal.

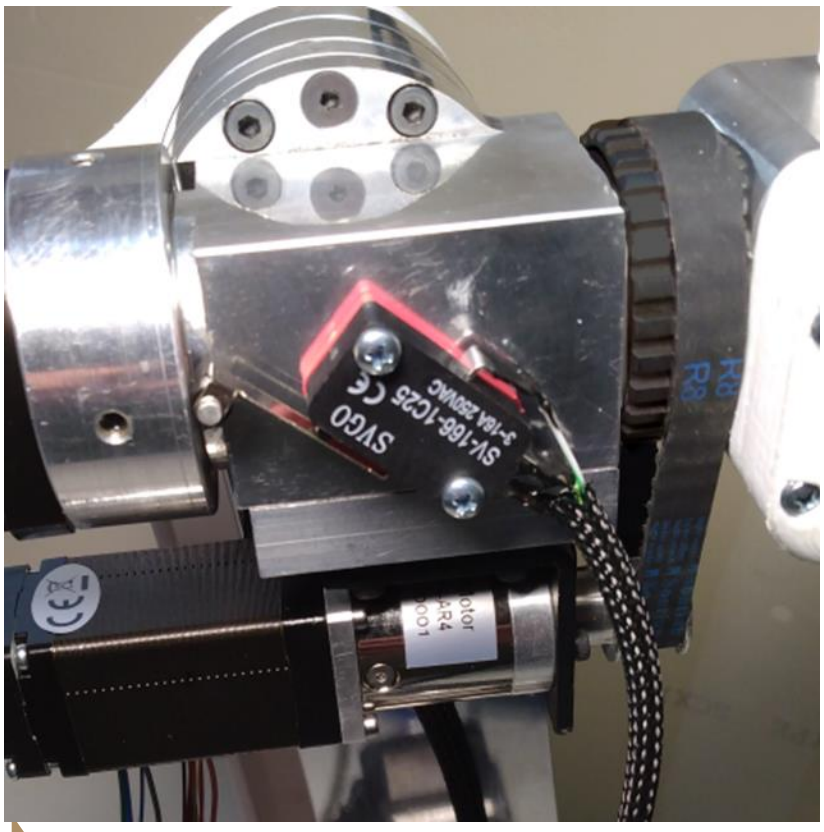
Solder the white with green stripe wire to the “COM” terminal.

Note: the green wire is not used.

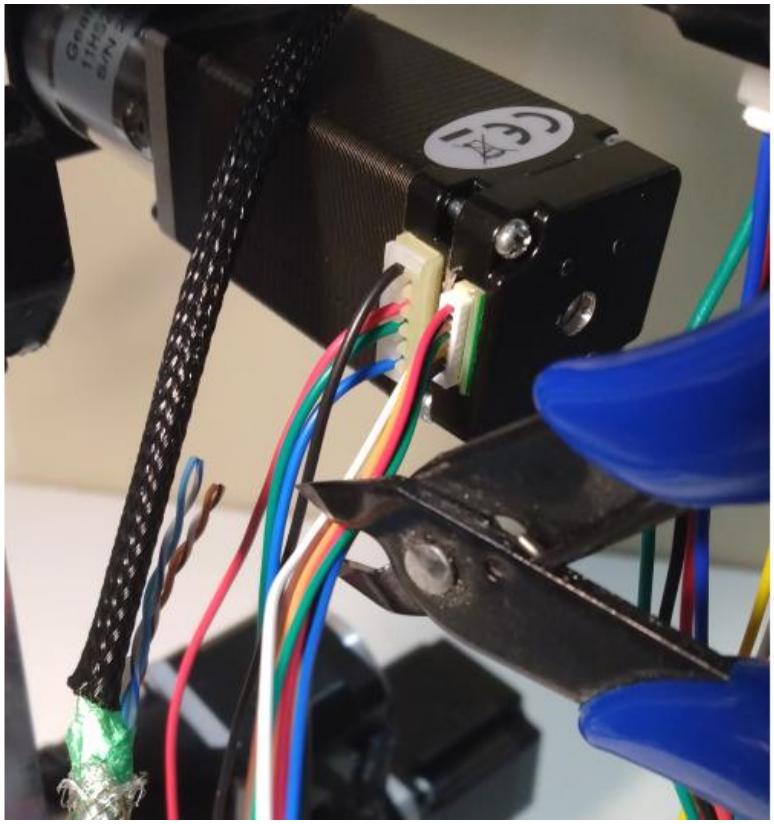
(also see wiring diagrams in chapter 4)



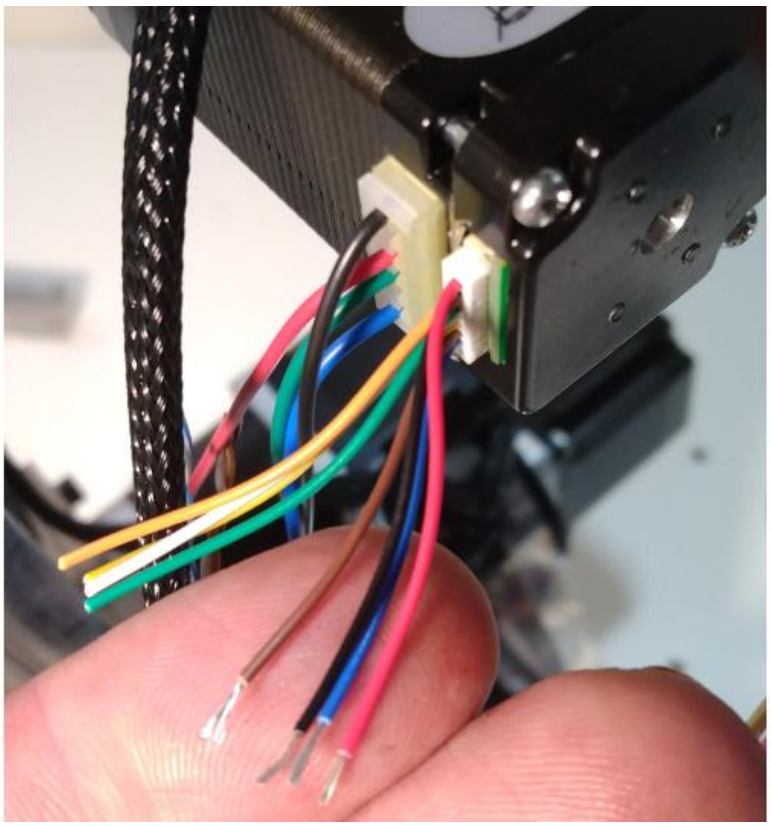
It is recommended to use liquid electrical tape to insulate terminals on limit switch.



Use (2) M3x14 Philips pan head screws to secure switch to J4 housing as shown in photo.

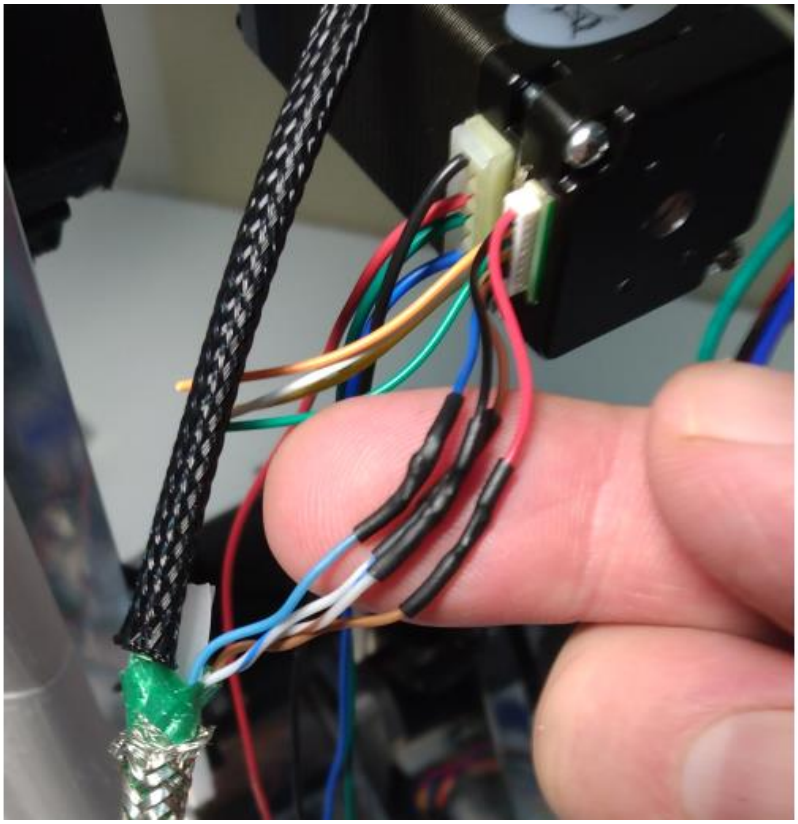


Cut the J4 encoder wires to a length of 4cm.



Use wire strippers to strip end of the red, black, brown and blue J4 encoder wires.

Note: only these 4 encoder wires will be used.



Solder and heat shrink the connection from the J4 encoder to the Cat6 cable as follows:

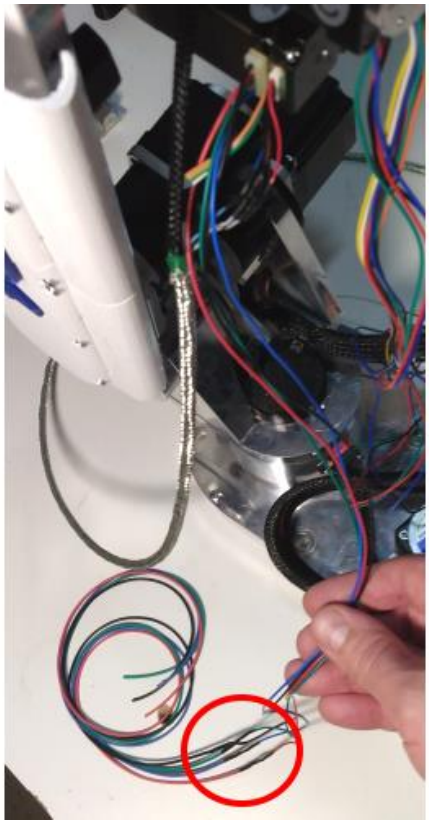
Encoder red wire to the cable brown wire.

Encoder black wire to the cable white – brown stripe wire.

Encoder brown wire to the cable white – blue stripe wire.

Encoder blue wire to the cable blue wire.

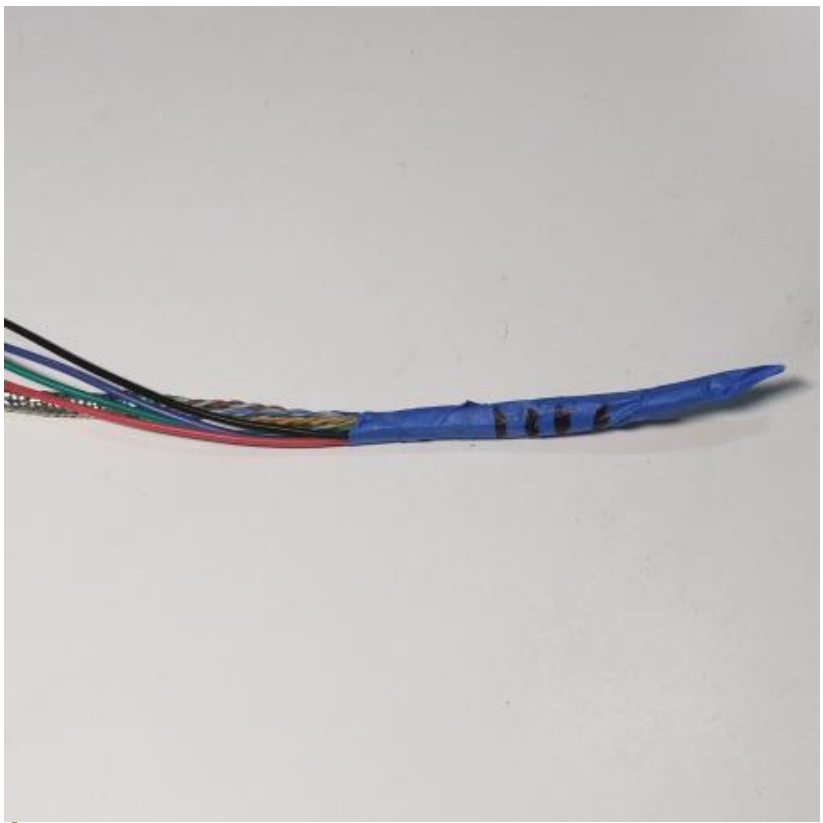
Cut Red, Black, Blue & Green 20awg wires to a length of 60cm long.



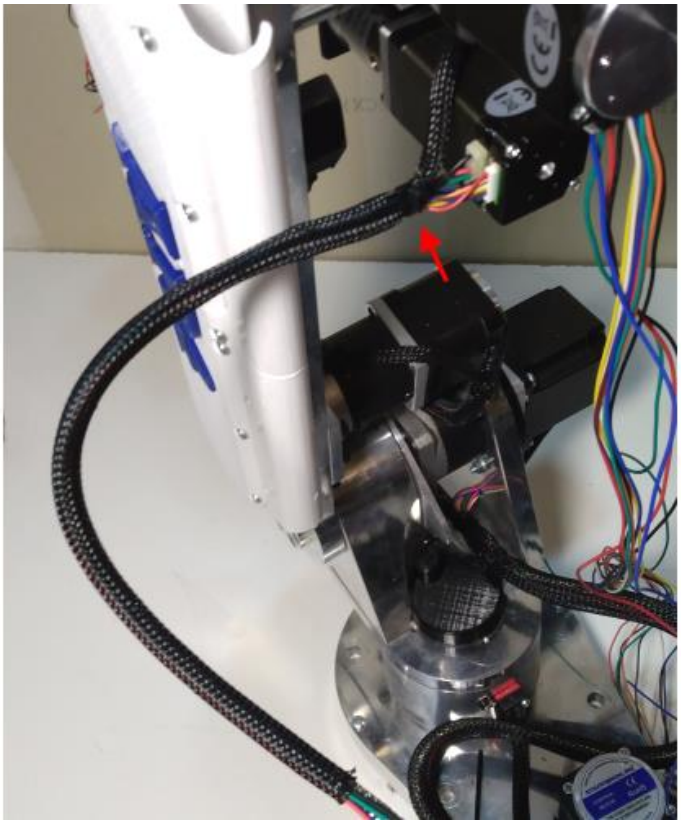
Solder and heat shrink 60cm long extension wires to the J4 motor wires as shown.

Be sure to match colors so that red goes to red and so on.

With the J4 motor wires extended the motor wires and Cat6 cable for J4 should now be the same length.

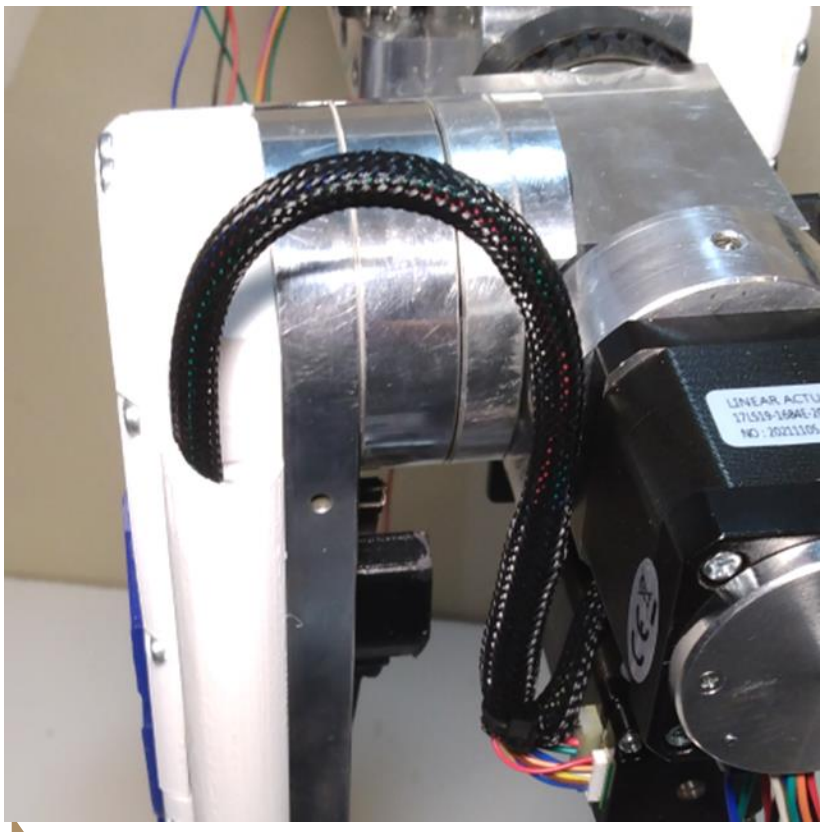


Wrap ends of J4 wires and Cat6 cable with tape and then use a marker to put (4) stripes on so that you will know these are for J4 when wires have been routed inside enclosure.

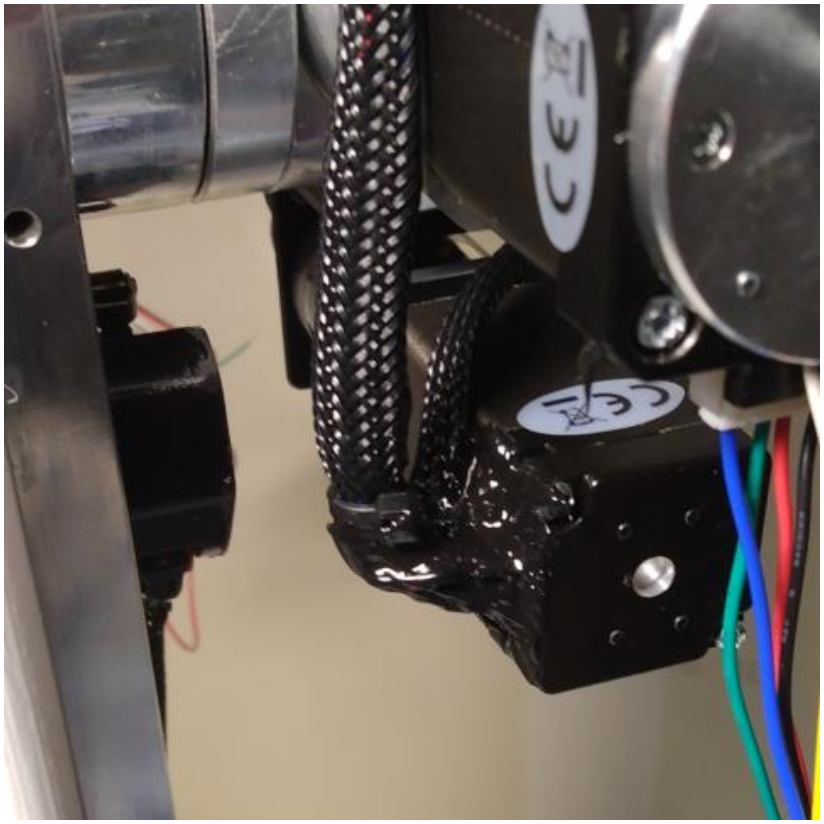


Cut length of ¼” braided sleeve to a length of 25cm long then route J4 motor wires and Cat6 cable through the sleeve.

This length of sleeve should slightly overlap the braided sleeve that goes to the J4 limit switch – use small cable tie to secure the braided sleeve where it overlaps the sleeve going to the limit switch (red arrow).



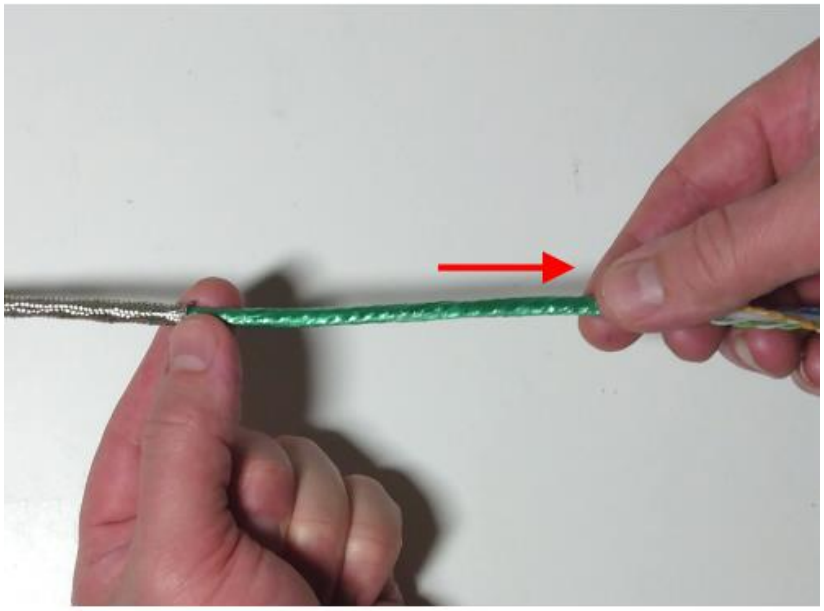
Temporarily route the J4 motor and cable wires into the J2 arm cable channel with the amount of arc and slack shown.



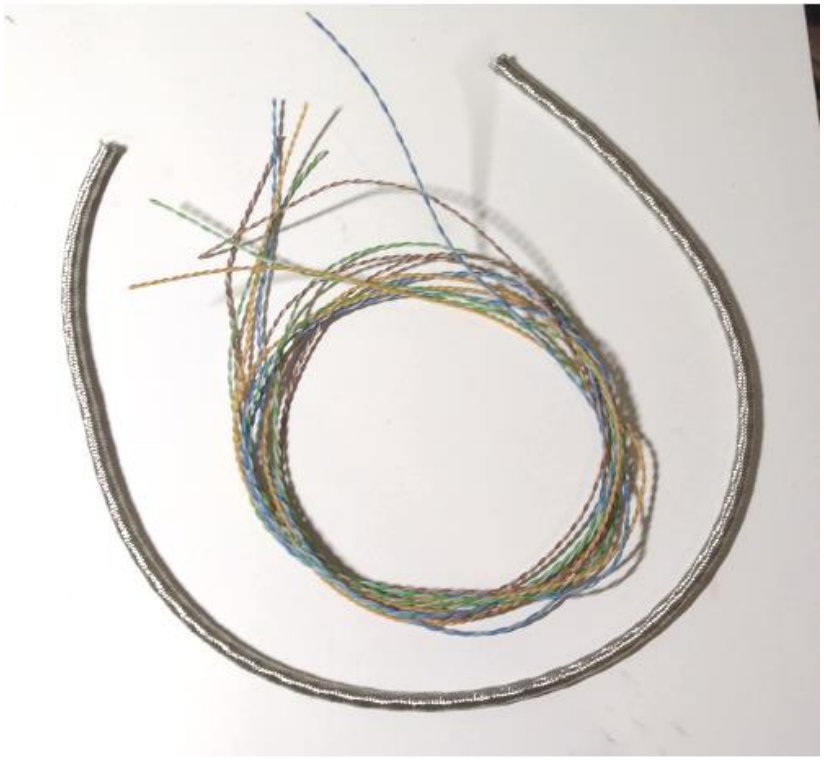
It is recommended to coat the exposed encoder and motor wires with liquid electrical tape.

Applying the liquid electrical tape can also be done later after fully testing the robot electrically.

For joint 5 cut a length of continuous flex Cat6 cable to a length of 130cm long and remove outer jacket. (see overview section on jacket removal)



Joint 5 is a little different from the other joints due to the fact that the J5 limit switch is not located close to the J5 motor and the limit switch is on the other side of joint 3. Because of this we will need to run the J5 limit switch wires separately from the J5 encoder wires. To make this happen we will need to separate the J5 limit switch wires from the J5 encoder wires. To separate the wires first grasp the shielding in one hand and pull on all the wires with other – you want to remove all the wires completely from the shielding.



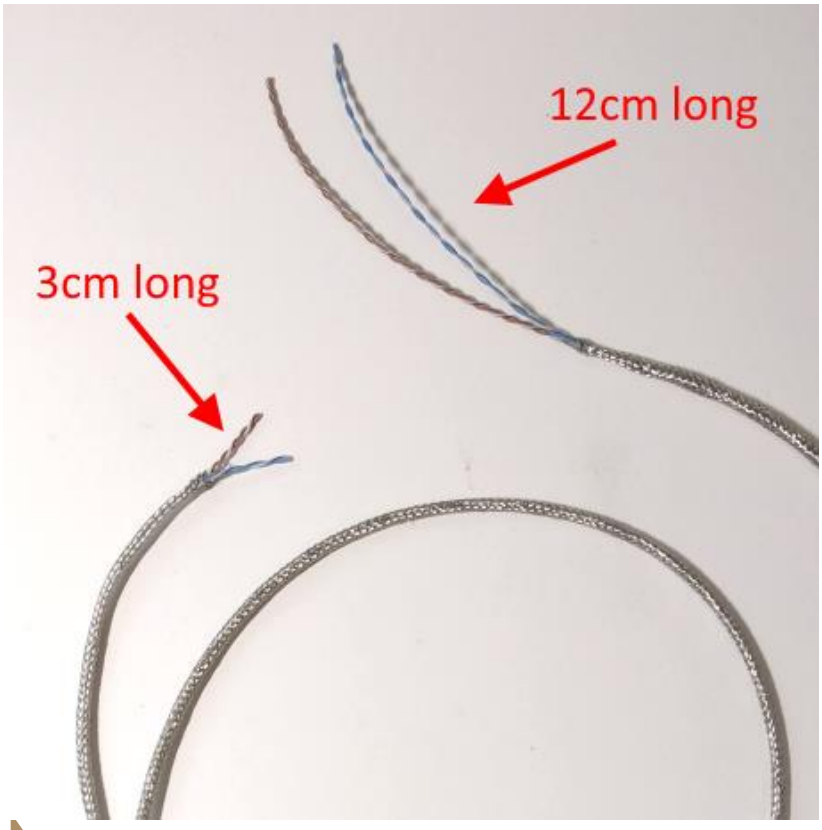
Pull all the wires out of the shielding and remove the green wrap and center core leaving just the shielding and the 4 twisted pairs.

Set the green and orange twisted pairs aside, they need to remain the full 130cm in length - they will be used separately in a future step.

Cut the blue and brown twisted pairs down to a length of **120cm**.

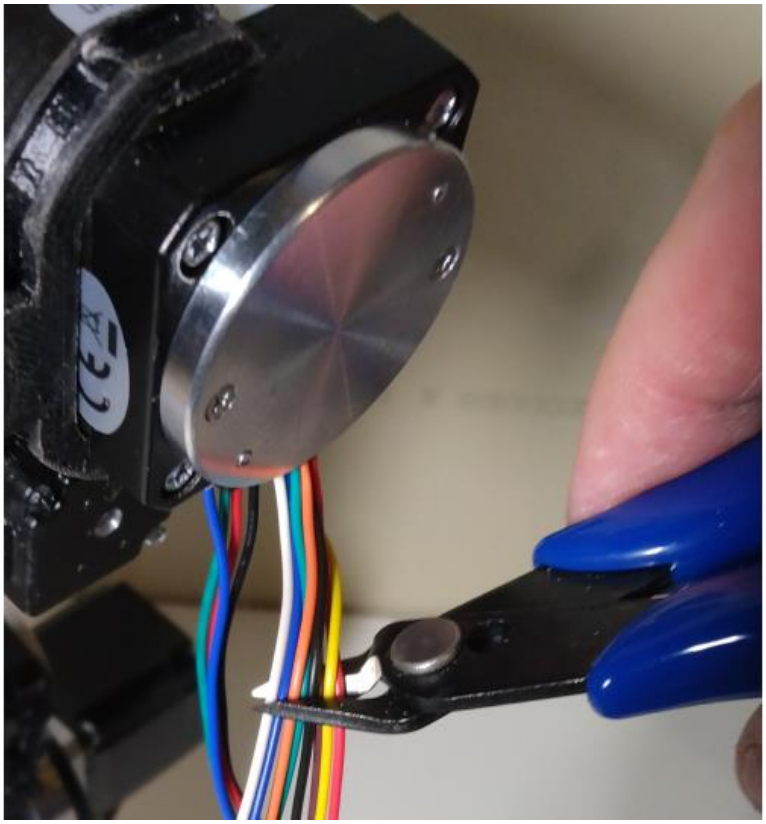
Cut the shielding down to a length of **105cm**

Feed the brown and blue twisted pairs back through the shielding.

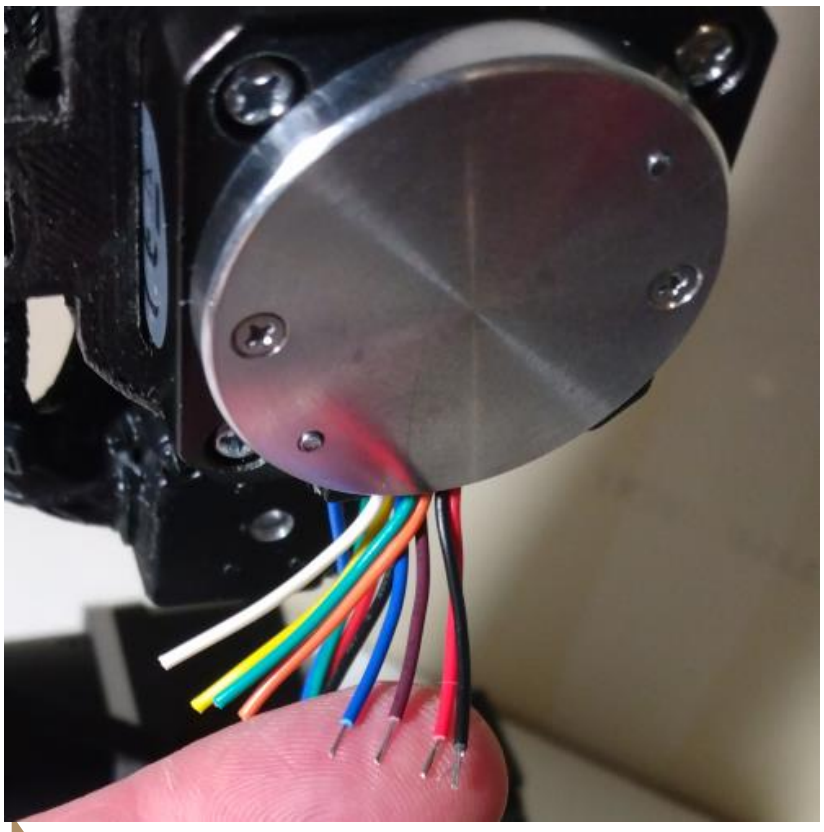


After feeding the brown and blue wire pairs through the shielding the wires should leave 12cm exposed from one end of the shielding and 3cm exposed from the other end of the shielding.

The end with 12cm of shielding removed will be the end of the cable that is routed to the base enclosure.

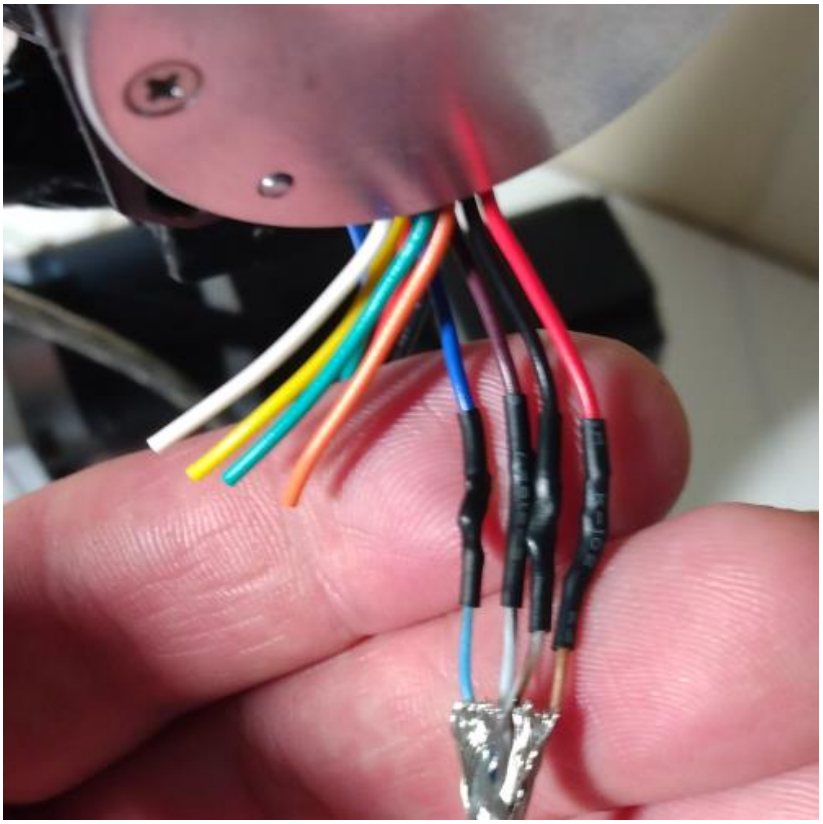


Cut the J5 encoder wires to a length of 3cm.



Use wire strippers to strip end of the red, black, brown and blue J5 encoder wires.

Note: only these 4 encoder wires will be used.



Solder and heat shrink the connection from the J5 encoder to the Cat6 cable as follows:

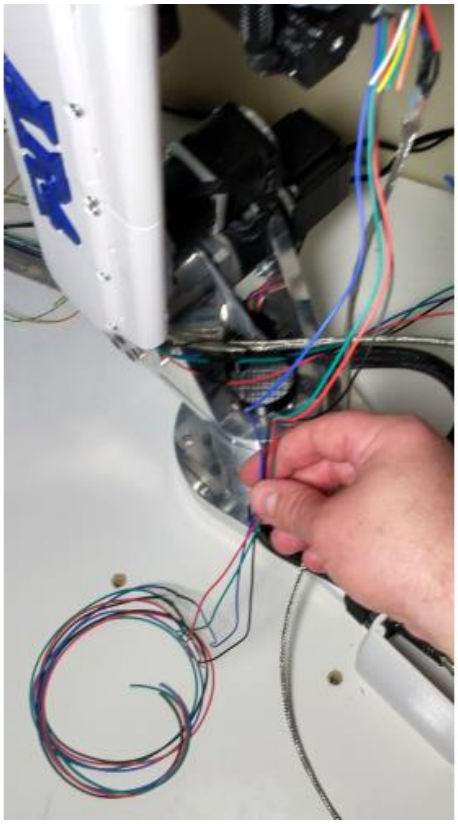
Encoder red wire to the cable brown wire.

Encoder black wire to the cable white – brown stripe wire.

Encoder brown wire to the cable white – blue stripe wire.

Encoder blue wire to the cable blue wire.

Cut Red, Black, Blue & Green 20awg wires to a length of 75cm long.



Solder and heat shrink 75cm long extension wires to the J5 motor wires as shown.

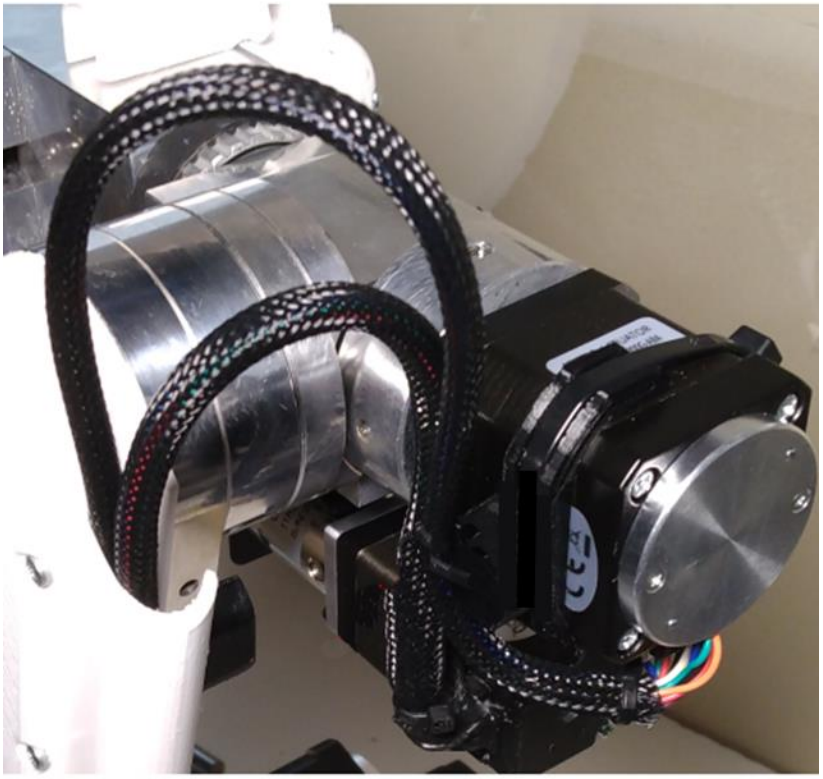
Be sure to match colors so that red goes to red and so on.

With the J5 motor wires extended the motor wires and Cat6 cable for J5 should now be the same length.

Cut length of ¼” braided sleeve to a length of 33cm long then route J5 motor wires and Cat6 cable through the sleeve.

Use small cable tie to secure the braided sleeve to motor wires and cable where shown (red arrow).

Secure the 3D printed J5 motor bracket to the J5 motor housing using a large cable tie as shown.



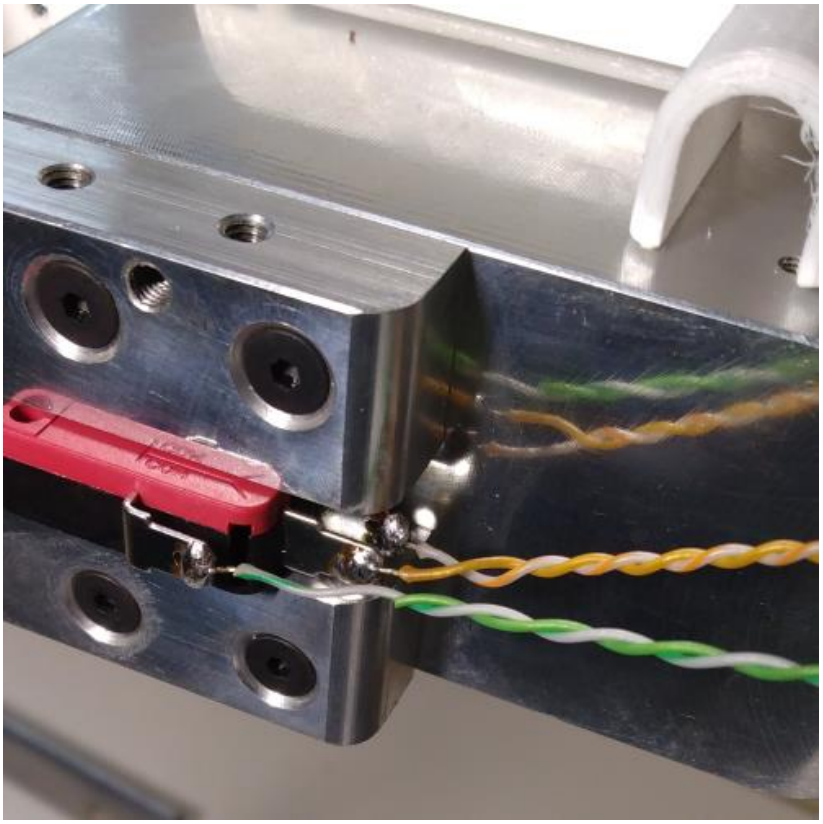
Temporarily route the J5 motor and cable wires into the J2 arm cable channel with the amount of arc and slack shown.

NOTE: the slack or amount of arc in the cable must leave enough room that J4 can fully articulate without pulling the cable.

Secure J5 wires and cable to the motor bracket with a small cable tie where shown (red arrow)

It is recommended to coat the exposed encoder and motor wires with liquid electrical tape (blue arrow).

Applying the liquid electrical tape can also be done later after fully testing the robot electrically.

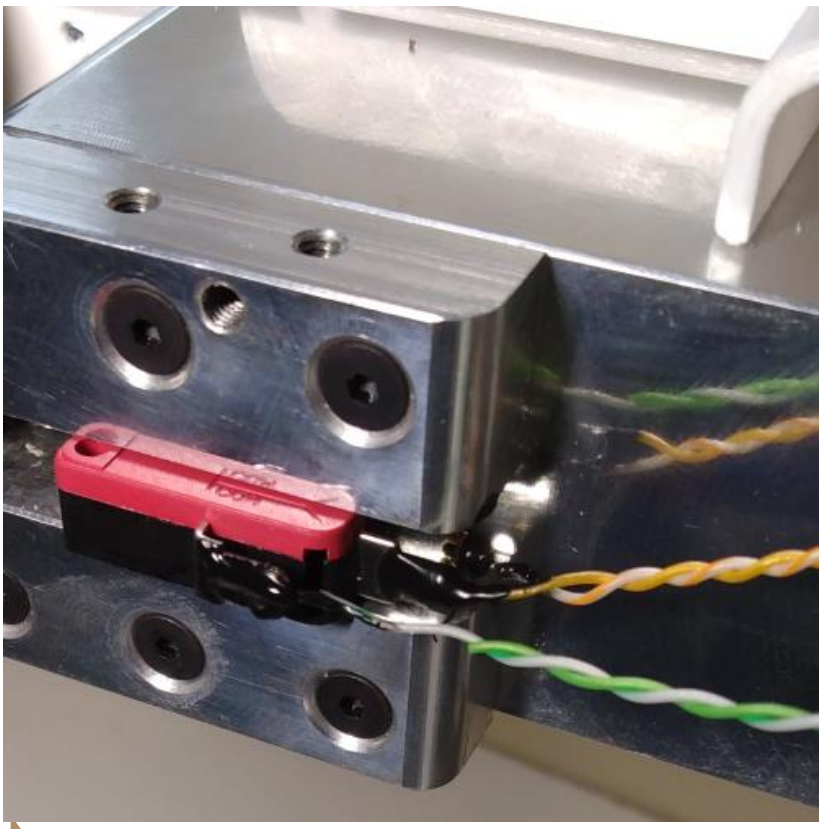


Using the 130cm long orange and green twisted pairs that were set aside earlier – solder wires to the J5 limit switch:

- Solder orange wire to “NO” terminal of SV-156-1C25 roller tip limit switch.
- Solder white with orange stripe wire to the “NC” terminal.
- Solder the white with green stripe wire to the “COM” terminal.

Note: the green wire is not used.

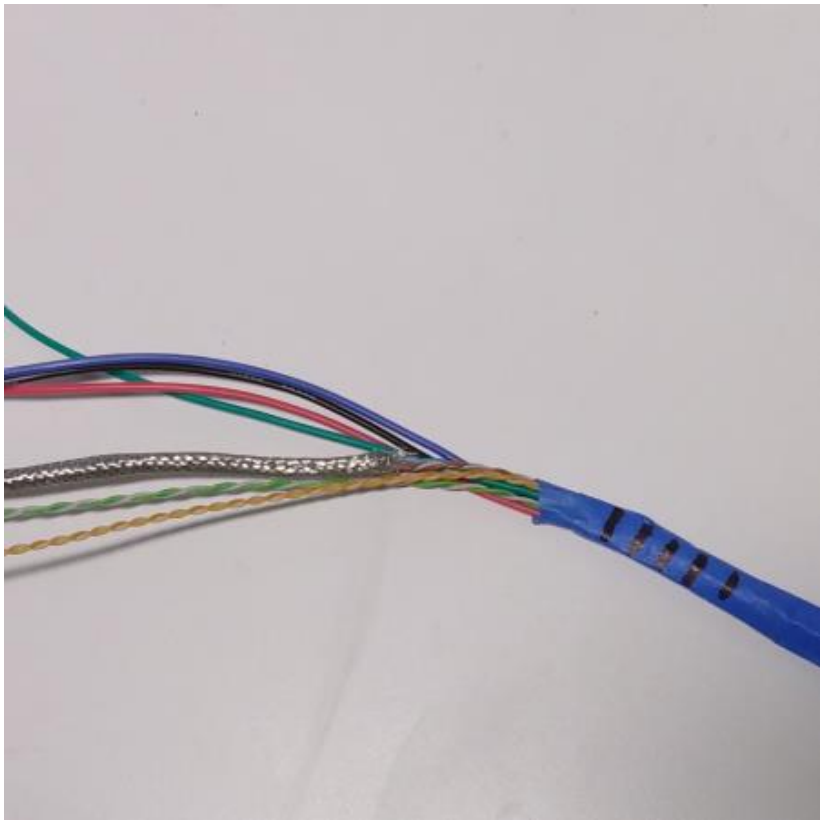
(also see wiring diagrams in chapter 4)



It is recommended to use liquid electrical tape to insulate terminals on limit switch.

Cut length of ¼” braided sleeve to a length of 50cm long then route J5 limit switch wires through the sleeve.

Route the J5 limit switch wire sleeve through the J5 side spacer cover and into the J2 arm cable channel as shown. Make sure to leave the amount of slack shown and that J4 can fully articulate.

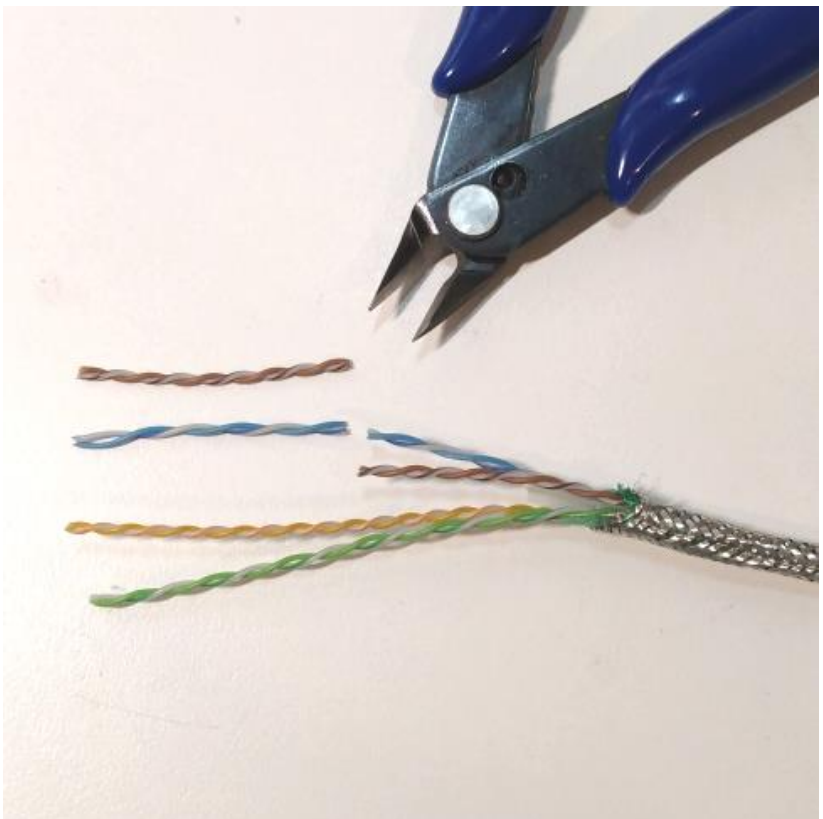


Wrap ends of J5 motor wires, limit switch wires and Cat6 cable with tape and then use a marker to put (5) stripes on so that you will know these are for J5 when wires have been routed inside enclosure.

For joint 6 cut a length of continuous flex Cat6 cable to a length of 150cm long and remove outer jacket. (see overview section on jacket removal)

Remove 12cm of shielding from one end of the cable and remove 7cm of shielding from the other end. (see overview section on removing shielding)

The end with 12cm of shielding removed will be the end of the cable that is routed to the base enclosure.

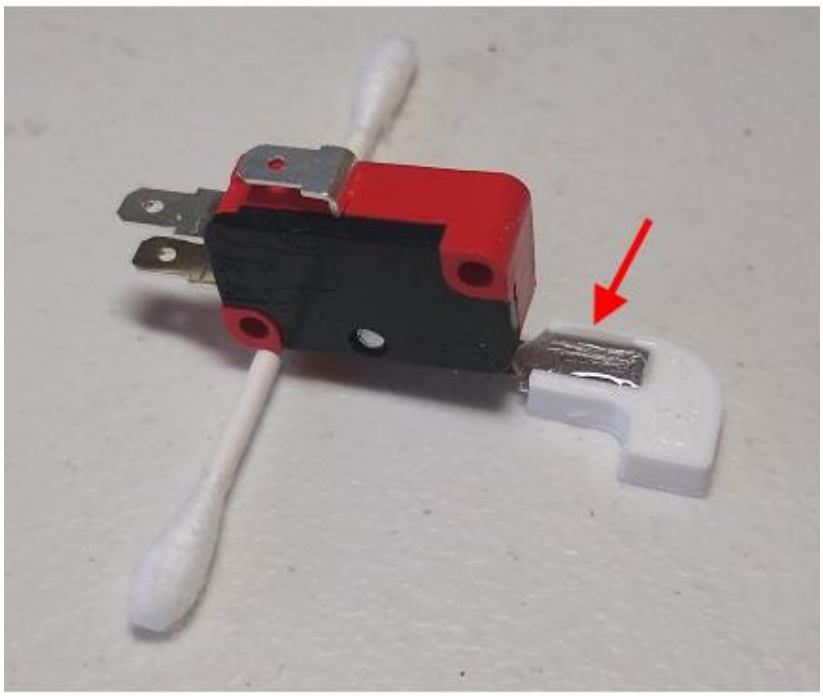


From the end of cable that has 7cm of shielding removed - cut and remove 4cm of the brown and blue twisted pairs leaving 3cm of wire exposed.

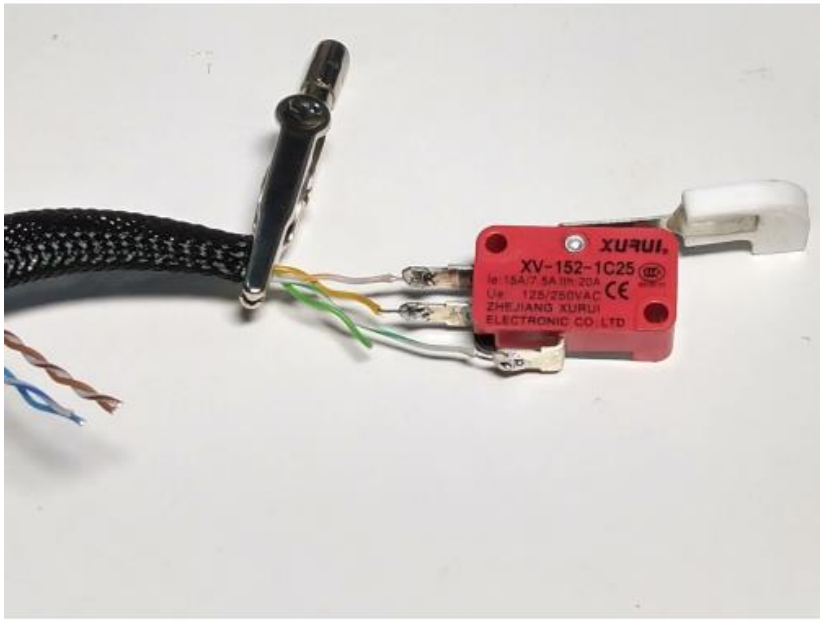
Cut length of ¼” braided sleeve to a length of 6cm

Route orange and green twisted pair through the braided sleeve – compress sleeve and use alligator clip to hold the braided sleeve back to give you room to solder wire ends to J6 limit switch.

Cut 1.5cm off of the orange twisted pair and strip all wire ends.



Use epoxy to secure J6 limit switch tip to the straight lever arm limit switch. Make sure it remains flat and fully seated while epoxy cures. You can use a small piece of cardboard or cotton swab to support the rear end of switch while epoxy cures.



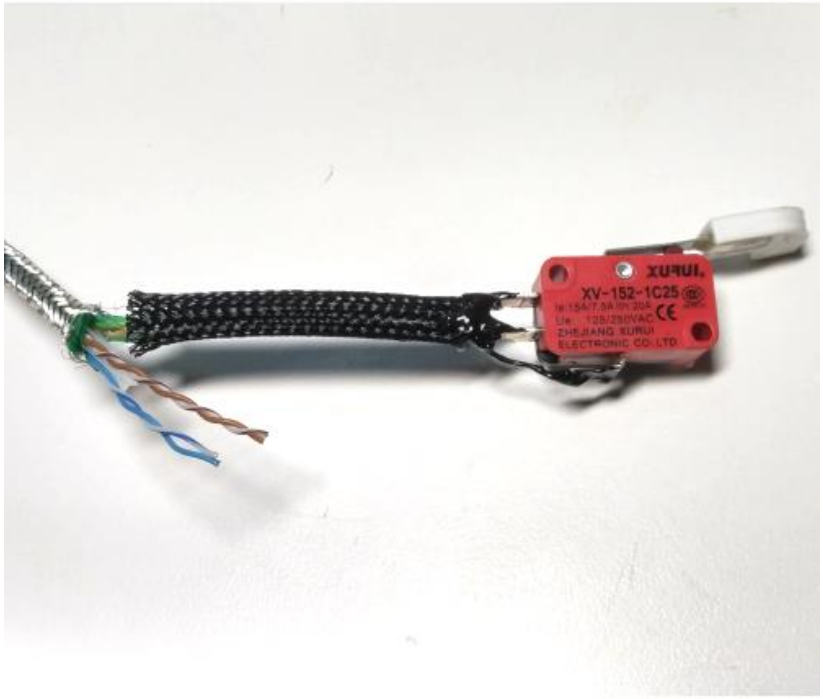
Solder orange wire to “NO” terminal of SV-156-1C25 roller tip limit switch.

Solder white with orange stripe wire to the “NC” terminal.

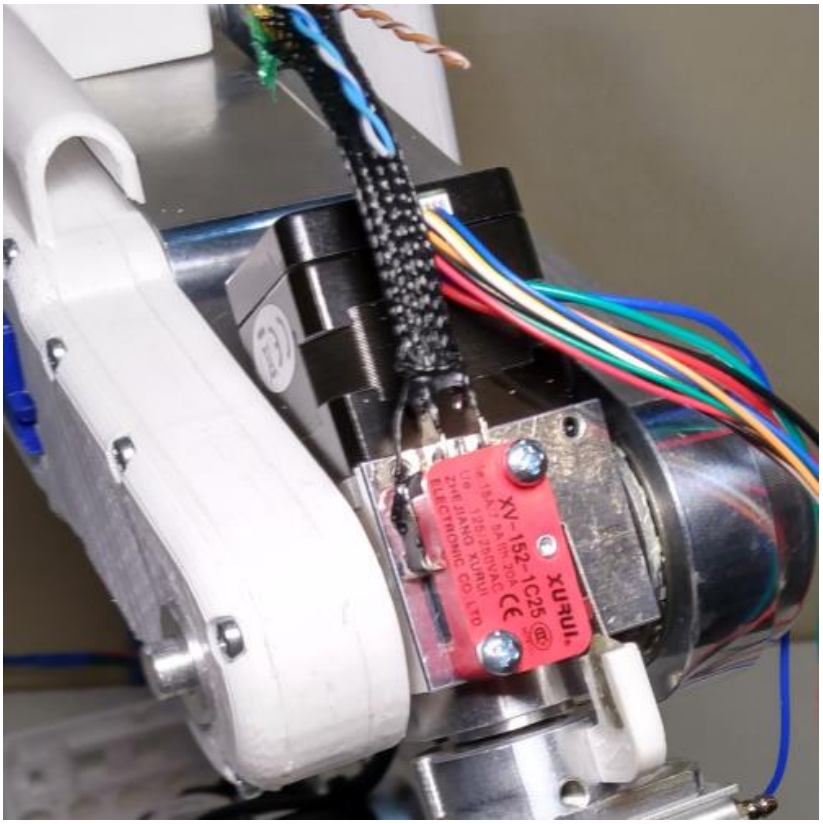
Solder the white with green stripe wire to the “COM” terminal.

Note: the green wire is not used.

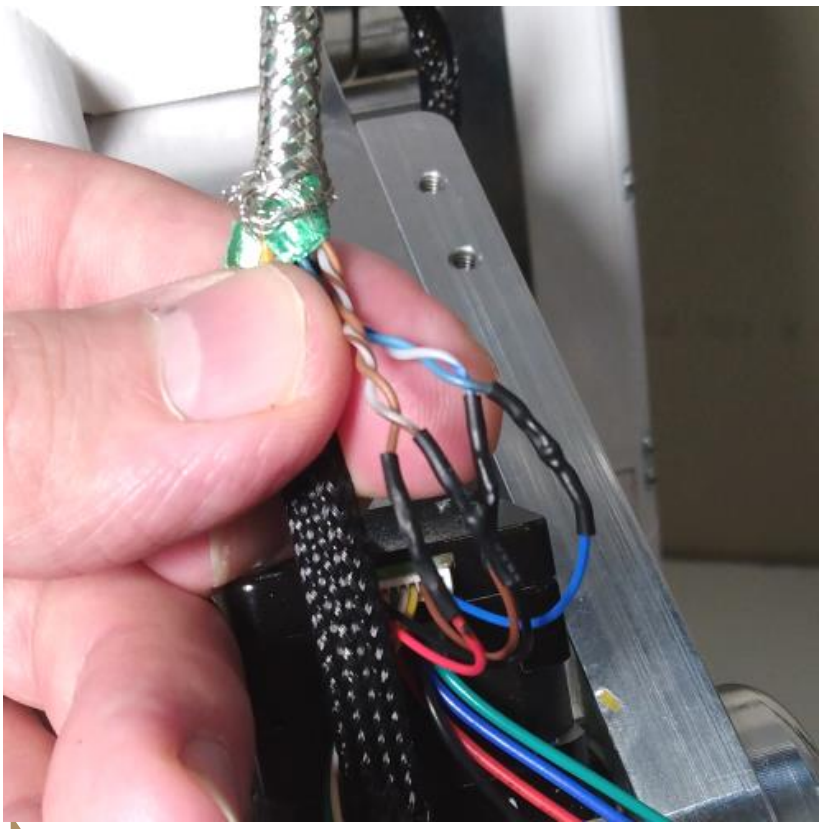
(also see wiring diagrams in chapter 4)



Coat switch terminals with liquid electrical tape, then remove alligator clip and allow braided sleeve to extend up to switch terminals as shown.



Install J6 limit switch onto J6 housing as shown using (2) M3x14 philps pan head screws.



Solder and heat shrink the connection from the J5 encoder to the Cat6 cable as follows:

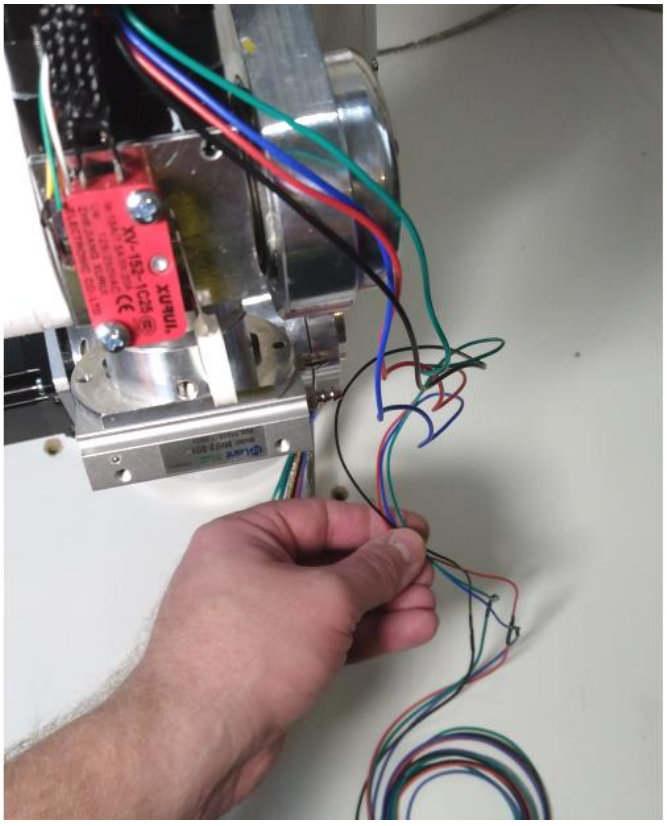
Encoder red wire to the cable brown wire.

Encoder black wire to the cable white – brown stripe wire.

Encoder brown wire to the cable white – blue stripe wire.

Encoder blue wire to the cable blue wire.

Cut Red, Black, Blue & Green 20awg wires to a length of 100cm long.



Solder and heat shrink 100cm long extension wires to the J6 motor wires as shown.

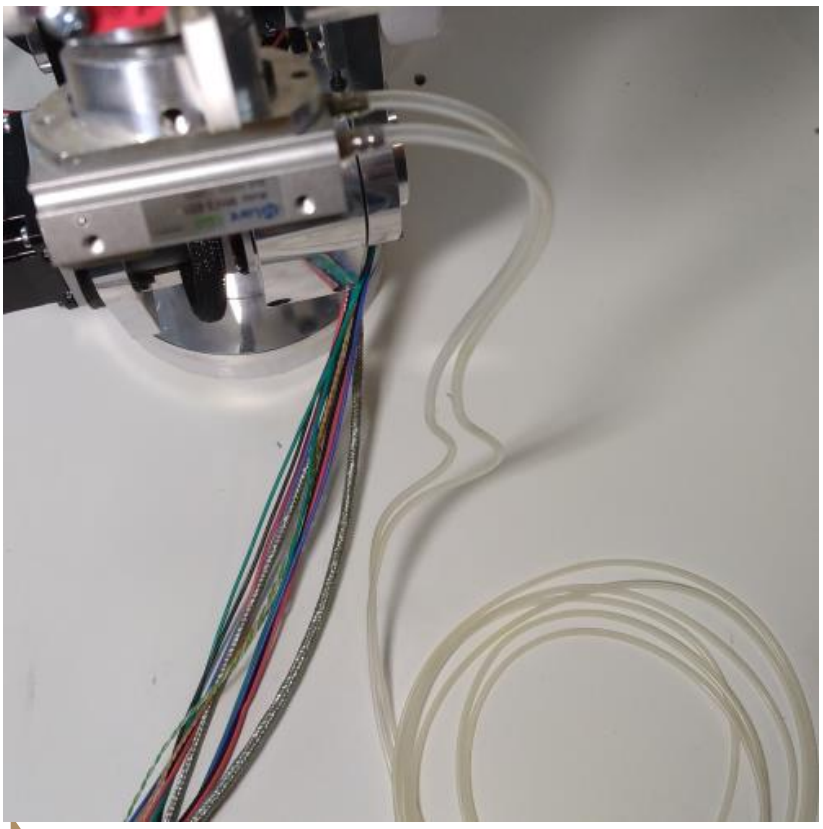
Be sure to match colors so that red goes to red and so on.

With the J6 motor wires extended the motor wires and Cat6 cable for J6 should now be the same length.

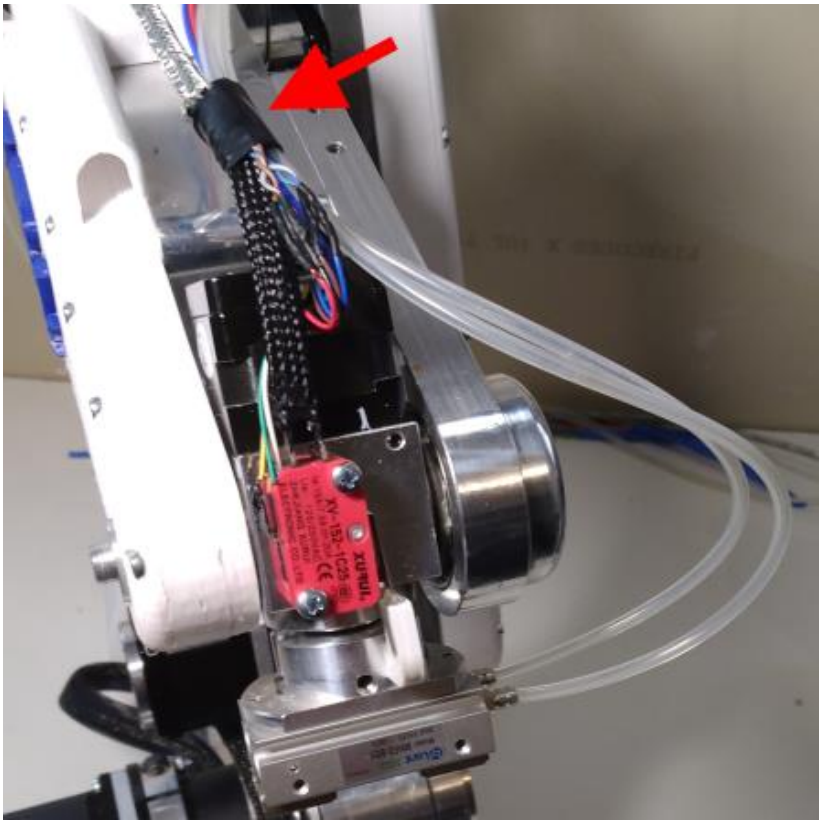
If installing a pneumatic gripper now is the time to run the air lines.

You can make the air lines any length you need, I am going to cut 2 lengths of tubing to 250cm (100”) each.

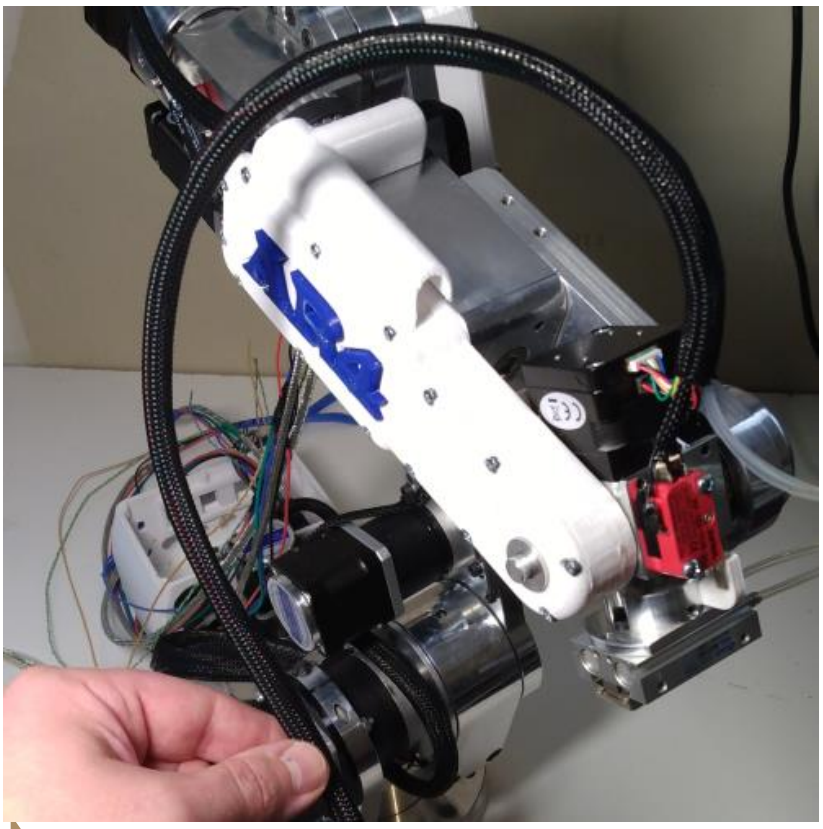
If you are going to use an electric gripper then instead of running pneumatic tubing run whatever electrical wire you may need for your servo gripper.



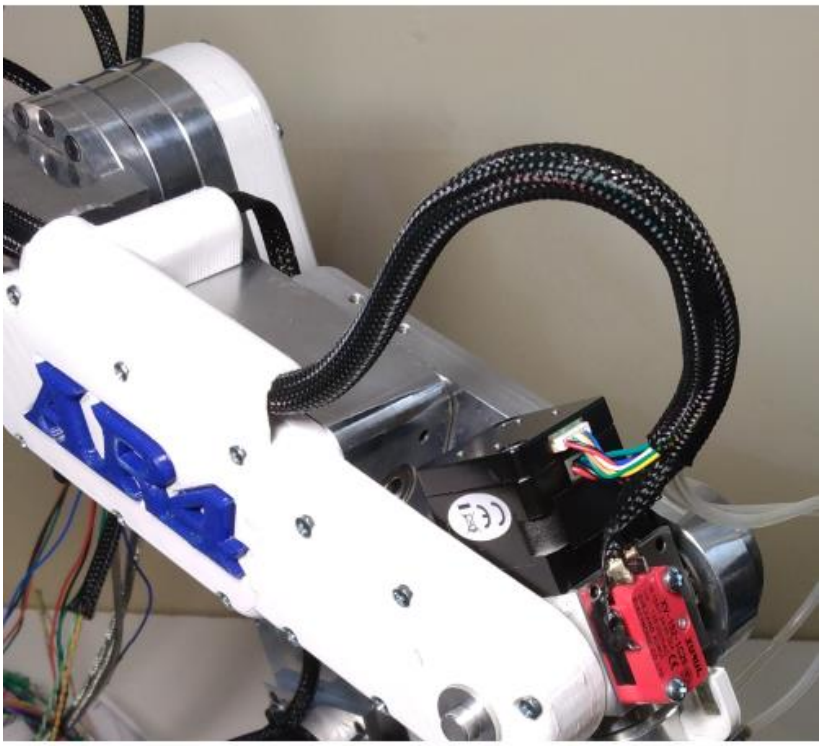
Connect ends end of tubing to the pneumatic gripper fittings.



Route the pneumatic lines along with encoder and motor wires and secure with a wrap of electrical tape. Make sure the pneumatic lines have the amount of slack shown and that J6 can fully articulate.



Cut length of ¼” braided sleeve to a length of 90cm long then route J6 motor wires and Cat6 cable through the sleeve.



Route J6 wires and sleeve through the J5 side spacer wire way as shown. Make sure to leave the amount of slack shown and that J5 can fully articulate.

It is recommended to coat the exposed encoder and motor wires with liquid electrical tape.

Applying the liquid electrical tape can also be done later after fully testing the robot electrically.

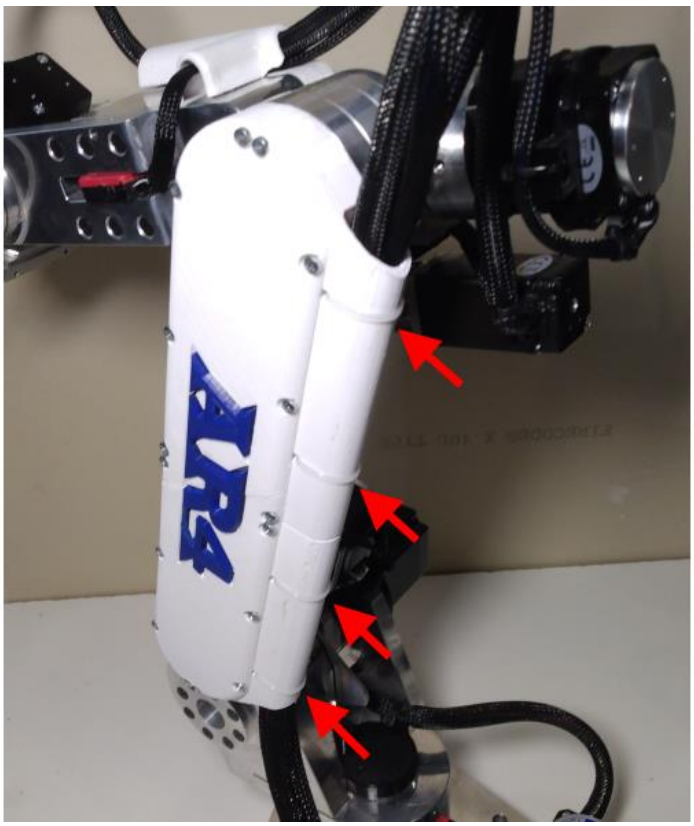
Route the J6 cable along with the J5 limit switch cable so that they are the same length and feed into the J2 side cover wire way as shown. Make sure they maintain the amount of slack shown so that J4 can fully articulate.

Make sure the J4 and J5 motor cables maintain the correct about of slack and then bind all the cables together temporarily with a small cable tie as shown.

Wrap ends of J6 motor wires, limit switch wires and Cat6 cable with tape and then use a marker to put (6) stripes on so that you will know these are for J6 when wires have been routed inside enclosure.

Cut length of 3/4” braided sleeve to a length of 70cm long then route J4, J5 and J6 motor wires and Cat6 cables through the sleeve.

Where the 3/4” braided sleeve overlaps the braided sleeve for the J4,5,6 cables just below the small cable tie wrap the end of the 3/4” braided sleeve with electrical tape. (red arrow)

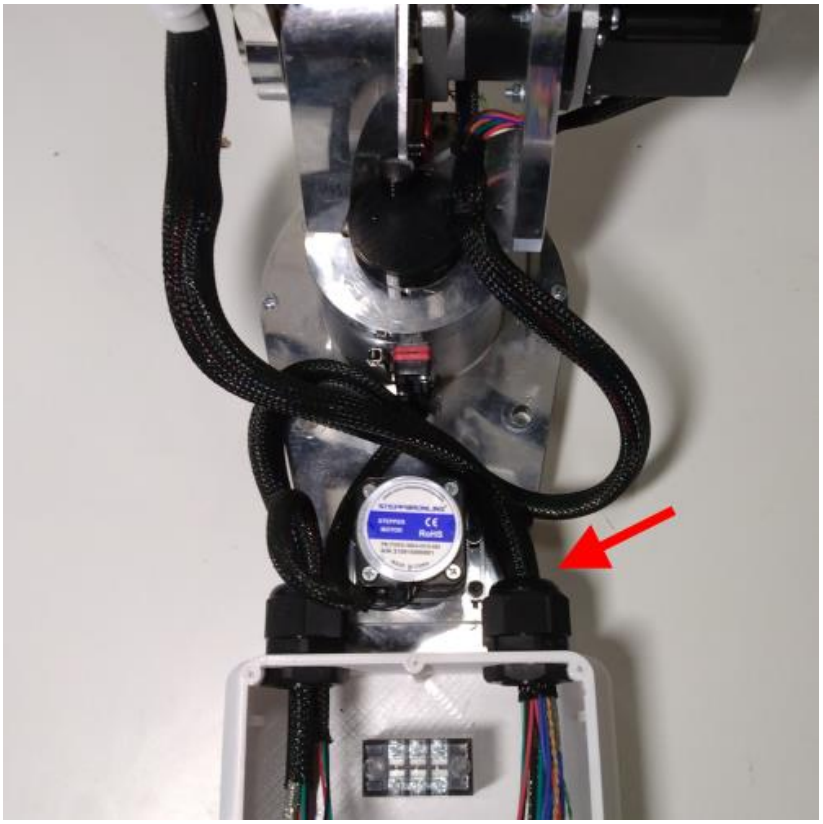


Insert the complete harness back into the J2 wireway as shown.

Secure wire harness to wireway with 4 small cable ties (red arrows) I have used clear cable ties for this application.

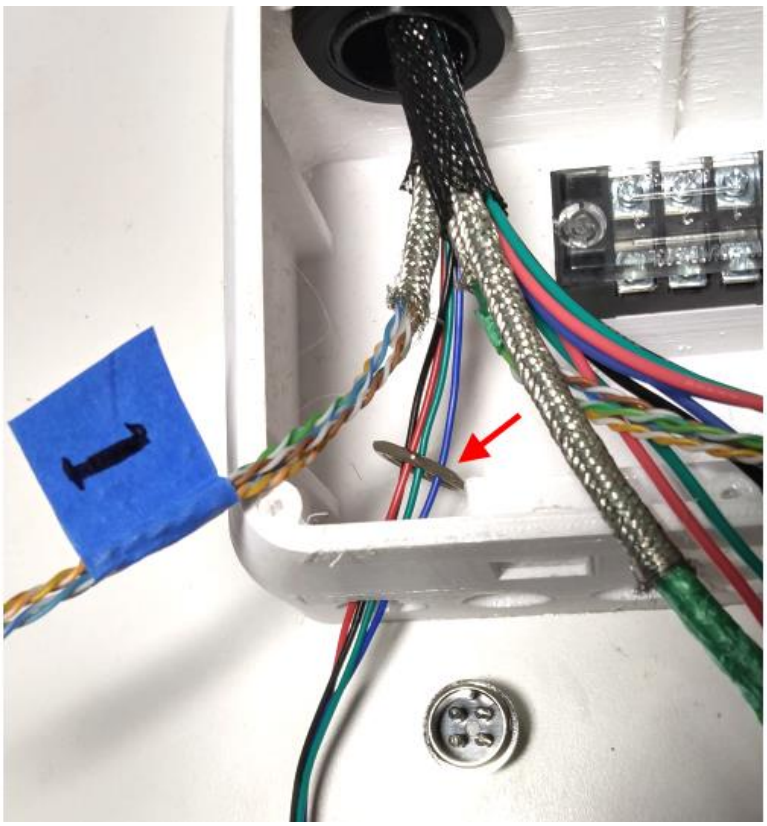
The top cable tie should overlap the harness where the wrap of electrical tape is at.

Carefully remove the cable tie that was used to temporality keep the 4 smaller cables together.



Route the wire harness from the J2 wireway and into the right side gland nut as shown. (red arrow)

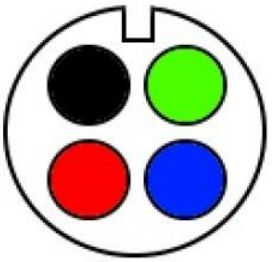
Make sure to leave the amount of slack shown and that J1 can fully articulate.



Locate the J1 motor and encoder wires. Use a small piece of tape to label the encoder wires so they don't get mixed up. Route the J1 motor wires through a GX16-4 socket connector nut (red arrow) and then route the wires through the far left hole in base enclosure.

Solder motor wires to GX16-4 aviation plug as shown.

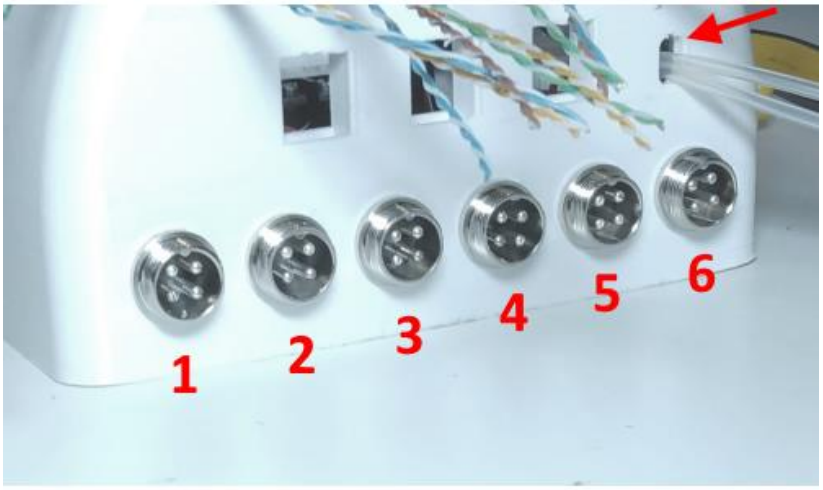
View from back of connector with notch up solder black to upper left, green to upper right, red to lower left and blue to lower right.



VIEW FROM BACKSIDE OF CONNECTOR

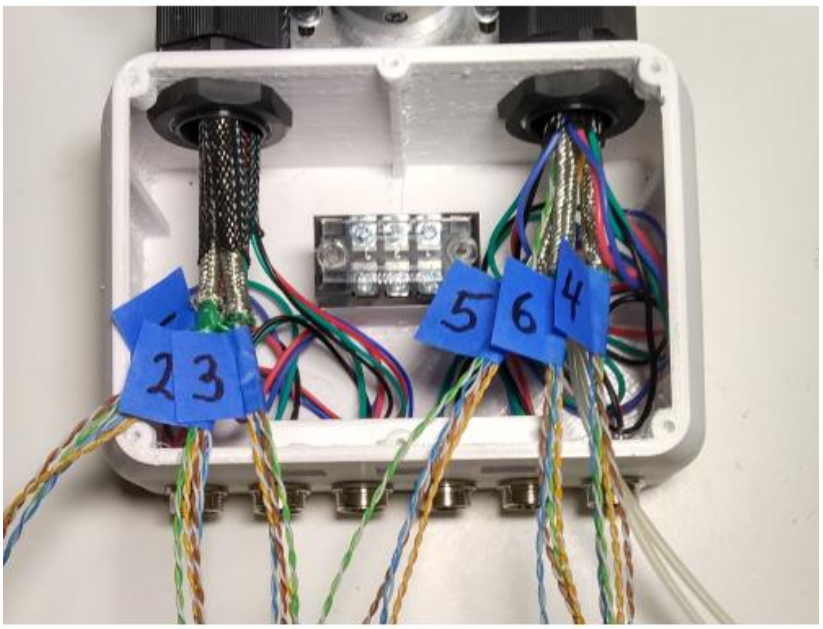
Install GX16-4 socket into enclosure as shown and tighten nut from back side.

Use a small flat blade screw driver and needle nose pliers to assist in tightening the nut.



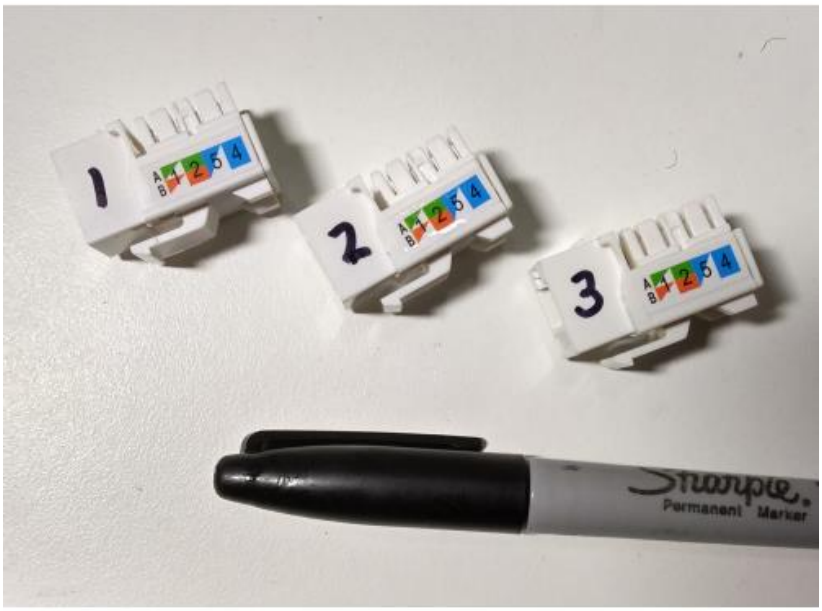
Repeat the last 3 steps for each joint installing the socket connectors starting with joint 1 on the left and ending with joint 6 on the right.

Feed the pneumatic lines out of the enclosure where shown (red arrow).

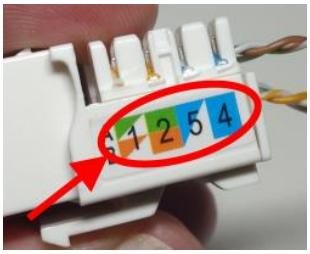


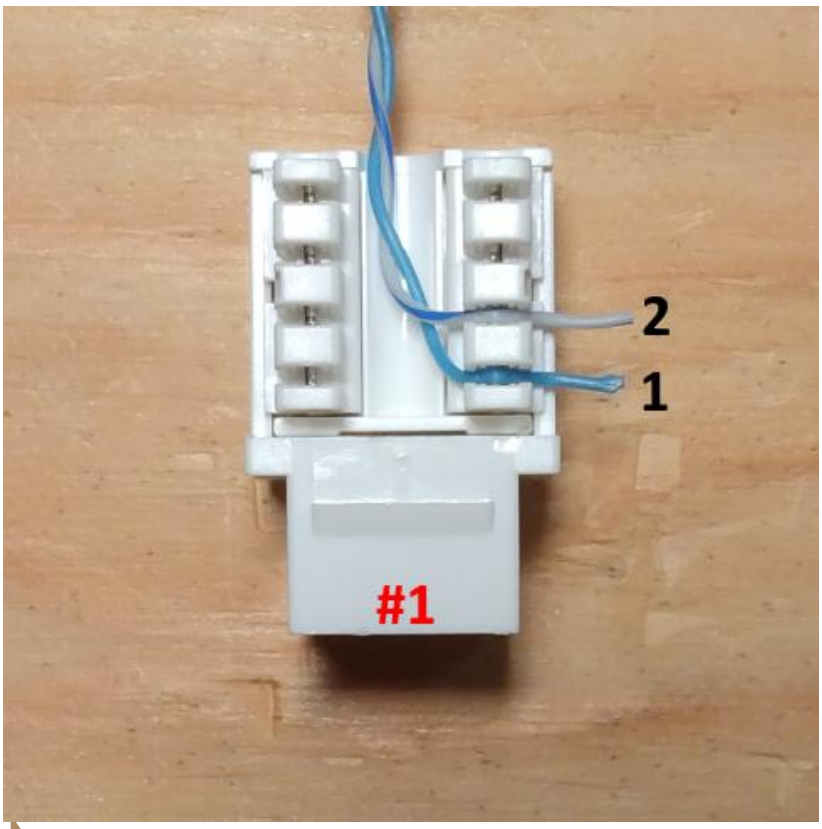
Make sure to label the encoder and limit switch wires as you go

Label (3) RJ45 keystone jacks 1, 2 and 3.



NOTE: In the following keystone jack steps; If you have sourced your own keystone jacks be sure to check the terminal number – not all keystone jacks are numbered the same – make sure to wire color to the terminal number per the instruction text, the colors and numbers will not always be in the same arrangement as the image shown.





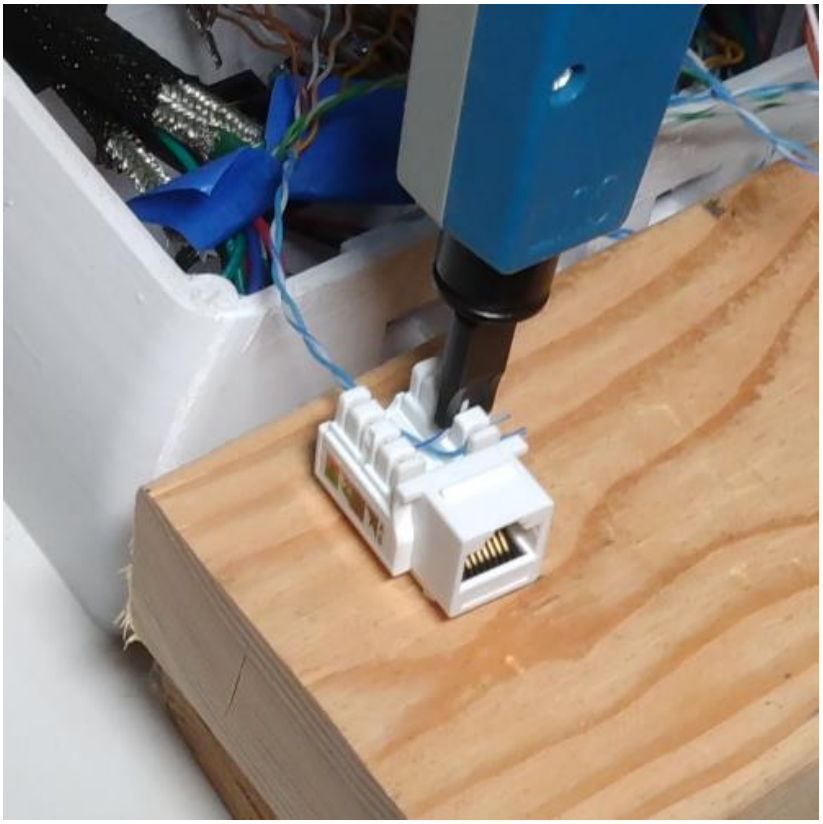
Place keystone jack #1 on a wood block next to the base enclosure.

Insert **J1 encoder** cable blue wire into slot 1 of the #1 keystone jack.

Insert **J1 encoder** cable white with blue stripe into slot 2 of the #1 keystone jack

ALSO REFER TO THE WIRING SCHEMATICS SHOWN IN CHAPTER 4

.

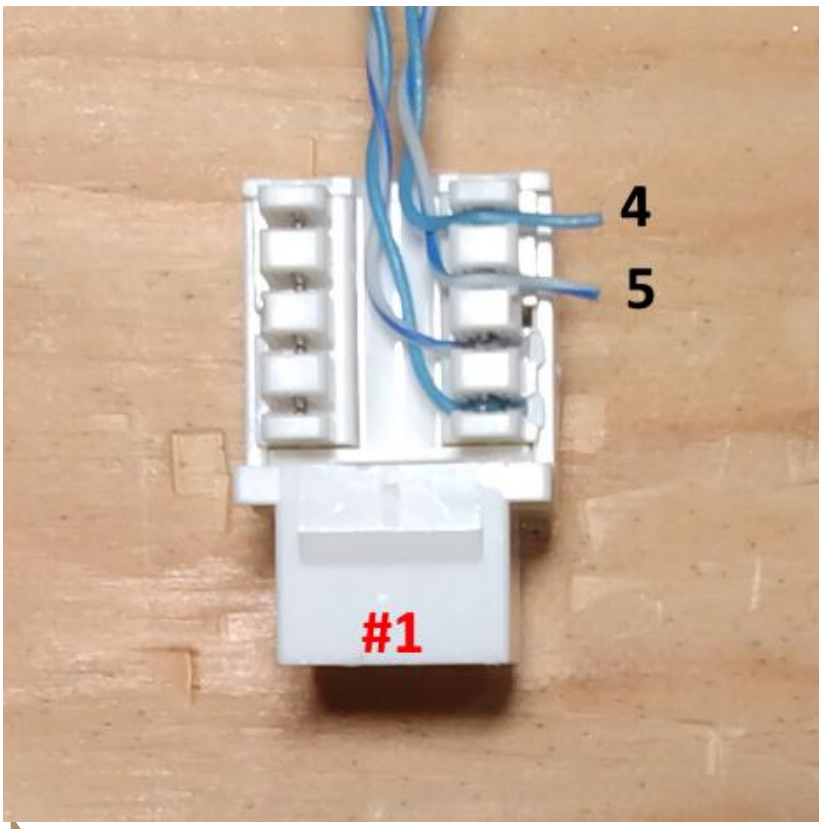


Use a network wire punch down impact tool to fully seat each wire down into the RJ45 keystone jack.

The tool should also trim each wire on the sides so make sure the cut side of the tool is facing out.

After each wire is seated use a multi meter and check continuity between the connection inside the socket to the end of the wire and verify you have a good connection – do not skip this step it is very important to check.

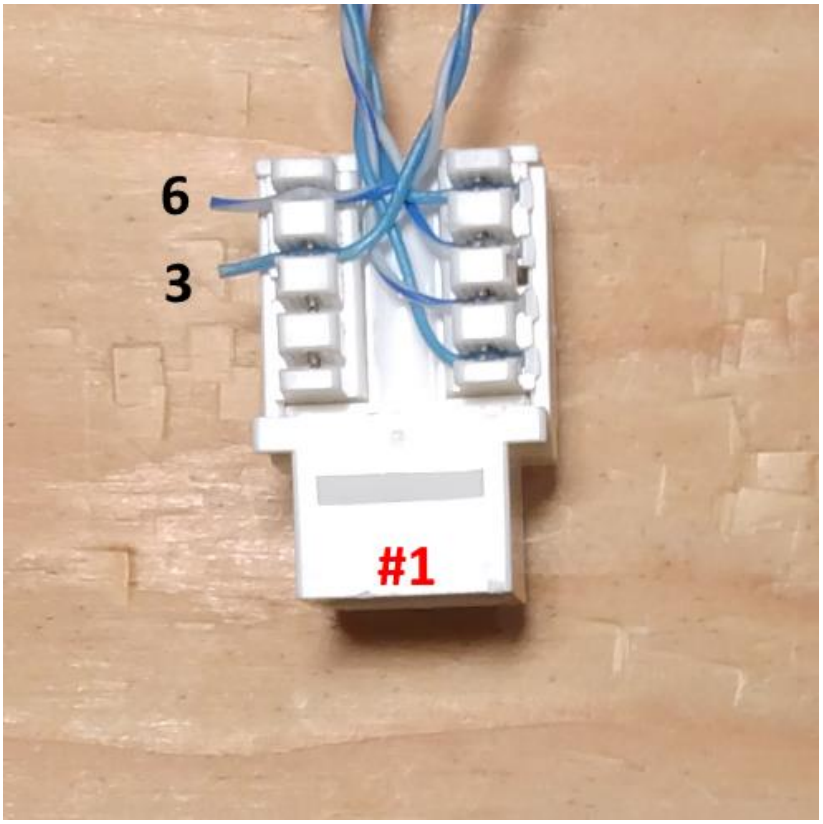
Use the network wire punch down tool as shown for all of the following RJ45 keystone jack wiring steps.



Insert **J2 encoder** cable blue wire into slot 4 of the #1 keystone jack.

Insert **J2 encoder** cable white with blue stripe into slot 5 of the #1 keystone jack

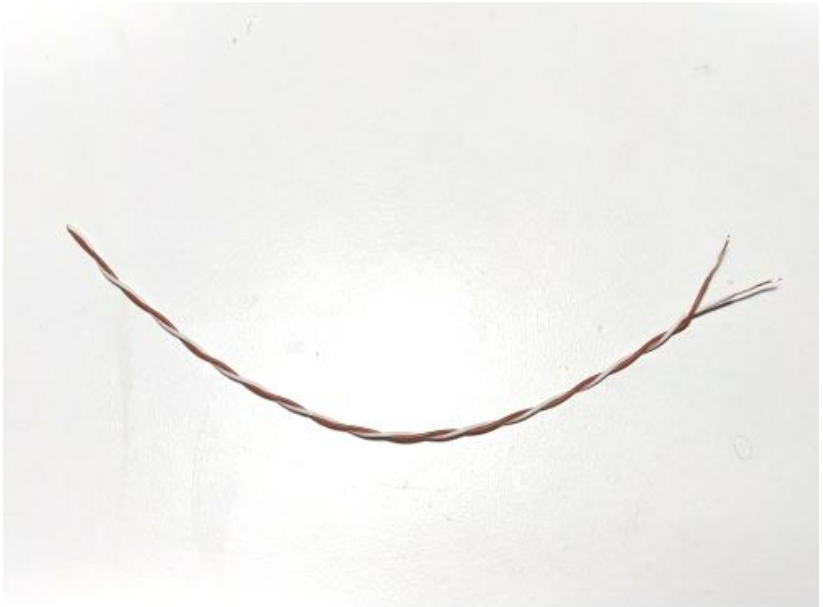
ALSO REFER TO THE WIRING SCHEMATICS SHOWN IN CHAPTER 4



Insert **J3 encoder** cable blue wire into slot 3 of the #1 keystone jack.

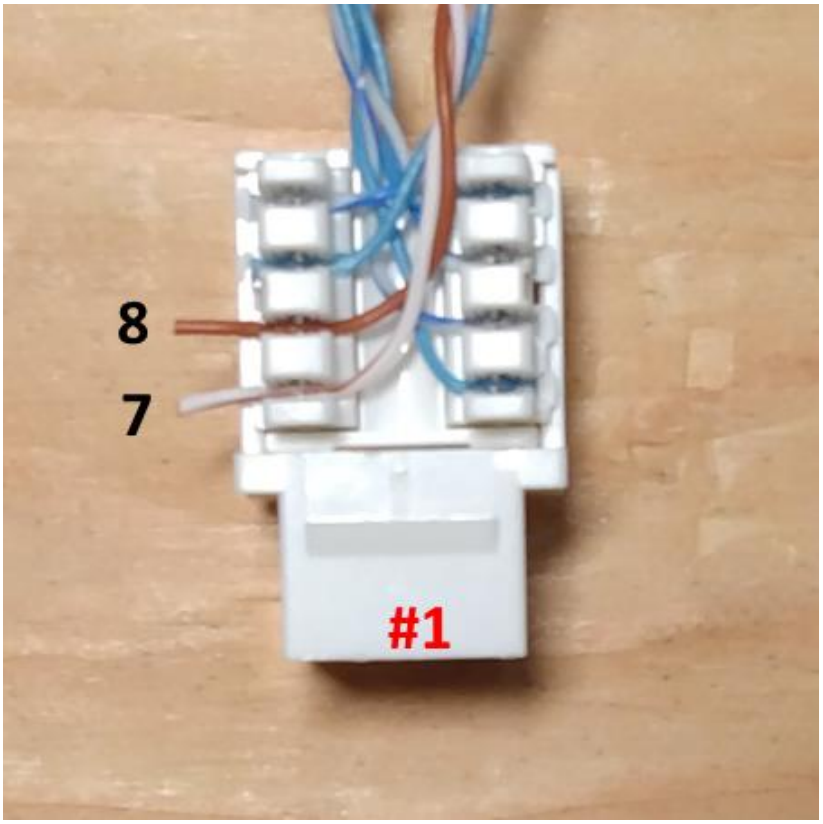
Insert **J3 encoder** cable white with blue stripe into slot 6 of the #1 keystone jack

ALSO REFER TO THE WIRING SCHEMATICS SHOWN IN CHAPTER 4



Cut length of brown / white twisted pair wire to a length of 18cm long.

Use wire strippers to strip one end of the wires.

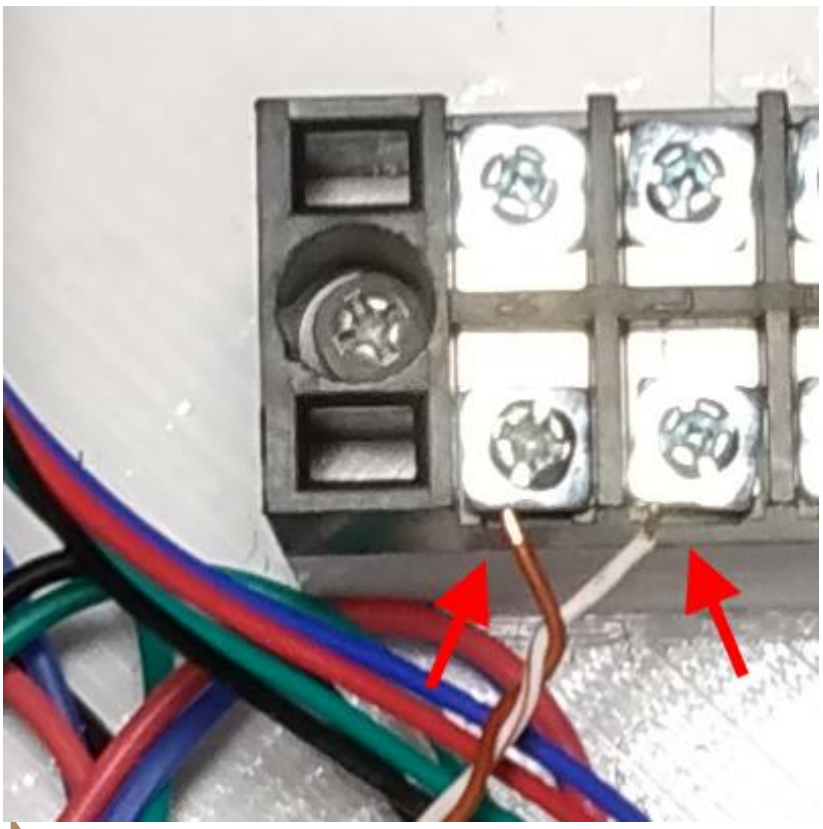


Insert brown wire from **18cm length** into slot 8 of the #1 keystone jack.

Insert the white with brown stripe from **18cm length** into slot 7 of the #1 keystone jack.

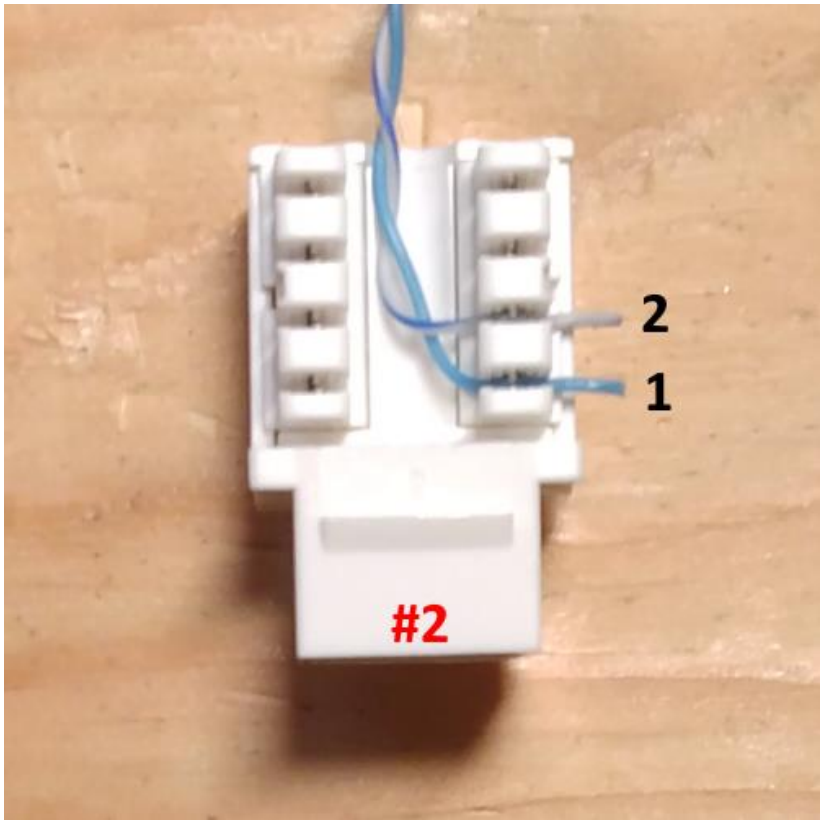
Use network wire punch down impact tool to seat wires.

ALSO REFER TO THE WIRING SCHEMATICS SHOWN IN CHAPTER 4



On the opposite end of the 18cm brown/white twisted pair secure the brown wire under the left terminal of the 3 terminal junction block inside base enclosure. Secure the white with brown stripe wire under the center terminal

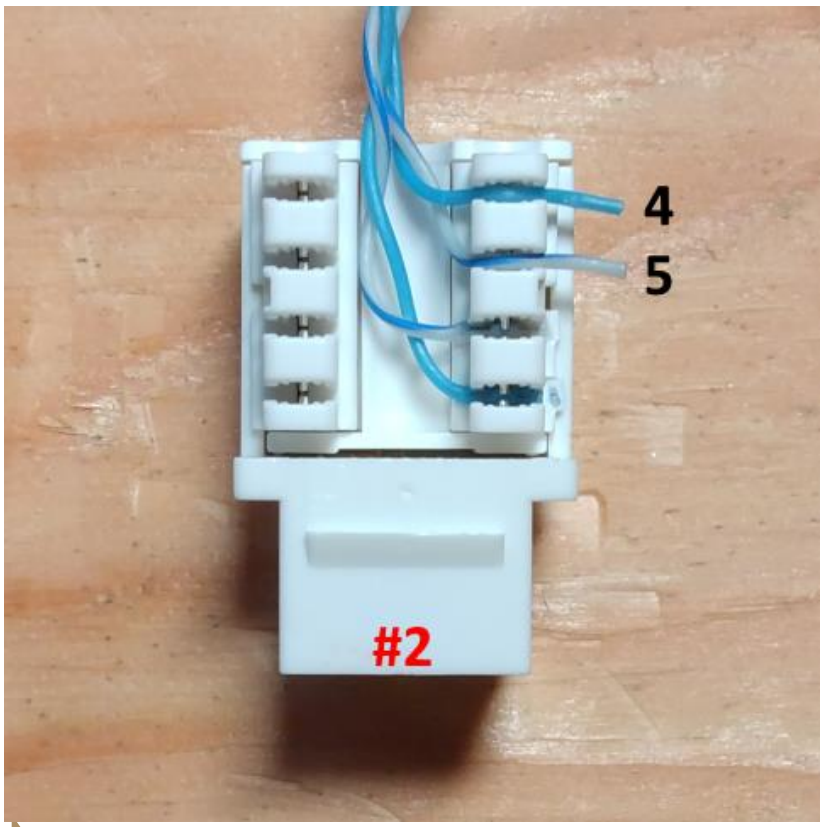
ALSO REFER TO THE WIRING SCHEMATICS SHOWN IN CHAPTER 4



Insert **J4 encoder** cable blue wire into slot 1 of the #2 keystone jack.

Insert **J4 encoder** cable white with blue stripe into slot 2 of the #2 keystone jack

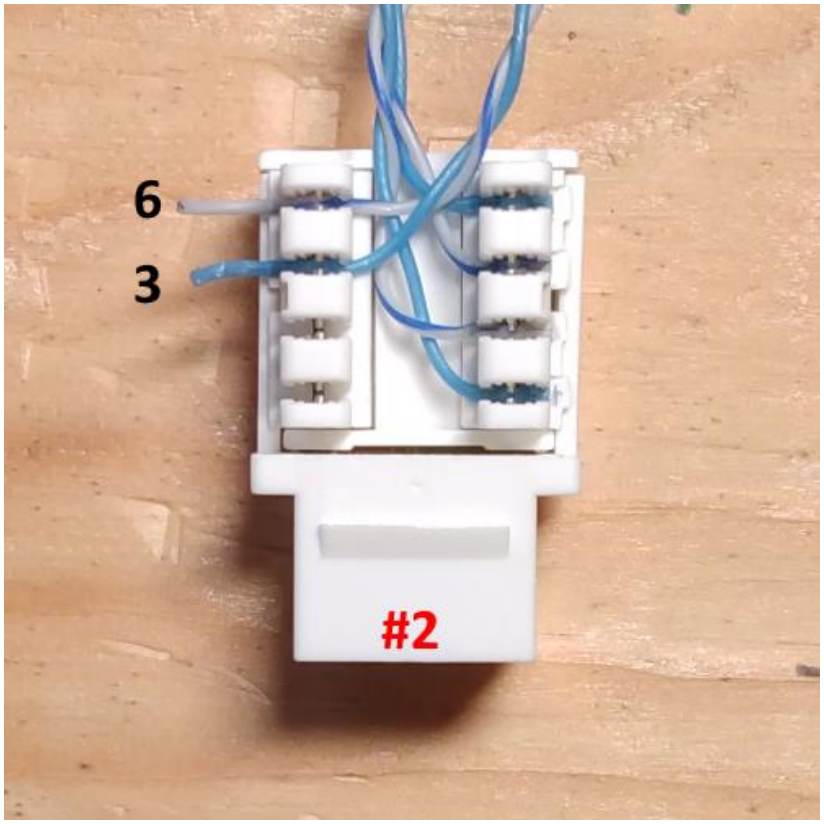
ALSO REFER TO THE WIRING SCHEMATICS SHOWN IN CHAPTER 4



Insert **J5 encoder** cable blue wire into slot 4 of the #2 keystone jack.

Insert **J5 encoder** cable white with blue stripe into slot 5 of the #2 keystone jack

ALSO REFER TO THE WIRING SCHEMATICS SHOWN IN CHAPTER 4

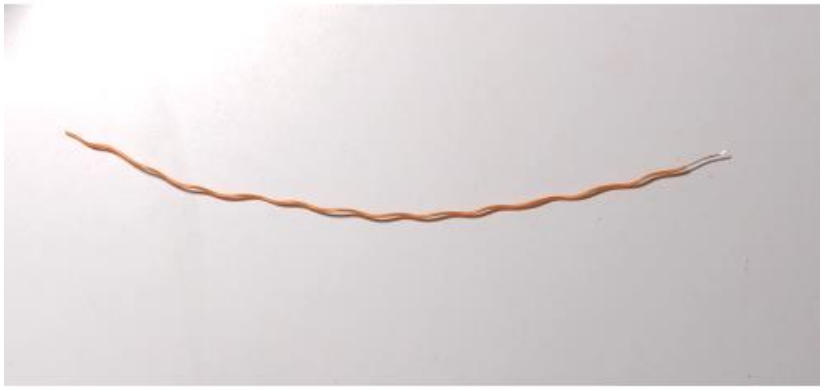


Insert **J6 encoder** cable blue wire into slot 3 of the #2 keystone jack.

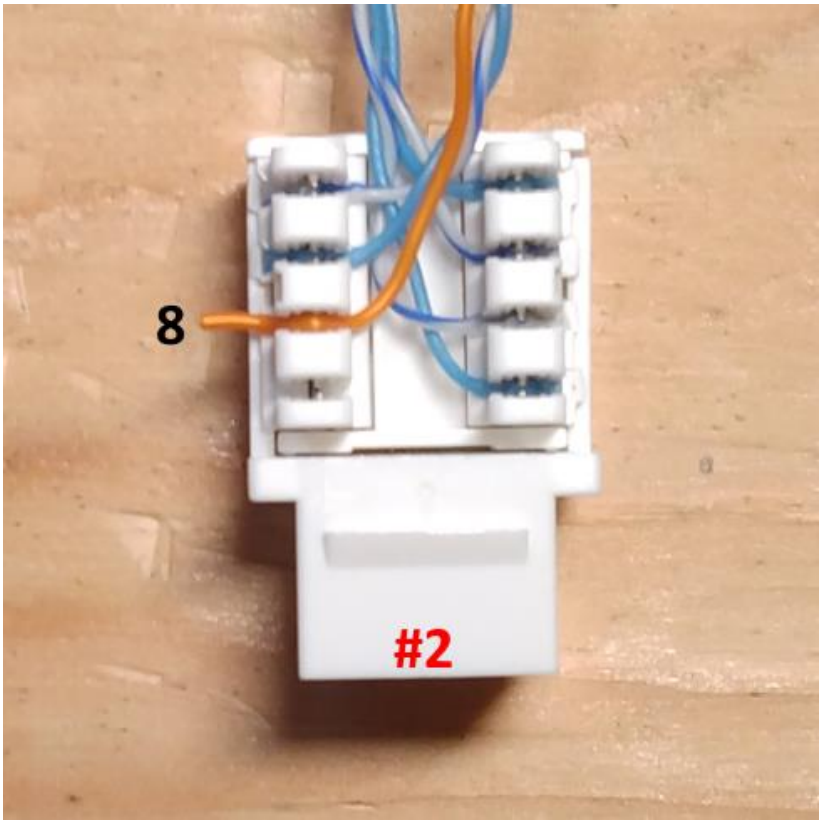
Insert **J6 encoder** cable white with blue stripe into slot 6 of the #2 keystone jack

ALSO REFER TO THE WIRING SCHEMATICS SHOWN IN CHAPTER 4

Cut length of orange single strand wire to a length of 18cm long.



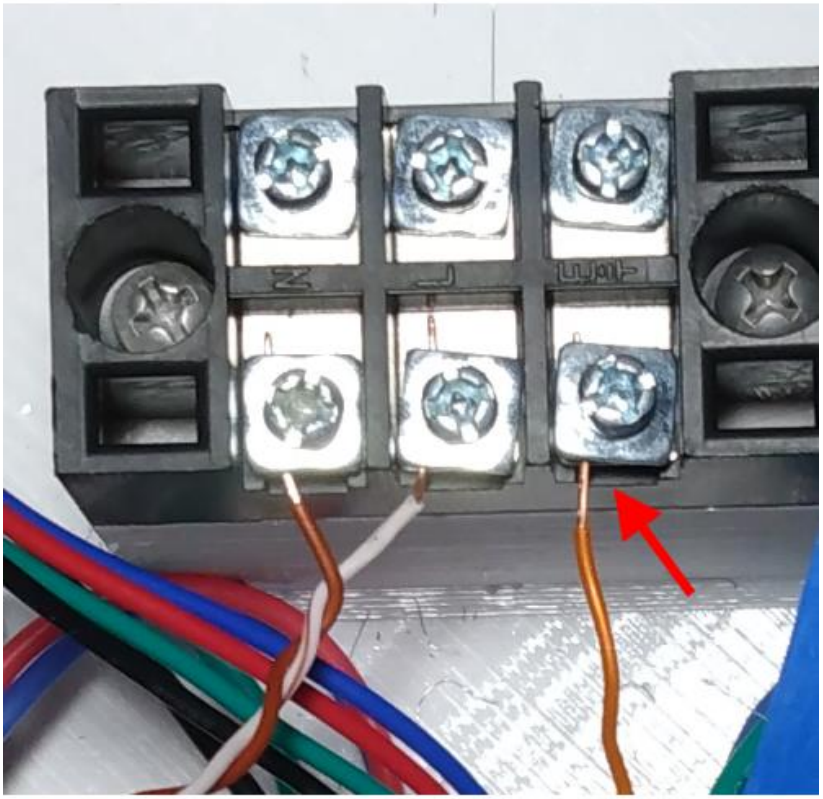
Use wire strippers to strip one end of the wire.



Insert orange wire from **18cm length** into slot 8 of the #2 keystone jack.

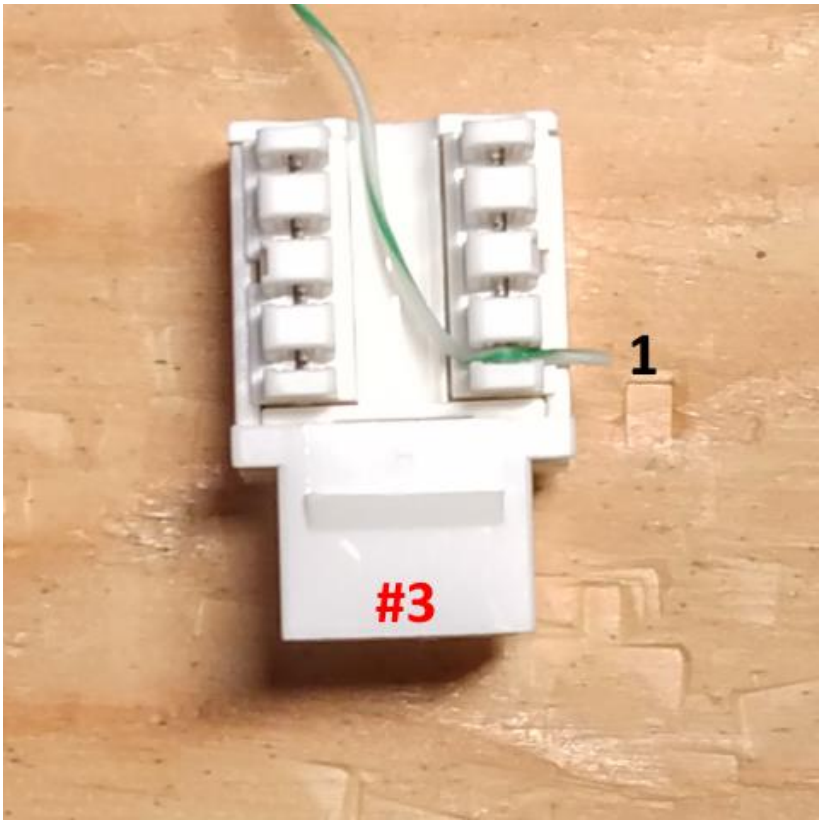
Use network wire punch down impact tool to seat wires.

ALSO REFER TO THE WIRING SCHEMATICS SHOWN IN CHAPTER 4



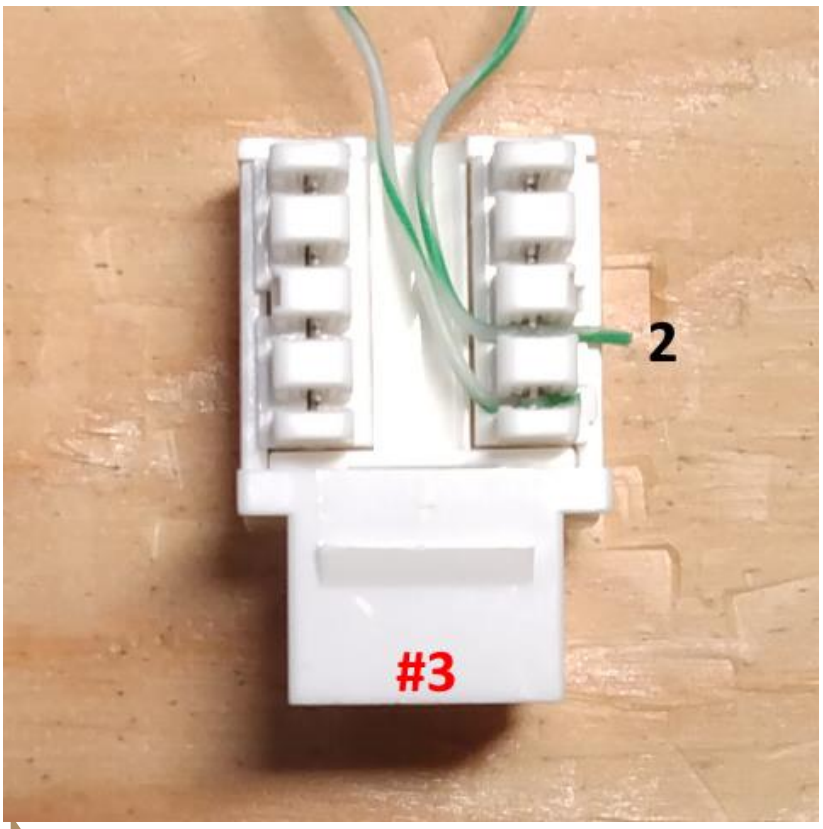
Secure the opposite end of the 18cm orange wire under the right terminal of the 3 terminal junction block inside base enclosure.

ALSO REFER TO THE WIRING SCHEMATICS SHOWN IN CHAPTER 4



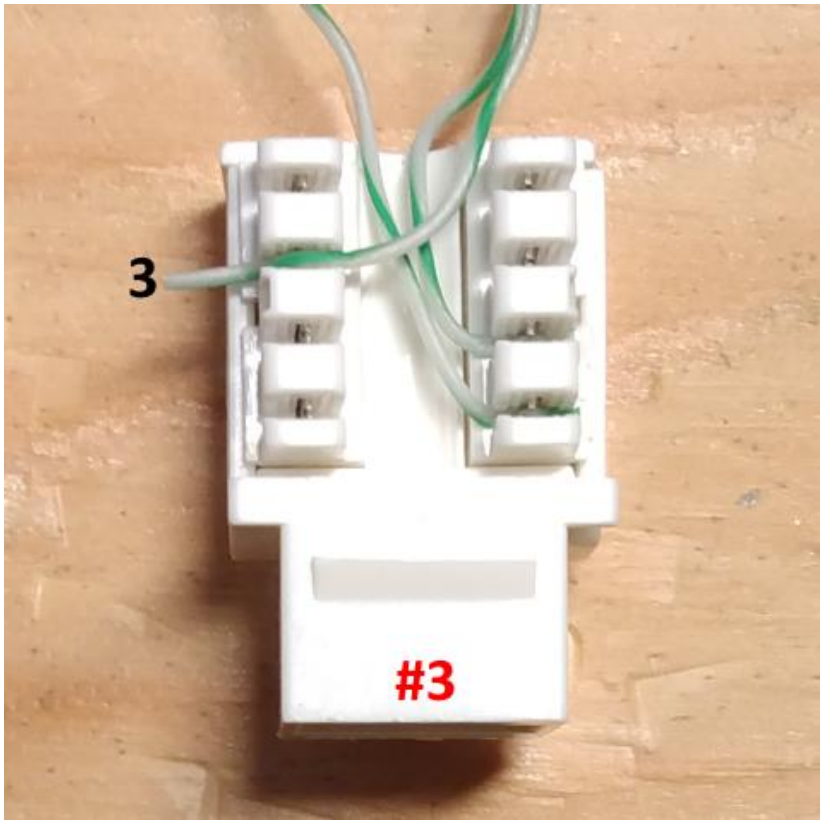
Insert **J1 limit switch** white with green stripe into slot 1 of the #3 keystone jack

ALSO REFER TO THE WIRING SCHEMATICS SHOWN IN CHAPTER 4



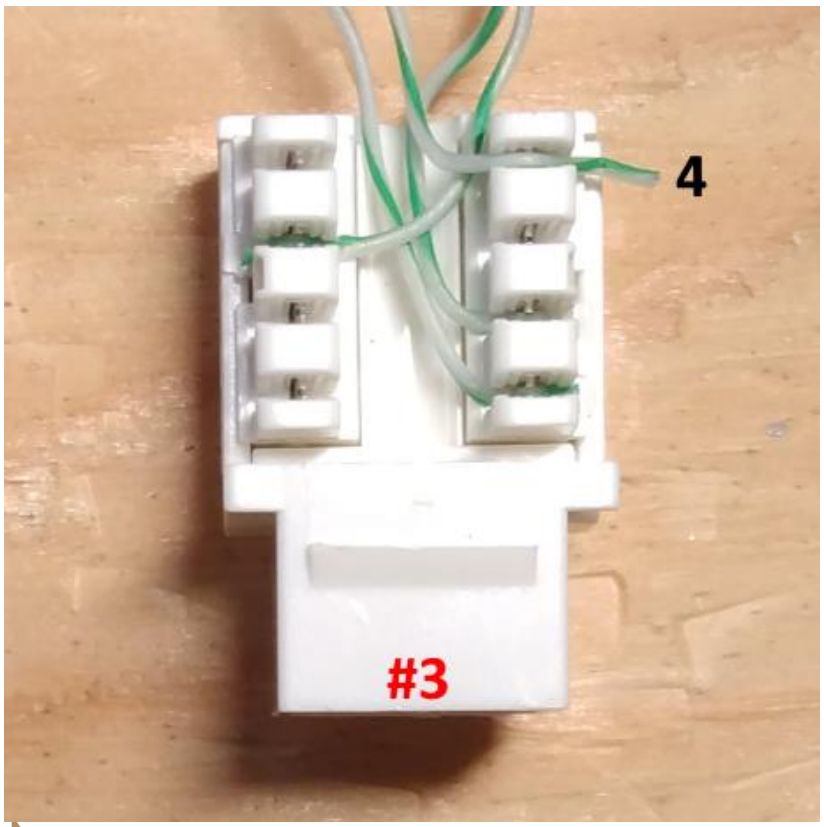
Insert **J2 limit switch** white with green stripe into slot 2 of the #3 keystone jack

ALSO REFER TO THE WIRING SCHEMATICS SHOWN IN CHAPTER 4



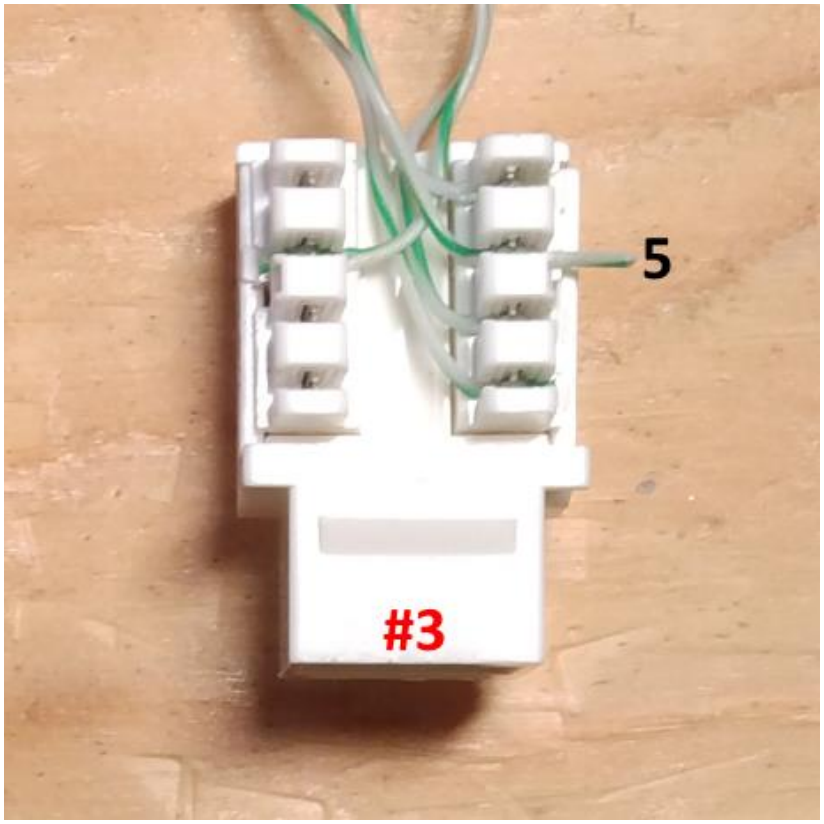
Insert **J3 limit switch** white with green stripe into slot 3 of the #3 keystone jack

ALSO REFER TO THE WIRING SCHEMATICS SHOWN IN CHAPTER 4



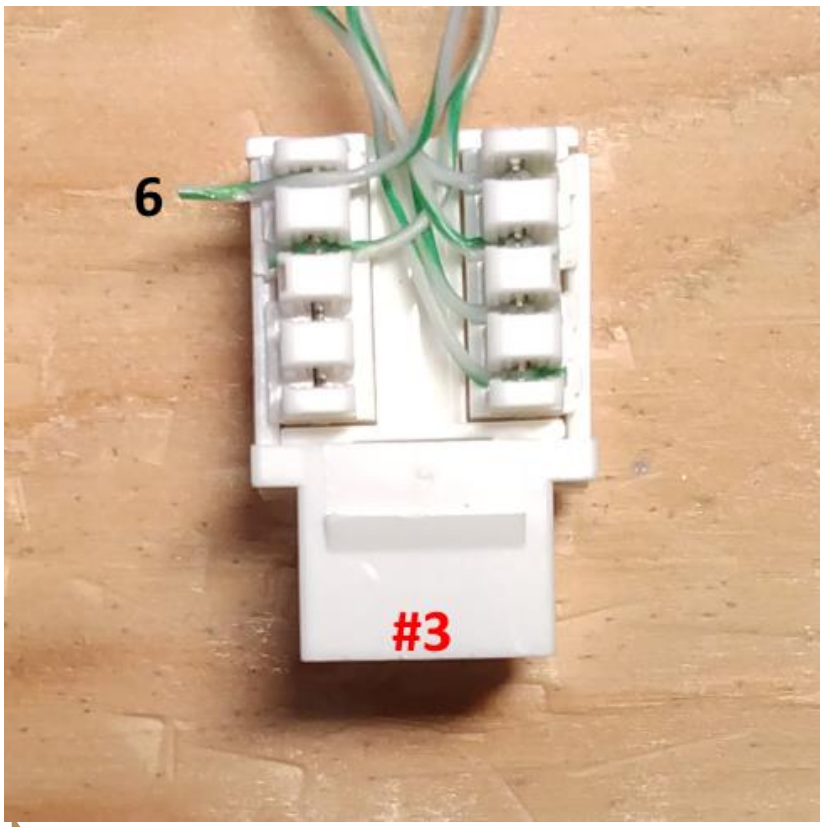
Insert **J4 limit switch** white with green stripe into slot 4 of the #3 keystone jack

ALSO REFER TO THE WIRING SCHEMATICS SHOWN IN CHAPTER 4



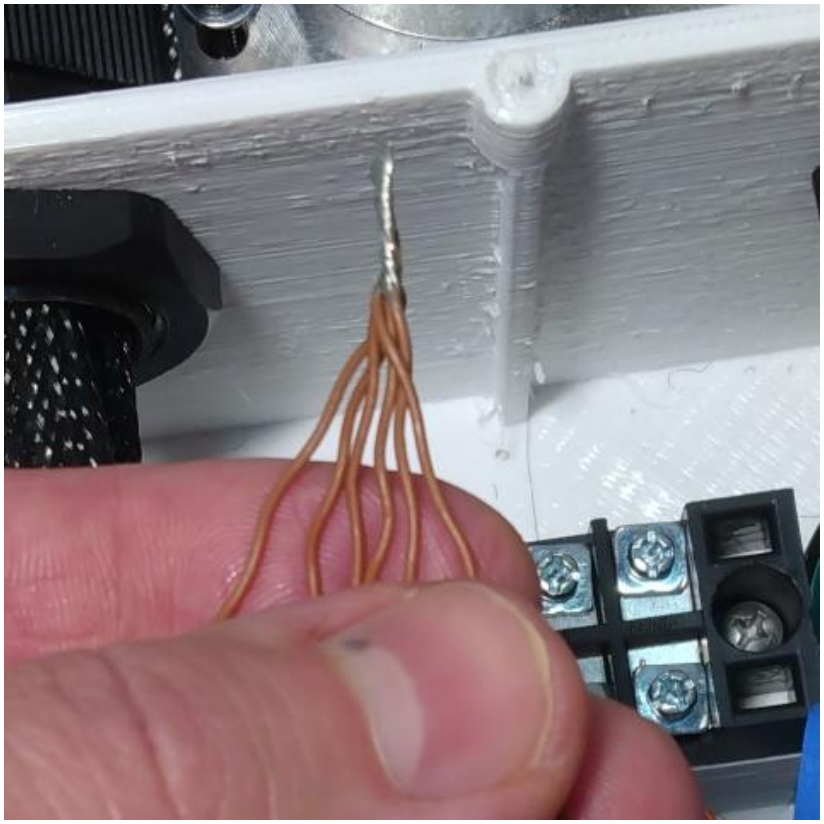
Insert **J5 limit switch** white with green stripe into slot 5 of the #3 keystone jack

ALSO REFER TO THE WIRING SCHEMATICS SHOWN IN CHAPTER 4



Insert **J6 limit switch** white with green stripe into slot 6 of the #3 keystone jack

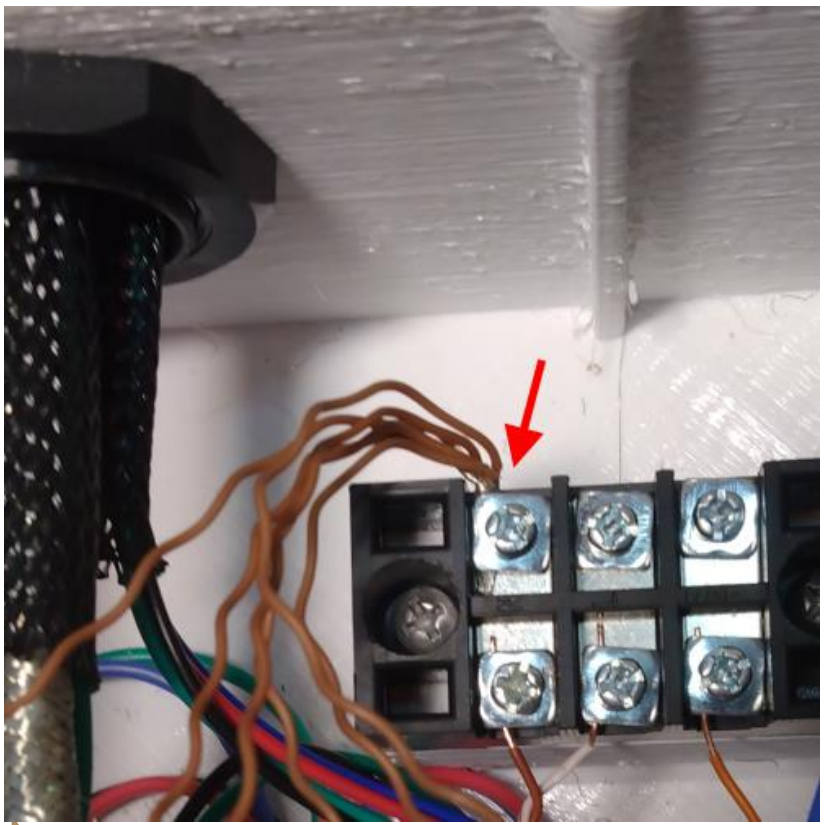
ALSO REFER TO THE WIRING SCHEMATICS SHOWN IN CHAPTER 4



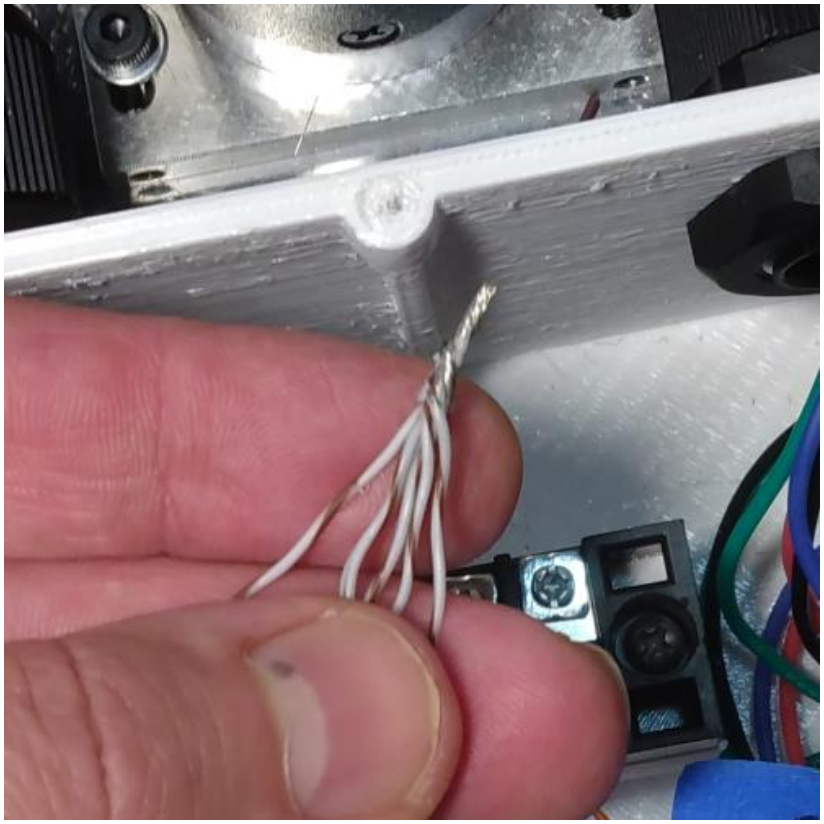
Strip ends and combine brown wires from all 6 encoder cables.

Using a lighter to quickly heat the end of the wire jacket makes stripping the end easier on these small wires.

I also recommend applying solder to the twisted ends to ensure conductivity to all wires.



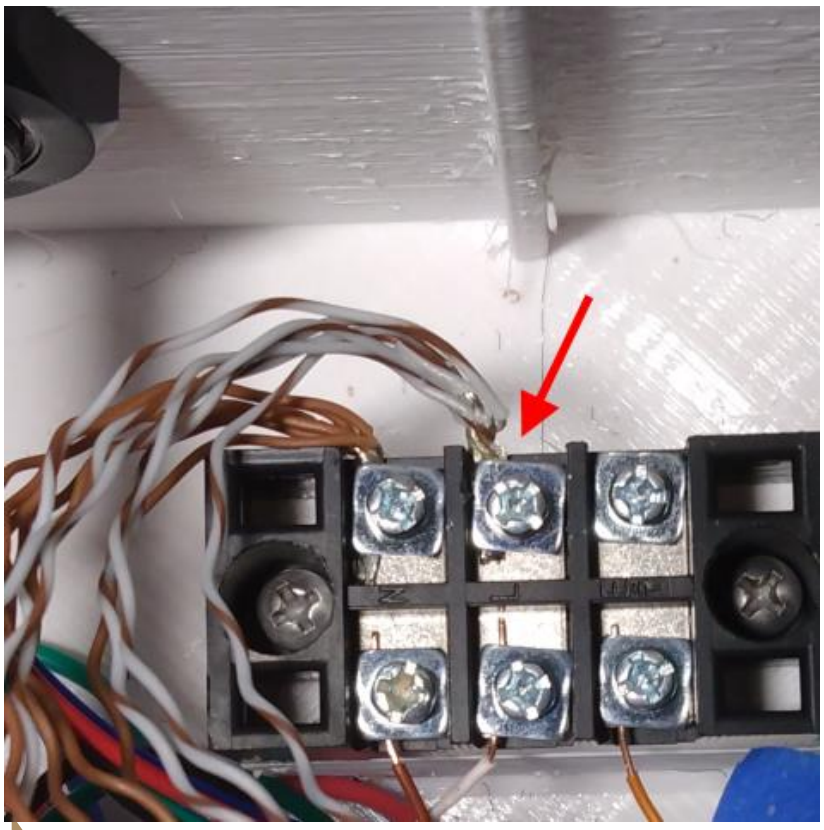
Secure the combined 6 brown wires in terminal #1 of the terminal junction block as shown.



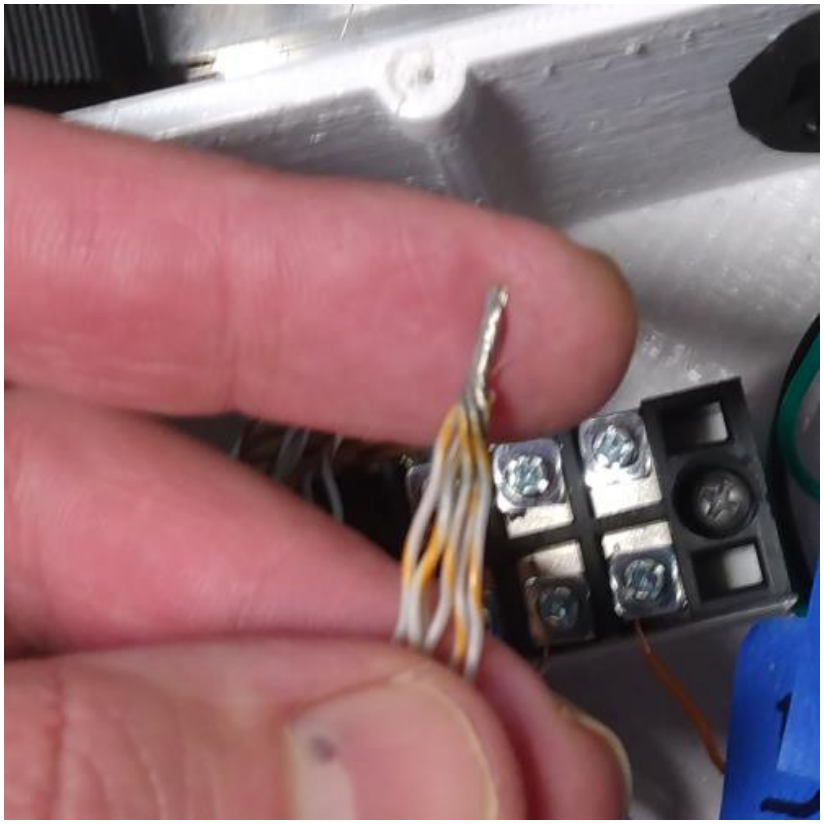
Strip ends and combine white/brown stripe wires from all 6 encoder cables.

Using a lighter to quickly heat the end of the wire jacket makes stripping the end easier on these small wires.

I also recommend applying solder to the twisted ends to ensure conductivity to all wires.



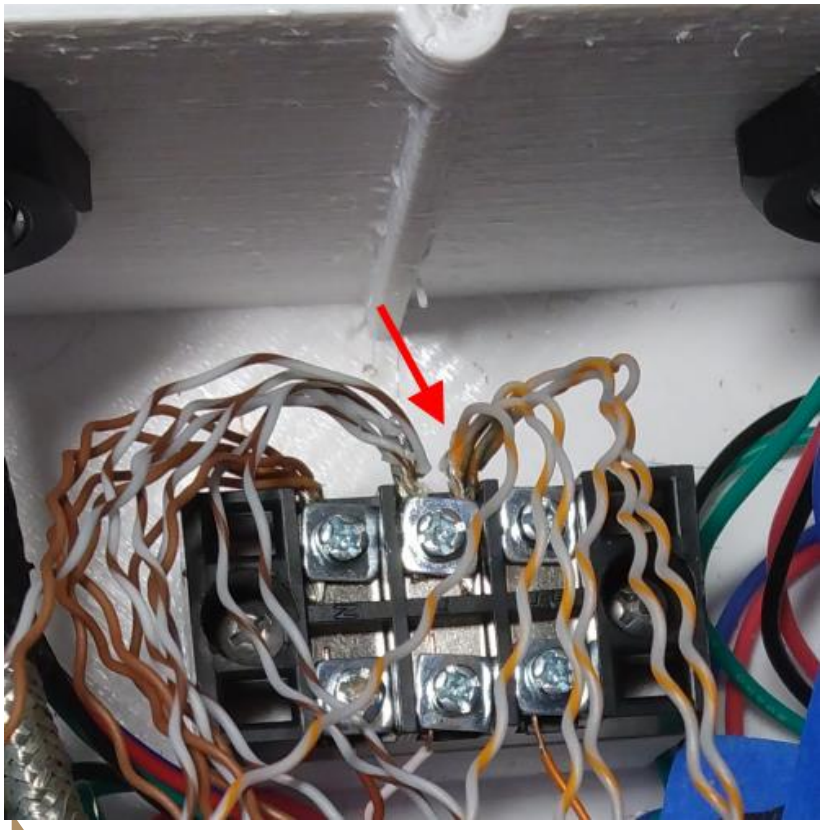
Secure the combined 6 white/brown stripe wires in terminal #2 of the terminal junction block as shown.



Strip ends and combine white/orange stripe wires from all 6 encoder cables.

Using a lighter to quickly heat the end of the wire jacket makes stripping the end easier on these small wires.

I also recommend applying solder to the twisted ends to ensure conductivity to all wires.

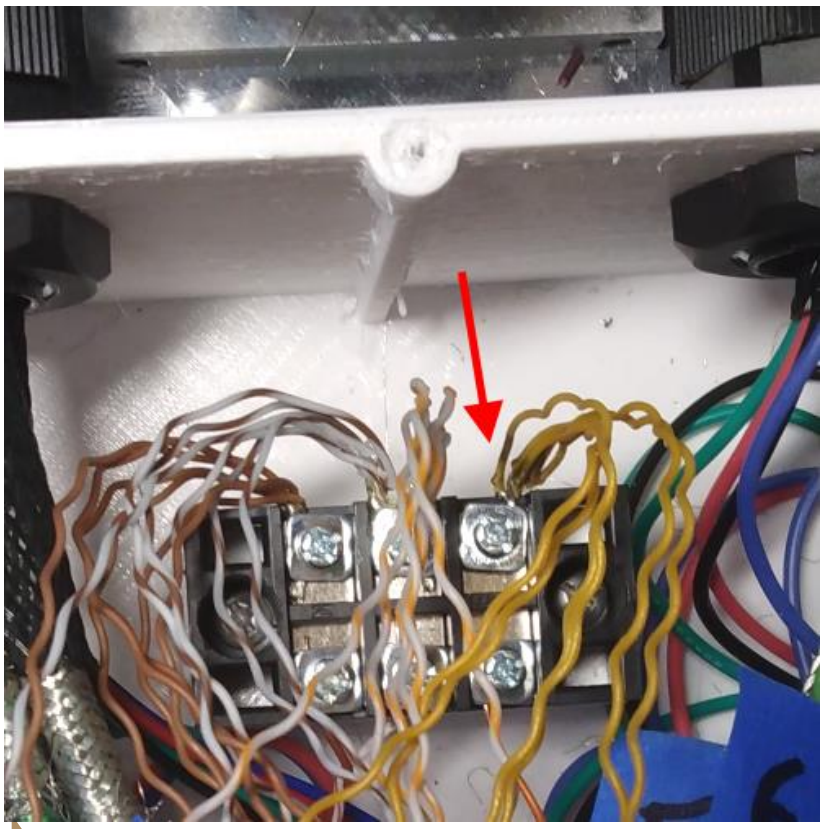


Secure the combined 6 white/orange stripe wires in terminal #2 of the terminal junction block along with the white/brown wires as shown.

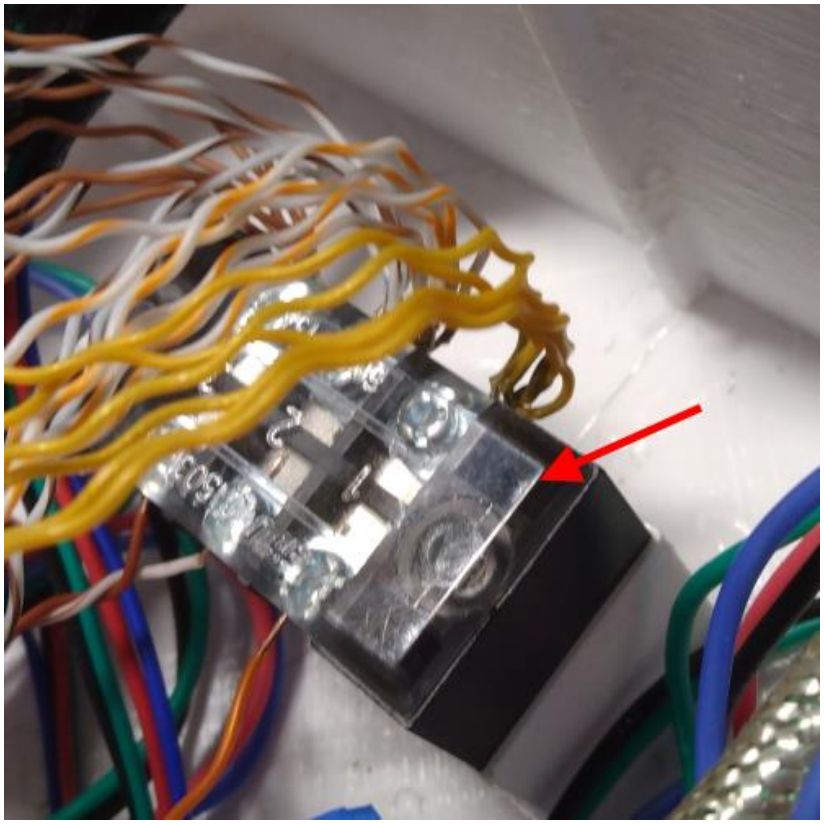
Strip ends and combine orange wires from all 6 encoder cables.

Using a lighter to quickly heat the end of the wire jacket makes stripping the end easier on these small wires.

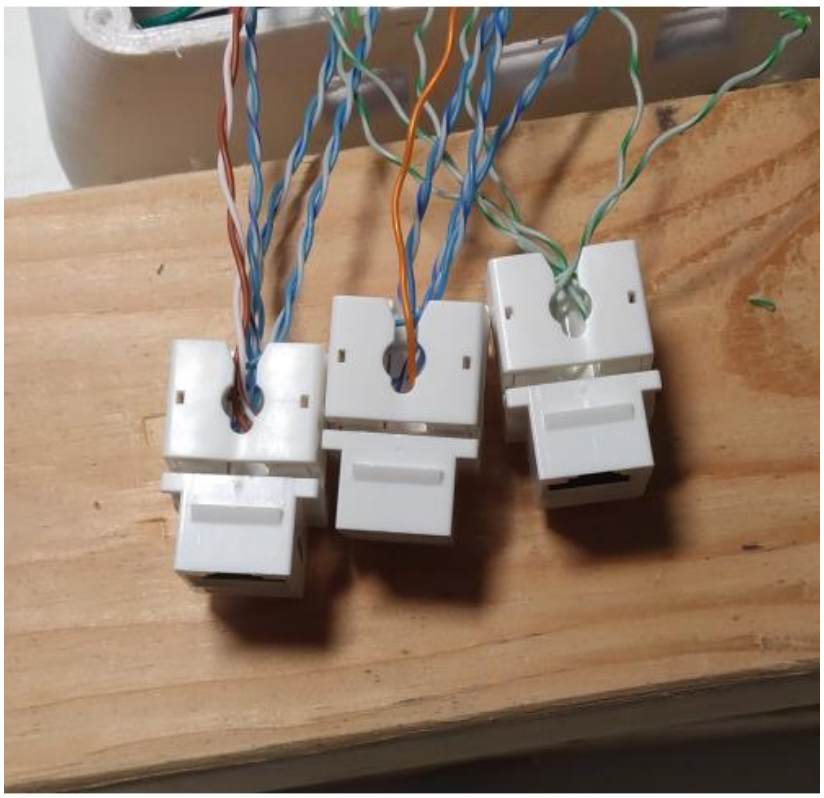
I also recommend applying solder to the twisted ends to ensure conductivity to all wires.



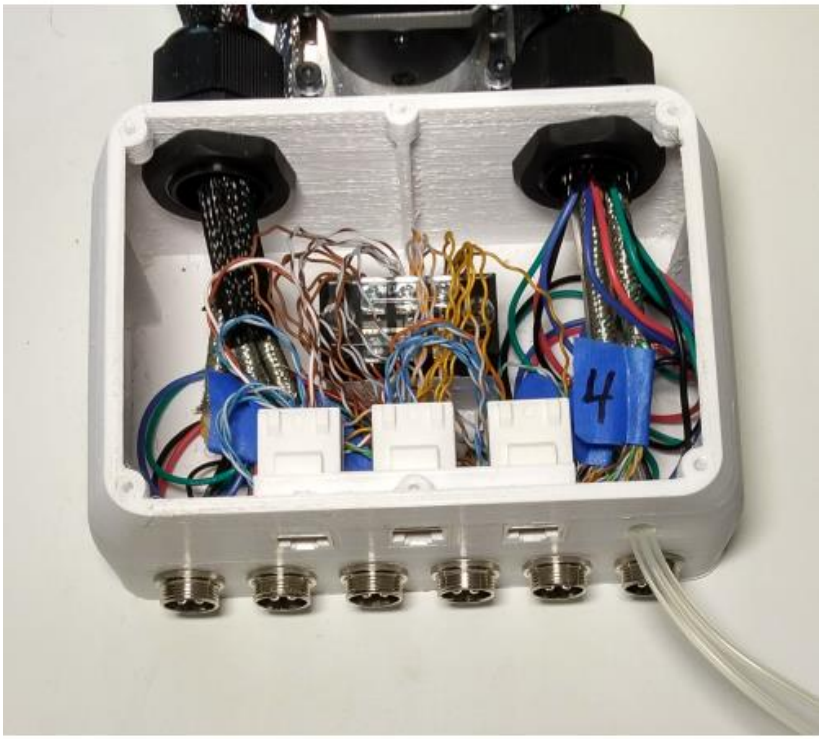
Secure the combined 6 orange wires in terminal #3 of the terminal junction block as shown.



Reinstall clear plastic cover on distribution block.



Press keystone jack covers in place on all 3 keystone jacks.



Install the 3 keystone jacks as shown. Jack #1 goes in the left socket, Jack #2 in the center and Jack #3 on the right.

Secure J1 enclosure lid using (6) #6 thread forming screws.

***NOTE**: use a 2.5mm drill bit to carefully clean up screw holes in base enclosure before installing screws.*

This concludes the assembly of the robot arm. After you have completed building the enclosure and cables in Chapter 3 please review Chapter 7 on starting up and calibrating the robot.

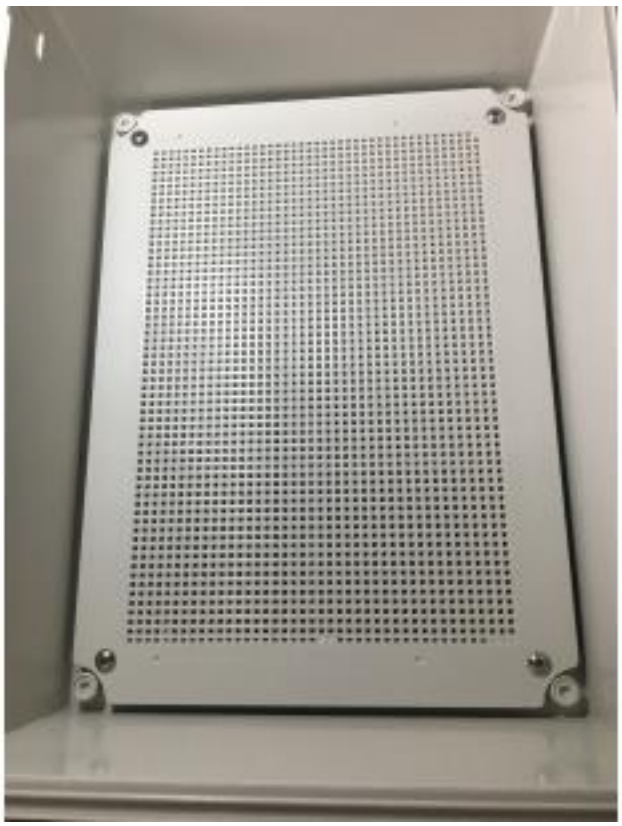
CHAPTER 3

ELECTRICAL ENCLOSURE
&
MOTOR CABLES
ASSEMBLY INSTRUCTIONS

The core electrical components kit does not include an enclosure as there are a wide variety of choices for enclosures or panels and it is up to the builder to select the encloser or panel that works best for them.

In this manual I use the BUD Industries NBF-32026 enclosure with backplane and vent.

The following layout of components in the enclosure is my recommendation but the drivers and components can be placed in any layout or orientation desired.



Install backplane into enclosure using (4) supplied screws.

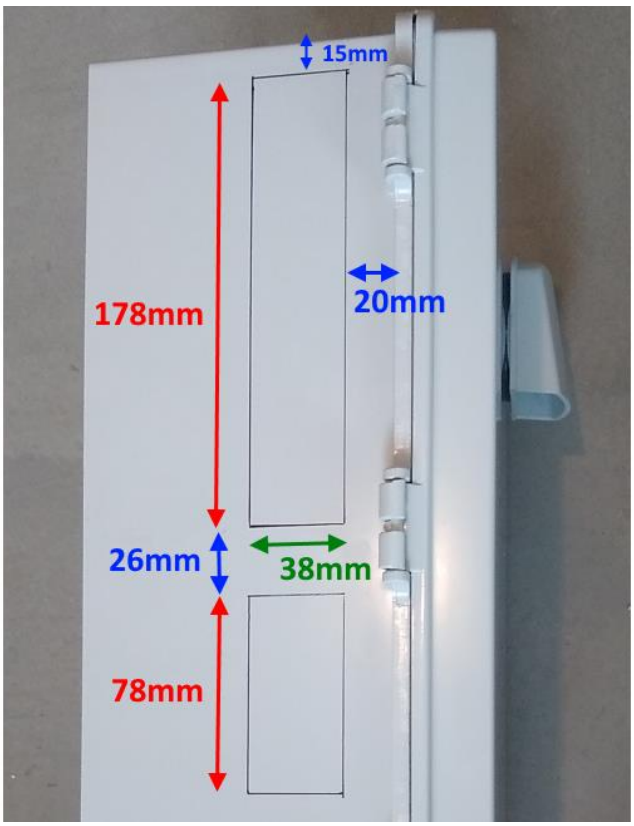
Use threaded ring from air vent to trace circle on enclosure door as shown.

Circle should be 3” (76mm) from right edge of door.

Circle should be 3” (76mm) from top edge of door.

Use an oscillating multi tool saw to cut out the hole for the air vent.

Install air vent as shown in upper right corner of enclosure door as shown.

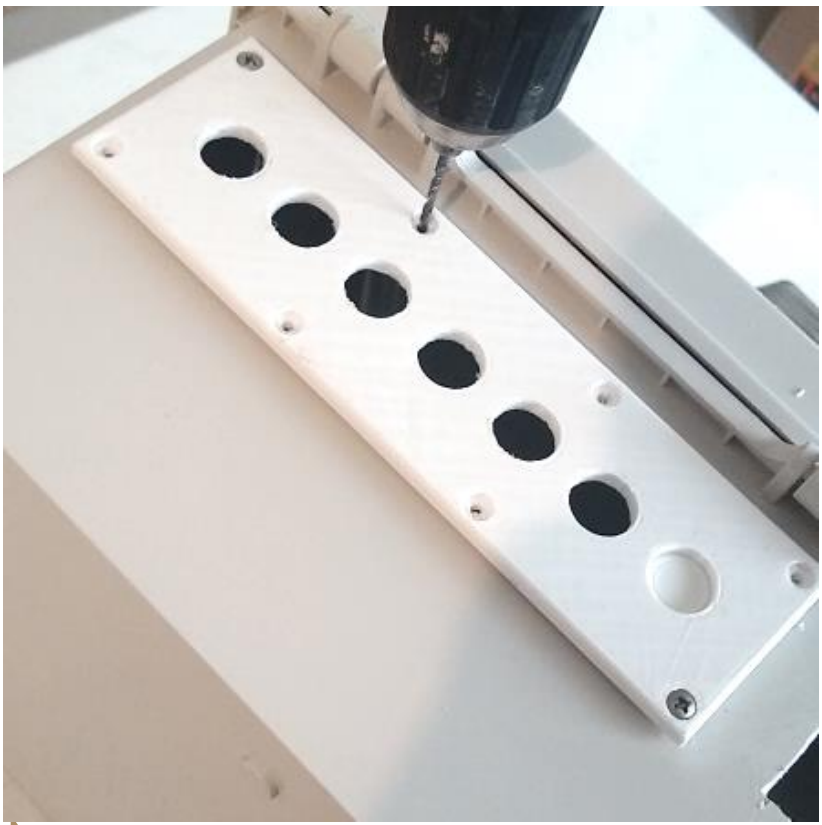


Use fine point marker and straight edge to mark 2 rectangles on left side (hinge side) of box as shown.

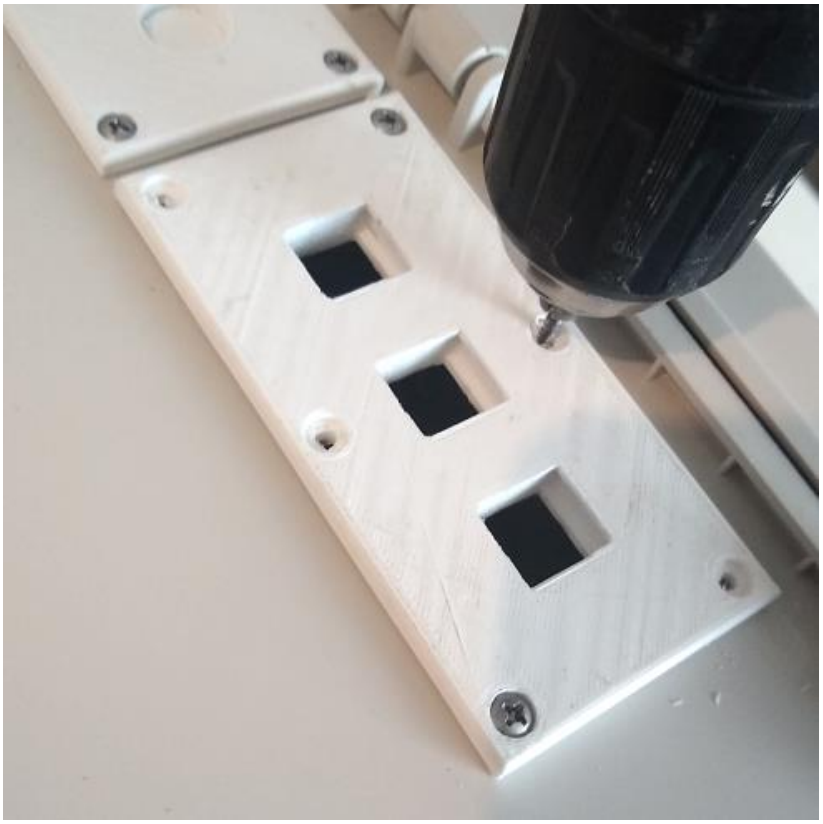
- Rectangles should be 20mm from hinge surface
- Top rectangle should be 15mm from top of enclosure
- Rectangles should be 38mm wide
- Top rectangle should be 178mm tall
- Bottom rectangle should be 78mm tall
- Rectangles should be 26mm apart

Use an oscillating multi tool saw to cut out both rectangles.

Cut to the inside of the lines and be very careful not to make the rectangles oversized. It is better they be too small – if they are too large you can have issues with the panel mounting screws being too close to the edge of the opening.

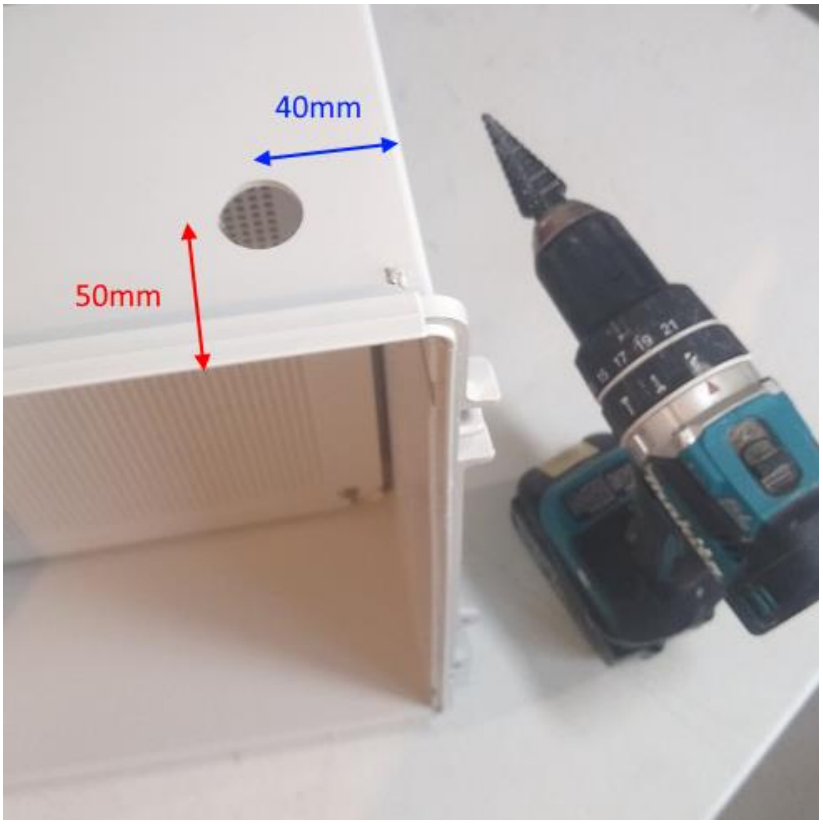


Place the panel mount face for the GX16 plugs over the larger rectangle and then drill and transfer the (8) mounting holes into the enclosure with a 3/32” or 2.3mm drill.



Place the panel mount face for the keystone sockets over the smaller rectangle and then drill and transfer the (6) mounting holes into the enclosure with a 3/32” or 2.3mm drill.

Secure both panel faces using (14) #6 thread forming screws.



Use step drill bit to drill a 22mm hole in top of enclosure in position shown.

Hole should be 40mm from the right side of enclosure and 50mm from the front edge of enclosure.

Use straight edge and fine tip marker to mark a rectangle as shown on right side of enclosure.

The rectangle should be **47mm** tall and **27mm** wide.

The rectangle should be located 50mm from back of enclosure and 25mm from bottom of enclosure.

Use an oscillating multi tool saw to cut out rectangle.

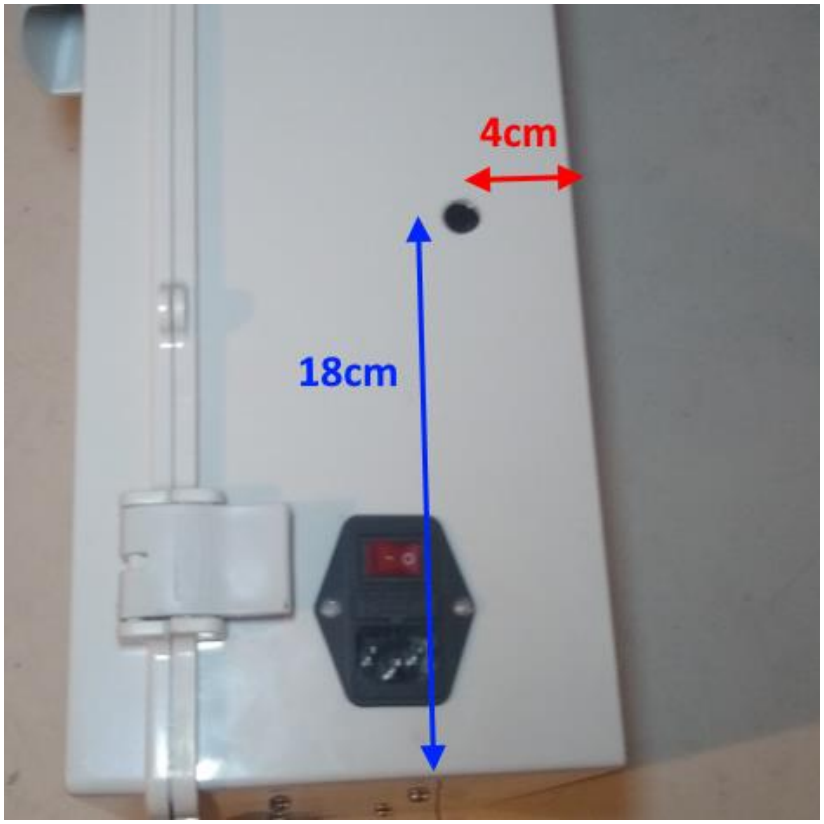
Cut to the inside of the lines and be very careful not to make the rectangle oversized.

Place the power inlet module inside rectangle and then drill and transfer the (2) mounting holes into the enclosure with a 3/32” or 2.3mm drill.

Secure power inlet module using (2) #6 thread forming screws.

NOTE: install 5x20 2amp fuse in inlet module.

Install E-Stop button in 22mm hole in top of enclosure as shown.

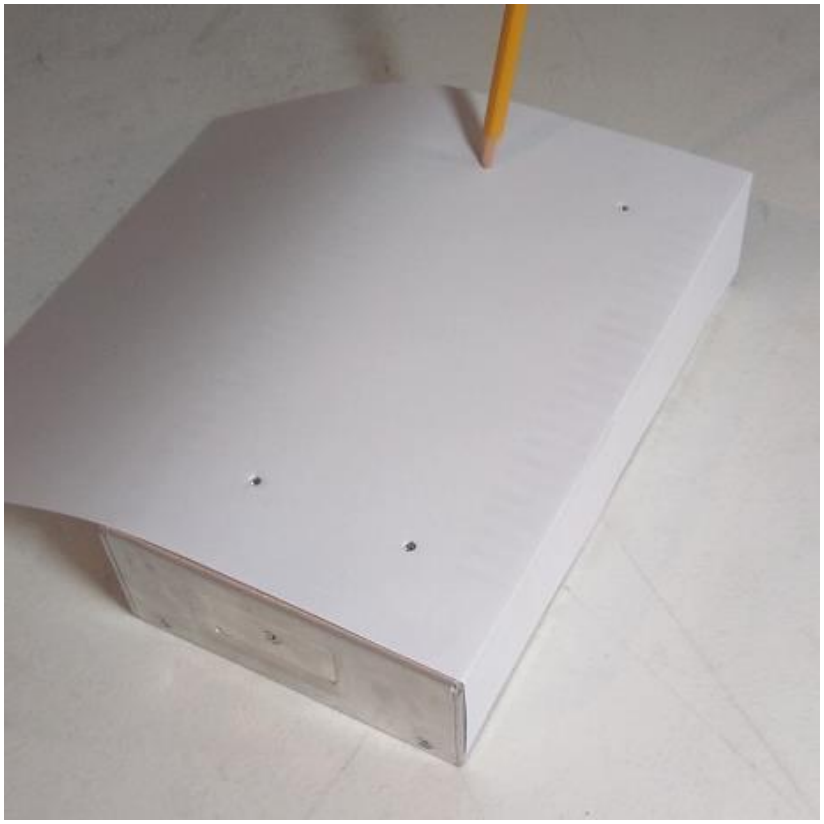


Drill 12mm diameter hole is side of enclosure as shown.

The hole should be 18cm from bottom of enclosure and 4cm from back of enclosure.

Note: *this hole is a pass through for the controller USB cables. If desired you could install a USB panel face pass through but in the interest of simplicity and keeping cost low I am using a simple pass through hole.*

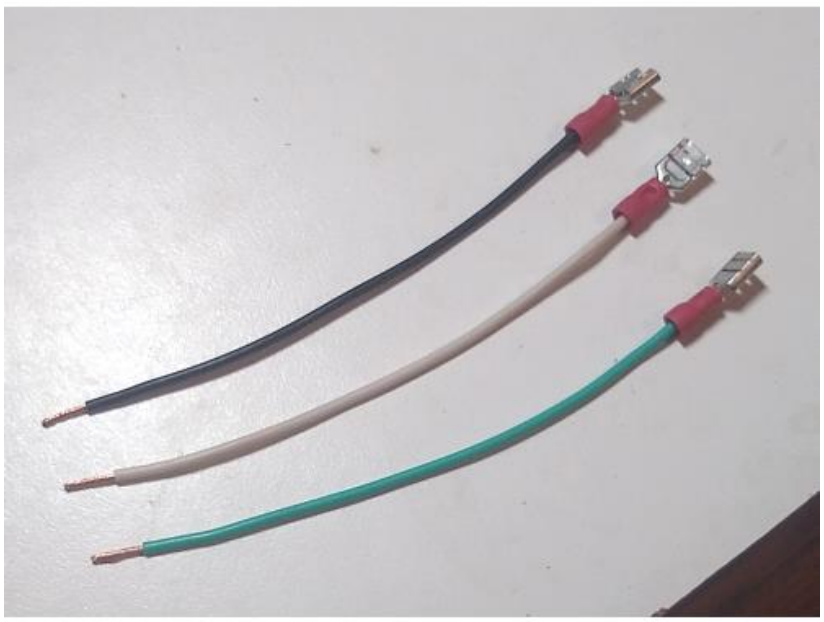
With 24vdc power supply upside down on surface, fold sheet of paper and lay sheet of paper across bottom of power supply as shown.



Use pencil to punch holes through paper where power supply mounting holes are located. This sheet of paper will be used as a template for drilling holes in the enclosure.

Place template as shown along bottom of enclosure and then use felt pen to mark mounting holes on enclosure wall.

Drill (4) marked holes using #20 or 4mm size drill.



Cut black white and green 18awg wires to a length of 12cm long.

I have cut these wires from some of the 18awg cable used to make the motor cables *(see bill of materials)*

Strip both ends and crimp female disconnect terminals to one end.

Connect wires to power supply as shown.

Green wire goes to ground.

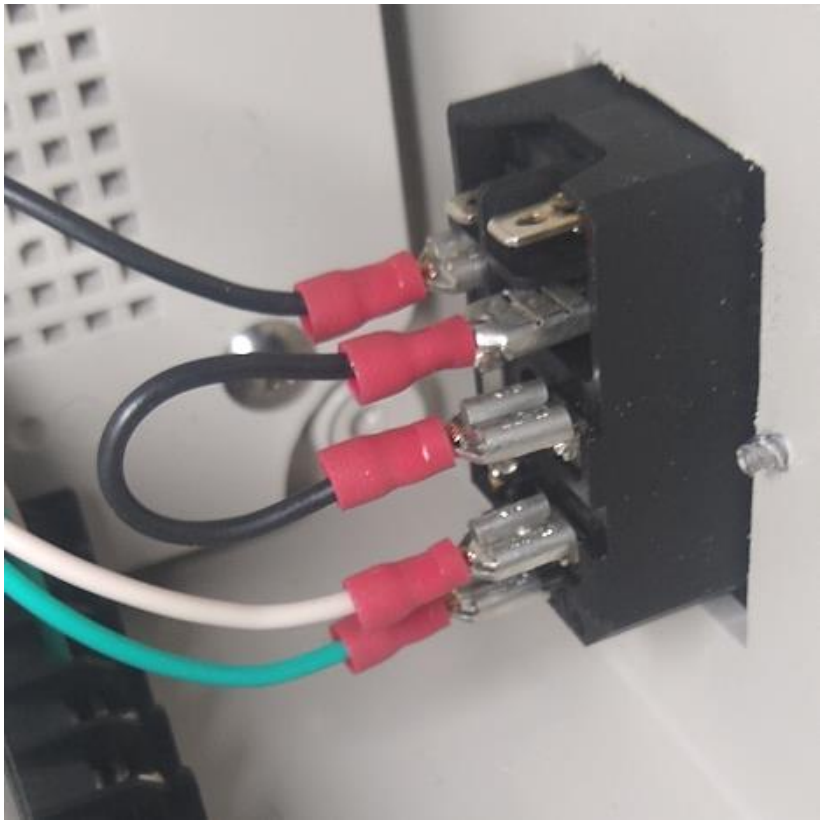
White wire goes to neutral.

Black wire goes to line.

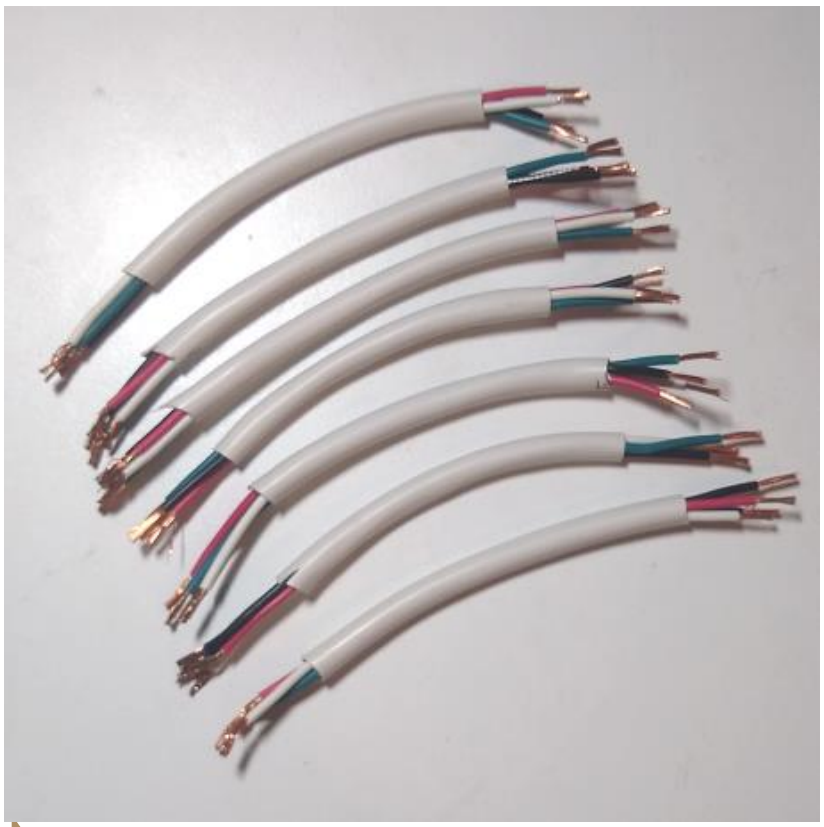
Secure power supply to bottom of enclosure using (4) M4x8 pan head screws as shown.

Connect the black white and green wires from power supply to the terminals on power inlet module as shown in photo.

Cut black 18awg wire to a length of 6cm then strip ends and crimp female disconnect terminals to each end.



Install jumper onto the terminals shown in photo on power inlet module.



Cut (6) 14cm lengths of 18awg 4 conductor cable (one for each driver).

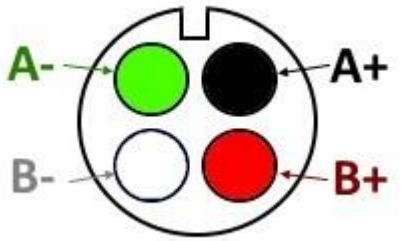
In this manual I will be showing an optional 7th axis driver for a travel track so I have cut one additional length of cable.

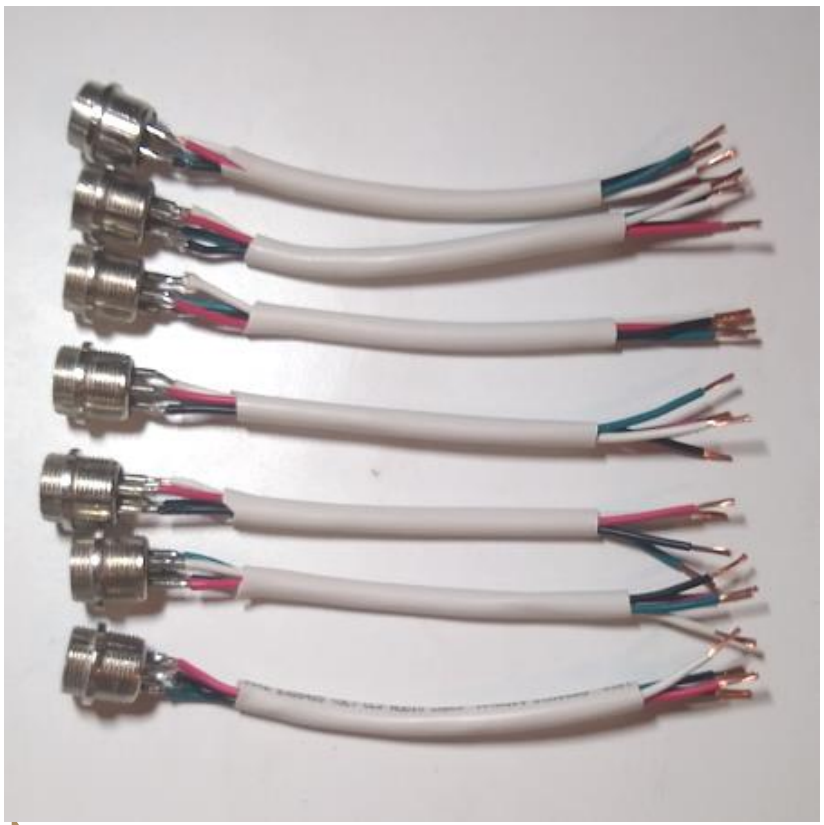
Use network cable stripper to remove 20mm of jacket from each end of cable and then strip the ends of each wire as shown.

Solder wires of the 14cm cable to the rear of a GX16-4 aviation plug.

The diagram below shows which terminals to solder each wire color.

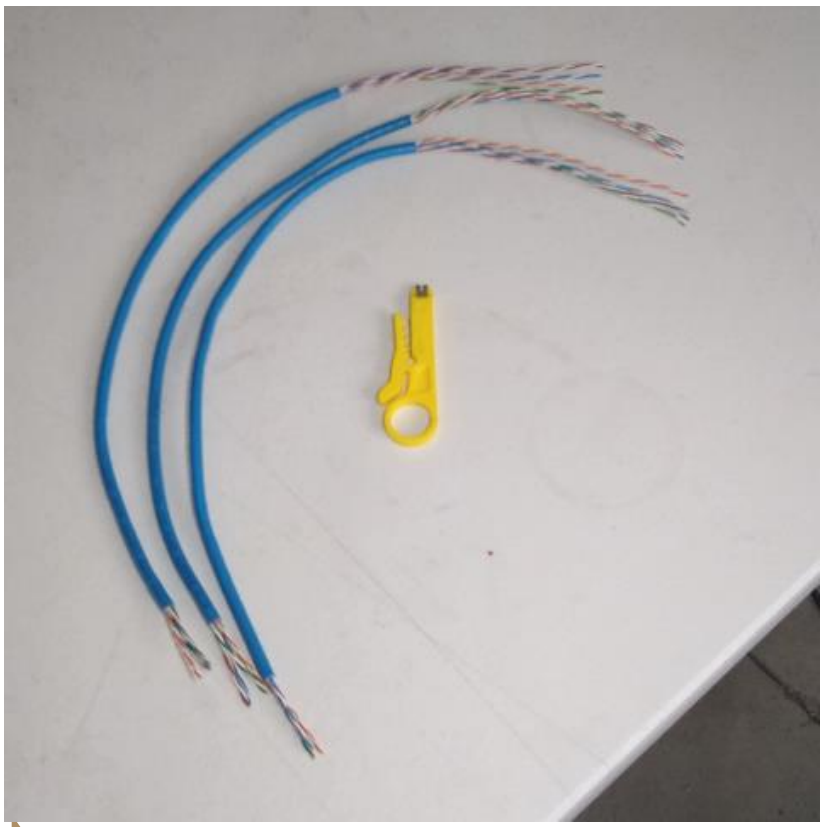
NOTE: this is showing the connector from the backside where wires





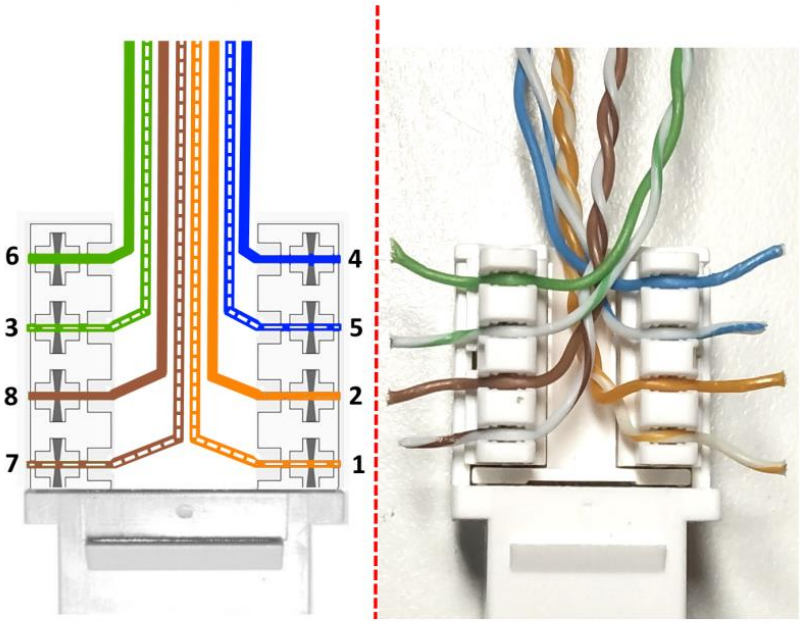
Repeat this for all motor/driver wires.

Install each GX16-4 cable assembly into panel pass through as shown.



Cut 3 lengths of Cat6 cable that are 48cm long.

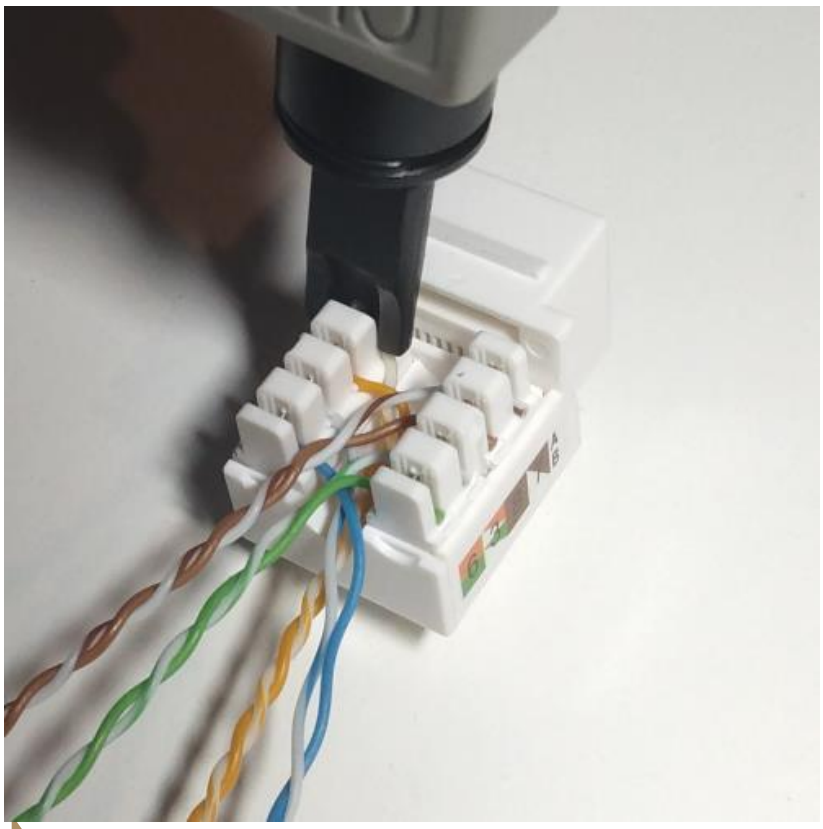
Use network cable stripper to remove 14cm of the cable jacket from one end of the cable and remove 4cm of the jacket from the other end.



Insert the ends of the Cat6 cable that have 4cm of jacket removed into an RJ45 keystone jack connector as shown.

- **orange / stripe - (1)**
- **orange – (2)**
- **green / stripe – (3)**
- **blue – (4)**
- **blue / stripe – (5)**
- **green – (6)**
- **brown / stipe – (7)**
- **brown – (8)**

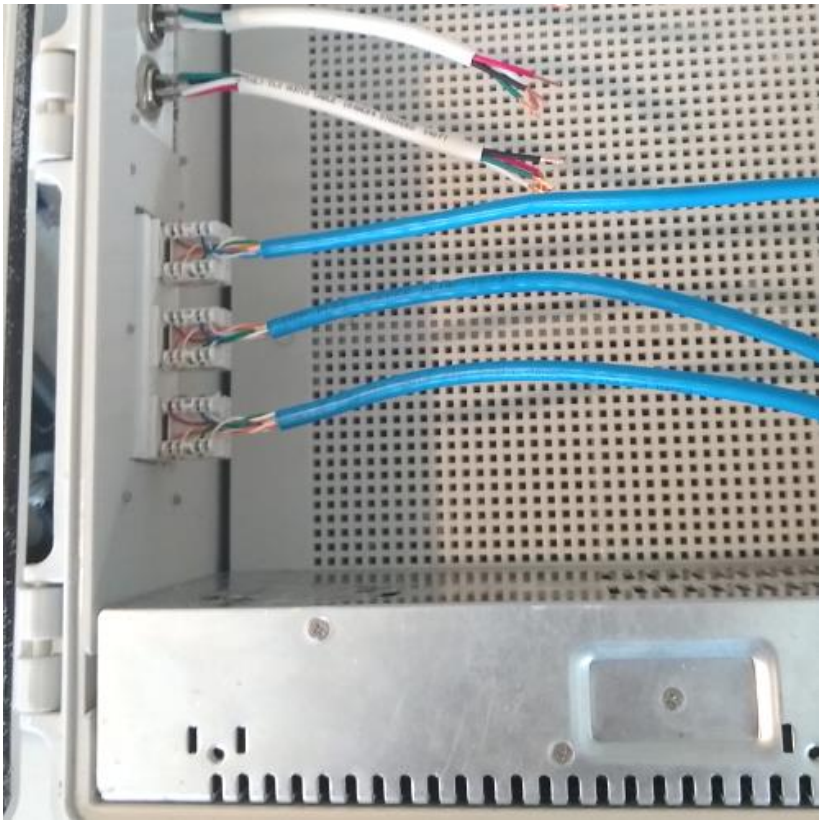
NOTE: If you have sourced your own keystone jacks be sure to check the terminal number – not all keystone jacks are numbered the same – make sure to wire color to the terminal number per the text above, the colors and numbers will not always be in the same arrangement as the image shown to the left.



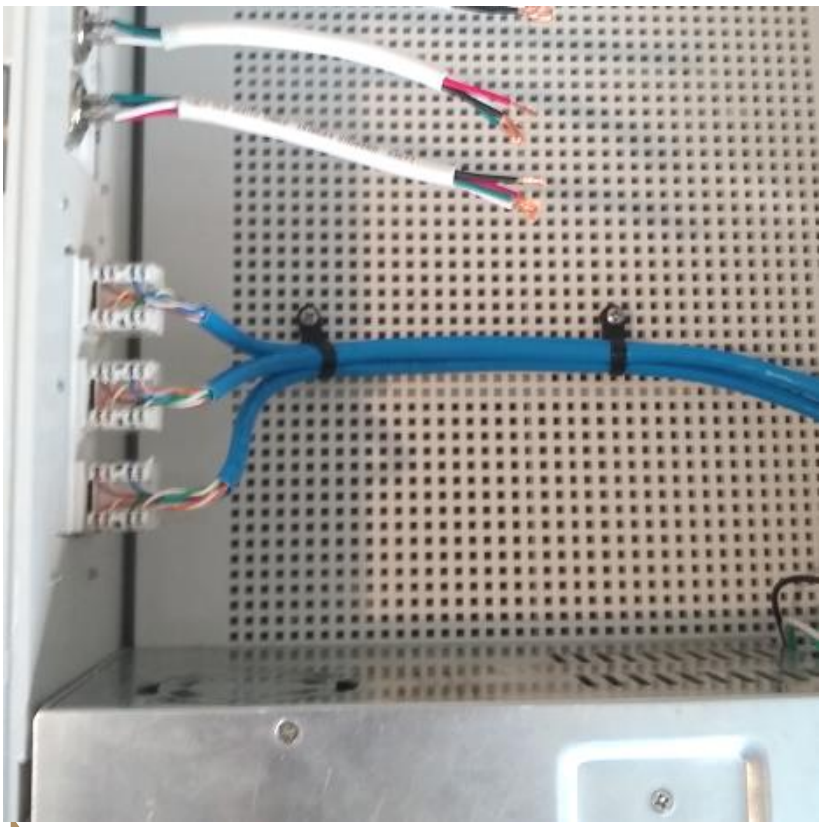
Use a network wire punch down impact tool to fully seat each wire down into the RJ45 keystone jack.

The tool should also trim each wire on the sides so make sure the cut side of the tool is facing out.

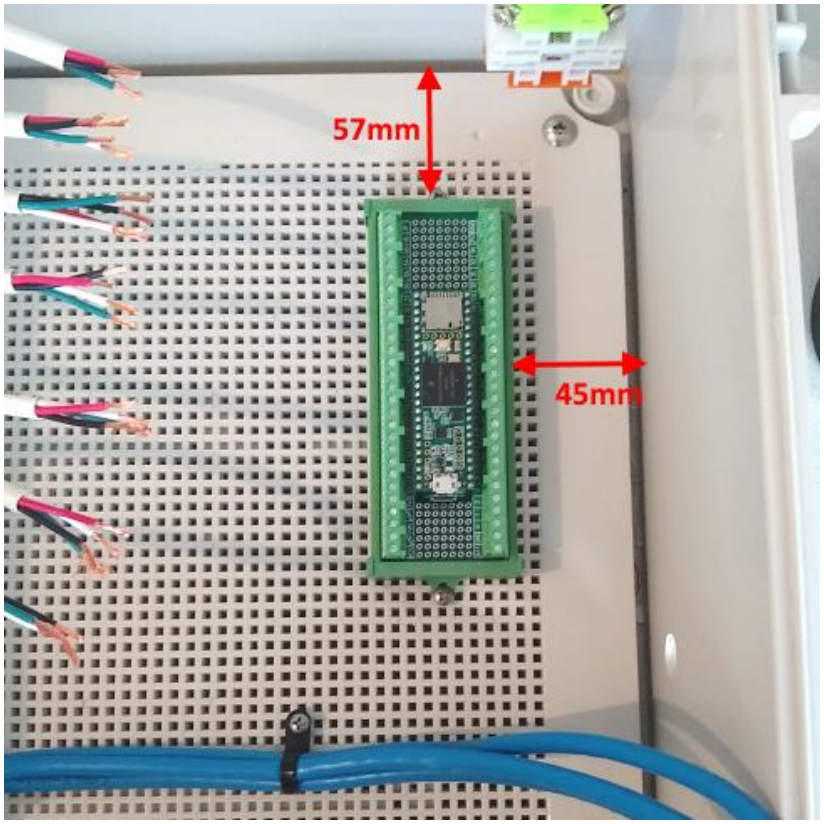
After each wire is seated use a multi meter and check continuity between the connection inside the socket to the end of the wire and verify you have a good connection – do not skip this step it is very important to check.



Install RJ45 keystone jack connectors into the enclosure keystone panel mount as shown.



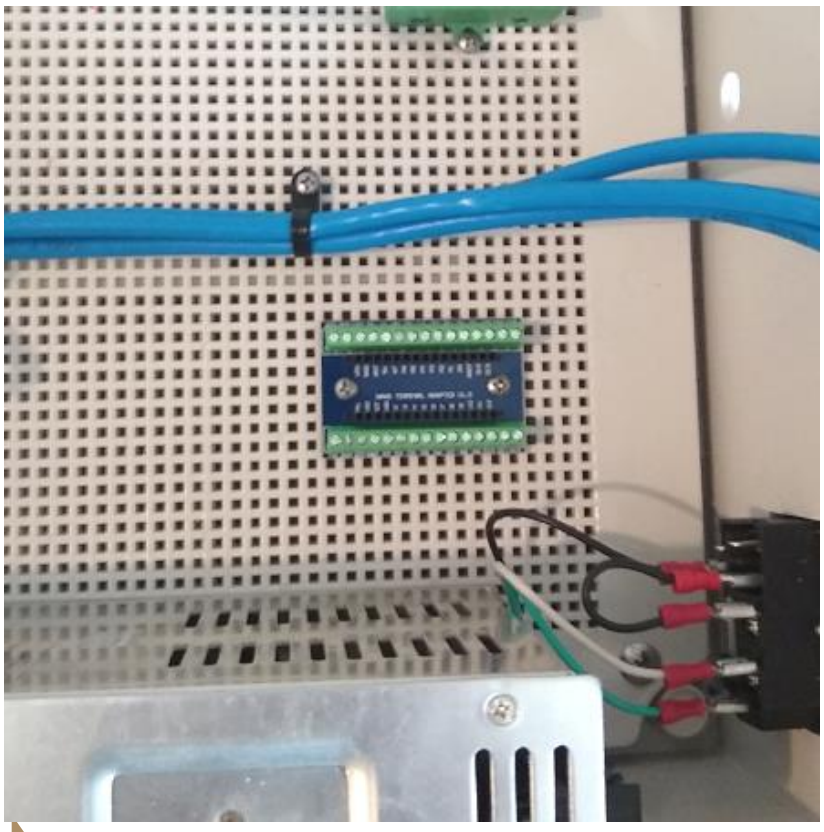
Use (2) cable mounting ties and (2) #6 thread forming screws to secure Cat6 cables as shown.



Install Teensy 4.1 control board into the terminal block breakout board.

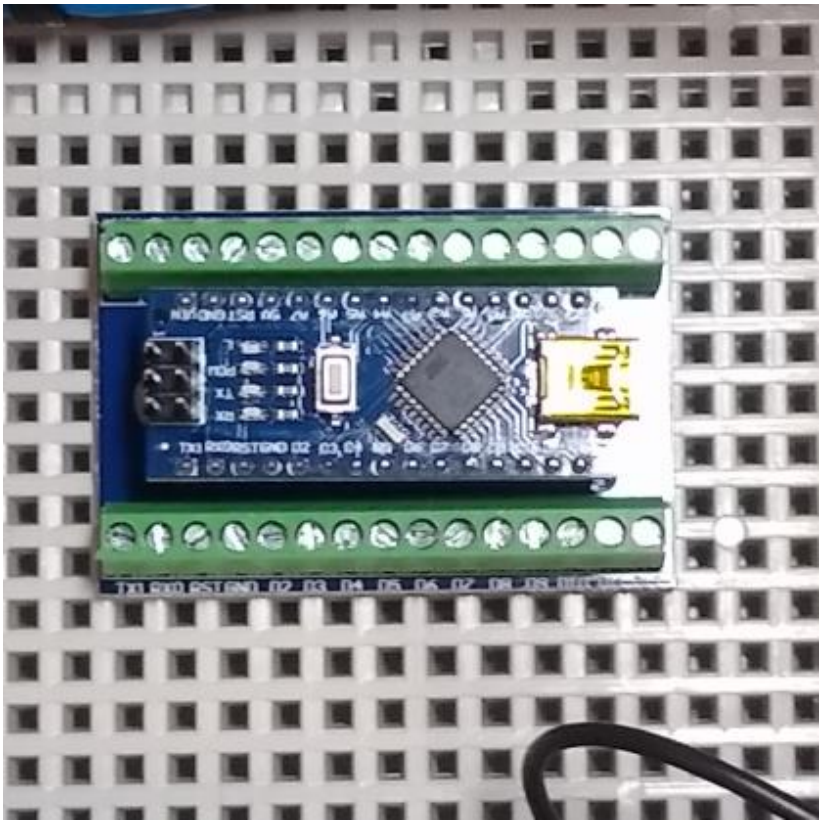
Mount the terminal breakout board as shown and secure with (2) #6 thread forming screws.

Board should be 45mm from right side of enclosure and 57mm from top of enclosure.

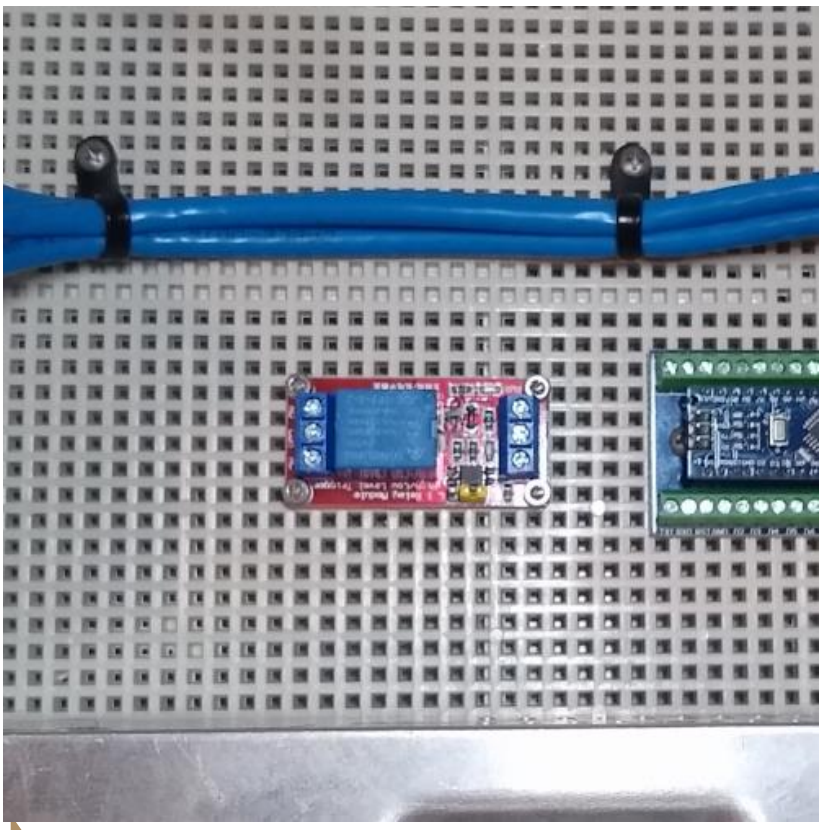


Mount Nano terminal breakout board as shown using (2) #6 thread forming screw.

The Arduino Nano board is not required and is included in this manual as an option. The Nano board is used as an auxiliary IO board to control peripheral devices such as a gripper or any other 5v device you might need the robot to control. You might use this in conjunction with a relay module to control a pneumatic gripper or you may use this board to control a servo gripper.



Install Arduino Nano board into the terminal breakout board.



Mount 5v relay module as shown.

The 5v relay module is not required and is included in this manual as an option. The relay module is used to control higher voltage peripheral devices. I will be using this module to control a 24v solenoid valve for the pneumatic gripper on the robot. You can install as many relay modules as needed for any devices you need the robot to control from the program.

Install the motor drives for joints 1 through 6 as shown in the photo.

Note: In this example I am showing an optional drive for a 7th axis travel track.

Connect each driver cable to its corresponding driver.

(top cable to the top driver and so on down to the bottom cable to the bottom driver)

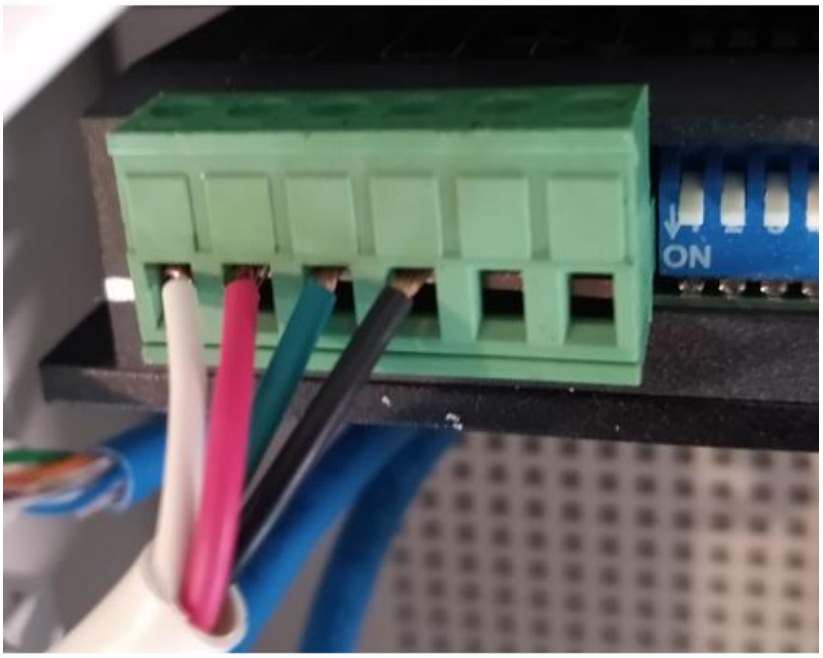
Connect each color wire to the labeled terminals as follows:

BLACK = A+

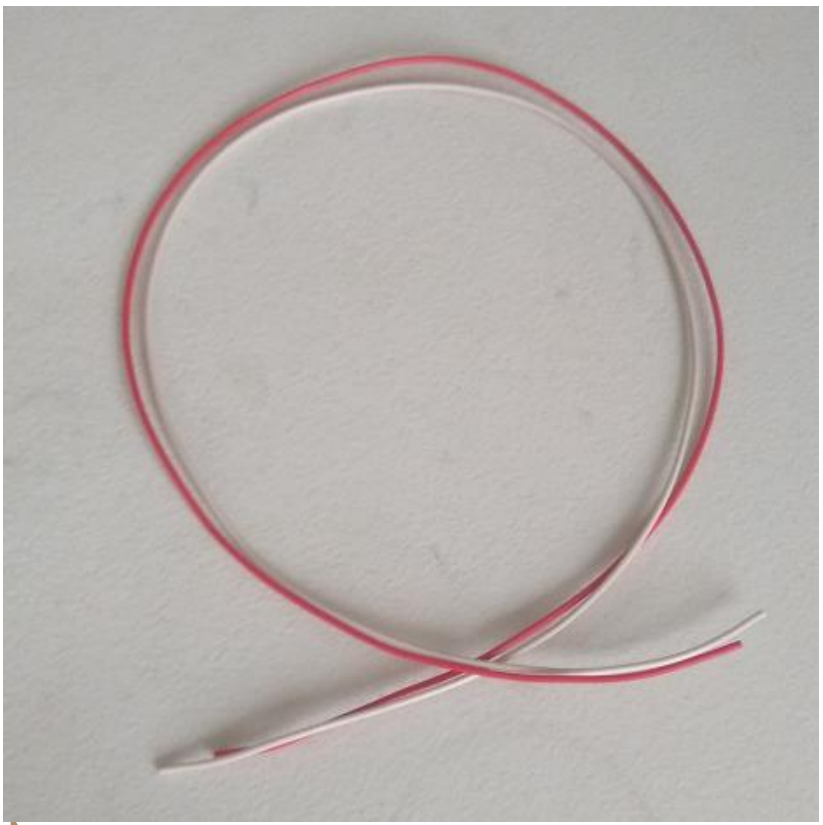
GREEN = A-

RED = B+

WHITE = B-

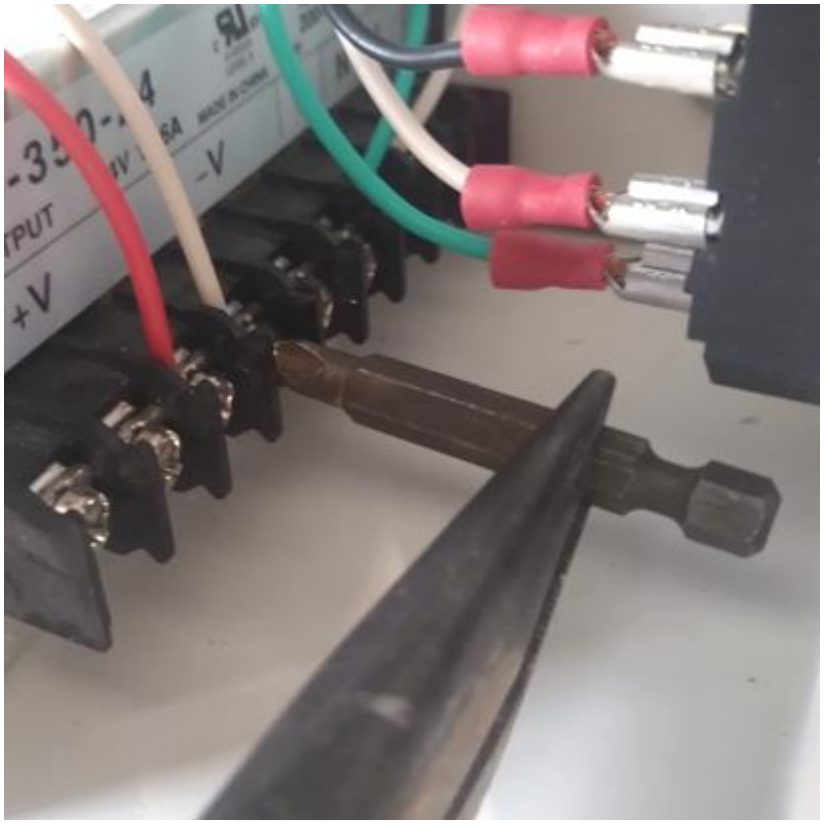


This picture shows a close up view of each wire connected to one of the drivers.



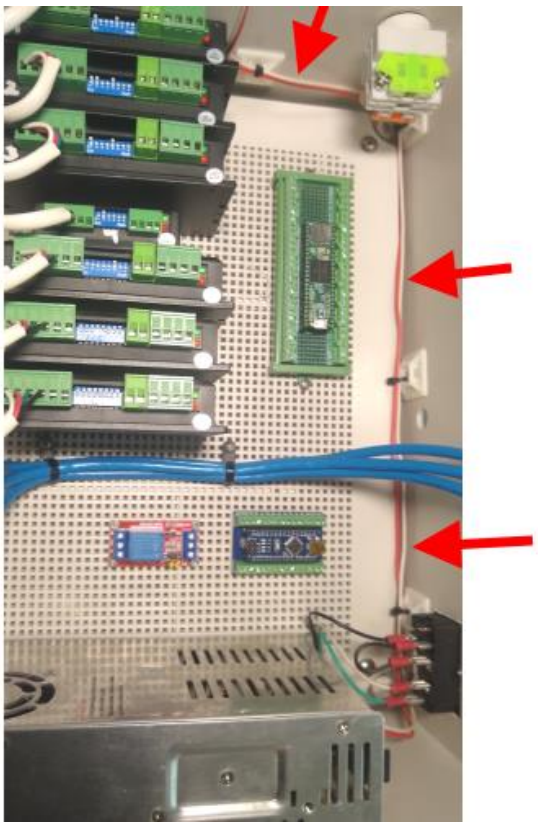
Cut red and white 18awg wires to a length of 54cm long.

I have cut these wires from some of the 18awg cable used to make the motor cables *(see bill of materials)*



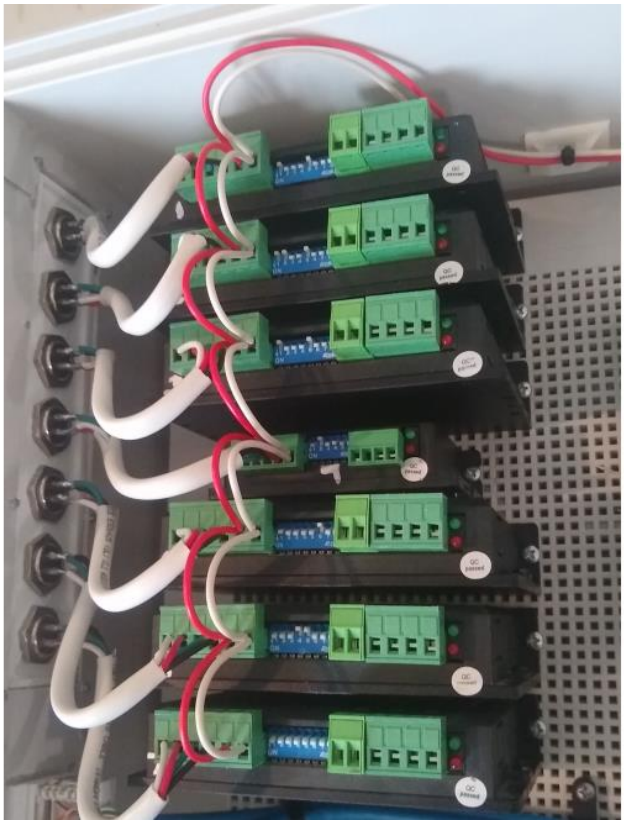
Strip ends of red and white wires, then connect the red wire to the +V terminal on the 24v power supply. Connect the white wire to the –V terminal on the 24v power supply.

This is a tight area so you will need to use a Philips bit to tighten the terminals.



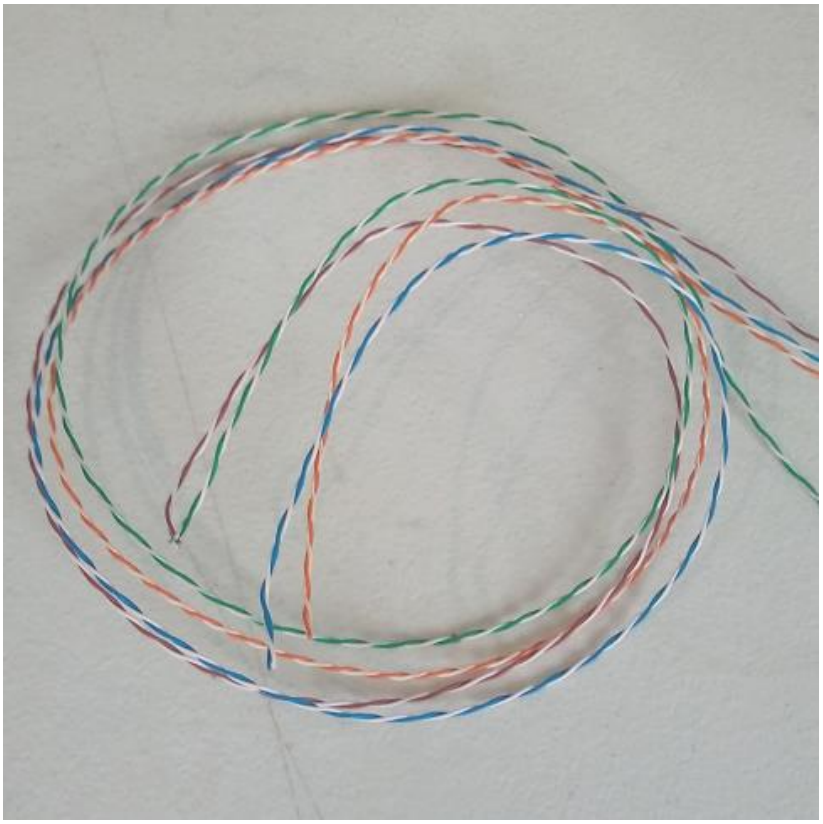
Use adhesive cable tie mounts and cable ties to mount 24v red and white wires along left side and then along top of enclosure as shown.

Cut 6 pieces of red and white 18awg wires to a length of 8cm long.

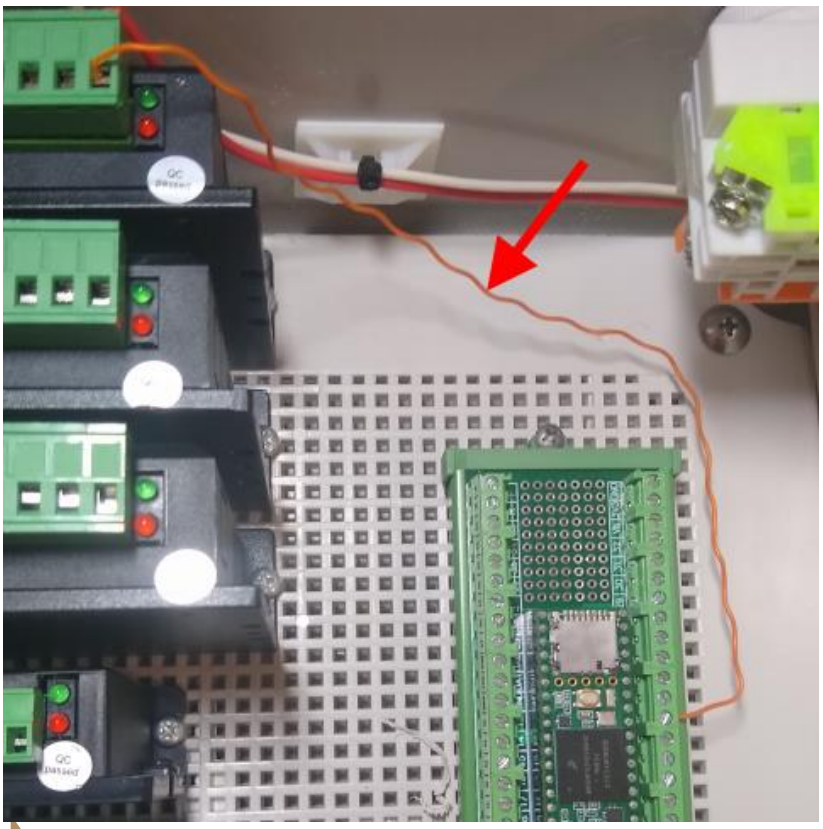


Jumper red wires to the “+V” terminal on each of the motor drivers.

Jumper white wires to the “GND” terminal on each of the motor drivers.



Cut a piece of Cat6 cable to a length of 100cm long then remove the jacket so you have the twisted pairs of wires to use for wiring the drivers to the teensy control board.



Separate the orange twisted pair and then run a length of orange wire from the 3.3v terminal to the +5v terminal on the top driver as shown.

***NOTE**: the DM542T and DM320T drivers are labeled 5v on the exterior but they are rated for and capable of operating just fine at the 3.3v teensy output.*

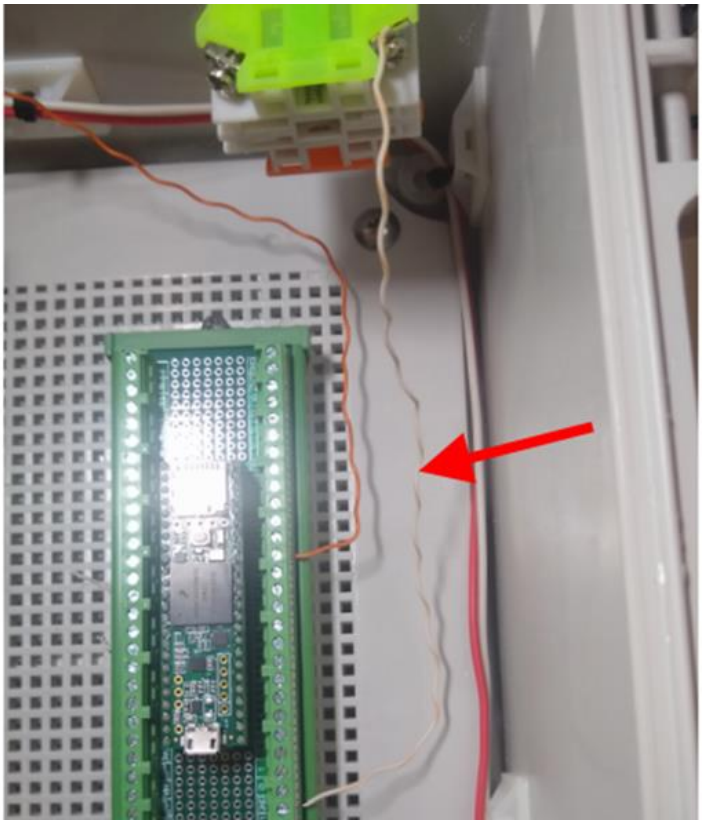
Cut 12 pieces of the orange wire to a length of 4cm.

Cut 6 pieces of the orange wire to a length of 6cm.

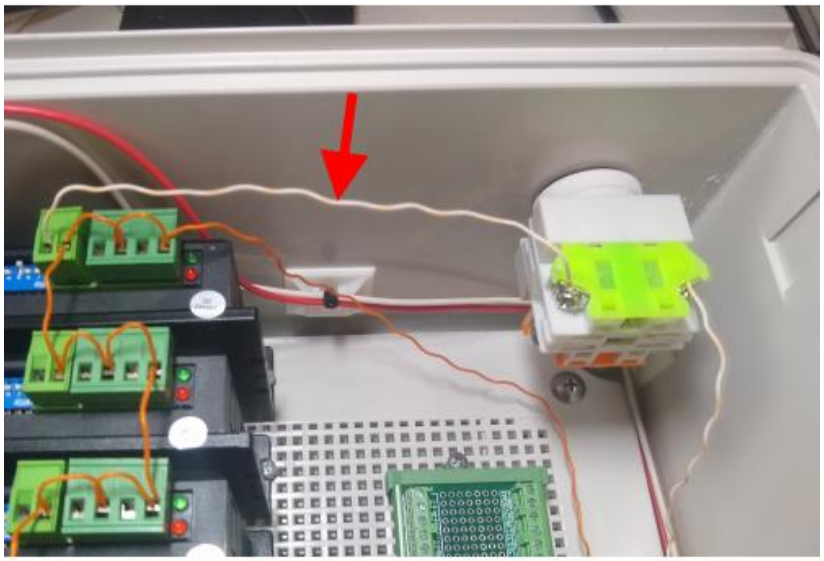
Use orange wires to jumper across the +5v terminals on all drivers as shown.

NOTE: *on the J4 driver (DM320T) you will only jumper to the terminal labeled "OPTO"*

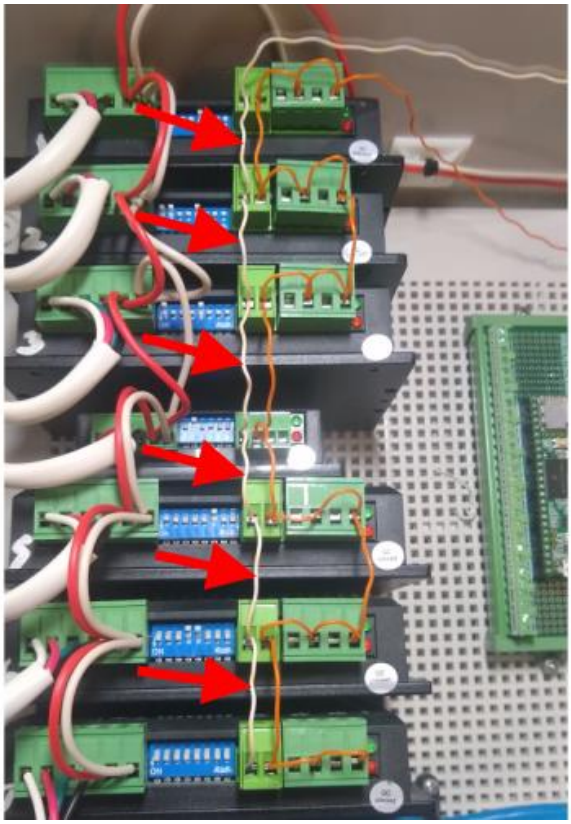
Also see the wiring schematics section in this manual.



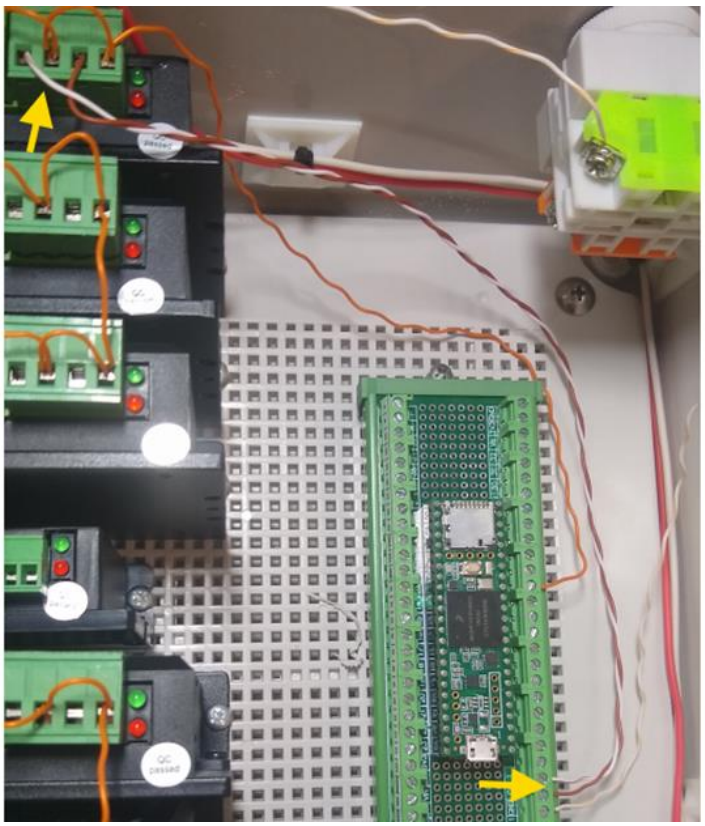
Connect a length of the white with orange stripe wire from the GND terminal on teensy board to one of the “normally open” terminals on the E-Stop button as shown.



Connect length of white with orange stripe wire from the other E-Stop terminal to the “ENA-” terminal on the top driver as shown.



Cut 6 pieces of the white with orange stripe wire to a length of 6cm and then jumper across the “ENA-” terminals of all drivers.



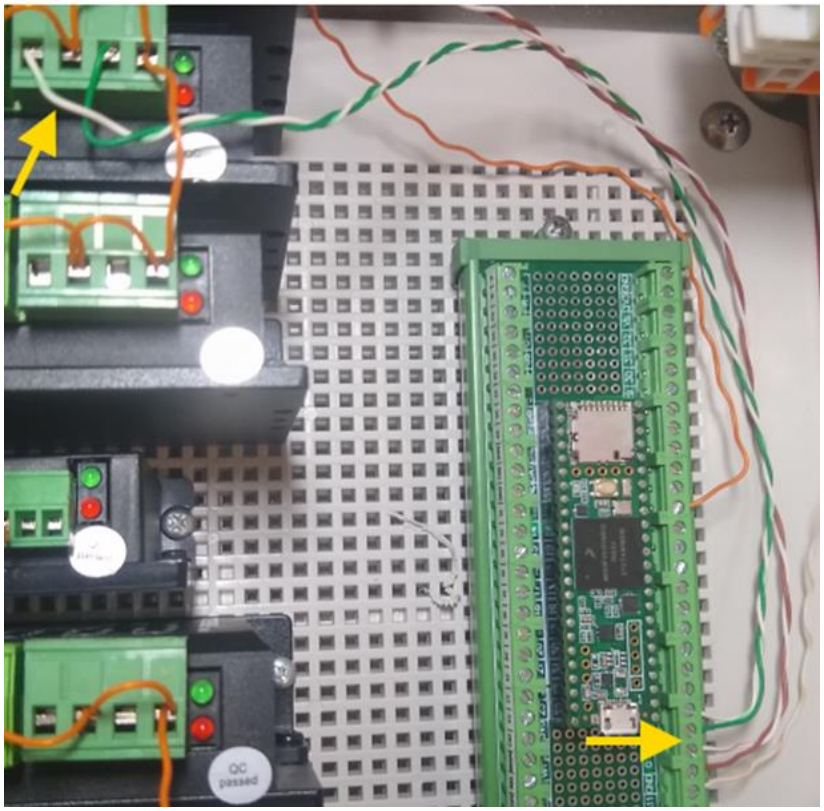
Cut a length of brown / white-brown stripe wire and connect from the Teensy 4.1 to the **J1** driver.

brown wire:

Teensy pin 0 to driver PUL-

brown stripe wire:

Teensy pin 1 to driver DIR-



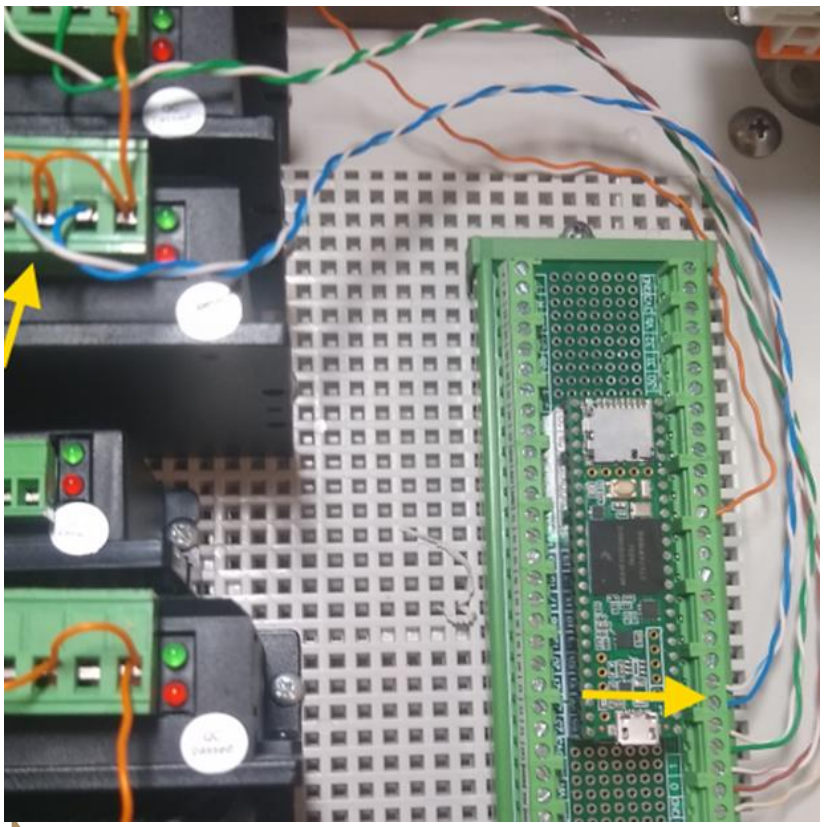
Cut a length of green / white- green stripe wire and connect from the Teensy 4.1 to the **J2** driver.

green wire:

Teensy pin 2 to driver PUL-

green stripe wire:

Teensy pin 3 to driver DIR-



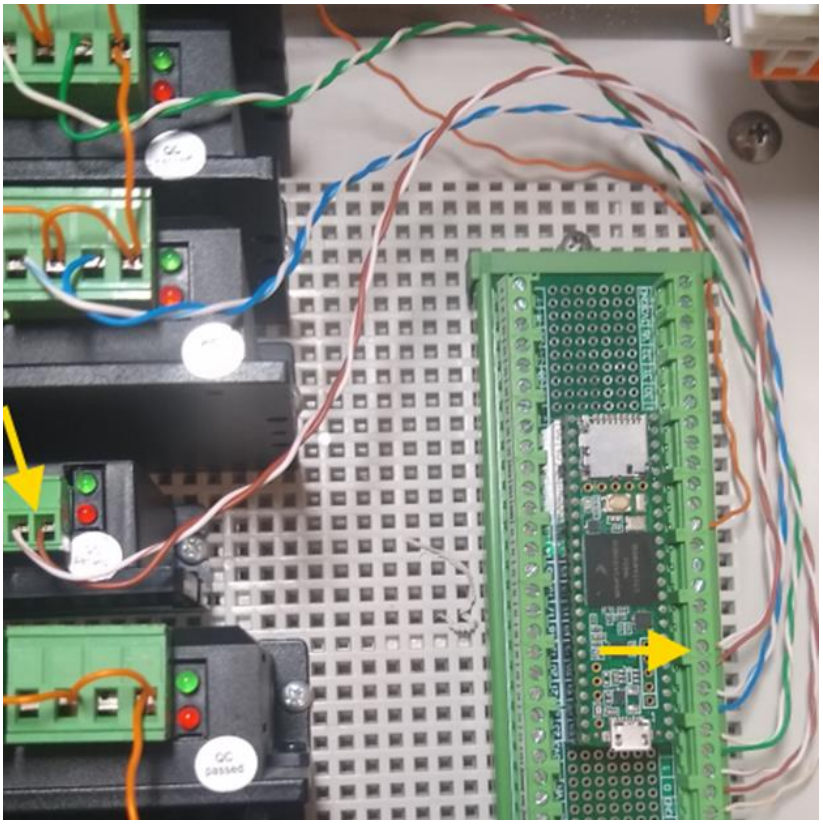
Cut a length of blue / white-blue stripe wire and connect from the Teensy 4.1 to the **J3** driver.

blue wire:

Teensy pin 4 to driver PUL-

blue stripe wire:

Teensy pin 5 to driver DIR-



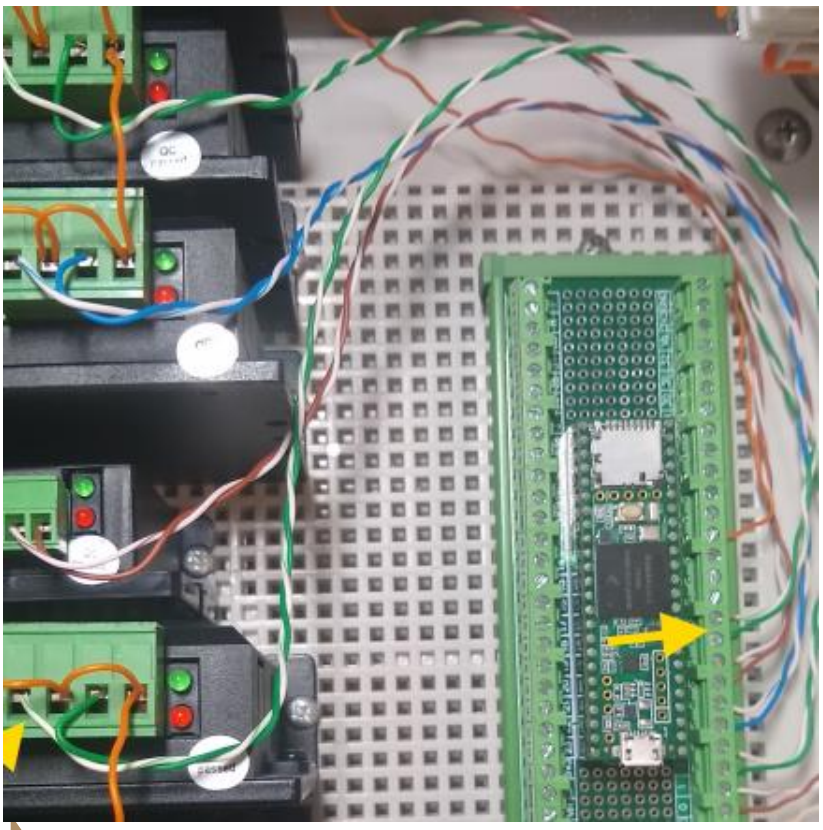
Cut a length of brown / white-brown stripe wire and connect from the Teensy 4.1 to the **J4** driver.

brown wire:

Teensy pin 6 to driver PUL-

brown stripe wire:

Teensy pin 7 to driver DIR-



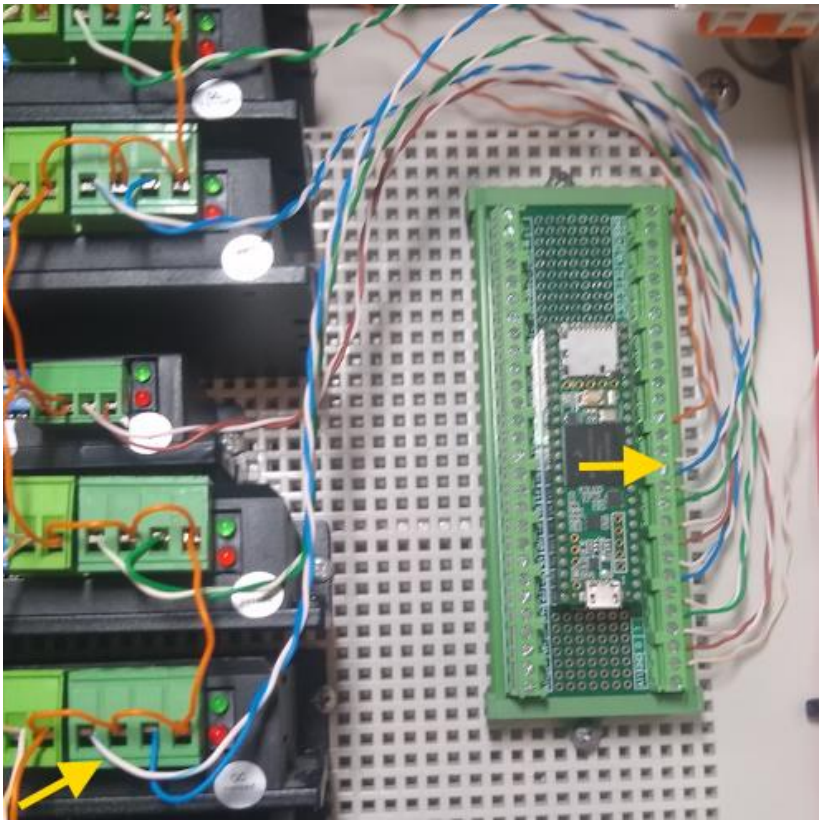
Cut a length of green / white-green stripe wire and connect from the Teensy 4.1 to the **J5** driver.

green wire:

Teensy pin 8 to driver PUL-

green stripe wire:

Teensy pin 9 to driver DIR-



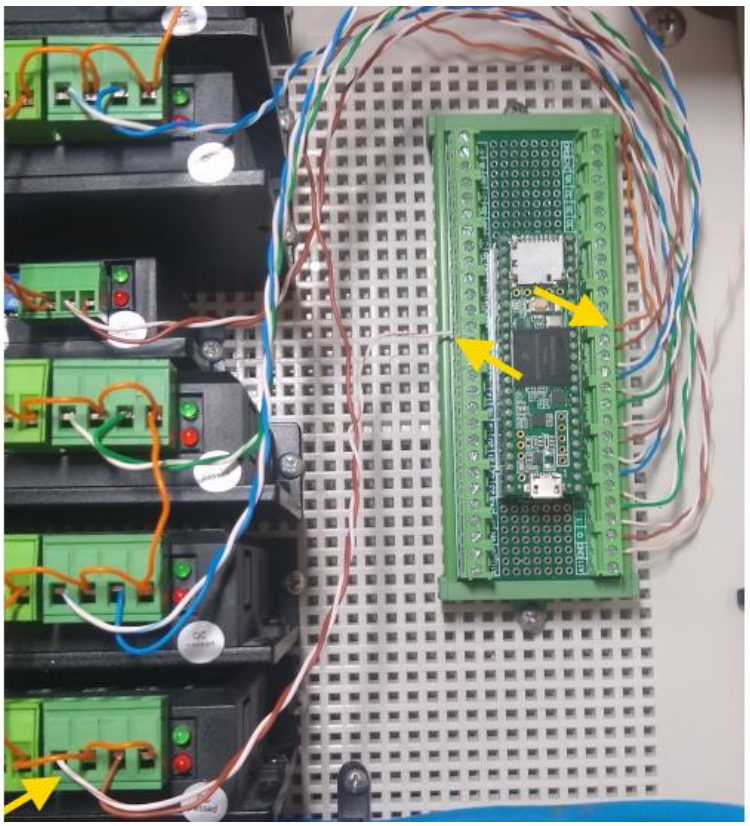
Cut a length of blue / white-blue stripe wire and connect from the Teensy 4.1 to the **J6** driver.

blue wire:

Teensy pin 10 to driver PUL-

blue stripe wire:

Teensy pin 11 to driver DIR-



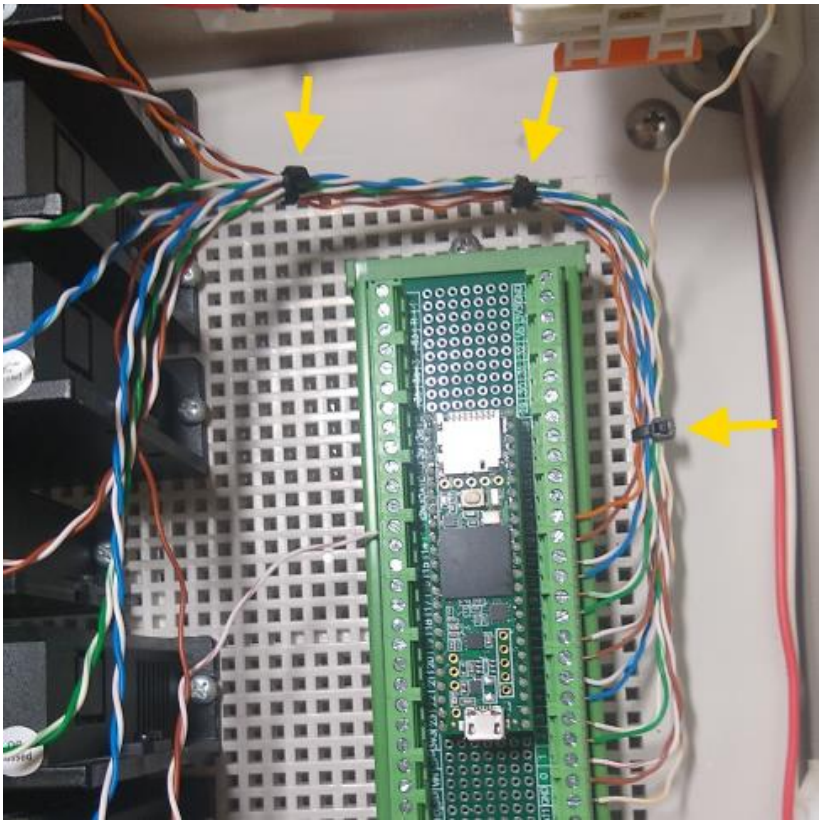
Cut a length of brown / white-brown stripe wire and connect from the Teensy 4.1 to the optional **J7** driver.

brown wire:

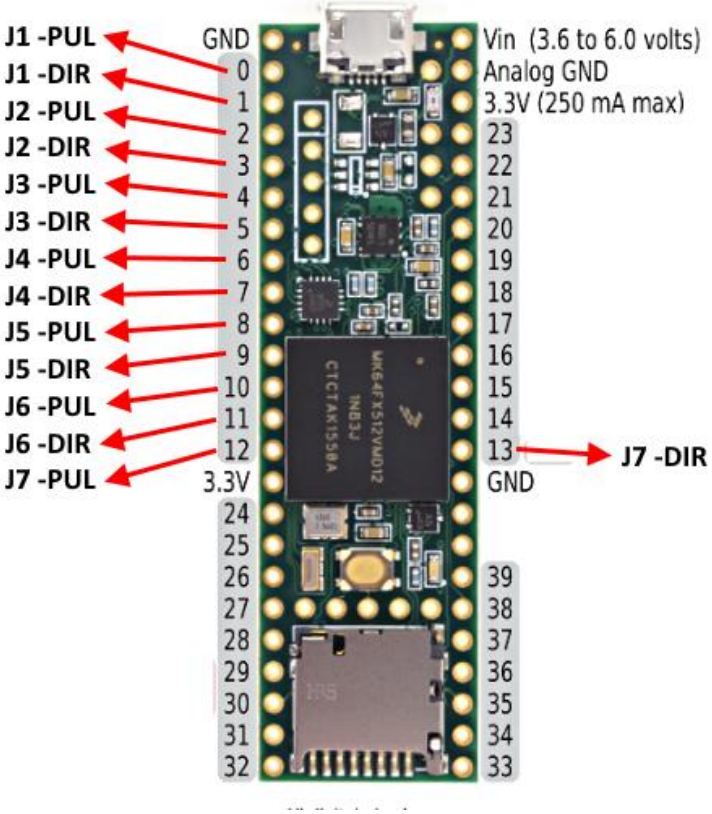
Teensy pin 12 to driver PUL-

brown stripe wire:

Teensy pin 13 to driver DIR-

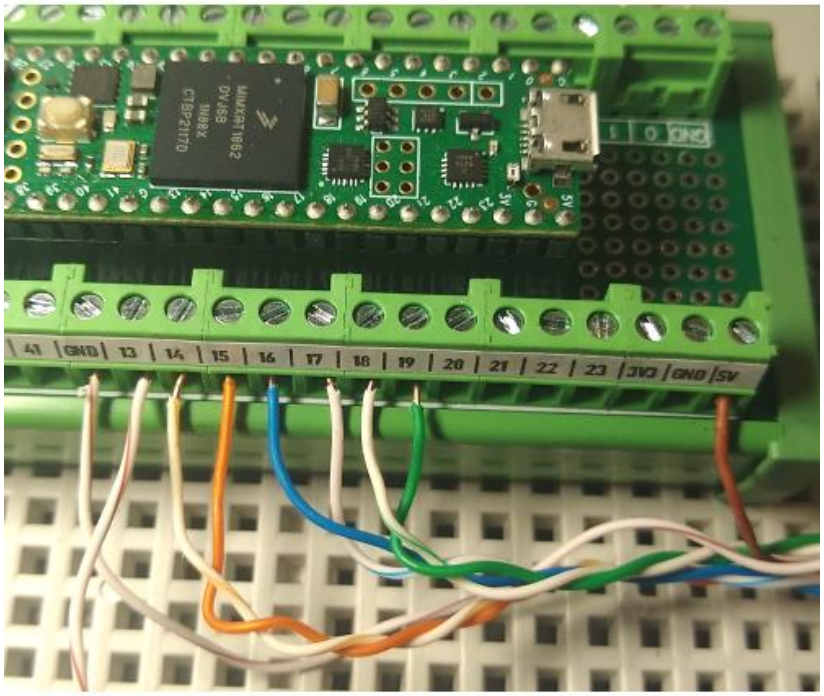


Use 3 small cable ties to bundle driver wires as shown.



This image shows an overview of the pulse and direction pin wiring to the Teensy 4.1 shown in the previous 8 steps.

NOTE: remember each of the wires from the Teensy 4.1 get wired to the negative pulse or direction input terminal on the driver.

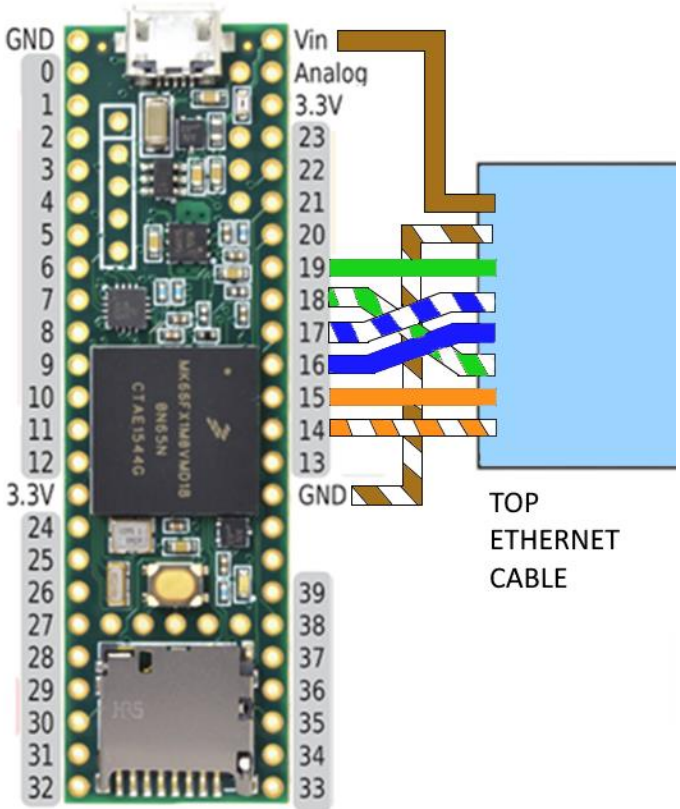


Locate Ethernet cable coming from the top Keystone jack. Remove additional 10cm from the top Ethernet cable jacket and route as shown. Connect the top Ethernet cable wires to the Teensy 4.1 as follows:

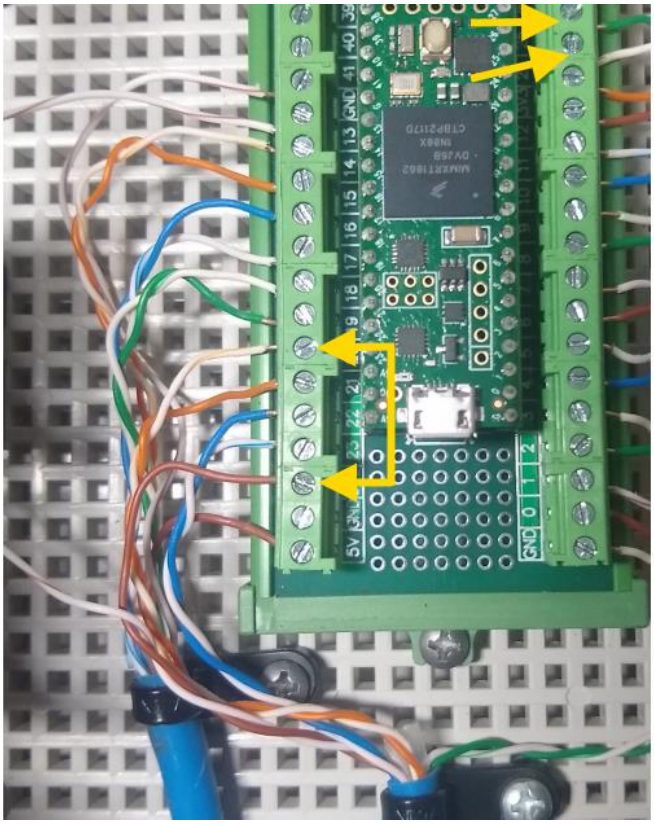
- Brown to Teensy pin **VIN**
- White / Brown-Stripe to Teensy pin **GND**
- White / Orange-Stripe to Teensy pin **#14**
- Orange to Teensy pin **#15**
- Blue to Teensy pin **#16**
- White / Blue-Stripe to Teensy pin **#17**
- Green/Stripe to Teensy pin **#18**
- Green to Teensy pin **#19**

(trim wires as needed):

NOTE: The top cable will be used for the encoders on Joints 1, 2 & 3.



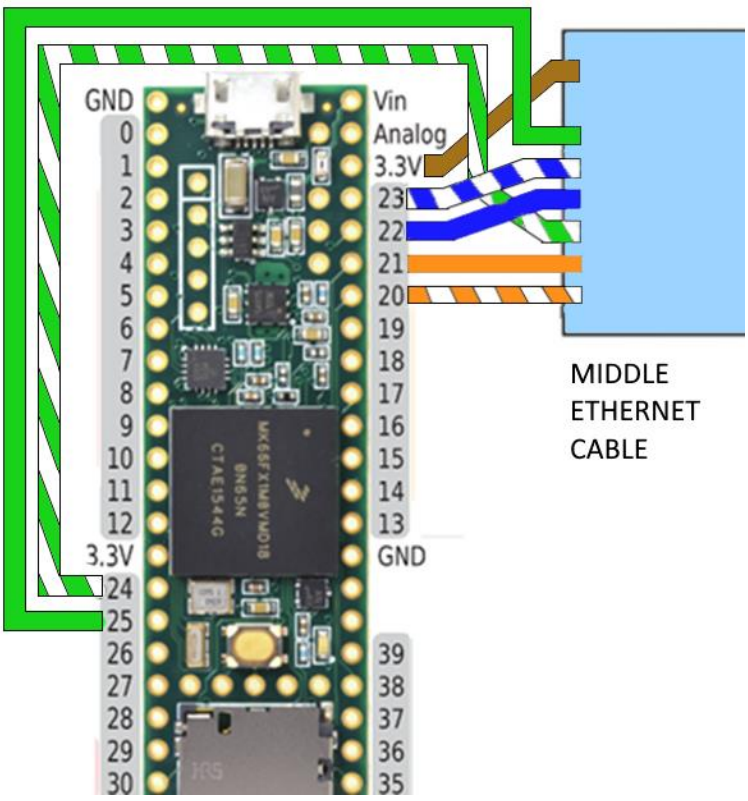
This diagram shows the wire connections for the top Ethernet cable to the Teensy 4.1 as outlined in the previous step.



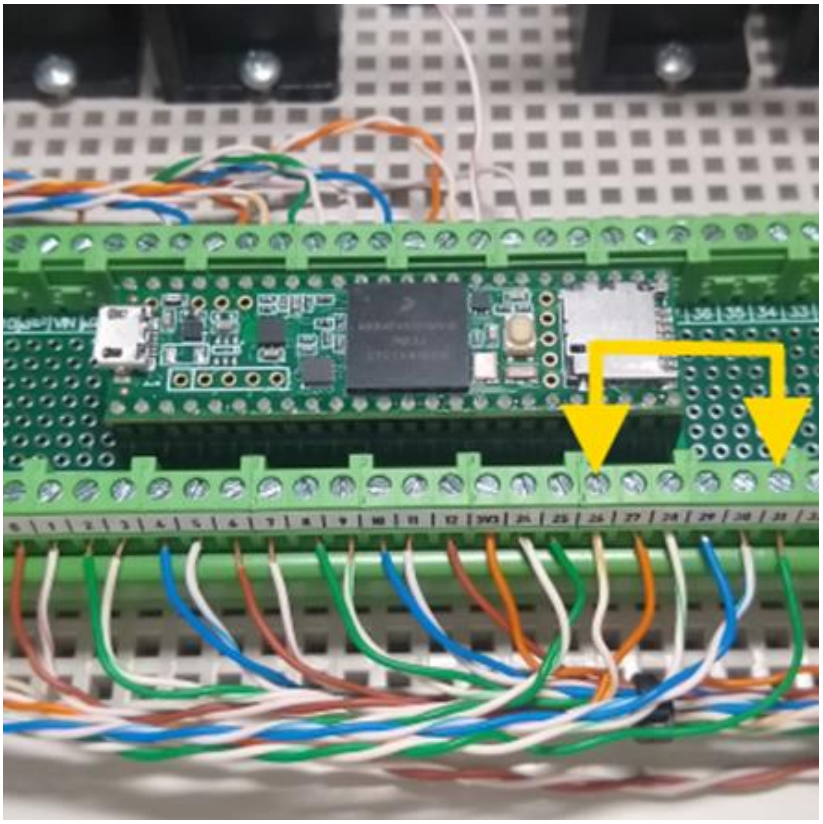
Locate Ethernet cable coming from the middle Keystone jack. Connect the middle Ethernet cable wires to the Teensy 4.1 as follows:

- Brown to Teensy pin **3.3v**
- White / Orange-Stripe to Teensy pin **#20**
- Orange to Teensy pin **#21**
- Blue to Teensy pin **#22**
- White / Blue-Stripe to Teensy pin **#23**
- White / Green-Stripe to Teensy pin **#24**
- Green to Teensy pin **#25**

NOTE: The middle cable will be used for the encoders on Joints 4, 5 & 6.



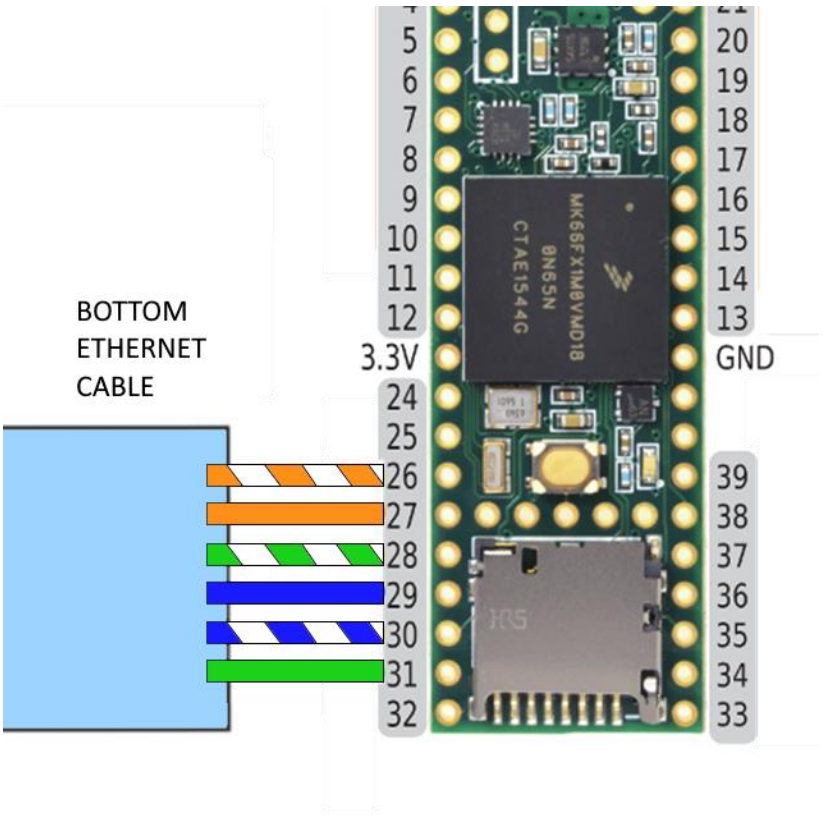
This diagram shows the wire connections for the middle Ethernet cable to the Teensy 4.1 as outlined in the previous step.



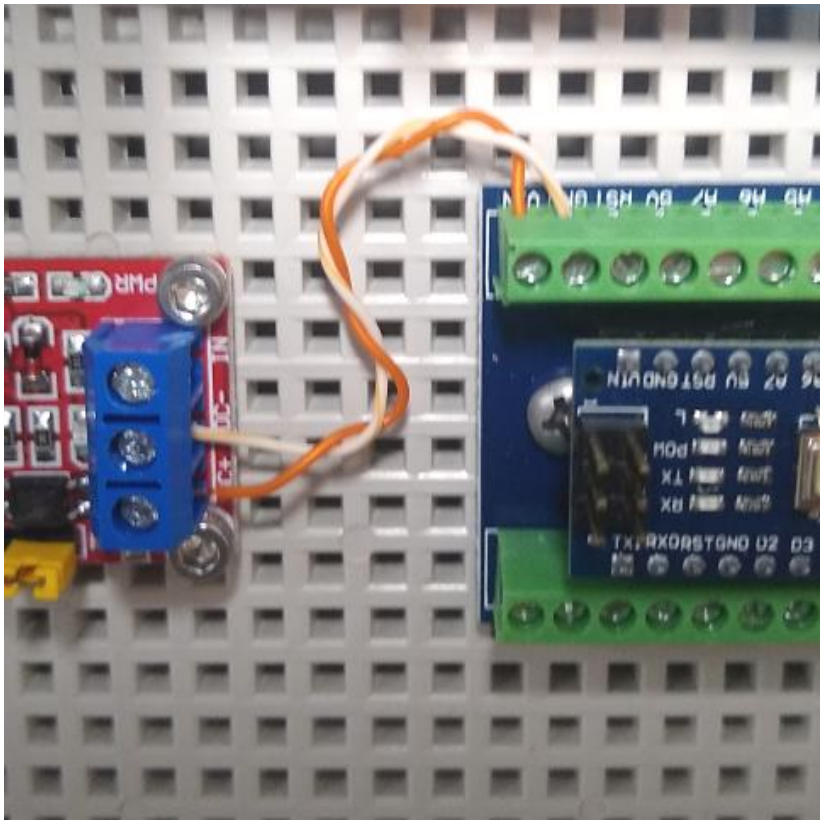
Connect the bottom Ethernet cable wires to the Teensy 4.1 as follows:

- White / Orange-Stripe to Teensy pin #**26**
- Orange to Teensy pin #**27**
- White / Green-Stripe to Teensy pin #**28**
- Blue to Teensy pin #**29**
- White / Blue-Stripe to Teensy pin #**30**
- Green to Teensy pin #**31**

NOTE: The bottom cable will be used for the 6 calibration limit switches on the robot.

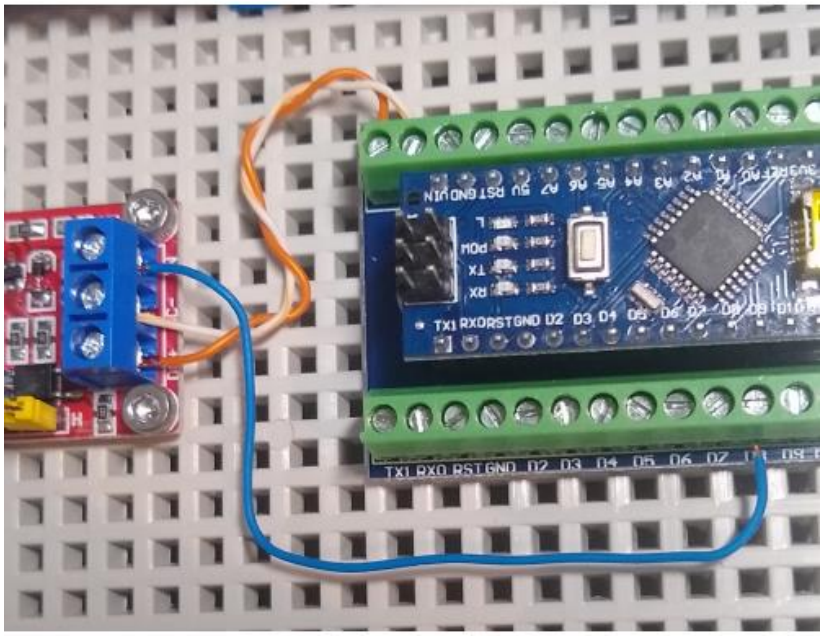


This diagram shows the wire connections for the bottom Ethernet cable to the Teensy 4.1 as outlined in the previous step.



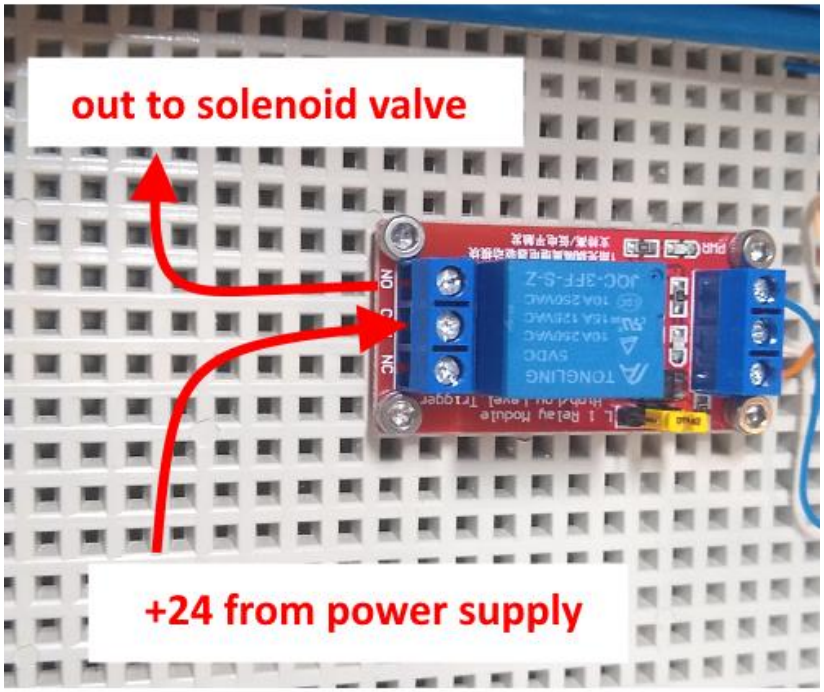
Connect the VIN terminal from Arduino Nano board to the DC+ terminal on 5v relay board.

Connect the GND terminal from Arduino Nano board to the DC- terminal on 5v relay board.



You can use any output of your choosing to control the relay board. In this example I am going to use pin 08. Connect pin “08” to the “IN” pin on relay board.

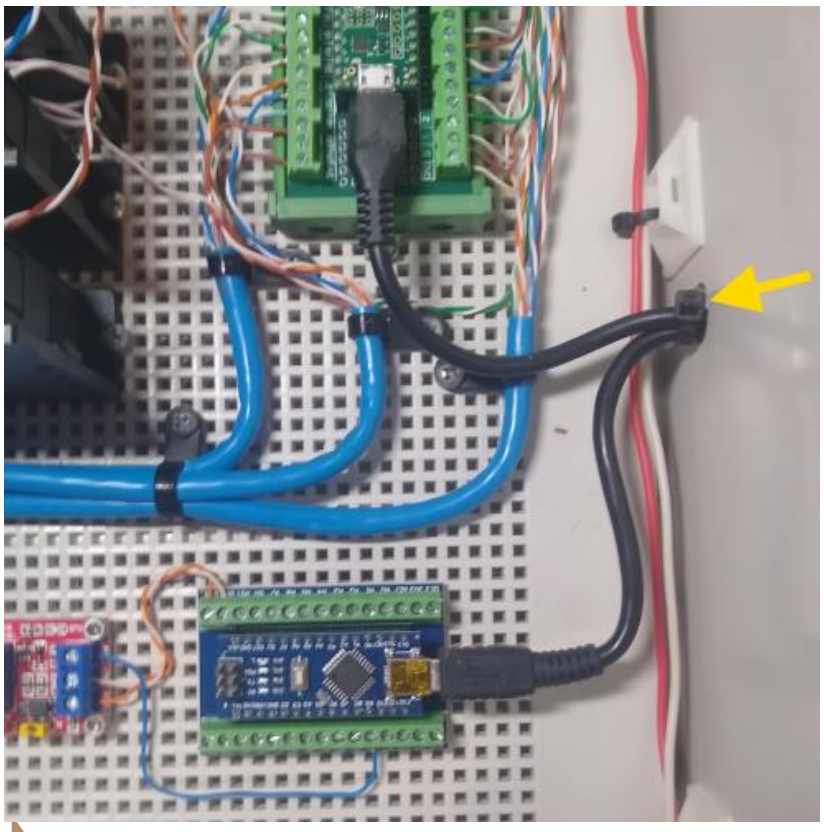
NOTE: *the Arduino Nano has 12 digital pins and the robot control software is configured such that pins 02 through 07 are digital inputs. Pins 08 through 13 are digital outputs.*



You can install as many relays as needed to control whatever devices you need.

You can also use the Arduino Nana analog outputs to control an electric servo gripper if desired.

In this example I am installing one relay to control a pneumatic gripper. For this example you would connect +24v to the relays COM terminal and then the NO terminal will pass the 24v to the solenoid valve when the program sets output pin 08 high.



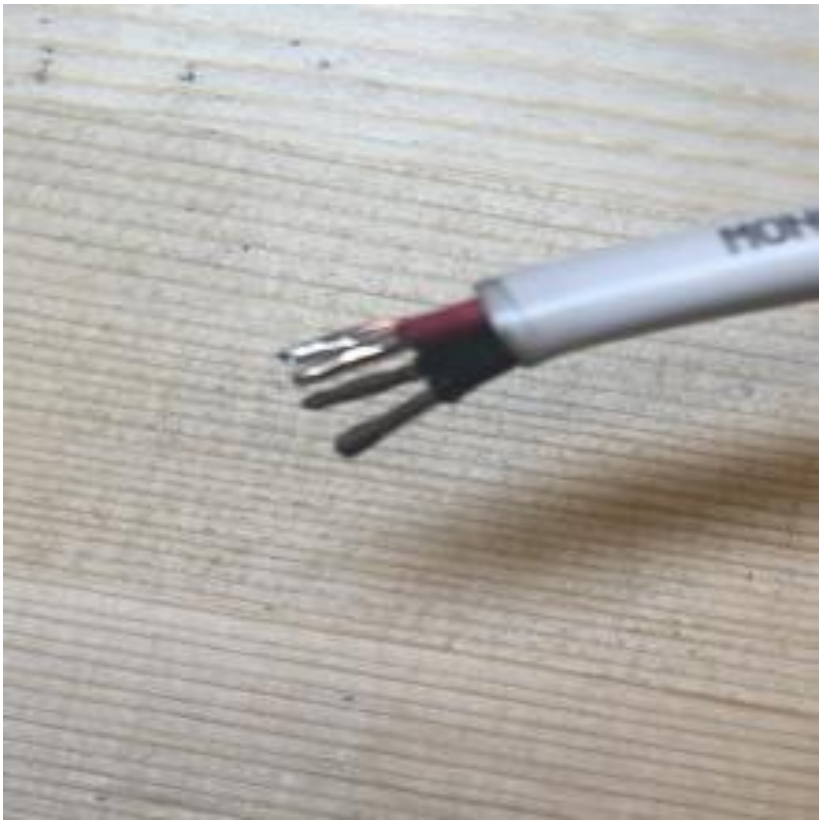
Connect USB cable to the Teensy 4.1 board and the Arduino Nano board. It is recommended to install a cable tie as shown (red arrow) around USB cables where shown to prevent cables from being pulled out.

Robot Motor Cables

You will need to make 6 cables for the robot and a 7th if you are building a travel track.

Cut each 18awg 4 conductor cable a length of 1.5 meters per cable.

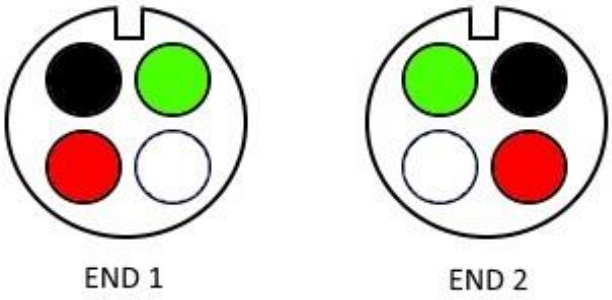
Strip 10mm of outer sheathing off each end of cable and then pre-install GX16-4 aviation plug metal housing over cable end as shown.



Strip 5mm sheathing off each wire and then tin each wire with solder as shown.

Pre apply solder to each contact on GX16-4 aviation plug connector.

Solder wires to each contact on GX16-4 aviation plug connector – see following steps for wire position.



VIEW FROM BACK SIDE OF CONNECTORS

Cables are “straight through” - solder wires on each end of cable mirror image to the other as shown in the sketch and photo shown.

Wrap electrical tape around solder joints to prevent any potential short on connector housing.

Slide connector housing over connector and install screw.

Tighten screws on wire clamp.

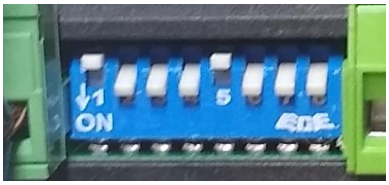
Repeat this process for each cable needed.

You will need (6) of these for the robot and (1) if building a travel track.

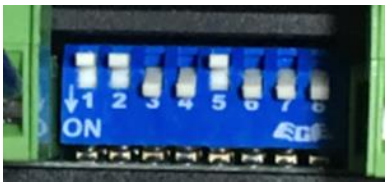
DIP SWITCH SETTING

THESE SETTINGS ARE USED FOR THE FOLLOWING SERIES MOTORS:

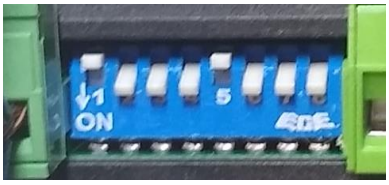
• J1 - 17HS15-1684D-HG10	1/2 STEPS	1.46 AMP
• J2 - 23HS22-2804D-HG50	1/2 STEPS	2.37 AMP
• J3 - 17HS15-1684D-HG50	1/2 STEPS	1.46 AMP
• J4 - 11HS20-0674D-PG14	1/2 STEPS	.5 AMP
• J5 - 17LS19-1684E-200G-C1	1/4 STEPS	1.00 AMP
• J6 - 14HS13-0804D-PG19	1/2 STEPS	1.00 AMP
• J7 – Nema 17 48mm body	1/2 STEPS	1.00 AMP



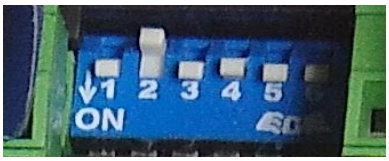
J1 – (DM542T):
SW1 = OFF SW2 = ON SW3 = ON SW4 = ON
SW5 = OFF SW6 = ON SW7 = ON SW8 = ON



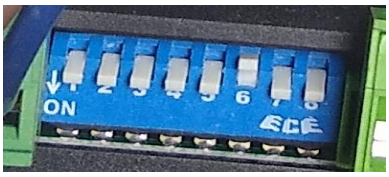
J2 – (DM542T):
SW1 = OFF SW2 = OFF SW3 = ON SW4 = ON
SW5 = OFF SW6 = ON SW7 = ON SW8 = ON



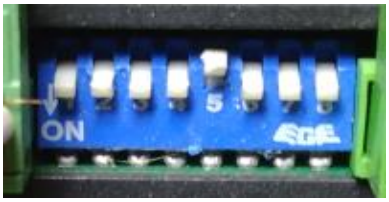
J3 – (DM542T):
SW1 = OFF SW2 = ON SW3 = ON SW4 = ON
SW5 = OFF SW6 = ON SW7 = ON SW8 = ON



J4 – (DM320T):
SW1 = ON SW2 = OFF SW3 = ON
SW4 = ON SW5 = ON SW6 = ON



J5 – (DM542T):
SW1 = ON SW2 = ON SW3 = ON SW4 = ON
SW5 = ON SW6 = OFF SW7 = ON SW8 = ON

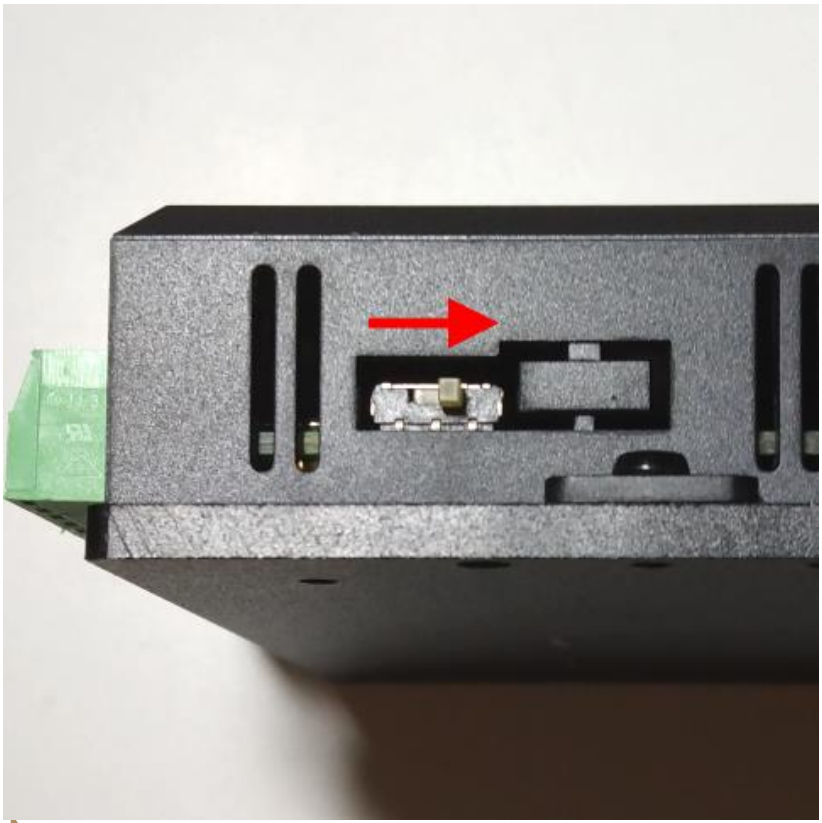


J6 – (DM542T):
SW1 = ON SW2 = ON SW3 = ON SW4 = ON
SW5 = OFF SW6 = ON SW7 = ON SW8 = ON

NOTE: If using a 7th joint travel track (nema 17) use the same setting as J1.

If you are using the newer version-4 DM542T drivers you will need to make sure the input voltage switch is set to the 5V position.

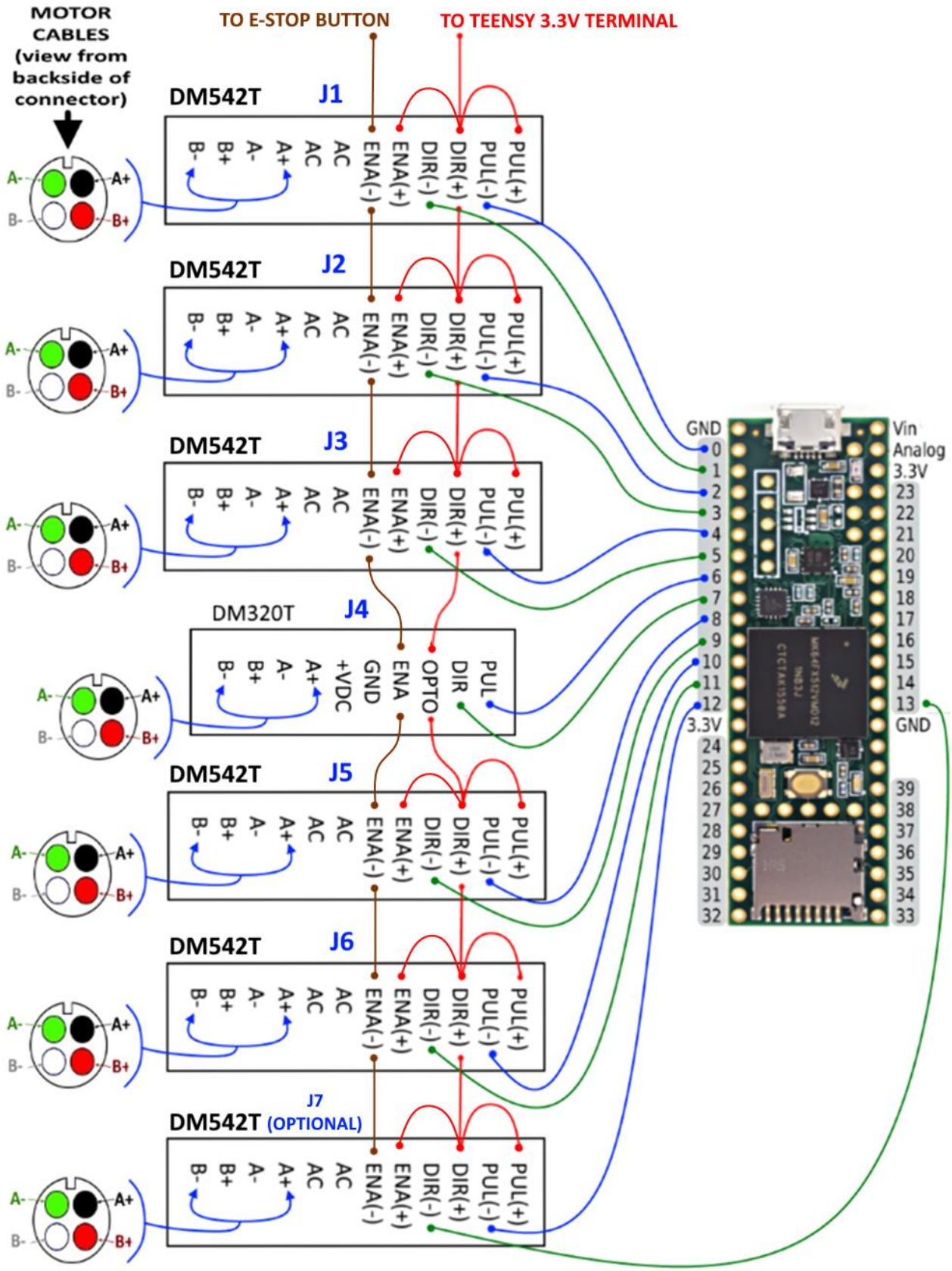
NOTE: the alarm terminals on the V4 driver are not used.



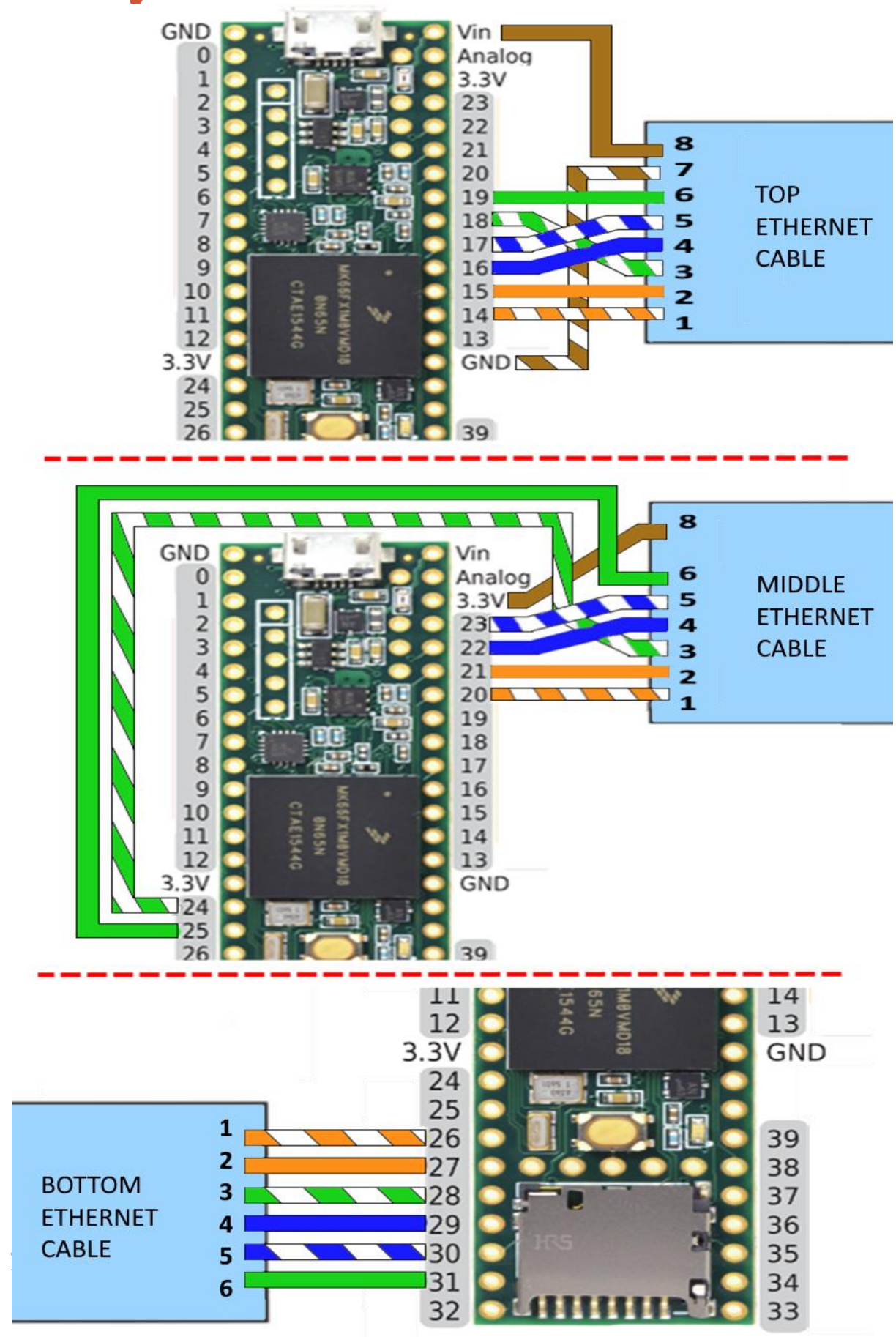
The input voltage switch should be to the right as shown.

CHAPTER 4
SCHEMATICS

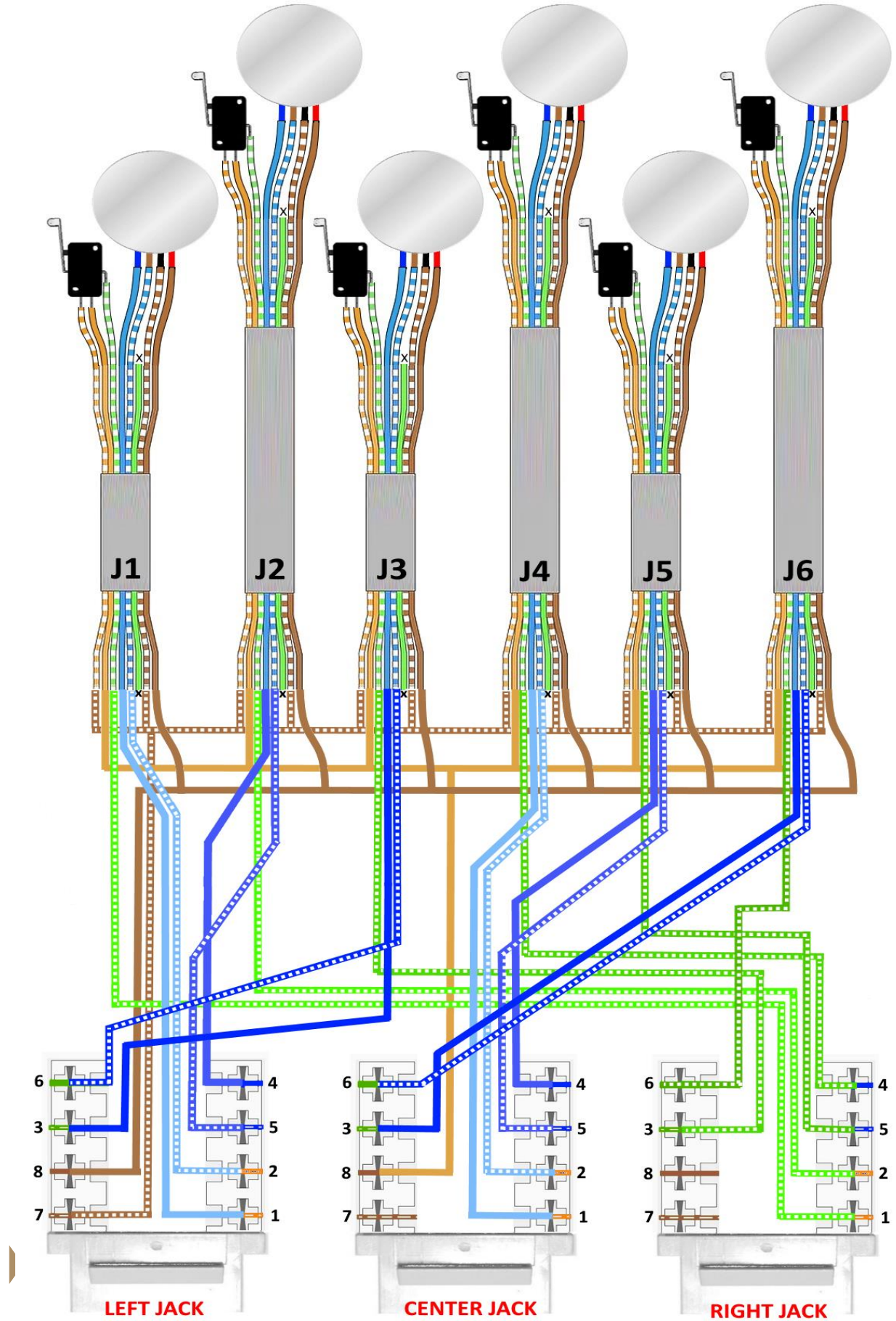
Teensy 4.1 to Drivers Schematic



Teensy 4.1 to RJ45 Jacks Schematic



Encoder & Limit Switch Schematic (Robot side)

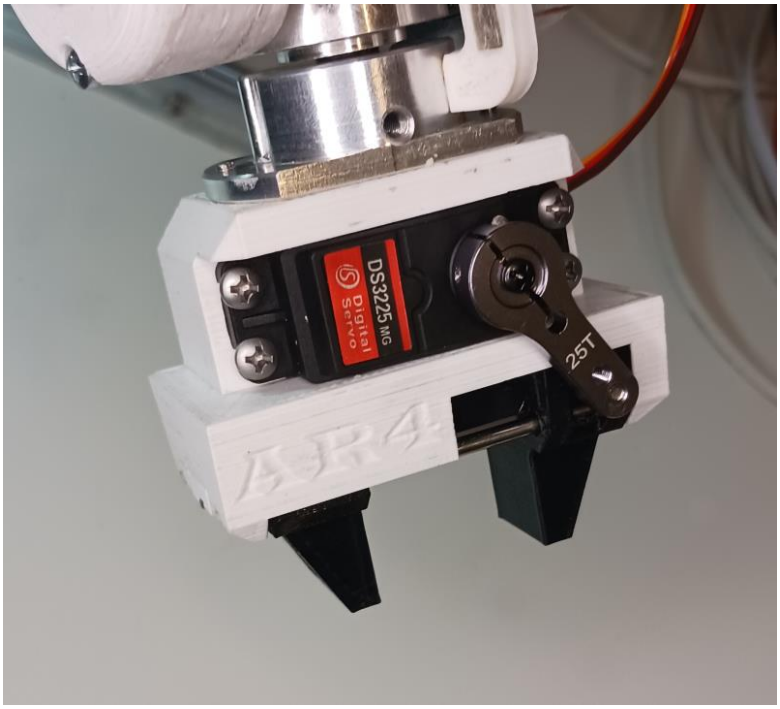


CHAPTER 5
ROBOT GRIPPERS

The recommended gripper for the AR4 robot is the SMC model MHF2-8D shown in the Bill of Materials. There is also a Servo gripper design available on the downloads page under AR4 downloads. You can use any pneumatic or electric servo gripper of your choosing. You can modify the J6 flange mount or create your own to use any gripper you like. The following page shows some notes on wiring for a servo gripper vs a pneumatic gripper.

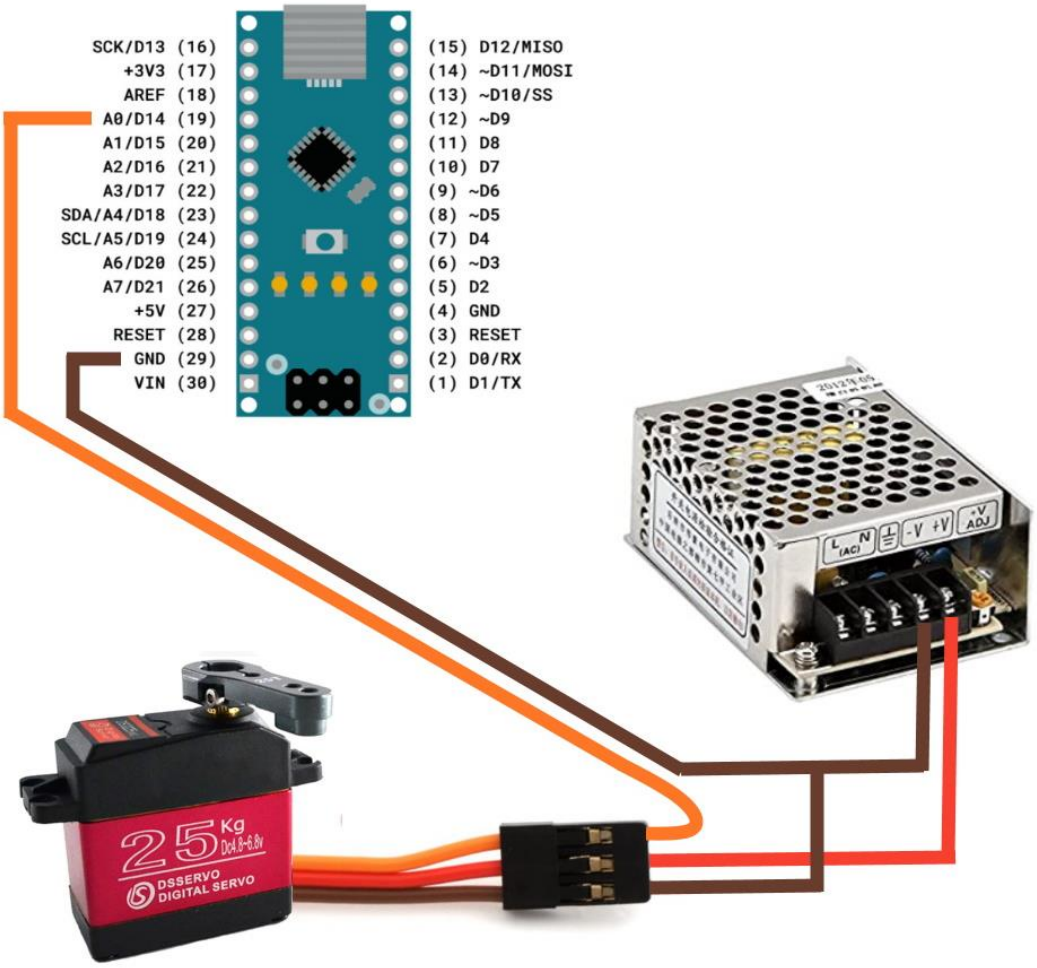
Please also see the tutorial video on grippers and IO connections:
https://youtu.be/76F6dS4ar8Y

If using a servo gripper you can use the AR4 gripper or any servo gripper of your choosing.

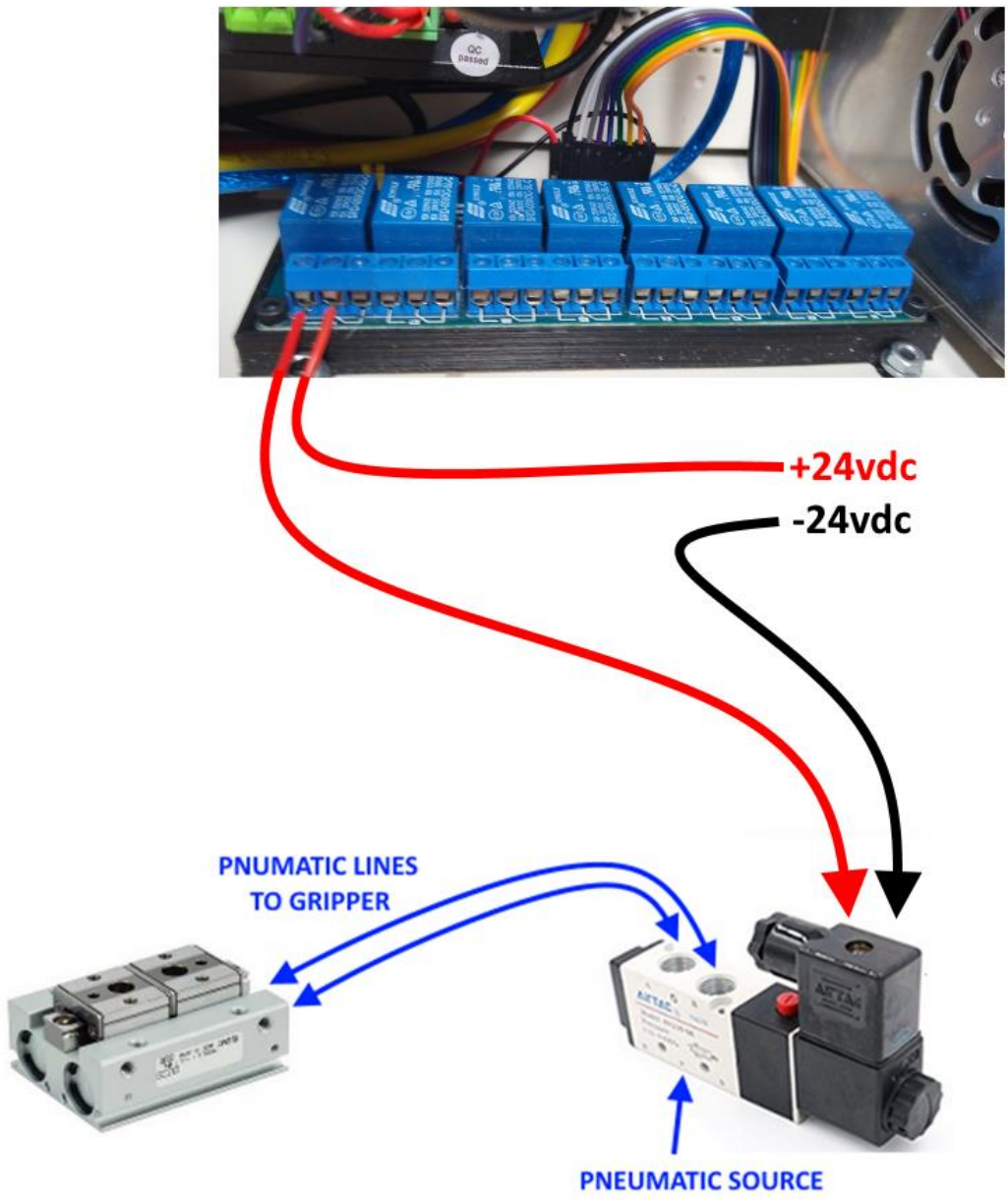


The AR4 servo gripper can be found on the downloads page under AR4 downloads.

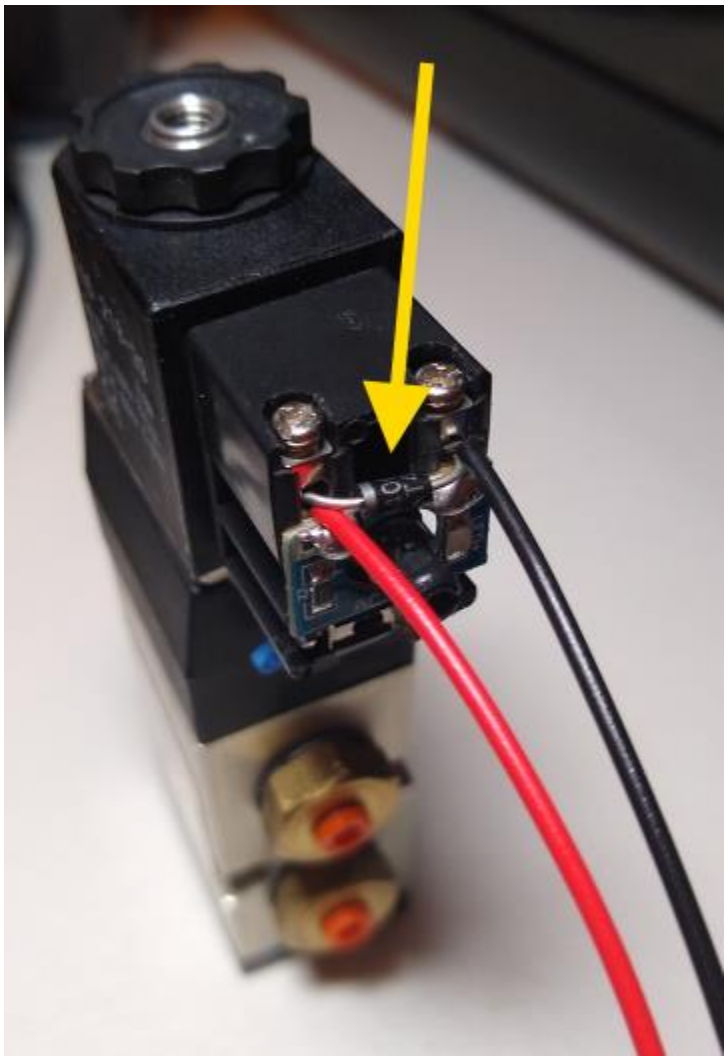
The servo gripper is wired as shown in this illustration. Please also see this video on grippers and robot IO
https://youtu.be/76F6dS4ar8Y



If using a pneumatic gripper you would connect a 24vdc solenoid valve to one of the relay outputs (Arduino outputs 28 through 36) and then use the "Set Output On" and "Set Output Off" commands to program relays to control your gripper.

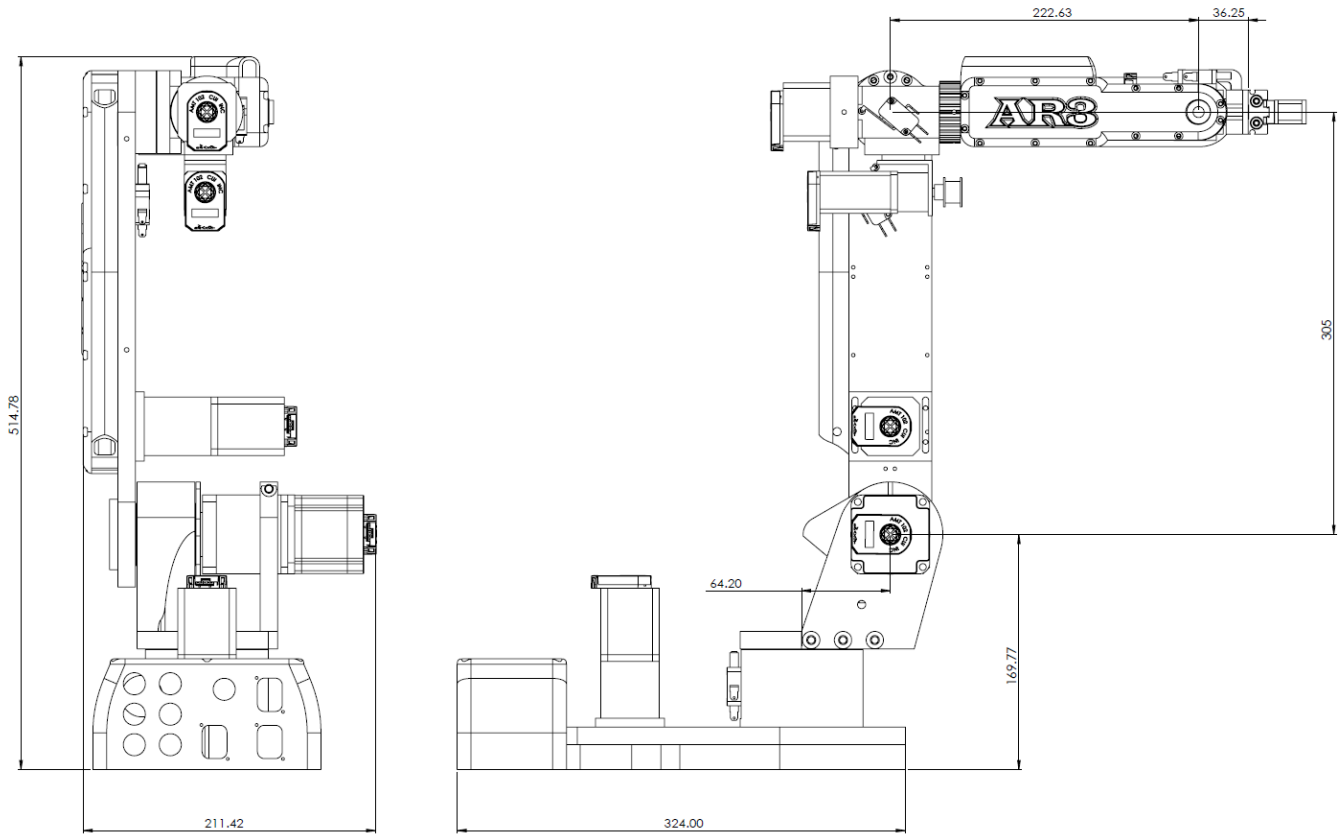


Solenoid valves for controlling pneumatic grippers tend to interrupt the serial connection to the controller. If you find the Teensy or Arduino are losing connection when the solenoid valve actuates install a flyover diode across the solenoid terminals (revers bias).

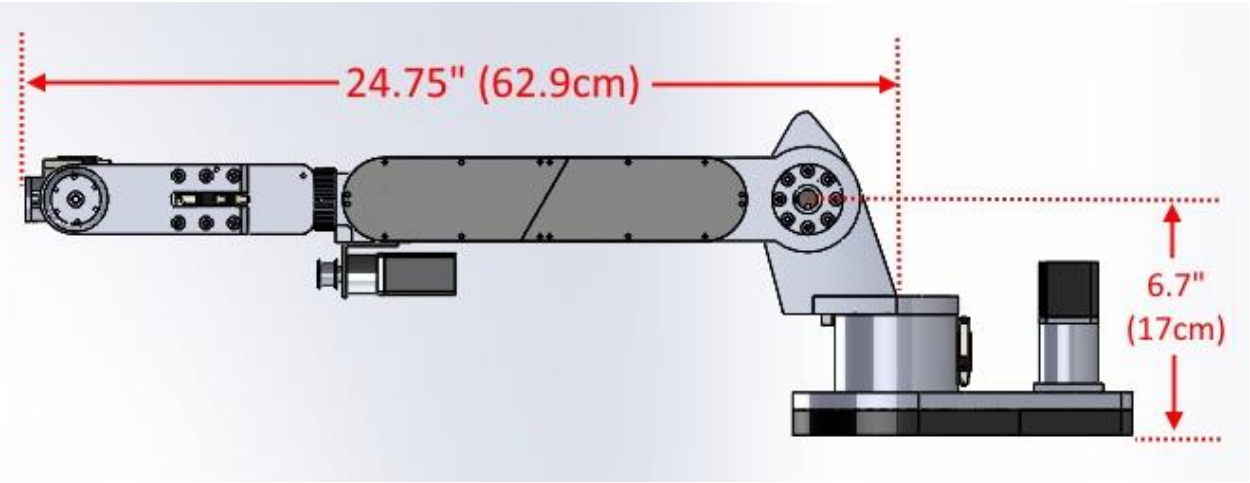


https://en.wikipedia.org/wiki/Flyback_diode

CHAPTER 6
ROBOT SPECIFICATIONS


222.63
36.25
514.78
305
64.20
169.77
211.42
324.00

Reach – 24.75 inches (62.9cm)
Payload – 4.15 lbs (1.9kg)
Repeatability - .2mm
Robot weight (aluminum) – 27lbs (12.25kg)
Enclosure weight – 12.5lbs (5.6kg)
Max Power Consumption – 8.25amp (198 watts)



CHAPTER 7
STARTUP PROCEEDURE

Please see the AR4 startup tutorial video:
https://youtu.be/OL6lXu8VU4s

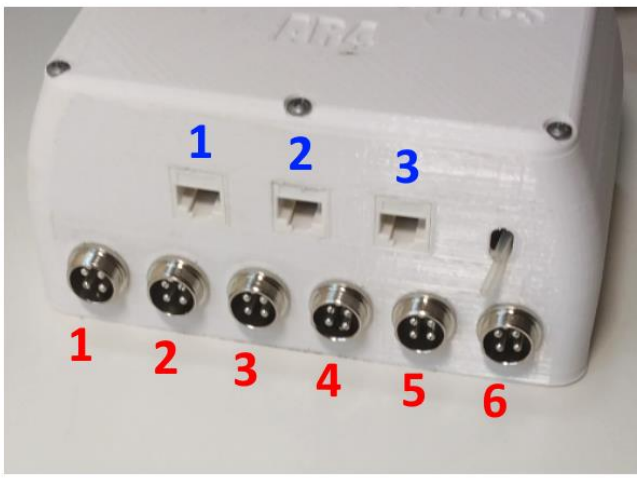
AR3 Robot Startup & Troubleshooting

Before powering up your control box double check all connections per the wiring schematic. Check continuity on all wires and connectors for each motor, encoder and limit switch. It is imperative that all wire connectors are crimped or soldered carefully and checked with a volt meter.

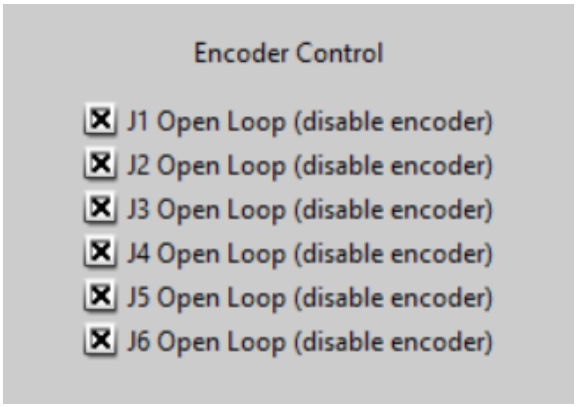
It is recommended that you plug in each of the (3) Ethernet cables prior to plugging in the USB port for the Teensy 4.1.

Use (3) high quality shielded Ethernet cables and connect the enclosure encoder and limit switch ports to the robot encoder and limit switch ports as shown in the diagram below:

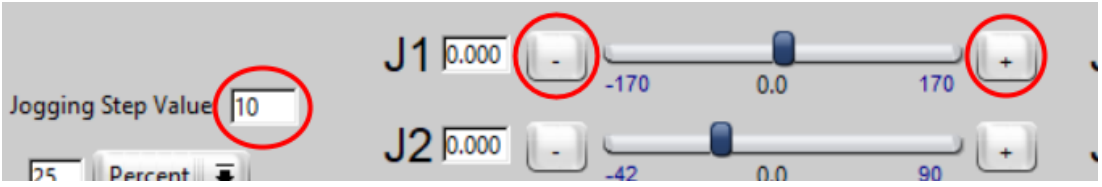
Connect all 6 motor cables as shown in the diagram below:



- Review the AR4 software startup video found on the tutorials page at www.anninrobotics.com and install the AR4 teensy 4.1 sketch on your teensy board and load the AR4 control software on your computer or laptop.
- After starting up the AR4 control software verify the log screen shows the message **"COMMUNICATIONS STARTED WITH TEENSY 4.1 BOARD"** and the system message at the top of the main control screen says **"SYSTEM READY".**
- The first step is to check that each motor runs and jogs in both directions. At this point we do not yet want to troubleshoot any encoder issue or have any potential encoder issues cause confusion when checking the motors. For now select the checkboxes on the Config Settings tab to disable all the encoders:



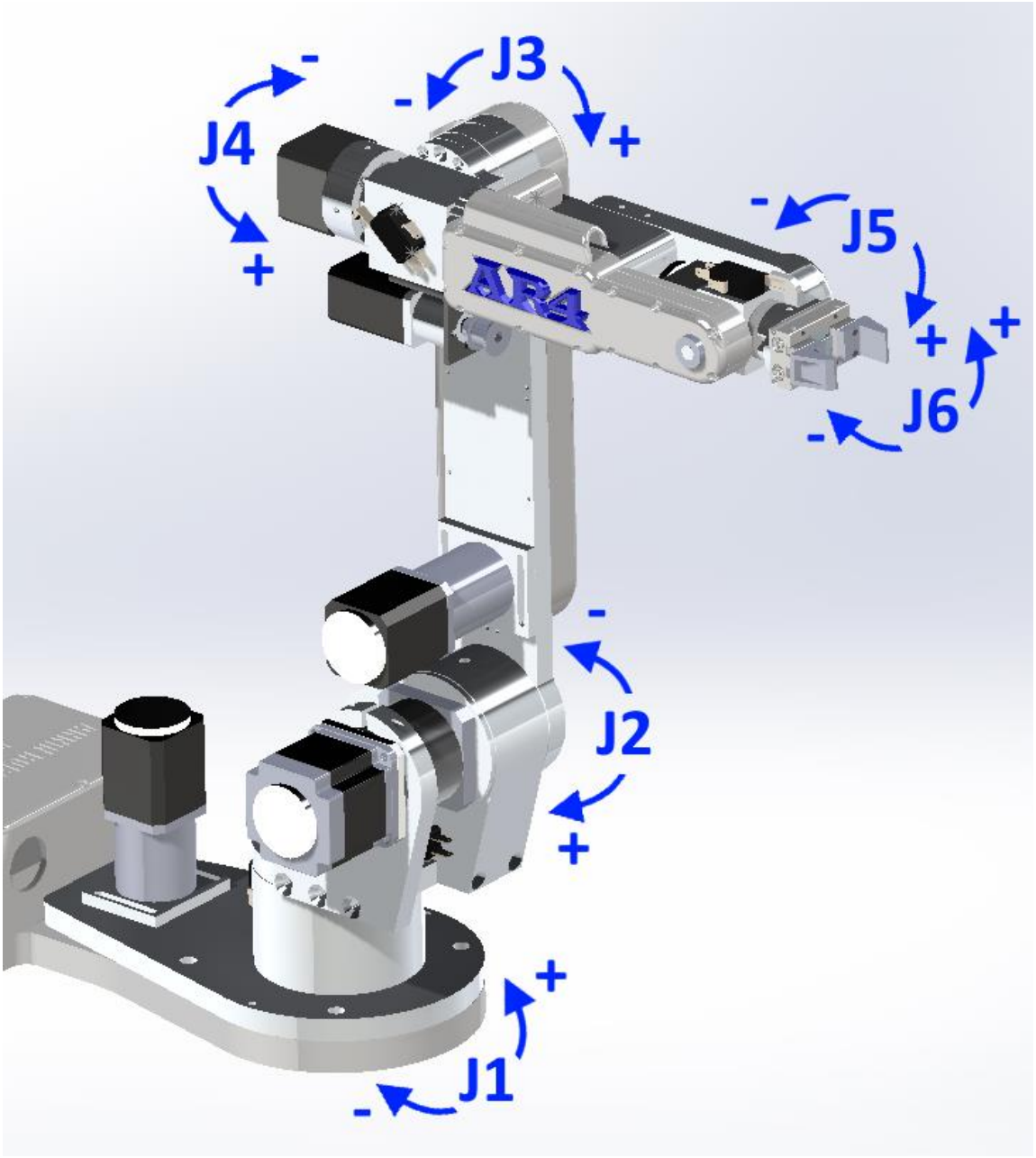
- On the Main Control screen jog each motor a small amount in each direction – set the jogging step value to 10 and press the + and – button for each joint.



- If any of the motors do not move at all there are generally 2 things to look for, first check the motor power wiring for the A+A-B+B- wires, this includes checking the wiring between the drivers and the sockets, checking the cables, try swapping motor cables with a known good cable, check the plug wiring in the base of the robot. The second thing to check is the pulse wire from the teensy to the affected driver – if the driver is not getting the pulse signal it will not move in either direction.

- If one of the motors only jogs in one direction this is typically an issue with the dir wire from the teensy to the affected driver – check that this wire is properly connected.

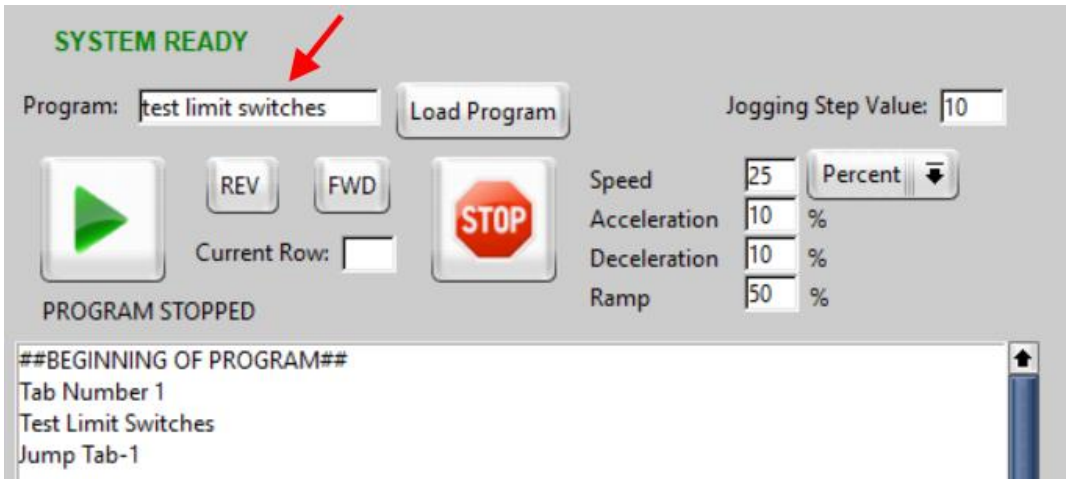
- After it is verified that all motors can jog in each direction it is important to check that each motor is jogging in the correct directions for the positive and negative directions, it is possible for miswiring of the A+A-B+B- to cause the motors to turn in the incorrect directions. Refer to the following diagram and verify each joint is jogging in the correct direction. If any of the motors are not jogging in the correct direction check the motor wiring and verify if you are using a different driver that is doesn't have a direction dip switch set incorrectly.


J3
-
-
+
J4
-
+
J5
-
+
+
J6
+
-
AR4
-
J2
+
+
J1
-

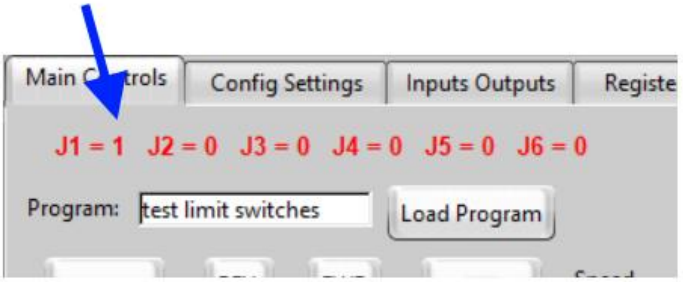
- After verifying each joint is jogging in the correct direction the next task is to verify each joint is jogging the correct distance. You can use a mechanical angle gauge but a digital angle gauge such as the one shown in the general assembly notes. Place the angle gauge on a flat surface of each joint and then verify when jogging that joint 10 degrees that it actually moves 10 degrees. For example on joint 3 place the gauge on the upper arm as shown – at this point it doesn't matter what position the joint is currently in, press the zero button – the gauge should read zero, now jog the joint down 10 degrees and verify it actually moves ten degrees.

- If you find a joint is not moving the correct distance the primary thing to check is the micro step settings on the driver, if the settings are incorrect the joint will not move the correct distance. The other mistake that I have seen is when the motors for J1 and J3 get mixed up and installed on the wrong joint.

- The next thing to check is each of the limit switches. Load the limit switch testing program: enter “test limit switches” in the program window and click the Load Program button.

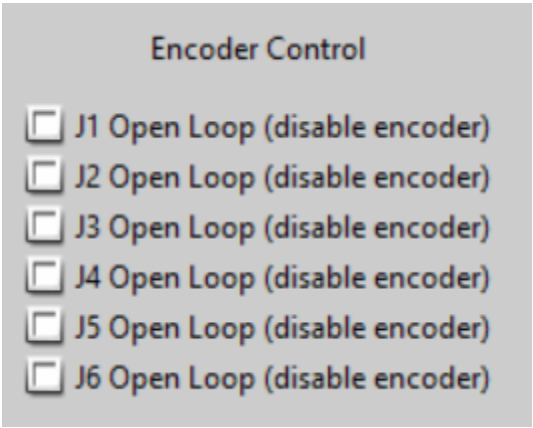


- Press the play button to run the program. When the program is running the system message at the top of the main controls screen will display a 0 or 1 value for each joint. You can now manually press each limit switch and verify it is working – the value should display 0 when the switch is not made and a 1 when the switch is made. NOTE: to test the J5 limit switch you will need a paper clip or small need nose pliers to reach in and pull on the switch lever arm. See example on next page checking the limit switch for Joint 1.



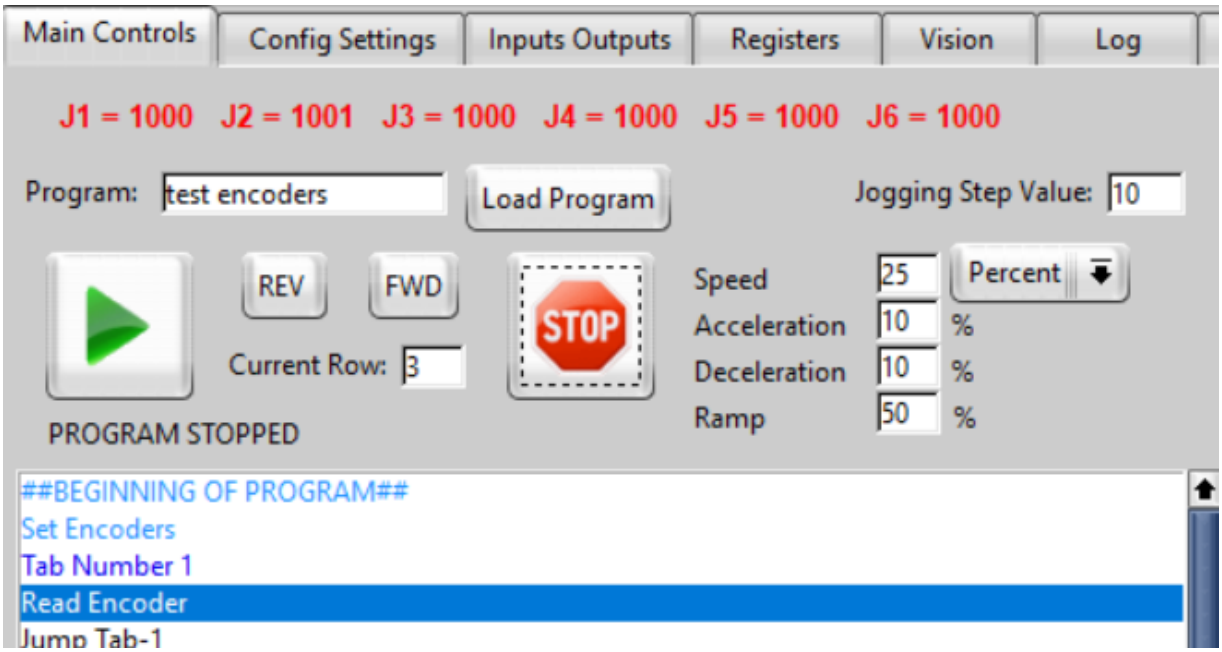
- If you find any of the limit switches are not responding first use a meter to verify that you are getting 5v on the left and center terminals of the distribution block in the base of the robot, then check that you are getting 3.3v on the right and center terminals of the distribution block. (the center terminal is GND, the right is +5 and the right is +3.3)
- Next check continuity from the switch terminals to the pins on the keystone jacks.
- The most common issue I see is the connection where the wires are punched down into the keystone jack – if you have bad signal or connection, I recommend removing the wire from the keystone jack, strip the end of that wire, tin the wire with solder and then re punch the soldered end into the keystone jack.
- Note that each limit switch should return GND to the respective teensy terminal when the switch is not made and return +3.3 to the teensy when the switch is made.

- Next we will check all the encoders, on the Config Settings tab uncheck the check boxes for disabling the encoders:



- Load the encoder testing program: enter “test encoders” in the program window and click the Load Program button. Press the play button to run the program. When the program is running the system message at the top of the main controls screen will display a value of 1000 for each joint. Turn of power to your control enclosure to remove power from the robot motors (don’t unplug the USB to your teensy board only shut off driver power). You can now manually manipulate each motor in both directions and verify the value shown for each encoder goes up or down depending on which direction you are moving each joint. See picture on next page to see what the screen should look like when testing the encoders.

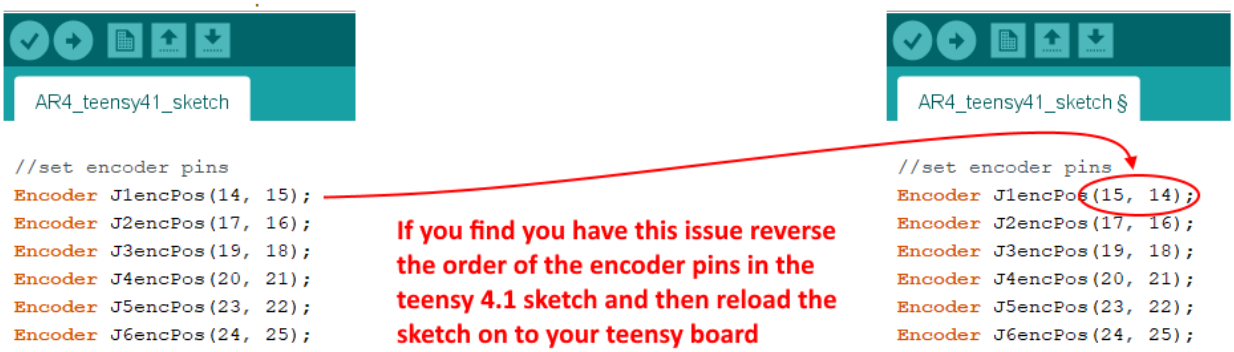
- When testing the encoders the 1000 number and the number of counts it shows are arbitrary and only meant to show you a display of the encoder functioning.



- If you find any of the encoders are not responding in either direction double check all of the wiring including the wiring of the keystone jacks as outlined in the previous section on checking the limit switch wiring.

- Next power your control enclosure back on and test jogging each joint – verify you do not get a joint collision or out of position alarm and that each joints position is reporting appropriately.

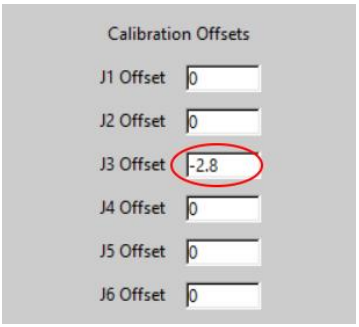
- If you jog a joint and you get a joint collision alarm check and see which direction the joint value is displaying – for example if you jog joint number one 10 degrees in the **positive** direction but the encoder corrects the display to show it actually moved 10 degrees in the **negative** direction you will need to reverse the AB phase being read in on the teensy. For example if you are having this issue on joint 1 open the teensy4.1 sketch and reverse the encoder pin values as shown in this example:



- The last step is to check your robots calibration. From the Config Settings tab click the Calibrate joint only button for each joint. The joint will travel to its limit switch, it will calibrate that joint to its limit and then travel back to zero. If you find a joint is off or not at zero after the calibration enter the amount the joint is off in the calibration offsets window for that joint, click the save button and then retry the calibration. See example on the next page.

- This example is for joint #3, in the picture below I have properly calibrated joints 1 and 2 first so that joint 2 is at a perfect 90 degrees, then I ran the calibration for joint 3 and then placed a digital level on the upper robot arm. You can see in this picture the joint is at an angle of 2.8°

- I then enter -2.8 in the calibration offset window and click save.



- Then after re-running the calibration the joint now calibrates correctly to a zero value.

This concludes the startup procedure, please review all the setup and programming videos on the tutorials page at www.anninrobotics.com

CHAPTER 8

ROBOT PROGRAMMING

Please see the AR4 programming tutorial video:
https://youtu.be/G1nNh6MS-Gc

1. COMMUNICATION
2. SPEED / ACCELERATION / DECELERATION
3. JOGGING
4. PROGRAMMING
5. CALIBRATION

1. COMMUNICATION

Determine which com port your Teensy 4.1 and Arduino is communicating on, you can find this Using Windows device manager, or you can open the Arduino sketch and click on the tools menu and then click on Port. Enter this in the "COM PORT" entry field for the device and click "Set Com". You should only have to do this once as the software will remember which com port the next time you open it.

2. SPEED / ACCELERATION / DECELERATION

The robots speed is set as a percentage of max speed. If you set the speed to 100 this will be the fastest the robot can move. Typical speed for jogging is between 10% and 25%. The acceleration and deceleration settings each have 2 parameters: a duration and a percentage. The duration is the percentage of the move you want the robot to accelerate or decelerate through, for example if you have a move that is 100mm long and you want the robot to quickly accelerate for only the first 5mm (or 5% of the move) you could set the Dur setting to 5 and then if you wanted the robot to come to a more gradual stop over the last 25mm (or 25% of the move) you could set the deceleration duration setting to 25. The second value which is percentage is a measure of amplitude, for example if you set the "speed %" setting to 10% it will accelerate or decelerate within 10% of whatever the speed setting is. For example, if your overall speed is 25% and your deceleration is 10% the robot will decelerate from 25% down to 2.5%. The Speed, Acc and Dec setting apply both to jogging and are applied to any positions you teach.

3. JOGGING

In the degrees to jog box enter the number of degrees you wish the robot to move and then press the corresponding "-" or "+" button to move each joint.. The second row of jog buttons allow you to jog the robot in Cartesian coordinates; enter the distance in millimeters you wish the robot to move and press the corresponding "-" or "+" to jog the robot. The third row of jog buttons allow you to jog the robot in tool coordinates; enter the distance in millimeters you wish the robot to move and press the corresponding "-" or "+" to jog the robot - this jogs the robot according to the gripper: think of it as jogging the gripper around depending on whatever direction it is oriented.

You can also jog the robot using an Xbox controller. Install the Xbox software per the windows PC Xbox controller adapter directions. To test it In the Windows start menu type joy.cpl and then click on the menu option for the Xbox controller, this will bring up a window that you can verify all the buttons are working. In this AR2 software click the Xbox button, the indicators on the screen should turn green and allow you to jog the robot per the button list in the next section. When you turn on Xbox control all jog distances are set to start at 5. All jogging is done with the D pad (analog sticks are not used). There are 3 modes for Xbox jogging - joint, Cartesian and reorient. The controller starts in joint mode where the D pad will start out controlling J1 and J2, you can then press the X button to shift to control J3 and J4, then press X again to shift to J5 and J6.

Press the A button to shift to Cartesian jogging, you then can jog axis X and Y using the D pad. Press the X button again to shift to axis Z. Press the B button to control orientation directions.

- jog distance up / down (L & R trigger buttons)
- speed up / down (L & R bumper buttons)
- shift joint mode (X button)
- shift Cartesian mode (A button)
- shift reorient mode (B button)
- jog track (back button)
- jog directions (use D pad)
- teach position (Y button) *this will implement whichever move type you have selected from the dropdown.
- first DO on/off assignment on Input Output tab (start button) *typical use for open close gripper

3. PROGRAMMING

a. Teaching Positions

Always select row in program window where you want the next move or instruction to be placed. From the move type drop down button select the move type you wish to insert and then press the "Teach New Position" button to insert the position into your program. All moves will apply the speed, acceleration and deceleration setting you have set to the move. Position move types are as follows:

- Move J - Move J is a joint move where all joints work together to complete the move, this will not necessarily be a straight line but a sweeping motion with all joints working together. This is the simplest and most common move to use.

- OFFS J - this is a joint move that is offset by the values of a stored position. this move will apply whatever stored position number you have set in the stored position field that is just above the "Teach New Position" button. (stored positions are explained in further detail below in the entry for Move SP).

- Move L - Move L is a linear move, this will execute a perfectly straight line to the position you teach. This program must send a series of waypoints that form the line to the Arduino, there is a couple second delay before any Move L while all waypoints are being transmitted.

- Move A - Move A is an arc move. You must teach 3 points to form an arc. First select "Move A beg" and teach the start point for your arc - the speed and orientation values for this first point will be applied to the entire arc move. Second you need to teach any mid-point on the arc - select "Move A Mid" and teach the second point. Finally select "Move A End" and teach the point you want at the end or your arc. Your command window will now have 3 lines of code in a row for each of the 3 points. When a "Move A Beg" line of code is executed the program will automatically run the next 2 lines of code to calculate the arc. The move will not work if these are out of order. There is a couple second delay before the Move A will execute while all waypoints to form the arc are being transmitted to the Arduino.

- Move C - Move C is a circle move. You must teach 3 points to form a circle. First select "Move C center" and teach the center point for your circle - the speed and orientation values for this first point will be applied to the entire circle move. Second you need to teach the start point on the circumference of the circle where you want the robot to begin and end the circle - select "Move C Start" and teach the second point. Finally select "Move C Plane" and teach a point anywhere on the same plane you want your circle, this point is only used to know which direction you want the circle to go and this third point defines the plane - in other words just teach another point on the circles circumference - it doesn't really matter where it is, it's not an executed point and only used for calculation

. Your command window will now have 3 lines of code in a row for each of the 3 points. When a "Move C Start" line of code is executed the program will automatically run the next 2 lines of code to calculate the circle. The move will not work if these are out of order. There is a couple second delay before the Move C will execute while all waypoints to form the arc are being transmitted to the Arduino.

- Move SP - SP stands for stored position. In the registers tab there are 16 stored positions you can set. You can set or save the X,Y,Z,Y,P,R for any position you want to execute later or multiple places in your program. When you teach a Move SP the robot will move to the position you have entered for the stored position on the register tab. *Stored positions can also be used for offsets - for example if you want the robot to come in above your part you may want to use an offset move with a stored position 25mm up in the Z direction - example: (0,0,-25,0,0,0).

- OFFS SP - this moves the robot to a stored position and then offsets that position by the value in another stored position. This is useful for stacking and placing parts in rows. This move will use the value in the stored position field that is just above the "Teach New Position" button for the primary move to execute, then for the stored position that it will be offset by it automatically picks the next stored position - but you can use the manual entry field to edit which stored position the move will be offset by (see section below on editing).

- Teach SP - this move command will insert 6 lines into your program which when executed will store the robots current position into a stored position register of your choice. This makes it easier to populate stored positions as you need.

The Stored Position button will allow you to enter lines of code that set individual elements of the X,Y,Z,Y,P,R in a stored position.

The modify position button is only used with Move J and allow you to modify the Move J line in your program that is currently highlighted.
The Delete button allows you to delete any line of code that is currently selected.

b. Pausing
- The wait time button inserts a line that will pause the program for the amount of time entered in seconds.
- The wait input on button will wait for the Arduino input entered in the entry field to come on before moving forward in the program. This can be used as a way to make the robot wait for something else to happen before proceeding or it can be placed at the beginning of a program as a way to have an automated start signal.
- The wait input off button will wait for the Arduino input entered in the entry field to turn off before moving forward in the program.

c. IO

- The set output on or set output off buttons allow you to insert a line of code that will turn Arduino IO of your choice on or off (see bottom on input outputs tab for available IO pins on the Arduino Mega). For example, if you have a pneumatic gripper you would hook up your solenoid per the wiring harness manual to output Arduino pin #38 and ender a line of code "Out On = 38" to control your gripper.

d. Navigation

You can create as many program routines as you like. Enter the name of the program you would like to create in the program field and press "load program", if the program does not already exist it will be created, if you have already created a program of that name it will be loaded. Programs are created in your software folder and can be deleted from that file location if no longer needed.

- The "Call Program" button allows you to insert a line of code that calls a program.
- The "Return" button inserts a line of code that will allow the called program to return to the program it came from. *note you cannot call another program from within a program that has already been called, you must return to the main program before calling another program. For example, you will likely want to create a program called "Main" from that program you might call a program called "Pickup Part" at the end of pickup part you will want to insert a "Return" line to get back to the "Main" program, then you can do other things or call other programs. You cannot call another program from "Pickup Part" you must first return to the main program.

- the "Create Tab" button allows you to create markers in your program that you can jump or navigate to based on conditions. *note you cannot have 2 tabs with the same number - each tab needs a new number. This functionality is very similar to basic programming.

- The "Jump to Tab" button allows you to jump to a tab, for example you could put "Tab 1" at the top of your program and at the bottom put a "Jump to Tab 1" and then your program would loop indefinitely.

The "If Register Jump" button allows you to jump to a tab based on the condition of a register. For example you could have a looping program as previously described but then add a line into your program that increments a register and then add a line prior to "Jump to Tab 1" that says "If Register 1 = 5 Jump to Tab 2" and then place a "Tab 2" at the very bottom after "Jump to Tab 1" so that the program will run 5 times and then jump to Tab 2 and stop.

e. Registers

The "Register" button allows you to set a register to a static value or you can add a "++" before the number and the register will then be incremented by the amount. For example, if you just enter a "1" it will always set that register to a value of 1 but if you enter "++1" it will then increment that register by 1 every time the line is run so that you can use this for counting. You can enter any number, for example you could enter "++3" and count by 3's if you like. The same is true for counting down or decrementing - just place a "--" before the number.

f. Servos

The Servo button allows you to control external servos - it's not for the robot itself, it's for use if you have a servo gripper or a servo actuator that you want the robot program to control. For example, if you had a servo gripper that you had hooked up to Arduino pin A0 per the wiring harness manual you could then insert a line of code "Servo number 0 to position: 180" to open the gripper and "Servo number 0 to position: 0" to close your gripper.

g. Editing lines of code

You can select a line of code in you command window and then press the "get selected" button, this will copy that line into the manual entry field. You can now edit the line of code in the manual entry field, some examples might be: changing the stored position number, changing a position, changing the robot speed or acceleration. Now with your edited line of code you can reselect the original line of code in your command window and then press the "replace" button and the old line of code will be replaced with the new edited line. The "insert" button will insert the test from the manual entry field into your program without replacing - you can use this to insert comments or hand written lines of code using the insert button, this can be used to copy a line of code from the program and then paste or insert in in numerous places in the program.

4. CALIBRATION

a. Auto Calibration

Pressing the auto calibration button will auto calibrate all axis. The robot will run to its full limit in the default directions and set each of the joint values accordingly. You can also use the individual buttons to calibrate each axis one at a time.

b. Force to midrange Calibration

This button allows you to force each axis to be calibrated at its mid-point. This is only used when setting up your robot - for example if your robot is not yet calibrated and you are trying to jog a joint around and you hit an axis limit this button will allow you to do what you need to do before you can auto calibrate your robot. Only use this button during construction and setup.

5. IO TAB

The buttons on the IO tab are simply a shortcut for you to quickly toggle servos or outputs. For example, if your gripper was wired to Arduino output #38 you could enter 38 into one of the "DO ON / OFF" fields and quickly open and close your gripper without having to execute a line of code from the program console.

ALSO, PLEASE REFER TO ALL OF THE PROGRAMMING AND CALIBRATION VIDEOS FOR FURTHER INFORMATION:
https://www.anninrobotics.com/tutorials

Version Log:

- 1.0 2/8/22 – original issue
- 1.1 3-11-22
  - Corrected RJ45 jack number on page 2211.2
- 1.2 4-17-21
  - Corrected pictures of J5 mechanical
  - calibration. Page 151.
- 1.3 6-25-21
  - Updated J4 3D printed pulley.
- 1.4 10-8-22
  - Added retaining compound to J4 shaft
- 1.5 11-3-22
  - Added arrows page 156
  - Corrected wire length page 181
  - Corrected typo on page 186
- 1.6 2-5-23
  - Changed to YGS gearbox for J2