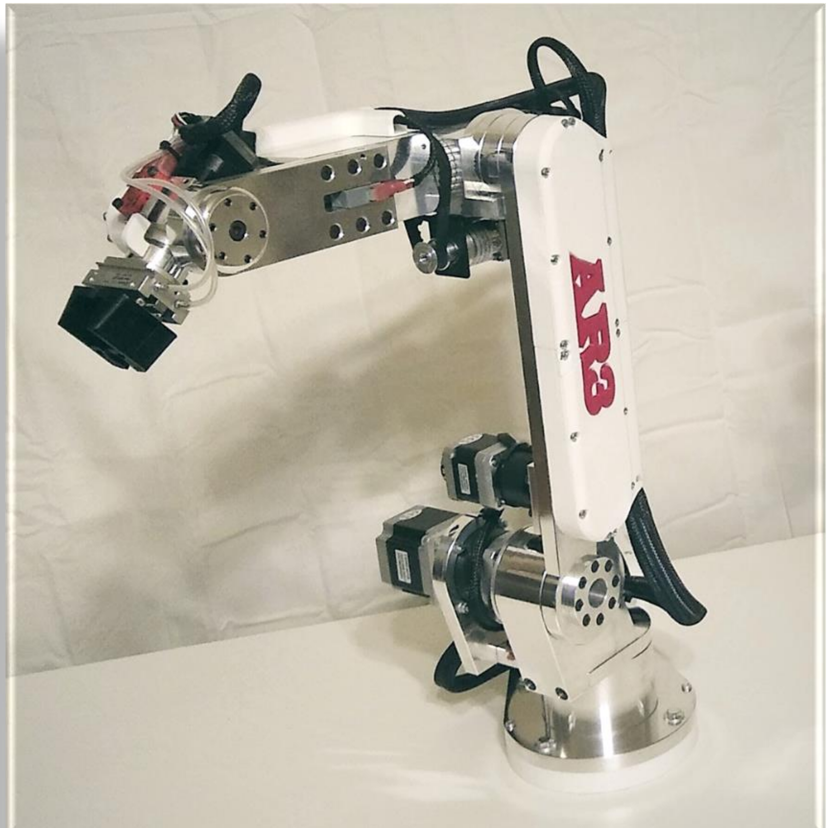
ANNIN ROBOTICS



Model AR3 Robot Manual

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 AR3 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** – You must source all of the electrical components shown in the Electrical components section of Chapter 1. These can easily be purchased from places such as Amazon or AliExpress. I currently don't have an electrical components kit available however I have had many requests and it is something I am looking into.

General Robot Assembly notes:

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

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.

Bearing Fit:

The CAD models for the AR2 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. Given customer feedback and the fact that most don't have access to a quality bearing press or hardware I have tried to make sure the aluminum kits offered are closer to a slip fit. If bearings get improperly wedged or tilted and then attempt to press, severe damage can occur. Given the opportunity for bearings to jam and permanently damage to occur I have opted to try and provide kits that error on the side of a looser fit to avoid part damage and frustration. If the tolerance stack up on your components results in a race that is slightly loose please use a small strip of shim stock or wax paper to alleviate any movement. A small dab of epoxy can also be used.

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 needed a very small about of white lithium 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, PET 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.

Electrical Enclosure:

- **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.

- **Enable Circuit**

Please note this assembly manual does not show wiring of the enable circuit. The enable circuit will likely not be used by most and is used to disable the motor drivers. The enable circuit disables each of the motor drives when 5vdc is applied to the enable terminals on the driver. Keeping safety in mind; if you have an application where the robot needs to be guarded by a "fence" circuit or safety door you can run +5vdc to all the ENA+ terminals and then -5vdc to safety switch, and then back from the safety switch to each of the ENA- terminals. When the safety switch is made and -5vdc is passed through the switch to the DIN rail enable terminal the circuit will be completed and the drives will be disabled. It is not necessary to use the enable circuit. For simplicity in design and lowest cost I chose to wire the E-Stop button to cut off 24vdc to the drivers. Most inexpensive E-Stop buttons are normally closed but if desired you could alternatively use a normally open E-Stop button or relay wired to the enable circuit rather than disrupting the 24vdc supply to the drivers.

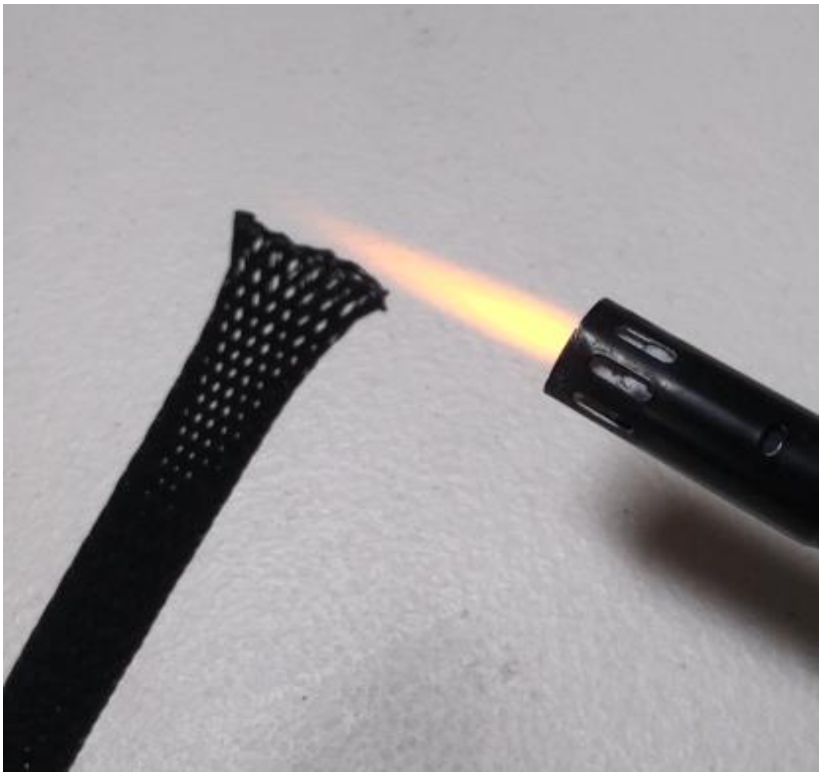
- **Arduino Mega and 8 Channel Relay Board**

Note the Arduino Mega and 8 channel relay board is not necessarily needed for the operation of the robot itself. The Arduino Mega is a good low cost board that can accept 5vdc inputs and outputs. The relay board has been included in the design for general purpose use or to control a pneumatic gripper solenoid (please see chapter on Robot Gripper). The 8 channel relay board can be used to control any higher voltage device or actuator that you may need the robot to control.

- **Arduino / Teensy 3.5 mount**

This manual shows mounting the control boards in a 3D printed raised mount. It also shows soldering female PCB pin headers to the Teensy 3.5. Alternatively you can use the Teensy 3.5 with male pins and a breadboard if desired. I prefer not to use breadboards and would rather take the time to solder the female pins in place, as of this point in time the Teensy 3.5 is not available with female header pins.

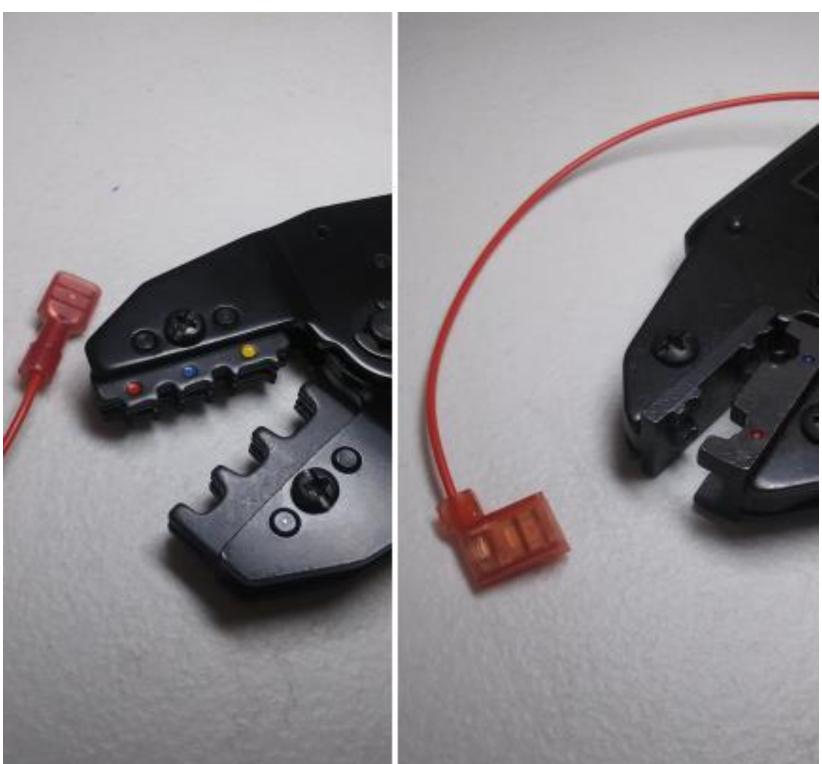
Using Braided Sleeve



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 sleeving 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.

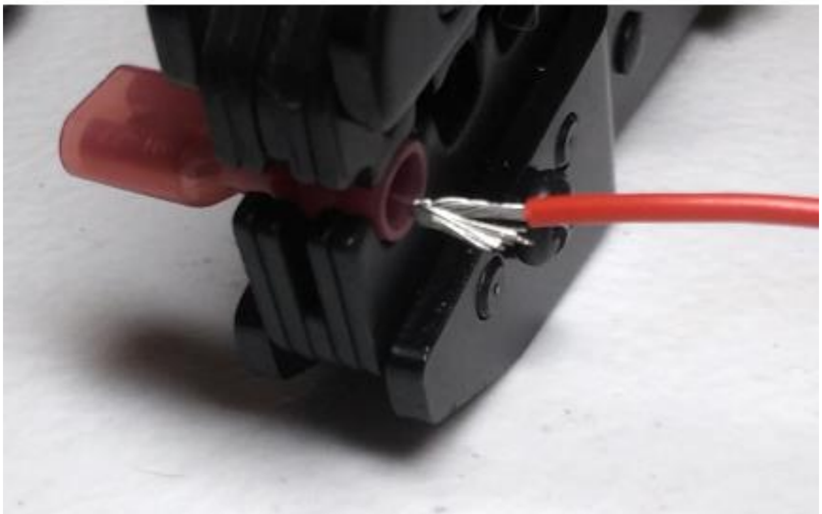
Using Crimp Quick Disconnects



Several steps in this manual will call for crimping both straight and 90° quick disconnects for 22awg wire.

Be sure to use a quality crimper for straight disconnects (shown left)

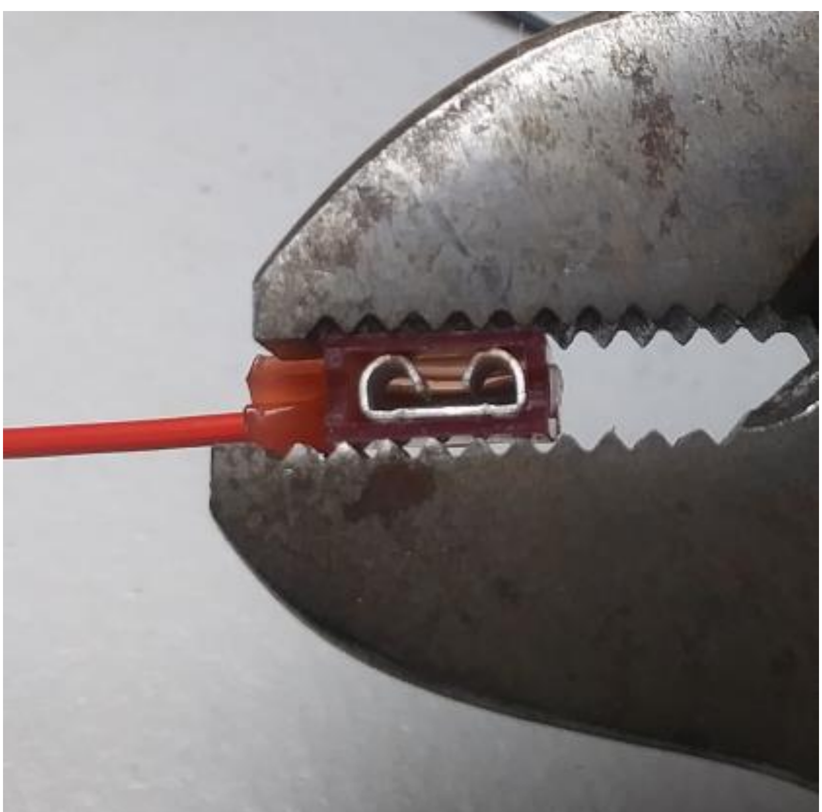
Be sure to use a quality crimper for 90° disconnects (shown right)



Note that I have found it helpful to strip 10mm of insulation off of wire and then fold wire over on itself before inserting into quick disconnect.

This ensures a tight wire fit into terminal.

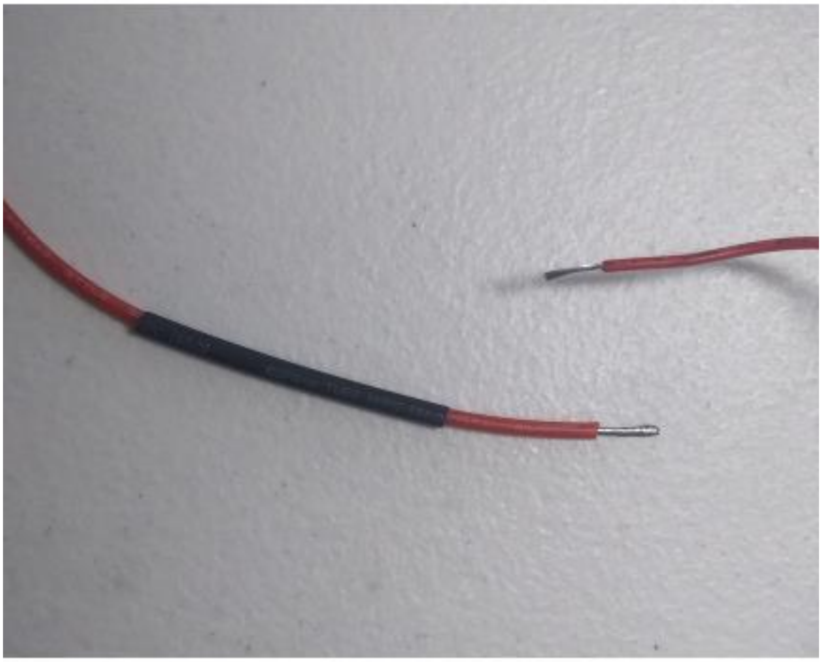
After crimping always pull on wire and make sure you have a good crimp.



Please also note that depending on supplier some quick disconnects do not plug onto limit switch terminals tightly. If you find quick disconnects slip off of terminals too easily you can place disconnect into a pair of pliers as shown and very gently close the disconnect gap slightly.

Be very careful not to compress connector too far – only gently compress if needed.

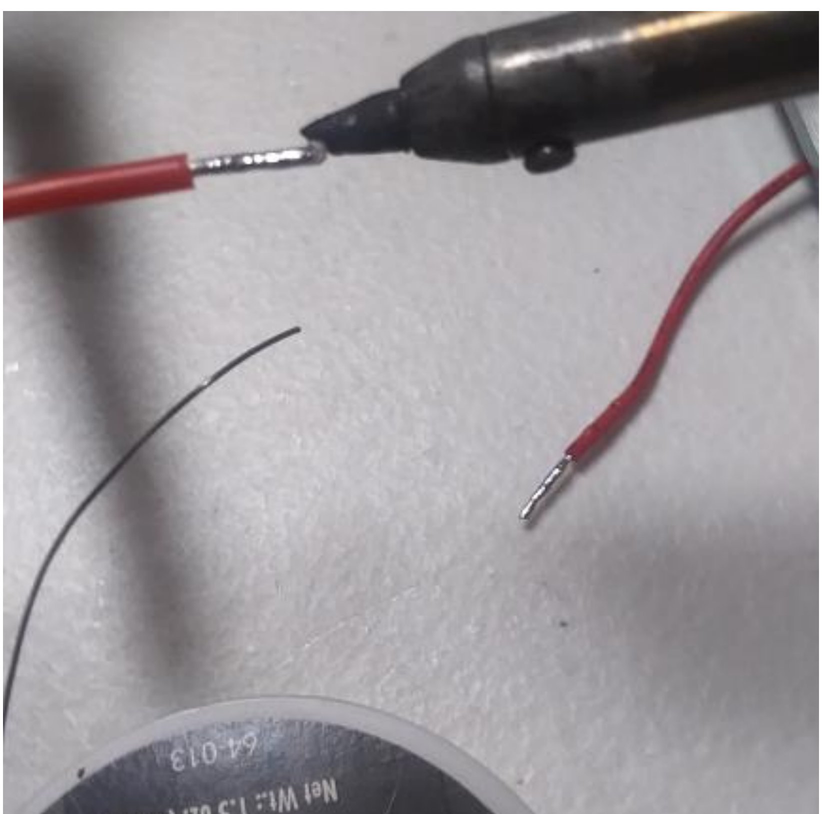
Soldering Wire Connections



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.

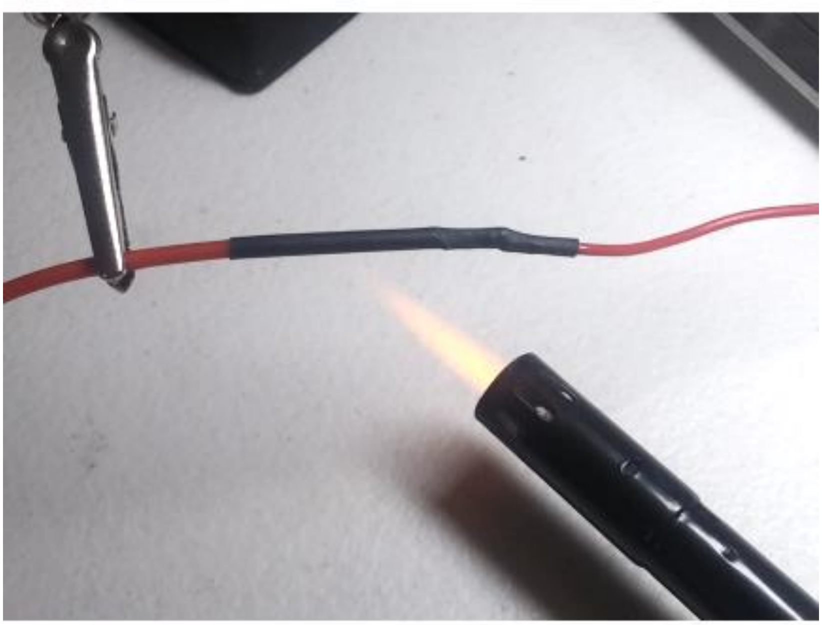
Insert length of heat shrink tube over one of the wire ends.



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.

Robot Rest Position:

Please note that stepper motors when not powered will go limp or drift downward and not always support the robot arm to stay in position when unpowered. When the robot is not powered on it should always be parked in a vertical position with J2 straight up and then J3 straight up – In the vertical position the robot will not go limp or fall over when the motors are not powered. When the robot is powered and the motors are energized there is no issue, the robot will be completely rigid and it wont be an issue to leave the robot in any position you like. During the assembly process you may experience the robot going limp or starting to fall over – this is normal and is not an issue, just try and keep the robot arms vertical or support the arm on an object such as a cardboard box or wood dowel if drift is experienced.

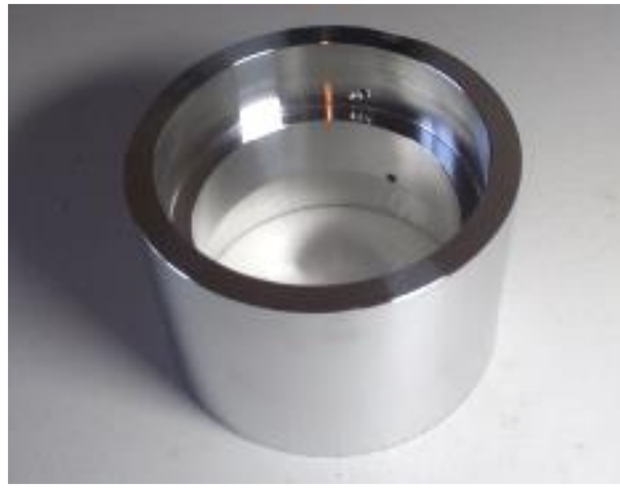
CHAPTER 1

BILL OF MATERIALS

Structural Components

Parts shown are made from aluminum but you can also 3D print the structural components if you are building a fully 3D printed robot. See downloads page **https://www.anninrobotics.com/downloads** for .stl print files. (see note below on J4 main shaft as this part cannot be 3D printed)

J1 BASE PLATE



J1 TURRET HOUSING

J1 SPINDLE

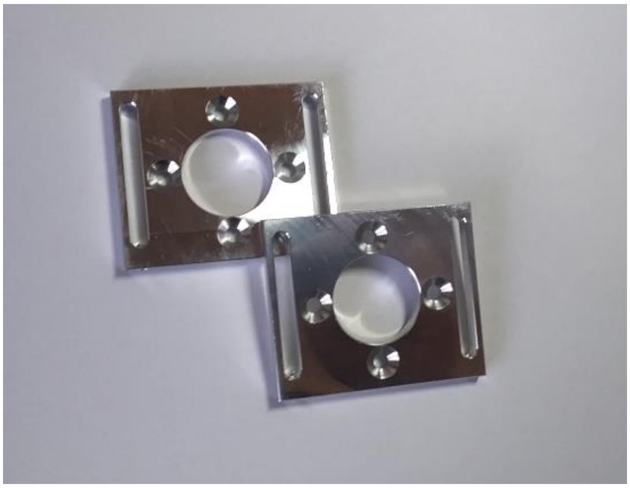
J1 PLATFORM

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 TIMING HUB

J4 MOTOR MOUNT

J5 HOUSING

J5 BELT CARRIER & J5 BELT CARRIER CLAMP

J5 BEARING POST

J5 IDLER TENSION BLOCK

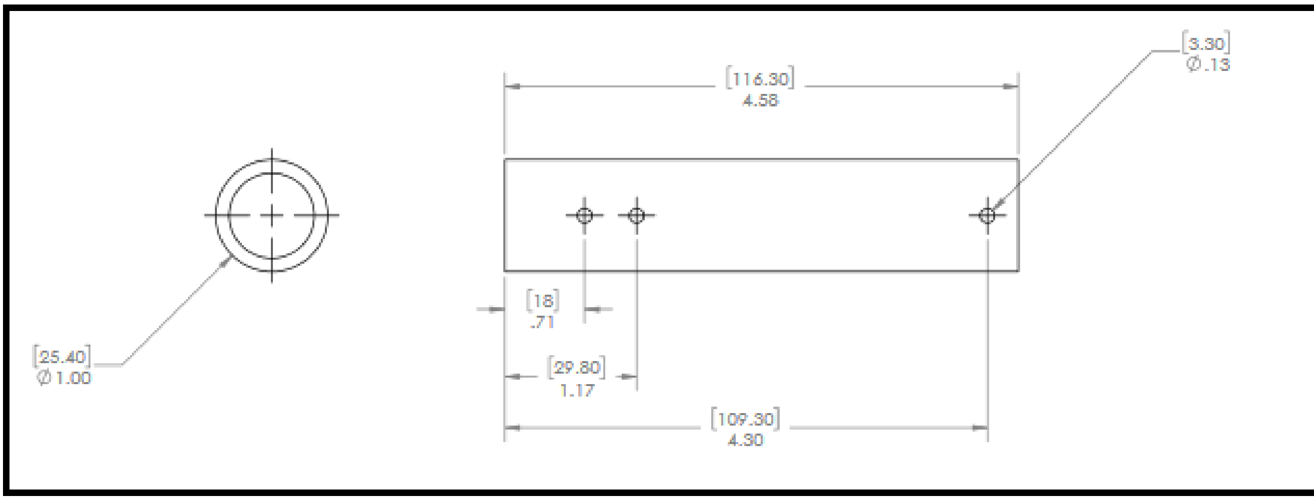
J6 MAIN BEARING ARM

J6 HOUSING SINGLE PIECE

J6 BEARING CAP

J6 GRIPPER MOUNT

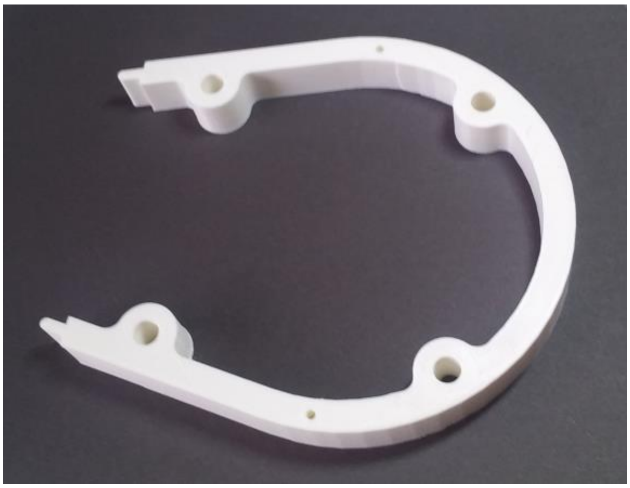
- Note on **J4 Main Shaft**: If you are building a 3D printed robot and do not have aluminum parts you will need to purchase a length of aluminum tubing, cut and drill as shown in this drawing. 1” OD .035” wall thickness tubing is available from McMaster Carr #1968T17 or can be sourced from other online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

Covers and Spacers

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 red logos.

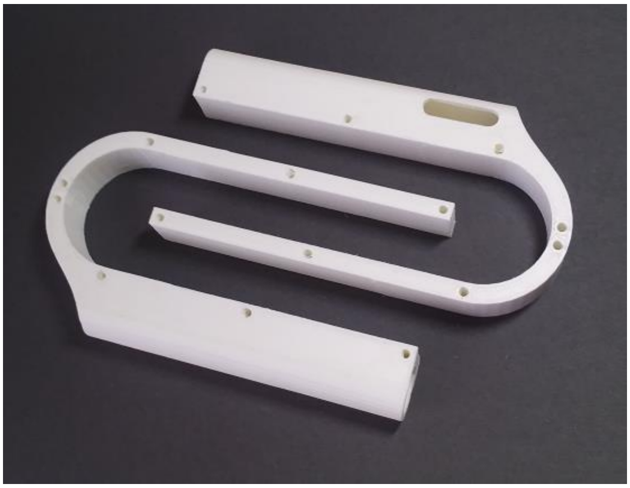


J1 BASE ENCLOSURE PART 1

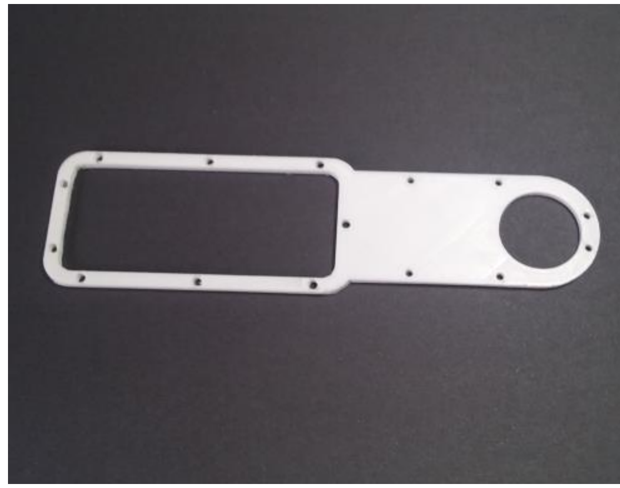
J1 BASE ENCLOSURE PART 2

J1 BASE ENCLOSURE CAP

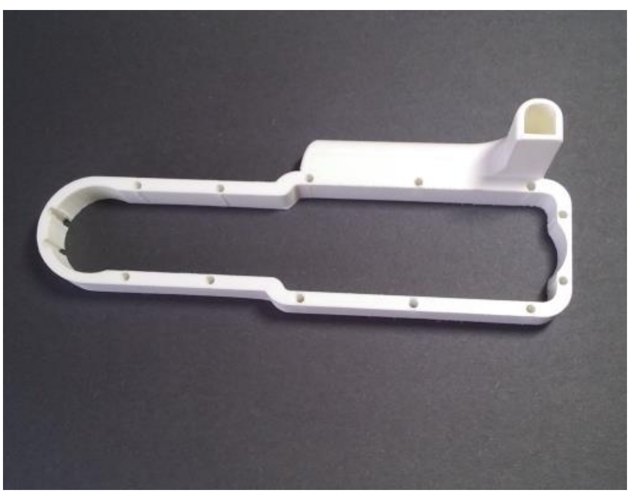
J2 UPPER AND LOWER SIDE COVERS



J2 UPPER AND LOWER ARM COVER SPACERS



J5 SIDE COVER



J5 SIDE COVER SPACER

J5 SIDE COVER CAP

J6 LIMIT SWITCH TIP

J2 & J5 ARM COVER LOGOS

J4 MOTOR SPACER – 4mm

Hardware Components

All Bearings, belts, chains, pulleys, sprockets, keys and screws are available on the robot kits page or can be sourced from various suppliers.

Qty. (2) 32009 (45x75x20mm) taper roller bearing for J1 - *Sourced from Amazon or Ali Express*

Qty. (2) 30206 (30x62x17.25mm) taper roller bearing for J2. - *Sourced from Amazon or Ali Express*

Qty. (1) 30204 (20x47x15.25mm) taper roller bear for J3. - *Sourced from Amazon or Ali Express*

Qty. (1) AXK3552/AS3552 (35x52x4mm) thrust bearing with washers. - *Sourced from Amazon or Ali Express*

Qty.(3) NTA1625 (1.00x1.5625x0.0781 inch) thrust bearing *(2 for J4 and 1 for J6) – Sourced from McMaster Carr*

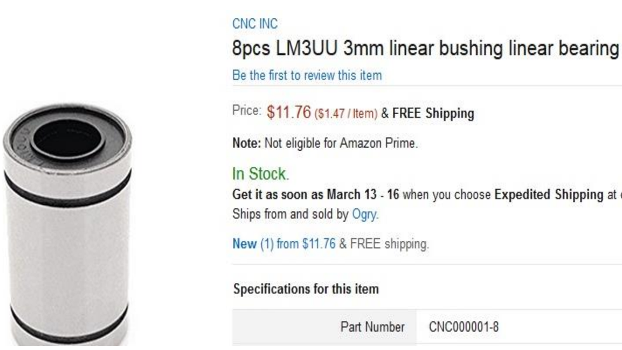
Qty.(4) TRA1625 (1.000x1.5625x0.0312 inch) thrust washer *(3 for J4 and 1 for J6) – Sourced from McMaster Carr*

Qty.(2) TRD1625 (1.000x1.5625x0.125 inch) thrust washer*(1 for J4 and 1 for J6) – Sourced from McMaster Carr*

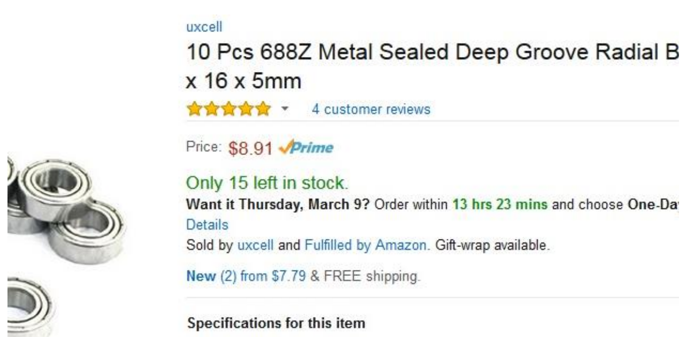
Qty.(2) B1616 (1x1-1/4x1 inch) needle roller bearing for - *Sourced from Amazon or Ali Express*

Qty. (1) HK1612 (16x22x12mm) needle roller bearing for J5 belt idler - *Sourced from Amazon or Ali Express*

Qty.(2) 3mm x 85mm shaft (you only need 2 but they are typically sold in lots of 10 or more and are typically 100mm long) – you will need to cut them down to 85mm long. - *Sourced from Amazon or Ali Express*

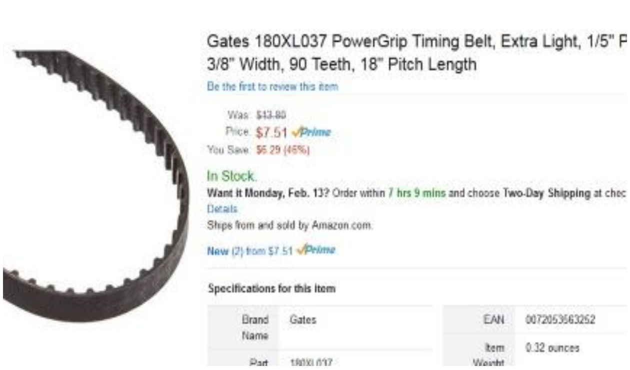


Qty.(4) LM3UU 3mm linear rod bearing (you only need 4 but are typically sold in lots) - *Sourced from Amazon or Ali Express*



Qty.(1) 688Z (8x16x5mm) groove ball bearing bearings (you only need 1 but are typically sold in lots) - *Sourced from Amazon or Ali Express*

Qty.(1) 30203 (17x40x13.25mm) taper roller bearing for J6 - *Sourced from Amazon or Ali Express*



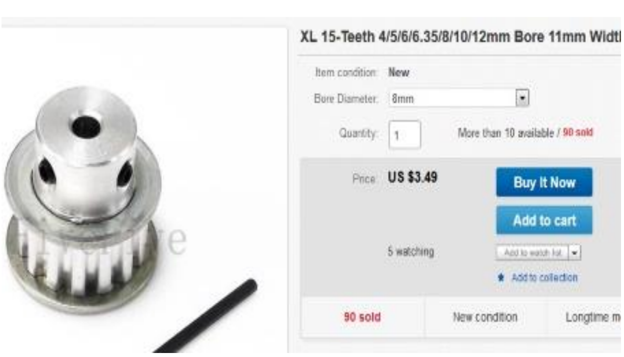
Qty. (1) 180XL037 belt for J1 - *Sourced from Amazon or Ali Express*

Qty.(1) 84XL037 belt for J4 - *Sourced from Amazon or Ali Express*

Qty.(1) J5 belt - *Sourced from Amazon or Ali Express*

Qty.(1) 60T XL pulley for J1 - *Sourced from Amazon or Servo City (there is also a 3D print file for this but I have not tested the 3D printed part in a built robot)*

NOTE: the Annin Robotics hardware kit comes with a machined aluminum version of this pulley.

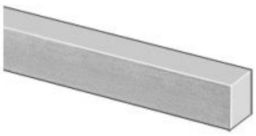


Qty.(2) XL 15 tooth 8mm bore pulley *(1 for J1 and 1 for J6) – Sourced from Ebay*

Qty.(1) XL 10 tooth 6mm bore pulley for J4 *– Sourced from Ebay*

Metric Key Stock

Undersized, Steel, 2mm x 2mm, 12" Length



Each

In stock
$1.87 Each
92288A710

ADD TO ORDER

You ordered 1 each on 01/20/17.

Material	Steel
Size	2 × 2 mm
Length	12"

Qty.(1) – 2mm x 2mm keystock (you need a length 50mm long) – *Sourced from McMaster Carr*

Keyed Rotary Shaft

1045 Carbon Steel, 8 mm Diameter, 300 mm Long

Each

In stock
$20.27 Each
1439K211

ADD TO ORDER

You ordered 1 each on 01/20/17.

Material	1045 Carbon Steel
Diameter	8 mm
Length	300 mm

Qty.(1) 8mm keyed rotary shaft (you will need a length that is 50mm long) – *Sourced from McMaster Carr*

J3 DRIVE OPTIONS:

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.

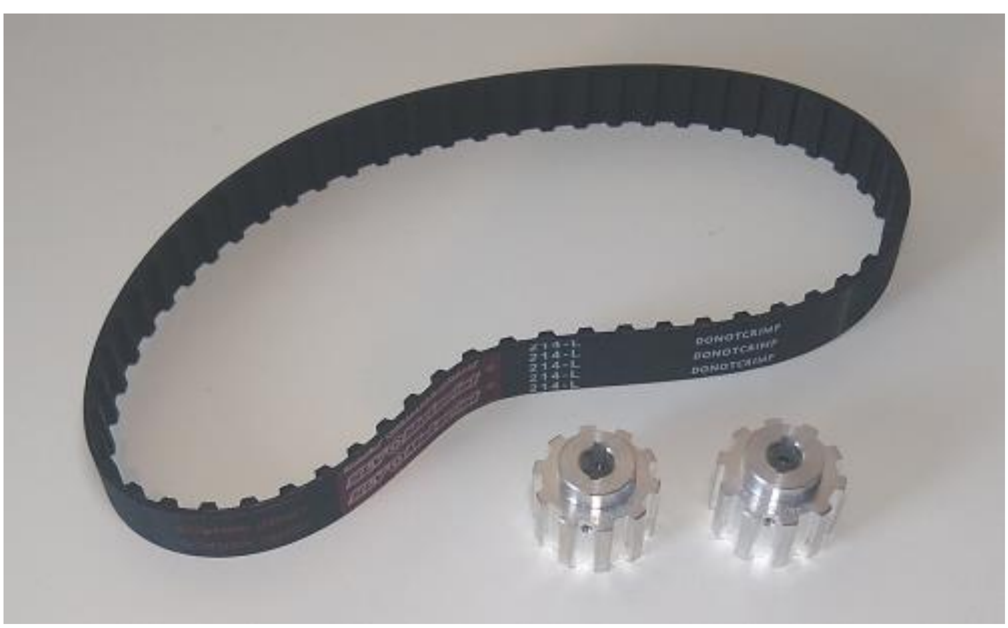
The Annin Robotics hardware kit comes with the newer belt and pulleys but I wanted to leave the chain and sprocket in the manual as an option for those building their own robot and wanting to use off the shelf components without having to purchase a hardware kit.

The following bill of materials 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)



OPTION 2 – CHAIN & SPROCKET

(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*

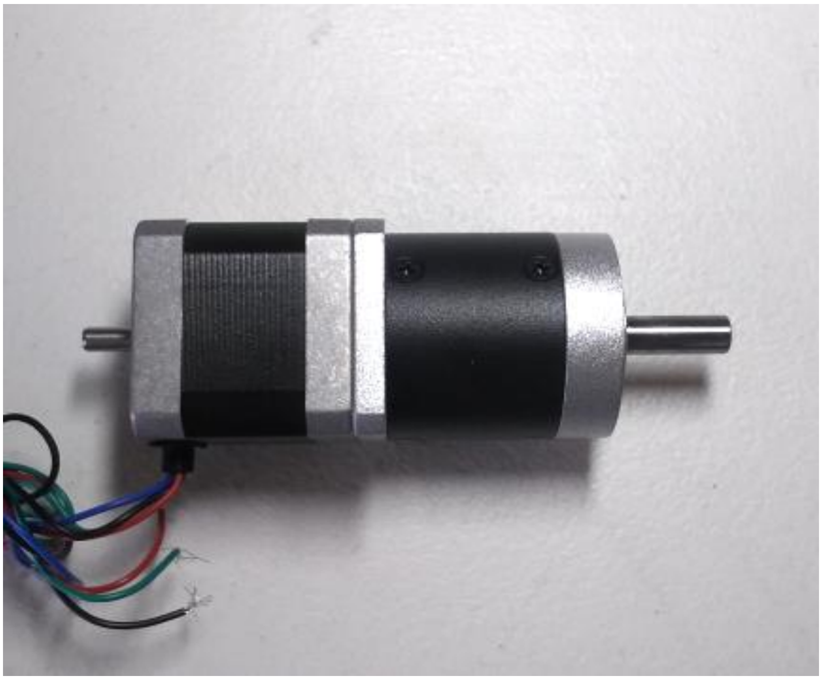
- Qty.(2) 04B 13 tooth 8mm bore 6mm pitch sprocket for J3 chain – *Sourced from McMaster Carr*

Metric screws needed: Quantity:

#4 x .25 Flat Head Screw	6
#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 Flat Head	20
M3x5 Socket Head Screw	1
M3x6 Set Screw	7
M3x8 Socket Head Screw	9
M4 Nuts	4
M4 Washers	36
M4x10 Flat Head Screw	16
M4x10 Set Screw	11
M4x10 Socket Head Screw	16
M4x14 Flat Head Screw	2
M4x14 Socket Head Screw	1
M4x18 Flat Head Screw	6
M4x20 Pan Head Screw	2
M4x20 Socket Head Screw	8
M4x35 Pan Head Screw	4
M4x5 Set Screw	21
M6x14 Socket Head Screw	13
M6x18 Flat Head Screw	9
M6x20 Socket Head Screw	3
M8x10 Socket Head Screw	1

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

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.

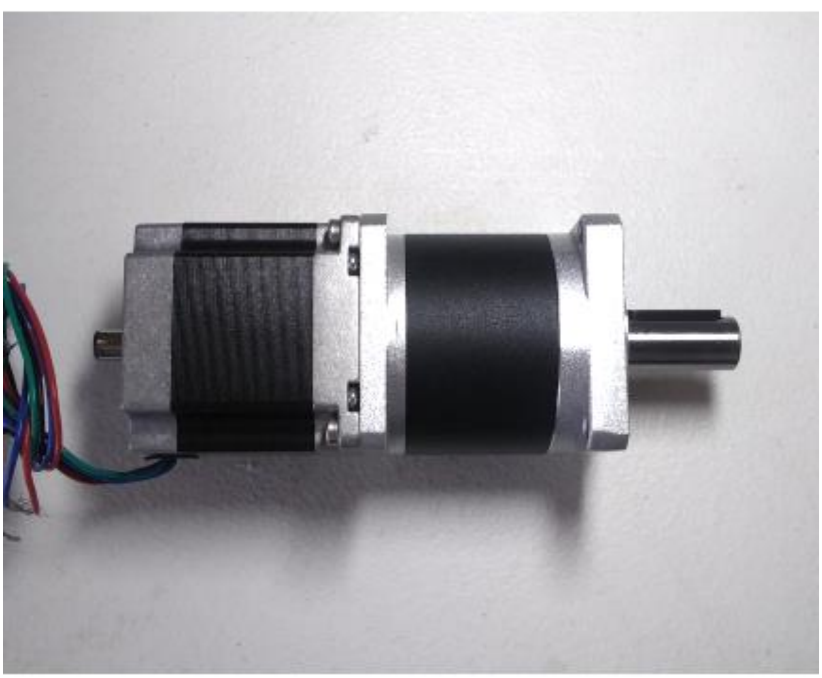


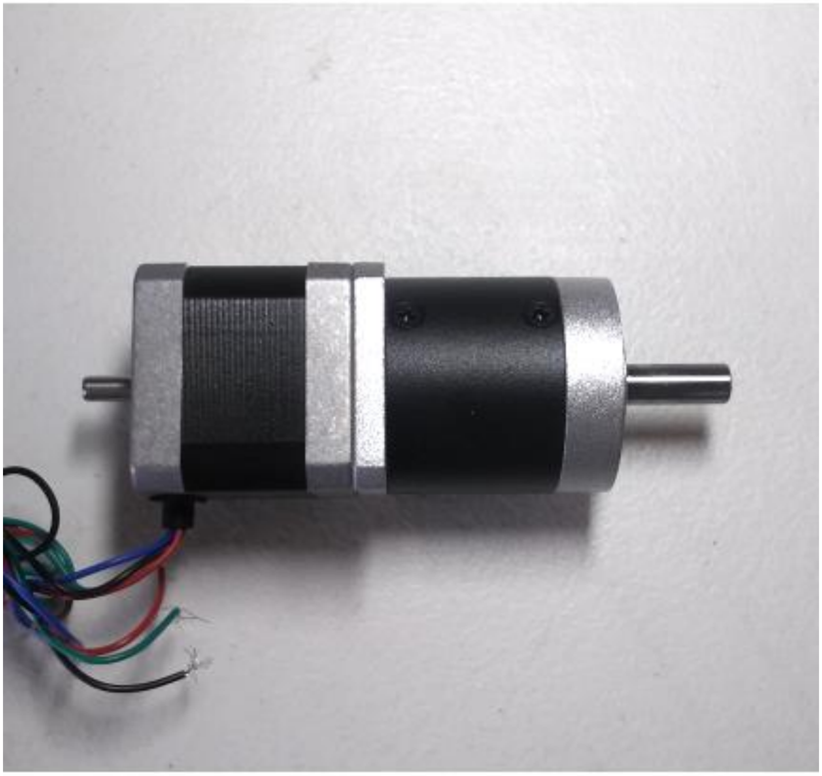
J1 motor

SKU: 17HS15-1684D-HG10-AR3

J2 motor

SKU: 23HS22-2804D-HG50-AR3





J3 motor

SKU: 17HS15-1684D-HG50-AR3

J4 motor

SKU: 11HS20-0674D-PG14-AR3

J5 motor

17LS19-1684E-200G-AR3

J6 motor

SKU: 14HS11-1004D-PG19-AR3

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

Power Supply as well as stepper motors package for the AR3 robot is available from Stepperonline

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 AR3 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.

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

DM320T digital stepper driver.

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

Stepper drivers as well as stepper motors package for the AR3 robot is available from Stepperonline

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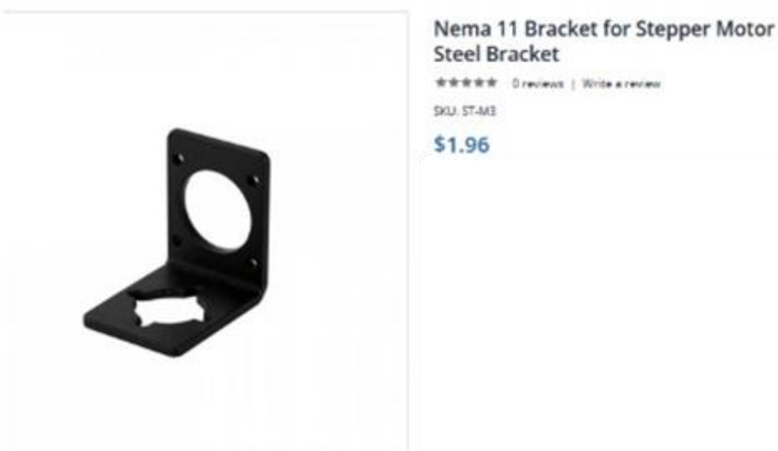


(1) Bracket for the J4 motor

#SKU: ST-M3

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

Electrical & Misc. Components

BUD Industries NBF-32026 Plastic ABS NEMA Economy Box.

Any appropriate enclosure designed to IP66 of IEC 529 and NEMA 1, 2, 4 and 4x specifications can be used or substituted. A larger enclosure would be ideal but I have found the NBF-32026 to be the most cost effective option.

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/

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

by BUD Industries

16 customer reviews

Amazon's Choice for "bud vent"

Price: $6.70 prime

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/

Phillips Rounded Head Thread-Forming Screws

for Plastic, Zinc-Plated Steel, Number 6 Size, 3/8" Long

Packs of 100

ADD TO ORDER

Delivers Wednesday
$7.66 per pack of 100
90380A146

1 pack ordered on March 21
0320CANNIN.

Material	Zinc-Plated Steel
Screw Size	No. 6
Screw Size Decimal Equivalent	0.138"
Length	3/8"
Head	
Diameter	0.27"
Height	0.097"
Drive Size	No. 2
Drive Style	Phillips
Drill Bit Size	No. 1/8"

(1) Box #6 x 3/8 thread forming screws.

Relay Mount:

This component must be printed on your 3D printer using the print file: "8 channel relay mount.STL" which can be found at: https://www.anninrobotics.com/downloads

Under the AR3 print files.

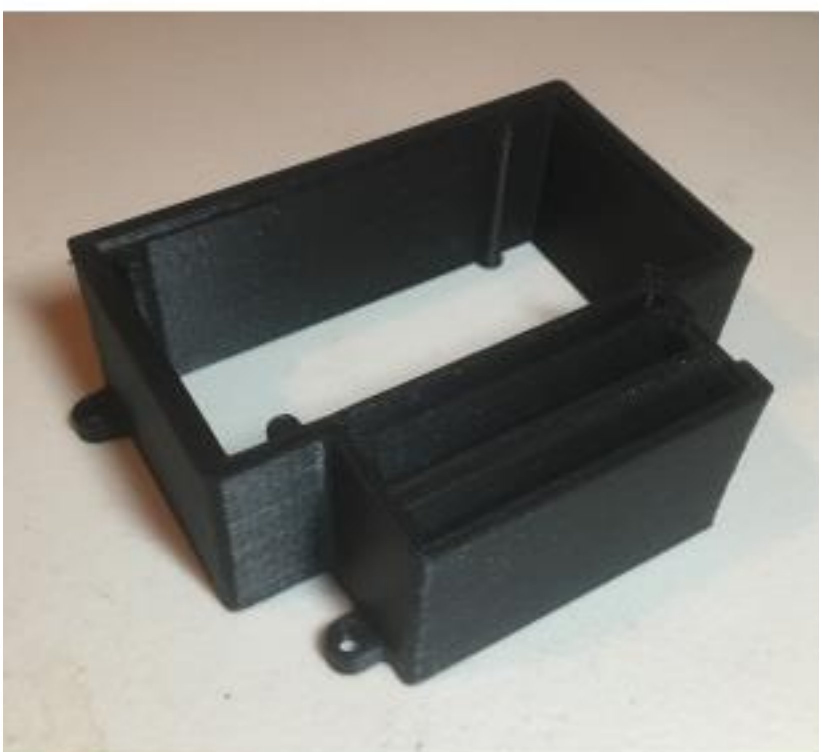
Printer settings used for ABS:

3 layer wall thickness

20% infill

220°C nozzle

(print setting not critical for this part)



Arduino Mount:

This component must be printed on your 3D printer using the print file: "Arduino Mount.STL" which can be found at: https://www.anninrobotics.com/downloads

Under the AR3 print files.

Printer settings used for ABS:

3 layer wall thickness

20% infill

220°C nozzle

(print setting not critical for this part)

Flexible Silicone Wire 18awg Electric Hook Up Wire 300V Cables electronic stranded wire cable electrics DIY BOX-1

by striveday

400 customer reviews | 68 answered questions

Amazon's Choice for "18awg stranded wire"

With Deal: $14.24 prime

5 meters of flexible 18awg silicon hook up wire. You will need 1 box containing at least 4 different colors (blue, black, green & red)

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

---

22 Gauge Silicone Wire Ultra Flexible 20 feet high temp 200 deg C 600V 22 AWG Silicone Wire 60 Strands of Tinned Copper Wire Stranded Wire Model Cable Black and Red Each Color 10 ft

by BNTECHGO

38 customer reviews

Price: $5.48 prime

20ft - 22awg red and black flexible silicone wire.

This item is typically available in 10’ roll so you will need (2) rolls. Available from Amazon or multiple online electrical supply vendors.

22 Gauge Silicone Wire Spool White 50 feet Ultra Flexible High Temp 200 deg C 600V 22 AWG Silicone Rubber Wire 60 Strands of Tinned Copper Wire Stranded Wire for Model Battery Low Impedance

by BNTECHGO

2 customer reviews

Price: $11.98 prime & FREE Returns

20ft - 22awg white flexible silicone wire.

This item is typically available in 50’ roll so you will have some extra.

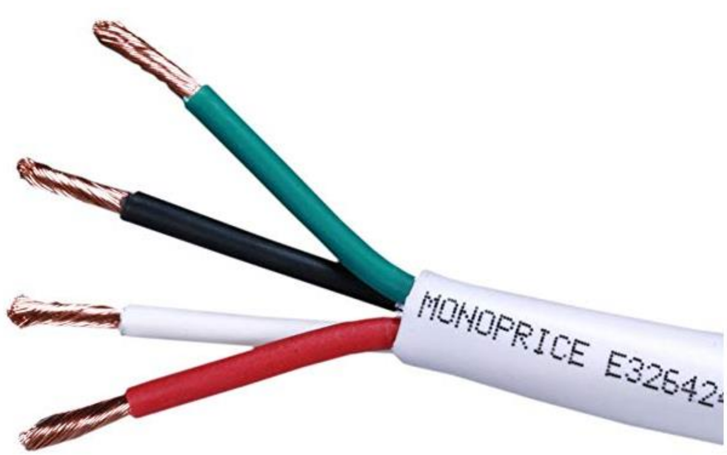
Monoprice Access Series 18 Gauge AWG CL2 Rated 4 Conductor Speaker Wire/Cable - 100ft Fire Safety in Wall Rated, Jacketed in White PVC Material 99.9% Oxygen-Free Pure Bare Copper

by Monoprice

690 customer reviews | 97 answered questions

Amazon's Choice for "18 awg 4 strand wire"

Price: $28.61 prime



18awg 4 conductor cable.

This item is typically available in 100’ roll from Amazon or multiple online electrical supply vendors.

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

(1) Roll 26awg twisted pair wire 5 meters long.

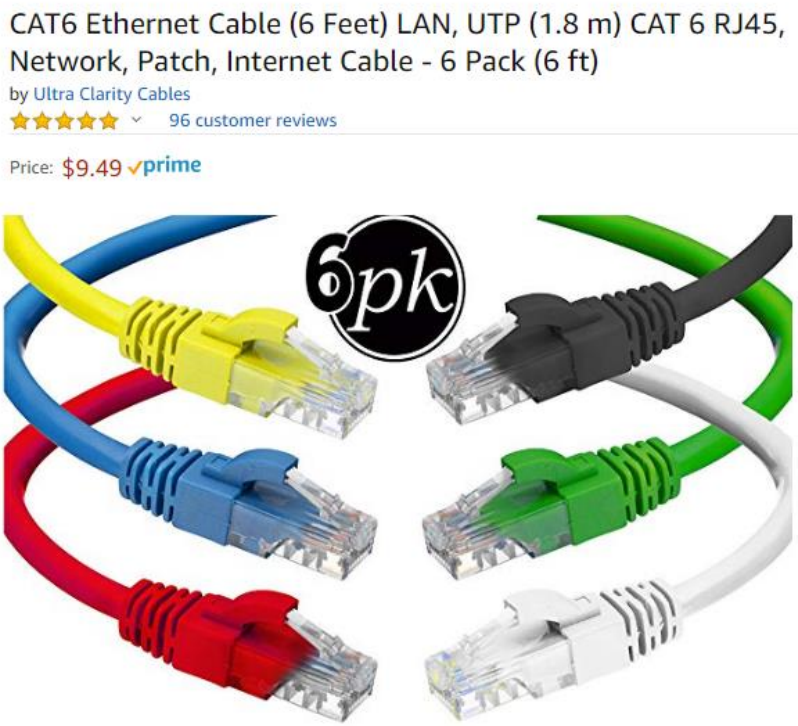
This item is available from Amazon or multiple online electrical supply vendors.

18awg primary electrical wire.

The colors used in this manual are white, black, green, brown and blue.

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

(6) 6’ long Ethernet cables.



For the robot assembly we will use a yellow, blue and red Ethernet cable. These cables will be cut where part of each cable is used inside the electrical enclosure and the other part is used for the robot.

The black, green and white Ethernet cables will not be cut and will be used between the control enclosure and the robot

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Set of breadboard jumper wires.

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

Ginsco 580 pcs 2:1 Heat Shrink Tube 6 Colors 11 Sizes Cable Wire Kit for DIY

622 customer reviews | 24 answered questions

Amazon's Choice for "heat shrink tube"

Price: $6.99 ✓prime

Heat Shrink tube kit.

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

Besteek 50ft - 1/2 Inch & 1/4 Inch Nylon Expandable Braided Cable Sleeving, Braided Wire Sleeve, Cable Sheath Mesh Wire Loom

by Besteek

61 customer reviews | 4 answered questions

Amazon's Choice for "automotive wire loom"

Price: $9.99 ✓prime & FREE Returns

Qty. (1) Roll of ½” braided sleeve.

Qty. (1) Roll of ¼” braided sleeve.

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

Qty. (2) PG-21 gland nuts.

Gland nuts are commonly available in the color black but I have chosen white for this robot build.

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

DIN rail and terminal blocks.

Color coded kit as the one shown is convenient but not necessary. Terminals can be any color and you can source components individually.

You will need:

DIN rail 5” (127mm) long

(16) Terminals

(8) jumpers

Qty.(1) straight lever XV-152-1C25 limit switch – *Sourced from Amazon or Ali Express*

Qty.(5) roller tip SV-166-1C25 limit switches – *Sourced from Amazon or Ali Express*

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

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

Emergency Stop Switch Push Button Switch

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

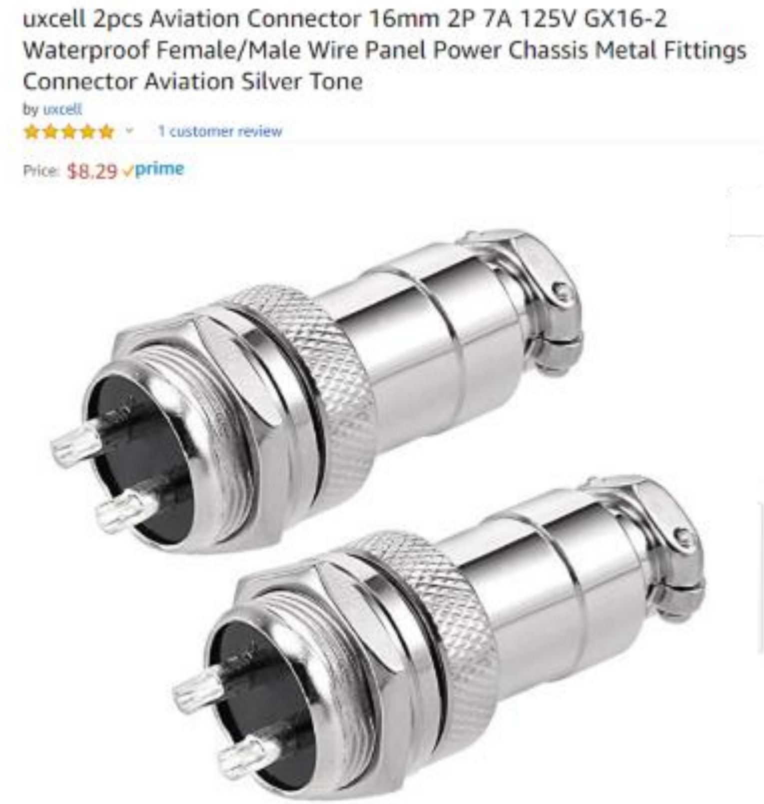
Qty (3) RJ45 CAT5e Feedthru Panel Mount Jack

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

Note: you will also need 3 of these in the robot base (see chapter 1) so there is a total of 6 needed.

Qty. (2) USB-B to USB-A Feedthru Panel Mount Jack

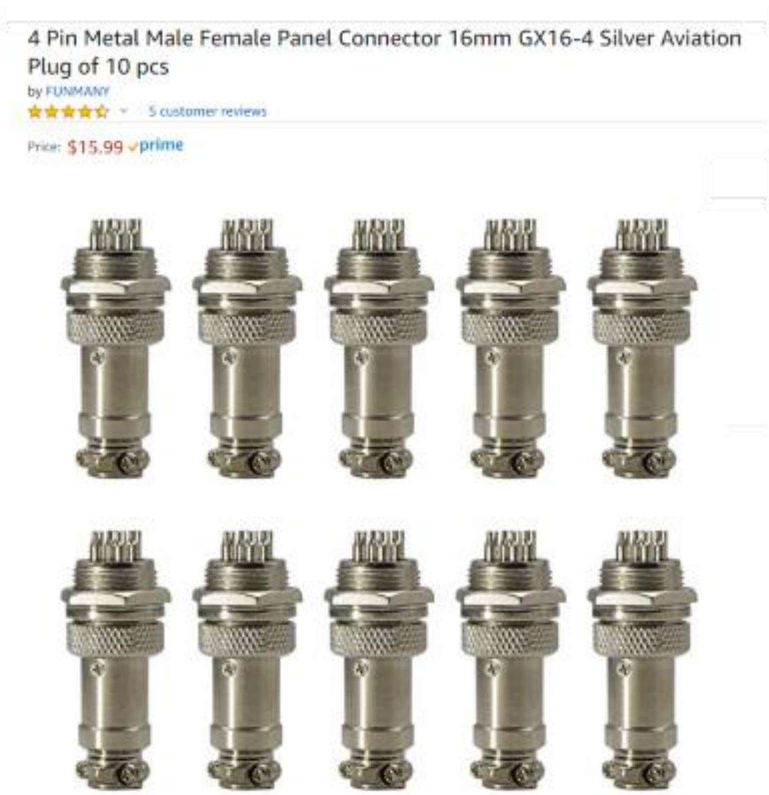
This item is available from Amazon or multiple online electrical supply vendors.



(2) GX16-2 aviation plugs.

You will need a total of (2) plugs, (1) cable will be made, (1) socket will be installed in this enclosure and (1) socket will be installed on the robot.

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



(14) GX16-4 aviation plugs.

You will need a total of 14 plugs, (7) cables will be made, (7) sockets will be installed in this enclosure and (7) sockets will be installed on the robot.

These plugs are typically sold in sets of 10, you may choose to buy 2 sets and have a few extra.

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

(12) 22 awg quick disconnect terminals.

(6) 22awg 90° quick disconnect terminals.

This item is available from suppliers such as Amazon, Ali Express or any hardware store.

You will need (5) 16awg wire ferrules and (20) 22awg ferrules. The ferrule kit shown is a good option if you do not already have a ferrule crimping tool.

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

Manufacturer	CUI Inc.
Manufacturer Part Number	AMT102-V

Price Break	Unit Price	Extended Price
1	23.63000	$23.63

Qty. (6) AMT102-V encoder.

This encoder is available from Amazon as well as multiple online electrical suppliers such as Digi-Key, Mouser and Arrow.

Phidgets

HighSpeed Encoder Cable 50cm ID: 3019_0 $5.00

Connector used is a Molex 50-57-9405.

Qty. (3) 3019_0 (50cm high speed encoder cable). This cable will be cut in half yielding (6) encoder pigtails.

The 3019_0 cable uses a Molex 50-57-9405 connector for the AMT102-V encoder.

This cable is available from Amazon, Phidgets or various other online retailers.

https://www.phidgets.com/?tier=3&catid=30&pcid=26&prodid=169

8 channel 5vdc relay module.

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

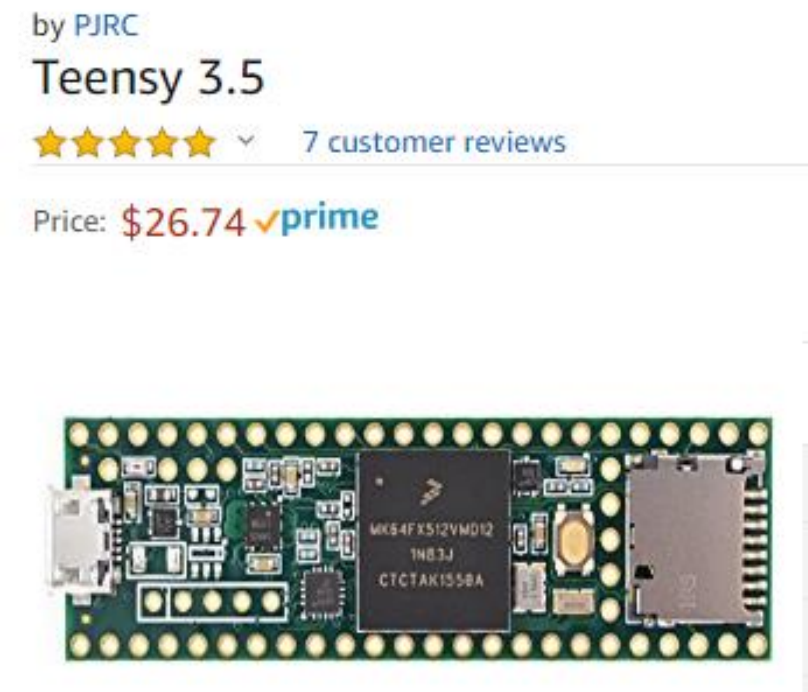
Note: Relay module is included in this project for general purpose needs. This relay module can be used to control your gripper or any other number of actuators or solenoids that you require the robot to control from the program console.

2.54mm female header pins.

You will need (2) header pin strips that have 24 pins each.

This item is typically available in 40 pin rows in sets of 10 as shown – in the instructions to follow we will cut these down to 24 pins long.

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



Teensy 3.5 controller without pins.

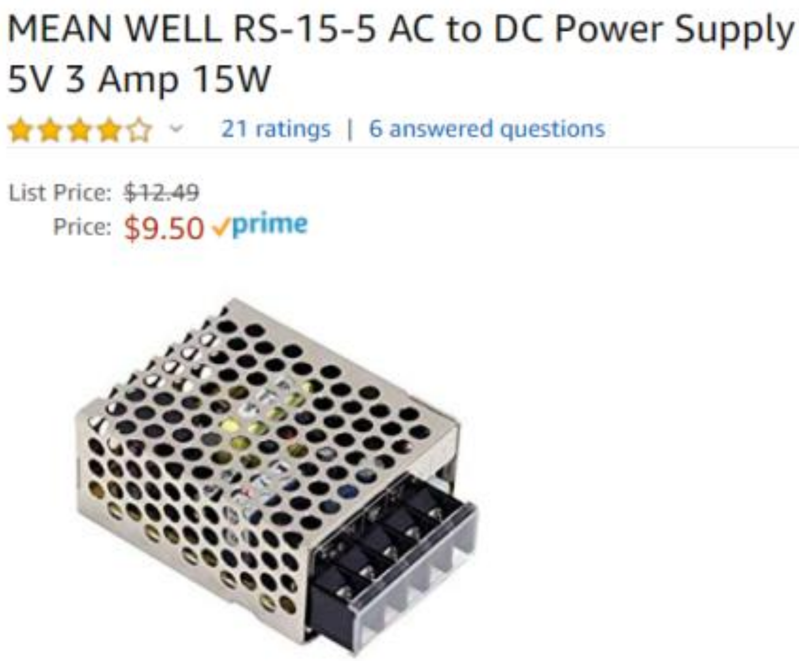
This item is available from Amazon, multiple online suppliers or https://www.pjrc.com/store/teensy35.html

Arduino Mega 2560 controller.

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

5vdc power supply

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



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

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

Price: $8.89 prime

3mm OD flexible tubing

You will need 3mm pneumatic tubing if using a pneumatic gripper for your robot.

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**

(2) M3 thread x 3mm tube fitting.

You will need 2 of these if using the SMC

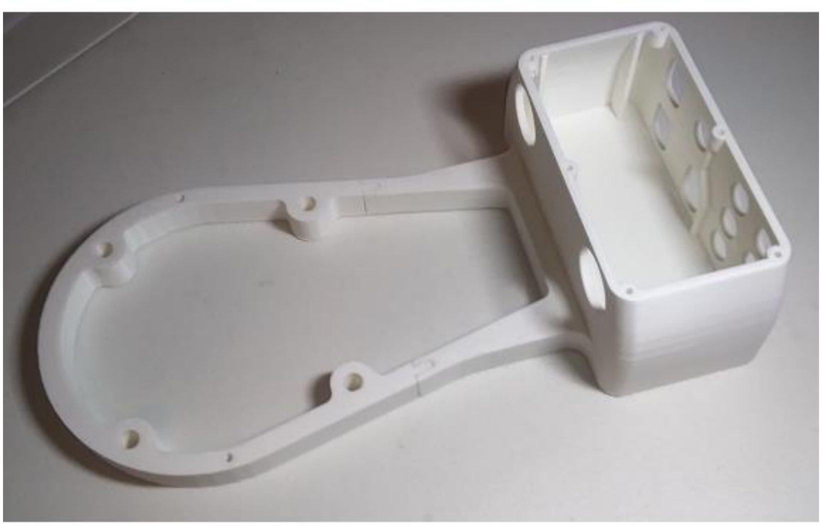
This item is available from Amazon or multiple online electrical supply vendors.

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

CHAPTER 2

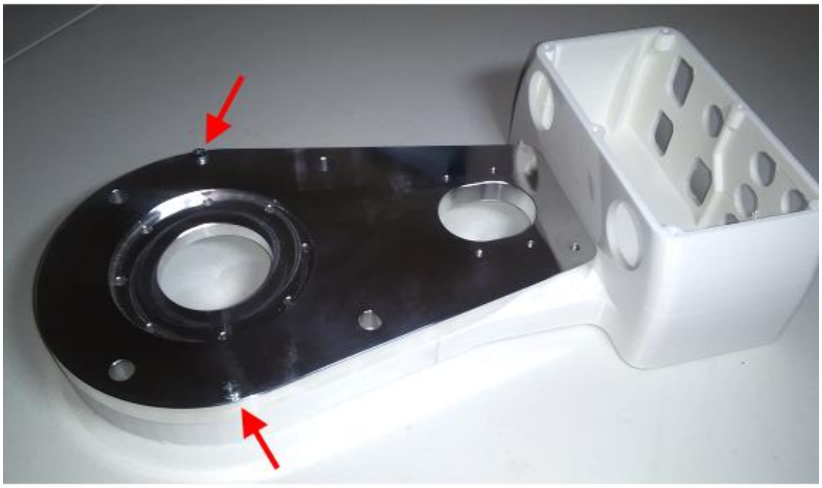
ROBOT ASSEMBLY INSTRUCTIONS

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



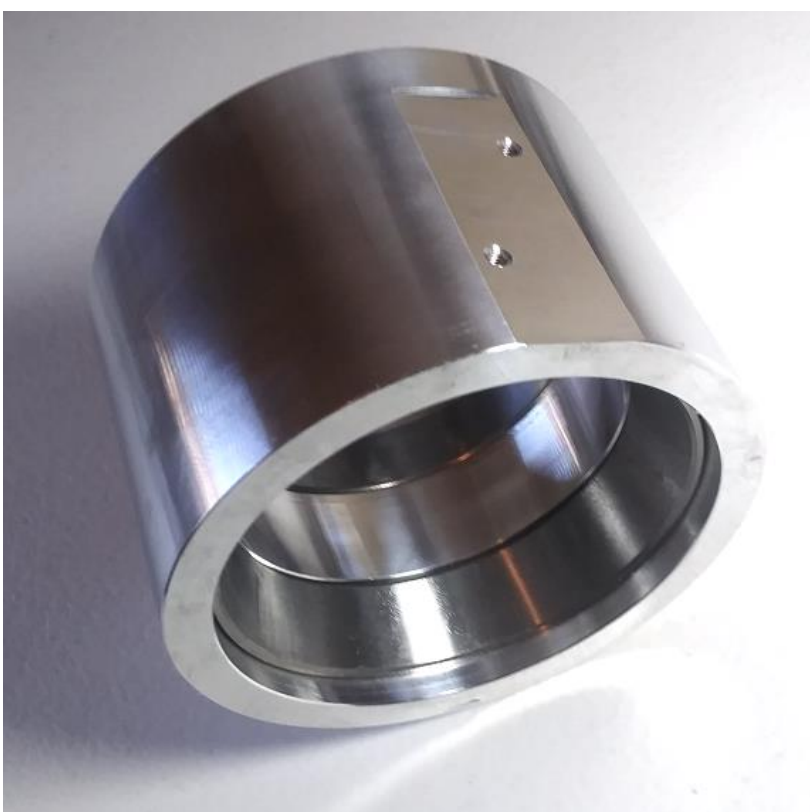
Epoxy J1 enclosure part 1 and part 2 together as shown.

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.

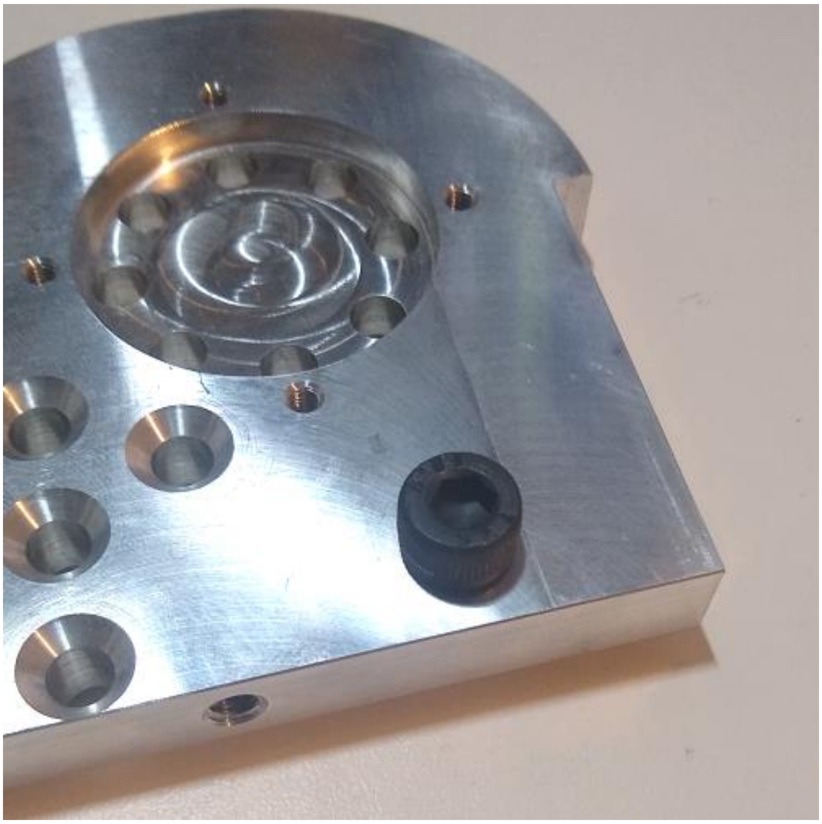


Press (x2) #32009 bearing races into the J1 turret housing. If you do not have access to a press place turret housing in oven @ 350° and bearing races in freezer for 60 minutes, quickly remove housing from oven – the cold races will drop into the expanded housing. (you will need to do this for both races one at a time)

(See notes on bearing fit in overview section)

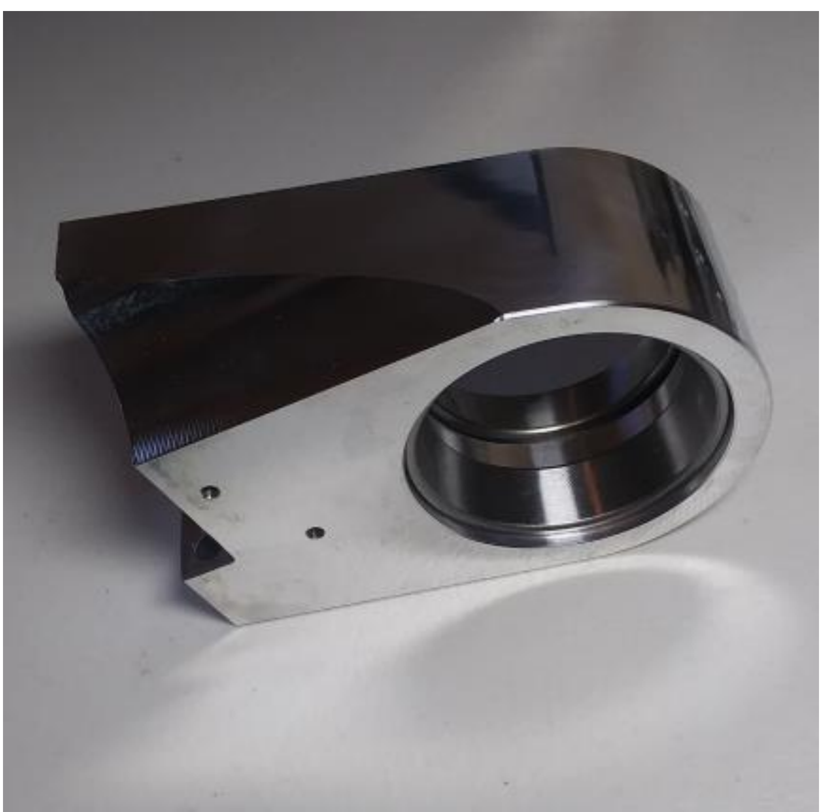
Install #32009 bearing on J1 spindle as shown.

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. Be very carefull. If you do not have access to a press place turret housing in oven @ 350° and bearing races in freezer for 60 minutes, quickly remove housing from oven – the cold races will drop into the expanded housing. (you will need to do this for both races one at a time)

(See notes on bearing fit in overview section)

Secure J2 turret housing to J1 platform using (6) M6x18 flat head screws.

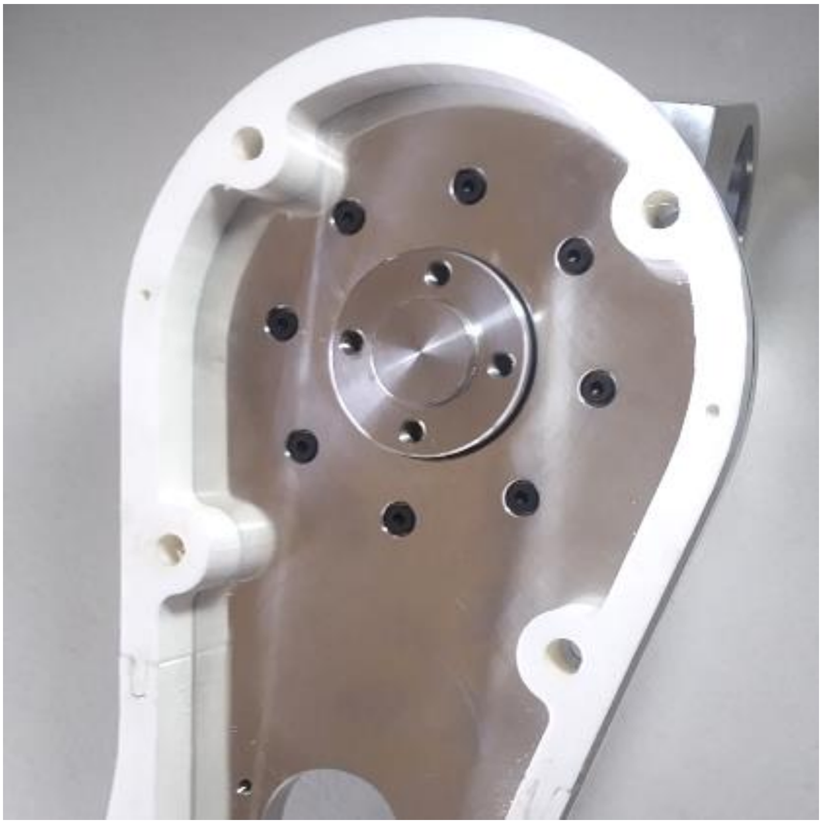
Install (2) M6 x 20 socket head screws in front of J2 turret housing going into the J1 platform.

Install platform assembly onto J1 spindle assembly and secure with (8) M6 X 14 socket head cap screws.

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

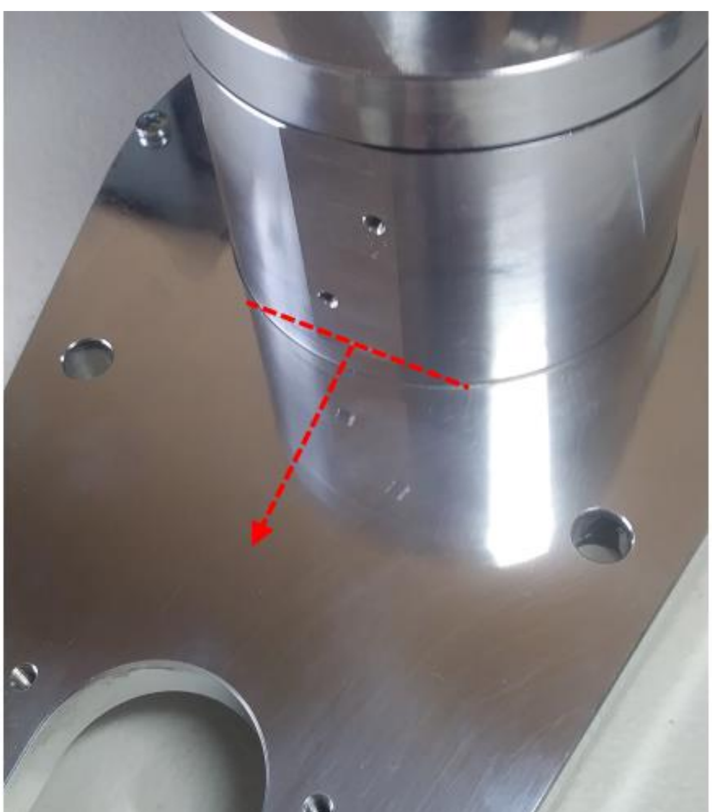
These place tension on the upper bearing.

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

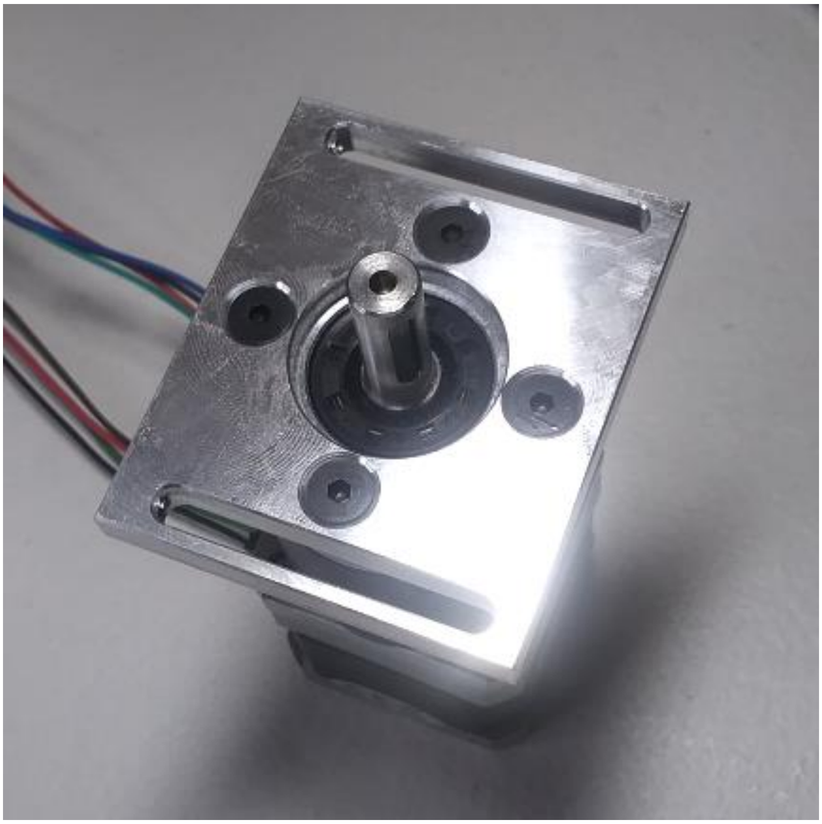


Secure J1 turret assembly to J1 base from the bottom using (8) M4x10 socket head cap screws.

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.

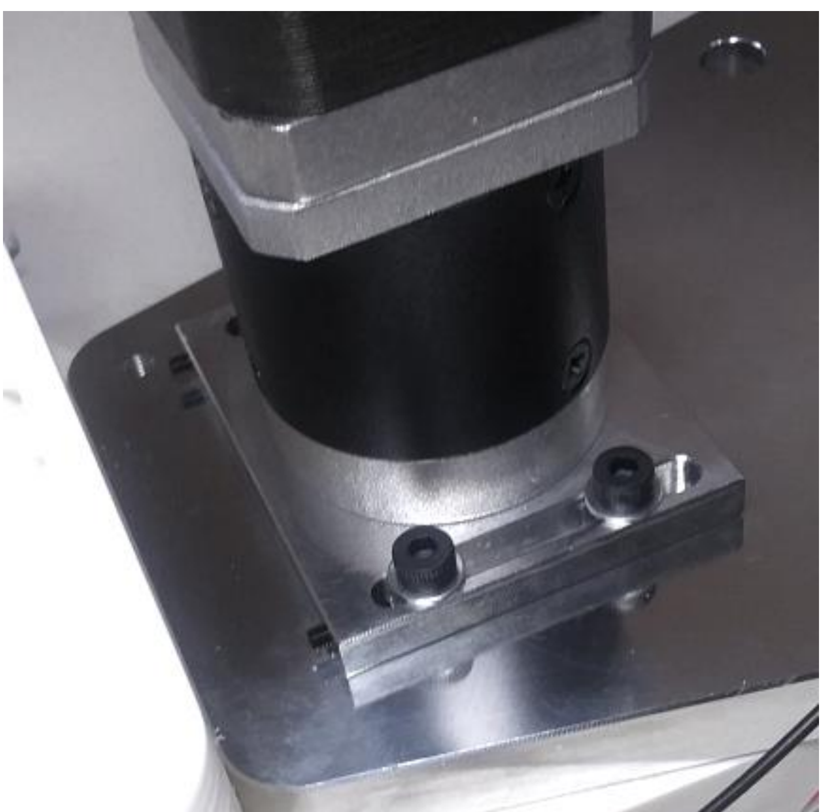


Install J1 motor mount to J1 motor using (4) M4x10 flat head screws.

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

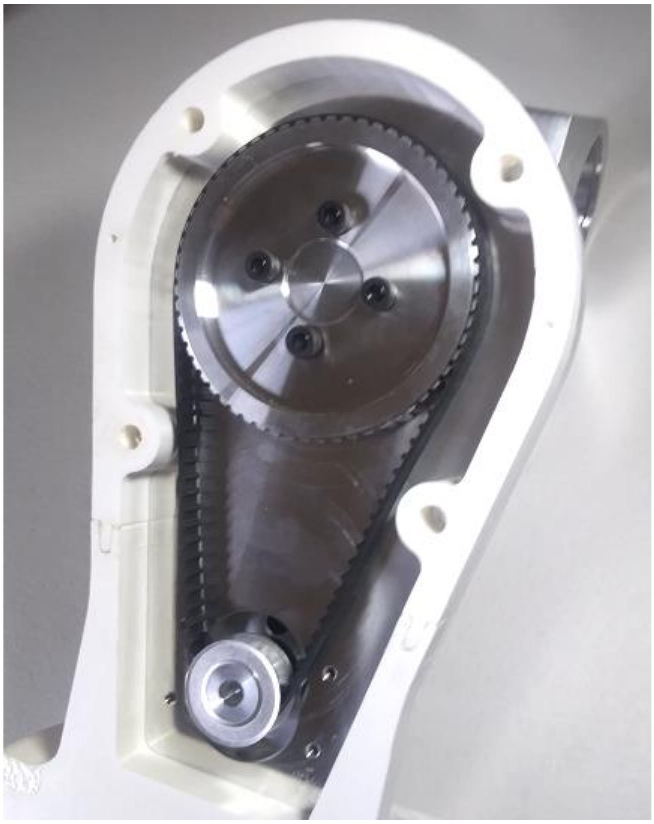
Install (2) M3x10 set screws in rear of motor mount slots.



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 the green (.197”) AMT-102 encoder sleeve on to the J1 motor as shown.

Please review the assembly instructions provided with the AMT-102 encoder.

Use (4) M3x5 flat head screws to mount the ENC-AMT102 base to the top of the J1 motor as shown.

Set dip switch settings on AMT-102 encoder as follows:

Switch 1 = Off

Switch 2 = Off

Switch 3 = Off

Switch 4 = **On**

This sets the encoder to a resolution of 512 steps per revolution or 1024 PR for both channels.

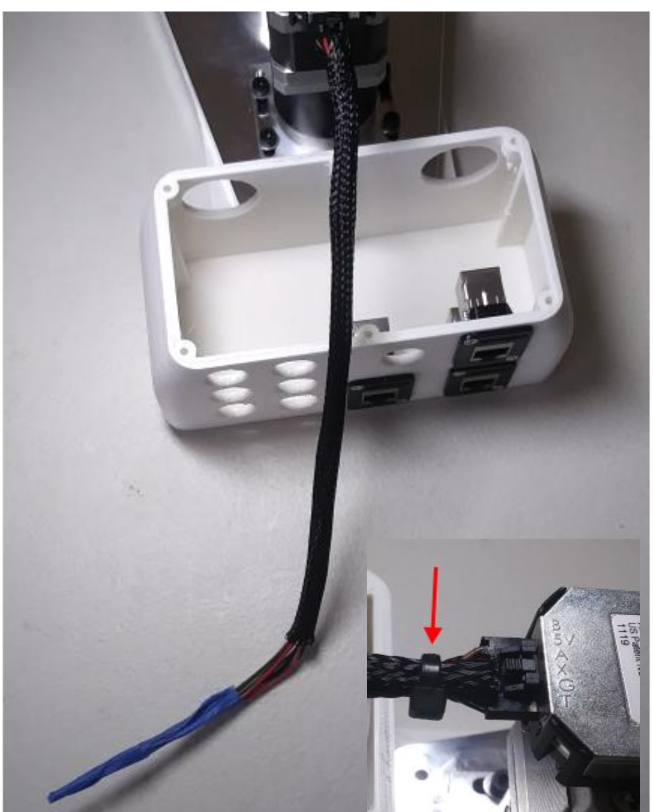
Install AMT-102 encoder on to J1 motor as shown.

Encoder will snap into the plastic base.

Cut (3) high speed encoder cables in half yielding a total of (6) encoder plug wire ends.

One of them will be used for the J1 motor in the following step – the other 5 will be used throughout this manual on the other 5 motors.

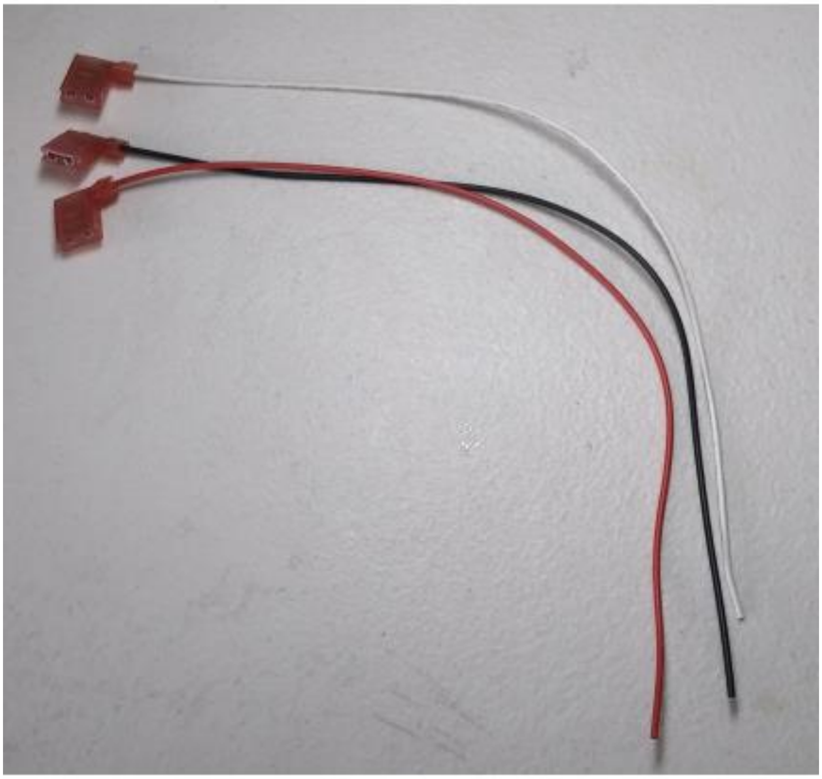
Install encoder wire end into J1 encoder as shown.



Cut length of ¼" braided sleeve to a length of 23cm (9") long then route J1 motor and encoder wires through the sleeve.

Attach small cable tie as shown near plug end.

Leave J1 wire loom off to the side for now, later in this manual, after connecting J2 & J3 wires, we will return to J1 wires and pull them into the enclosure and solder them to their connections.



Cut lengths of red, black and white 22awg wire to lengths of 26cm (10”) long.

Crimp 90° quick disconnect to the end of each wire.

Install wires with quick disconnects onto SV-166-1C25 roller tip limit switch and then install limit switch onto J1 turret housing as shown.

Use (2) M3x14 socket head or Philips pan head screws to secure switch to housing.

Be sure to connect wires as follows:

- Black to NC2 terminal
- Red to NO3 terminal
- White to COM1 terminal

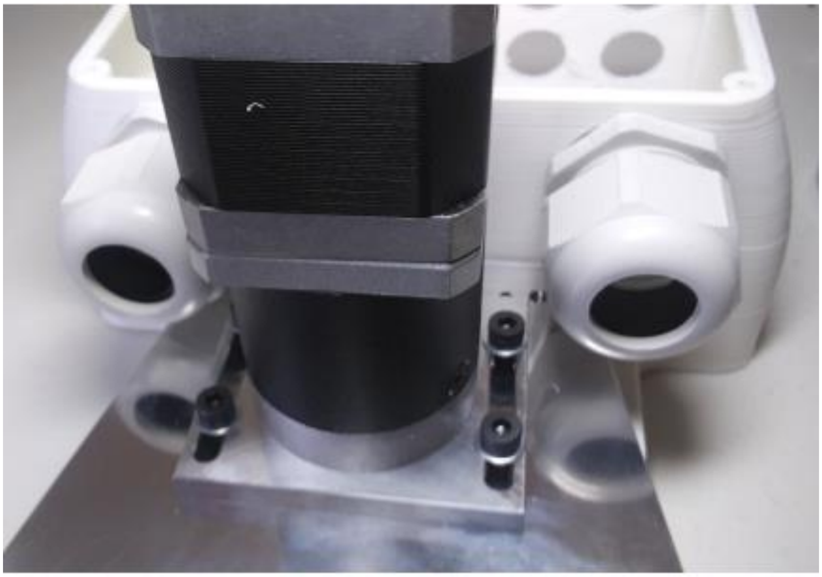
NOTE: Red and Black connectors need to be slightly bent to either side to create clearance for switch to be mounted.

Cut length of ¼” braided sleeve to length of 19cm (9.5”) long and then install over J1 limit switch wires as shown.

Install small cable tie around sleeve at switch end as shown.

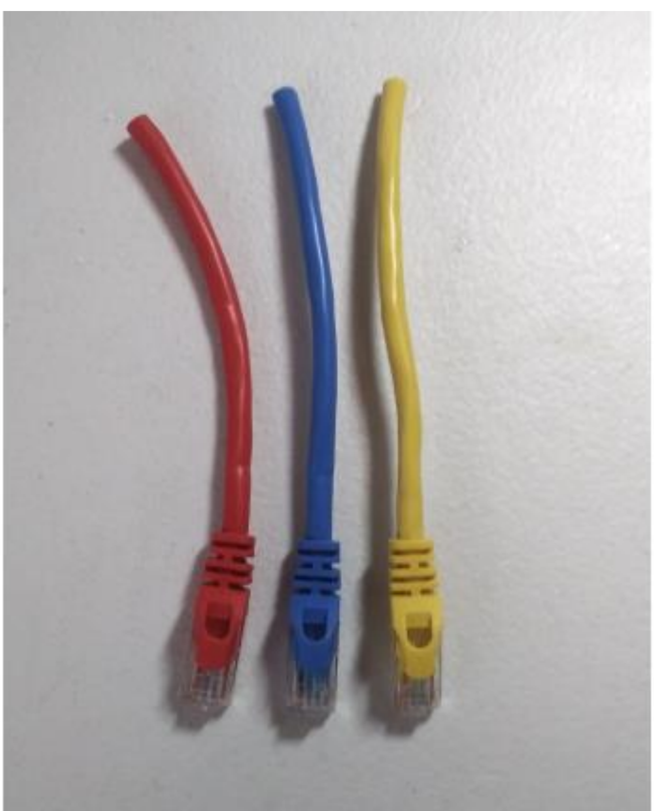
Leave J1 limit switch wire loom off to the side for now, later in this manual, after connecting J2 & J3 wires, we will return to J1 wires and pull them into the enclosure and solder them to their connections.

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



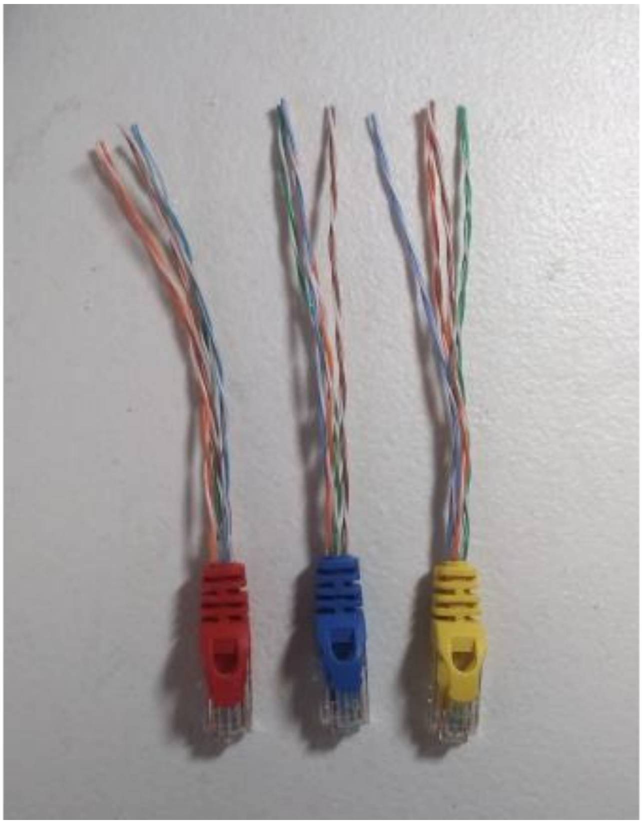
Clear all (6) RJ45 mounting holes using a #41 (2.4mm) drill.

Install (3) RJ45 panel mount jacks as shown and secure with (6) #4 flat head screws.



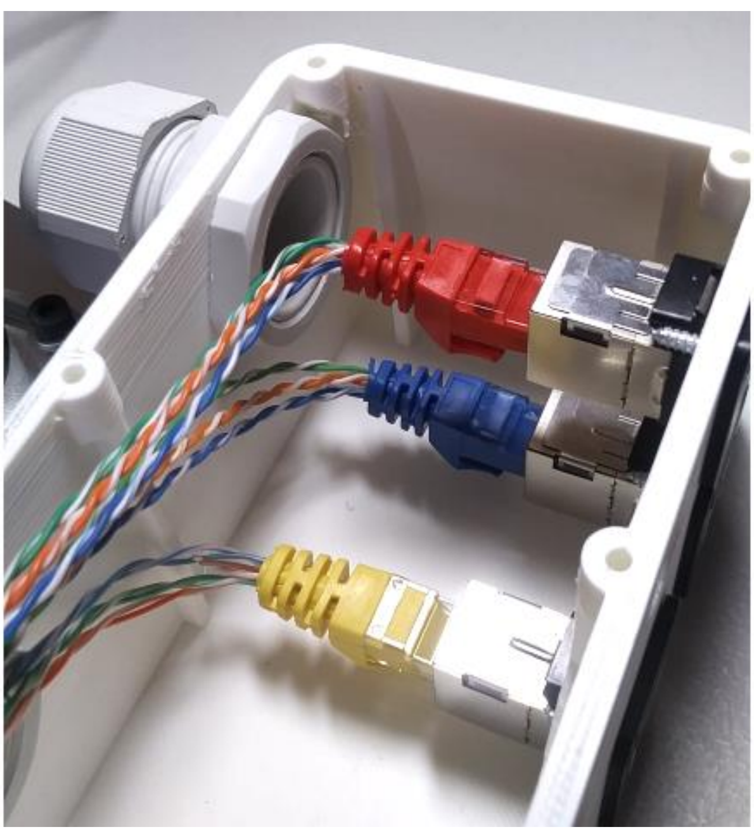
Cut yellow, blue and red Ethernet cables to overall length of 15cm (6”)

Note: save remaining end of yellow, blue and red Ethernet cables for use in assembly of the electrical enclosure.

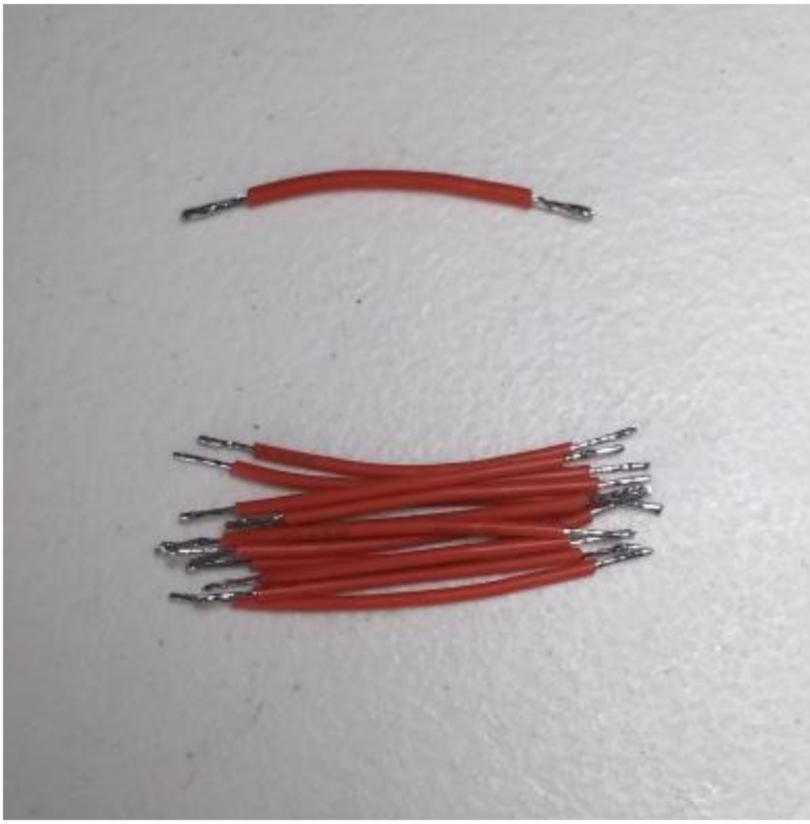


Use a razor blade to carefully score sheathing at end of connector and then gently remove all sheathing.

NOTE: be extremely careful when scoring the sheathing that you don't cut through and damage the wires.



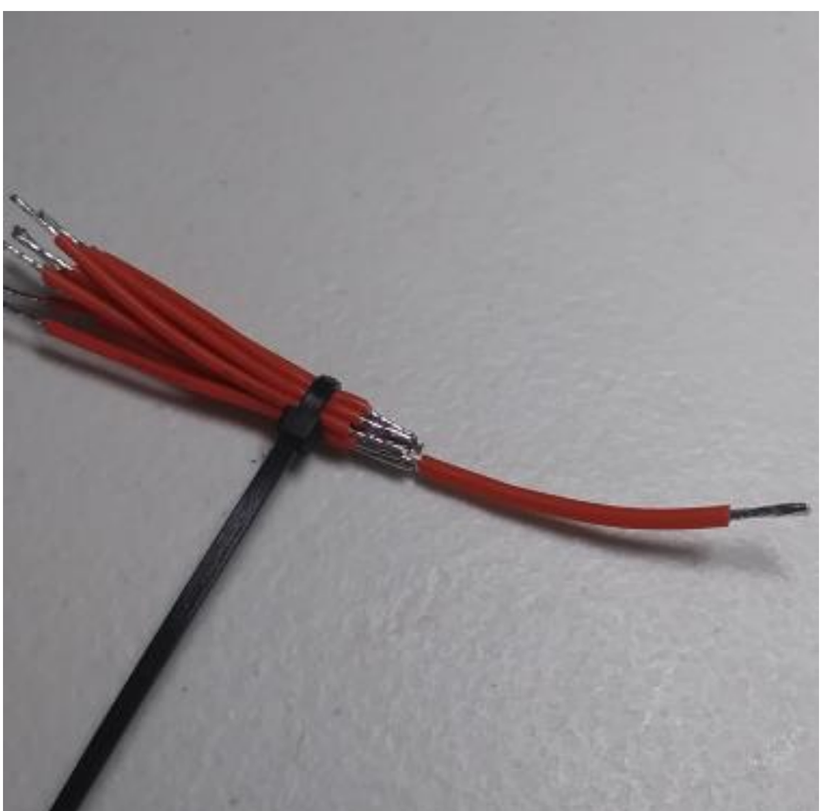
Cut off and remove the brown and white pair of wires from each cable and then plug the red, blue and yellow Ethernet cables inside enclosure into RJ45 panel jacks in the positions shown in the photo.



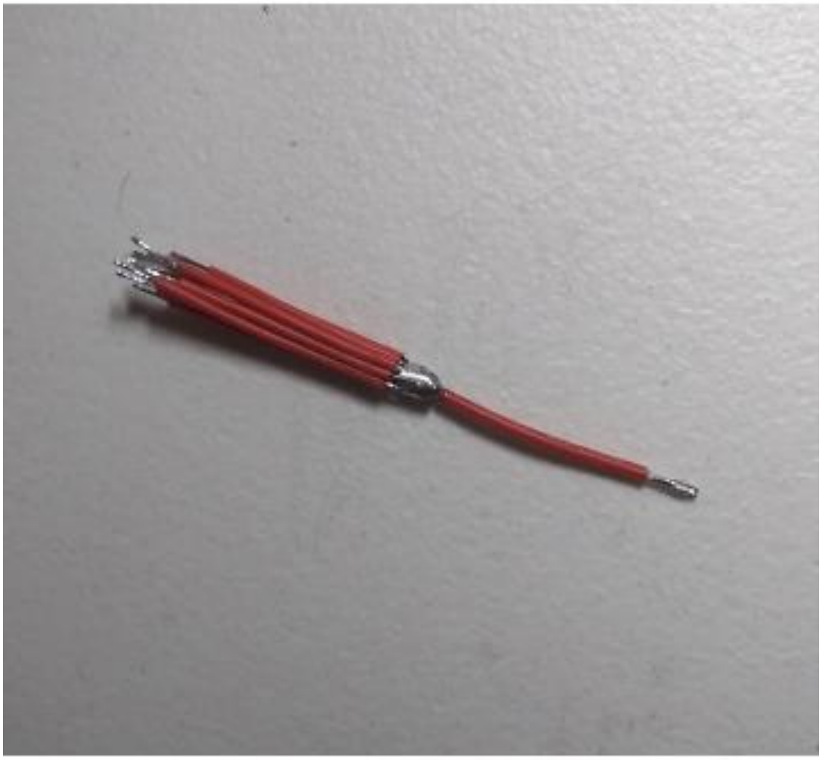
Cut (1) length 18awg red wire to 5cm (2”) long.

Cut (12) lenthgs of 22awg red wire to 5cm (2”) long.

Pre apply solder to the ends of each wire. This is also known as tinning the end of each wire.

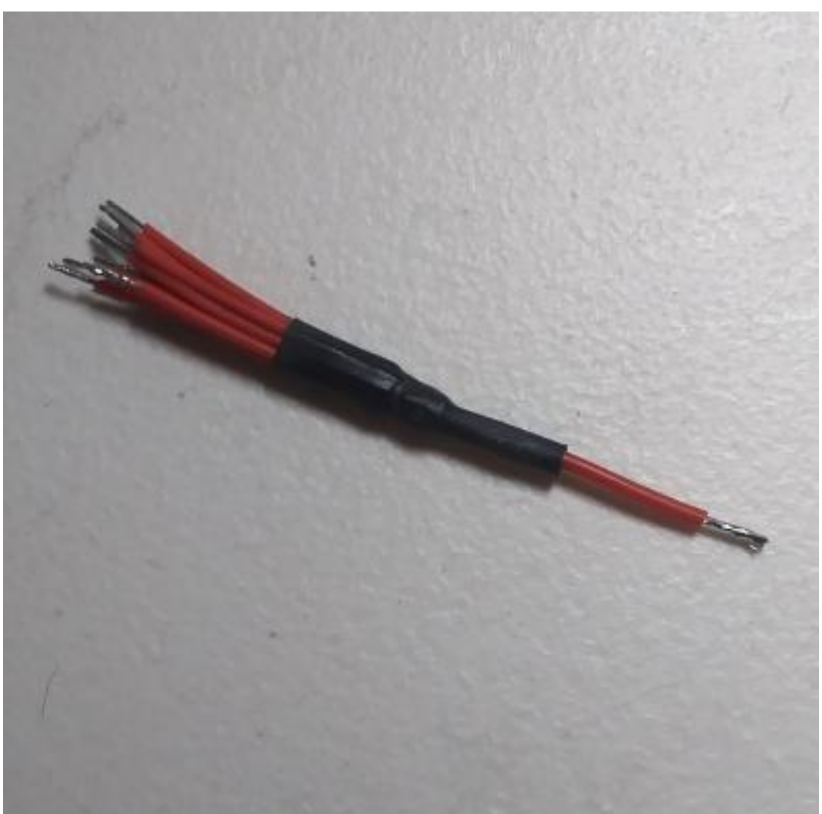


Use small cable tie to group the (12) 22awg wires together and then insert the (1) 18awg wire into the center of the 22awg wires as shown.



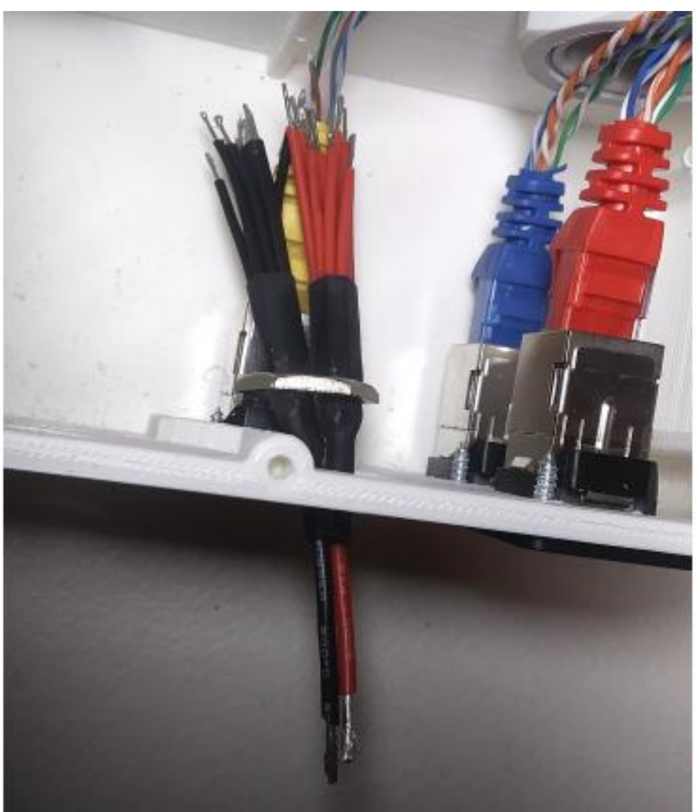
Solder bundle of wires together as shown and then remove cable tie.

Make sure all wire ends are soldered together thoroughly and non are loose or can be removed.

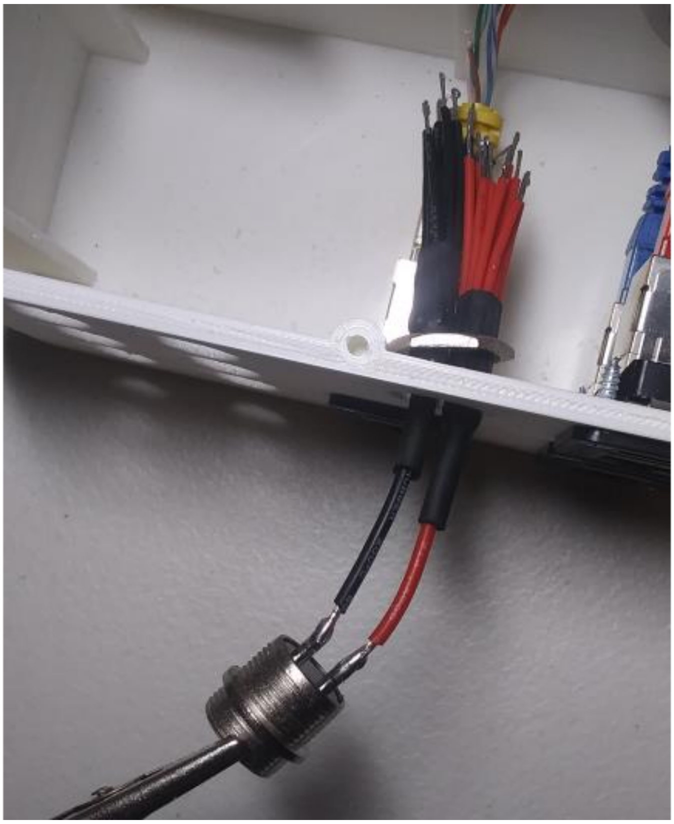


Apply heat shrink tubing around solder joint as shown.

Repeat the previous (4) steps using black 22awg wire to create a second wire bundle, but on this bundle of black wires add one extra wire for a total of (13) leads on the -5vdc bundle.

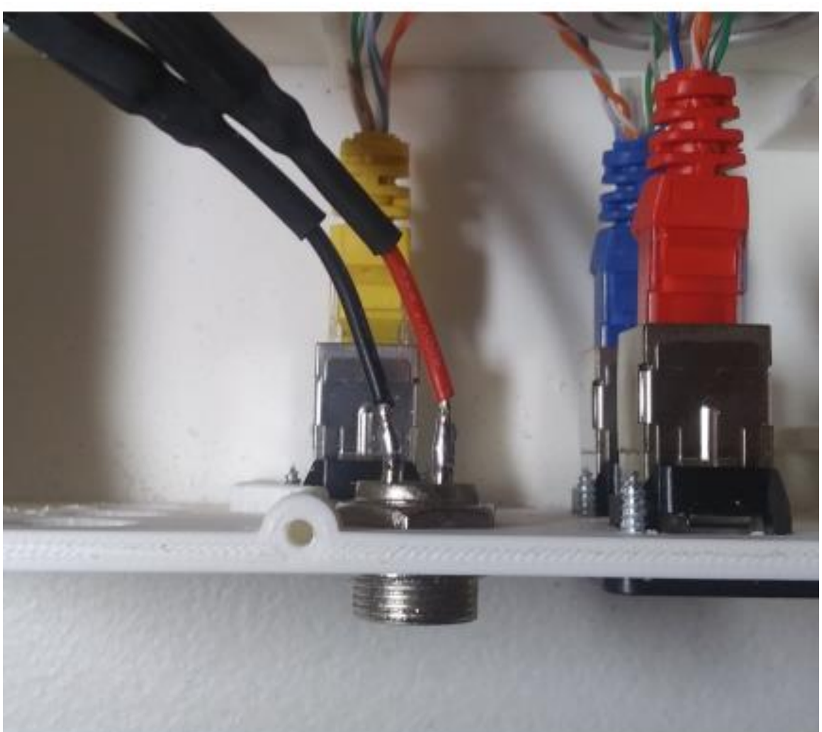


Insert the single 18awg wire from both bundles through GX16-2 aviation plug nut and then through top right hole in J1 base enclosure as shown.



Solder 18awg wires to GX16-2 aviation plug terminals as shown.

GX16-2 aviation plug notch should be facing upward so that the black bundle is on the left side of the plug and the red bundle is on the right side of the plug.



Insert plug and tighten nut.

These bundles will supply 5vdc to all the encoders and limit switches.

Install large heat shrink tube or electrical tape over 5vdc plug solder joints as shown to avoid exposed terminals inside enclosure.

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).

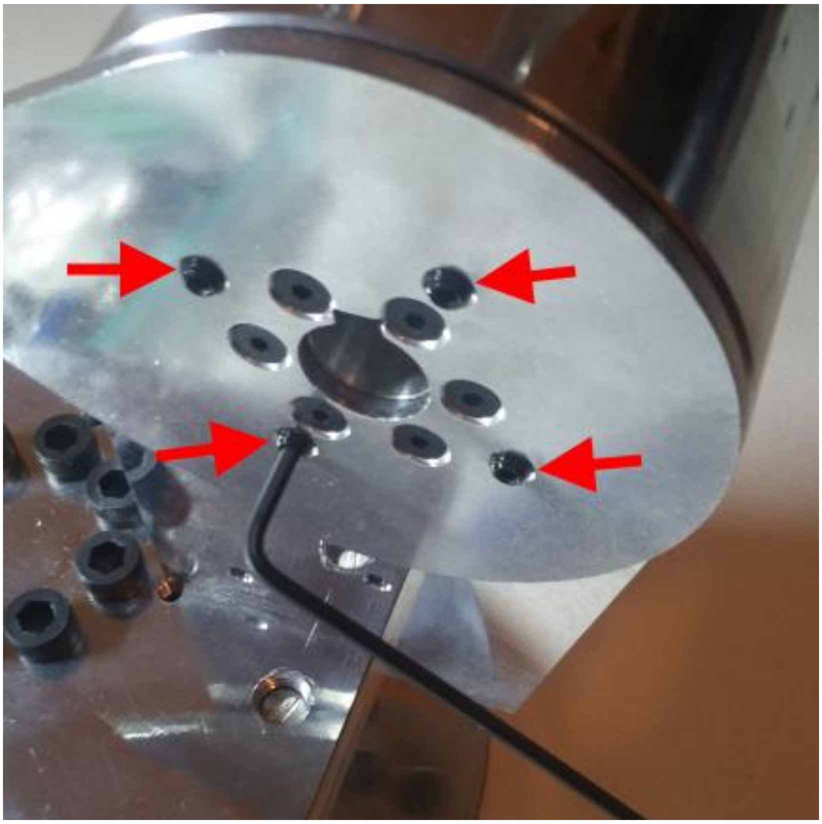
Install #30206 bearing onto J2 spindle as shown.

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

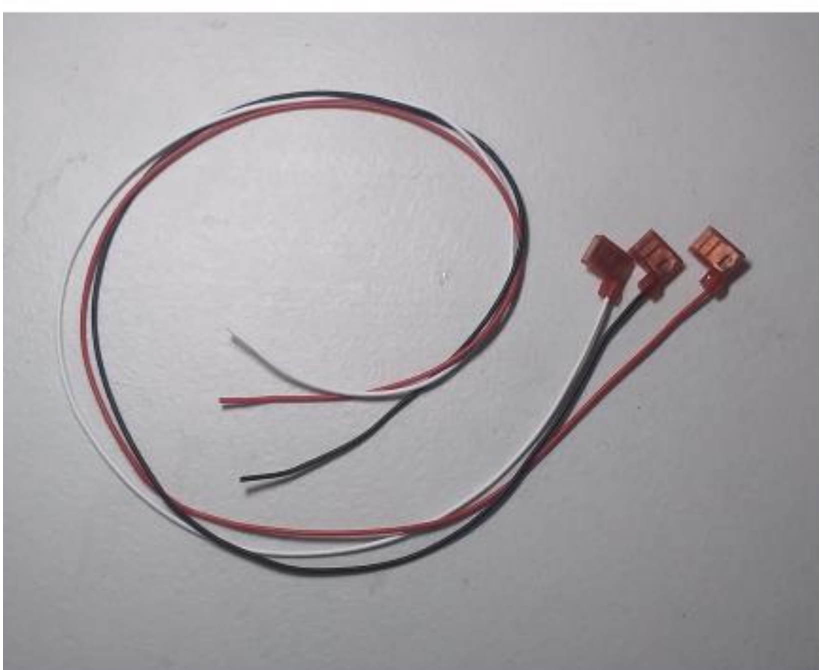
Install J2 arm assembly into J2 turret housing and then install the other #30206 bearing from opposite side as shown.

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.

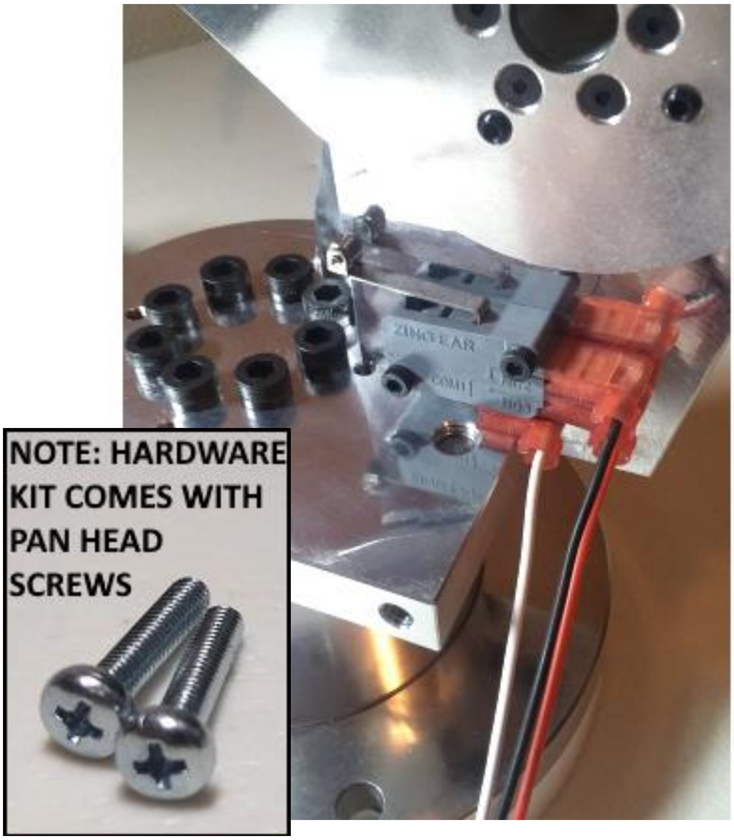


Install (4) M4x5 set screws and tighten until there is no play in J2 bearings. These set screws set the bearing tension – remember to apply loctite to set screw threads.



Cut lengths of red, black and white 22awg wire to lengths of 61cm (24”) long.

Crimp 90° quick disconnect to the end of each wire.



Install wires with quick disconnects onto SV-166-1C25 roller tip limit switch and then install limit switch onto J2 turret housing as shown.

Use (2) M3x14 socket head or Philips pan head screws to secure switch to housing.

Be sure to connect wires as follows:

- Black to NC2 terminal
- Red to NO3 terminal
- White to COM1 terminal

Wrap small piece of tape around end of the J2 limit switch wires and use marker to mark wire with 2 stripes so that you will know this is for J2 after pulling it into enclosure.

Use 9/32” or 7.2mm drill to enlarge pass through hole on J2 motor mount.

This hole was originally a smaller size for the AR2 robot – We will now pass the J2 motor wires and encoder wires through this hole on the AR3 robot so having it a larger size will be helpful.

Remove the (4) M4 cap screws and lock washers from head of J2 gear motor.

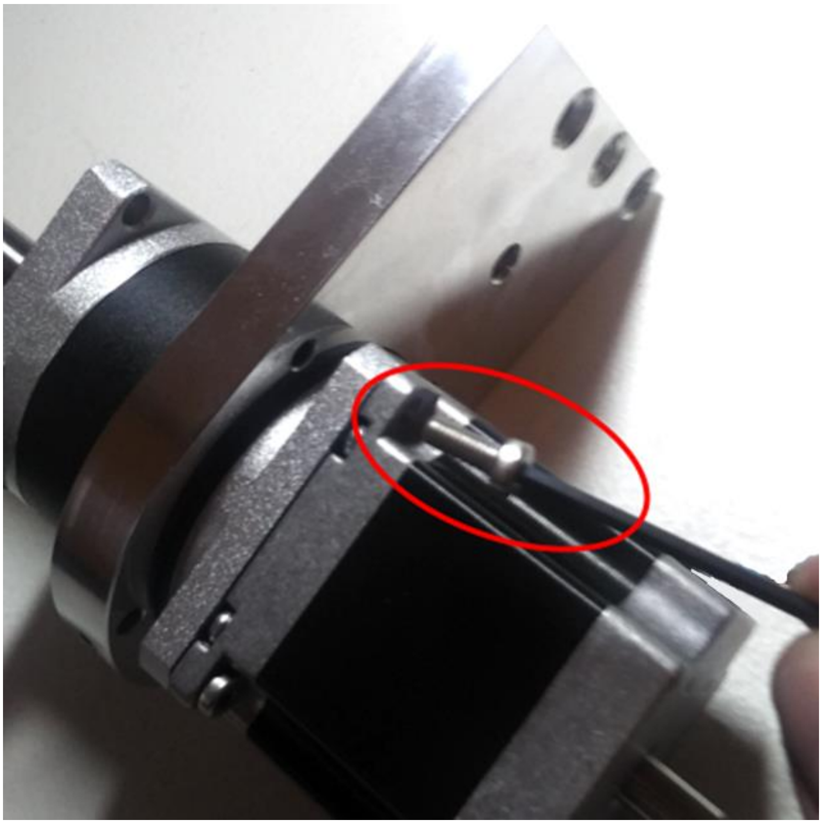
Carefully remove the gearbox motor shaft bearing assembly as shown.

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

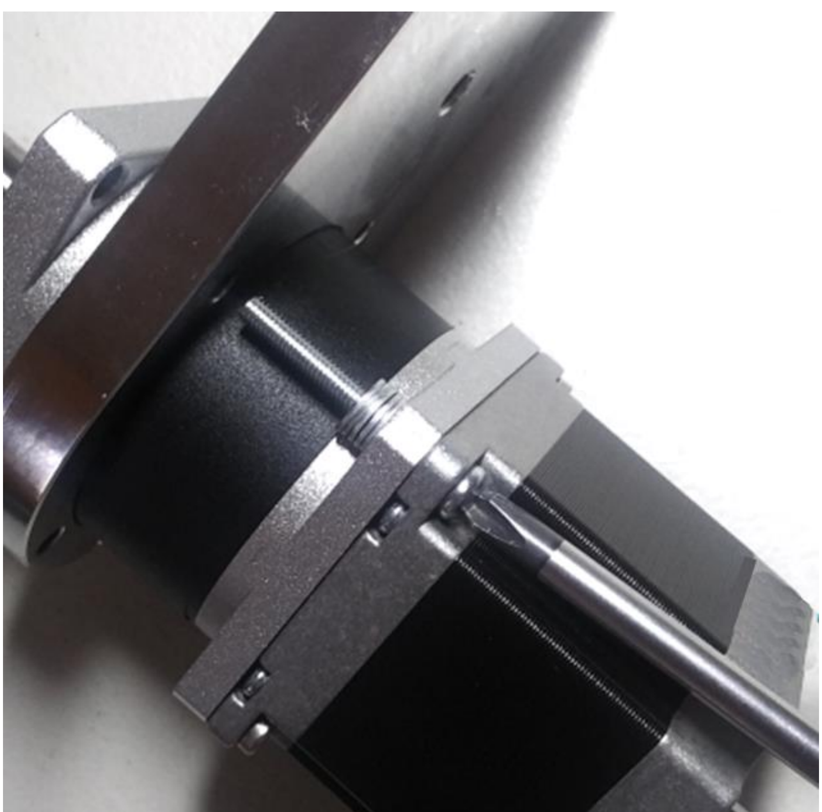
Make sure motor wires are facing to the right (red arrow).

Carefully re-install J2 gearbox motor shaft bearing assembly as shown and tighten the M4 cap screws.

Then turn motor rear shaft by hand until the main shaft keyway is facing upward as shown.

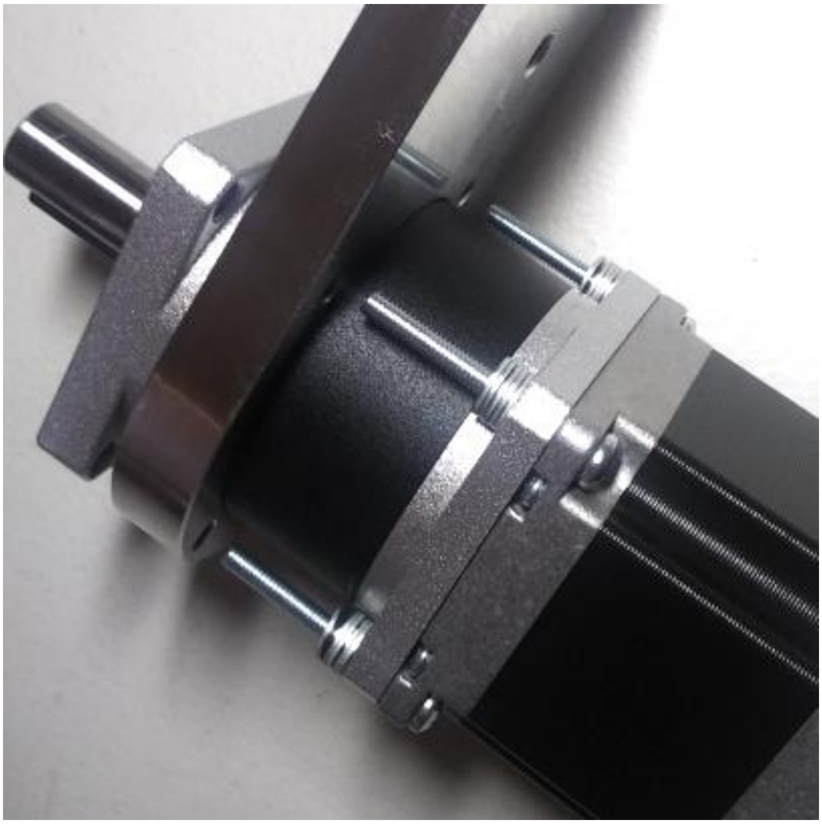


Remove one of the factory M4 screws holding the J2 motor to the J2 gearbox.

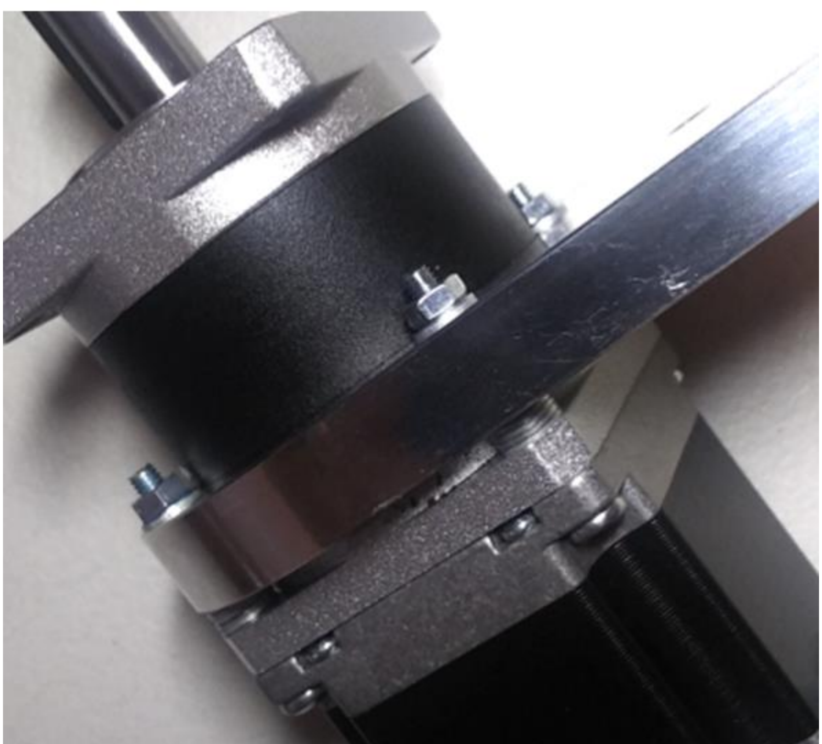


Replace factory screw with M4x35 Philips head pan screw, then place (6) M4 washers over screw threads on gear box side as shown.

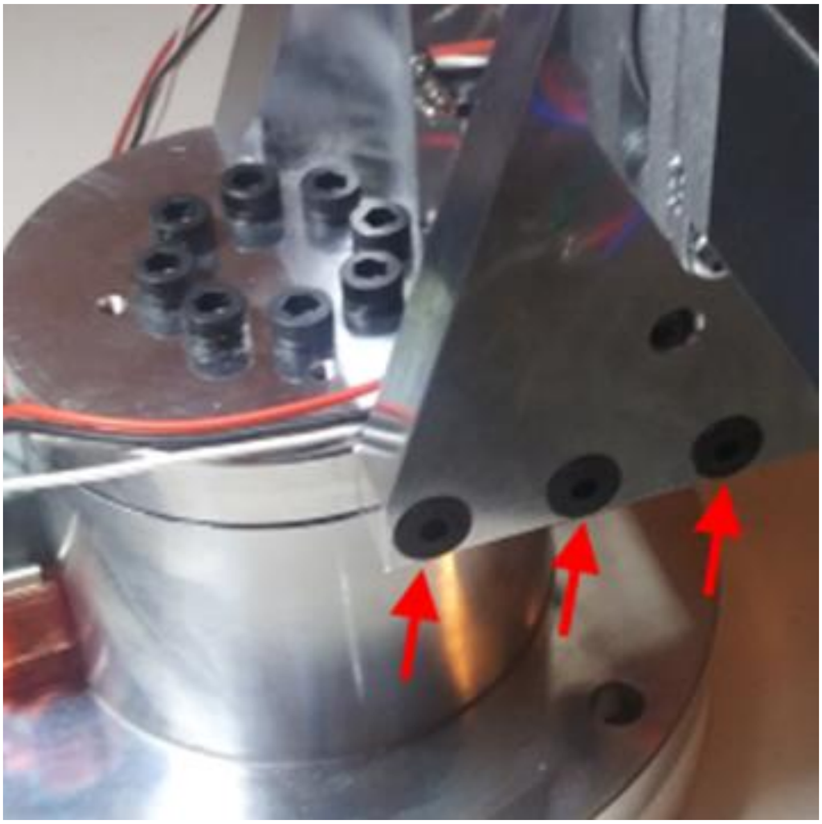
Save one of the factory screws as we will utilize it in a future step.



Repeat this process for the remaining (3) screws replacing the factory screws one at a time with M4x35 pan head screws and placing (6) M4 washers over each screw post.



Slide J2 motor mount plate over the M4x35 screw posts as shown and then install and tighten M4 washer and nut.



Install J2 motor assembly onto robot sliding the J2 motor shaft into the J2 spindle.

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

Make sure there is approx. 1mm gap between the J2 gearbox motor housing and the J2 tension ring set screws as shown.

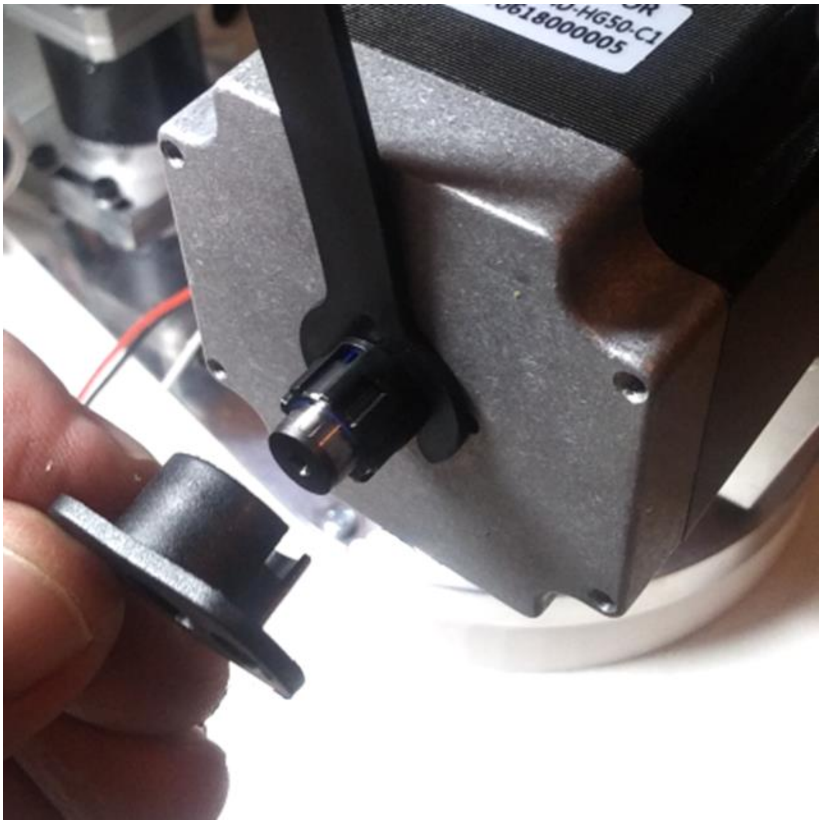
If for any reason the motor is too close to the set screws add one additional M4 washer between J2 mounting plate and J2 motor on 35mm screw posts.

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

NOTE: do not over tighten and deform gear box housing. This only needs to be tight enough to locate gearbox radially.

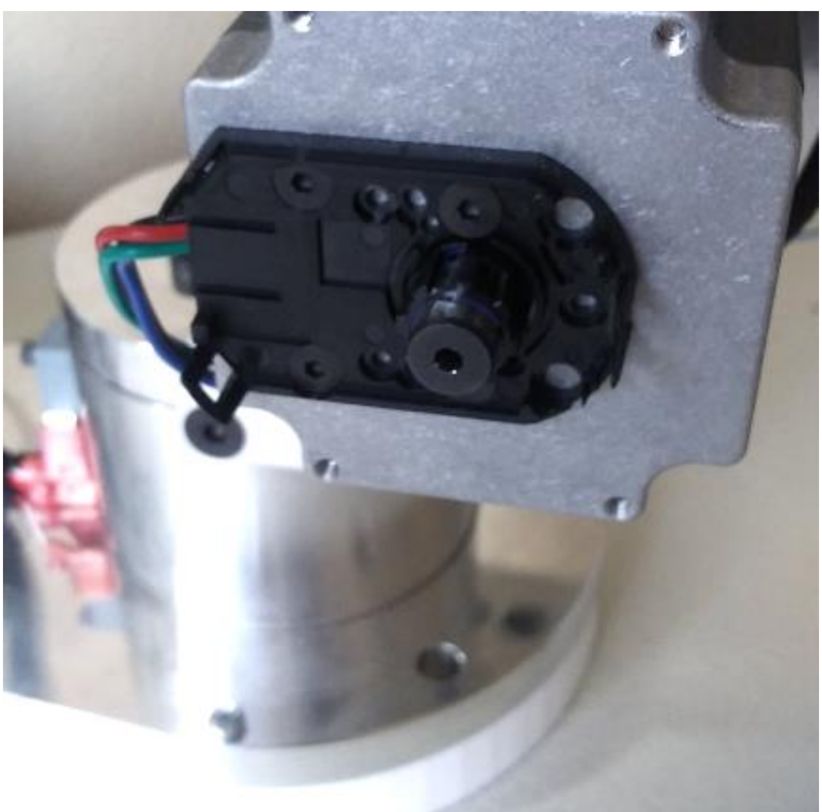
Tighten the M3 set screw for the J2 spindle.

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



Install the Blue (.315”) AMT-102 encoder sleeve on to the J2 motor as shown.

Please review the assembly instructions provided with the AMT-102 encoder.



Use (4) M3x5 flat head screws to mount the ENC-AMT102 base to the top of the J1 motor as shown.

Set dip switch settings on AMT-102 encoder as follows:

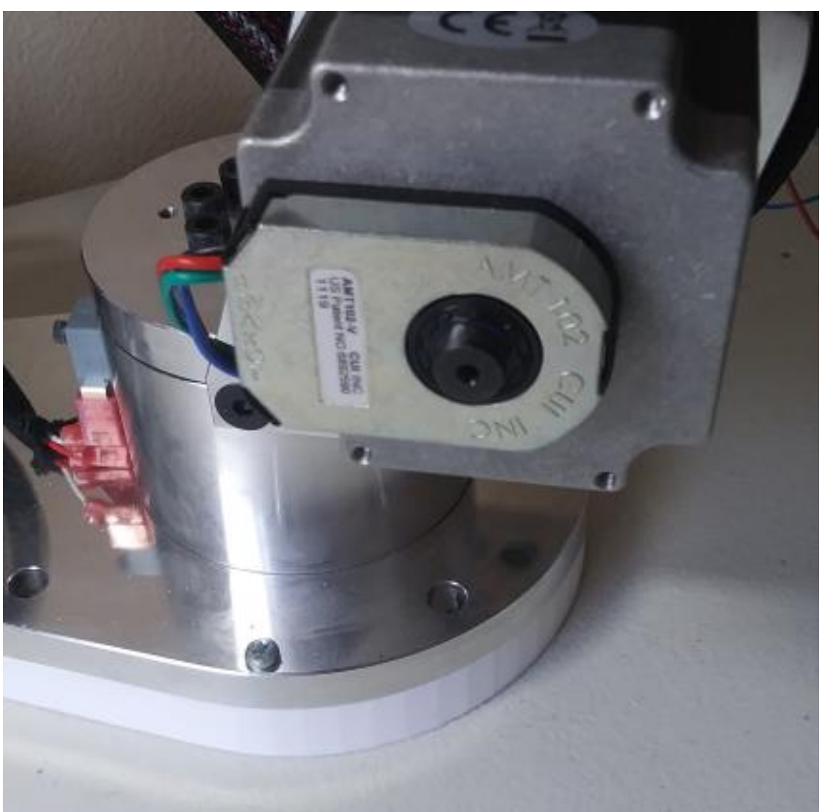
Switch 1 = Off

Switch 2 = Off

Switch 3 = Off

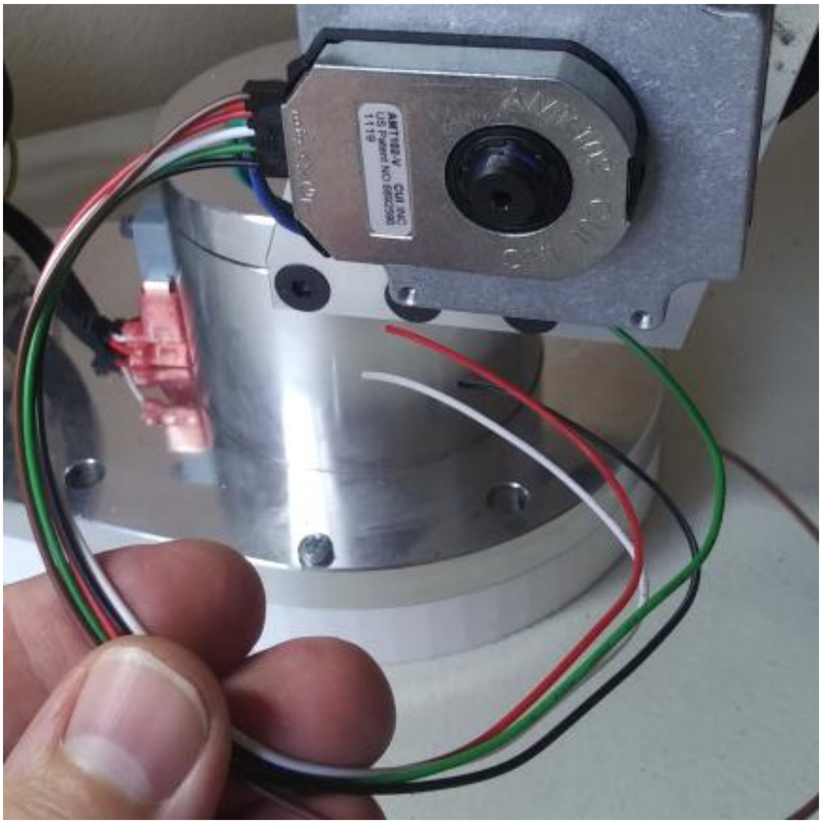
Switch 4 = **On**

This sets the encoder to a resolution of 512 steps per revolution or 1024 PR for both channels.

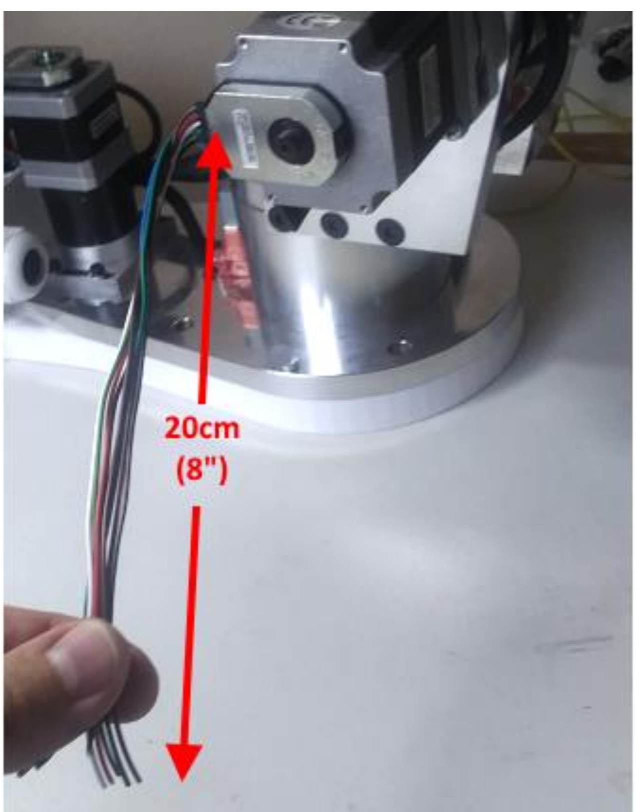


Install AMT-103 encoder on to J2 motor as shown.

Encoder will snap into the plastic base.

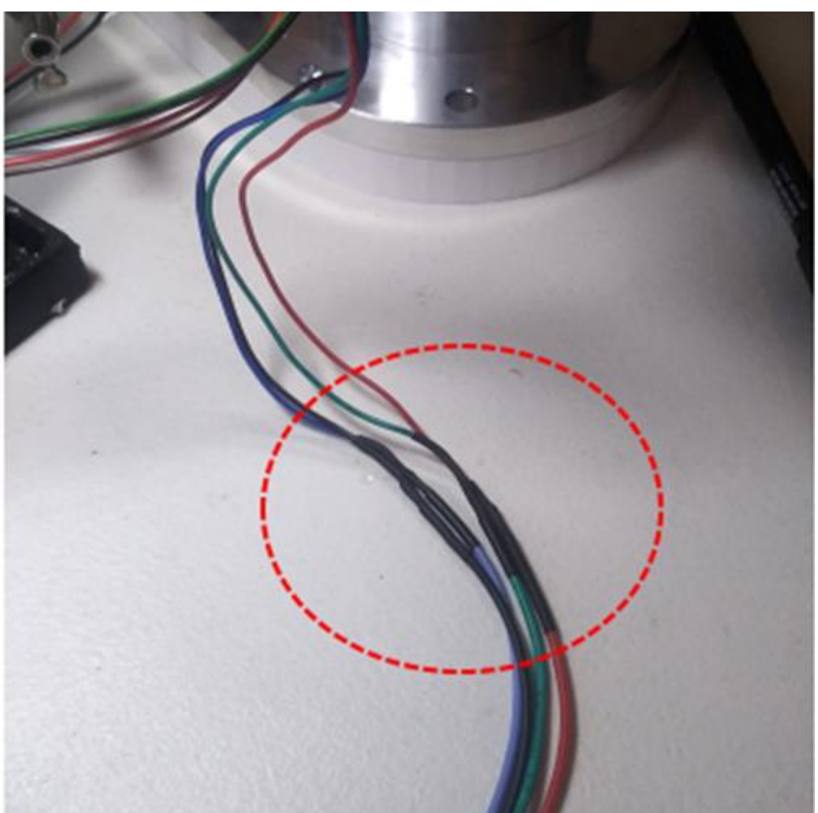


Install encoder wire end into J2 encoder as shown.



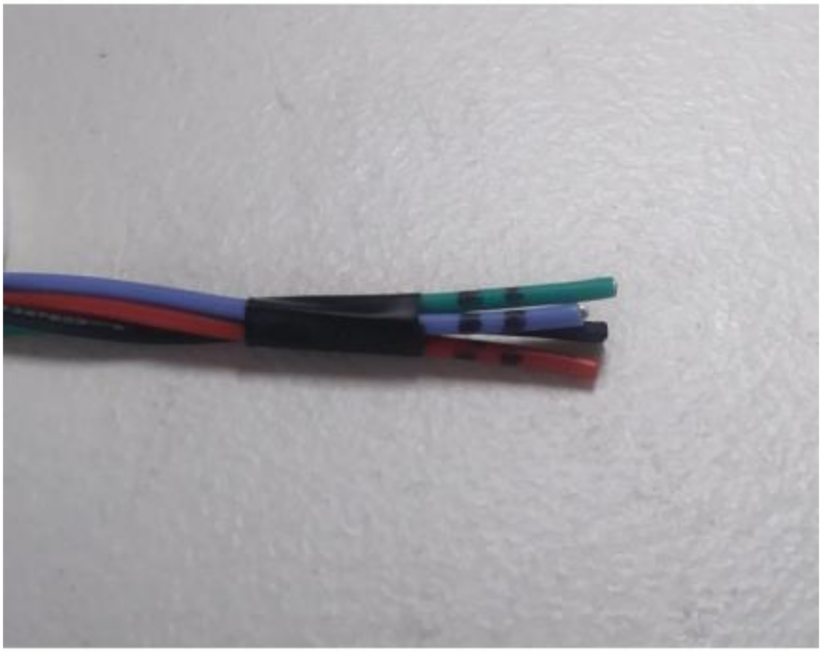
Trim J2 motor and encoder wires to a length of 20cm (8”) long.

Cut Red, Black, Blue & Green 18awg wires to a length of 56cm (22”) long.

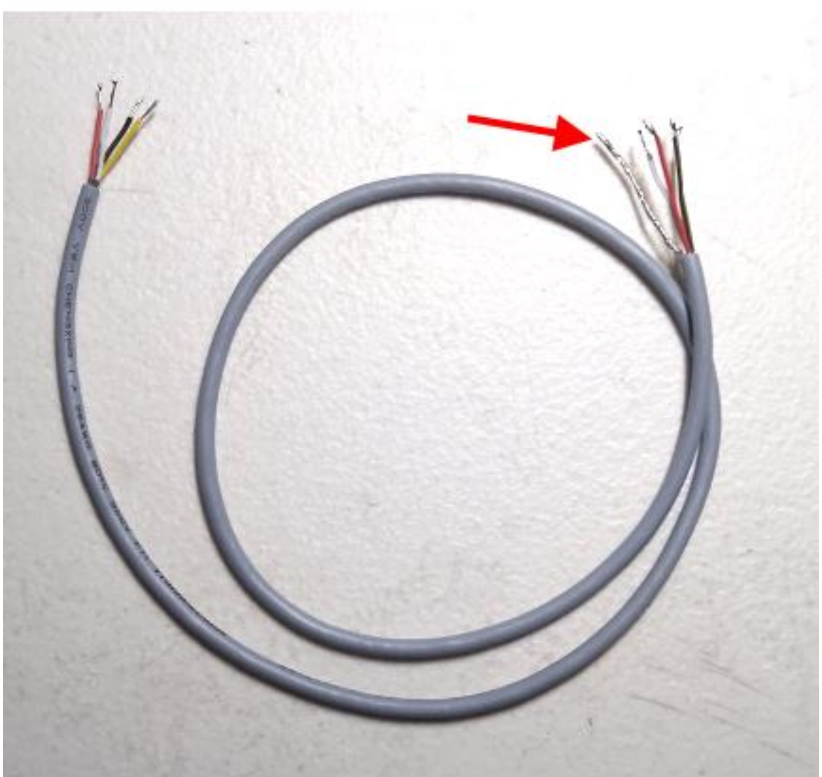


Solder and heat shrink 22” long extension wires to the J2 motor wires as shown.

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



Wrap ends of J2 extension wires with tape and then use a marker to put (2) stripes on each wiring indicating the wires are for joint 2 so that you will know these are for J2 when wires have been routed inside enclosure

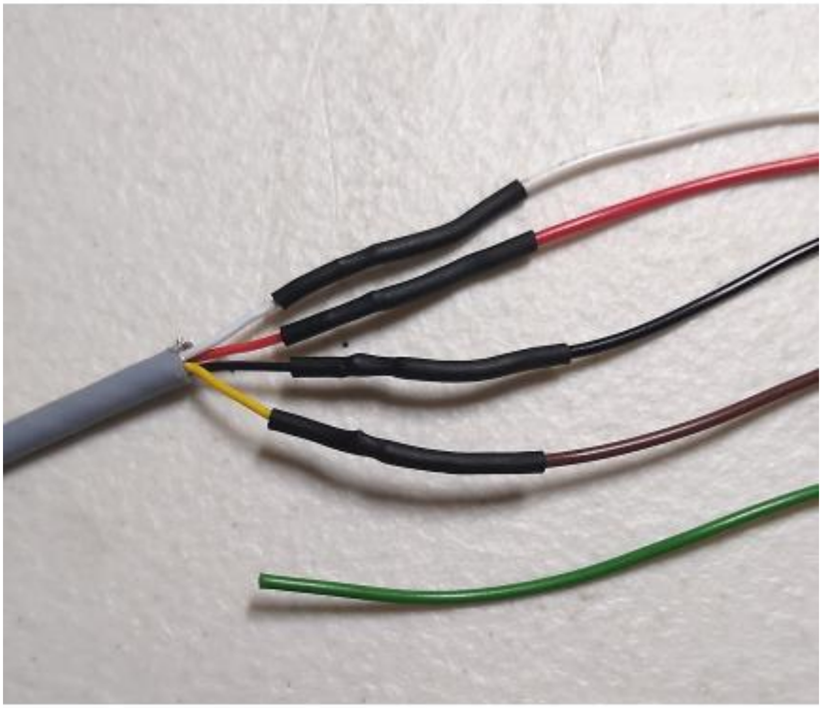


Cut 26awg shielded 4 conductor control cable to a length of 56cm (22”) long.

Carefully score outer jacket with razor knife, remove 2.5cm (1”) of the grey outer jacket on both ends of cable. (be careful to not damage wires or shielding when removing jacket.

On one end of the cable cut and remove the shielding wires, on the other end twist them together to create a ground wire. (red arrow).

Strip ends of all wires and pre-apply solder to ends of wires on both ends of cable – including the ground wire. (this is also known as tinning the wires).

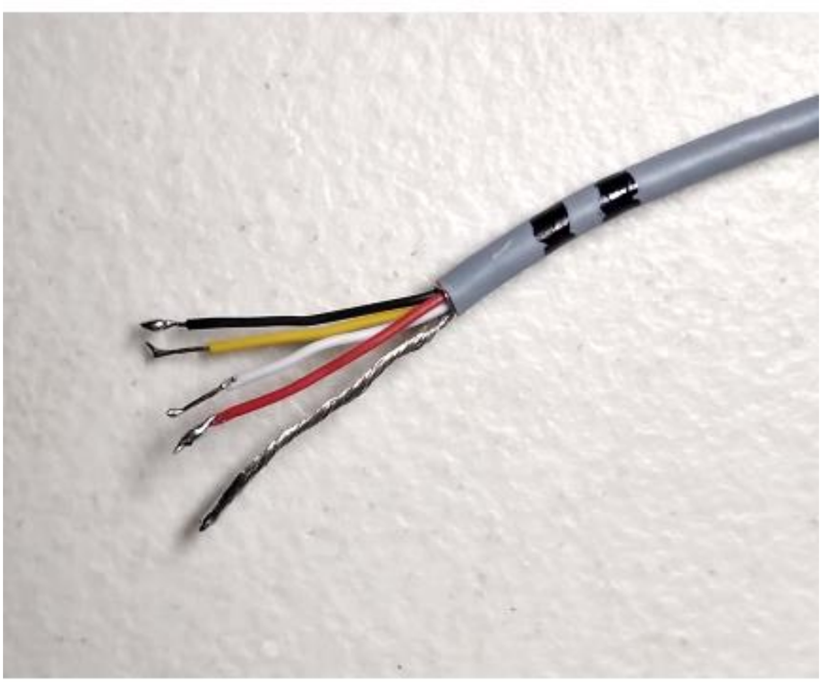


Solder and heat shrink the J2 encoder wires to the 26awg control wires as follows:

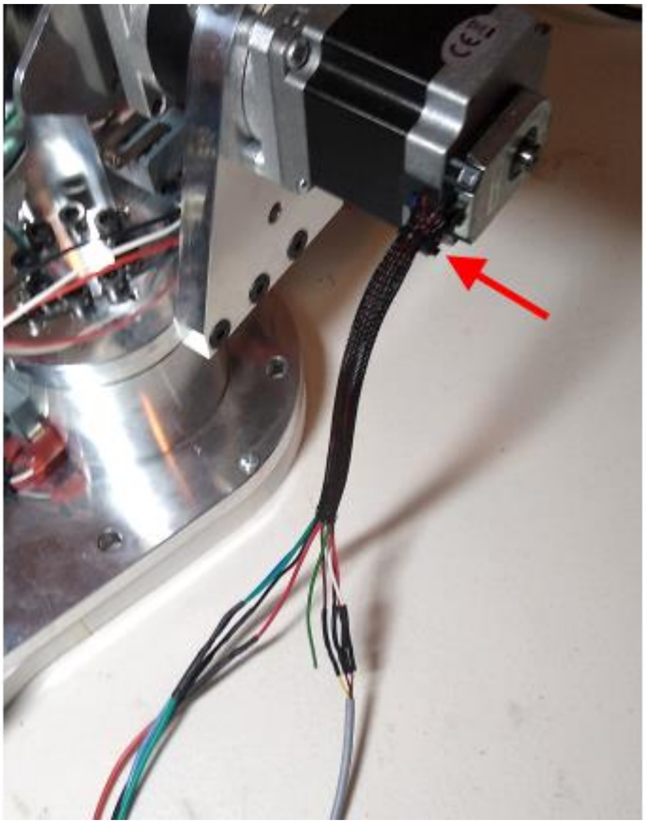
- **Red** goes to **red**
- **Black** goes to **black**
- **White** goes to **white**
- **Brown** goes to **yellow**

The green wire coming from the encoder will not be used.

The twisted ground wires are on the opposite end of cable that will be routed into base enclosure.

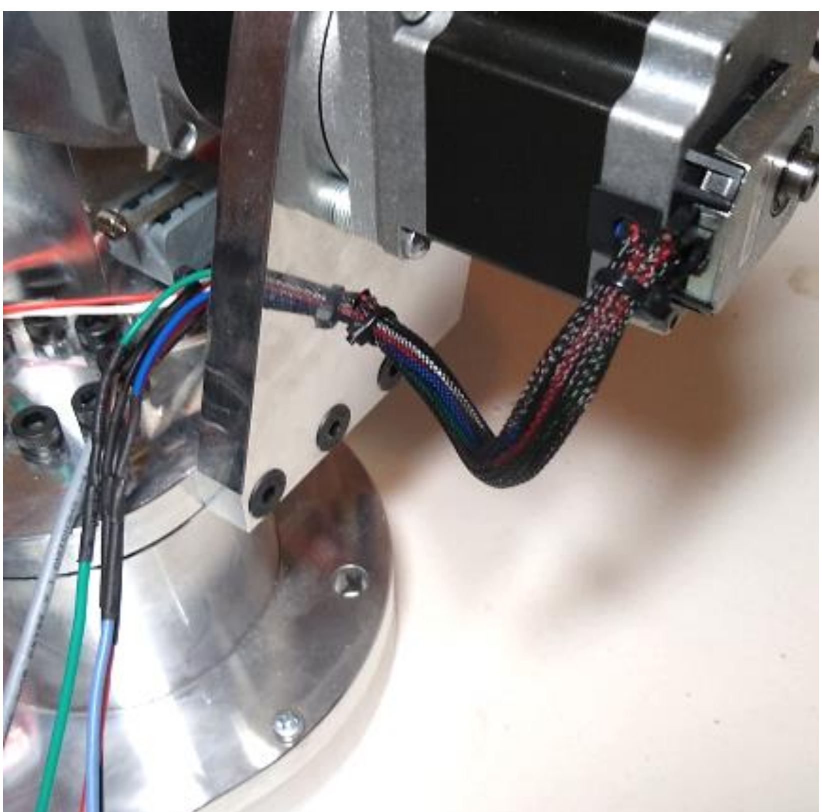


Use a marker to put (2) stripes on opposite end of cable indicating the cable is for joint 2 so that you will know these are for J2 when wires have been routed inside enclosure.



Cut length of ¼” braided sleeve to 13cm (5”) long.

Tape ends of wires and then slide braided sleeve over J2 motor wires and encoder cable up to motor and encoder and then secure with a small cable tie (red arrow).



Feed J2 wires through J2 motor mount plate side hole as shown.

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

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.

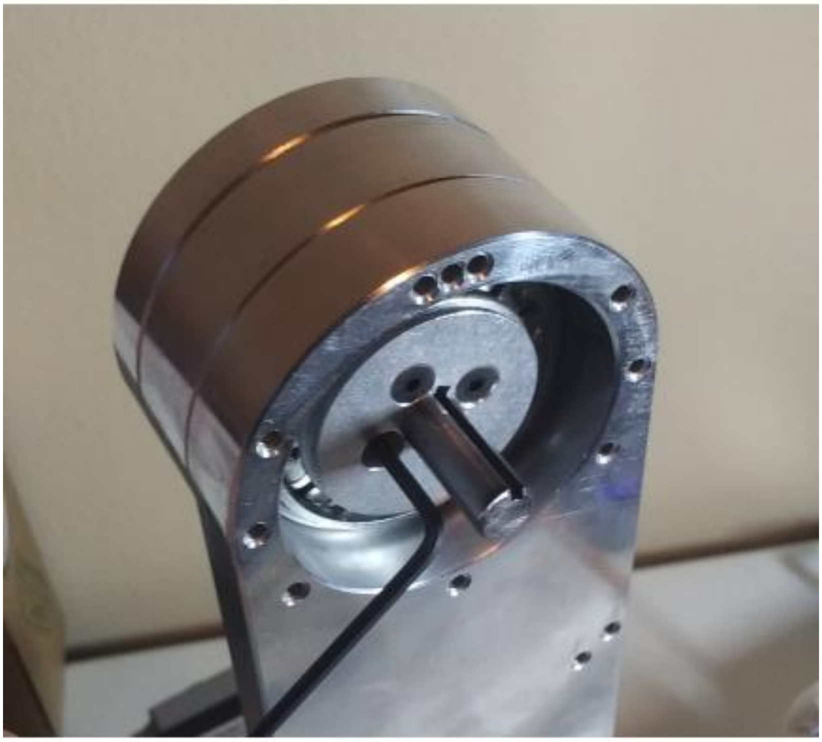
- 8mm shaft should be 50mm long.
- 2x2mm keystock should be 25mm long if using a chain and sprocket. (shown)
- 2x2mm keystock should be 50mm long if using a belt and pulley.

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.

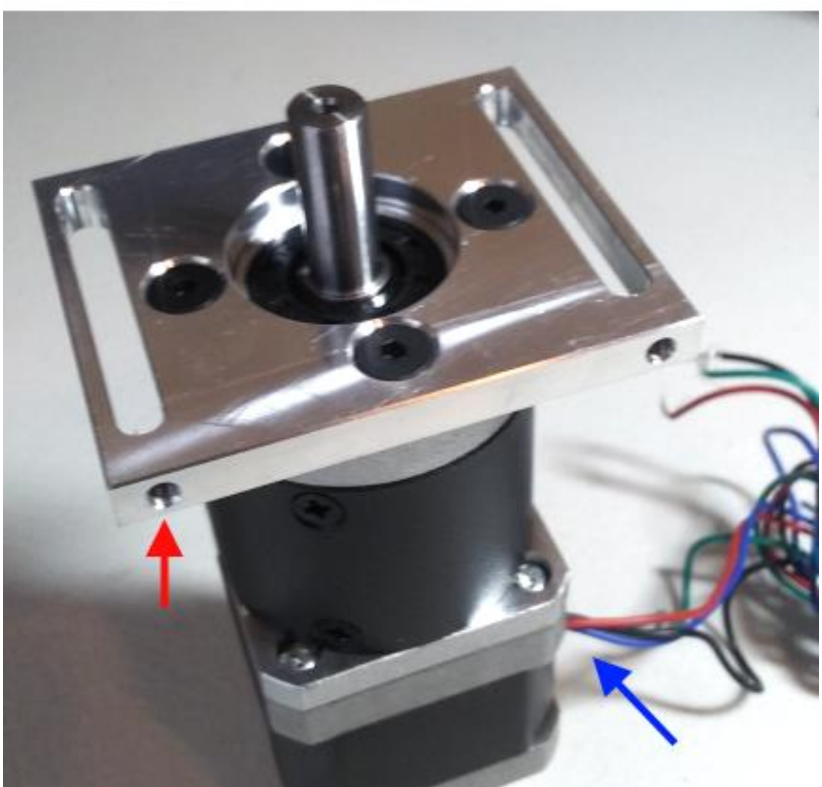
While holding the J3 spindle and bearing in place insert #30204 bearing over J3 spindle shaft as shown.



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

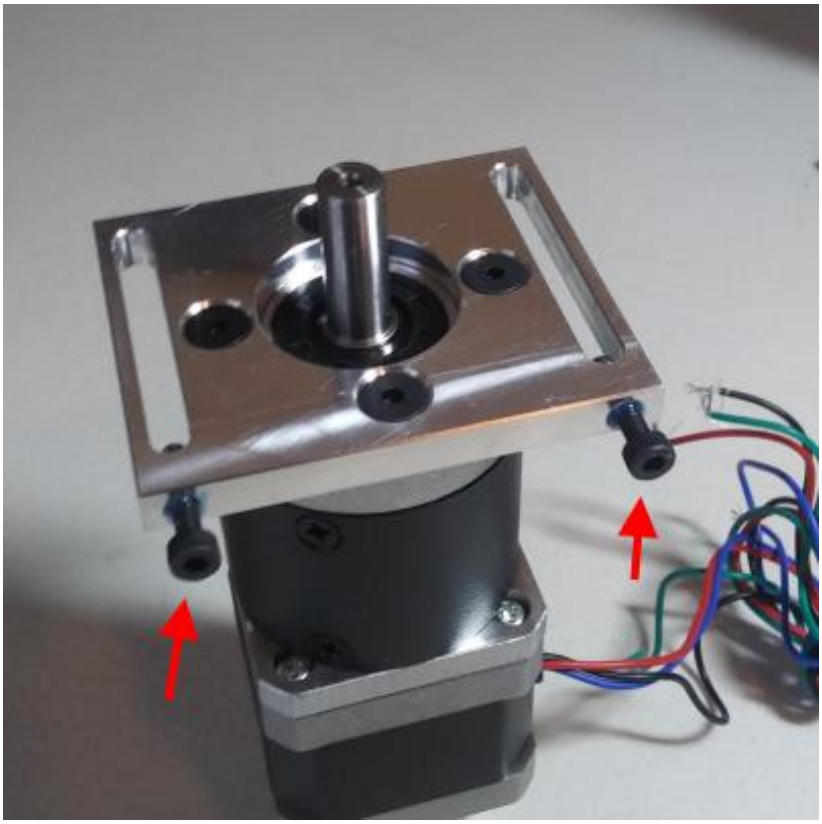
Tension screws so that there is no play in bearing but not too tight that the J3 shaft does not rotate smoothly.

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.

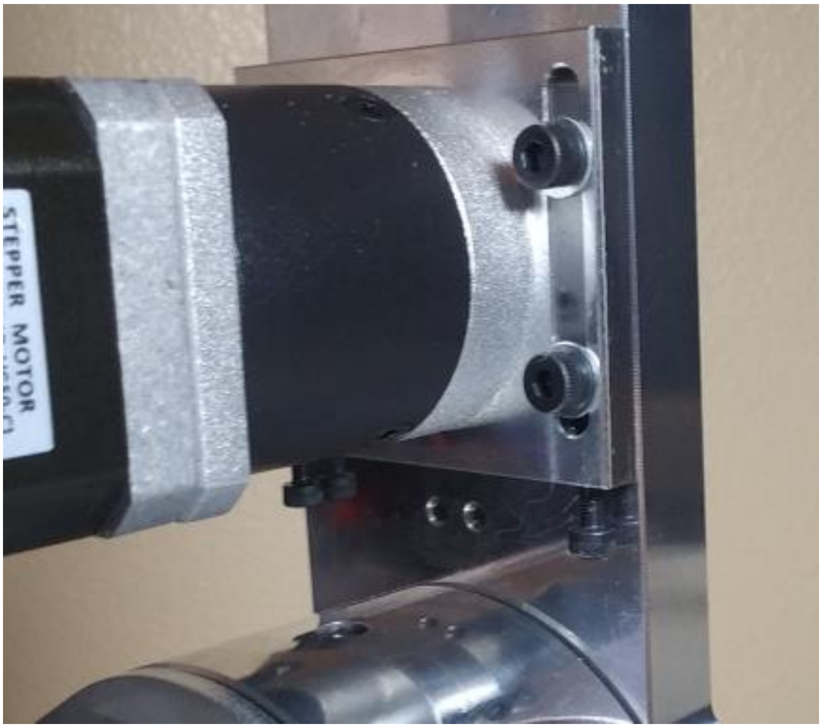
Make sure that the tension holes (red arrows) are 90° to the motor wires (blue arrows) in the orientation shown in the photo.



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

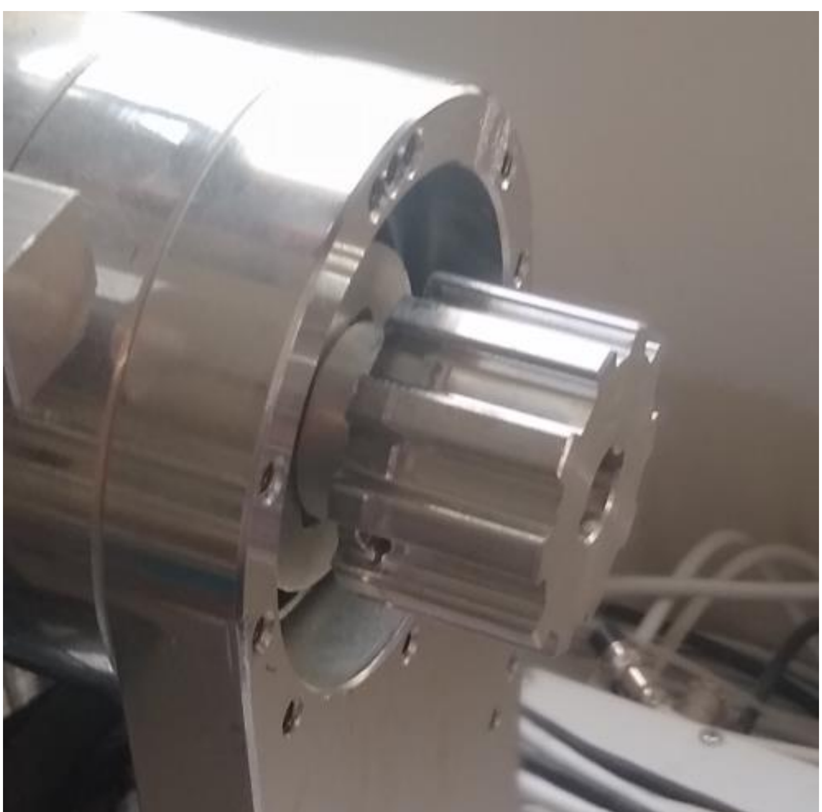
- In the following steps we are going to install the J3 drive belt (or chain).
- When designing the AR3 I tried to make as many of the components as simple as possible and out of standard thickness plate material where possible. Keeping the J2 arm and J3 motor mount as simple as possible meant the J3 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



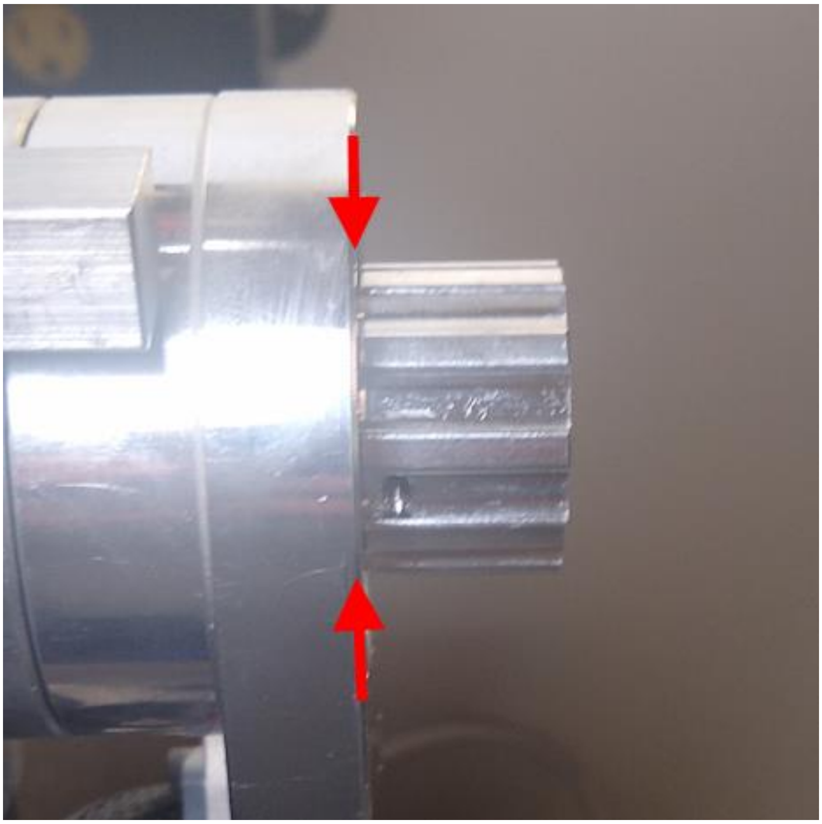
Secure J3 motor assembly to J2 arm using (4) M4x20 socket head cap screws and (4) washers.

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.

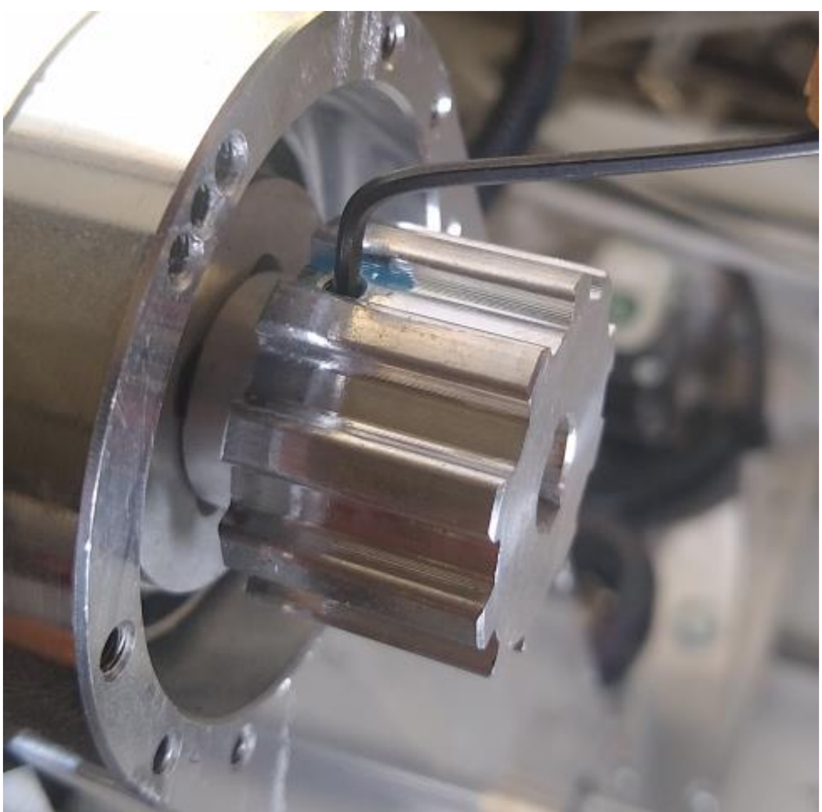


Install L10 pulley onto J3 8mm shaft.

Note that the L10 pulley has a 2mm key slot and a 3mm key slot – be sure to install the 2mm key slot over the J3 shafts 2mm key.



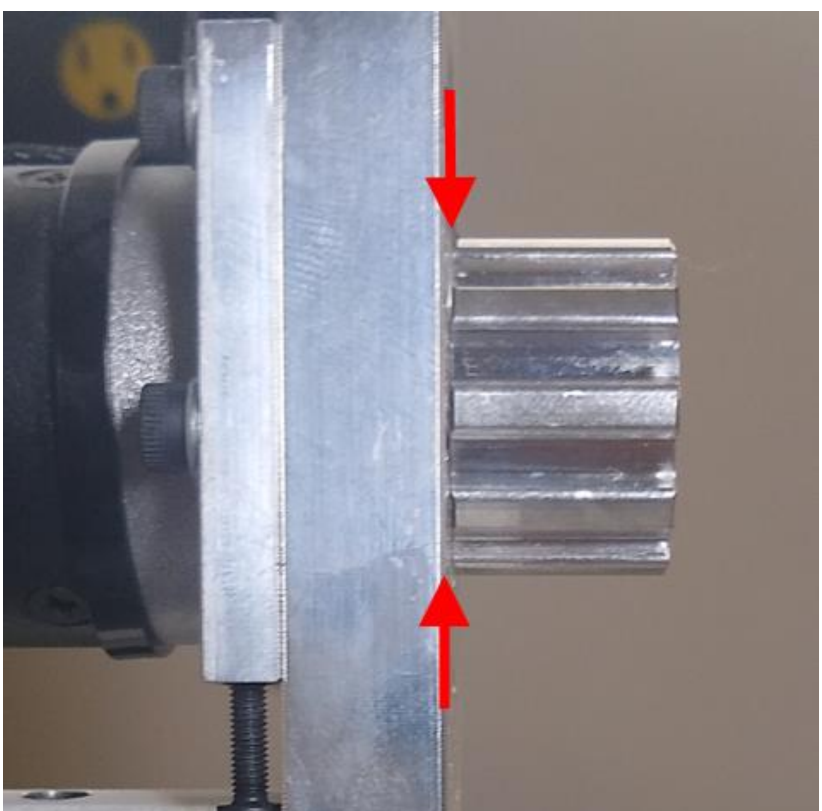
Note that the left or inside edge of pulley should be flush with J2 plate as indicated by the red arrows.



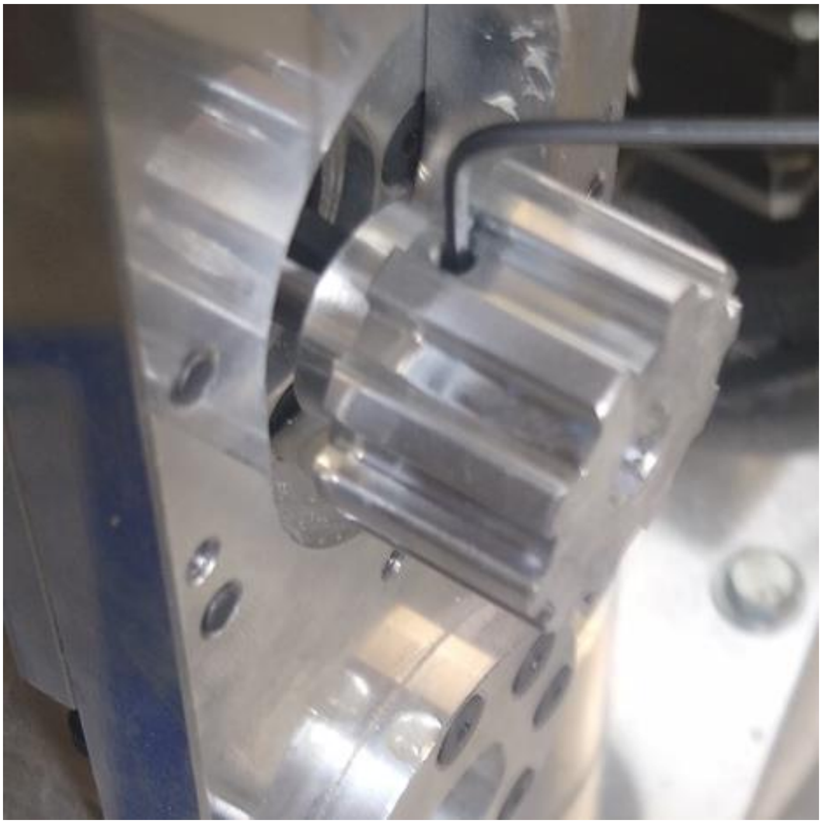
Install and tighten M3x4 set screw in threaded hole on 2mm key side of pulley.

Install L10 pulley onto J3 motor shaft.

Note that the L10 pulley has a 2mm key slot and a 3mm key slot – be sure to install the 3mm key slot over the J3 motors 3mm key.



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 3mm key side of pulley.

Install 214L belt as shown over both L10 pulleys.

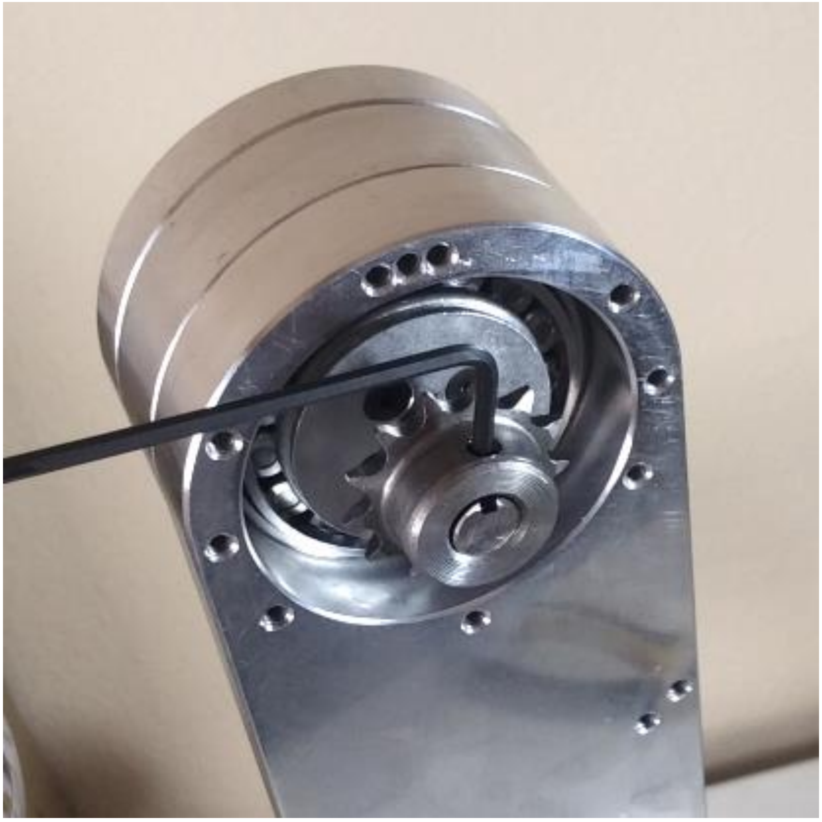
END OF OPTION 1 (belt and pulley)

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.

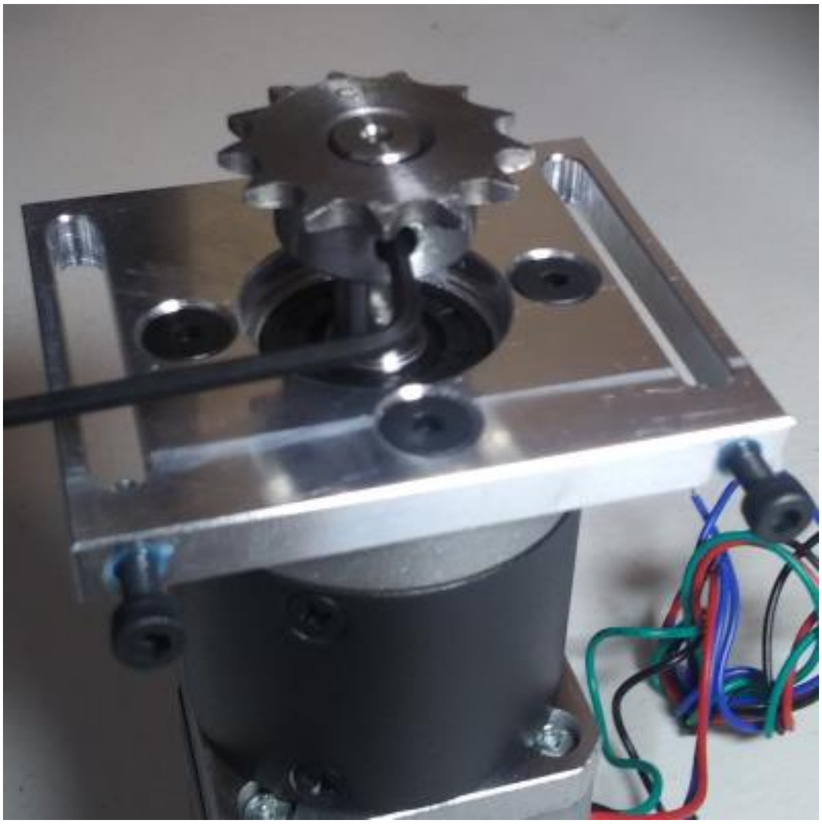
If using un-broached sprocket make sure one of the set screws is seated into J3 shaft slot.

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.



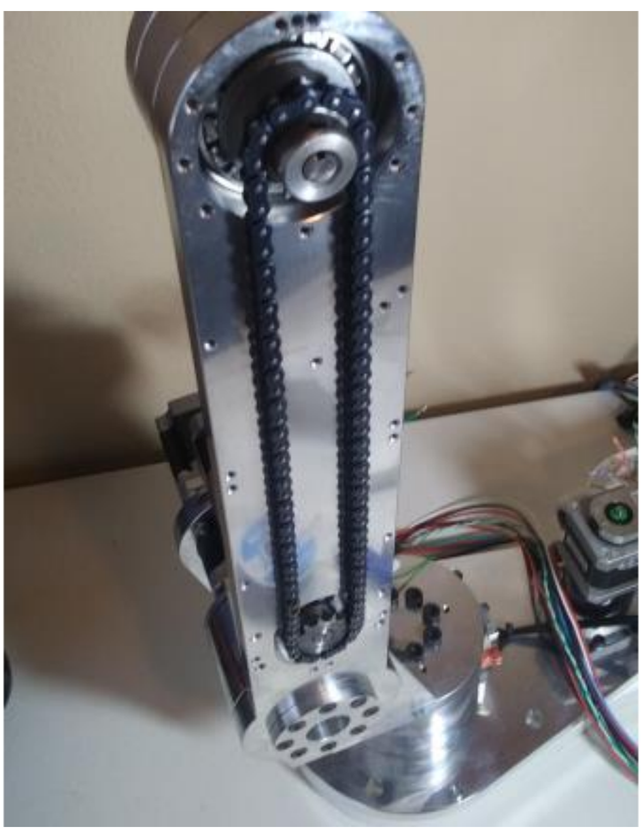
Install 13 tooth 8mm bore drive sprocket on J3 gear motor shaft as shown and tighten set screws.

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.

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.

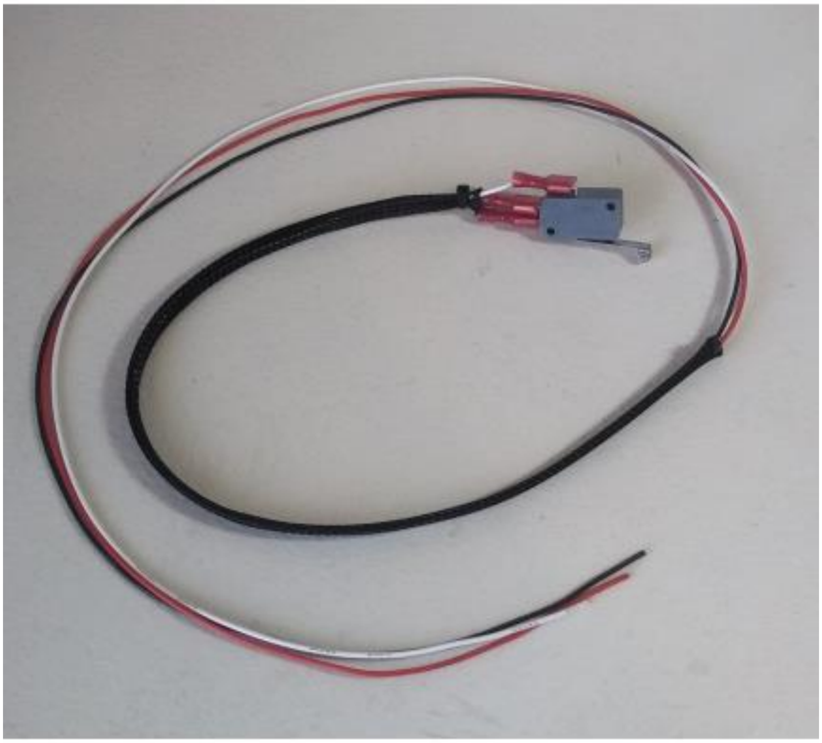
Install remaining M3x25 Philips head pan screws.

There are a total of (16) screws.

Secure AR3 logo into recess in J2 side cover using epoxy.

Cut lengths of red, black and white 22awg wire to lengths of 107cm (42”) long.

Crimp quick disconnect to the end of each wire.



Install wires with quick disconnects onto SV-166-1C25 roller tip limit switch

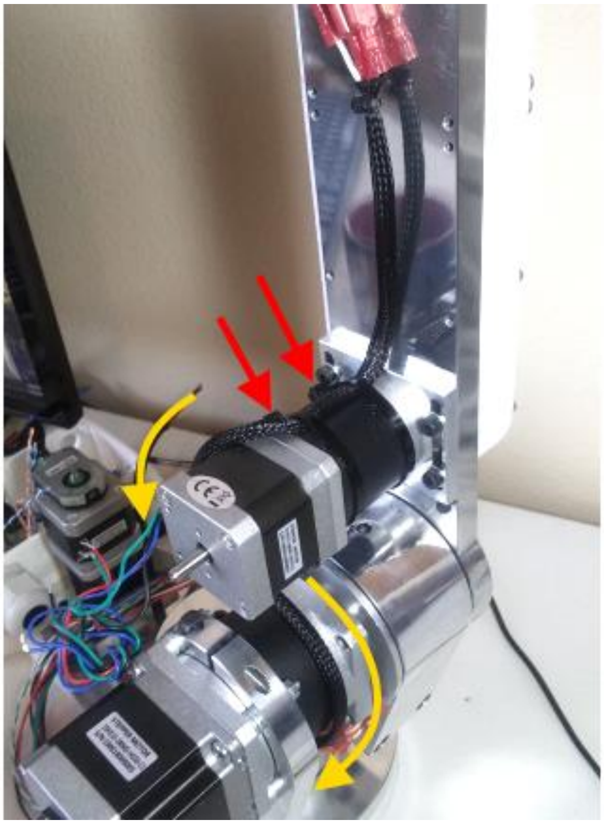
Be sure to connect wires as follows:

- Black to NC2 terminal
- Red to NO3 terminal
- White to COM1 terminal

Cut length of ¼” braided sleeve to length of 41cm (16”) and slide over the 22awg wires up to limit switch as shown. Secure braided sleeve to wires with small cable tie close to quick disconnect.

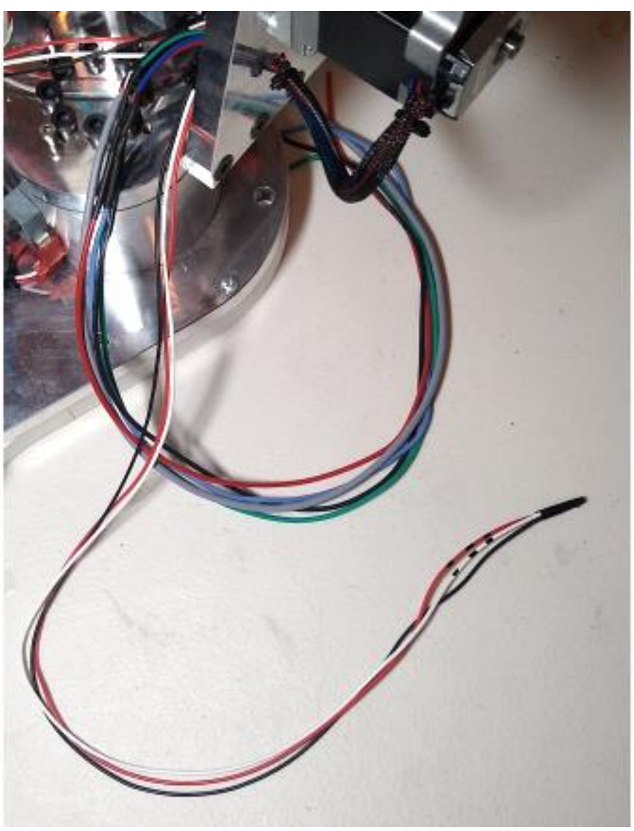
Install the J3 limit switch onto J2 arm as shown.

Use (2) M3x14 socket head or Philips head pan screws to secure switch inside of arm.



Secure J3 limit switch wire to top of J3 gearbox housing using 2 medium size cable ties (red arrows).

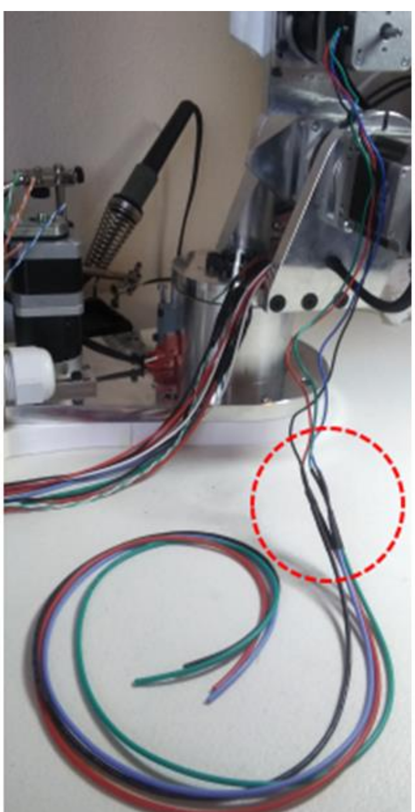
Then route the J3 limit switch wire behind the J3 motor and then around the front of the J2 motor gear box (yellow arrow).



The J3 limit switch wires will route behind J2 gearbox and join the group of wires from the J2 motor.

Wrap the end of the J3 limit switch wires with tape and then mark wires with (3) stripes to indicate the wires are for Joint 3.

Cut Red, Black, Blue & Green 18awg wires to a length of 56cm (22”) long.



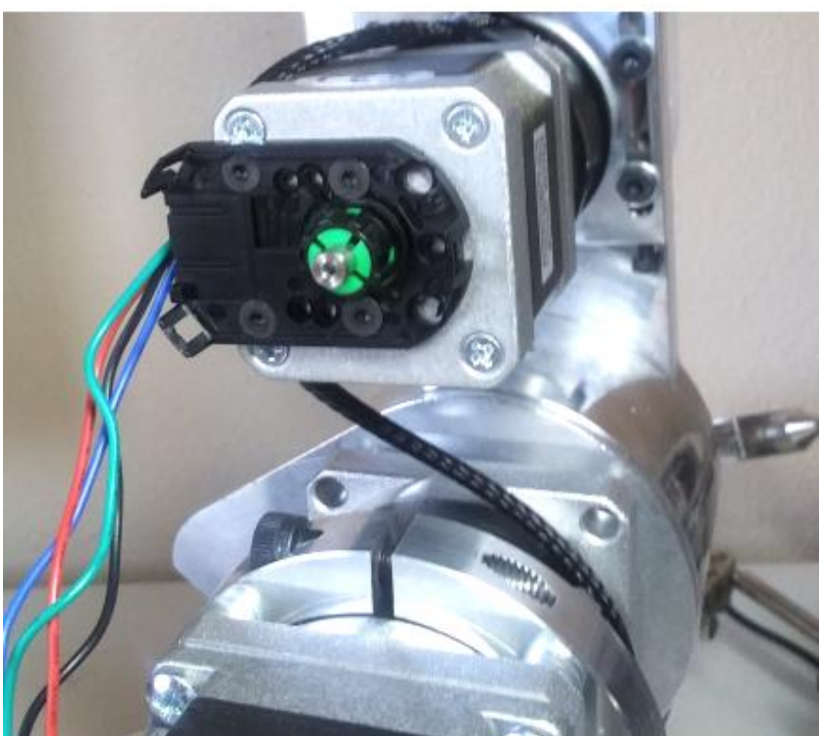
Solder and heat shrink 56cm (22”) long extension wires to the J3 motor wires as shown.

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

Tape ends of J2 motor wires together and use marker to mark wires with (3) stripes so that you will know these are for J3 when wires have been routed inside enclosure

Install the green (.197”) AMT-102 encoder sleeve on to the J3 motor as shown.

Please review the assembly instructions provided with the AMT-102 encoder.



Use (4) M3x5 flat head screws to mount the ENC-AMT102 base to the top of the J3 motor as shown.

Set dip switch settings on AMT-102 encoder as follows:

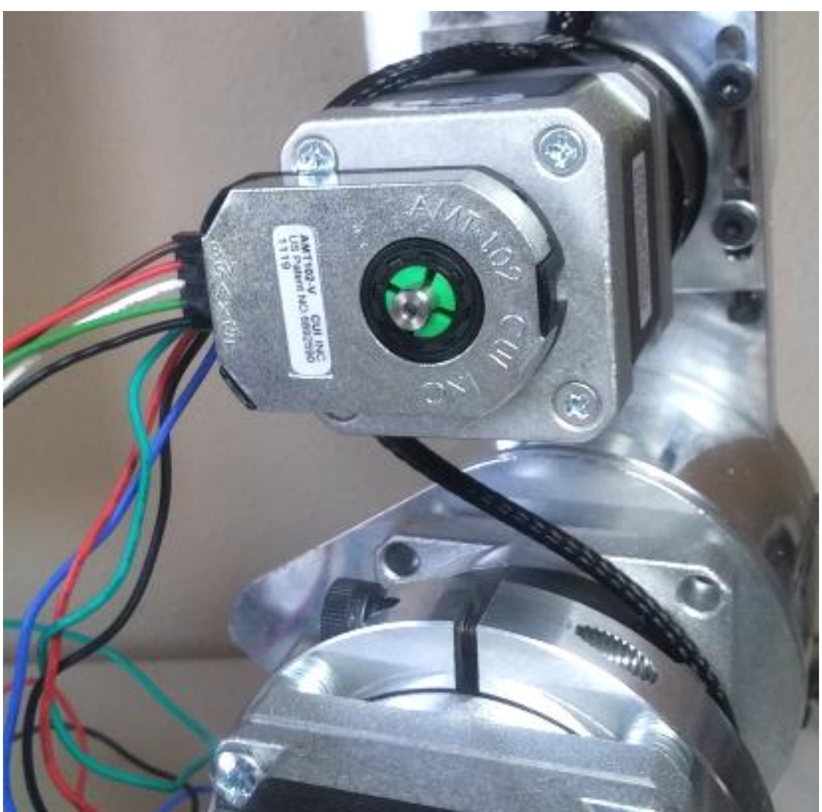
Switch 1 = Off

Switch 2 = Off

Switch 3 = Off

Switch 4 = **On**

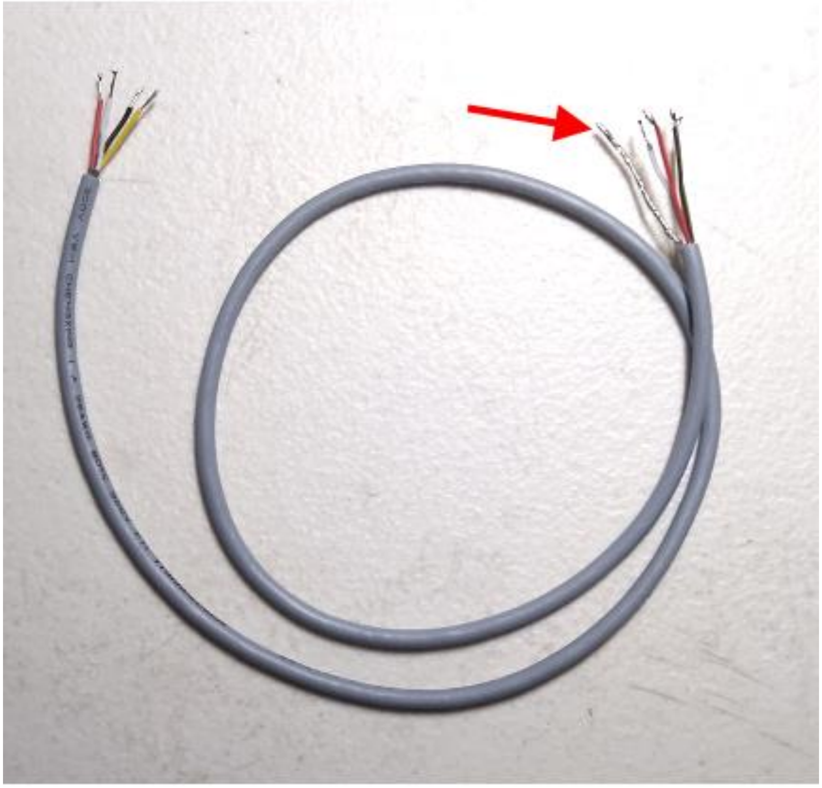
This sets the encoder to a resolution of 512 steps per revolution or 1024 PR for both channels.



Install AMT-103 encoder on to J3 motor as shown.

Encoder will snap into the plastic base.

Then plug encoder wire into J3 encoder.



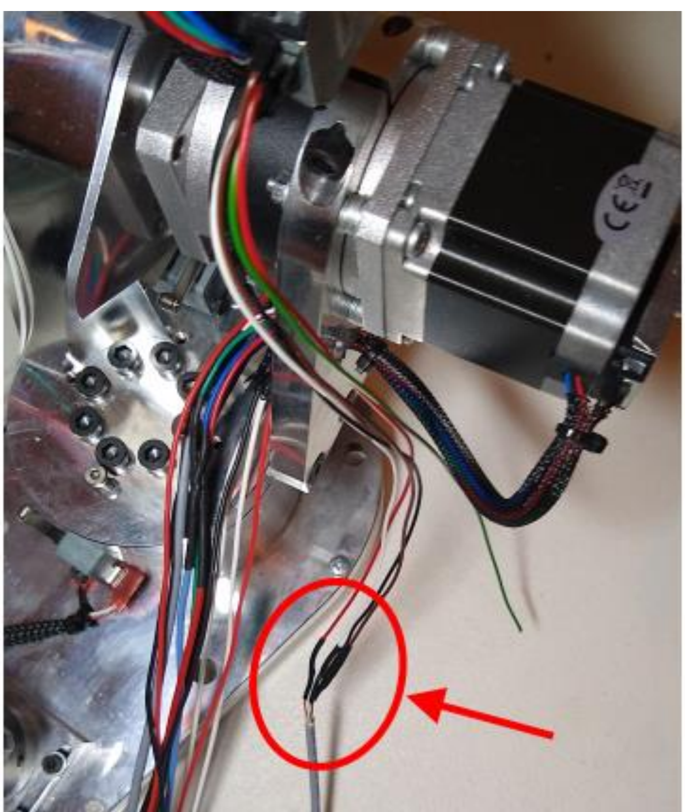
Cut 26awg shielded 4 conductor control cable to a length of 56cm (22”) long.

Carefully score outer jacket with razor knife, remove 2.5cm (1”) of the grey outer jacket on both ends of cable. (be careful to not damage wires or shielding when removing jacket.

On one end of the cable cut and remove the shielding wires, on the other end twist them together to create a ground wire. (red arrow).

Strip ends of all wires and pre-apply solder to ends of wires on both ends of cable – including the ground wire. (this is also known as tinning the wires).

.

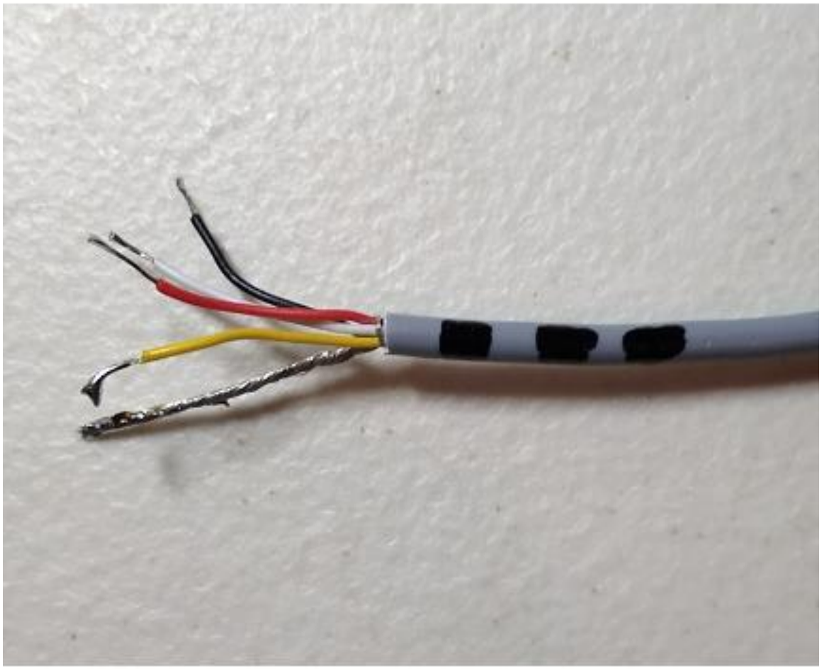


Solder and heat shrink the J3 encoder wires to the 26awg control wires as follows:

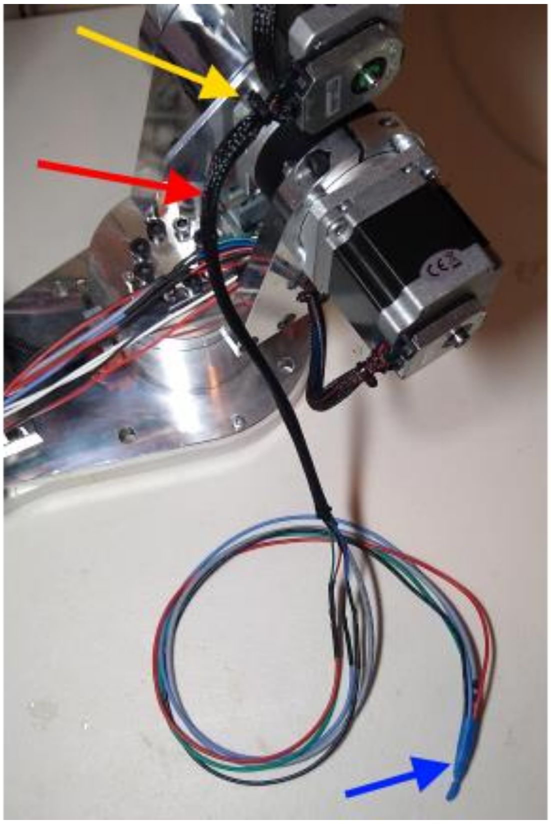
- **Red** goes to **red**
- **Black** goes to **black**
- **White** goes to **white**
- **Brown** goes to **yellow**

The green wire coming from the encoder will not be used.

The twisted ground wires are on the opposite end of cable that will be routed into base enclosure.



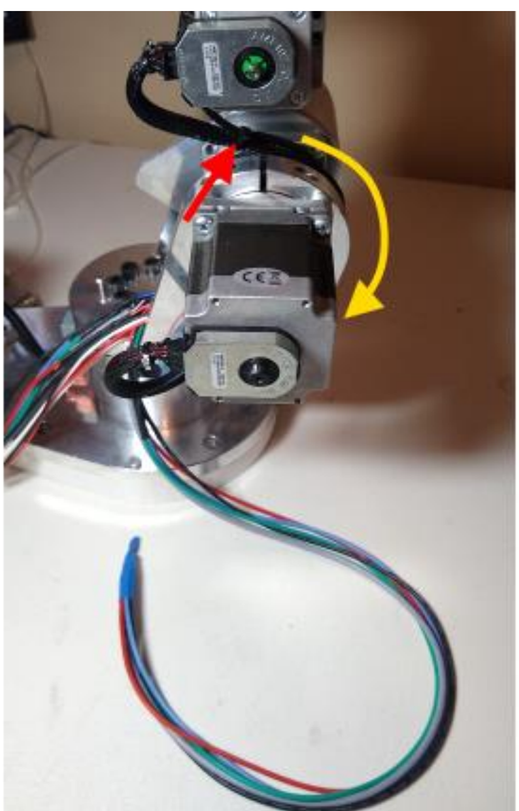
Use a marker to put (3) stripes on opposite end of cable indicating the cable is for joint 3 so that you will know these are for J3 when wires have been routed inside enclosure.



Cut length of ¼” braided sleeve to length of 26cm (10”) long (red arrow).

Wrap ends of J3 motor wires and J3 encoder wires with painters tape (blue arrow) and then route all J3 wires through braided sleeve.

Secure braided sleeve to wires at motor base using small cable tie (yellow arrow).



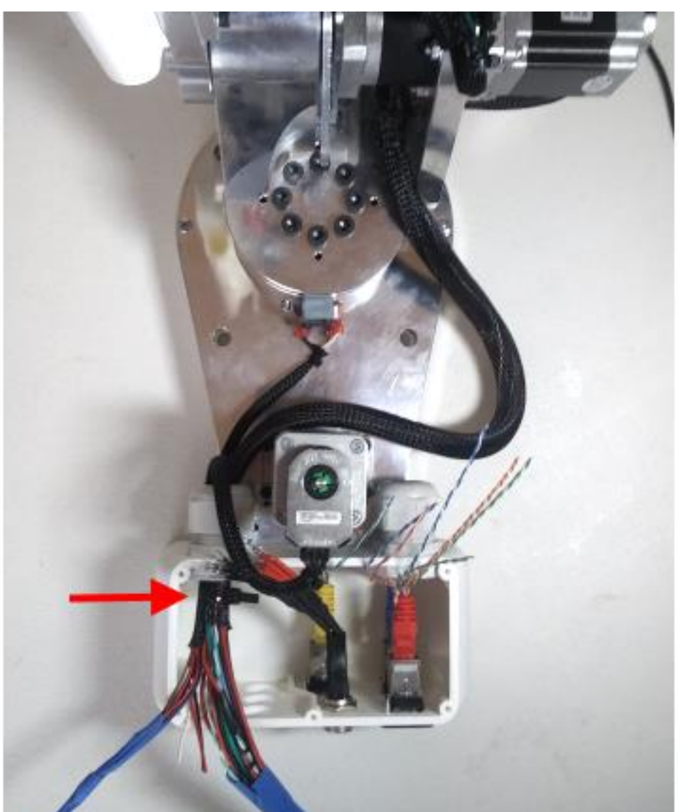
Route J3 wires over the J2 gear box and through center of robot joining the other J2 wires (yellow arrow).

Secure the J3 motor/encoder wire bundle to the J3 encoder wires with small cable tie (red arrow).

Cut length of ½” braided sleeve to length of 51cm (20”) long.

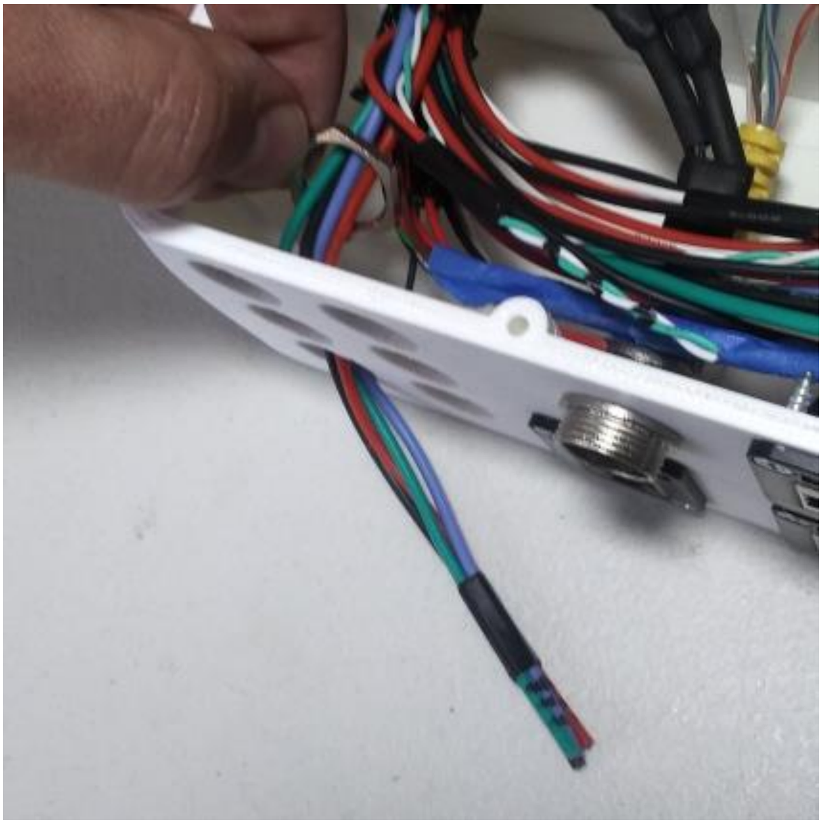
Wrap ends of all J2 and J3 wires with painters tape and then route all wires through braided sleeve.

Wrap small cable tie around end of braided sleeve so that it is tight to the bundle of wires (yellow arrow).

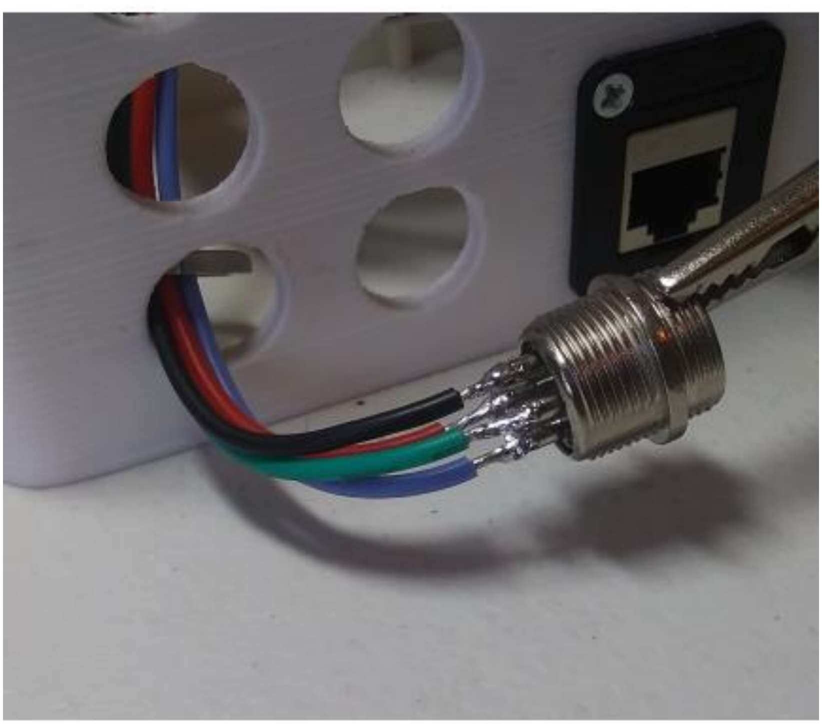


Route the J2 wire loom, The J1 motor wires and the J1 encoder wires into the left enclosure gland nut as shown.

Wrap a large cable tie around all 3 wire bundles inside enclosure to keep wire bundles from pulling back out of enclosure (red arrow).

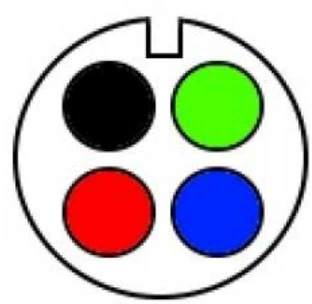


Route red, black, green & blue 18awg J3 motor wires through nut from a GX16-4 aviation plug and then through the bottom left hole of enclosure as shown.



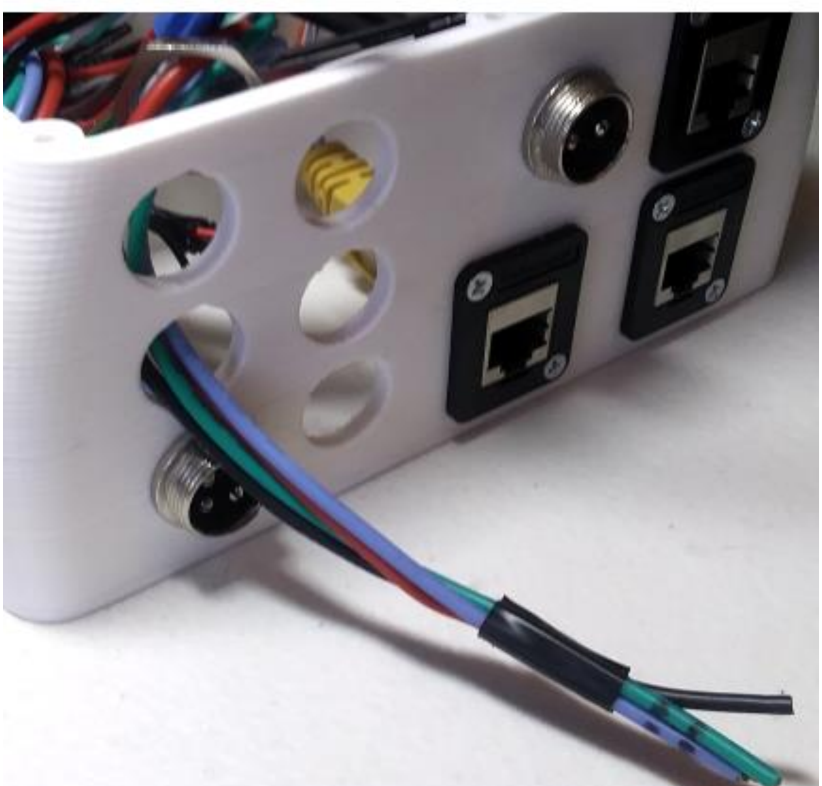
Solder motor wires to GX16-4 aviation plug as shown.

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.

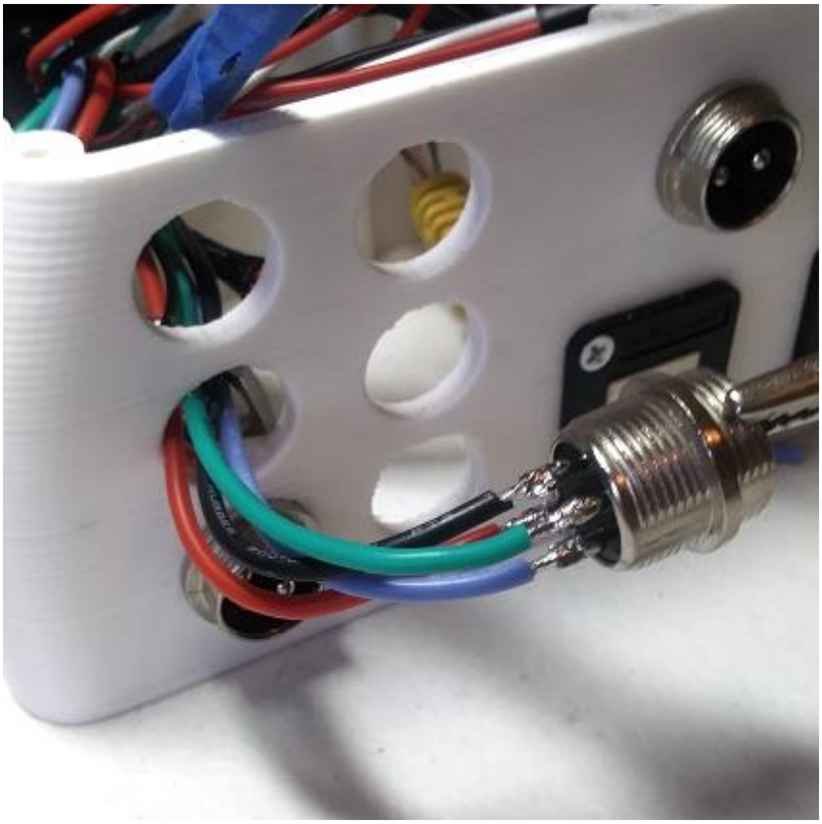


VIEW FROM BACKSIDE OF CONNECTOR

Install J3 plug into enclosure and tighten nut from backside.

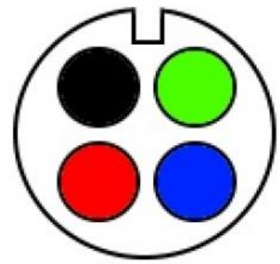


Route red, black, green & blue 18awg J2 motor wires through nut from a GX16-4 aviation plug and then through the middle left hole of enclosure as shown.

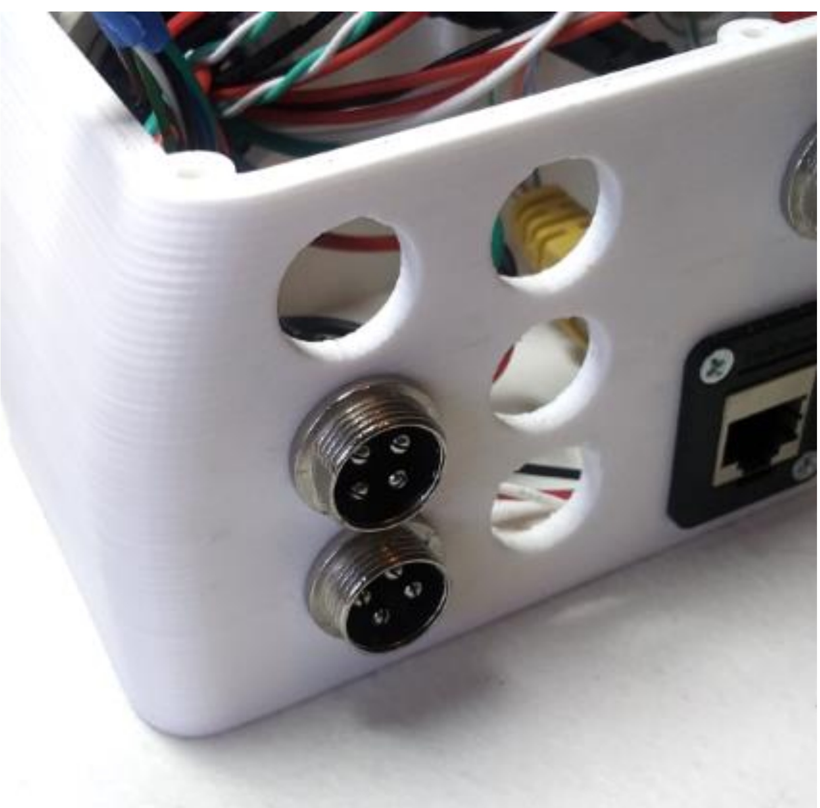


Solder motor wires to GX16-4 aviation plug as shown.

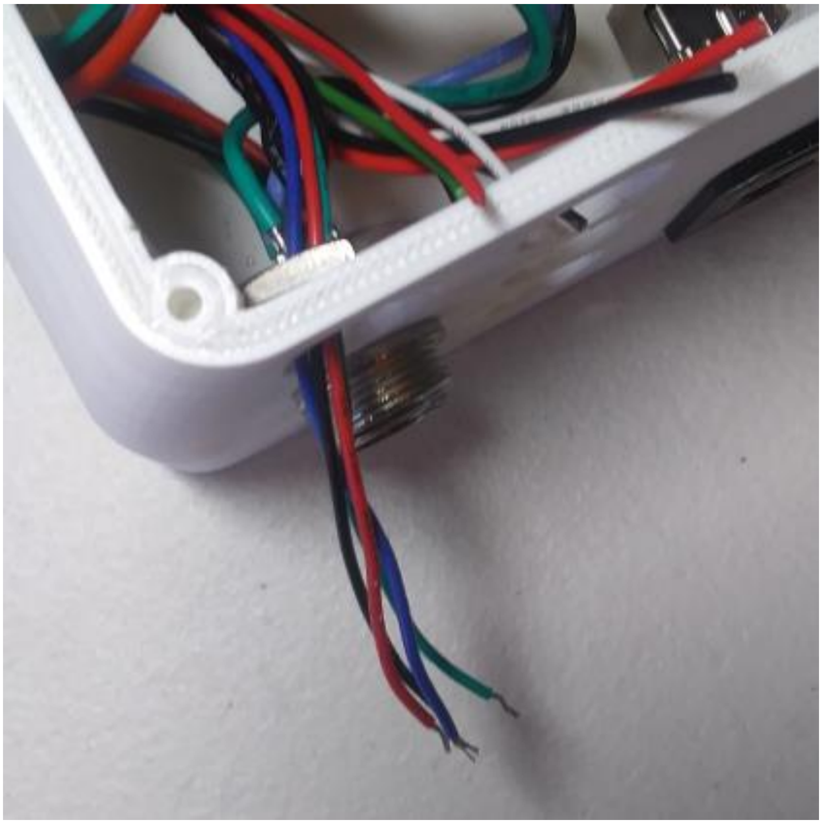
View from back of connector with notch up solder black to upper left, green to upper right, red to lower left and blue to lower right.



VIEW FROM BACKSIDE OF CONNECTOR



Install J2 plug into enclosure and tighten nut from backside.

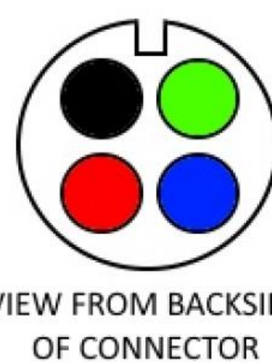


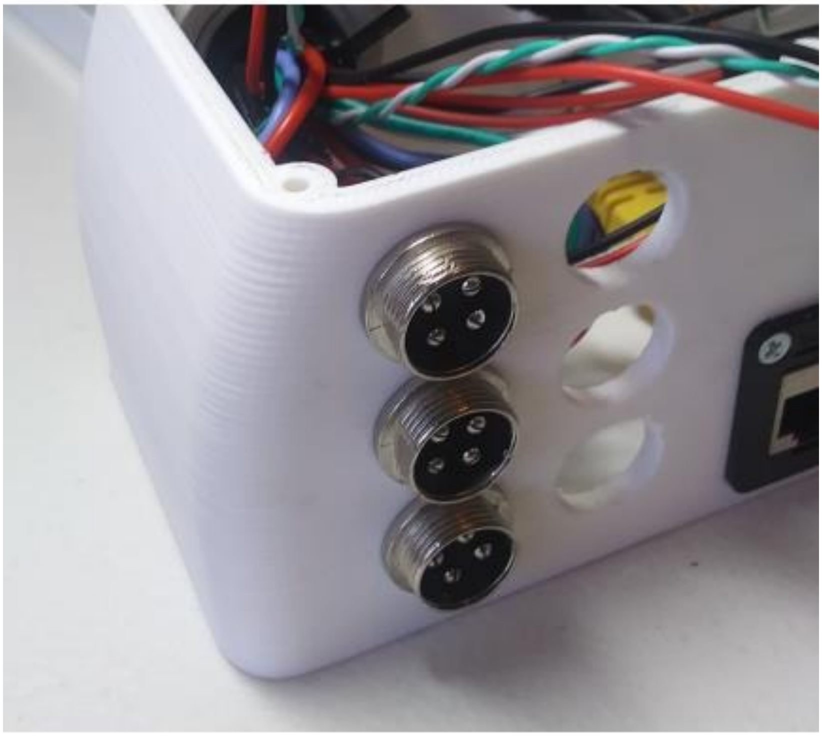
Route red, black, green & blue J1 motor wires through nut from a GX16-4 aviation plug and then through the middle left hole of enclosure as shown.

These are the factory wires from the J1 motor.

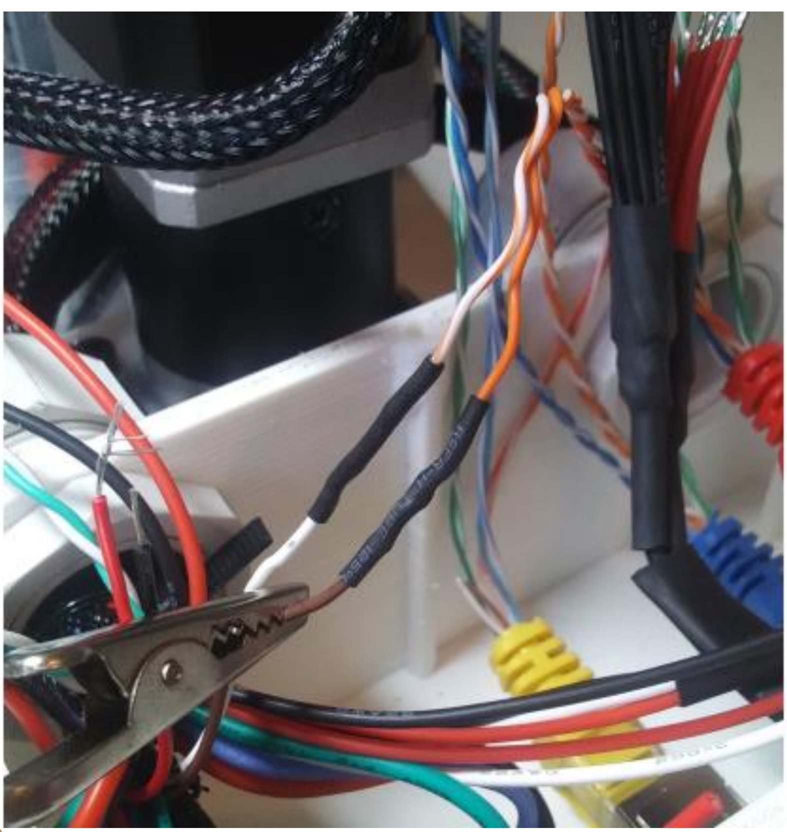
Solder motor wires to GX16-4 aviation plug as shown.

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.





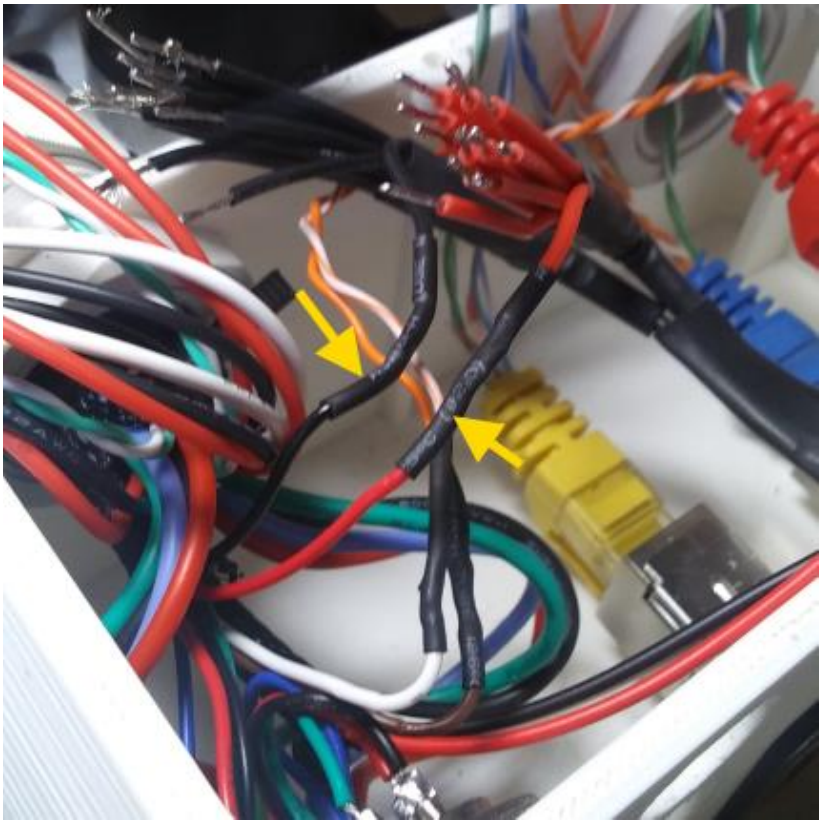
Install J1 plug into enclosure and tighten nut from backside.



Solder and heat shrink the J1 encoder A-B wires to the Red Ethernet cable A-B wires for J1 (orange – orange stripe).

- Encoder white wire goes to Red Ethernet cable - white with orange stripe wire.
- Encoder brown wire goes to Red Ethernet cable - orange wire.

(ALSO SEE THE WIRING DIAGRAMS IN CHAPTER 4)

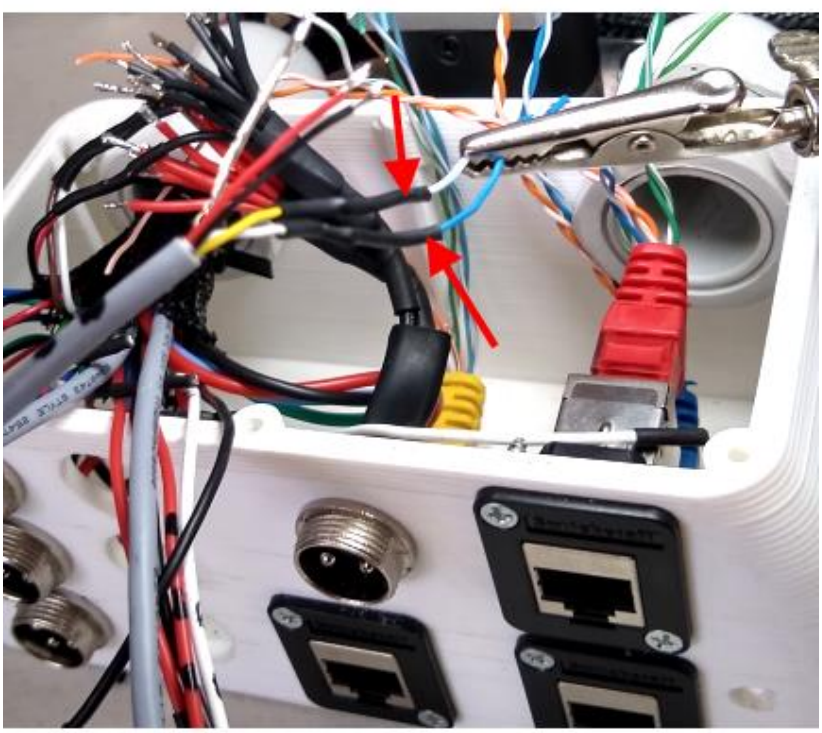


Solder and heat shrink the 5vdc red and black wires from the J1 encoder to one of the red and black 5vdc source bundle wires.

- Black wire from J1 encoder goes to one of the black wires from -5vdc bundle.

- Red wire from the J1 encoder goes to one of the red wires from the 5vdc bundle.

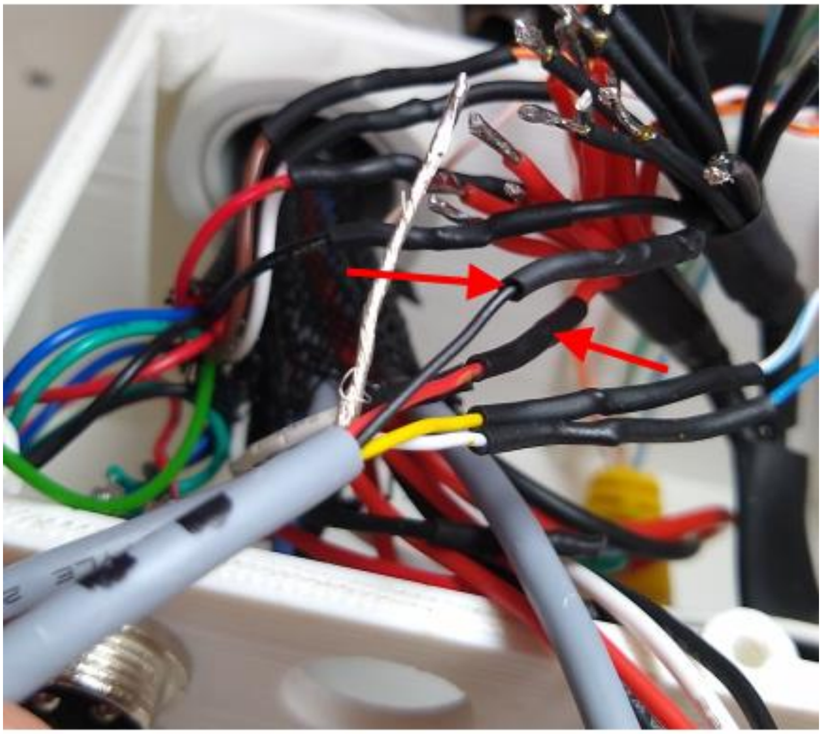
(ALSO SEE THE WIRING DIAGRAMS IN CHAPTER 4)



Solder and heat shrink the J2 encoder A-B wires to the Red Ethernet cable A-B wires for J2 (blue-blue stripe).

- Encoder cable white wire goes to Red Ethernet cable – blue wire.
- Encoder cable yellow wire goes to Red Ethernet cable – white with blue stripe wire.

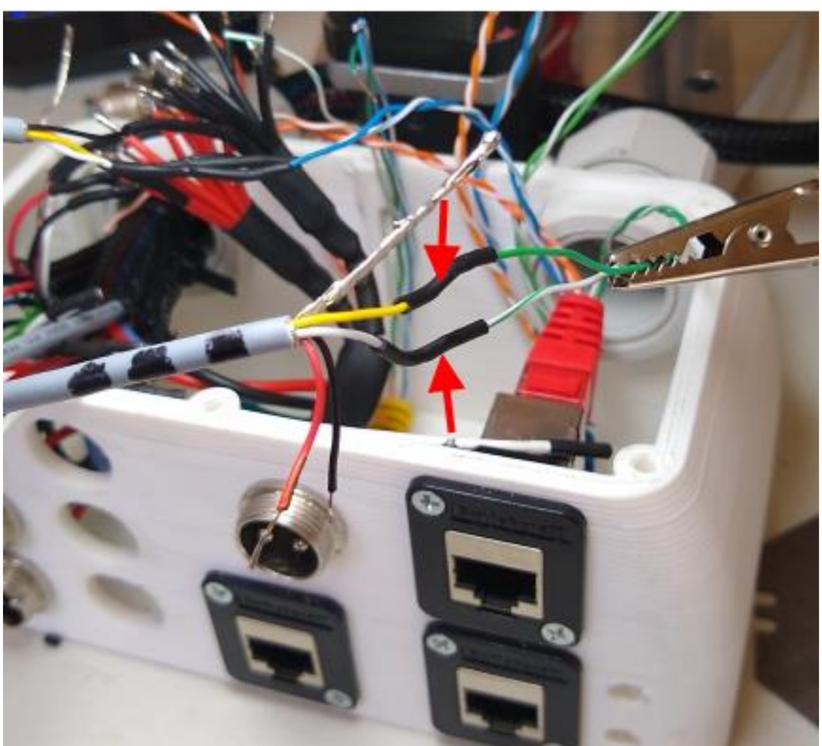
(ALSO SEE THE WIRING DIAGRAMS IN CHAPTER 4)



Solder and heat shrink the 5vdc red and black wires from the J2 encoder cable to one of the red and black 5vdc source bundle wires.

- Black wire from J2 encoder goes to one of the black wires from -5vdc bundle.
- Red wire from the J2 encoder goes to one of the red wires from the 5vdc bundle.

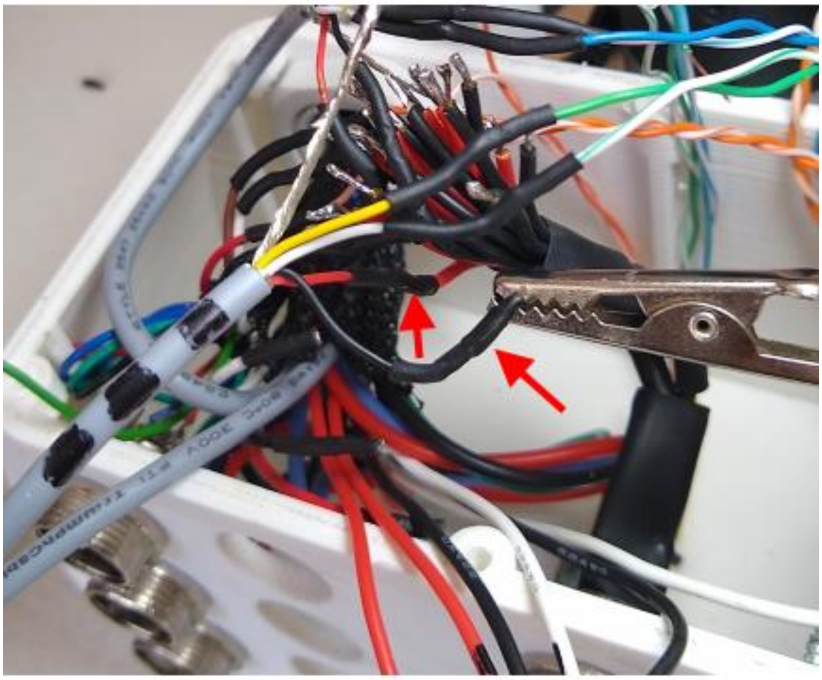
(ALSO SEE THE WIRING DIAGRAMS IN CHAPTER 4)



Solder and heat shrink the J3 encoder A-B wires to the Red Ethernet cable A-B wires for J3 (green-green stripe).

- Encoder cable white wire goes to Red Ethernet cable – white with green stripe wire.
- Encoder cable yellow wire goes to Red Ethernet cable – green wire.

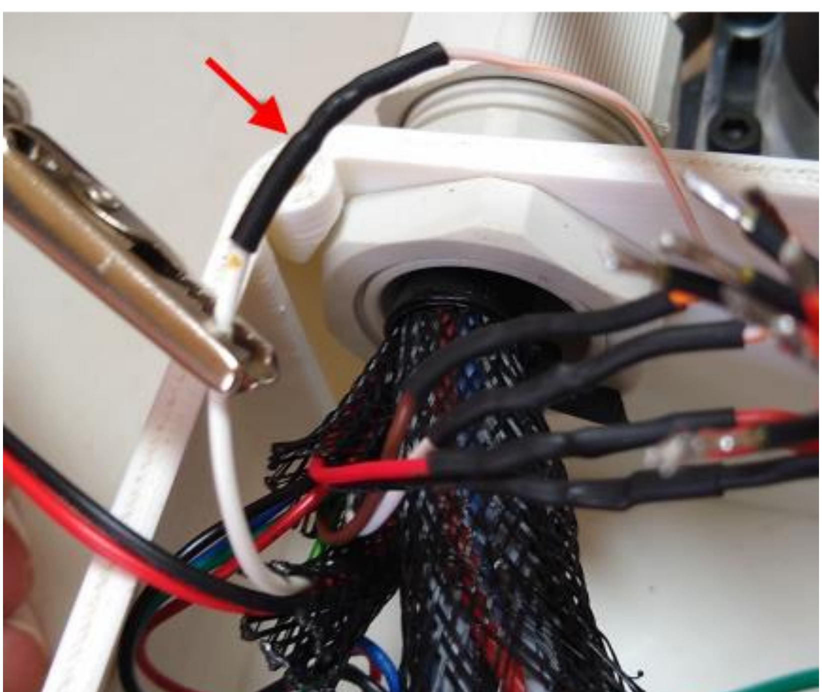
(ALSO SEE THE WIRING DIAGRAMS IN CHAPTER 4)



Solder and heat shrink the 5vdc red and black wires from the J3 encoder to one of the red and black 5vdc source bundle wires.

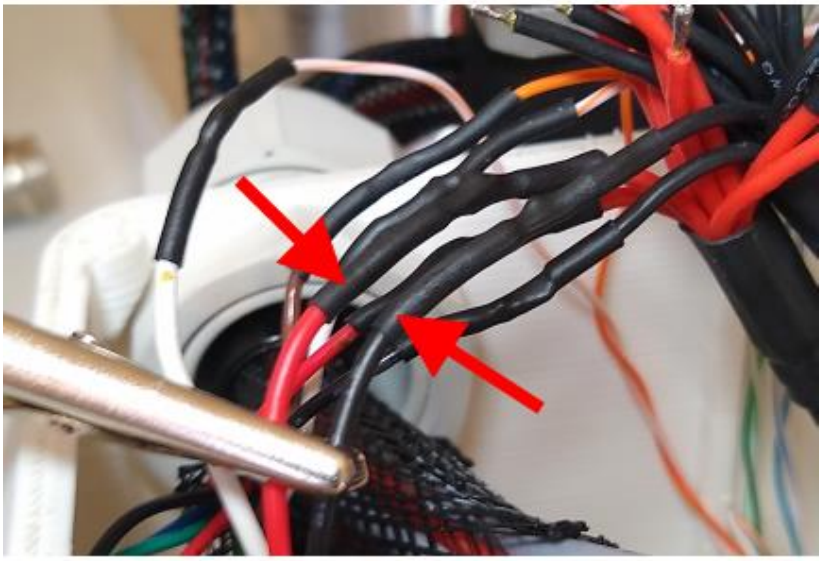
- Black wire from J3 encoder goes to one of the black wires from -5vdc bundle.
- Red wire from the J3 encoder goes to one of the red wires from the 5vdc bundle.

(ALSO SEE THE WIRING DIAGRAMS IN CHAPTER 4)



Solder and heat shrink the J1 limit switch signal wire (white) to the yellow Ethernet cable wire for J1 (white with orange stripe)

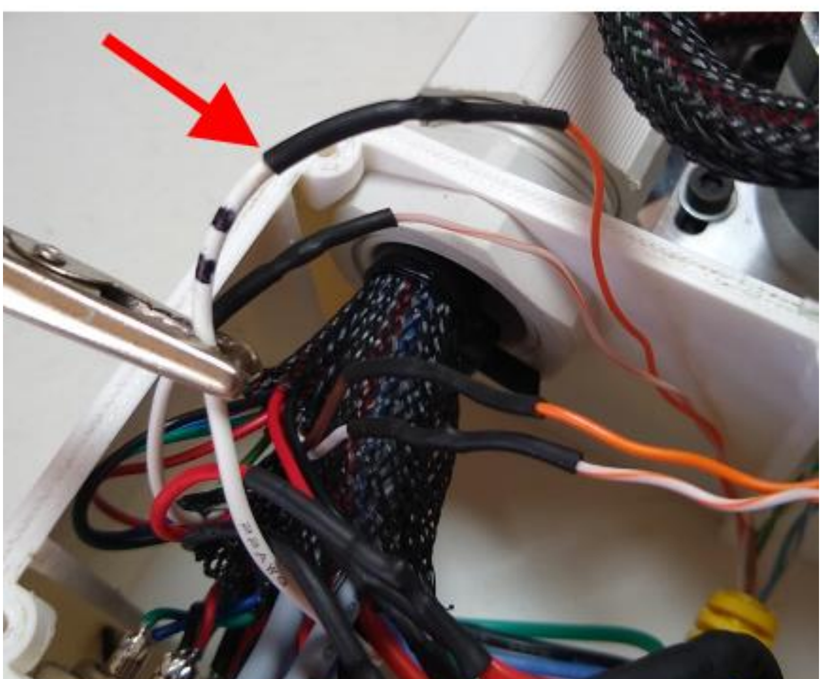
(ALSO SEE THE WIRING DIAGRAMS IN CHAPTER 4)



Solder and heat shrink the 5vdc red and black wires from the J1 limit switch to one of the red and black 5vdc source bundle wires.

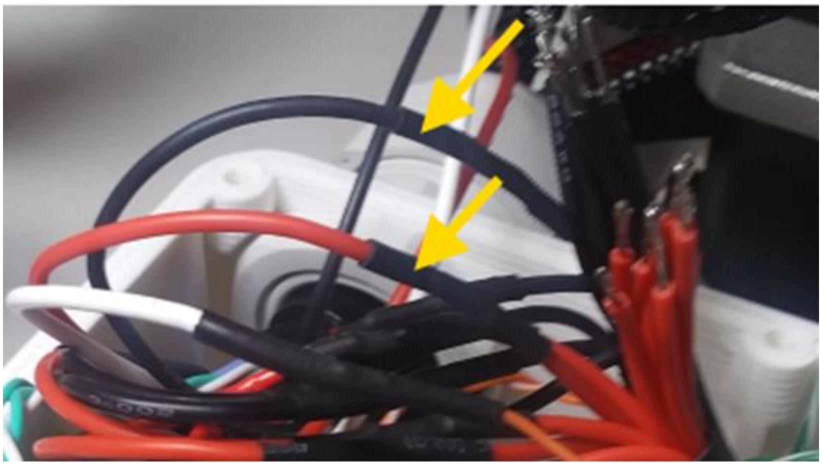
- Black wire from J1 limit switch goes to one of the black wires from -5vdc bundle.
- Red wire from the J1 limit switch goes to one of the red wires from the 5vdc bundle.

(ALSO SEE THE WIRING DIAGRAMS IN CHAPTER 4)



Solder and heat shrink the J2 limit switch signal wire (white) to the yellow Ethernet cable wire for J2 (orange)

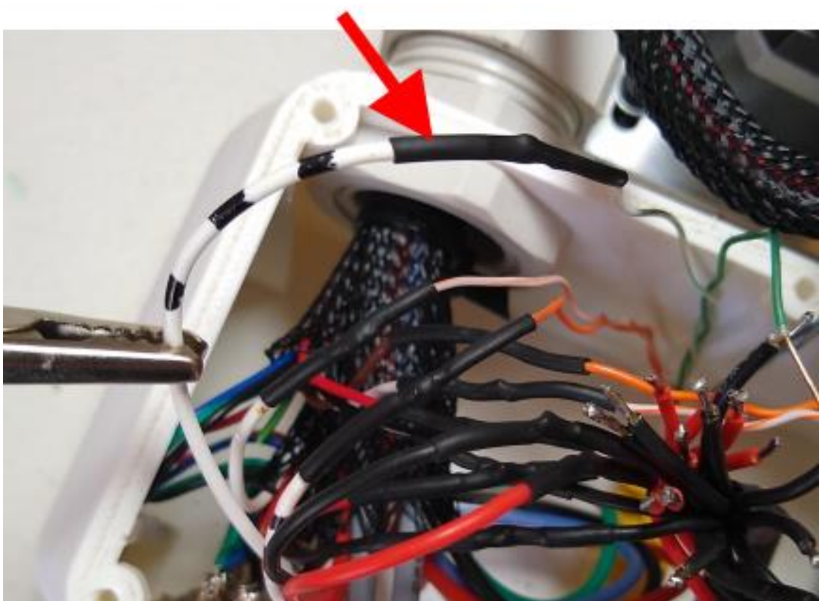
(ALSO SEE THE WIRING DIAGRAMS IN CHAPTER 4)



Solder and heat shrink the 5vdc red and black wires from the J2 limit switch to one of the red and black 5vdc source bundle wires.

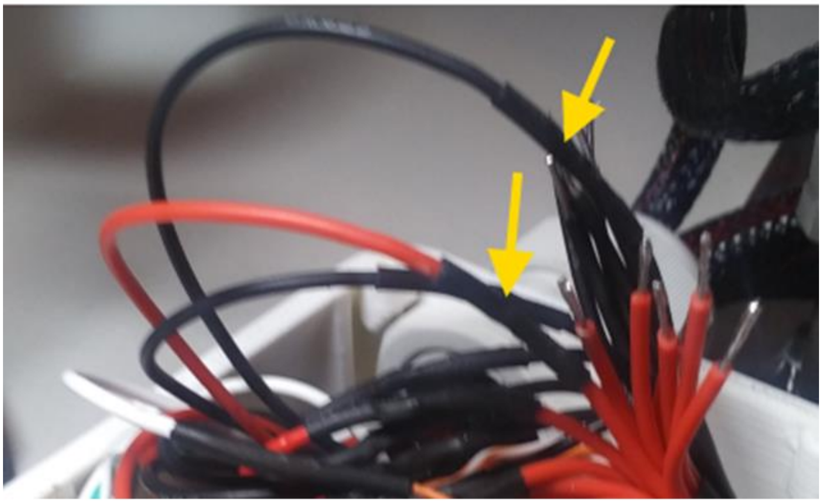
- Black wire from J2 limit switch goes to one of the black wires from -5vdc bundle.
- Red wire from the J2 limit switch goes to one of the red wires from the 5vdc bundle.

(ALSO SEE THE WIRING DIAGRAMS IN CHAPTER 4)



Solder and heat shrink the J3 limit switch signal wire (white) to the yellow Ethernet cable wire for J3 (white with green stripe).

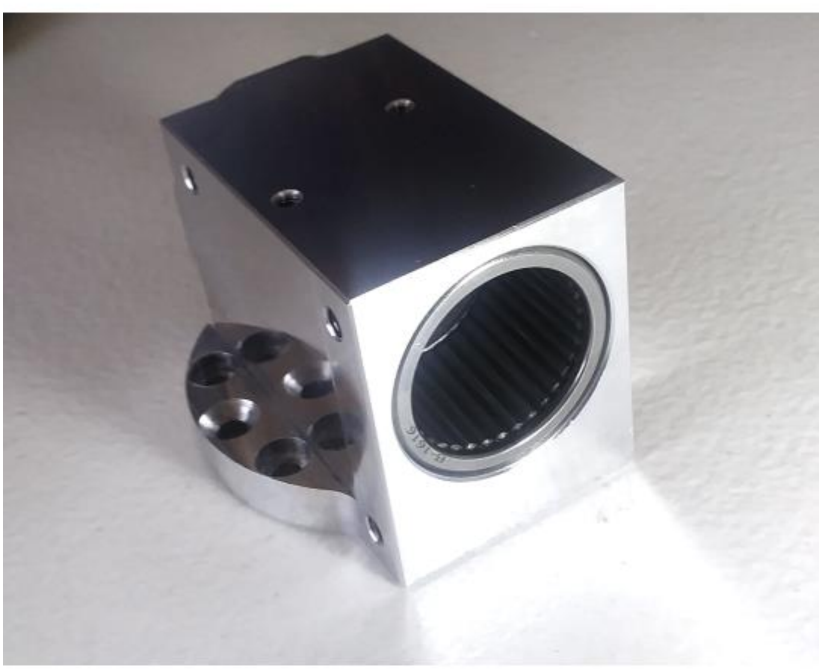
(ALSO SEE THE WIRING DIAGRAMS IN CHAPTER 4)



Solder and heat shrink the 5vdc red and black wires from the J3 limit switch to one of the red and black 5vdc source bundle wires.

- Black wire from J3 limit switch goes to one of the black wires from -5vdc bundle.
- Red wire from the J3 limit switch goes to one of the red wires from the 5vdc bundle.

(ALSO SEE THE WIRING DIAGRAMS IN CHAPTER 4)



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

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

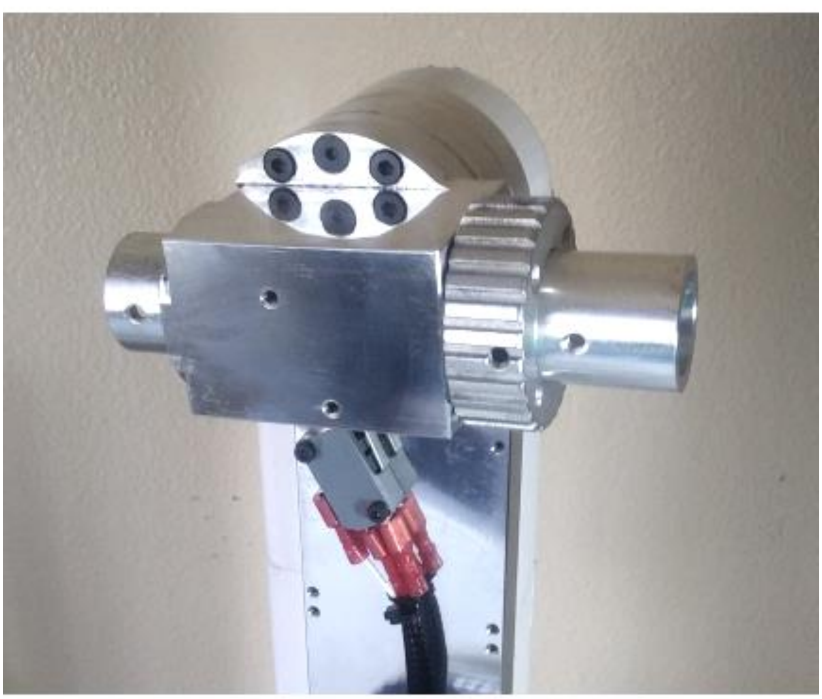
Secure J4 timing hub to J4 main shaft using (4) M4x5 set screws.

Note that one of the set screws needs to seat into the 2nd hole in J4 main shaft.

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.

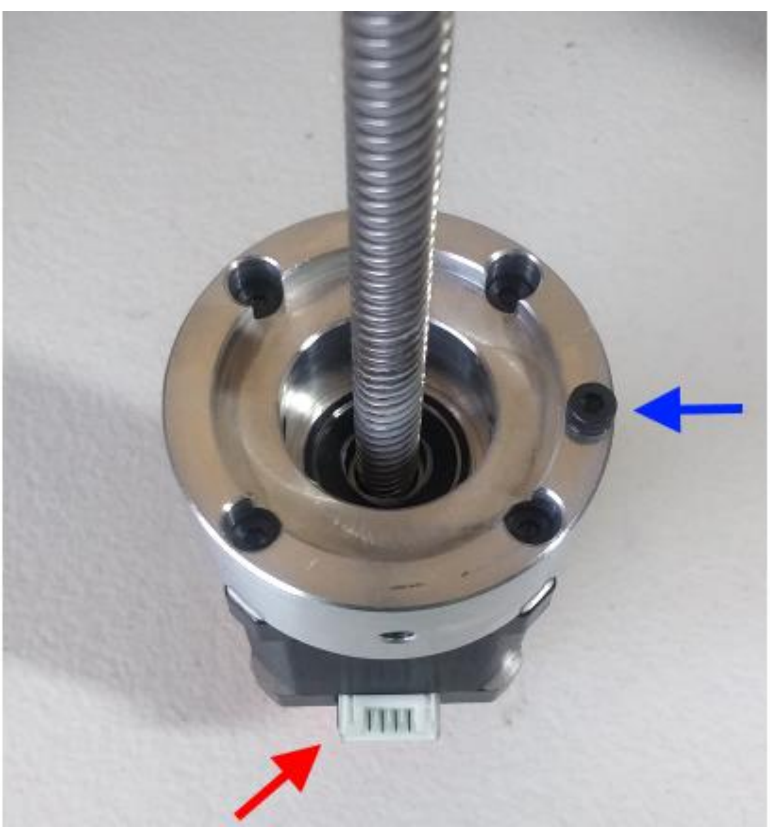


Install J4 tube / timing hub assembly into the J4 turret as shown.

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.

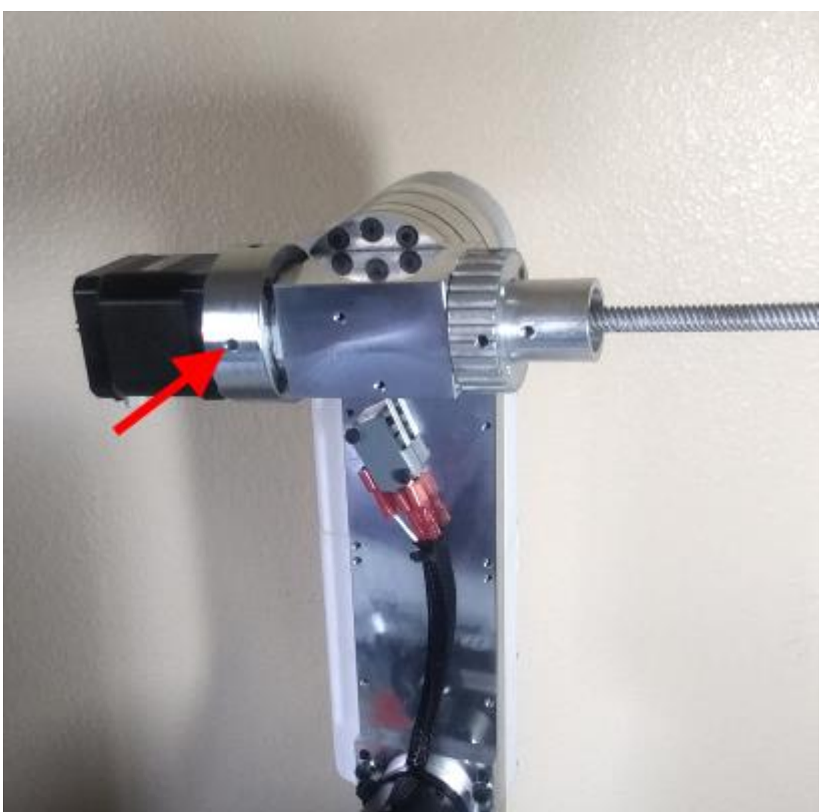
Note the motor connector is facing downward (red arrow) and the timing lug screw is 90° to the right (blue arrow).

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.

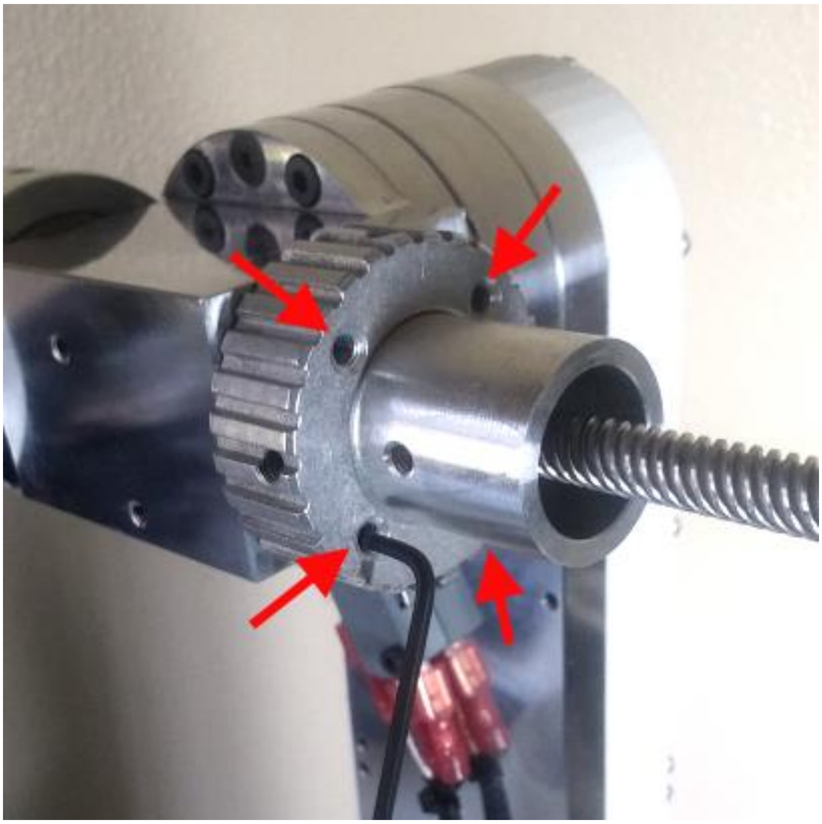
Install (1) NTA1625 (1” ID) need roller bearing over J5 motor shaft and into J5 motor mount recess as shown.

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.

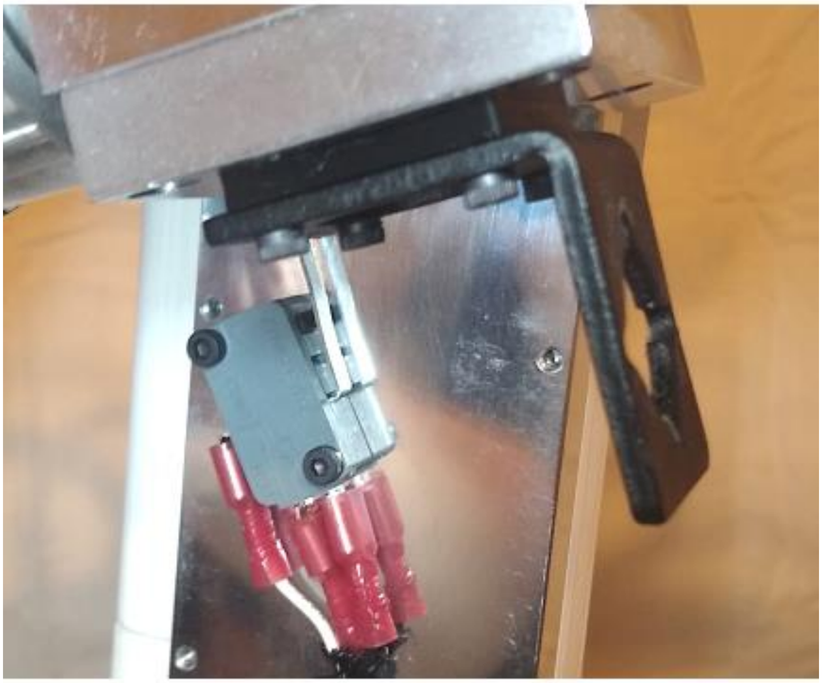
Be careful that bearings stay in place in J5 motor mount and slide over the end of the J4 main tube. When J5 motor mount is fully seated over J4 main tube and bearings are flush to J4 housing secure J5 motor mount to J4 tube using (4) M4x10 set screws. With motor connector facing down the set screw facing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

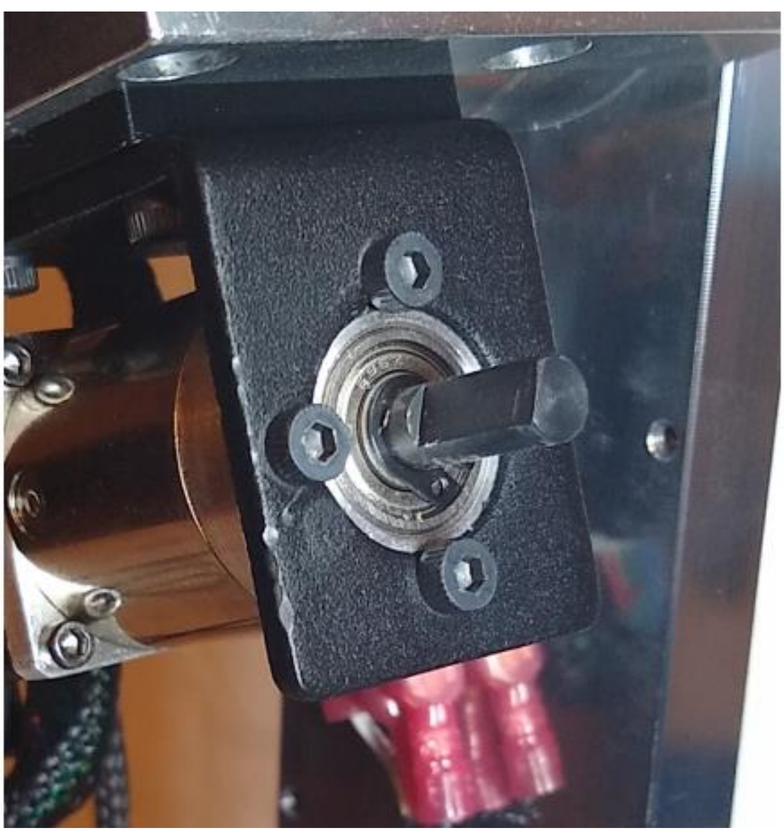
Install J4 motor mount / limit switch contact block as shown and secure with (3) M4x10 socket head cap screws.



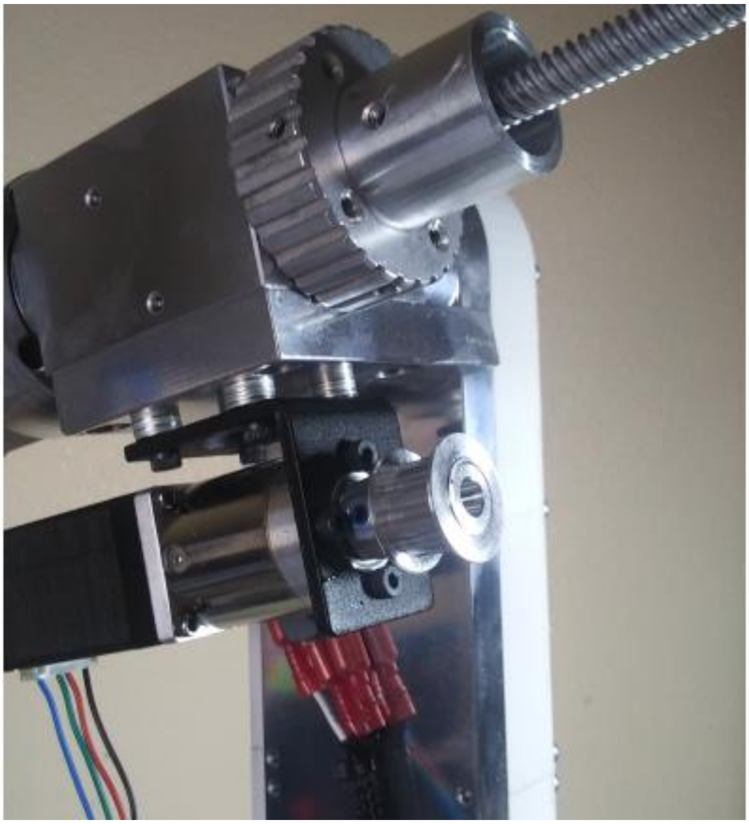
Install Nema 11 motor mount bracket as shown, place the 3D printed part “J4 motor spacer – 4mm” between the bracket and the aluminum.

Secure with (4) M3x14 socket head cap screws.

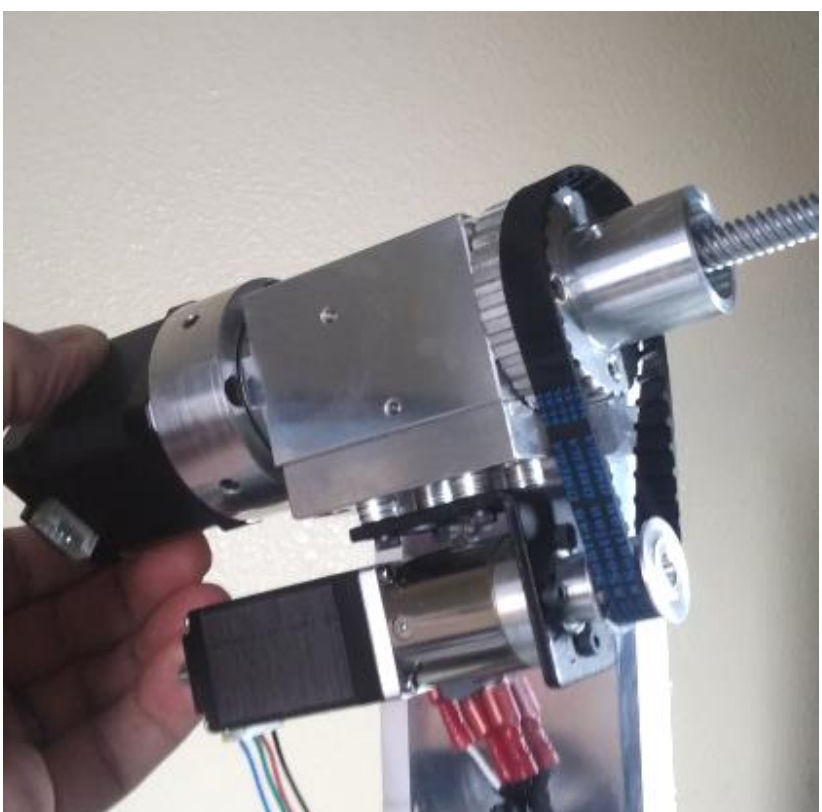
The covers and spacers print files comes with 2mm, 3mm, 4mm and 5mm thicknesses of the “J4 motor spacer” so that you have some options to tension the belt given variation in the belt. If you are printing a 3D printed version I have found the 2mm spacer may fit best depending on your printer and filament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



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



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.

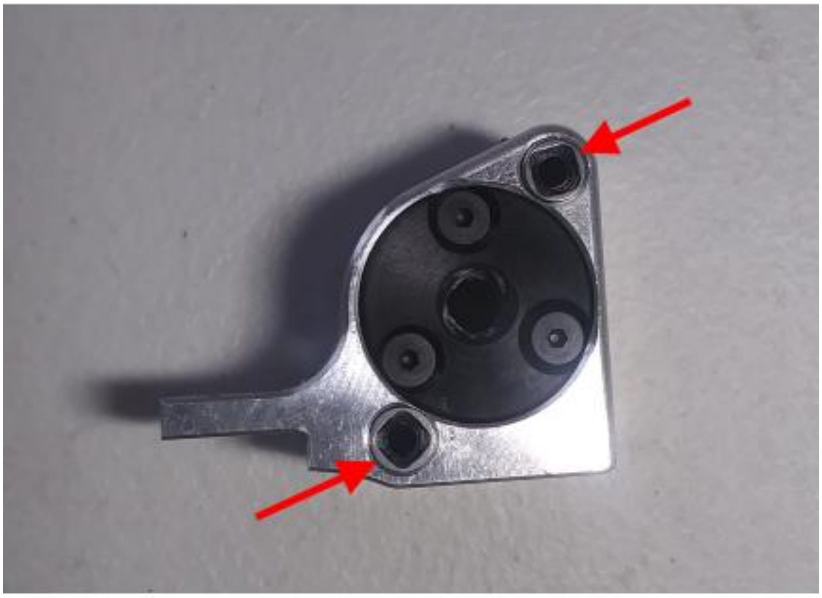
Install POM nut into the J5 carrier as shown and secure with (3) M3x10 flat head screws.

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

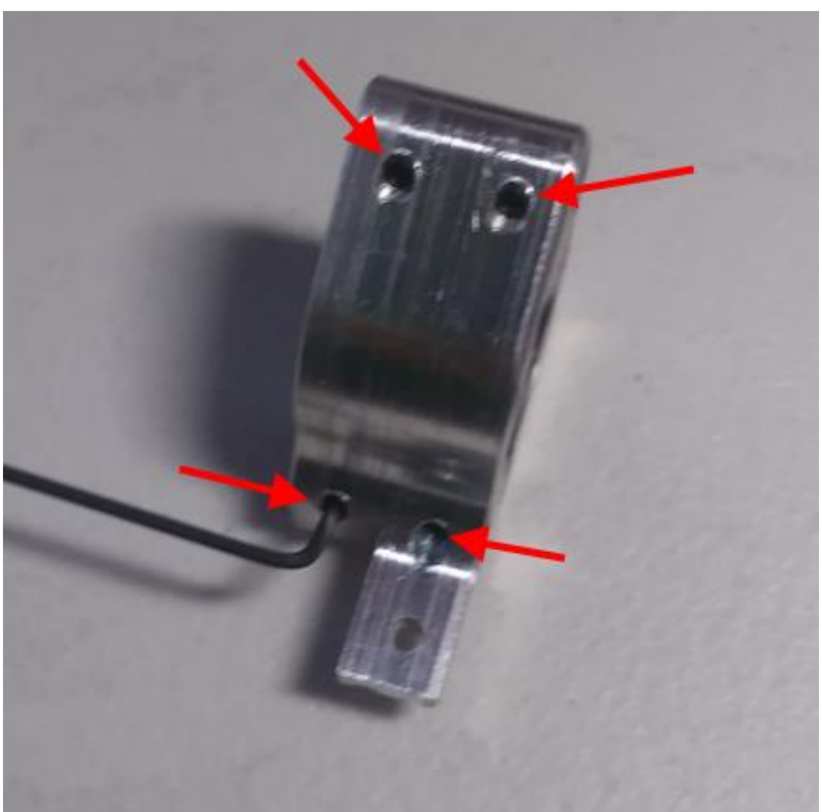
- the inner ball bearings can be dislodged if forced.

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.

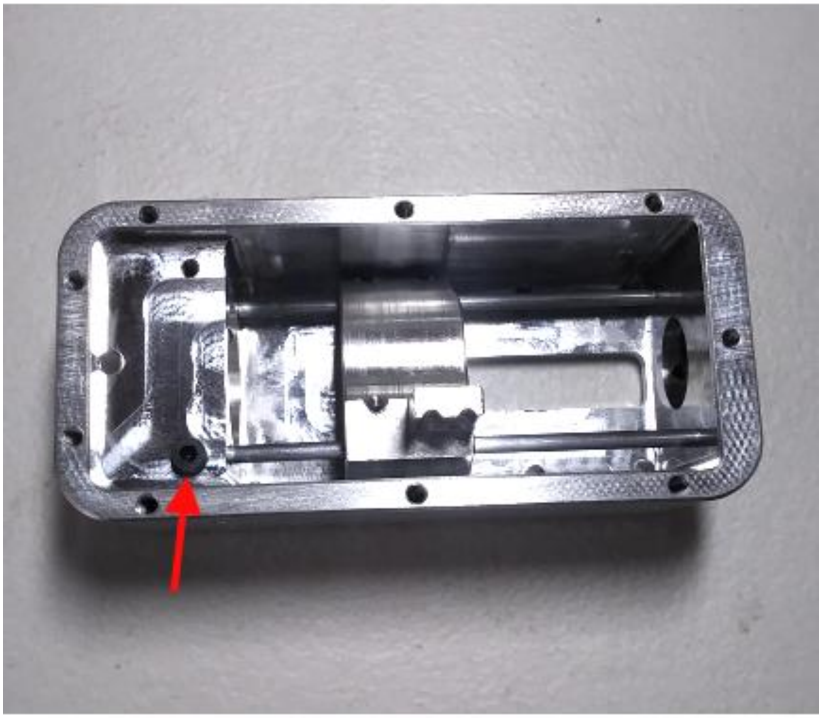
Install 2 bearings per side – pictures shown 2 installed on front side of carrier, also install 2 on back side.



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

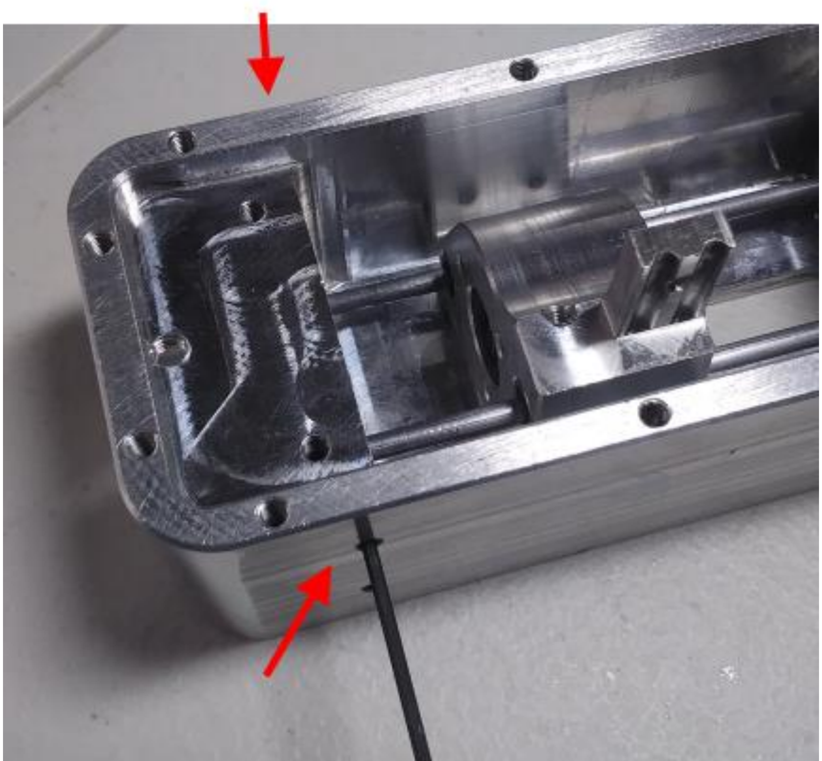
The rods that come with the hardware kit are already 85mm long but if you have sourced your own rods they typically come in lengths of 100mm and you would need to use an abrasive saw to cut (2) 3mm linear rods down to 85mm in length.

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



Temporarily install M4x8 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.

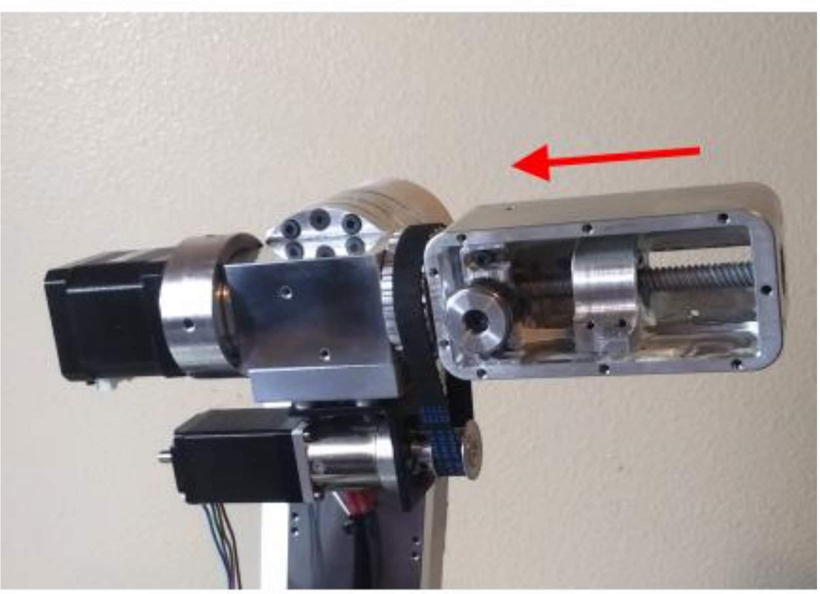
Install the J5 idler tension block and secure with (2) M3x8 socket head cap screws.

Install HK1612 bearing over the J5 bearing post as shown.

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

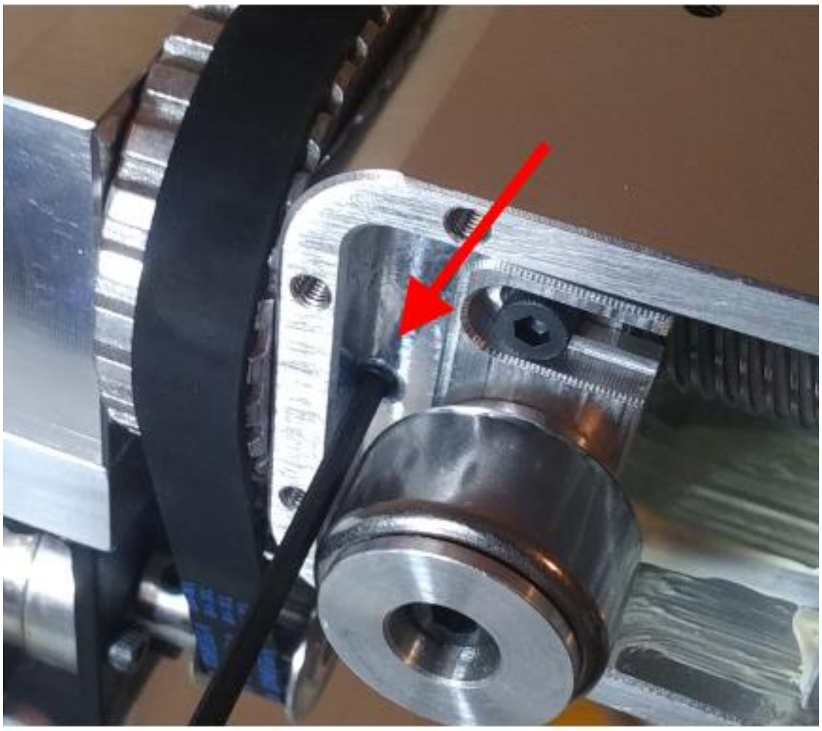
Install 688Z bearing in end of J5 housing as shown and then secure with (2) M3x6 set screws from each side.

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

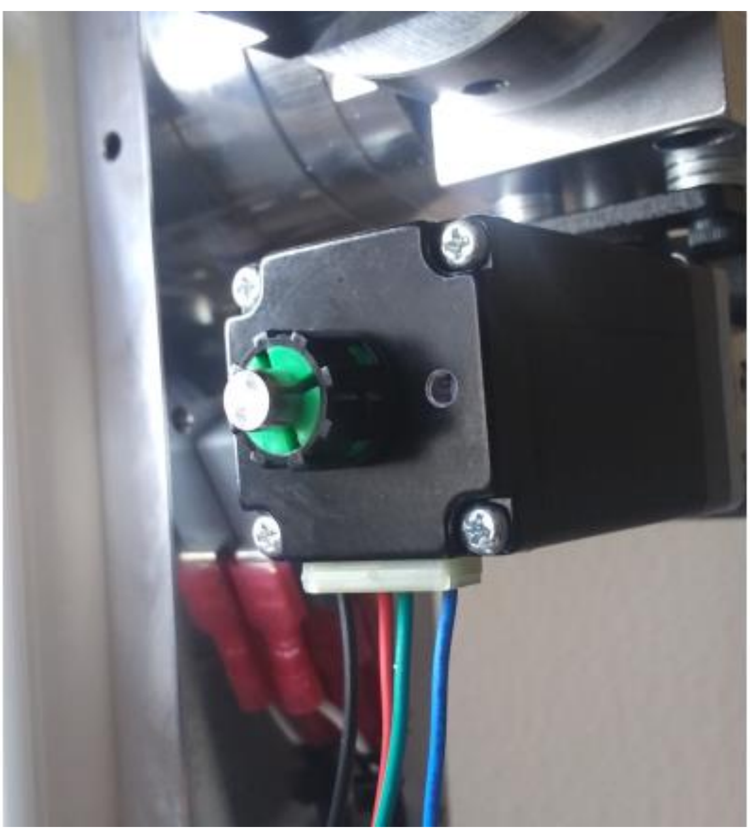


Slide J5 housing assembly forward onto J4 main tube until fully seated against J4 timing hub.

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 M4x5 set screw (red arrow) to secure J5 housing to J4 main tube, make sure screw threads into hole in J4 main shaft to ensure clocking is correct.



Install the green (.197”) AMT-102 encoder sleeve on to the J4 motor as shown.

Please review the assembly instructions provided with the AMT-102 encoder.

Use (2) M3x5 flat head screws to mount the ENC-AMT102 base to the top of the J4 motor as shown.

Set dip switch settings on AMT-102 encoder as follows:

Switch 1 = Off

Switch 2 = Off

Switch 3 = Off

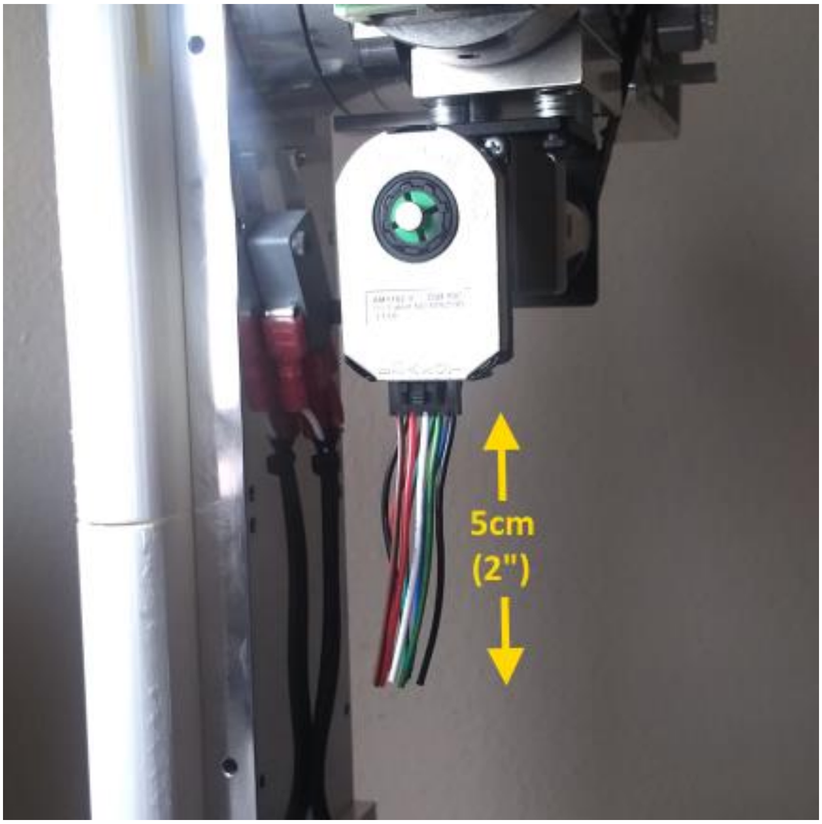
Switch 4 = **On**

This sets the encoder to a resolution of 512 steps per revolution or 1024 PR for both channels.

Install AMT-103 encoder on to J4 motor as shown.

Encoder will snap into the plastic base.

Install encoder wire end into J4 encoder as shown.



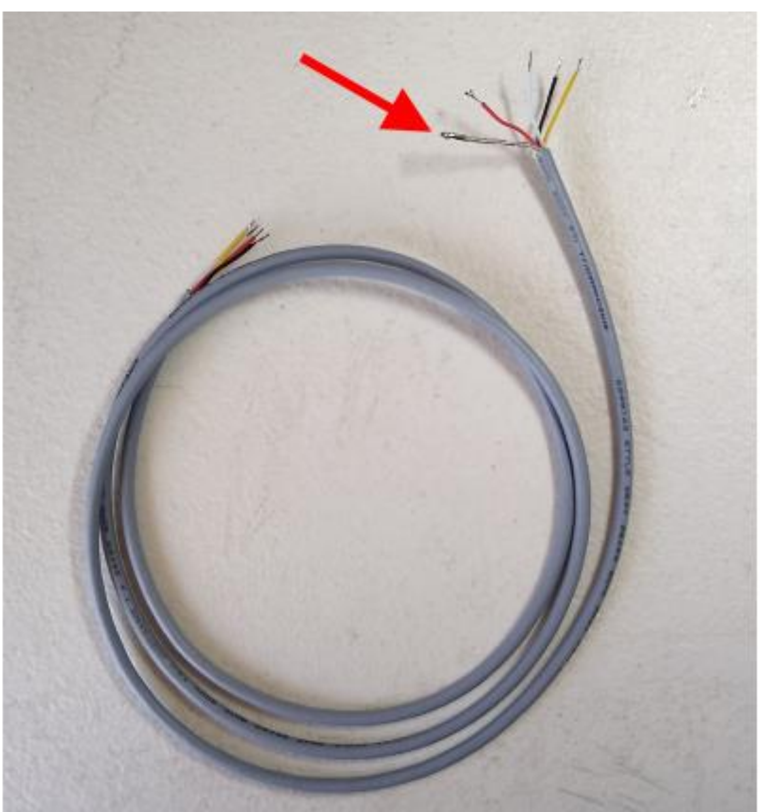
Cut J4 motor and encoder wires down to length of 5cm (2”) as shown.

Cut Red, Black, Blue & Green 18awg wires to a length of 107cm (42”) long

Solder and heat shrink 107cm (42”) long extension wires to the J4 motor wires as shown.

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

Tape ends of J4 motor wires together and use marker to mark wires with (4) stripes so that you will know these are for J4 when wires have been routed inside enclosure

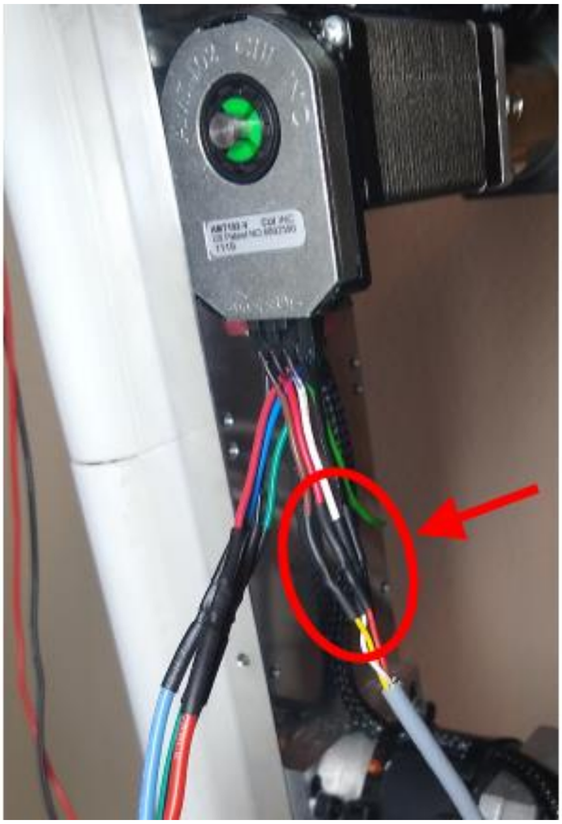


Cut 26awg shielded 4 conductor control cable to a length of 107cm (42”) long.

Carefully score outer jacket with razor knife, remove 2.5cm (1”) of the grey outer jacket on both ends of cable. (be careful to not damage wires or shielding when removing jacket.

On one end of the cable cut and remove the shielding wires, on the other end twist them together to create a ground wire. (red arrow).

Strip ends of all wires at both ends of cable and pre-apply solder to ends of wires – including the ground wire. (this is also known as tinning the wires).



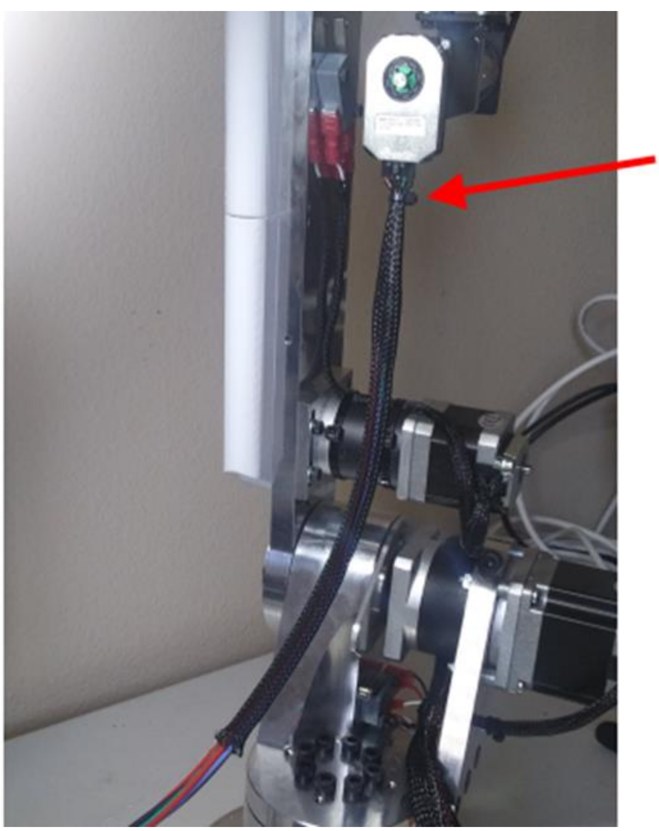
Solder and heat shrink the J4 encoder wires to the 26awg control wires as follows:

- **Red** goes to **red**
- **Black** goes to **black**
- **White** goes to **white**
- **Brown** goes to **yellow**

The green wire coming from the encoder will not be used.

The twisted ground wires are on the opposite end of cable that will be routed into base enclosure.

Use a marker to put (3) stripes on opposite end of cable indicating the cable is for joint 3 so that you will know these are for J3 when wires have been routed inside enclosure.



Cut length of ¼” braided sleeve to length of 26cm (10”) long.

Route braided sleeve over J4 motor and encoder wires as shown.

Secure sleeve with small cable tie (red arrow)

Secure wires and sleeve to left side of J4 motor using large cable tie as shown (red arrow).

Route J4 wires and sleeve into side slot of upper arm spacer as shown.

Make sure there is enough slack or arch in wires that arch comes level with J5 motor mount (dashed line).

Cut lengths of red, black and white 22awg wire to lengths of 112cm (44”) long.

Crimp quick disconnect to the end of each wire.

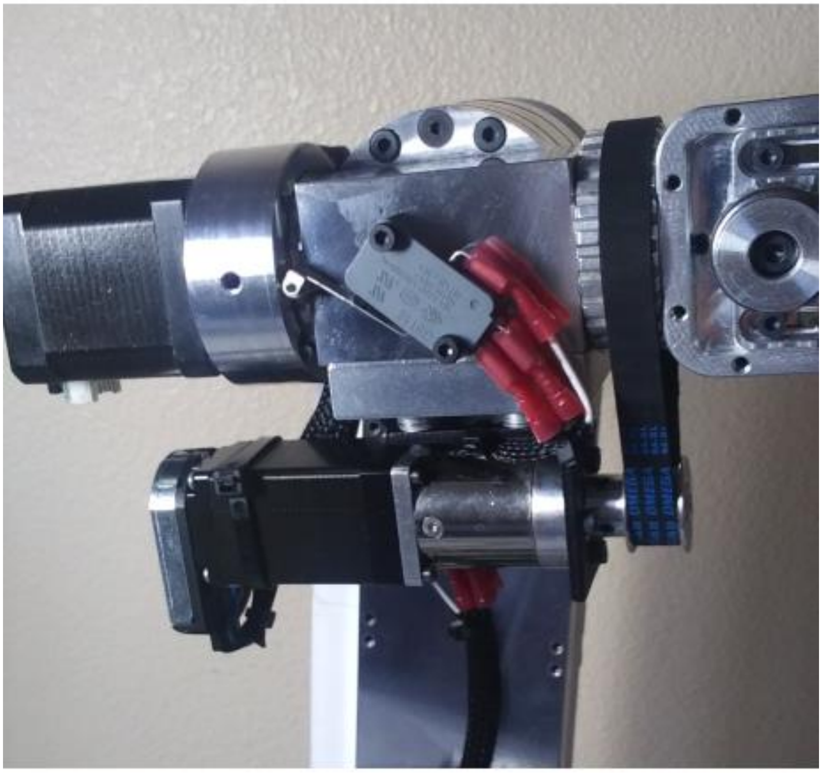
Install wires with quick disconnects onto SV-166-1C25 roller tip limit switch

Be sure to connect wires as follows:

- Black to NC2 terminal
- Red to NO3 terminal
- White to COM1 terminal

Cut length of ¼” braided sleeve to length of 28cm (11”) and slide over the 22awg wires up to limit switch as shown. Secure braided sleeve to wires with small cable tie close to quick disconnect.

Mark ends of wires with (4) stripes so you will know these are for the J4 limit switch when routed inside enclosure.



Install the J4 limit switch onto J4 turret housing as shown.

Use (2) M3x14 socket head or Philips head pan screws to secure switch inside of arm.

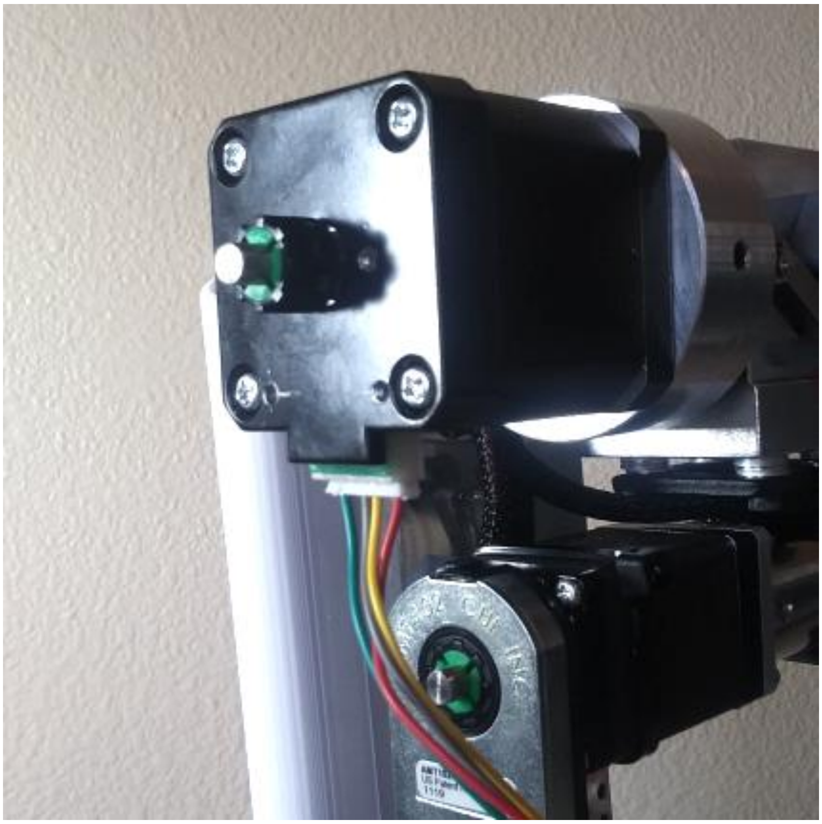
Route J4 limit switch wires and braided sleeve over J4 gear box to other side of J4 motor.

Route J4 limit wires and sleeve so that they join the J4 motor wires.

Secure J4 limit wires/sleeve to J4 motor wires with small cable tie (red arrow).

Route J4 limit wires into slot in upper J2 arm spacer (yellow arrow).

Make sure limit switch wires have the same arch and amount of slack as the J4 motor wires.



Install the green (.197”) AMT-102 encoder sleeve on to the J5 motor as shown.

Please review the assembly instructions provided with the AMT-102 encoder.

Use (4) M3x5 flat head screws to mount the ENC-AMT102 base to the top of the J5 motor as shown.

Set dip switch settings on AMT-102 encoder as follows:

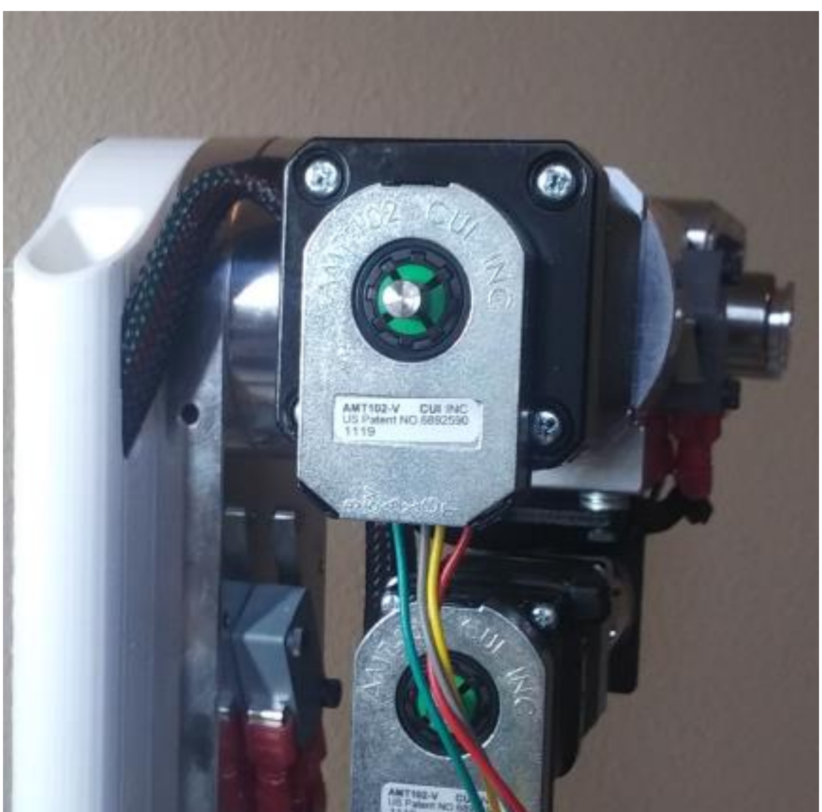
Switch 1 = Off

Switch 2 = Off

Switch 3 = Off

Switch 4 = **On**

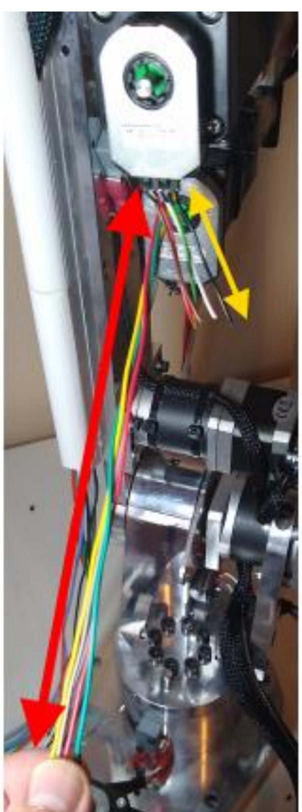
This sets the encoder to a resolution of 512 steps per revolution or 1024 PR for both channels.



Install AMT-103 encoder on to J5 motor as shown.

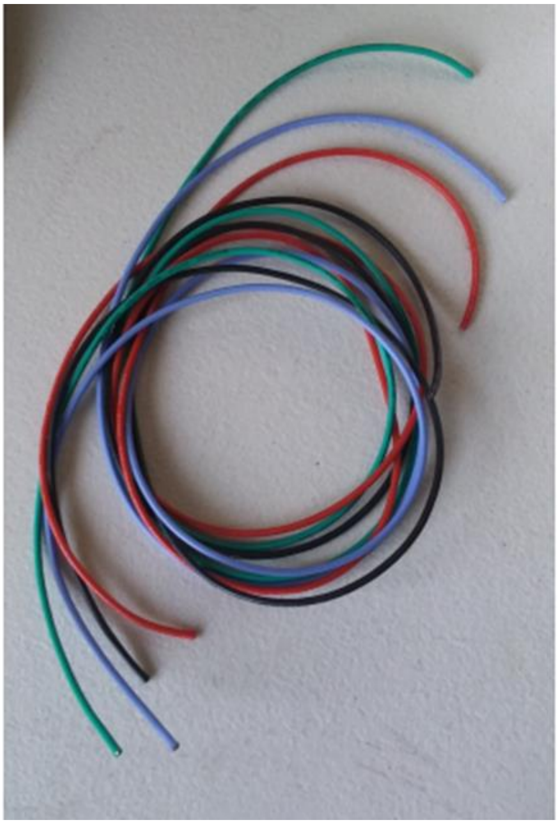
Encoder will snap into the plastic base.

Install encoder wire end into J5 encoder as shown.

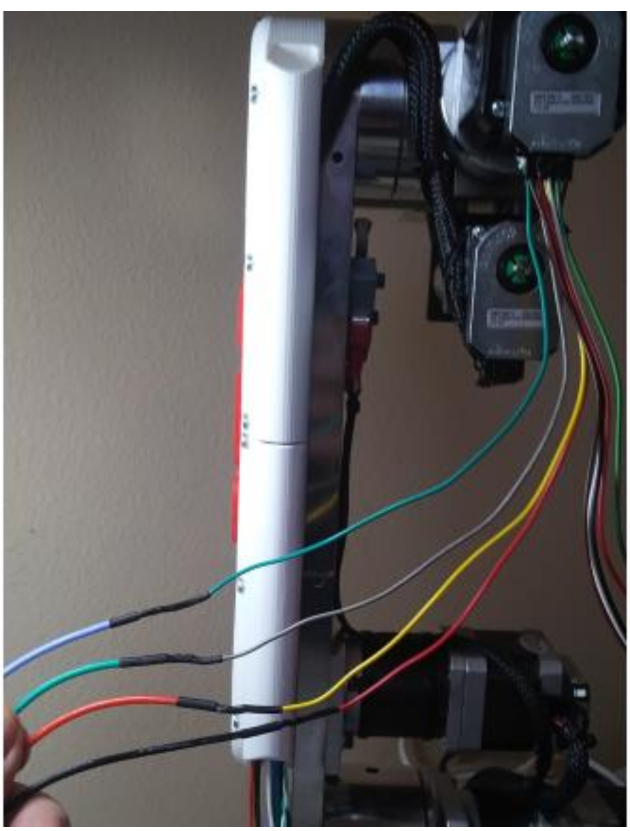


Cut J5 motor wires to length of 26cm (10”) long – (red arrow)

Cut J5 encoder wires to length of 5cm (2”) long – (yellow arrow)



Cut Red, Black, Blue & Green 18awg wires to a length of 97cm (38”) long

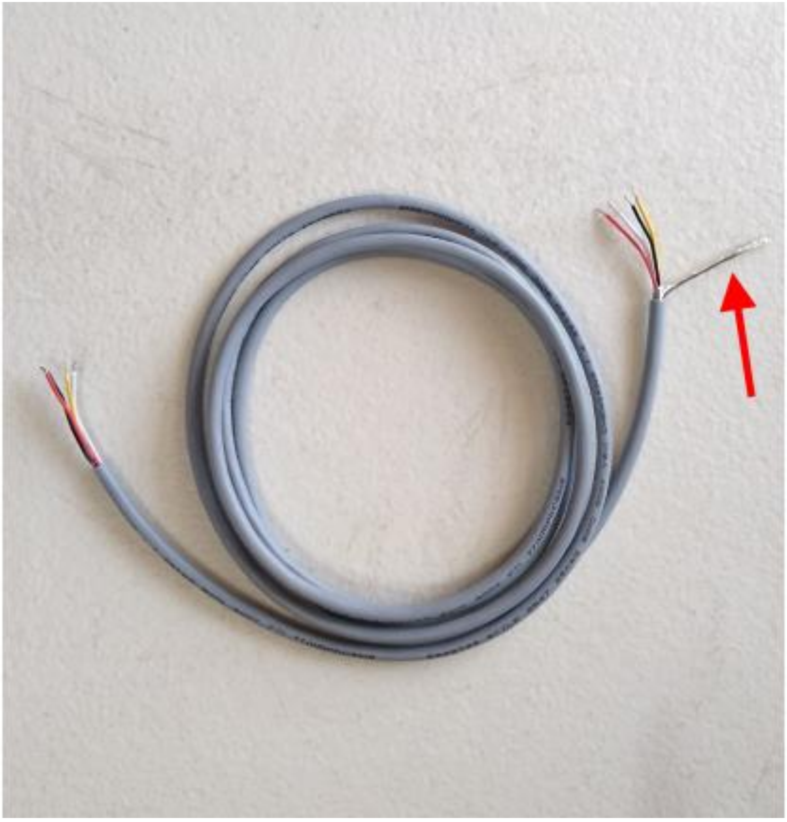


Solder and heat shrink 94cm (37”) long extension wires to the J5 motor wires as shown.

NOTE: The J5 motor wires are not the standard colors – make connections as follows:

- **Red** motor wire (A+) to **Black** extension wire.
- **Grey** motor wire (A-) to **Green** extension wire.
- **Yellow** motor wire (B+) to **Red** extension wire.
- **Green** motor wire (B-) to **Blue** extension wire.

Tape ends of J5 motor wires together and use marker to mark wires with (5) stripes so that you will know these are for J5 when wires have been routed inside enclosure

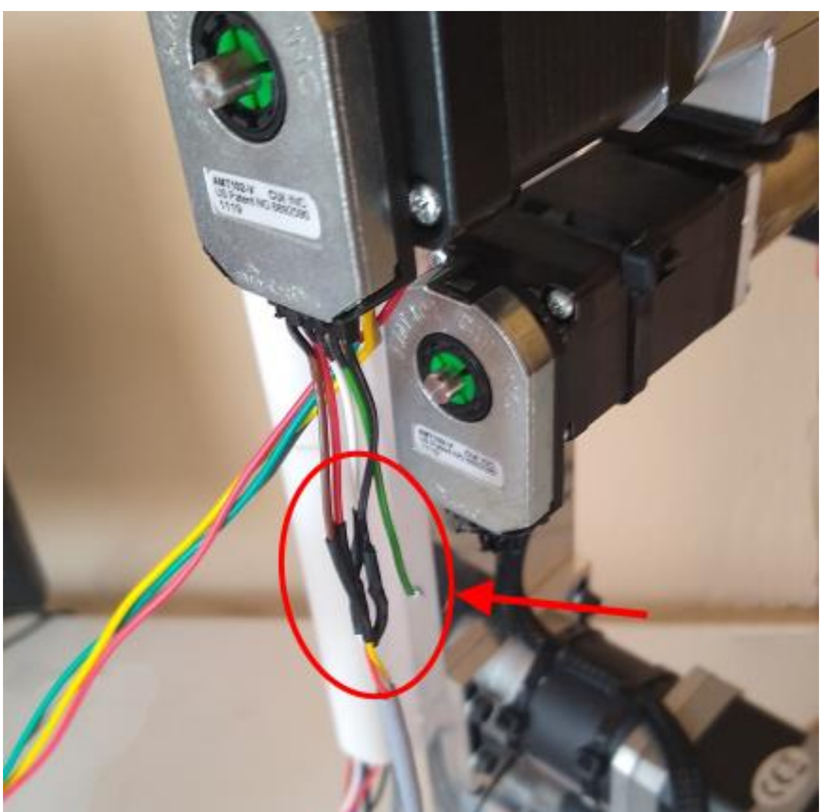


Cut 26awg shielded 4 conductor control cable to a length of 110cm (43”) long.

Carefully score outer jacket with razor knife, remove 2.5cm (1”) of the grey outer jacket on both ends of cable. (be careful to not damage wires or shielding when removing jacket.

On one end of the cable cut and remove the shielding wires, on the other end twist them together to create a ground wire. (red arrow).

Strip ends of all wires at both ends of cable and pre-apply solder to ends of wires – including the ground wire. (this is also known as tinning the wires).



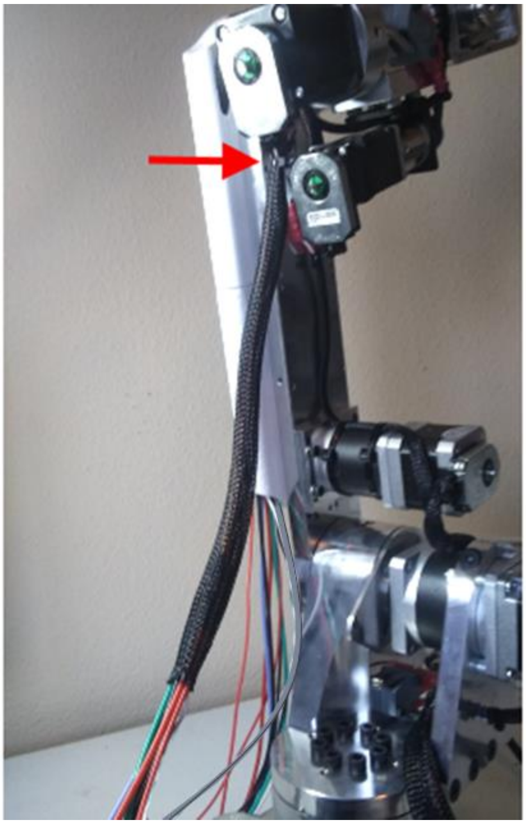
Solder and heat shrink the J5 encoder wires to the 26awg control wires as follows:

- **Red** goes to **red**
- **Black** goes to **black**
- **White** goes to **white**
- **Brown** goes to **yellow**

The green wire coming from the encoder will not be used.

The twisted ground wires are on the opposite end of cable that will be routed into base enclosure.

Use a marker to put (5) stripes on opposite end of cable indicating the cable is for joint 5 so that you will know these are for J5 when wires have been routed inside enclosure.



Cut length of ¼” braided sleeve to length of 28cm (11”) long.

Route braided sleeve over J5 motor and encoder wires as shown.

Secure sleeve with small cable tie (red arrow)

Secure wires and sleeve to left side of J5 motor using large cable tie as shown (red arrow).

Route J5 motor/encoder wires into upper J2 arm spacer access as shown.

Make sure J5 motor/encoder wires have an arch that is 3cm (1.25”) higher than the J4 wires arch.

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

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

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

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.

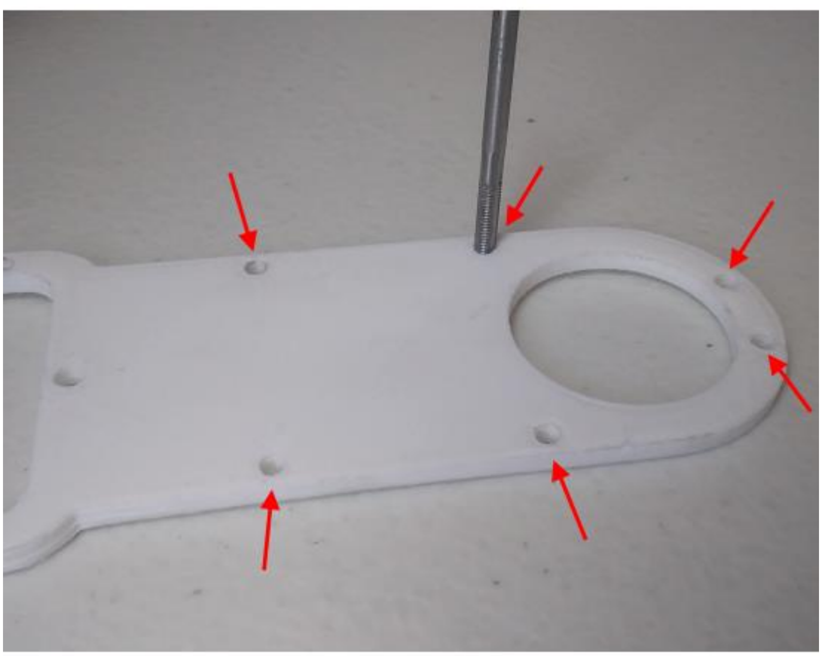
Install J6 housing from left side as shown and then install the J6 bearing cap (with bearings) from the right. Secure bearing Cap to J6 housing using (1) M6x14 socket head cap screw.

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 cover (red arrows).

Use #30 (.128” or 3.25mm) drill bit to clear the rear (9) holes on J5 side cover spacer.

Install J5 side cover 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).

Depending on manufacturer or supplier stock availability the OD of XL15 flange may vary.

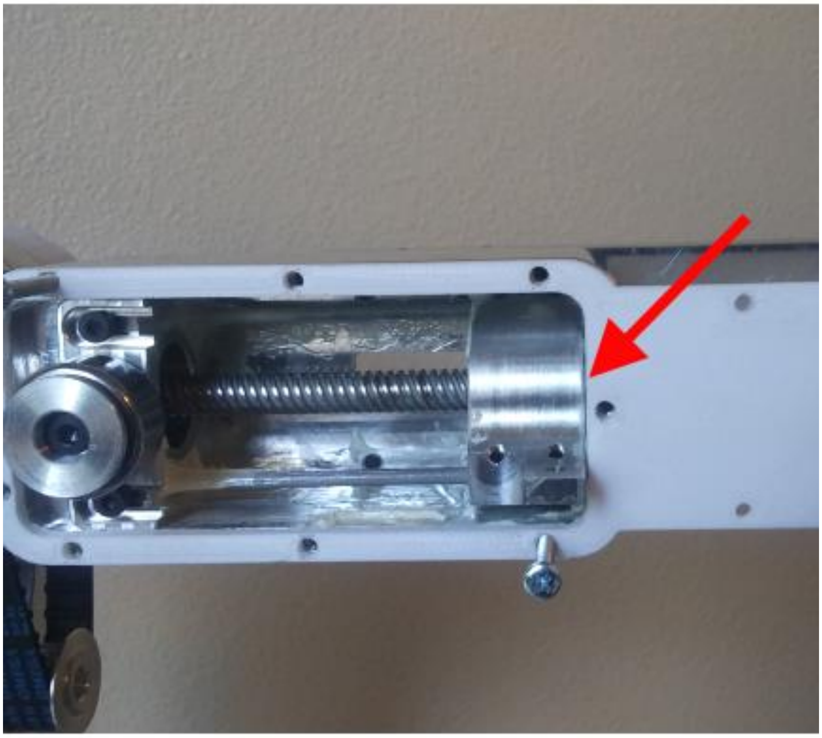
Make sure your XL15 sprockets flange OD is between 28mm and 30mm.

If your XL15 pulleys flanges are slightly large 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.

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.

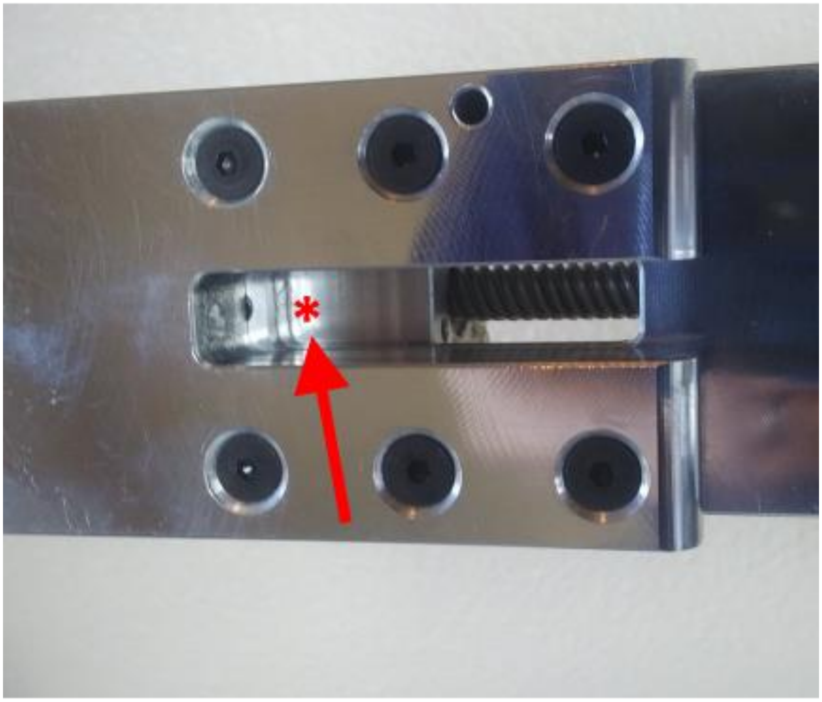
Cut lengths of red, black and white 22awg wire to lengths of 127cm (50”) long.

Crimp quick disconnect to the end of each wire.

Install wires with quick disconnects onto SV-166-1C25 roller tip limit switch

Be sure to connect wires as follows:

- Black to NC2 terminal
- Red to NO3 terminal
- White to COM1 terminal



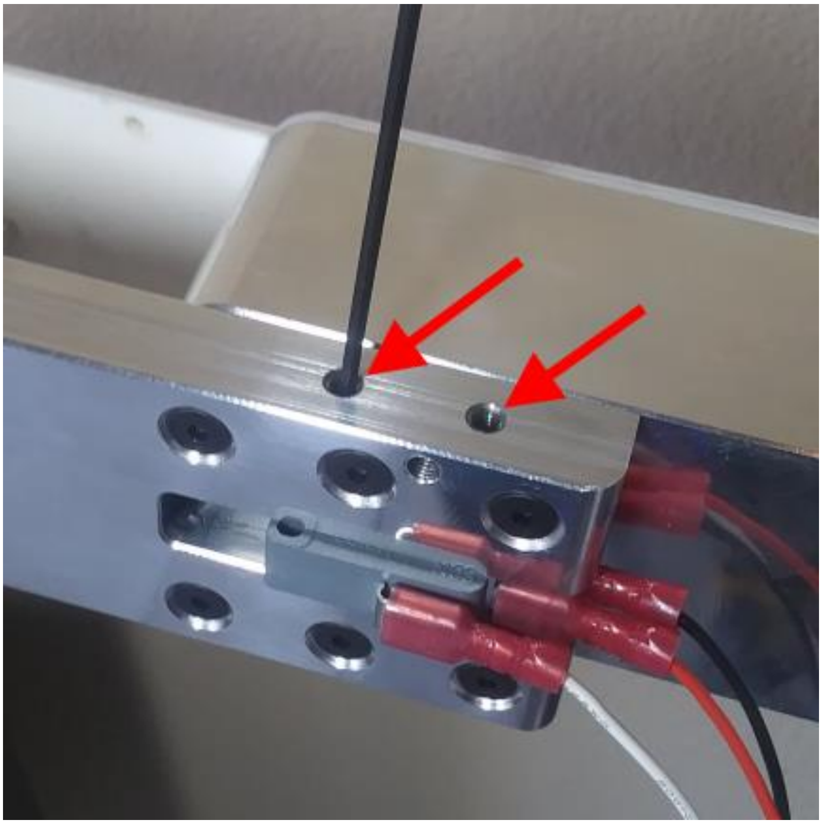
In the next steps we are going to install the J5 limit switch, when installed we want the roller tip of the limit switch to make contact with the leading edge of the J5 carrier.

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.

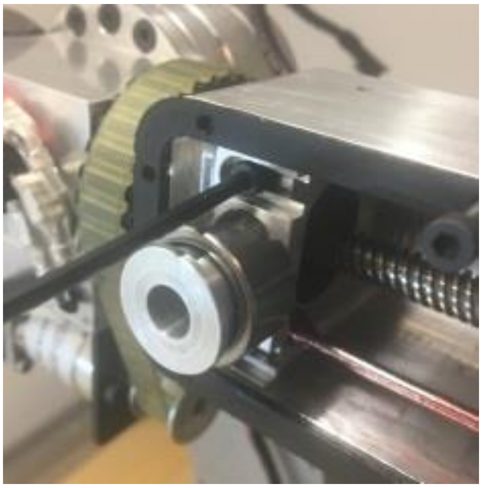
Set screws should be snug and keep limit switch secured but not too tight – do not over-tighten and damage switch.

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.

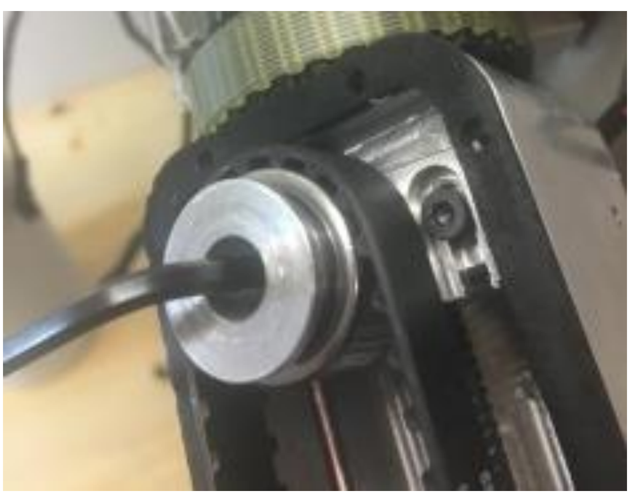
Hole should be directly between 2 of the ribs.



Adjust J5 idler tension block so that belt just barely too tight to fit and tighten mounting screws.

Belt should be just barely too tight so that you <u>cant</u> slip it over the idler bearing.

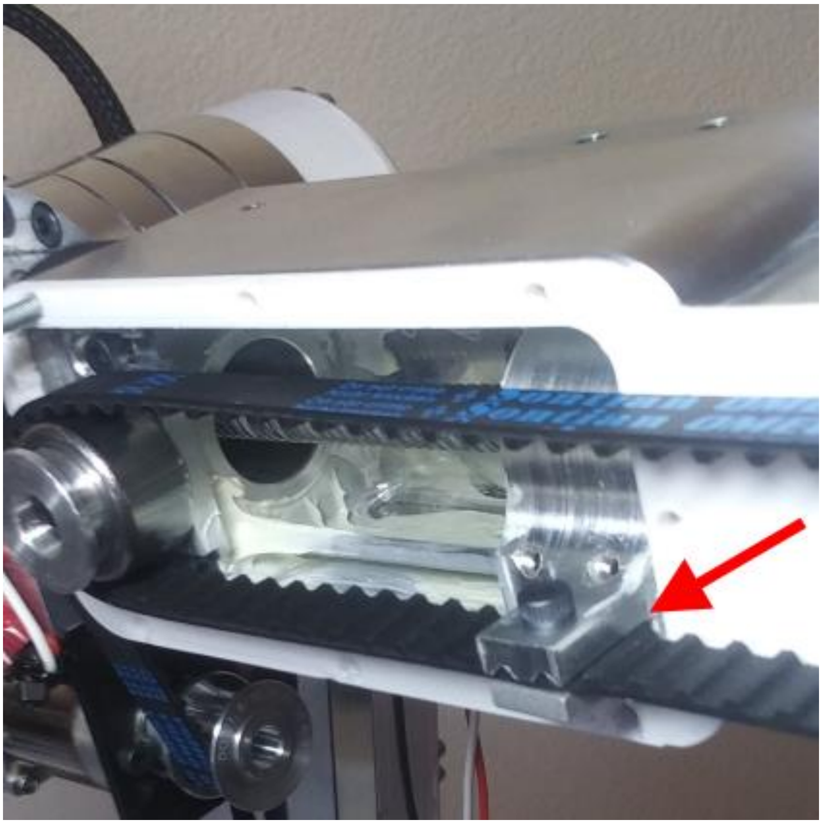
Note: when using 3D printed components you may not be able to get the belt this tight.



Loosen bearing post mounting screw so that post tips back and belt can now slide belt onto bearing.

Next tighten post mounting screw – this should now 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 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).

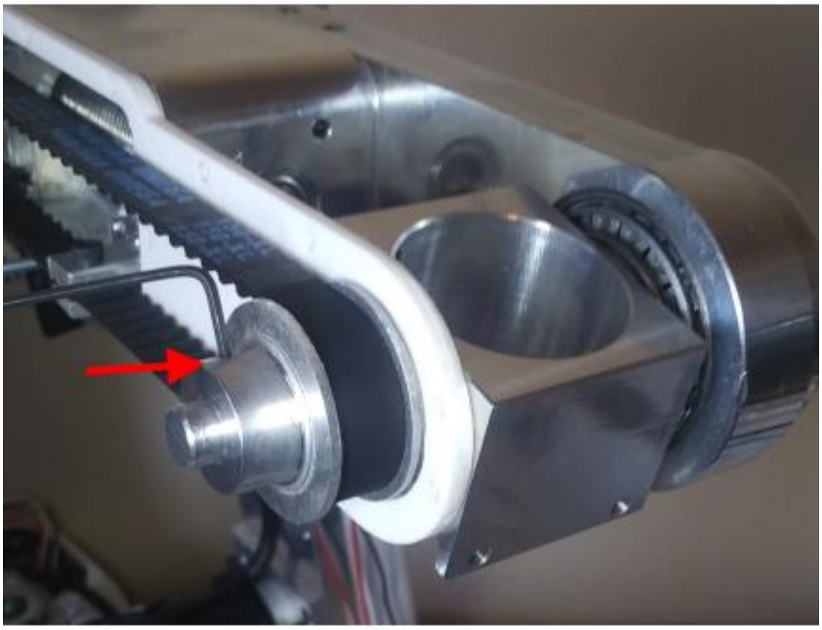
Make sure screw is tight and belt is secured to J5 carrier.

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).



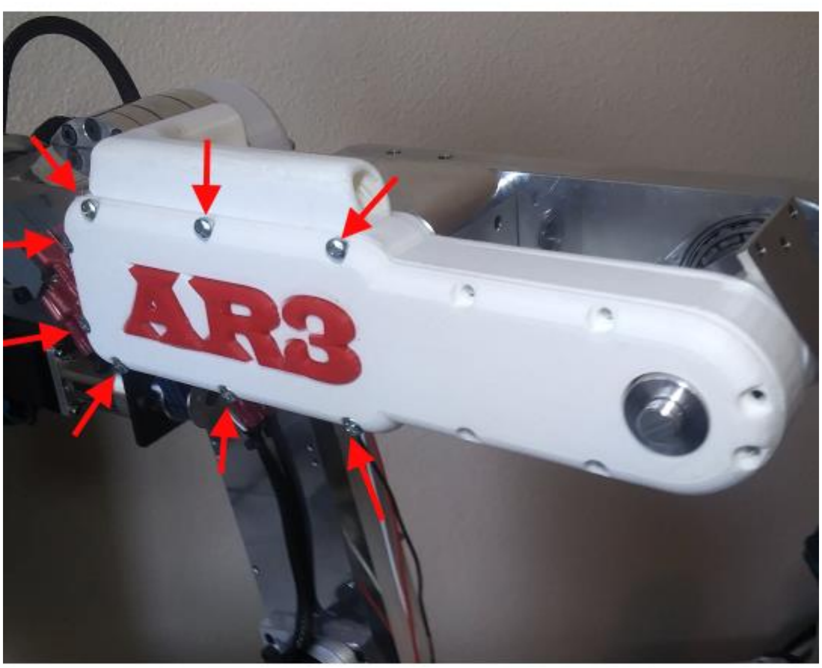
With J5 carrier in the forward position (switch clicked) and the J6 carrier at 105° tighten the XL15 pulley set screws.

The J5 angle is now mechanically calibrated.

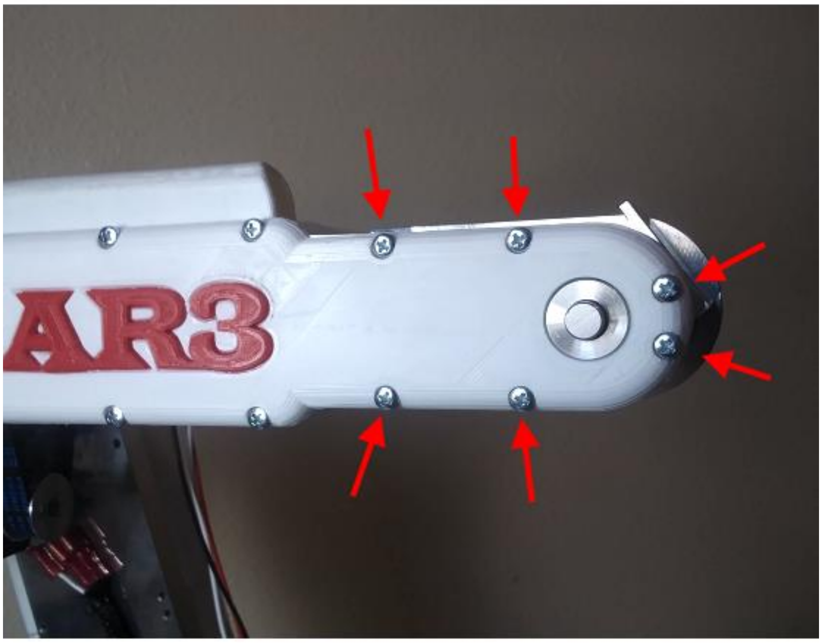
This calibration can be refined further after the robot has been started up. After startup you can run the auto calibration procedure and then jog J5 to the zero position – at that point if the joint is not perfectly straight out zero degrees you can loosen these set screws and adjust the J6 housing to perfect zero – this will also be covered in the startup and calibration video for the AR3 robot.

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 AR3 logo into recess in J5 cover cap and secure with epoxy.



Install J5 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 cover cap and spacer to the rear side cover.

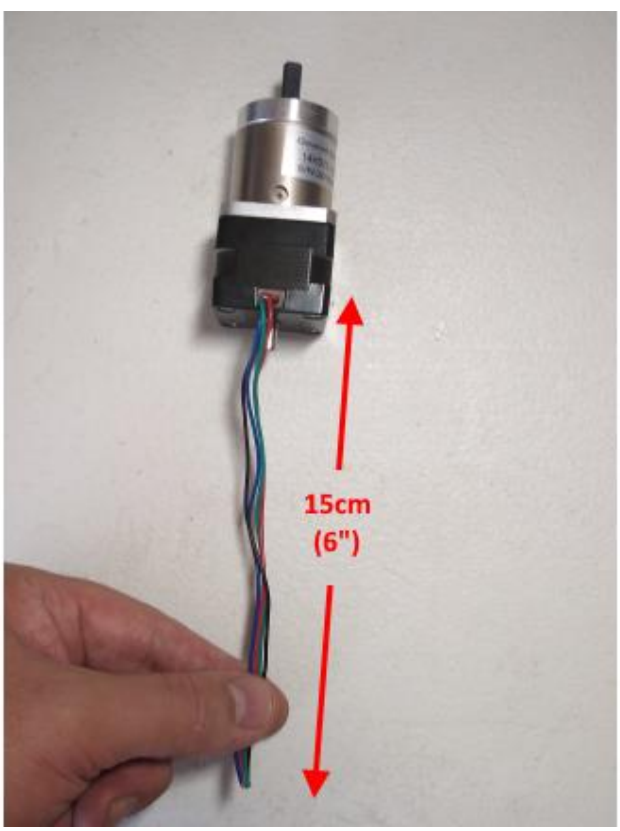
Cut length of ¼” braided sleeve to length of 10cm (4”) long.

Route braided sleeve over J5 limit switch wires as shown.

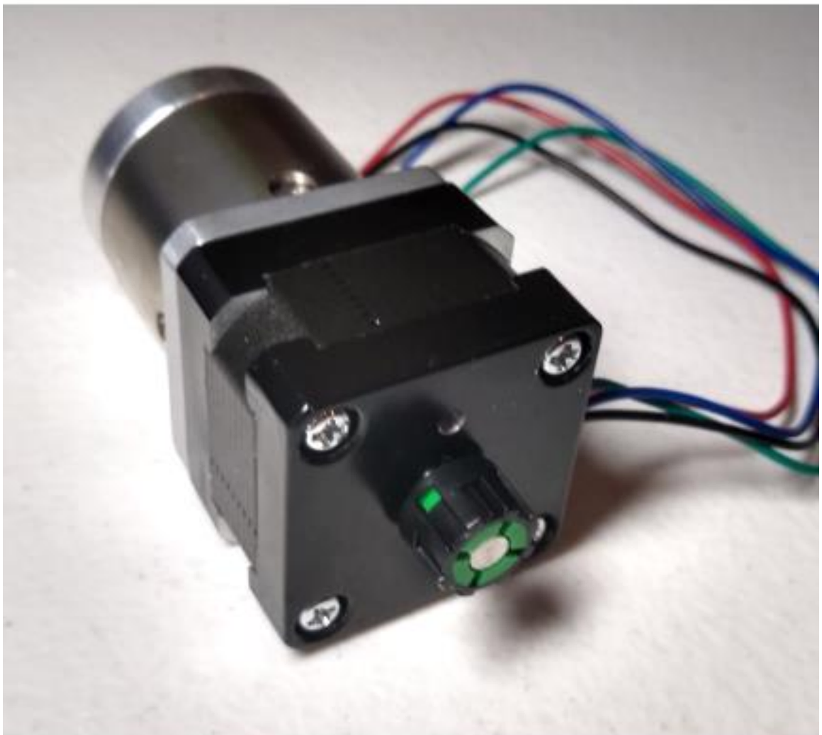
Secure sleeve with small cable tie (red arrow)

Route J5 limit switch wires through J5 spacer passage so that sheething enters the shorter tube on the side and then the red, black and white wires exit the rear tube as shown.

Tape ends of J5 limit switch wires together and use marker to mark wires with (5) stripes so that you will know these are for J5 when wires have been routed inside enclosure.



Cut J6 motor wires down to a length of 15cm (6”) long as shown.



Install the green (.197”) AMT-102 encoder sleeve on to the J6 motor as shown.

Please review the assembly instructions provided with the AMT-102 encoder.

Use (2) M3x5 flat head screws to mount the ENC-AMT102 base to the top of the J6 motor as shown.

Set dip switch settings on AMT-102 encoder as follows:

Switch 1 = Off

Switch 2 = Off

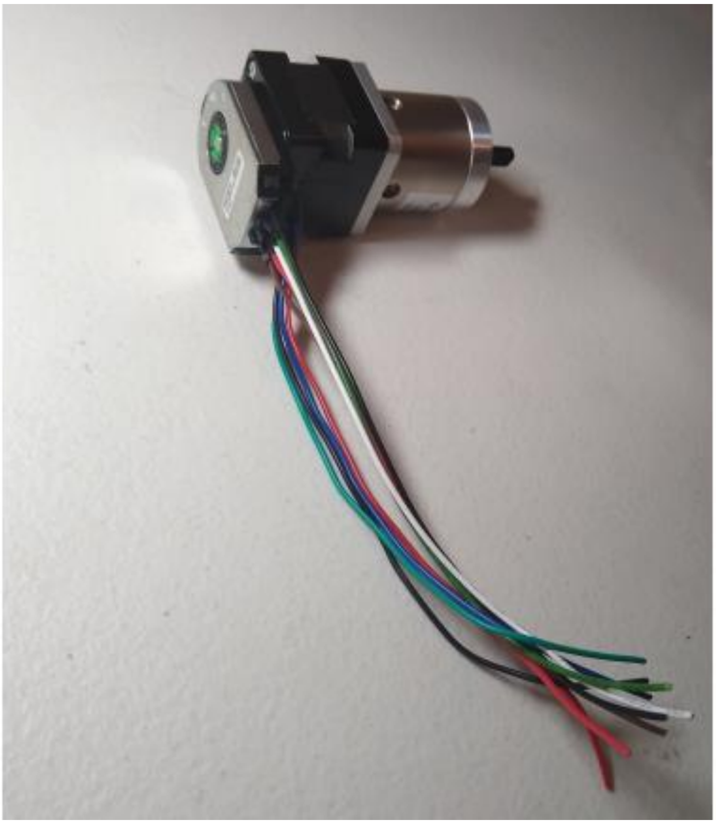
Switch 3 = Off

Switch 4 = **On**

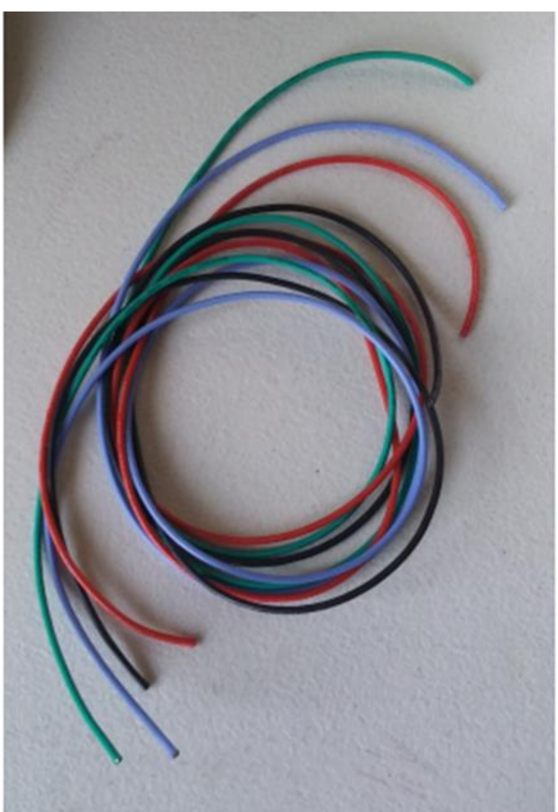
This sets the encoder to a resolution of 512 steps per revolution or 1024 PR for both channels.

Install AMT-103 encoder on to J5 motor as shown.

Encoder will snap into the plastic base.



Install encoder wire end into J6 encoder as shown and then cut encoder wires down to the same length as the motor wires (15cm).

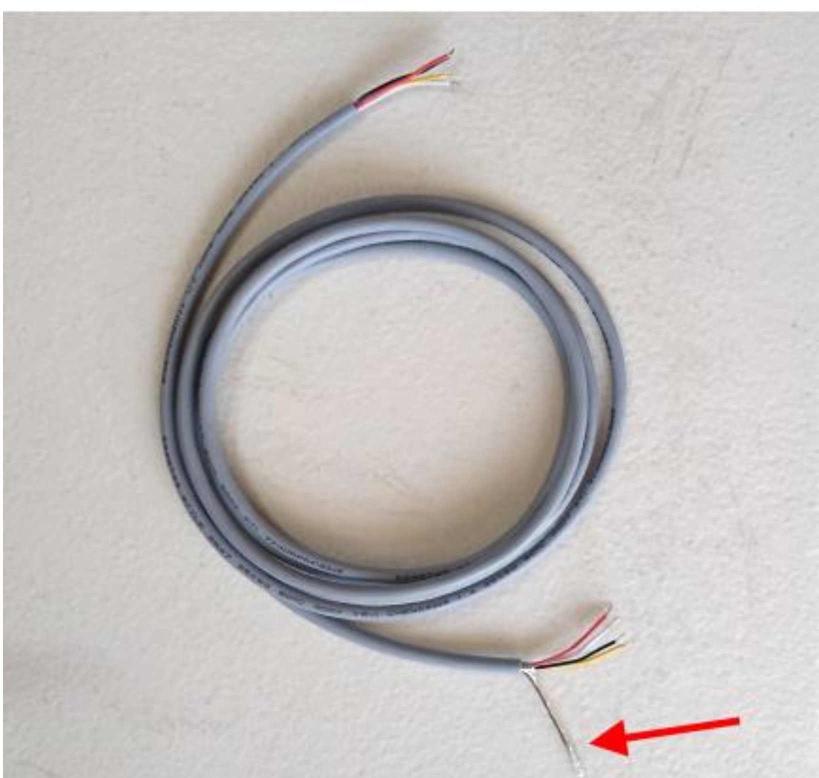


Cut Red, Black, Blue & Green 18awg wires to a length of 130cm (52”) long

Solder and heat shrink 130cm (52”) long extension wires to the J6 motor wires as shown.

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

Tape ends of J6 motor wires together and use marker to mark wires with (6) stripes so that you will know these are for J6 when wires have been routed inside enclosure

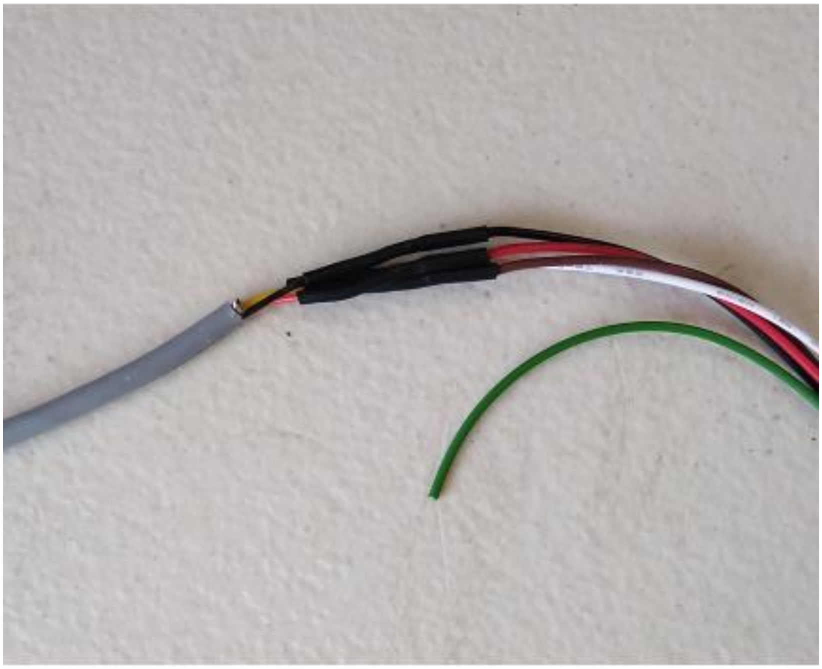


Cut 26awg shielded 4 conductor control cable to a length of 130cm (52”) long.

Carefully score outer jacket with razor knife, remove 2.5cm (1”) of the grey outer jacket on both ends of cable. (be careful to not damage wires or shielding when removing jacket.

On one end of the cable cut and remove the shielding wires, on the other end twist them together to create a ground wire. (red arrow).

Strip ends of all wires at both ends of cable and pre-apply solder to ends of wires – including the ground wire. (this is also known as tinning the wires).



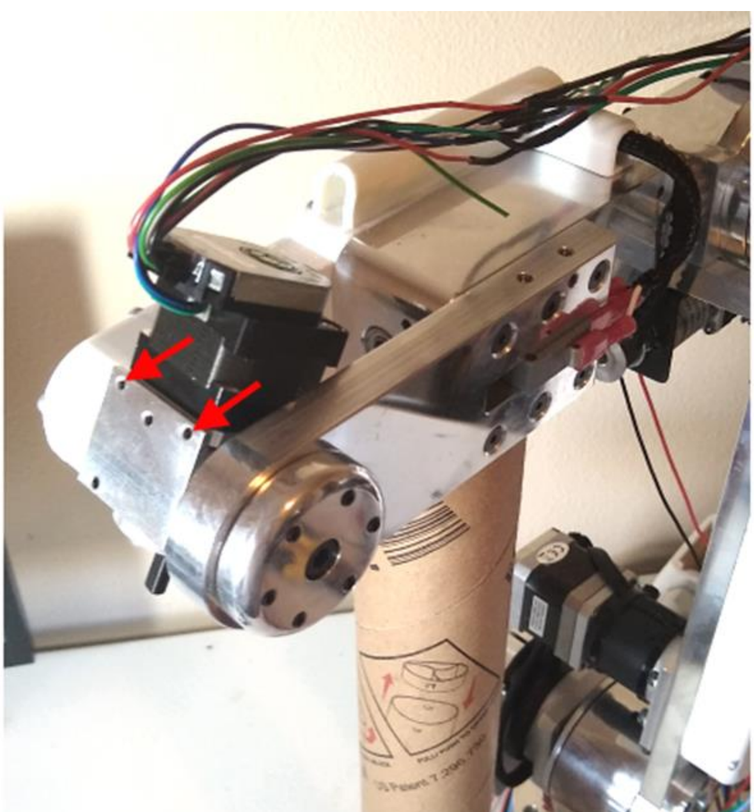
Solder and heat shrink the J6 encoder wires to the 26awg control wires as follows:

- **Red** goes to **red**
- **Black** goes to **black**
- **White** goes to **white**
- **Brown** goes to **yellow**

The green wire coming from the encoder will not be used.

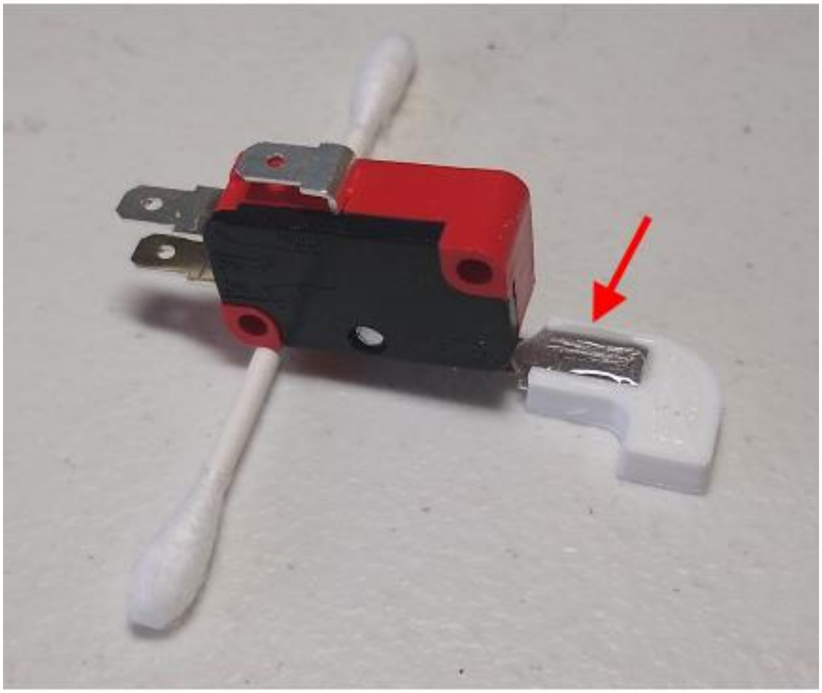
The twisted ground wires are on the opposite end of cable that will be routed into base enclosure.

Use a marker to put (3) stripes on opposite end of cable indicating the cable is for joint 3 so that you will know these are for J3 when wires have been routed inside enclosure.



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.



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.

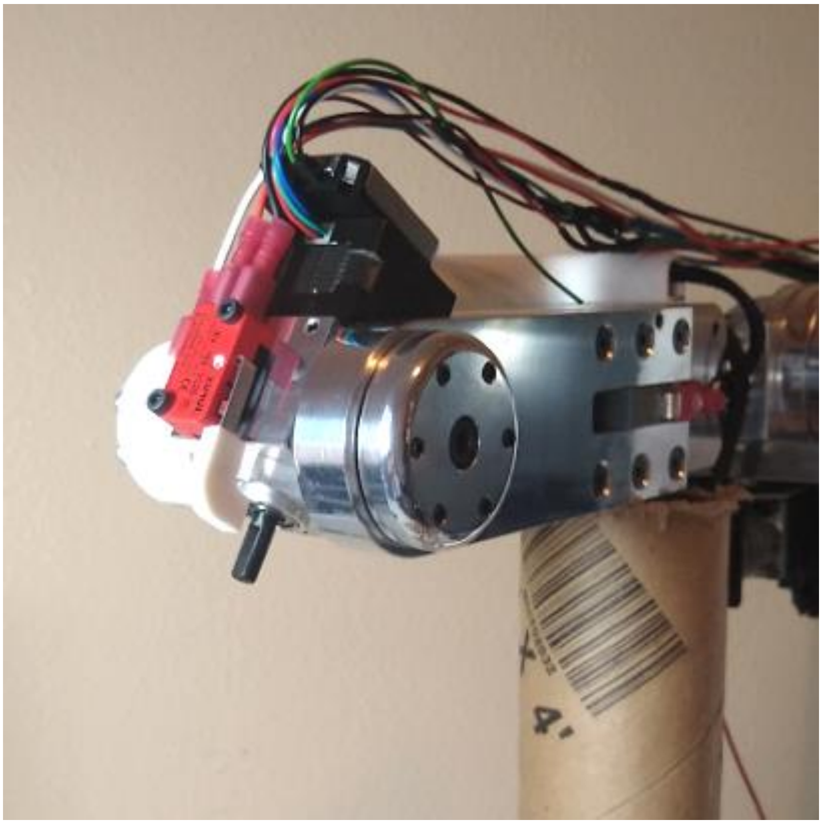
Cut lengths of red, black and white 22awg wire to lengths of 147cm (58”) long.

Crimp quick disconnect to the end of each wire.

Install wires with quick disconnects onto SV-166-1C25 straight lever limit switch

Be sure to connect wires as follows:

- Black to NC2 terminal
- Red to NO3 terminal
- White to COM1 terminal



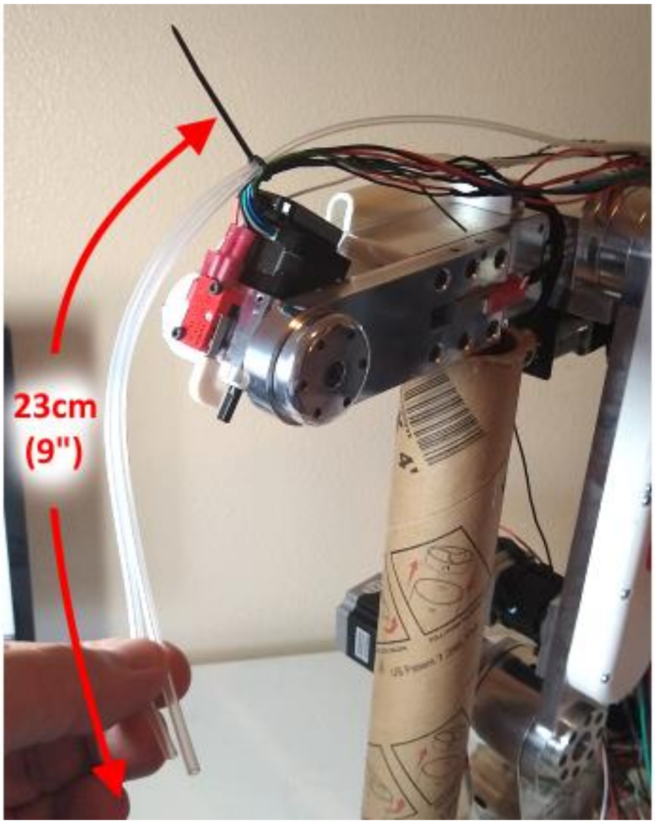
Install J6 limit switch onto J6 housing as shown using (2) M3x14 socket head or philps pan head screws.

Tape ends of J6 limit switch wires together and use marker to mark wires with (6) stripes so that you will know these are for J6 when wires have been routed inside enclosure

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.



Run the pneumatic tubing along with all the J6 motor, encoder and limit switch wires. Run the tubing 23cm (9”) past where the encoder and motor wires go into the motor and encoder and then use a small cable tie to temporarily hold them in place as shown.

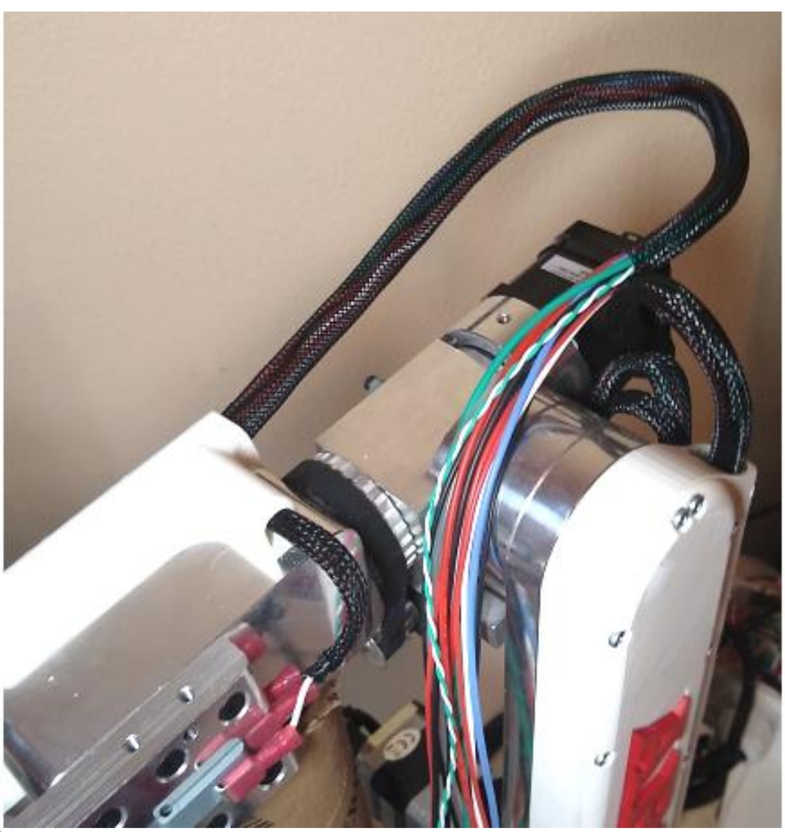
Wrap ends of J6 motor, encoder and limit switch wires as well as ends of pneumatic tubes with painters tape so that the bundle of wires can easily be fed through braided sleeve.

Cut a 25cm (10”) length of ¼” braided sleeve and feed all J6 wires and tube through the sleeve as shown.

Feed all J6 wires and pneumatic tubing through the J5 spacer passage as shown.

Tuck approx. 3cm (1”) of sleeve inside the leading end of the J5 spacer passage.

Remove the cable tie used to hold the pneumatic lines in place and wrap braided sheeth end at J6 wires and tubing outlet with black electrical tape (red arrow).



Cut length of ¼” braided sleeve to length of 46cm (18”) and feed all J6 wires and pneumatic tube through the sleeve as shown.

Tuck 3cm (1”) of sleeving into the trailing end of the J5 spacer passage.

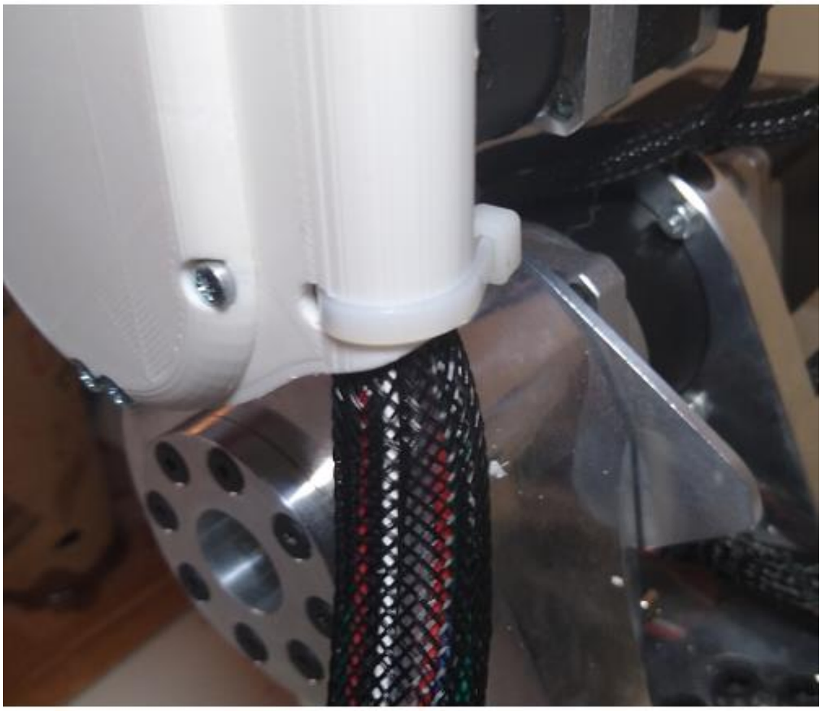
Route all of the J6 wires down through the wire-way channel on the back of the J2 arm spacer as shown.

Be careful not to pull too hard on wires as you are working them down the wire-way along with the J3 and J4 wires. They are a snug fit and it does take a little time to work them down.

Tuck 3cm (1”) of the braided sleeve down into the top of the wire-way channel.

Again wrap ends of J6, J5 and J4 motor, encoder and limit switch wires as well as ends of pneumatic tubes with painters tape so that the bundle of wires can easily be fed through braided sleeve.

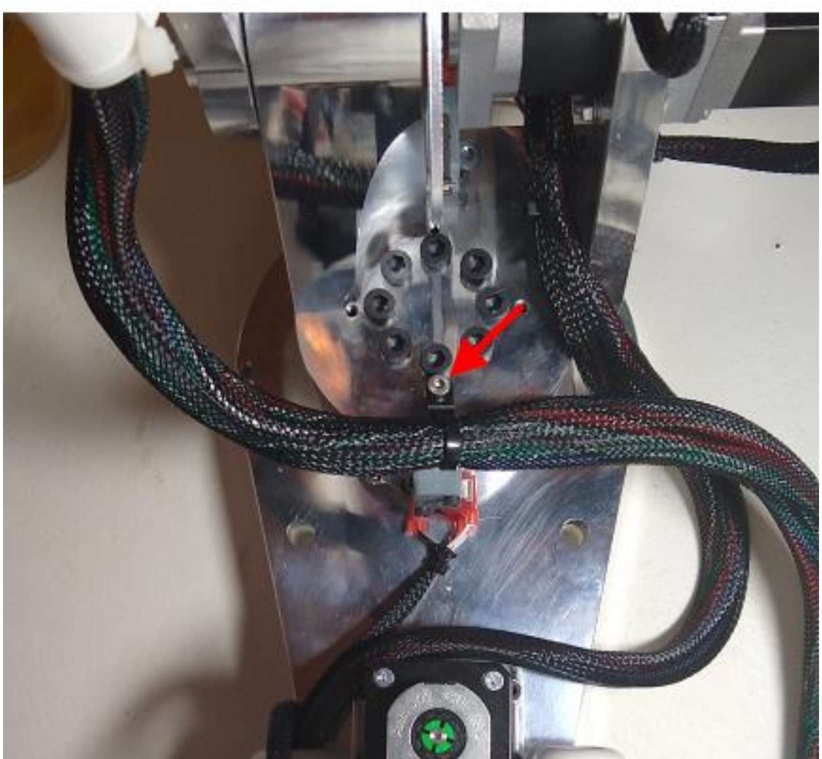
Cut 84cm (33”) length of ½” braided sleeve and feed all wires and tubes coming from bottom of J2 spacer arm wire-way through braided sleeve as shown.



Tuck 3cm (1”) of the ½” braided sleeve up into the bottom end of the J2 spacer arm wire-way.

Once this is done install cable tie through 6mm hole in wire-way, push it back and around wires and sleeve inside wire way and then use needle nose pliers to get it back out the 6mm hole on opposite side. Snug wire tie to keep wires and sleeve from working their way out of wire-way.

Do not get cable tie too tight, you do not want to restrict the airflow in pneumatic tubes.



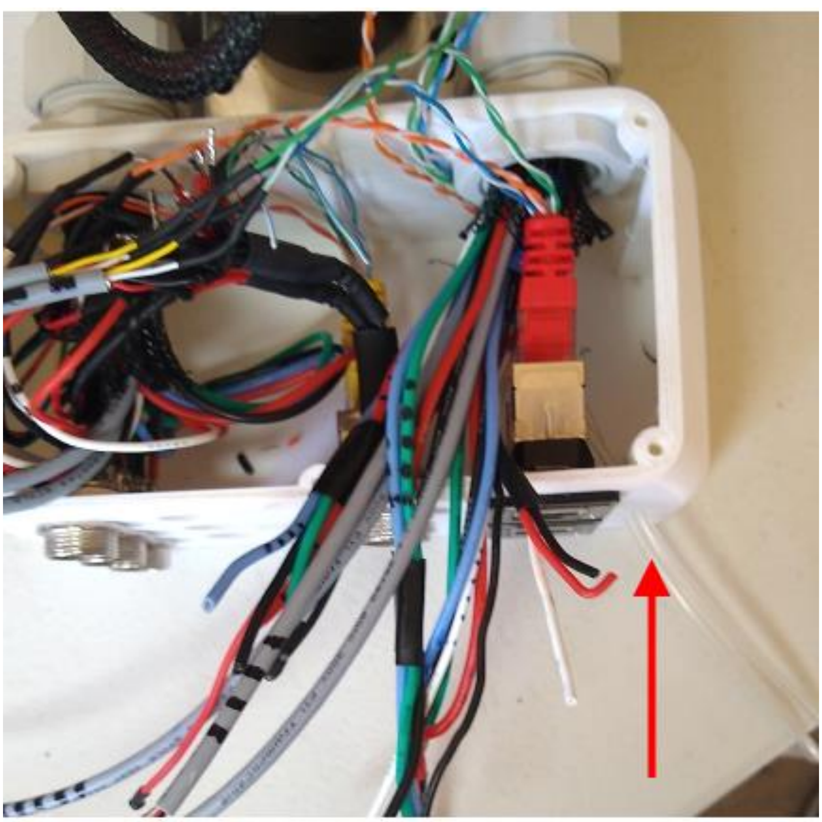
Use a mounting hole cable tie to secure the J4-6 wire loom to the J1 base platform as shown.

Secure cable tie to platform using one of the removed factory screws from the J2 motor earlier in this manual. The screw will thread over the top of and into the set screw hole shown (red arrow).

Route J4-6 wire loom through right gland nut as shown.

Temporarily unplug the red Ethernet plug to assist in pulling it through.

Make sure to leave amount of slack shown in loom prior to entering the enclosure – the amount of slack should match the amount of slack in the J1-3 loom below it.

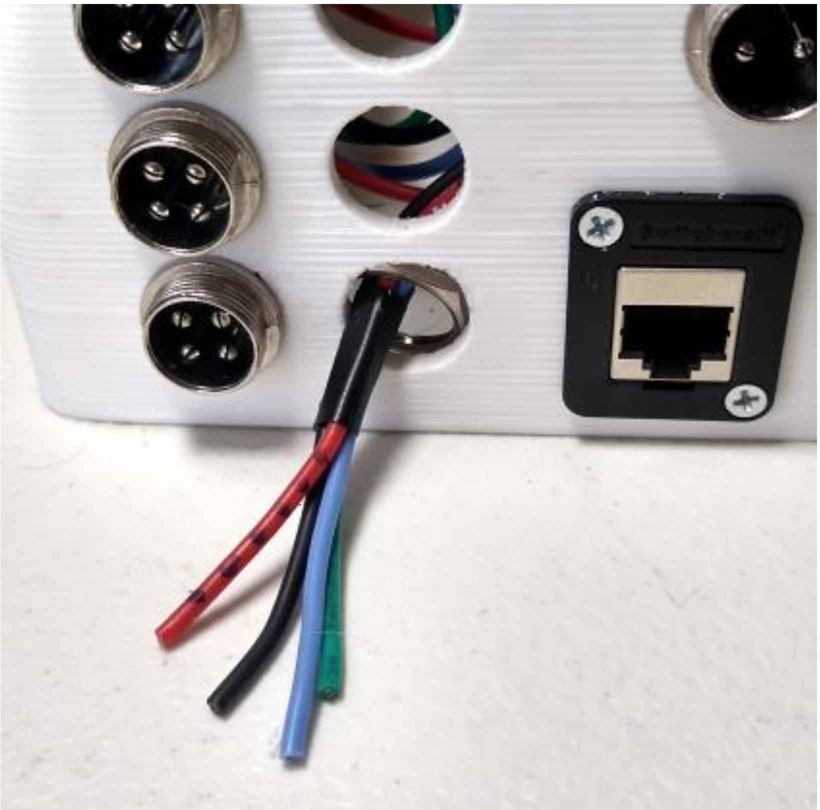


Route the (2) pneumatic lines out of the base enclosure through the (2) access holes shown (red arrow).

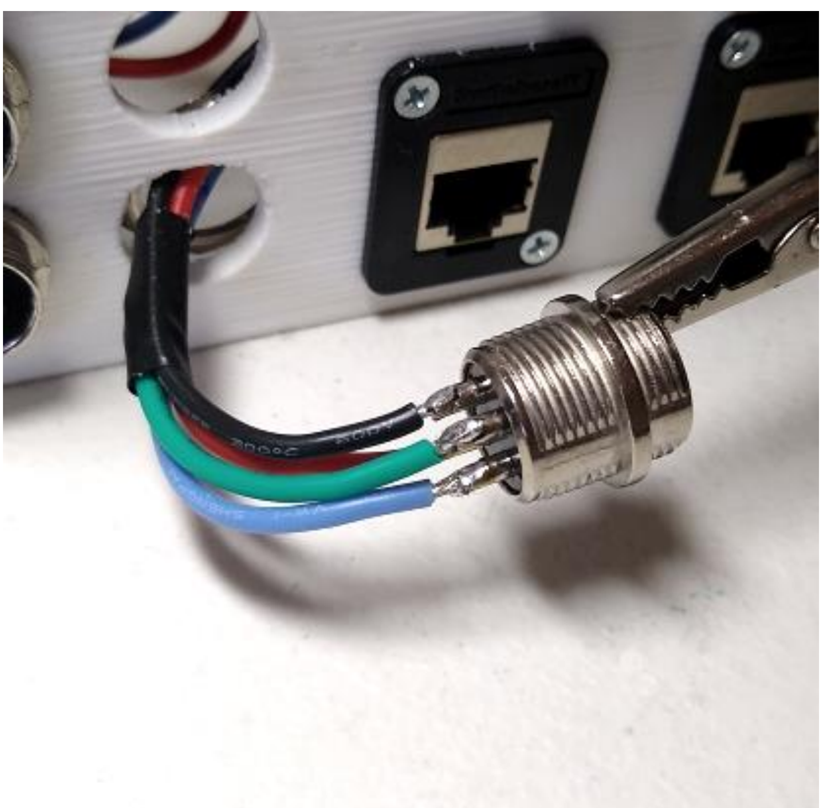
Remove all the blue painters tape that was used to keep each of the wire bundles together for passing through the sleeve.

Trim braided sleeve back if necessary.

Reinstall the red Ethernet plug as shown.

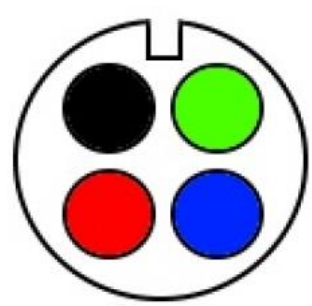


Route red, black, green & blue 18awg J6 motor wires through nut from a GX16-4 aviation plug and then through the bottom right hole of enclosure as shown.



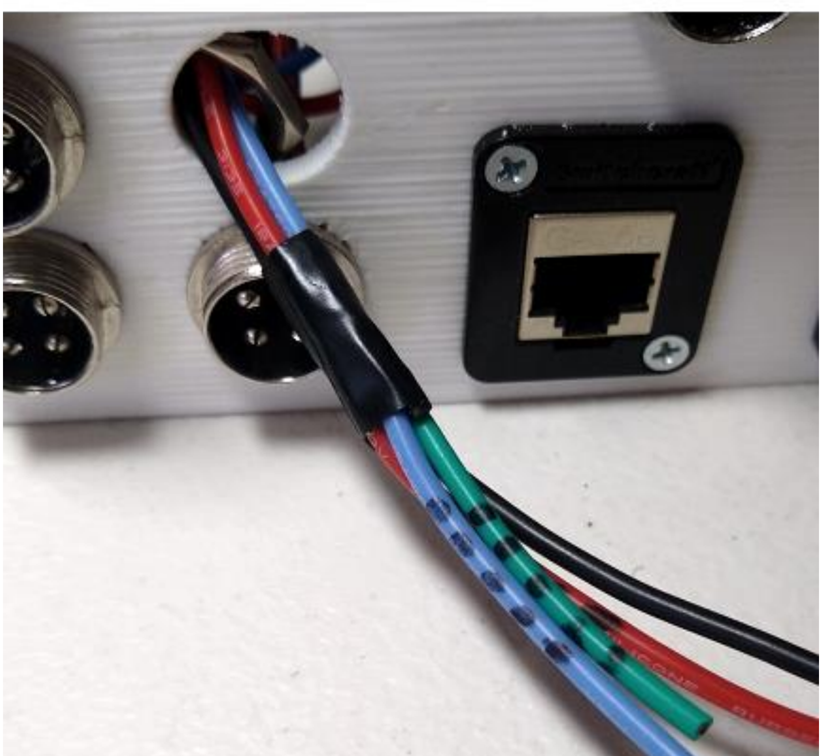
Solder motor wires to GX16-4 aviation plug as shown.

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.

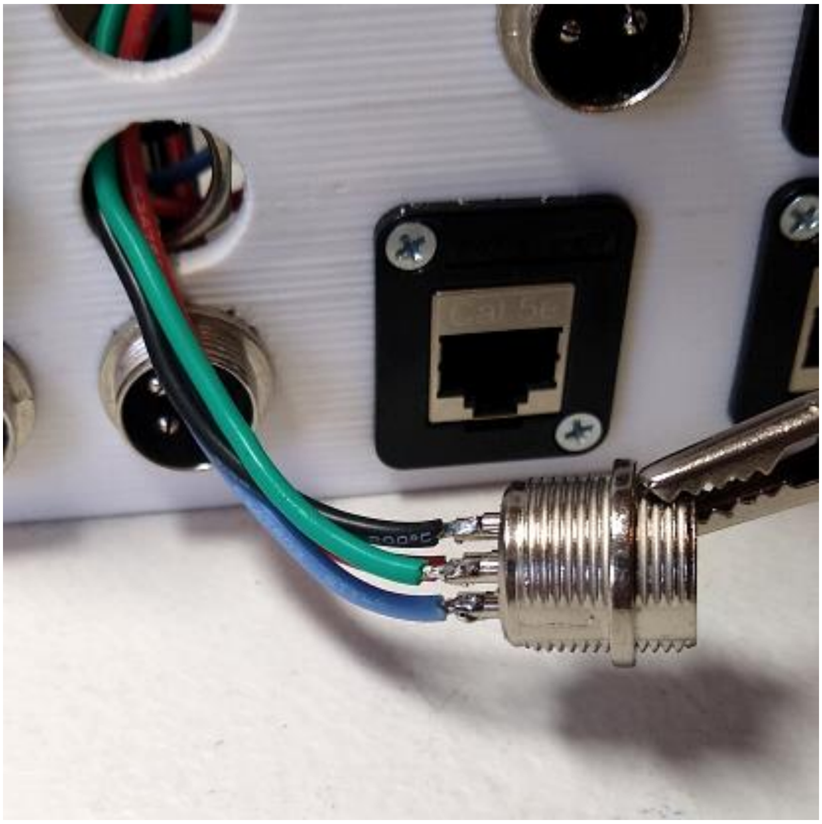


VIEW FROM BACKSIDE OF CONNECTOR

Install J6 plug into enclosure and tighten nut from backside.

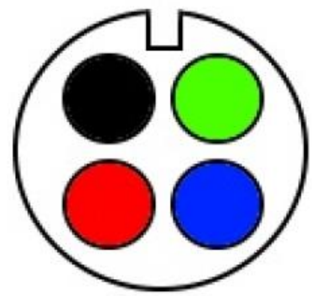


Route red, black, green & blue 18awg J5 motor wires through nut from a GX16-4 aviation plug and then through the middle right hole of enclosure as shown.



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

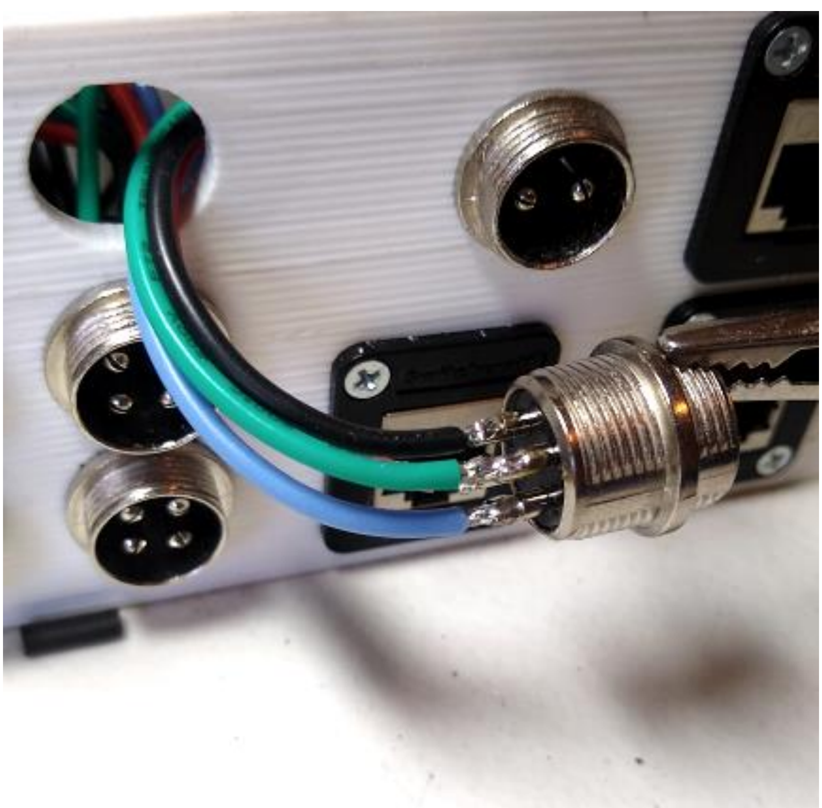
View from back of connector with notch up solder black to upper left, green to upper right, red to lower left and blue to lower right.



VIEW FROM BACKSIDE OF CONNECTOR

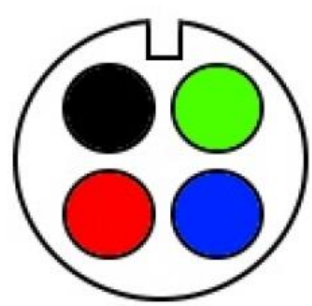
Install J5 plug into enclosure and tighten nut from backside.

Route red, black, green & blue 18awg J4 motor wires through nut from a GX16-4 aviation plug and then through the top right hole of enclosure as shown.



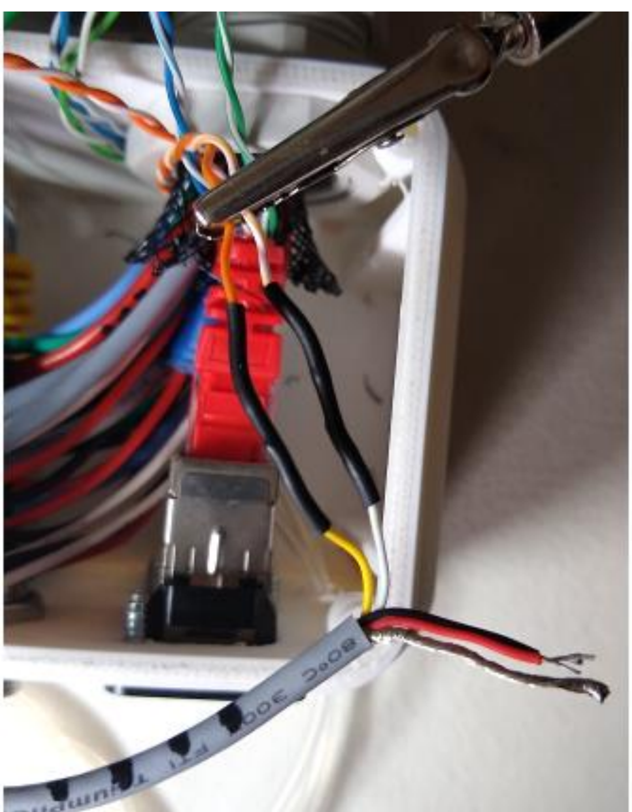
Solder motor wires to GX16-4 aviation plug as shown.

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.



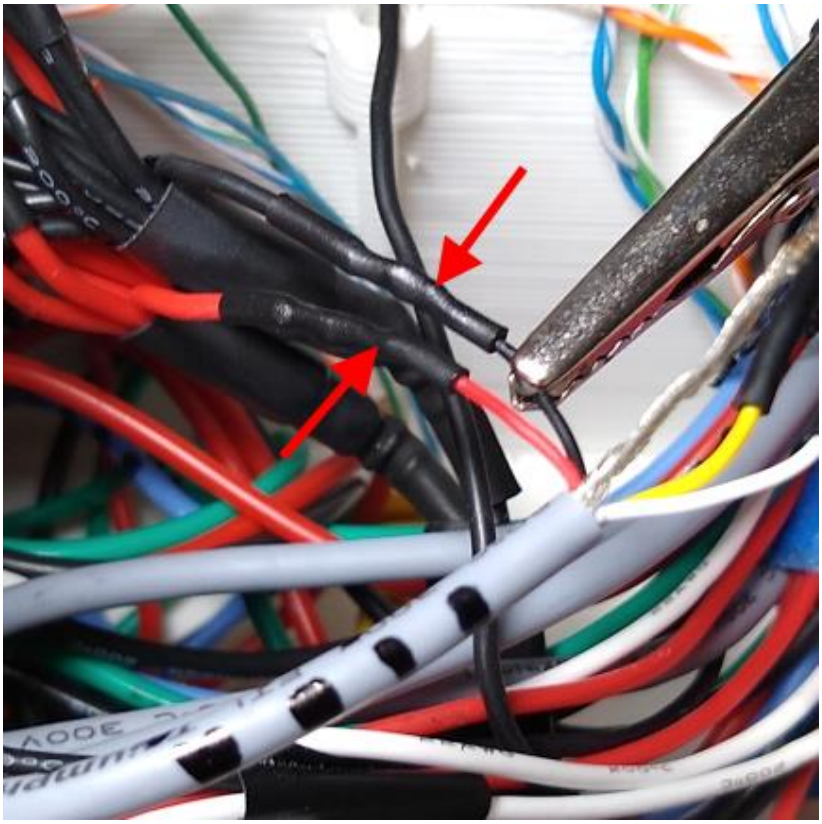
VIEW FROM BACKSIDE OF CONNECTOR

Install J4 plug into enclosure and tighten nut from backside.



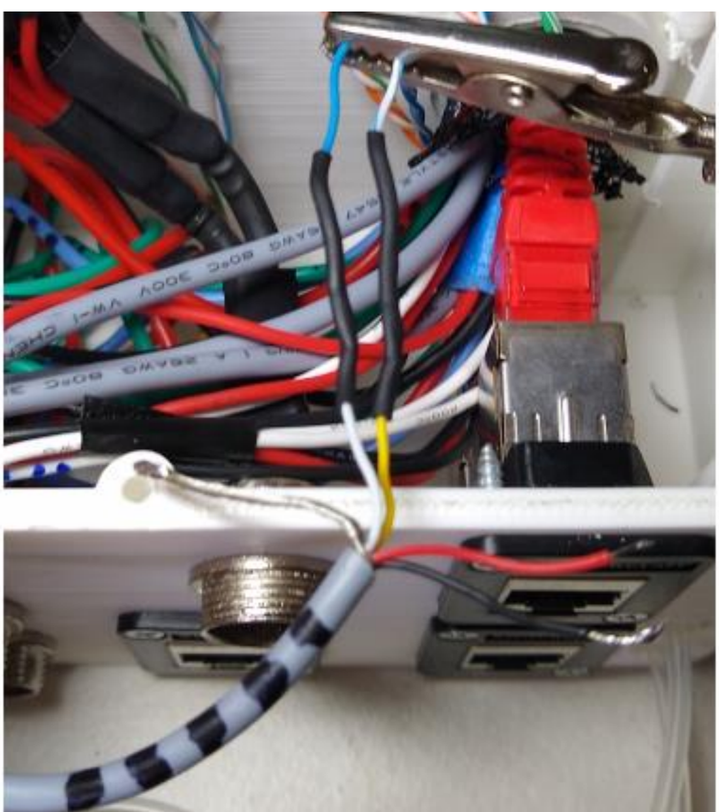
Solder and heat shrink the J4 encoder A-B wires to the Blue Ethernet cable A-B wires for J4 (orange-orange stripe).

- Encoder cable white wire goes to Blue Ethernet cable – orange with white stripe wire.
- Encoder cable yellow wire goes to Blue Ethernet cable – orange wire.



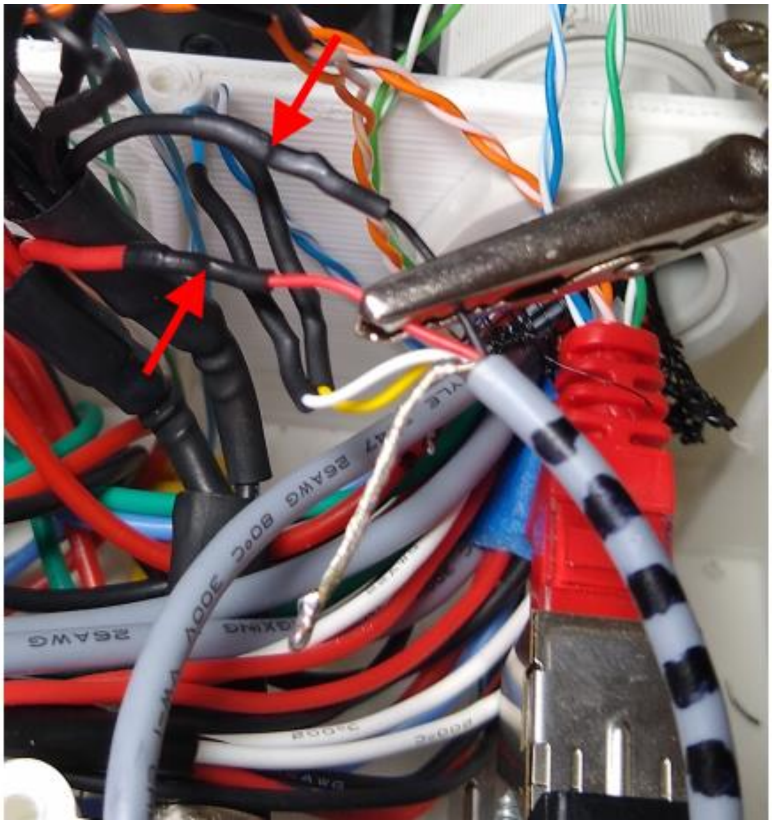
Solder and heat shrink the 5vdc red and black wires from the J4 encoder cable to one of the red and black 5vdc source bundle wires.

- Black wire from J4 encoder goes to one of the black wires from - 5vdc bundle.
- Red wire from the J4 encoder goes to one of the red wires from the 5vdc bundle.



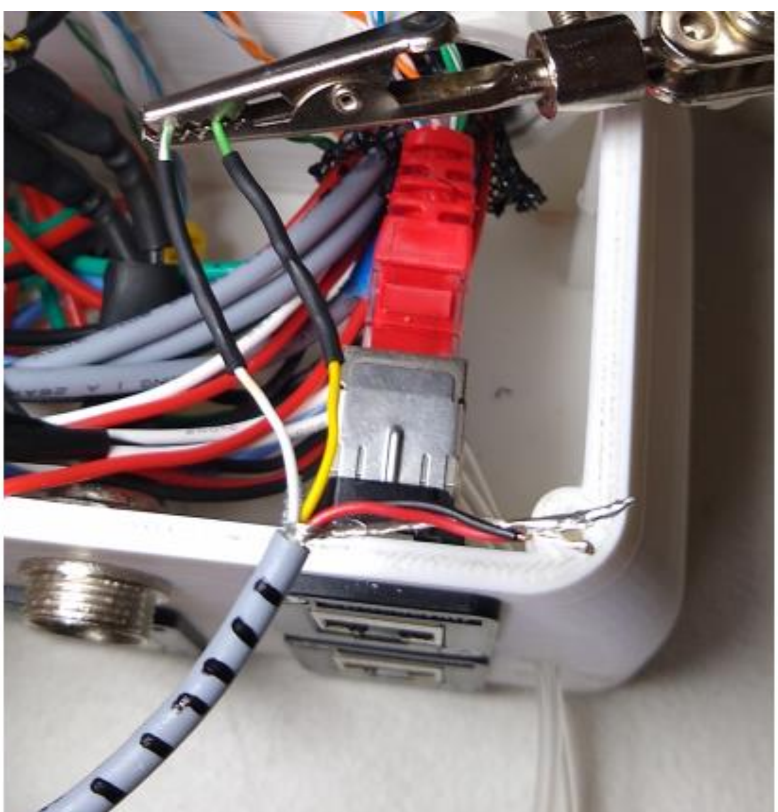
Solder and heat shrink the J5 encoder A-B wires to the Blue Ethernet cable A-B wires for J5 (blue – white / blue stripe).

- Encoder white wire goes to Blue Ethernet cable – blue wire.
- Encoder green wire goes to Blue Ethernet cable – blue with white stripe wire.



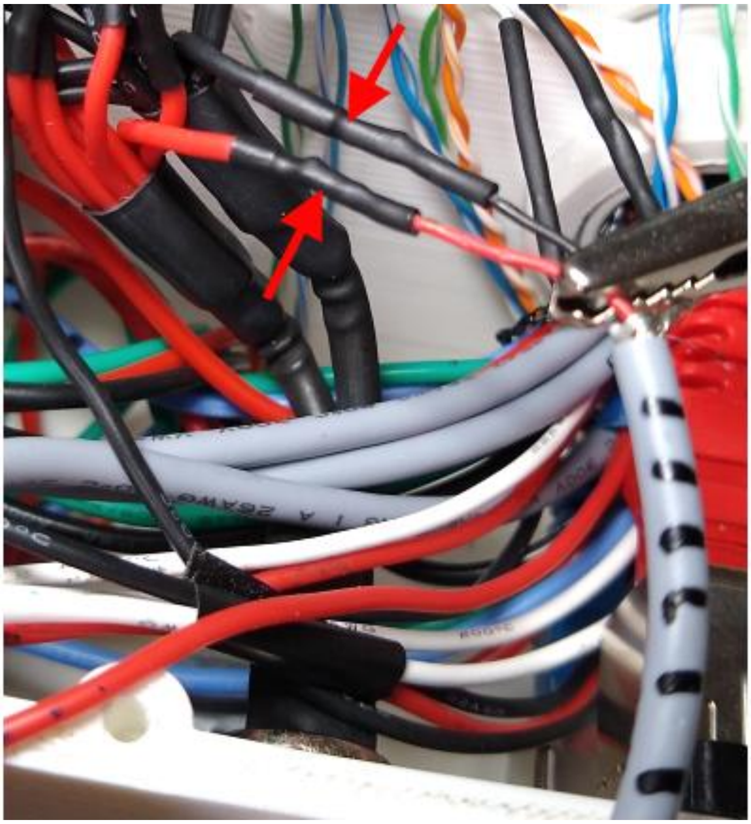
Solder and heat shrink the 5vdc red and black wires from the J5 encoder to one of the red and black 5vdc source bundle wires.

- Black wire from J5 encoder goes to one of the black wires from -5vdc bundle.
- Red wire from the J5 encoder goes to one of the red wires from the 5vdc bundle.



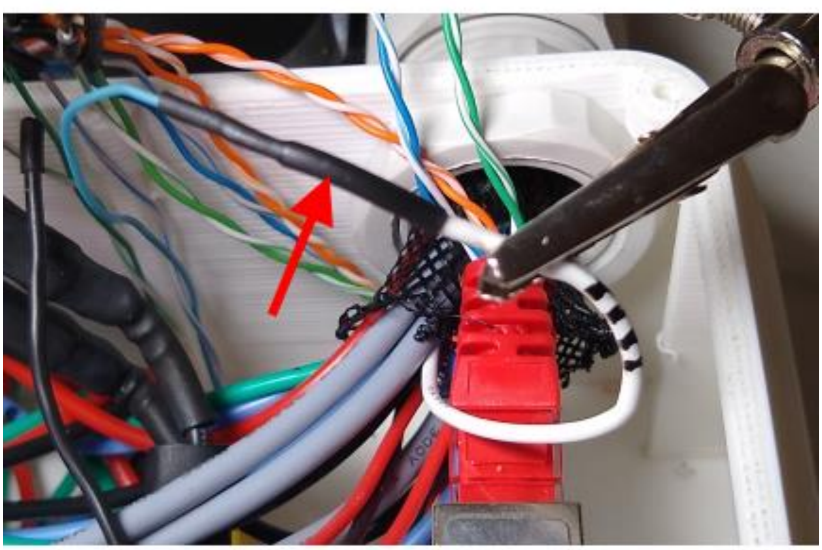
Solder and heat shrink the J6 encoder A-B wires to the Blue Ethernet cable A-B wires for J6 (white/green stripe - green).

- Encoder cable white wire goes to Blue Ethernet cable – white with green stripe wire.
- Encoder cable yellow wire goes to Blue Ethernet cable – green wire.



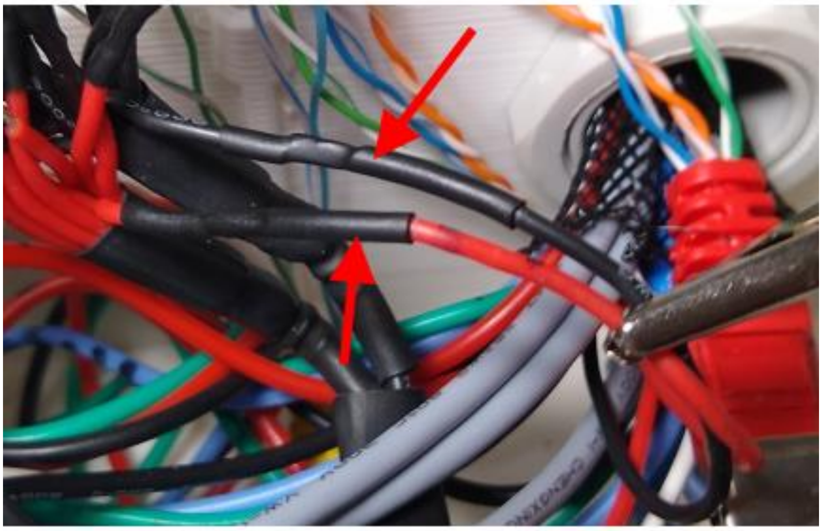
Solder and heat shrink the 5vdc red and black wires from the J6 encoder cable to one of the red and black 5vdc source bundle wires.

- Black wire from J6 encoder goes to one of the black wires from - 5vdc bundle.
- Red wire from the J6 encoder goes to one of the red wires from the 5vdc bundle.



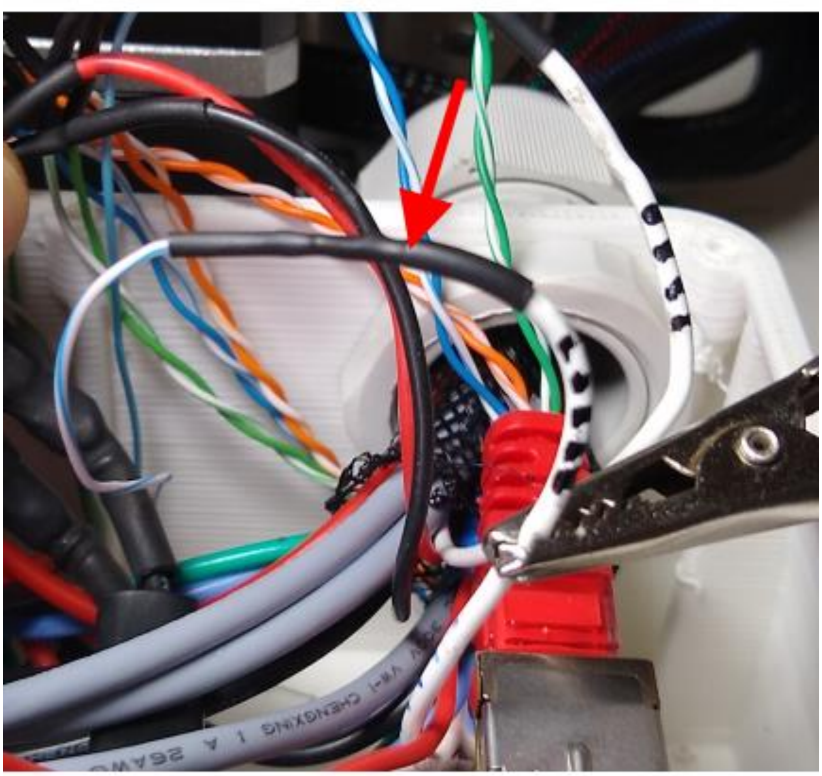
Solder and heat shrink the J4 limit switch signal wire (white) to the Yellow Ethernet cable wire for the J4 limit switch (blue)

- J4 limit switch wire (white) to Yellow Ethernet cable – (blue)



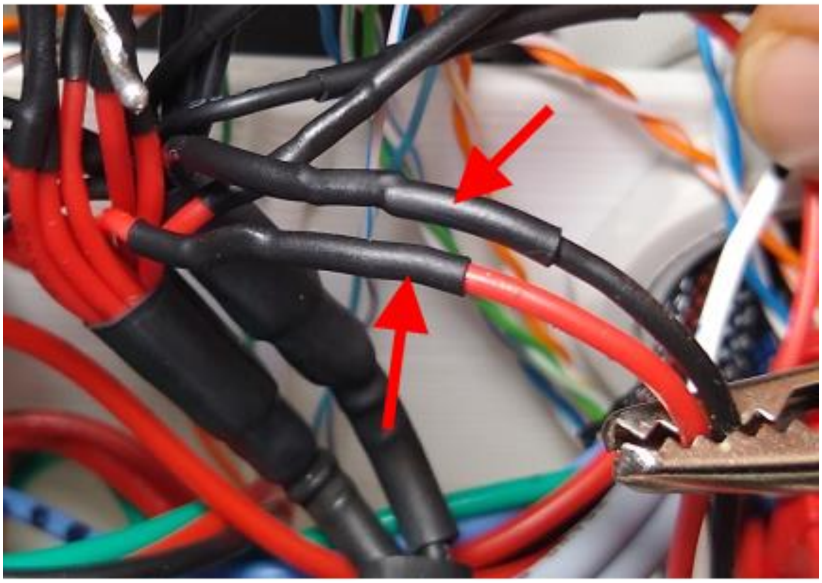
Solder and heat shrink the 5vdc red and black wires from the J4 limit switch to one of the red and black 5vdc source bundle wires.

- Black wire from J4 limit switch goes to one of the black wires from -5vdc bundle.
- Red wire from the J4 limit switch goes to one of the red wires from the 5vdc bundle.



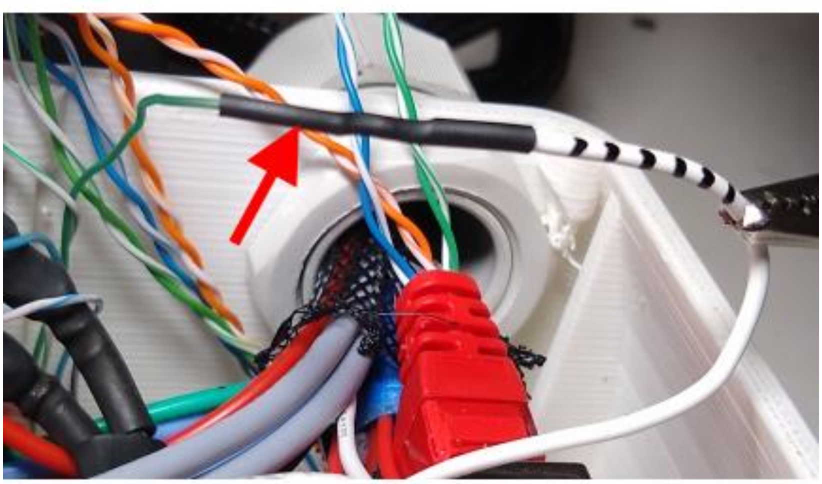
Solder and heat shrink the J5 limit switch signal wire (white) to the Yellow Ethernet cable wire for the J5 limit switch (white / blue stripe)

- J5 limit switch wire (white) to Yellow Ethernet cable – (white / blue stripe)



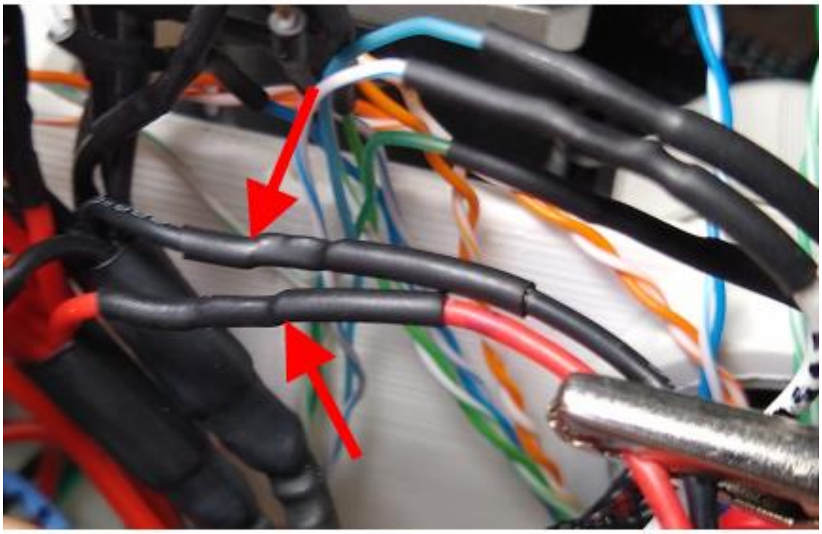
Solder and heat shrink the 5vdc red and black wires from the J5 limit switch to one of the red and black 5vdc source bundle wires.

- Black wire from J5 limit switch goes to one of the black wires from -5vdc bundle.
- Red wire from the J5 limit switch goes to one of the red wires from the 5vdc bundle.



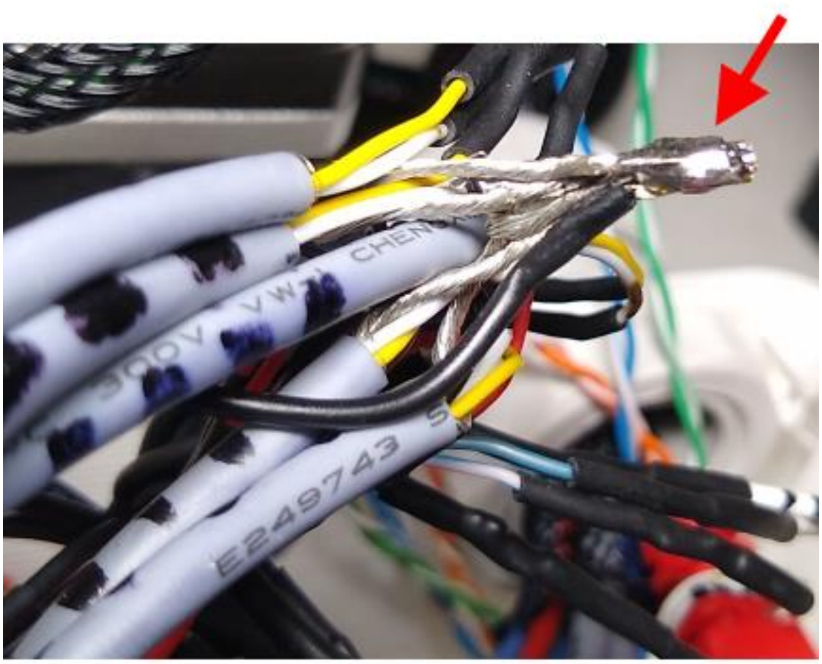
Solder and heat shrink the J6 limit switch signal wire (white) to the Yellow Ethernet cable wire for the J6 limit switch (green)

- J6 limit switch wire (white) to Yellow Ethernet cable – (green)



Solder and heat shrink the 5vdc red and black wires from the J6 limit switch to one of the red and black 5vdc source bundle wires.

- Black wire from J6 limit switch goes to one of the black wires from -5vdc bundle.
- Red wire from the J6 limit switch goes to one of the red wires from the 5vdc bundle.



Bring the ground wires from the 5 encoder cables together and solder them together as shown.

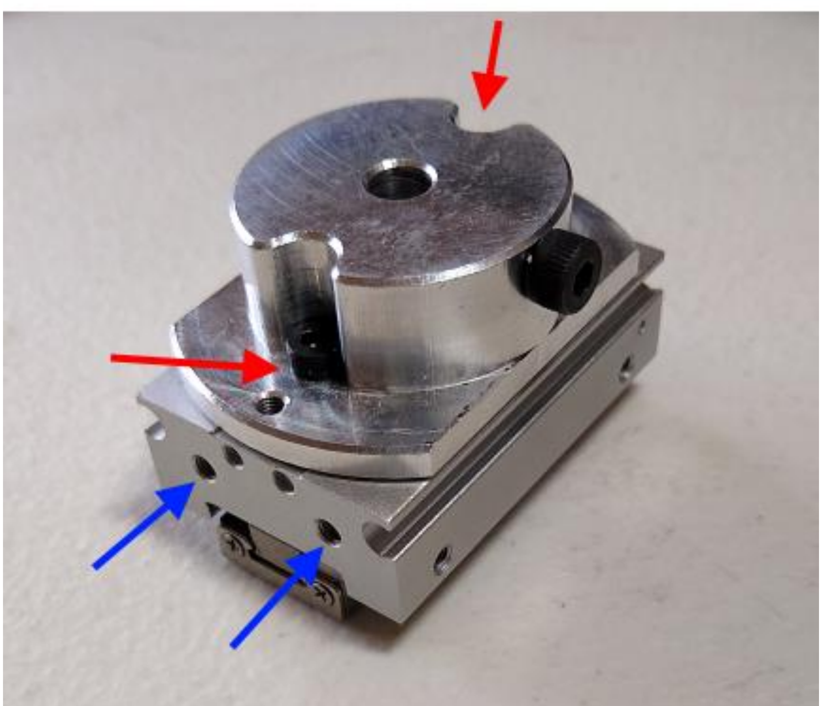
Also solder the last black -5vdc wire from the bundle to this joint.

Carefully tuck all wires into enclosure.

Install base enclosure cap and secure with (6) #6 x3/8 thread forming screws.

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)



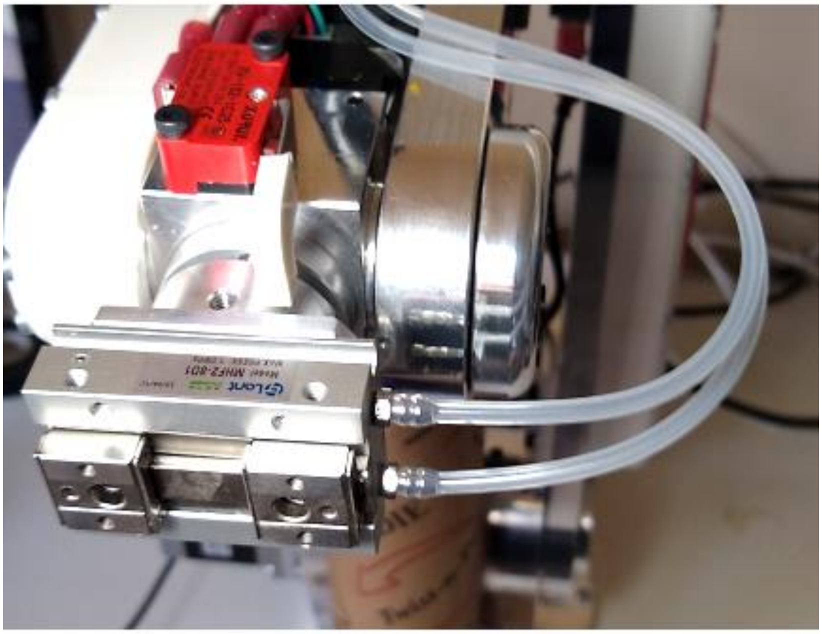
Secure J6 gripper mount to MHF2-8D1 gripper using (2) M3x8 socket head cap screws (red arrows).

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.

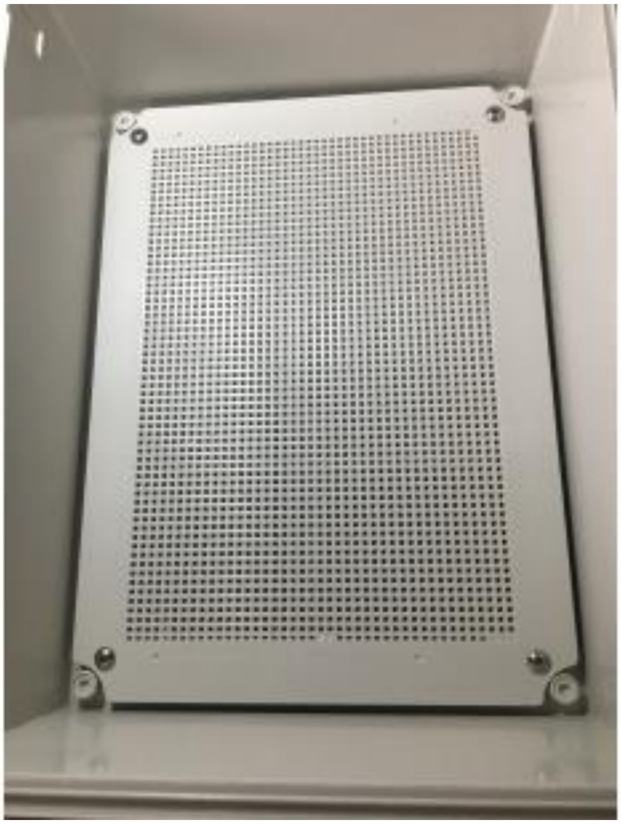
Timing lug set screw should be facing down and pneumatic barb fittings should be on the right.



Install air lines on to pneumatic barb fittings as shown.

CHAPTER 3

ELECTRICAL ENCLOSURE
&
MOTOR CABLES
ASSEMBLY INSTRUCTIONS



Install backplane into enclosure using (4) supplied screws.

On left hinge side of enclosure use marker and straight edge to draw rectangle as shown.

Rectangle should measure:

1.875” (48mm) wide

1.125” (29mm) tall

Rectangle should be centered in side panel of enclosure and be .75” (19mm) down from top.

On front panel of enclosure mark (2) points as shown.

Points should be 1” (26mm) from bottom.

Left point should be 1.5” (38mm) from left hinge side of door.

Points should be 1.5” (38mm) apart from each other.

On front panel of enclosure draw (3) rectangles as shown.

Rectangles should measure:

.70” (18mm) wide.

.95” (24mm) tall.

Rectangles center should be 2.25” (58mm) from bottom.

Left rectangles center should be 1.5” (38mm) from left hinge side of door.

Rectangles center should be 1.5” (38mm) apart from each other.

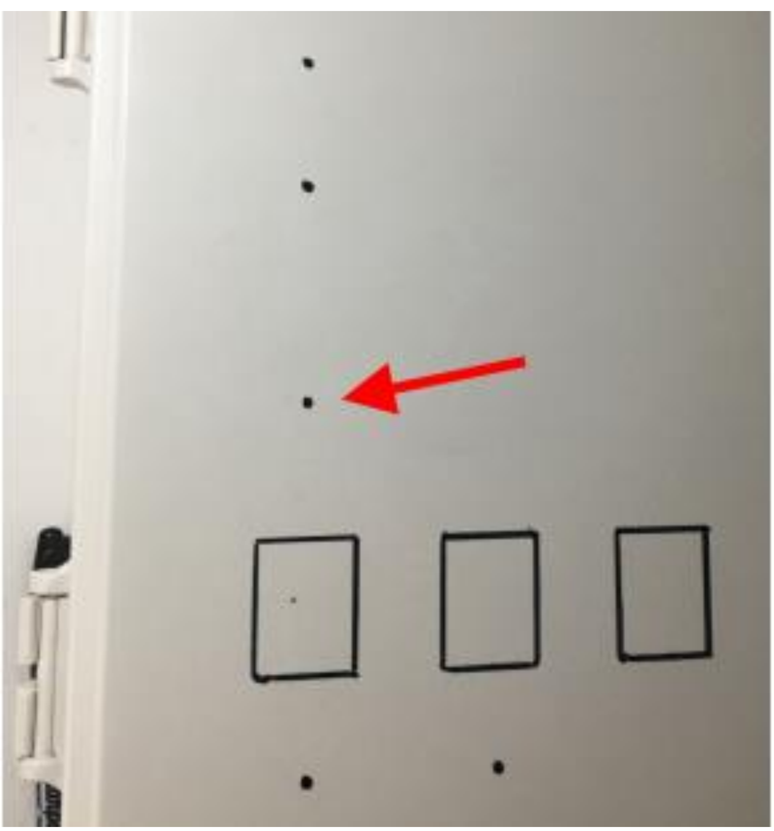
Mark 7 points on front door of enclosure as shown.

Points should be 1.5” (38mm) from left hinge edge.

Top point should be 3.5” (89mm) from top.

Points should be 1” (25.5mm) apart.

Note: 7th (bottom) point is optional for 7th axis travel track.



Mark additional point on front door of enclosure as shown.

Point should be 1.5” (38mm) from left edge.

Point should be 4” (102mm) from bottom.

Mark point in upper left corner of door as shown.

Point should be 1.5” (38mm)

From top of door.

Point should be 1.5” (38mm)

From left hinge side of door.

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 rocker switch module.

Use an oscillating multi tool saw to cut out the hole for the air vent and the (3) RJ45 ports.

Drill lower two holes for USB ports using stepped drill bit as shown.

Holes should be drilled to size: .875” (22mm)

Drill (8) aviation plug holes using stepped drill bit as shown.

Holes should be drilled to size: .625” (16mm)

Drill emergency stop button hole using stepped drill bit as shown.

Hole should be drilled to size: 1” (25mm)

Install rocker switch module and then drill 2 mounting holes as shown using #38 (.108) drill.

Secure rocker switch module using (2) #6 thread forming screws.

Install (2) USB panel feedthru jacks and drill mounting holes using #38 (.108) drill.

Secure USB feedthru jacks using (4) #6 thread forming screws.

Install (3) RJ45 panel feedthru jacks and drill mounting holes using #38 (.108) drill.

Secure RJ45 feedthru jacks using (6) #6 thread forming screws.

Install emergency stop button as shown in upper left corner of enclosure door as shown.

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

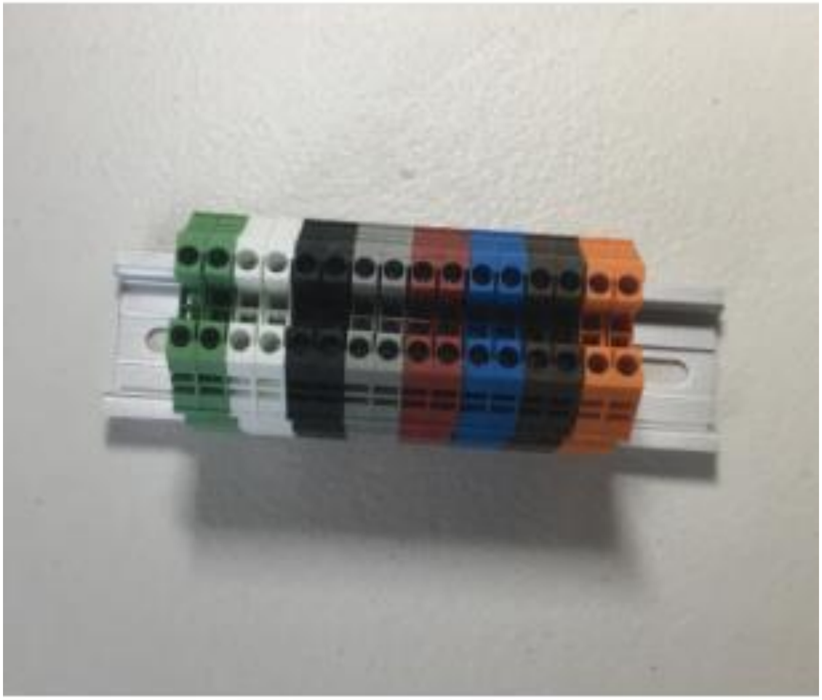
With 24vdc power supply upside down on surface, fold sheet of paper and lay sheet of paper across bottom of power supply as shown.

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 wall.

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

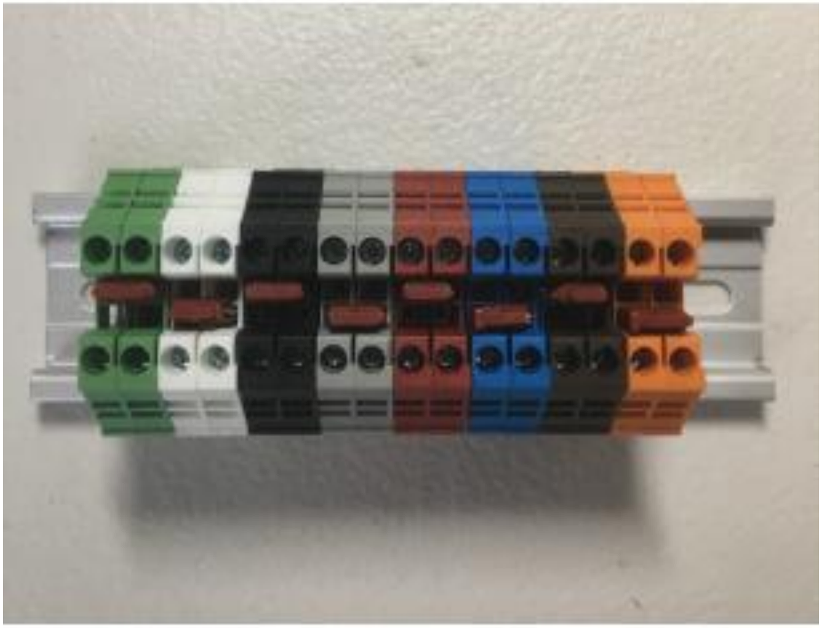
Drill (4) marked holes using #20 or 4mm size drill.

Secure power supply to bottom rightof enclosure as shown using (4) 3mm button head cap screws.



Cut DIN rail to length of 5” (127mm) and then install (16) terminal blocks as shown.

Cut jumpers strips down to (8) pairs of jumpers as shown.



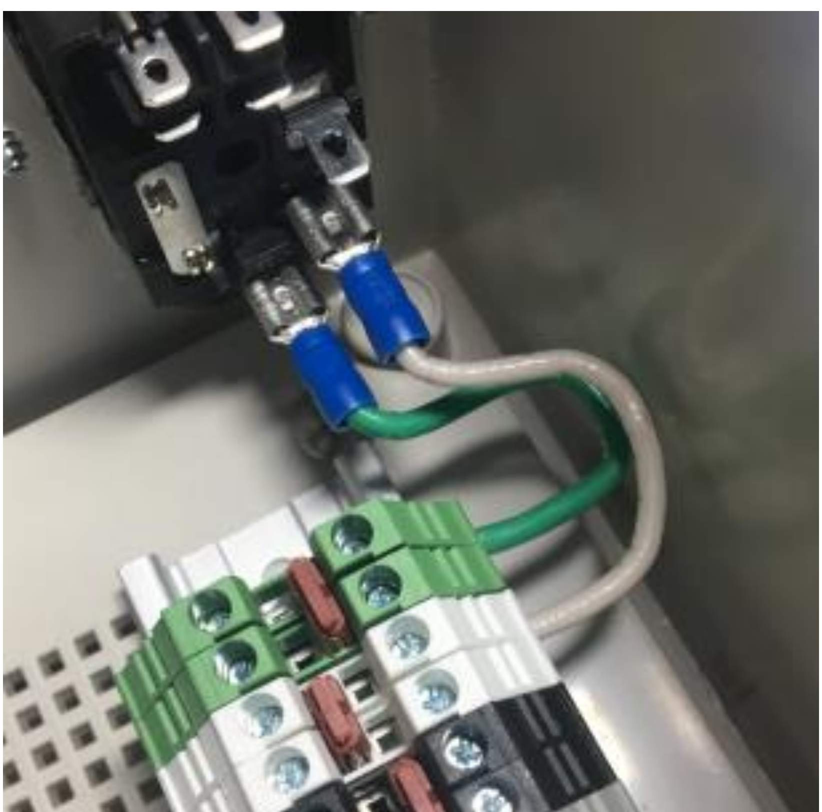
Install jumpers into terminals as shown. You will now have (8) pairs of cross connected terminals.

Alternate jumper position high/low as shown and make sure there is no opportunity for jumpers to touch one another.

Secure DIN rail terminal assembly as shown using (2) #6 thread forming screws.

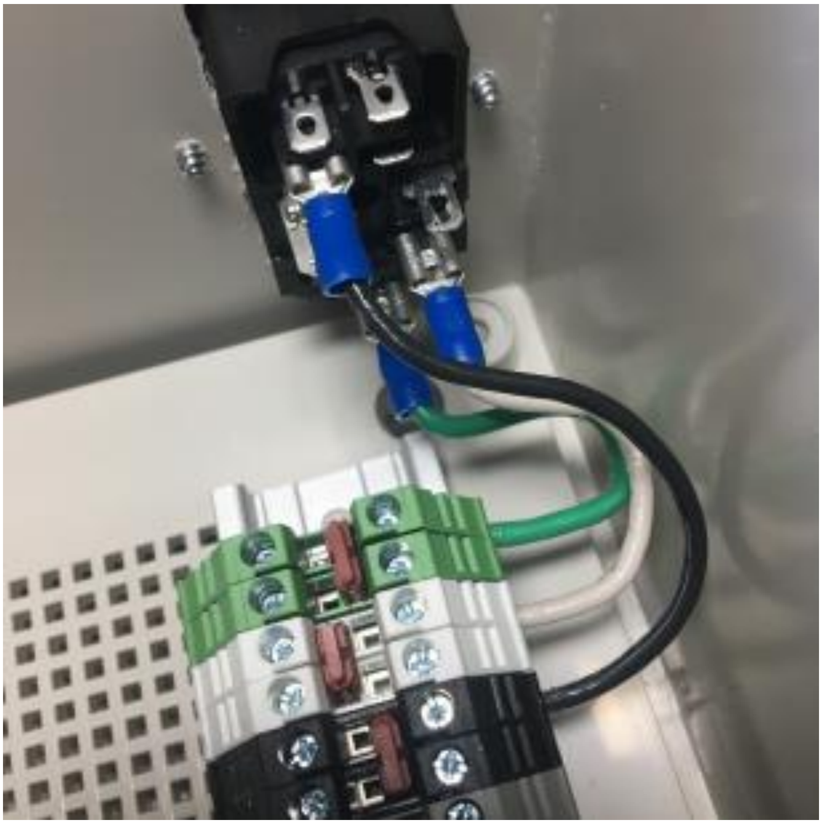
Use 18awg green wire to connect bottom terminal on rocker switch module to first pair of DIN rail terminals as shown.

Note: Use crimp slide connector to connect end of wire attached to rocker switch module.



Use 18awg white wire to connect second from bottom right terminal on rocker switch module to second pair of DIN rail terminals as shown.

Note: Use crimp slide connector to connect end of wire attached to rocker switch module.

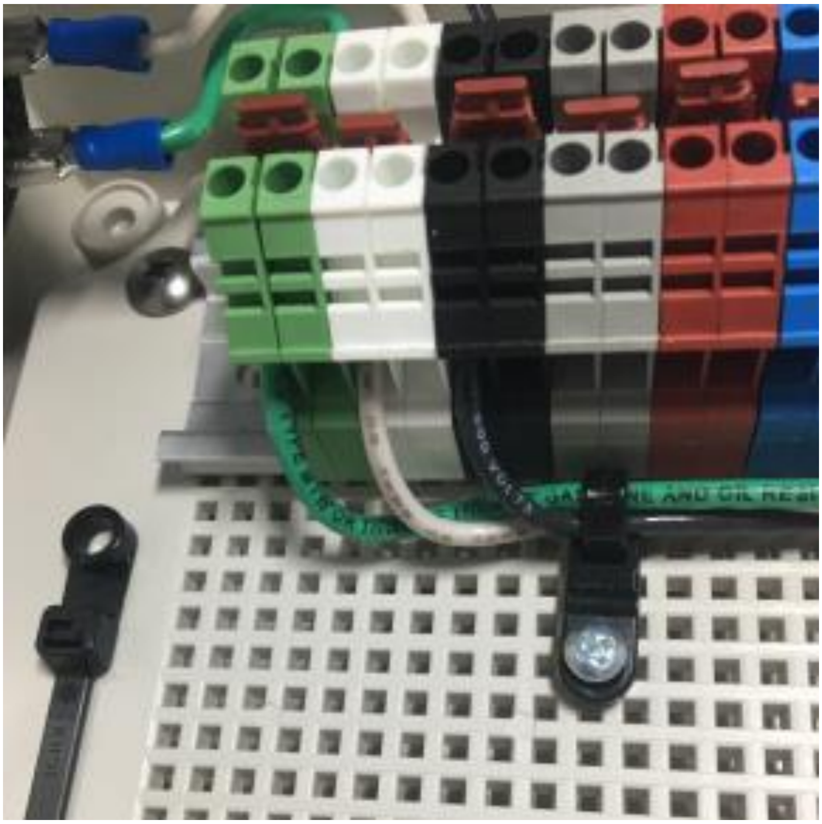


Use 18awg black wire to connect second from top left terminal on rocker switch module to third pair of DIN rail terminals as shown.

Note: Use crimp slide connector to connect end of wire attached to rocker switch module.

Use 18awg black wire to create jumper and connect 2 middle right terminal on rocker switch as shown.

Note: Use crimp slide connectors on both ends of wire to rocker switch module.

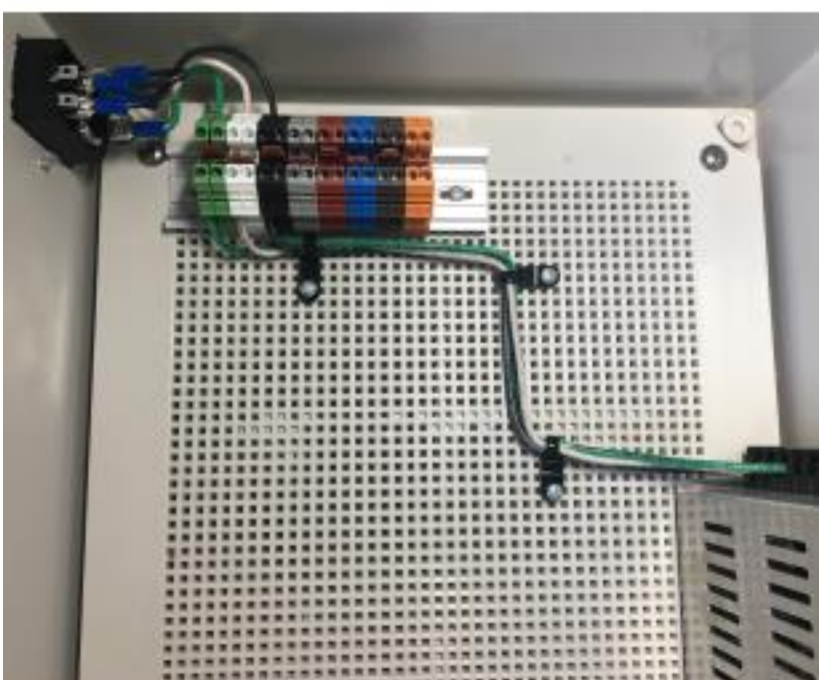


Use 18awg green wire and connect to bottom of first (ground) pair of DIN terminals.

Use 18awg white wire and connect to bottom of second (neutral) pair of DIN terminals.

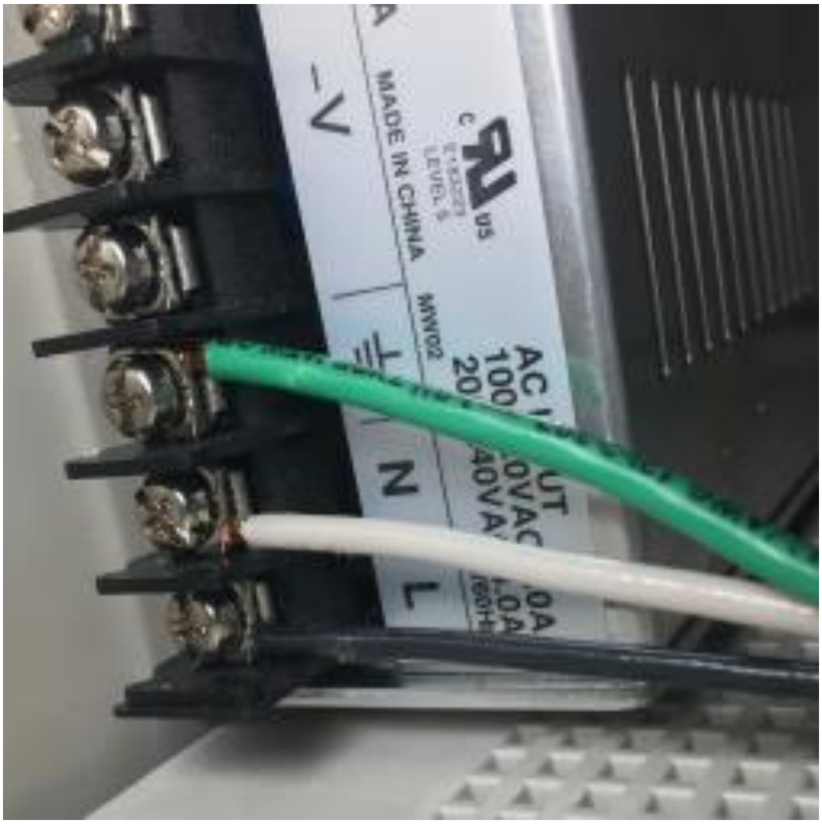
Use 18awg black wire and connect to bottom of third (line) pair of DIN terminals.

Use mounting hole cable tie and #6 thread forming screw to secure wires as shown.



Route the green, white and black wires to 24vdc power supply as shown.

Use (2) additional mounting hole cable ties and #6 thread forming screws to secure wires as shown.

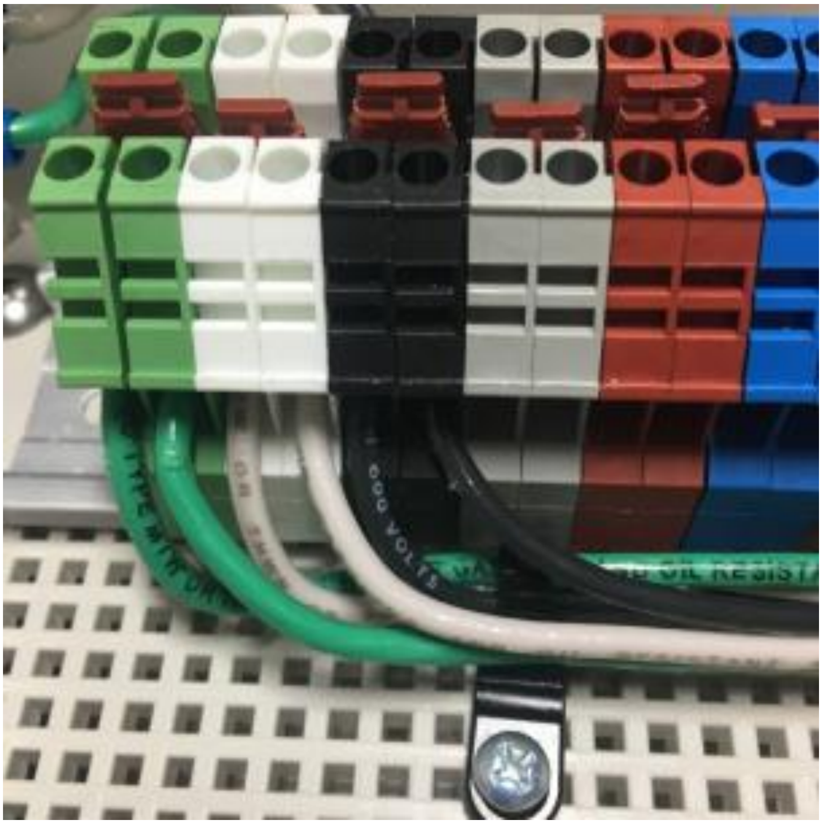


At the 24vdc power supply terminals connect the green wire to the ground terminal, connect the white wire to the neutral or “N” terminal and connect the black wire to the line of “L” terminal as shown.

Mount 5vdc power supply in the location shown.

Use (2) #6 thread forming screws to secure power supply.

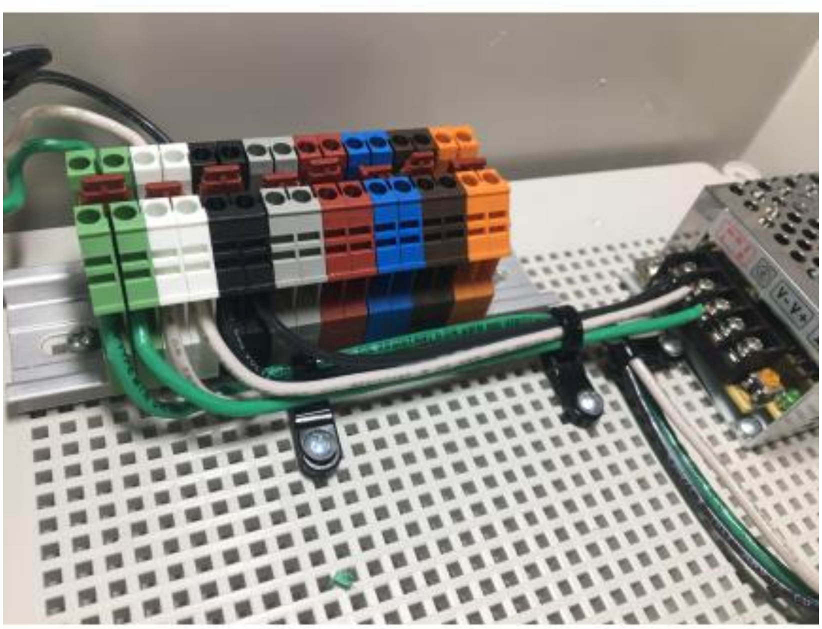
NOTE: Upper right hole in backplane will need to be marked and drilled.



Use 18awg green wire and connect second wire to bottom of first (ground) pair of DIN terminals.

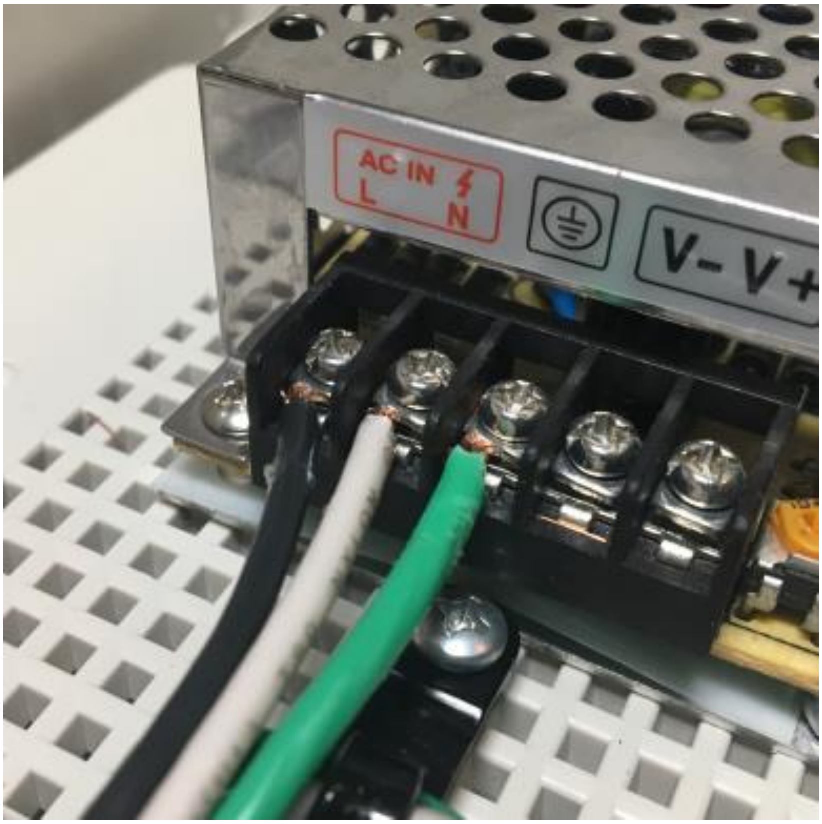
Use 18awg white wire and connect second wire to bottom of second (neutral) pair of DIN terminals.

Use 18awg black wire and connect second wire to bottom of third (line) pair of DIN terminals.

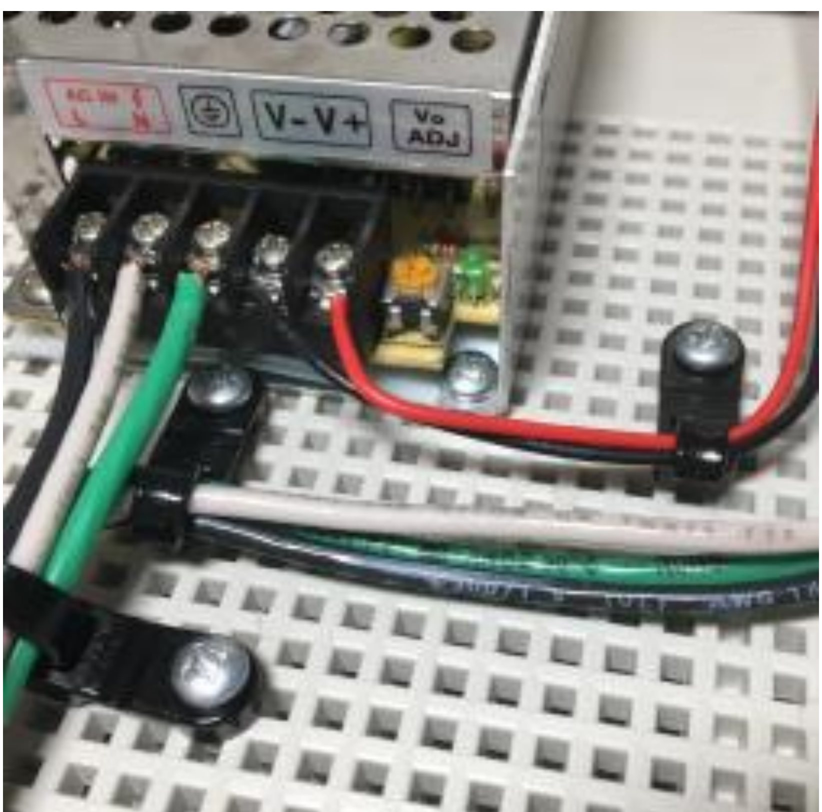


Route second pair of green, white and black wires to 5vdc power supply as shown.

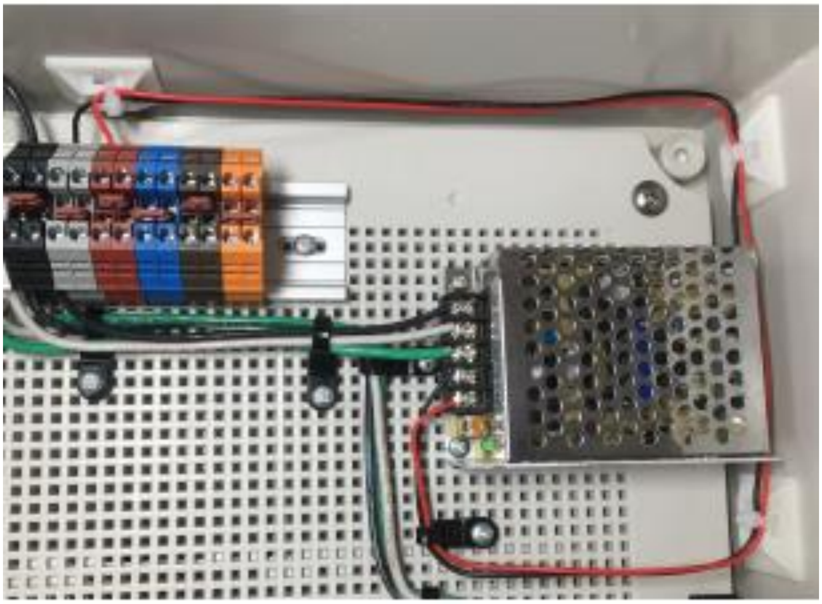
Use (1) additional mounting hole cable tie and #6 thread forming screws to secure wires as shown.



At the 5vdc power supply terminals connect the green wire to the ground terminal, connect the white wire to the neutral or “N” terminal and connect the black wire to the line of “L” terminal as shown.



Use 22awg red and black wires; at the 5vdc power supply terminals connect the black wire to the V- terminal, connect the red wire to the V+ terminal.



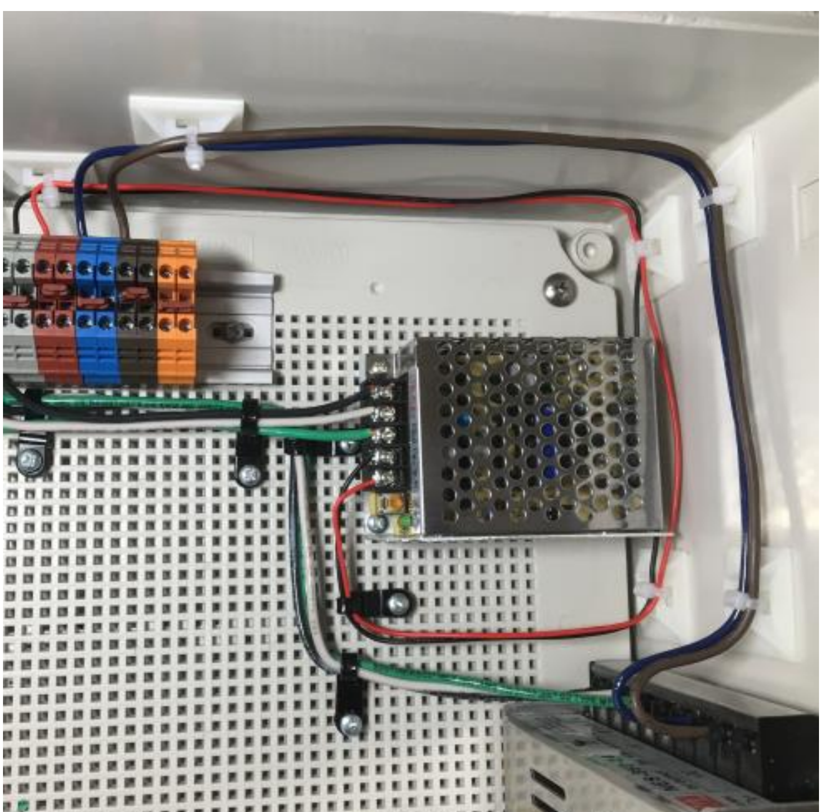
Route the black and red wires from 5vdc power supply to the 4th and 5th set of DIN rail terminals as shown.

Use (1) mounting hole cable tie with #6 thread forming screw to secure wires to backplane and then use (3) adhesive cable tie mounts to secure wires to enclosure walls as shown.

Connect 22awg black wire from 5vdc power supply to 4th pair of DIN rail terminals.

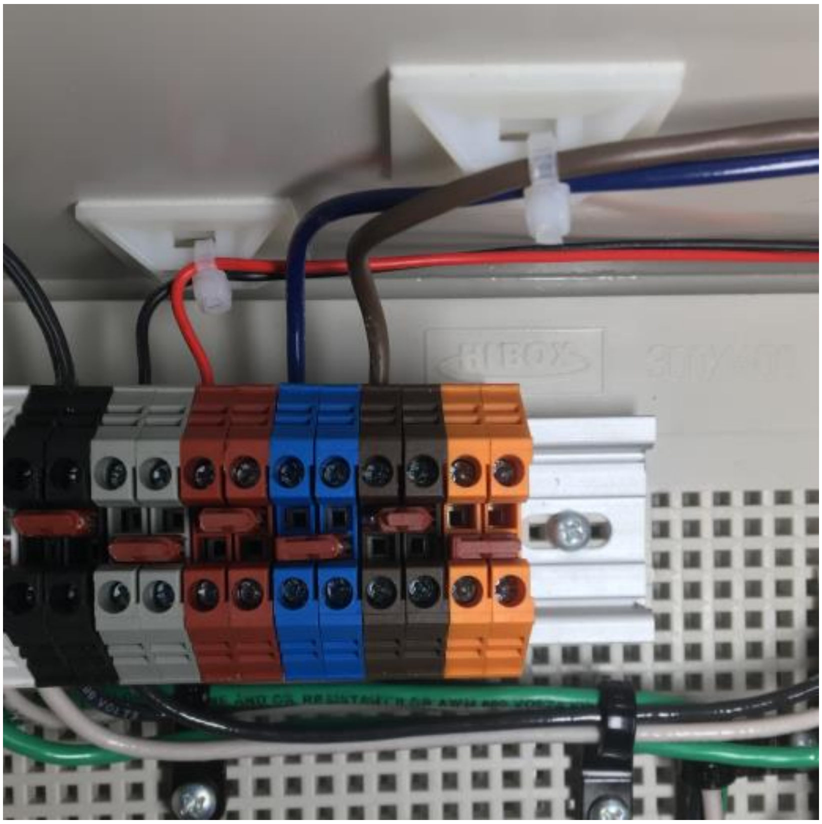
Connect 22awg red wire from 5vdc power supply to 5th pair of DIN rail terminals.

Use 18awg brown and blue wires; at the 24vdc power supply terminals connect the brown wire to the V+ terminal, connect the blue wire to the V- terminal.



Route the brown and blue wires from 24vdc power supply to the 6th and 7th set of DIN rail terminals as shown.

Use (3) adhesive cable tie mounts to secure wires to enclosure walls as shown.



Connect 18awg blue wire from 24vdc power supply to 6^{th} pair of DIN rail terminals.

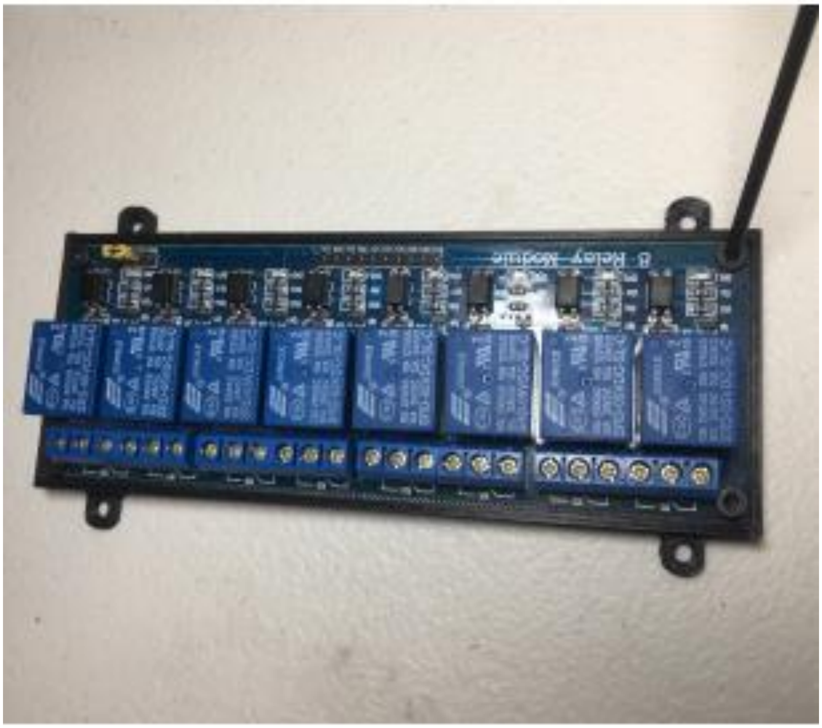
Connect 18awg brown wire from 24vdc power supply to 7^{th} pair of DIN rail terminals.

Place relay mount in position shown and mark 4 mounting holes with marker.

Right side of relay mount should be approx. 5mm from power supply and 15mm from bottom front edge of enclosure.

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

Use M3 tap to thread all (4) holes in relay mount.

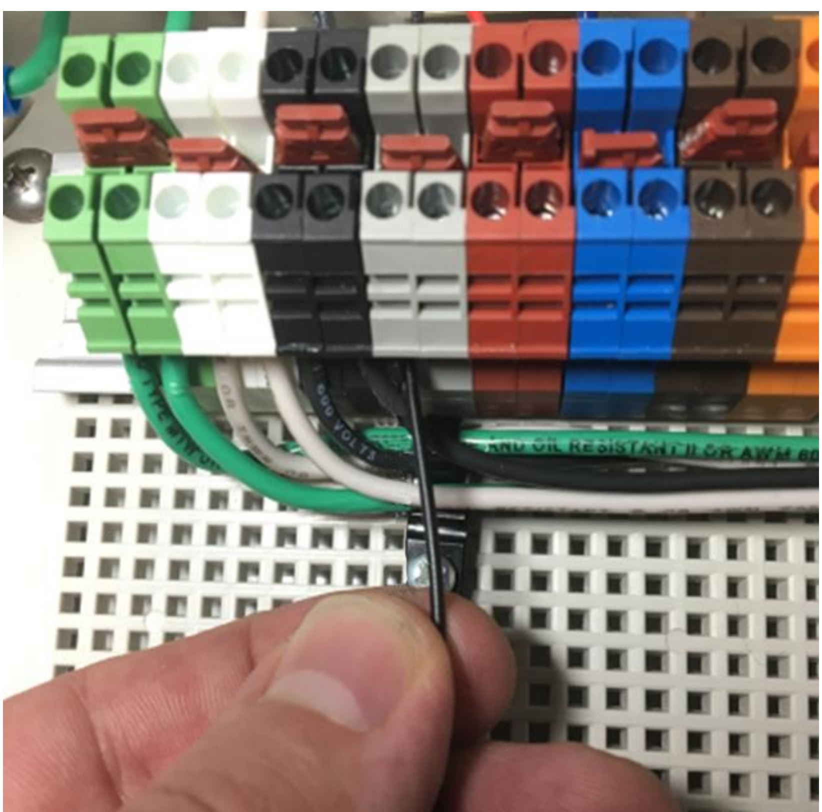


Secure 8 channel relay module to relay mount using (4) M3 cap screws.

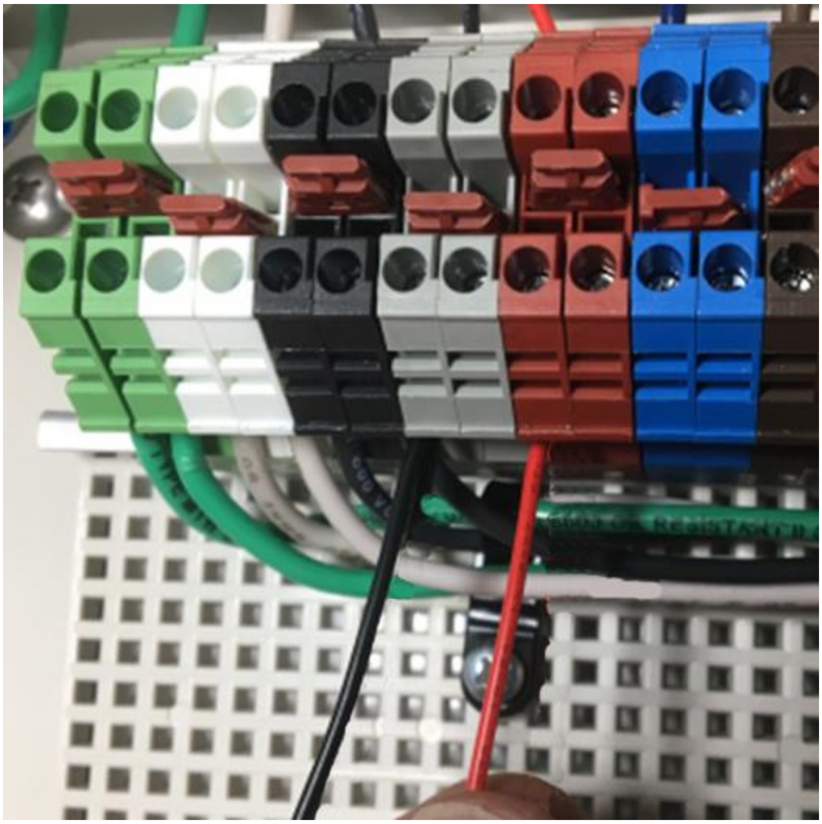
Secure relay module and mount assembly to bottom of enclosure using (4) 3mm button head cap screws, (4) 3mm washers and (4) 3mm hex nuts.

Install (1) GX16-2 aviation plug socket in enclosure door in bottom hole above RJ45 connectors as shown.

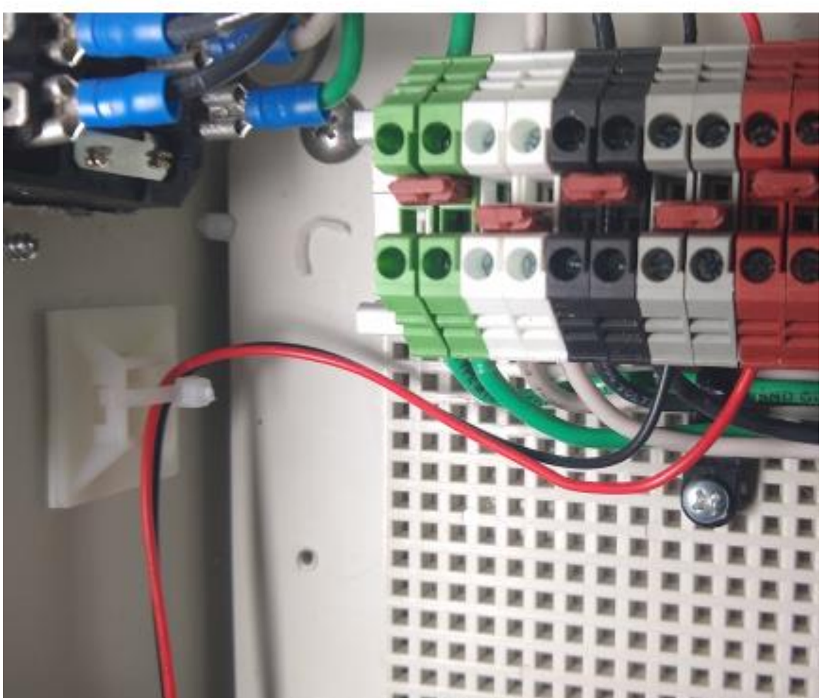
Note: make sure that socket alignment notch is mounted in the up position.



Connect length of 22awg black wire to 4th pair of DIN rail terminals (-5vdc).



Connect length of 22awg red wire to 5th pair of DIN rail terminals (+5vdc).



Use adhesive cable tie mount and cable ties on left enclosure wall and route wires down left side of enclosure wall and then down to the bottom.

Use adhesive cable mount on bottom of enclosure and route the 2 wires as shown down to bottom of enclosure.

Note: cut and strip wire ends as shown.

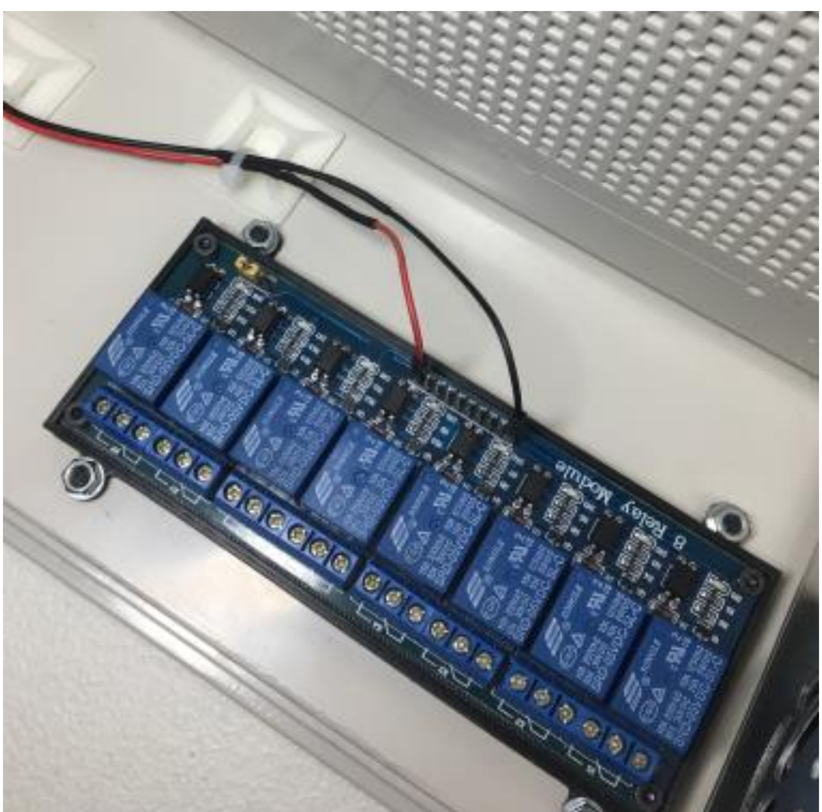
Cut and strip ends from (2) female end breadboard jumper wires as shown.

One jumper should be red and the other black.

Slide length of 2mm heat shrink tube over each wire.

Use soldering iron and silver bearing rosin core electrical solder to solder ends of red and black 5vdc supply wires to ends of female bread board jumper wires as shown.

Slide heat shrink tube over solder joints and then use head gun to shrink tubing around joint.



Connect red wire female connector to VCC terminal of relay module.

Connect black wire female connector to GND terminal of relay module.

Secure wires to base of enclosure using adhesive mount cable tie as shown.

Install Stepper drivers as shown along left side of enclosure and secure to backplane using #6 thread forming screws.

- Starting at the top install (3) DM542T drivers for axis 1,2 &3.
- Then install (1) DM320T driver for axis 4.
- Then install (2) more DM542T drivers for axis 5 & 6.

If you are going to build a travel track you can install one additional DM542T driver at the bottom (this is optional)

NOTE the drivers used in this manual are blue in color but the DM542T are black and are identical to the ones shown in this manual.

NOTE: When installing drivers you will need to drill left hole in backplane.

You can use an extended drill bit as shown or use driver as template then mark and drill each hole prior to installation.

Connect 18awg brown wire from 7th pair of DIN rail terminals (+24vdc) to bottom terminal on E-Stop button as shown.

NOTE: Leave enough slack so that door will open and close fully.

Connect 18awg brown wire from top terminal on E-Stop button to 5th terminal on top stepper driver shown.

NOTE: 5th terminal on stepper driver is labeled "AC" or "+Vdc"

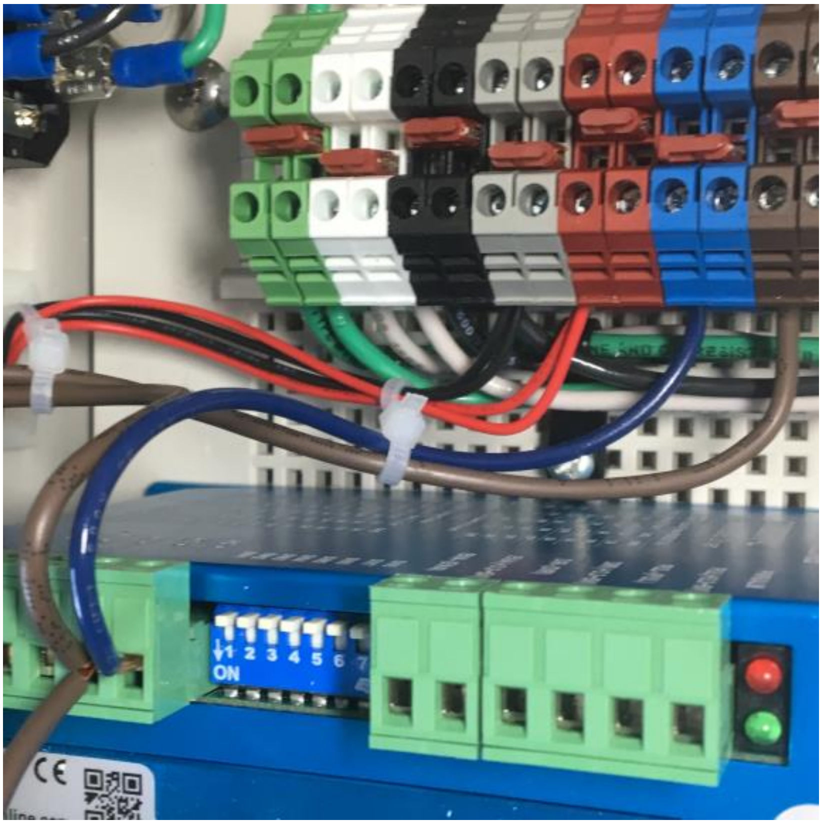
Use (1) adhesive cable mount and (3) cable ties to secure brown wires as shown.

Cut (6) lengths of 18awg brown wire approx. 70mm long.

Then jumper the wires down from the top stepper driver to each stepper driver below.

The brown wire should be connected to the 5th terminal on each driver as shown.

NOTE: 5th terminal on stepper driver is labeled "AC" or "+Vdc"



Connect 18awg blue wire from 6th pair of DIN rail terminals (-24vdc) to the 6th terminal on stepper driver as shown.

NOTE: 6th terminal on stepper driver is labeled “AC” or “GND”

Cut (6) lengths of 18awg blue wire approx. 70mm long.

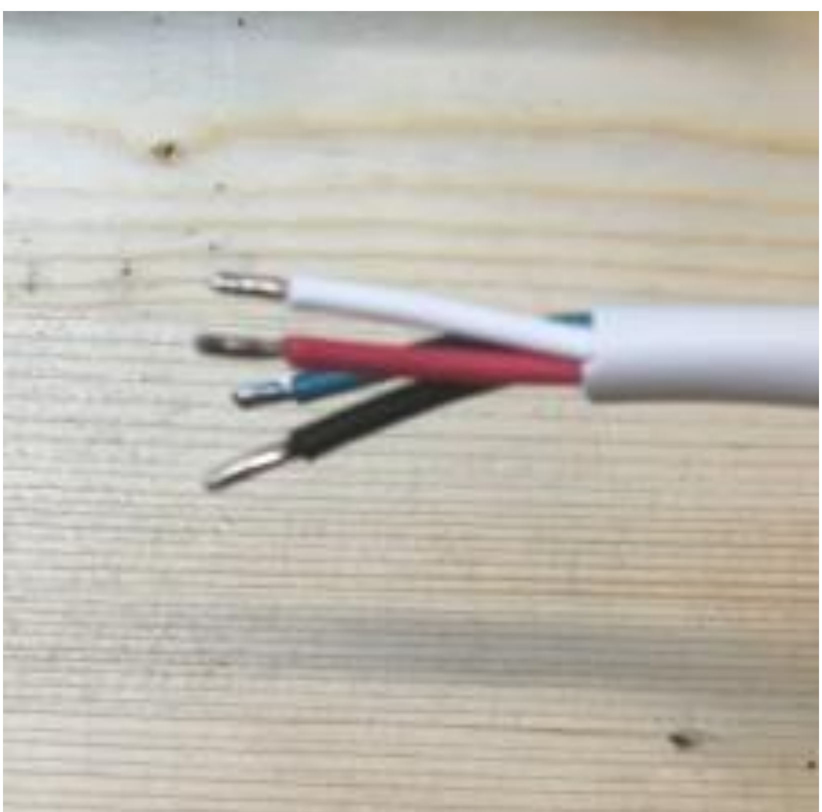
Then jumper the wires down from the top stepper driver to each stepper driver below.

The brown wire should be connected to the 6th terminal on each driver as shown.

NOTE: 6th terminal on stepper driver is labeled “AC” or “GND”

Cut (6) lengths of 4 strand cable approx. 500mm long

Cut a 7th if installing driver for a 7th axis travel track.

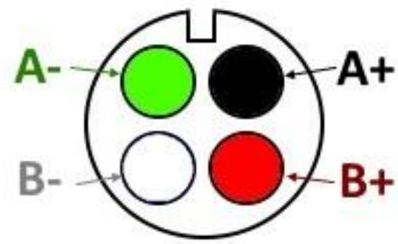


Use soldering iron and silver bearing rosin core electrical solder to tin the wire ends with solder as shown. Also pre-apply solder to the solder connection joints on the aviation plugs.

Solder wires as shown to the rear of the GX16-4 aviation plug.

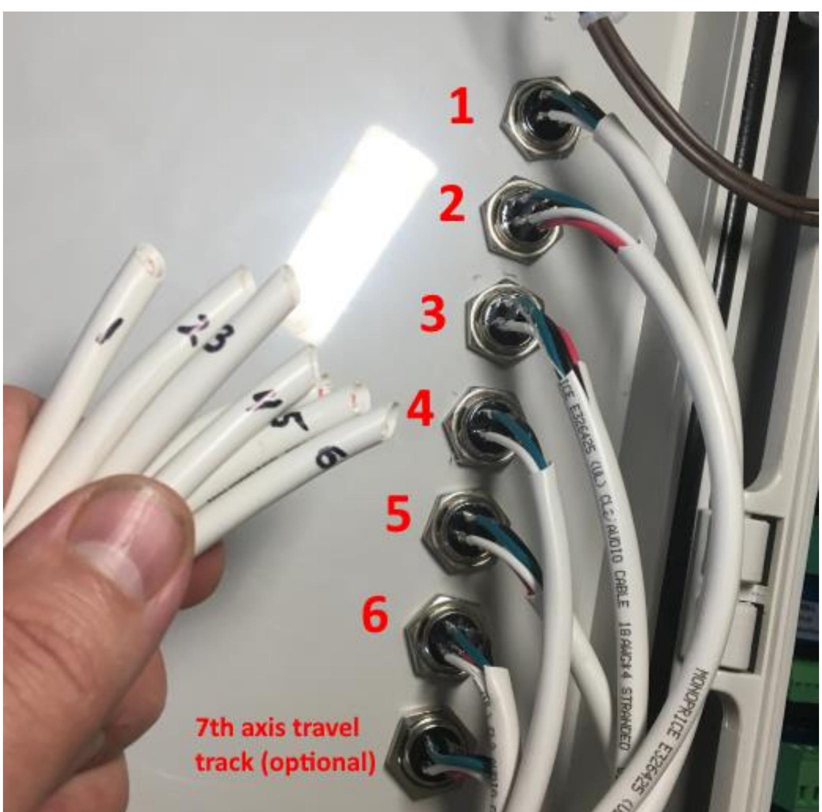
The diagram below shows which terminals to solder each wire color.

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



Repeat this for all motor/driver wires.

Install each GX16-4 with motor driver wire as shown.



Mark the ends of each wire so that you can easily identify which driver each wire will go to.

The wire from the top plug will go to axis 1, the next down will go to axis 2 and so on down to the bottom plug.

NOTE: Bottom plug is optional for 7th axis travel track.

Install adhesive cable mount in on inside lip of door just below center hinge and bundle all driver wires as shown.

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)

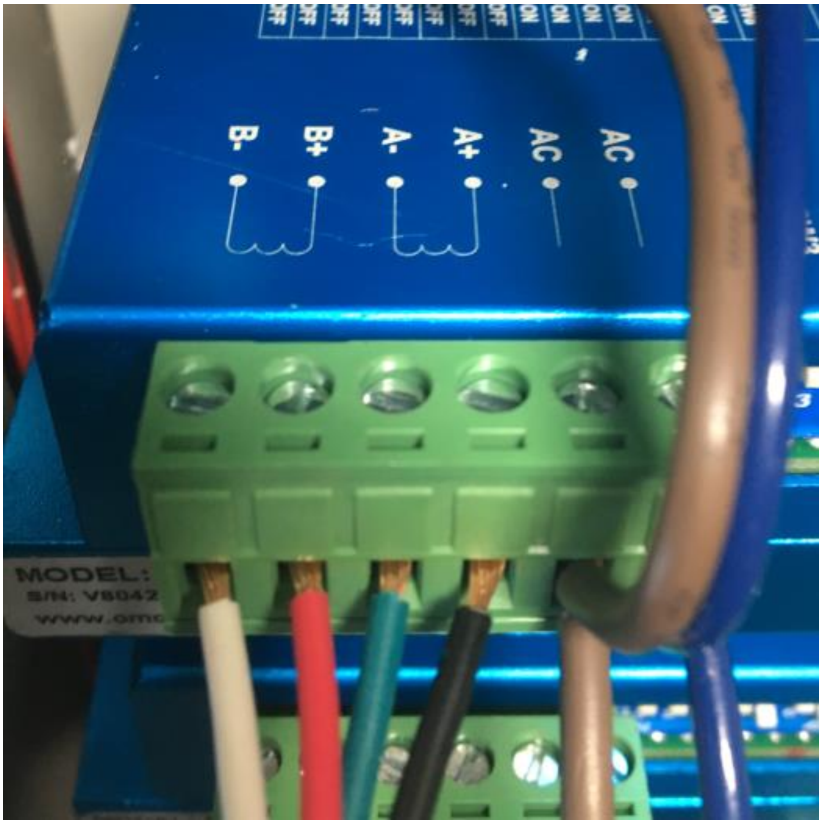
Connect each color wire to the labeled terminals as follows:

BLACK = A+

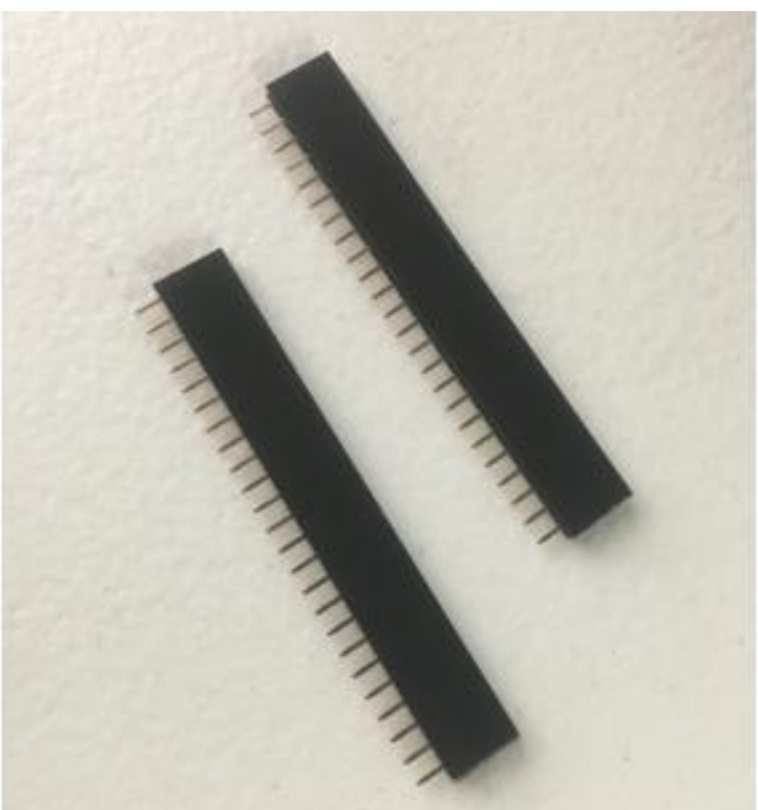
GREEN = A-

RED = B+

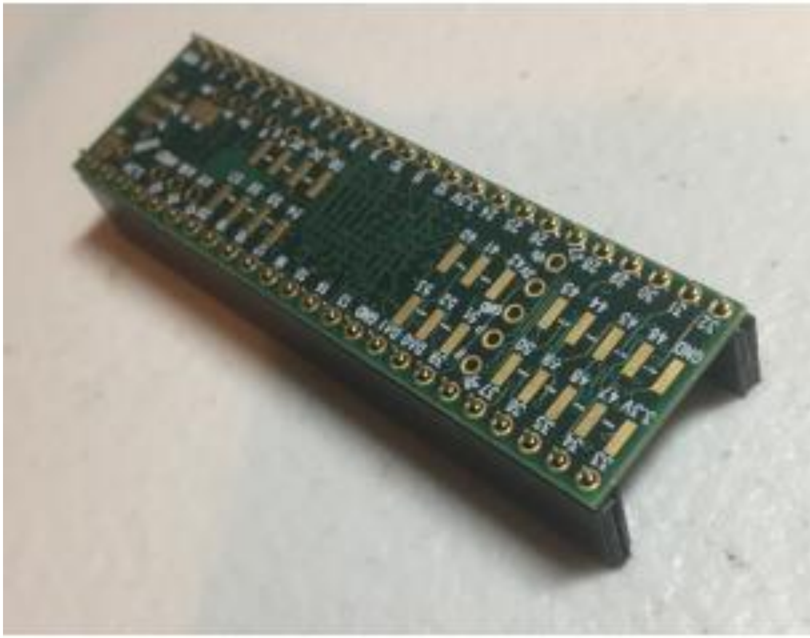
WHITE = B-



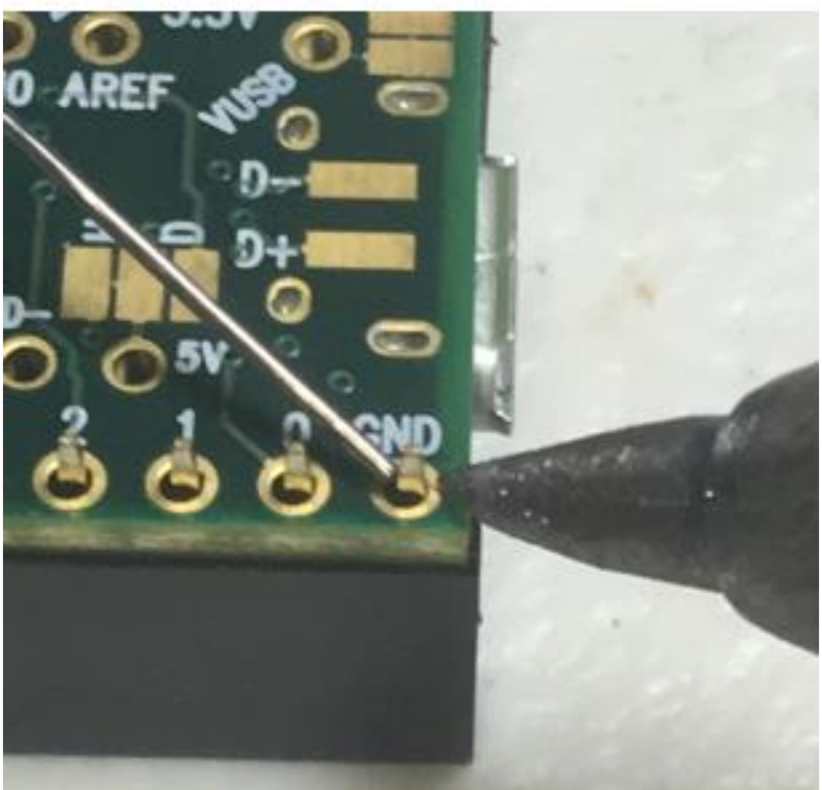
This picture shows a close up view of each wire connected to one of the drivers.



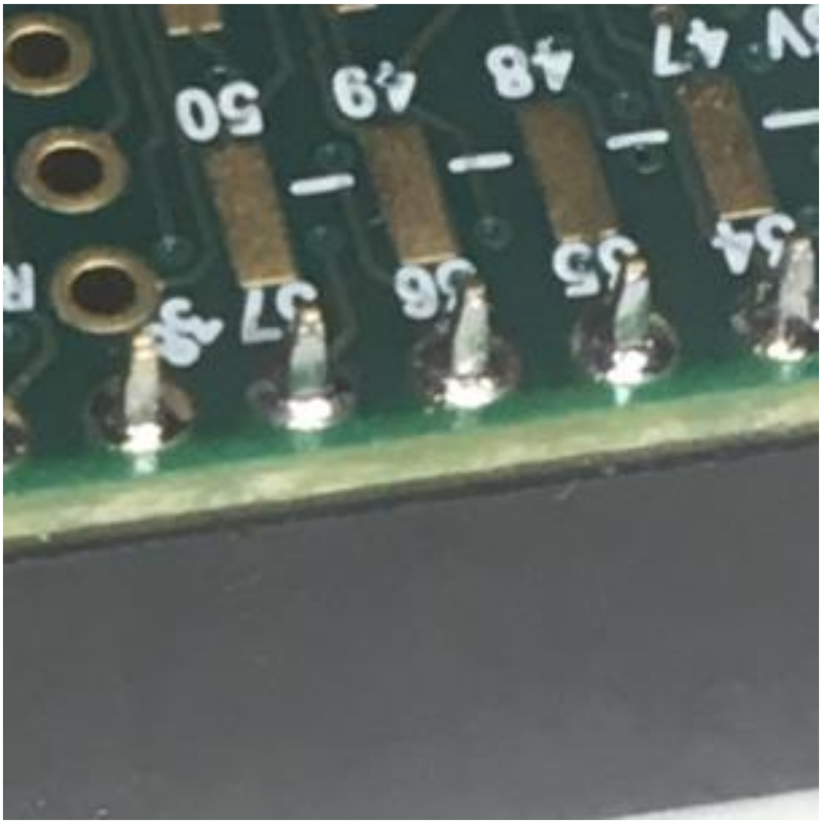
Use cutters to cut (2) 40 pin PCB header pin strips down to be 24 pins long as shown.



Place Teensy 3.5 board upside down on PCB header pin strips as shown.

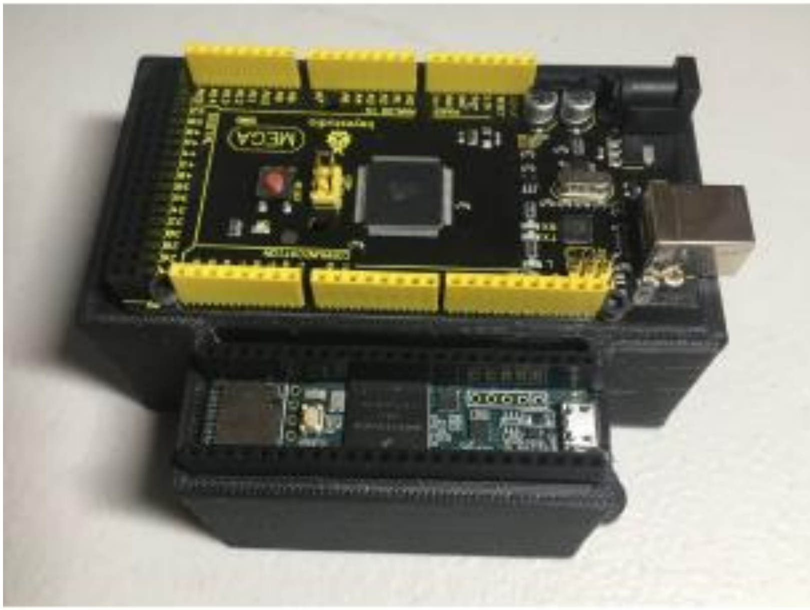


Use soldering iron and silver bearing rosin core electrical solder to solder each of the PCB female header pins to the terminals on Teensy 3.5 controller.



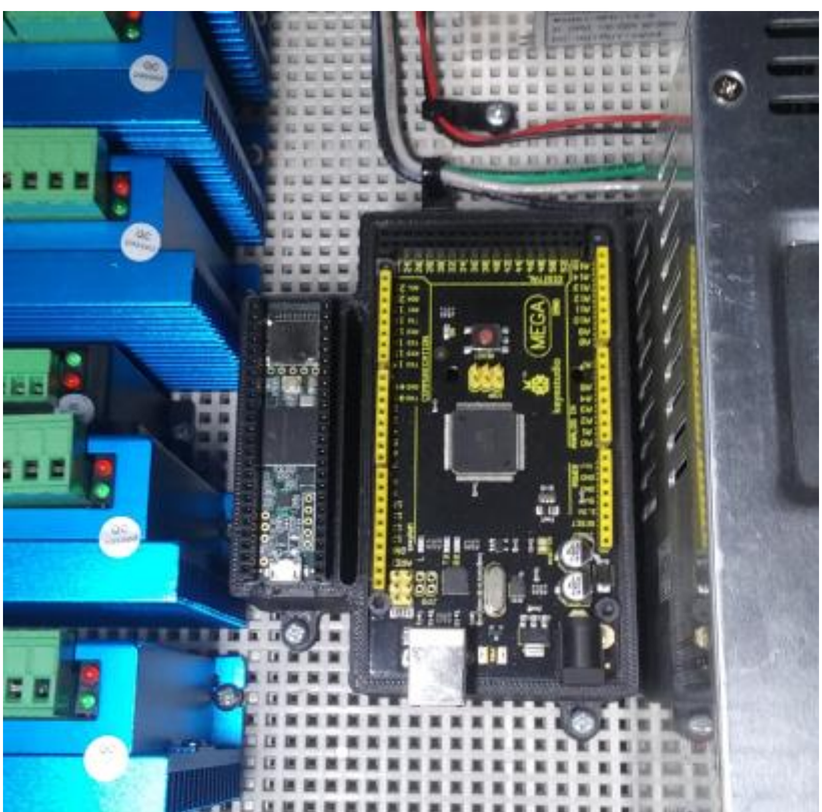
Each joint should be completely soldered as shown.

Teensy 3.5 controller should look like this after soldering both lengths of header pins.



Use (4) 3mm screws to secure Arduino Mega 2560 to 3D printed mount as shown.

Use small amount of silicone along center rib to mount Teensy 3.5 to 3D printed mount as shown.

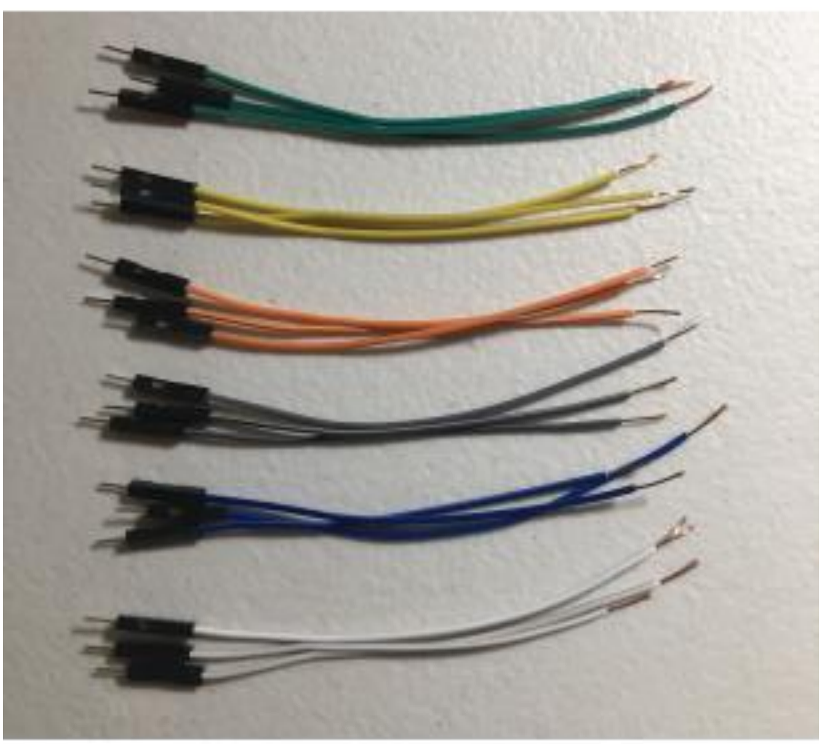


Secure Arduino/Teensy mount assembly to backplane using (4) #6 thread forming screws in position shown.

Cut yellow, blue and red Ethernet cables to length of 50cm (20”)

Remove 5cm (2”) of outer sheathing and strips ends of each wire.

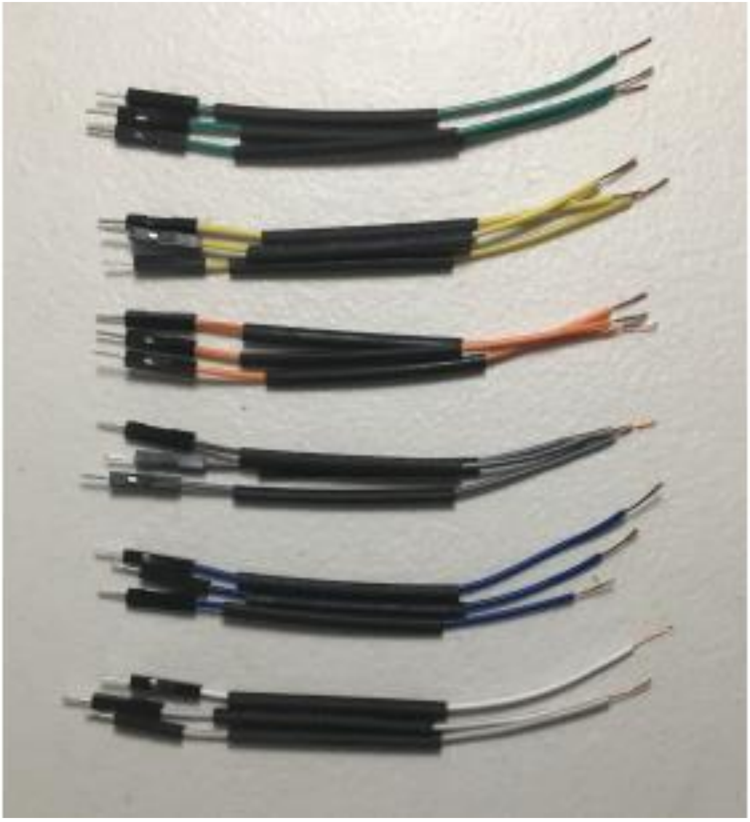
Note: save remaining end of yellow, blue and red Ethernet cables for use in assembly of the robot.



Cut and strip ends of (21) jumper wires as shown.

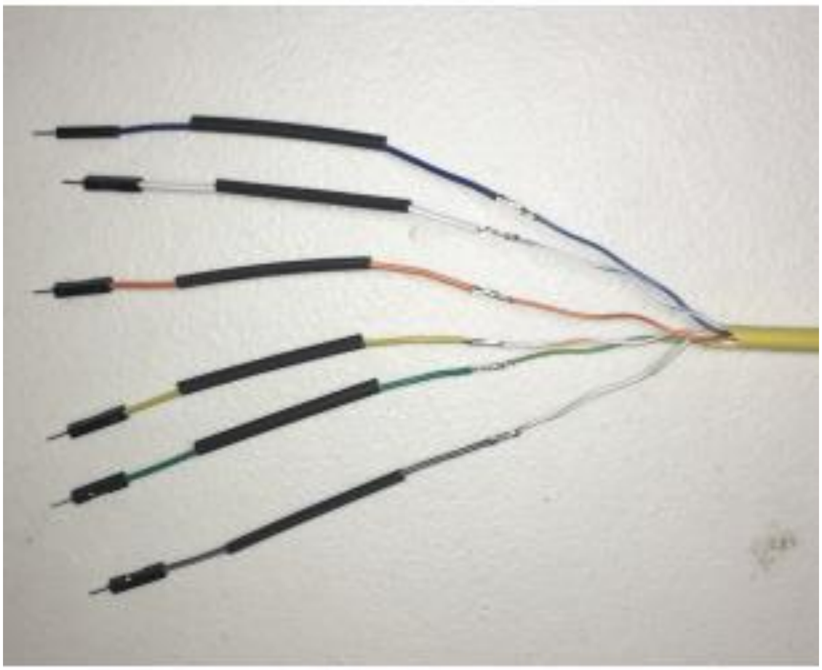
You will need (3) of each color: green, yellow, orange, grey, blue and white.

Each wire should be approx. 110mm long.



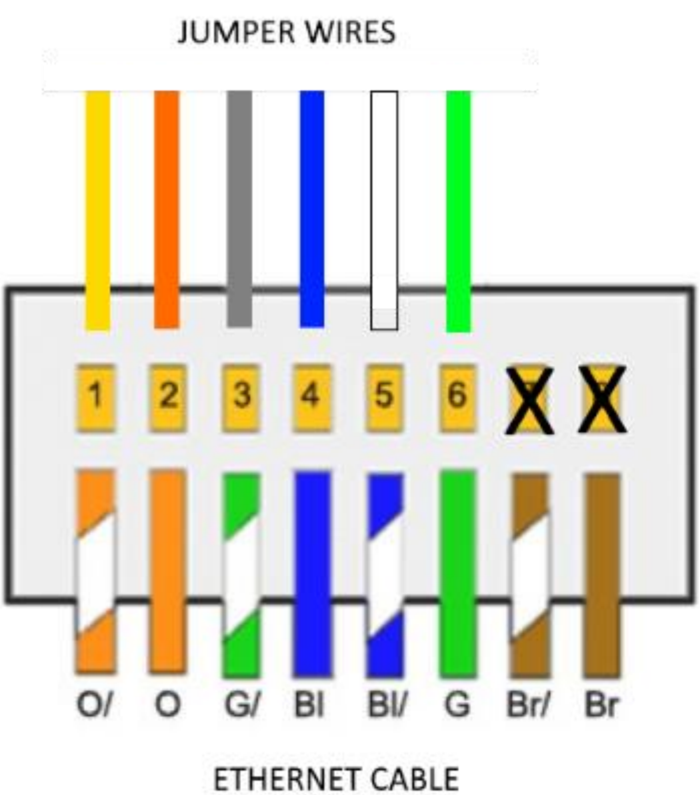
Slide length of 2mm heat shrink tube over each wire.

Cut and remove (brown – white/brown stripe) pair of wires from yellow Ethernet cable.

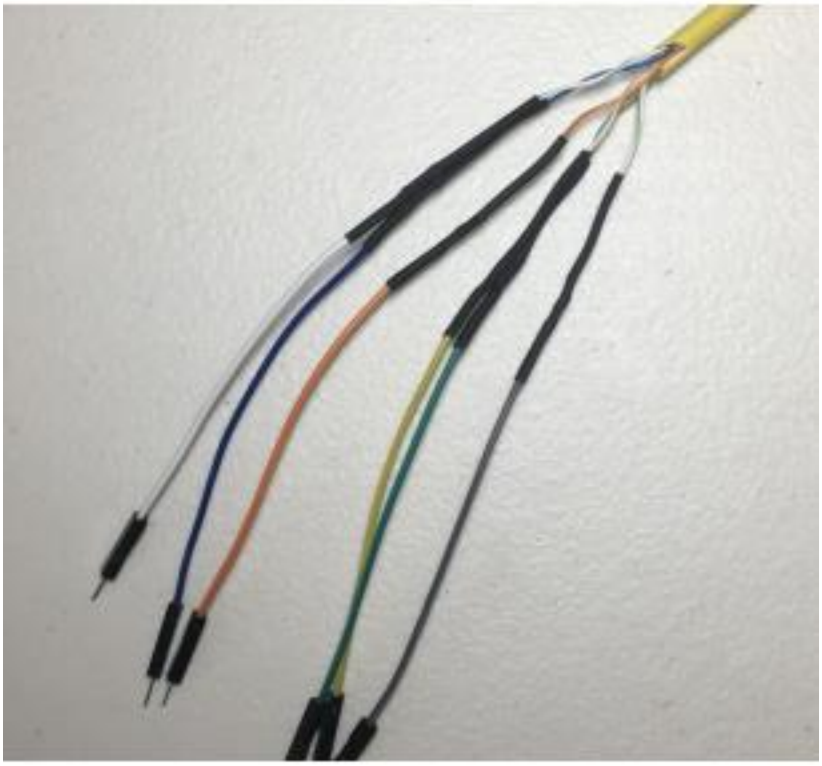


Use soldering iron and silver bearing rosin core electrical solder to solder jumper wires to Ethernet wires as follows:

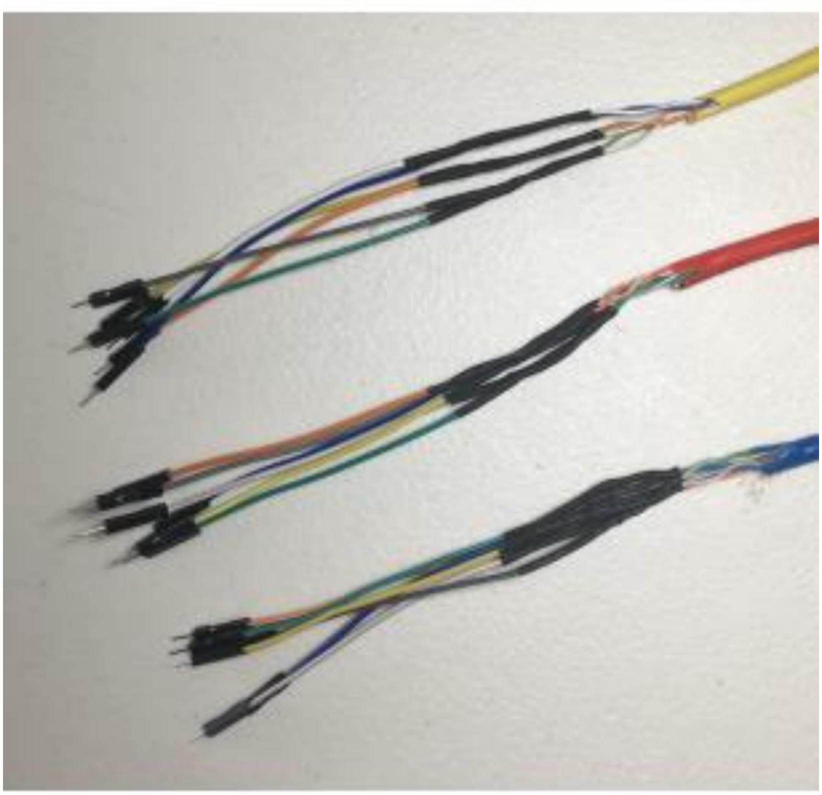
- **Blue** jumper wire to **blue** Ethernet wire.
- **White** jumper wire to **blue stripe** Ethernet wire.
- **Orange** jumper wire to **orange** Ethernet wire.
- **Yellow** jumper to **orange stripe** Ethernet wire
- **Green** jumper wire to **green** Ethernet wire.
- **Grey** jumper wire to **green stripe** Ethernet wire.



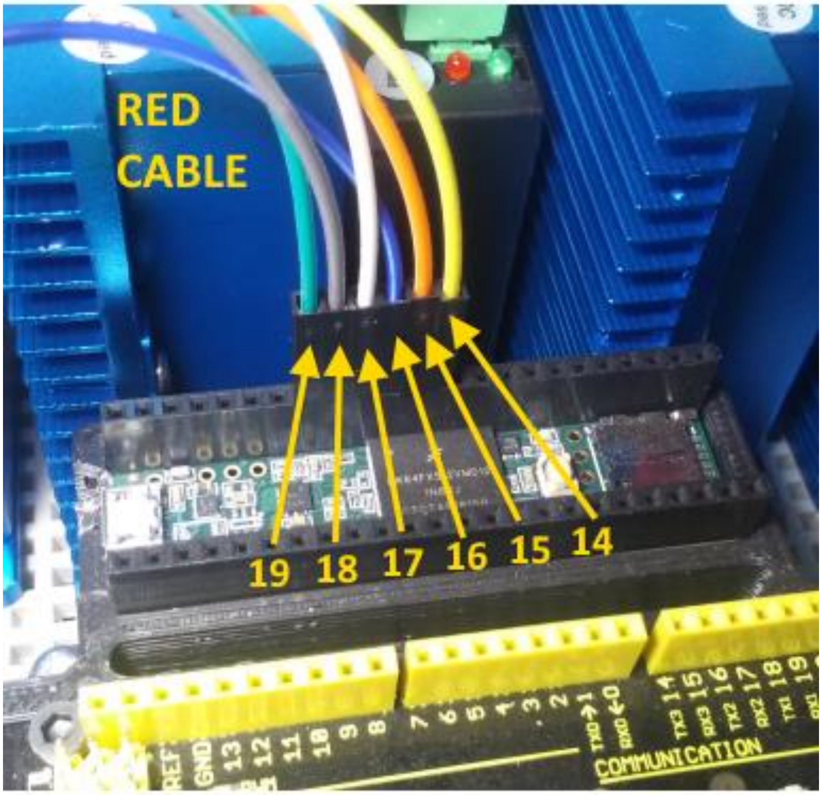
This diagram shows the transition soldering the jumper wires (top) to the Ethernet cable wires (bottom).



Slide heat shrink tubing over each solder joint and then use heat gun to shrink tubing.



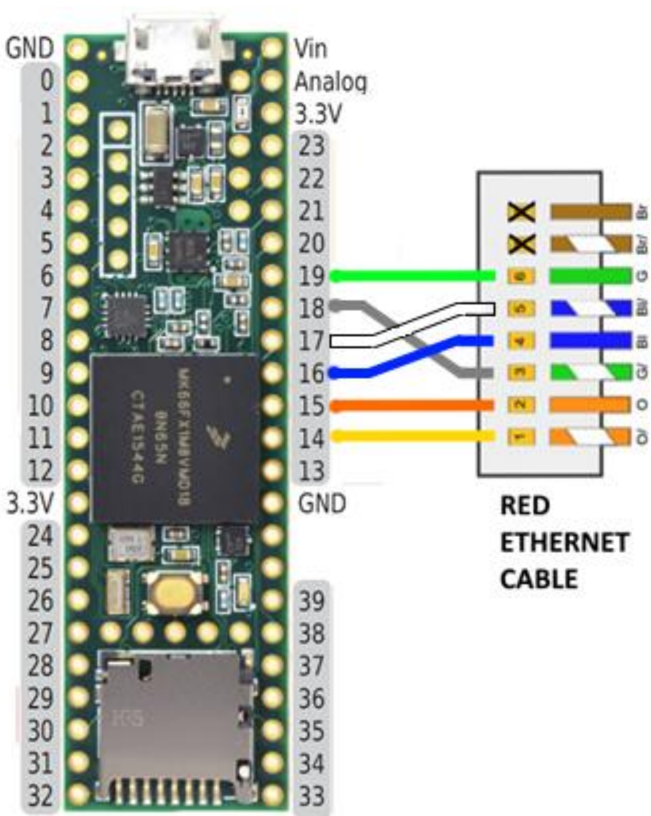
Repeat the previous 4 steps for the red *and* blue Ethernet wires as shown.



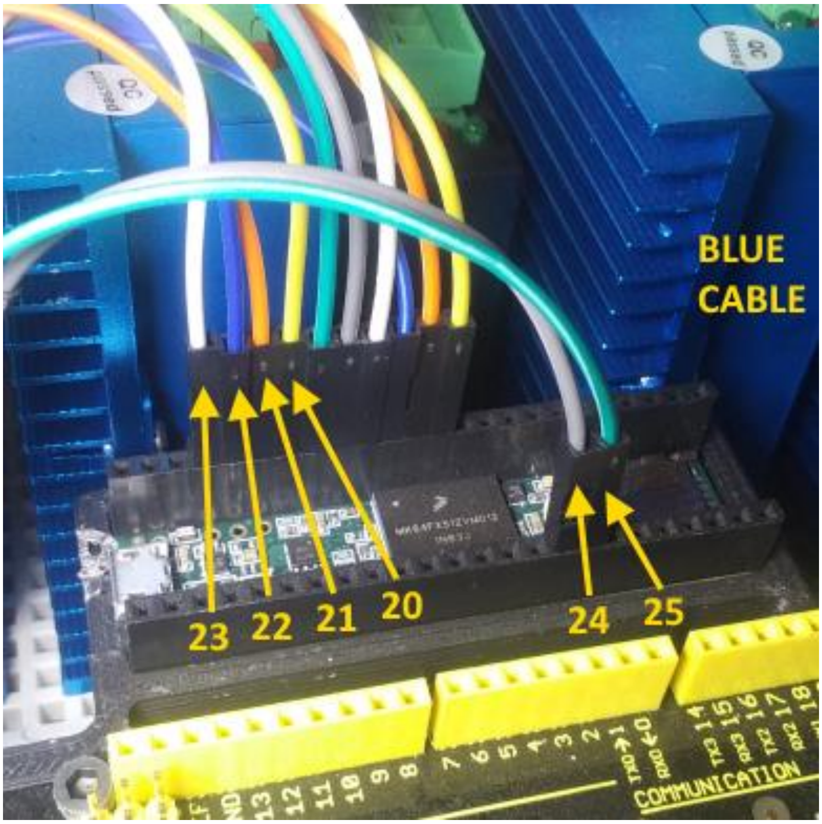
Connect the red Ethernet cable wires to the Teensy 3.5 as follows:

- Yellow to Teensy pin #14
- Orange to Teensy pin #15
- Blue to Teensy pin #16
- White to Teensy pin #17
- Grey to Teensy pin #18
- Green to Teensy pin #19

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



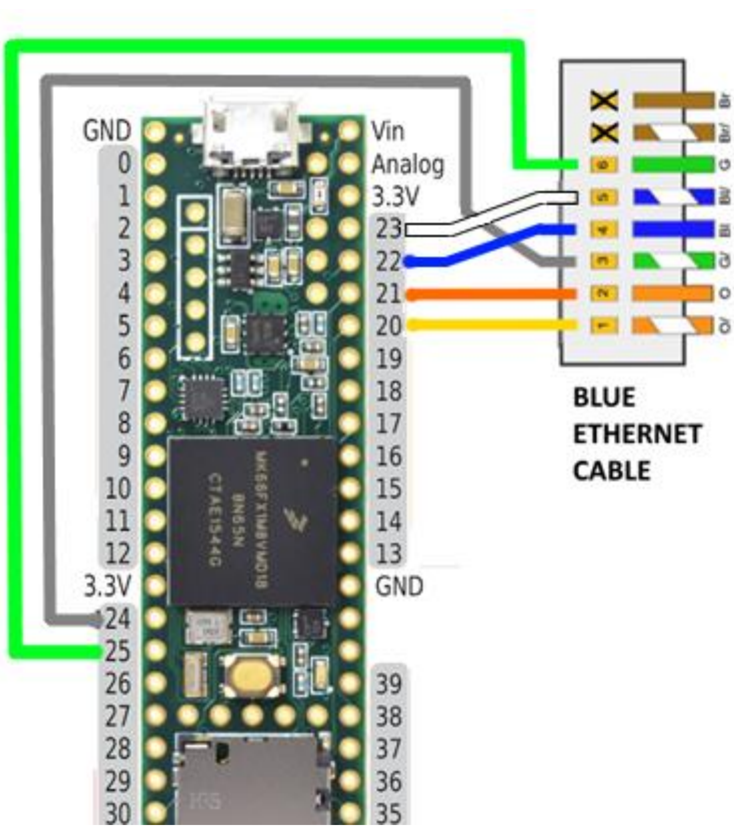
This diagram shows the wire connections for the red Ethernet cable to the Teensy 3.5 as outlined in the previous step.



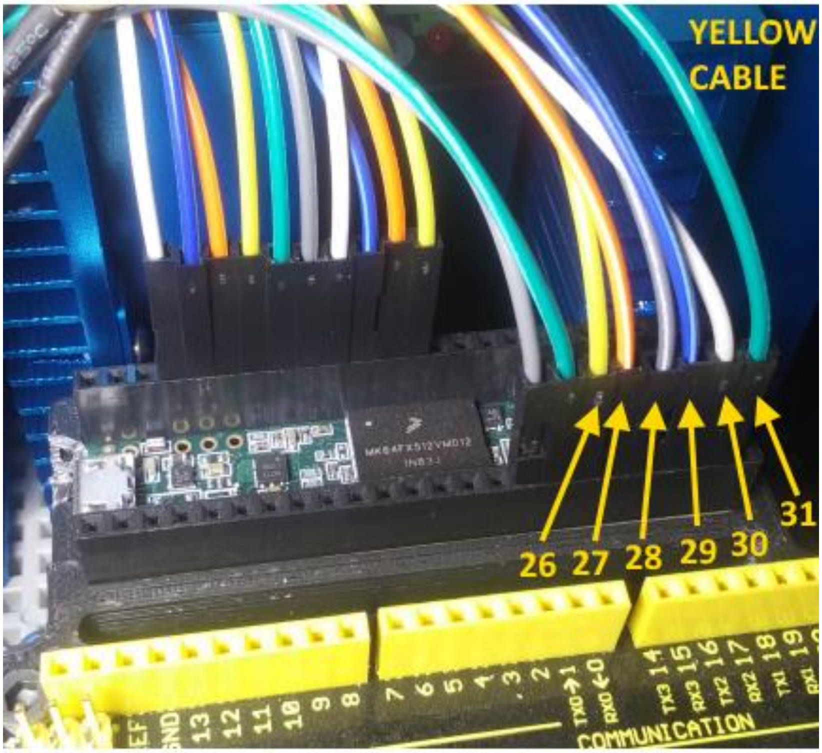
Connect the blue Ethernet cable wires to the Teensy 3.5 as follows:

- Yellow to Teensy pin #20
- Orange to Teensy pin #21
- Blue to Teensy pin #22
- White to Teensy pin #23
- Grey to Teensy pin #24
- Green to Teensy pin #25

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



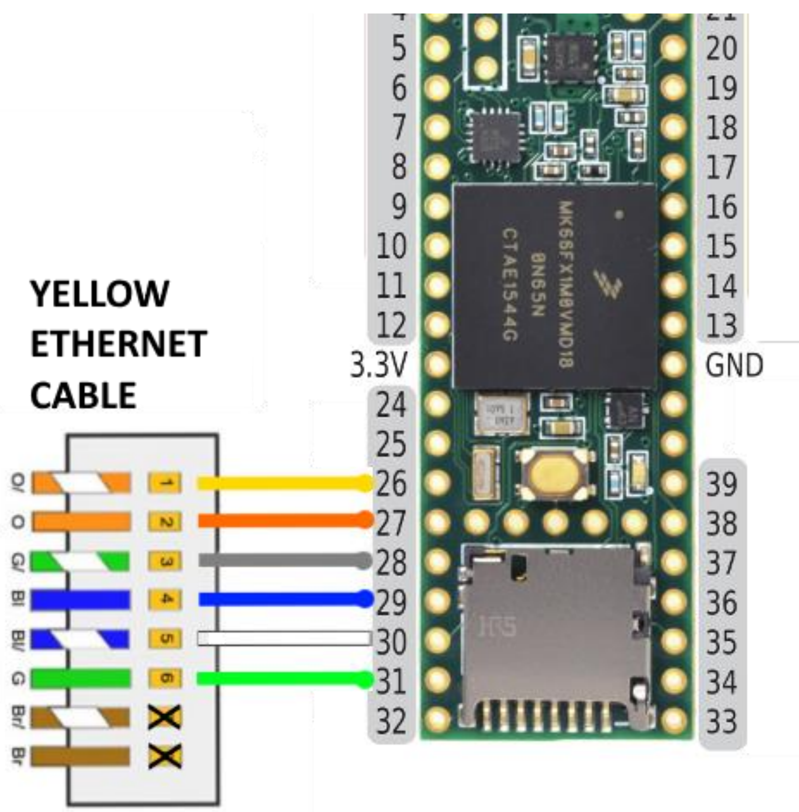
This diagram shows the wire connections for the blue Ethernet cable to the Teensy 3.5 as outlined in the previous step.



Connect the yellow Ethernet cable wires to the Teensy 3.5 as follows:

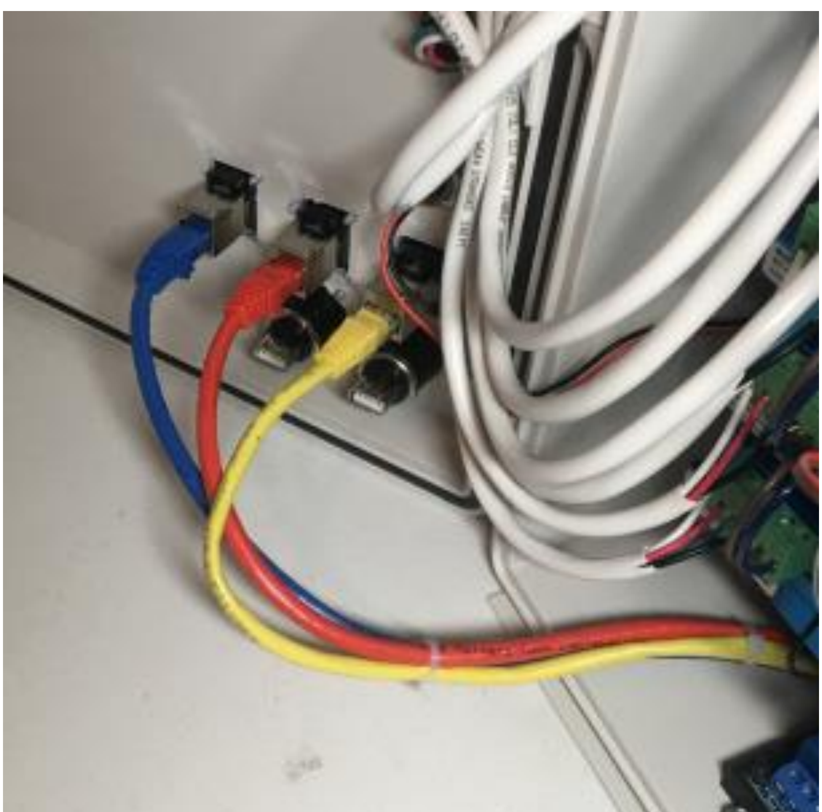
- Yellow to Teensy pin #26
- Orange to Teensy pin #27
- Grey to Teensy pin #28
- Blue to Teensy pin #29
- White to Teensy pin #30
- Green to Teensy pin #31

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



This diagram shows the wire connections for the yellow Ethernet cable to the Teensy 3.5 as outlined in the previous step.

Use mounting hole cable tie and #6 thread forming screw to secure the red, blue and yellow Ethernet cables to backplane as shown.



Connect other end of blue, red and yellow Ethernet cable to RJ45 panel jacks as shown.

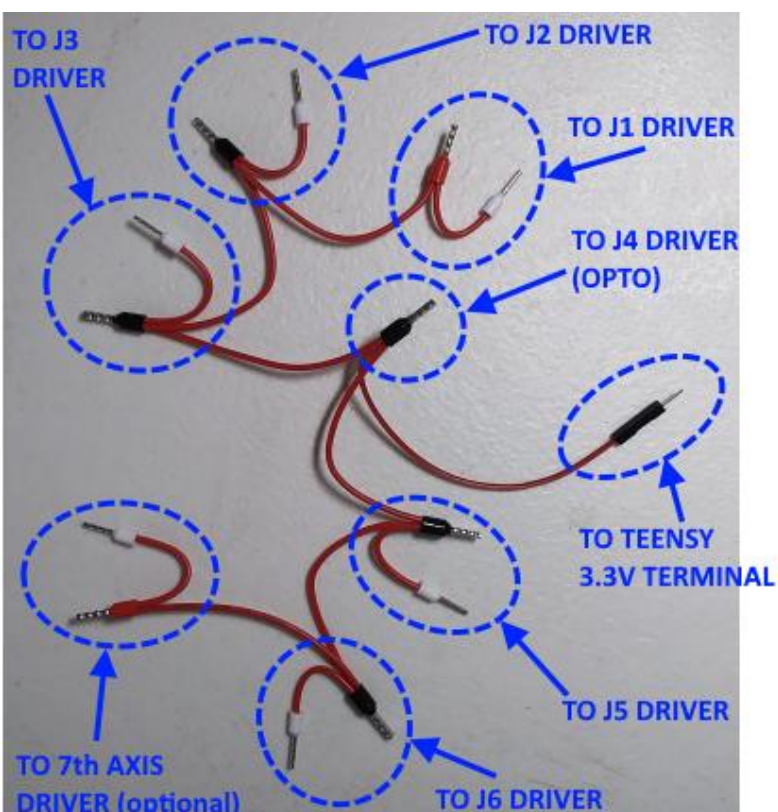
NOTE: Yellow should be closest to the hinge, red in the middle and blue toward the outside of door.

Cut and strip ends from 22awg red wire as follows:

(6) Pieces 80mm long

(6) Pieces 45mm long

Also cut (1) jumper wire in half and strip end as shown.

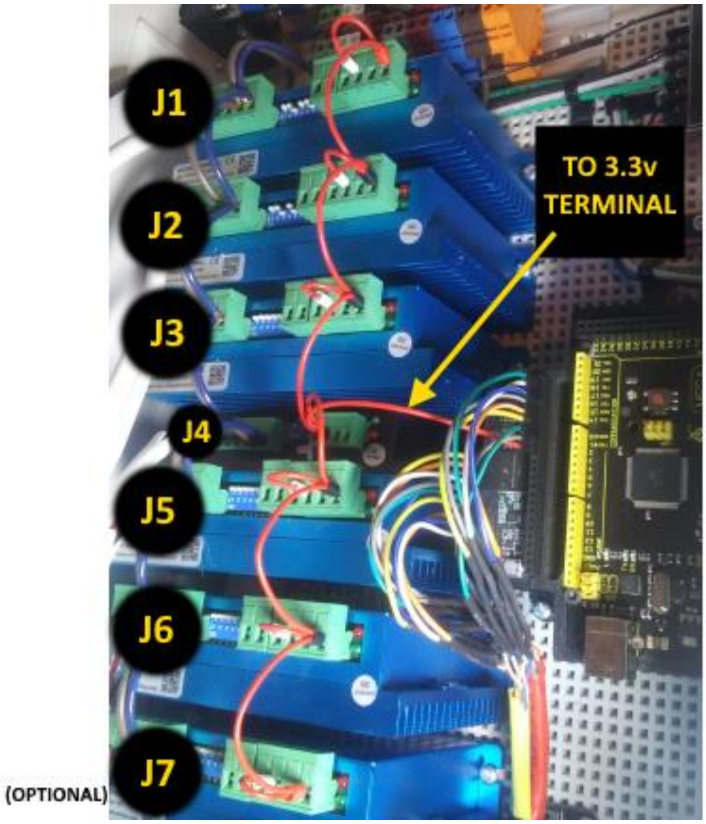


Use wire ferules and crimper to string all (13) wires together as shown.

String groups of (2) 45mm jumpers for each driver with the exception of the axis 4 driver which will have a single jumper going to the Opto terminal and standard jumper wire that goes to the teensy 3.3v terminal.

Use 22awg ferrules (white) for single end wires.

Use 16awg ferrules (black) for triple wire connections.

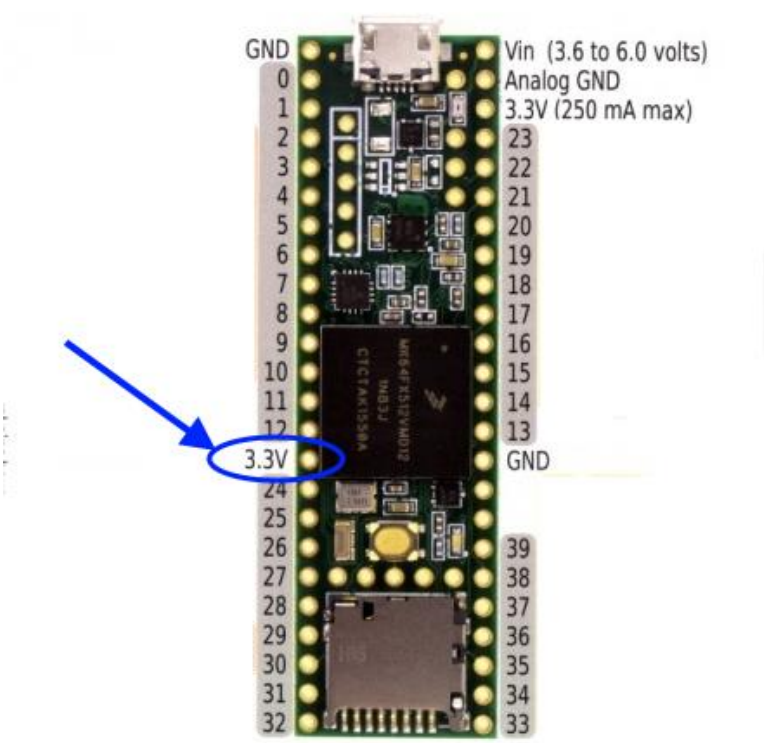


The next step is to run 3.3vdc to all the (+3.3v) terminals across all of the stepper drivers. The drivers are NPN or negative switching which means the step and direction pulses will be made by the negative wire and the positive is high or on all the time on all the (+3.3v) terminals. Each driver has (2) positive terminals that require a constant +3.3v signal:

- PUL(+3.3 – 5V)
- DIR(+3.3 – 5V)

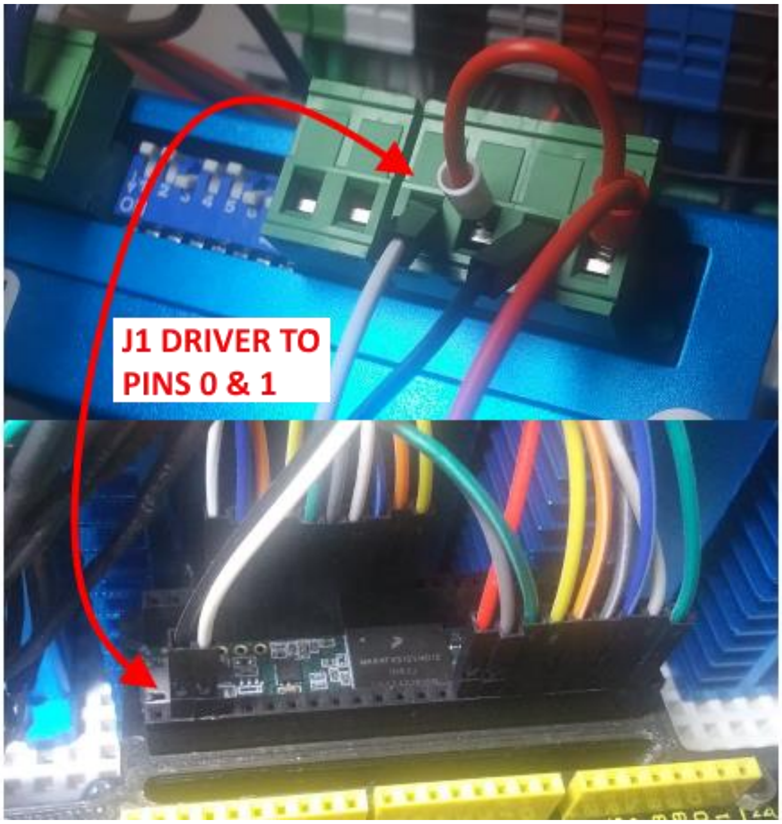
NOTE: when you get to the J4 DM320T driver it only as one (+3.3 or 5) terminal which is labeled “Opto”.

(Also refer to the wiring schematic chapter)



Make sure that the jumper wire from the J4 terminal gets plugged into the 3.3V terminal on the Teensy 3.5 as shown.

This will supply 3.3V to all drivers.



Connect a pair of breadboard jumper wires (black & white)

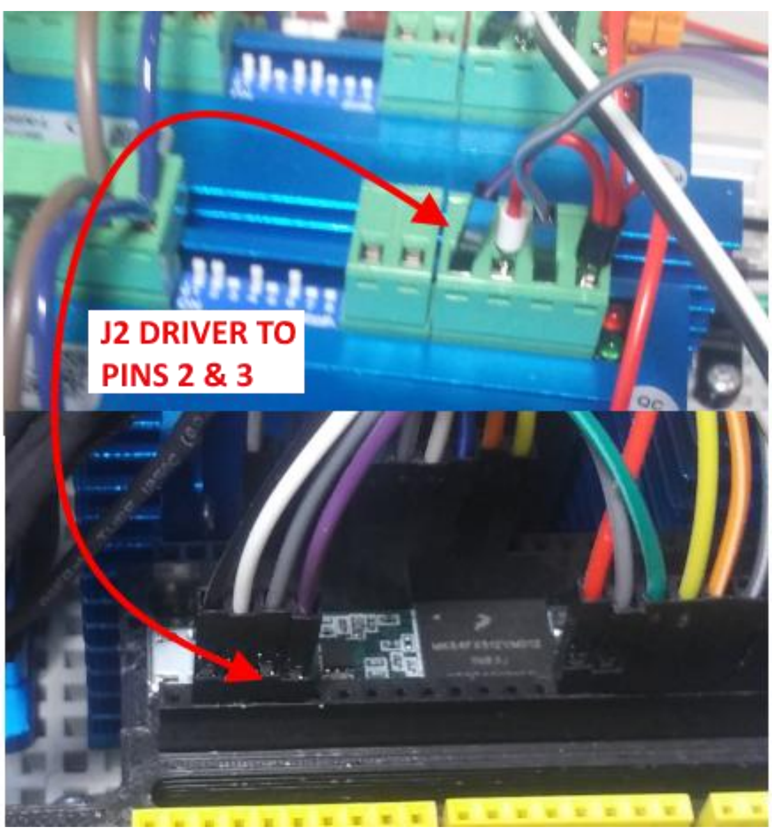
From Teensy 3.5 to the **J1** driver.

Black wire:

Teensy pin 0 to driver PUL-

White wire:

Teensy pin 1 to driver DIR-



Connect a pair of breadboard jumper wires (grey & purple)

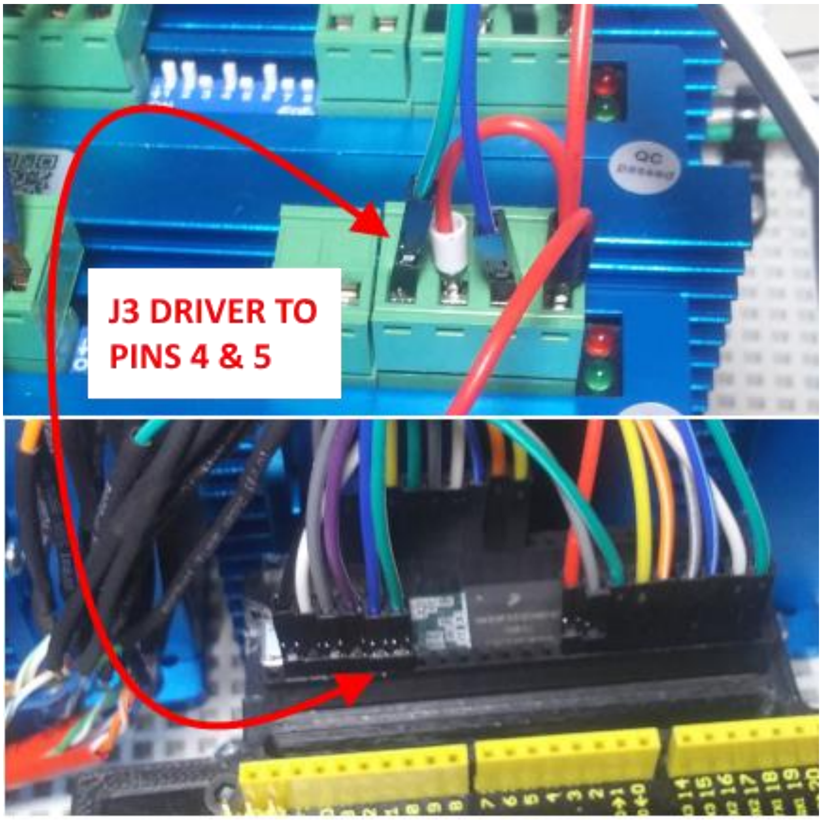
From Teensy 3.5 to the **J2** driver.

Grey wire:

Teensy pin 2 to driver PUL-

Purple wire:

Teensy pin 3 to driver DIR-



Connect a pair of breadboard jumper wires (blue & green)

From Teensy 3.5 to the **J3** driver.

Blue wire:

Teensy pin 4 to driver PUL-

Green wire:

Teensy pin 5 to driver DIR-

Connect a pair of breadboard jumper wires (yellow & orange)

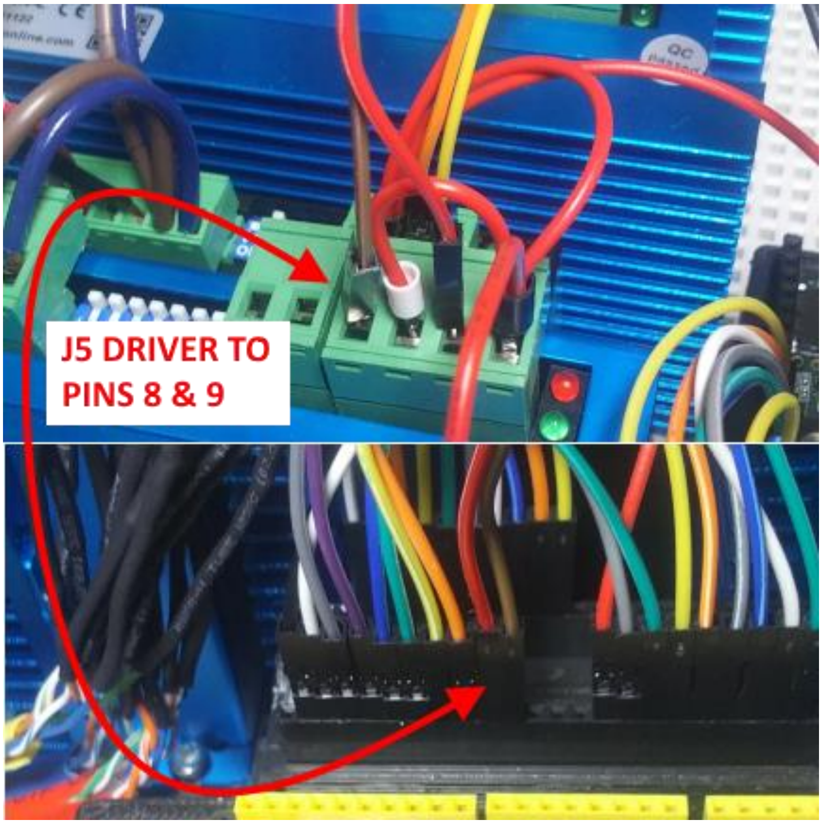
From Teensy 3.5 to the **J4** driver.

Yellow wire:

Teensy pin 6 to driver PUL-

Orange wire:

Teensy pin 7 to driver DIR-



Connect a pair of breadboard jumper wires (red & brown)

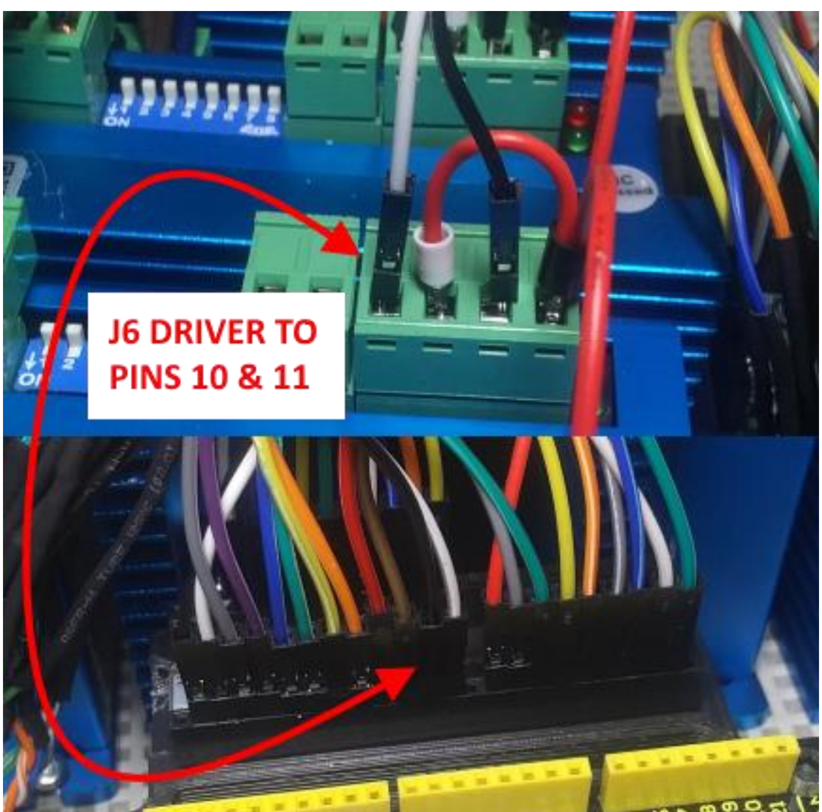
From Teensy 3.5 to the **J5** driver.

Red wire:

Teensy pin 8 to driver PUL-

Brown wire:

Teensy pin 9 to driver DIR-



Connect a pair of breadboard jumper wires (black & white)

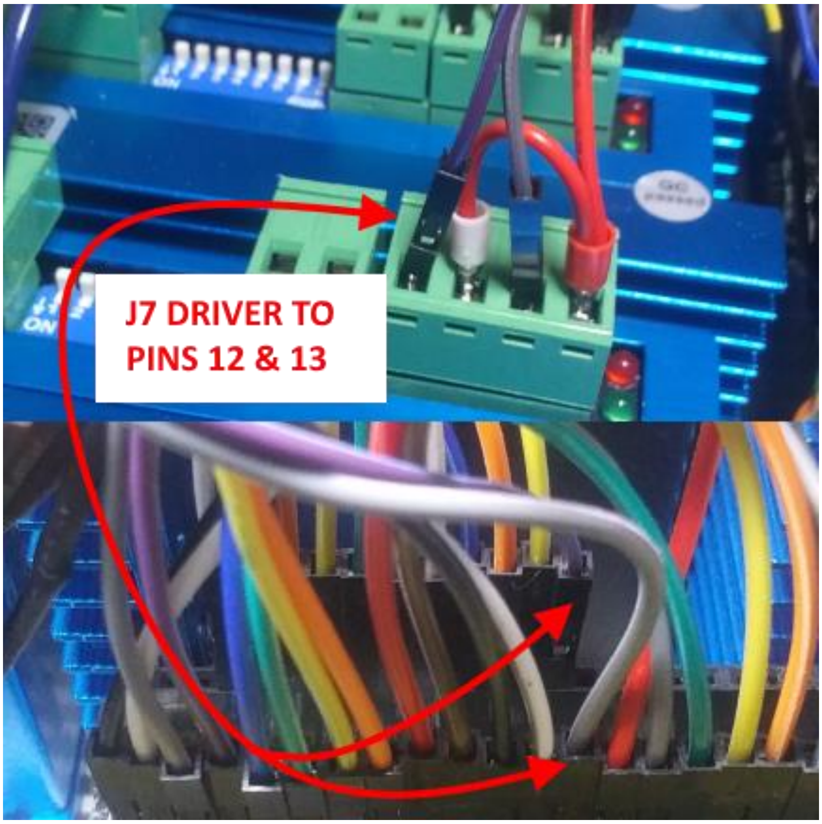
From Teensy 3.5 to the **J6** driver.

Black wire:

Teensy pin 10 to driver PUL-

White wire:

Teensy pin 11 to driver DIR-



Connect a pair of breadboard jumper wires (grey & purple)

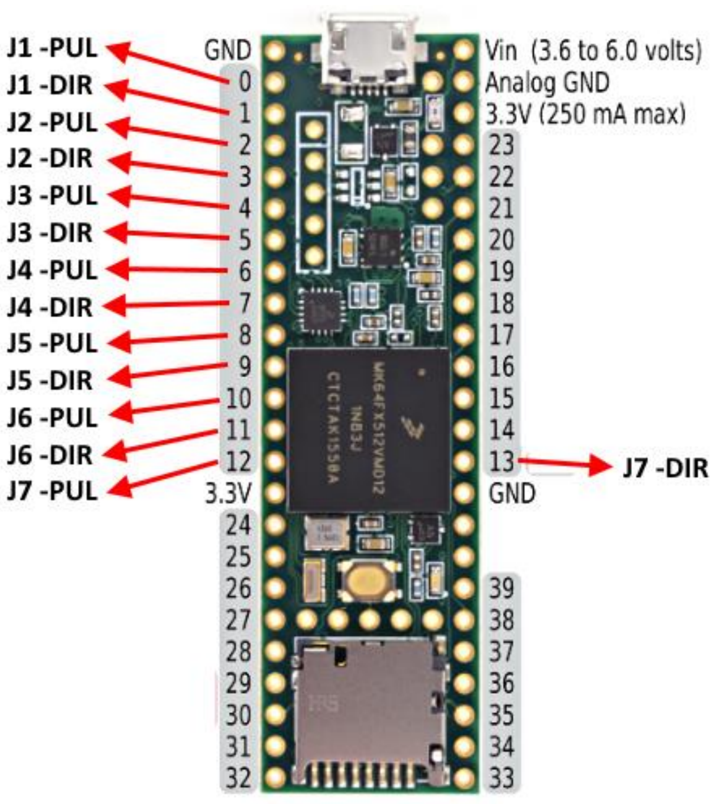
From Teensy 3.5 to the **J7** (optional travel track) driver.

Grey wire:

Teensy pin 12 to driver PUL-

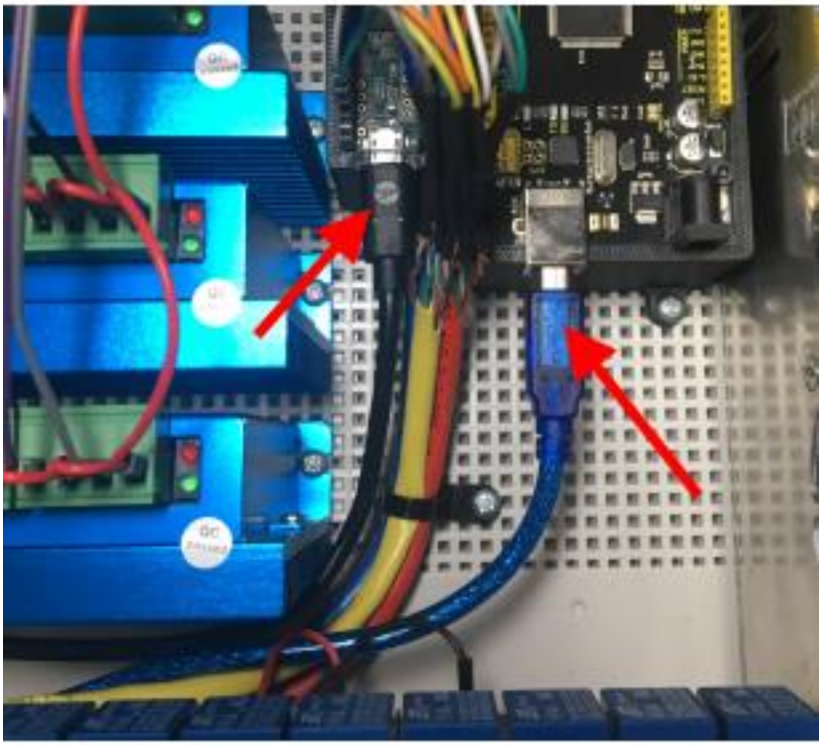
Purple wire:

Teensy pin 13 to driver DIR-



This image shows an overview of the pulse and direction pin wiring to the Teensy 3.5 shown in the previous 7 steps.

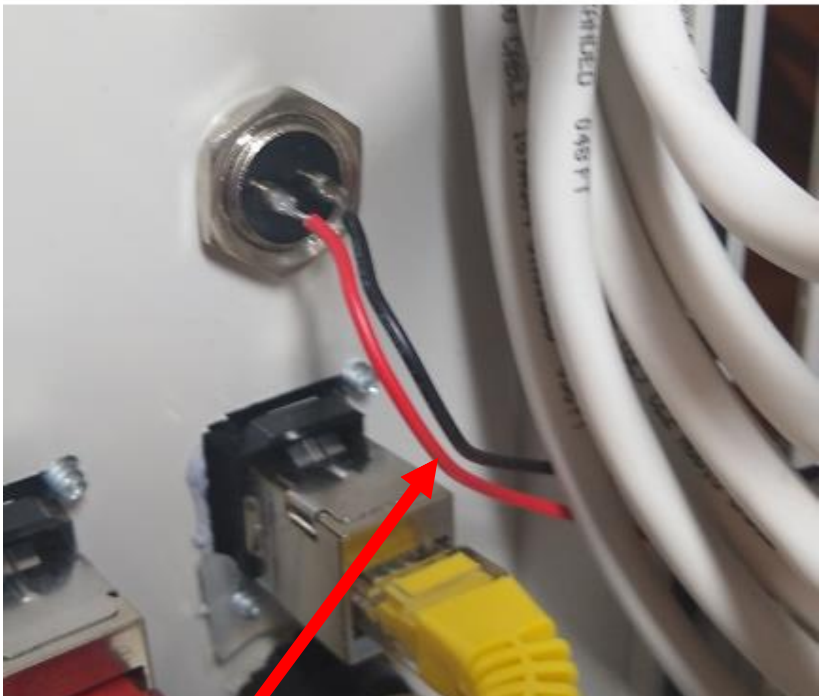
NOTE: remember each of the wires from the Teensy 3.5 get wired to the negative pulse or direction input terminal on the driver.



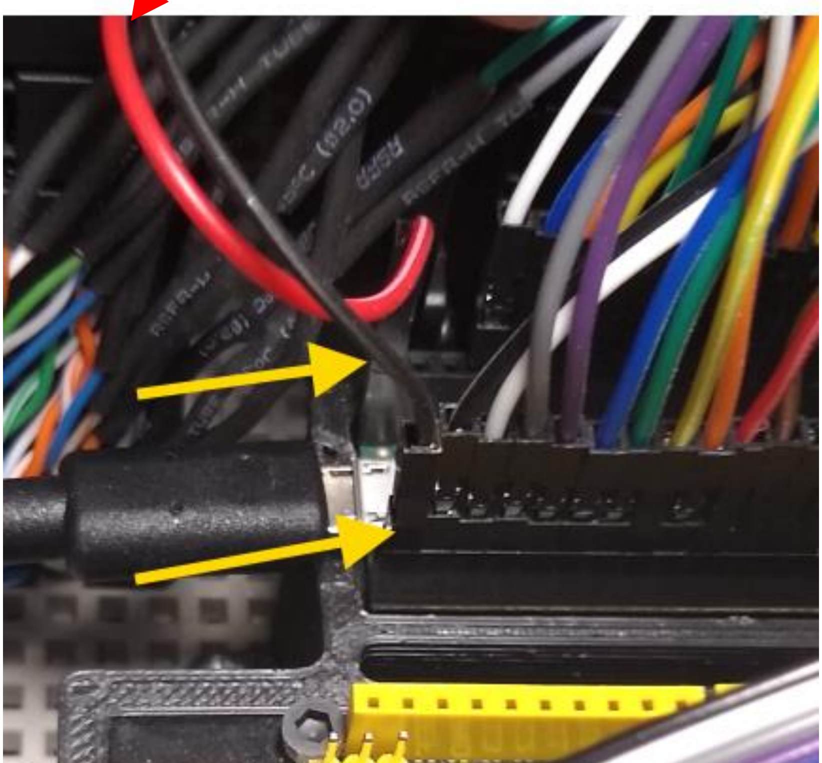
Connect USB cables to Arduino Mega 2560 and Teensy 3.5 as shown.

Connect USB cables to USB panel jacks in door as shown.

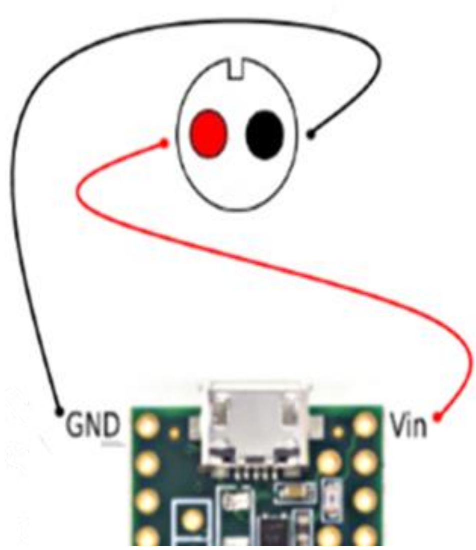
NOTE: Teensy 3.5 cable should be closest to door hinge.

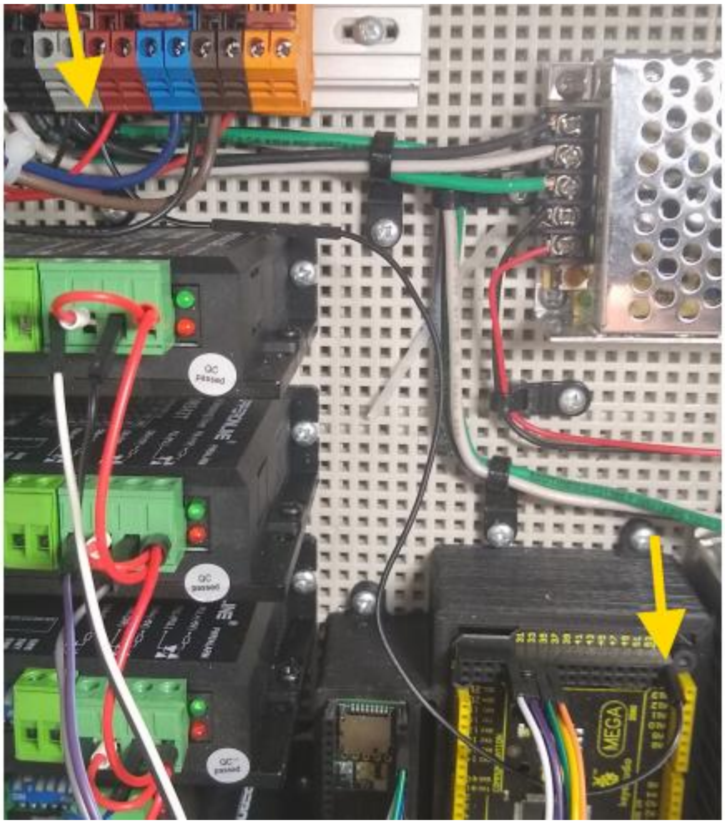


Solder lengths of 22awg red and black wire to GX16-2 plug as shown.



Solder and heat shrink red and black jumper wires to wires coming from GX16-2 plug and then connect them to the Teensy 3.5 on pins Vin & GND



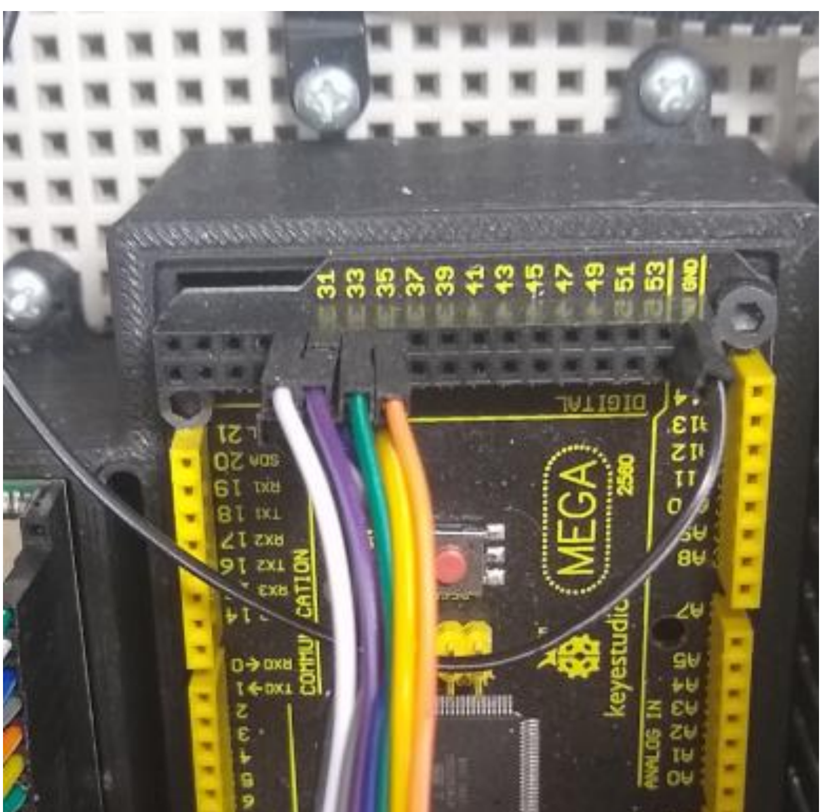


Connect black jumper wire from GND terminal on Mega 2560 board to -5vdc terminal (4th terminal block set).

This allows the Arduino mega to share a ground connection with the 8 relay board so the relay board functions correctly.

Connect extended jumper wire from Arduino 2560 to 4^{th} pair of DIN rail terminals as shown.

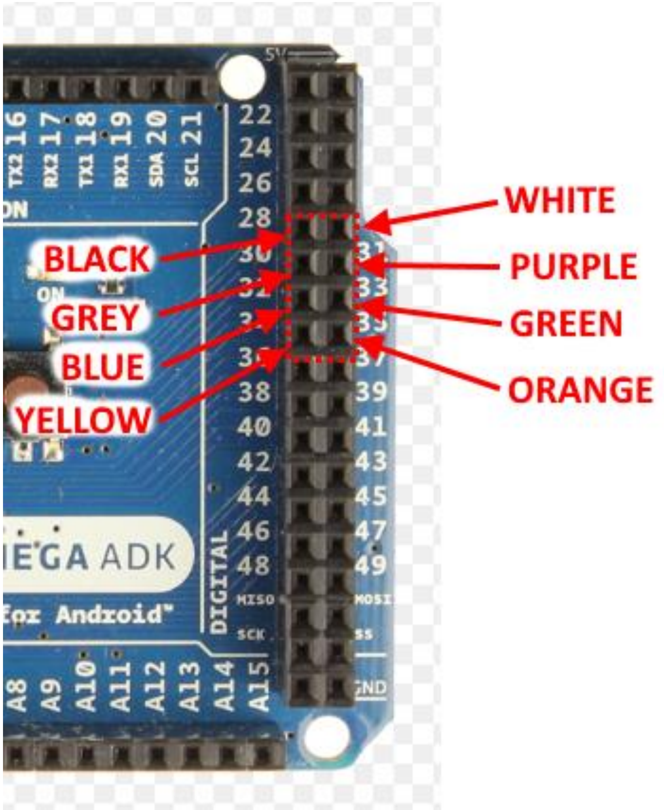
Note: You should now have GND jumpered from the -5vdc power supply to the Arduino so that both share a common ground.



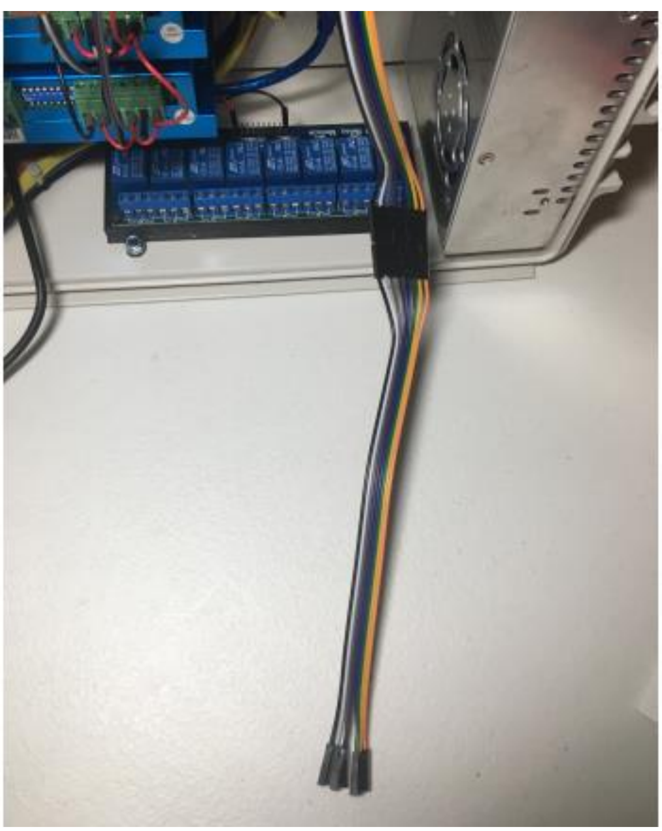
Connect ribbon of (8) jumper wires from Arduino pin 28 through pin 35.

These jumpers should be male on the end connecting to the Arduino and female at the other end.

- Black to pin 28
- White to pin 29
- Grey to pin 30
- Purple to pin 31
- Blue to pin 32
- Green to pin 33
- Yellow to pin 34
- Orange to pin 35



This diagram shows connection of the (8) jumper wires to pins 28 through 35 of the Arduino illustrated in the previous step.



Extend the (8) jumper wires with another ribbon of jumper wires that are the same colors.

This ribbon of jumper wires will again be male to female.

Connect ribbon of jumper wires to 8 channel relay board as follows:

- Black to relay pin 1
- White to relay pin 2
- Grey to relay pin 3
- Purple to relay pin 4
- Blue to relay pin 5
- Green to relay pin 6
- Yellow to relay pin 7
- Orange to relay pin 8

Note: Relay module is for general purpose needs such as a gripper solenoid – please see chapter on gripper wiring.

When closing enclosure door, wires and cables can be tight when an optional 7th axis driver has been installed.

Make sure USB cables travel down below 7th axis driver and to the left of the 8 channel relay board. Make sure Ethernet cables bend down away from 7th axis driver as shown.

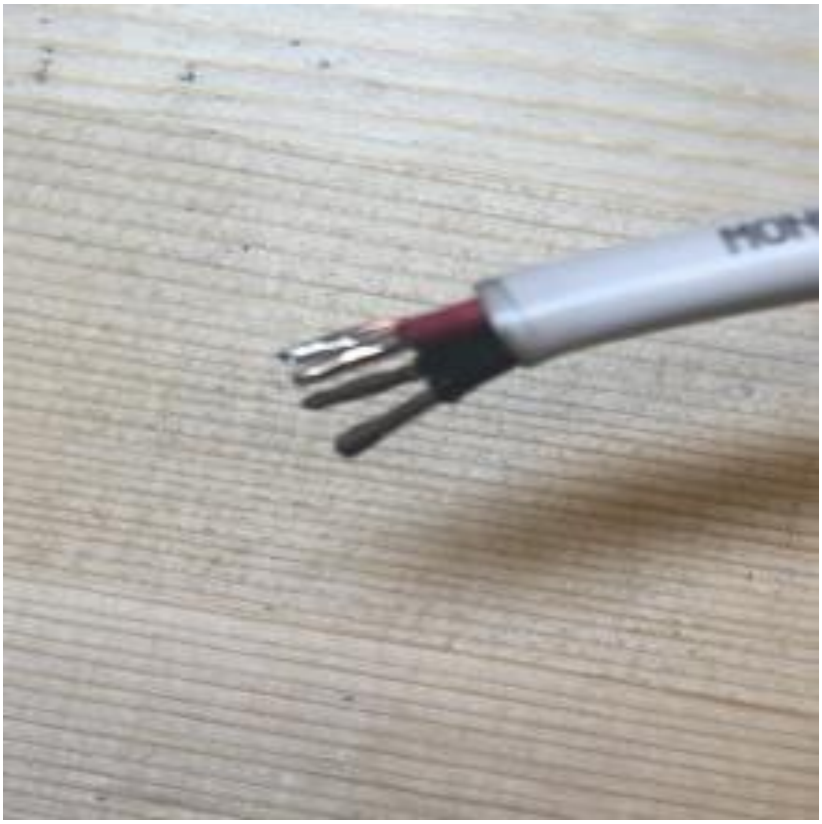
Make sure all motor driver cables coil neatly as shown and that door closes easily.

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 to whatever length you need – in this example I have cut each cable to 6' long.

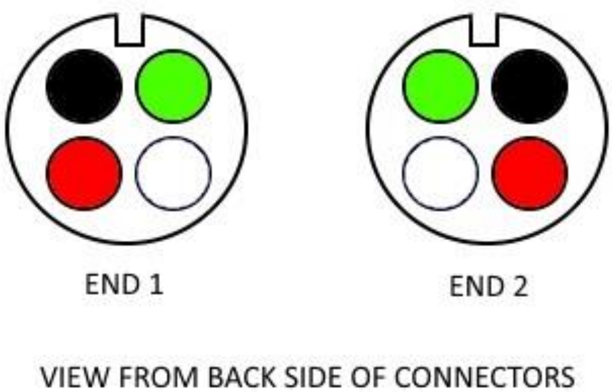
Strip 10mm of outer sheathing off each end of cable and then pre-install GX16-4 aviation plug metal housing over cable end as shown.



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.



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.

Robot 5v Power Cable

You will also need (1) power cable to supply 5vdc to the robot to power the encoders and the limit switches.

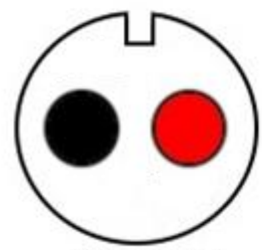
Cut length of 18awg 4 conductor cable to whatever length you need, in this example I have cut cable to 6' long. Cable should be the same length as the motor cables you made in the previous steps.

Strip 10mm of outer sheathing off each end of cable and then pre-install GX16-2 aviation plug metal housing over cable end as shown.

Use cutters to remove the white and green wires leaving only (2) wires (red and black) for the 5vdc power.

With slot facing up solder red wire on right side and black wire on left side.

Do this for both ends of cable.



Wrap solder joints with electrical tape to avoid the possibility of solder connections shorting on the aviation plug housing.

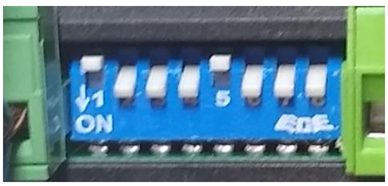
Slide aviation plug housing into place over end connector, tighten and install screws.

5vdc power cable is complete.

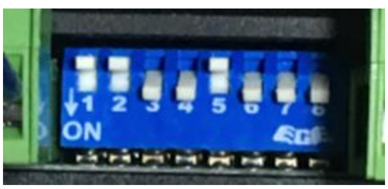
DIP SWITCH SETTING

THESE SETTINGS ARE USED FOR THE FOLLOWING SERIES MOTORS:

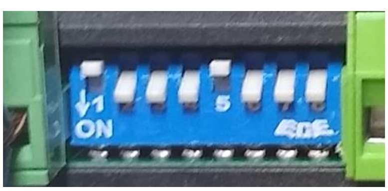
• J1 - 17HS15-1684D-HG10	1/2 STEPS	1.46 AMP
• J2 - 23HS22-2804D-HG50	1/2 STEPS	2.37 AMP
• J3 - 17HS15-1684D-HG50	1/2 STEPS	1.46 AMP
• J4 - 11HS20-0674D-PG14	1/2 STEPS	.5 AMP
• J5 - 17LS19-1684E-200G-C1	1/4 STEPS	1.00 AMP
• J6 - 14HS13-0804D-PG19	1/2 STEPS	1.00 AMP
• J7 – Nema 17 48mm body	1/2 STEPS	1.00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



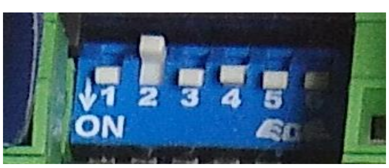
J1 – (DM542T):
SW1 = OFF SW2 = ON SW3 = ON SW4 = ON
SW5 = OFF SW6 = ON SW7 = ON SW8 = ON



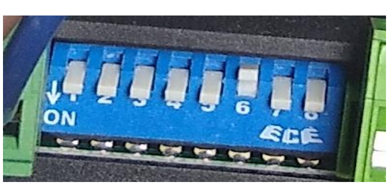
J2 – (DM542T):
SW1 = OFF SW2 = OFF SW3 = ON SW4 = ON
SW5 = OFF SW6 = ON SW7 = ON SW8 = ON



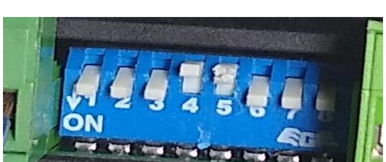
J3 – (DM542T):
SW1 = OFF SW2 = ON SW3 = ON SW4 = ON
SW5 = OFF SW6 = ON SW7 = ON SW8 = ON



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



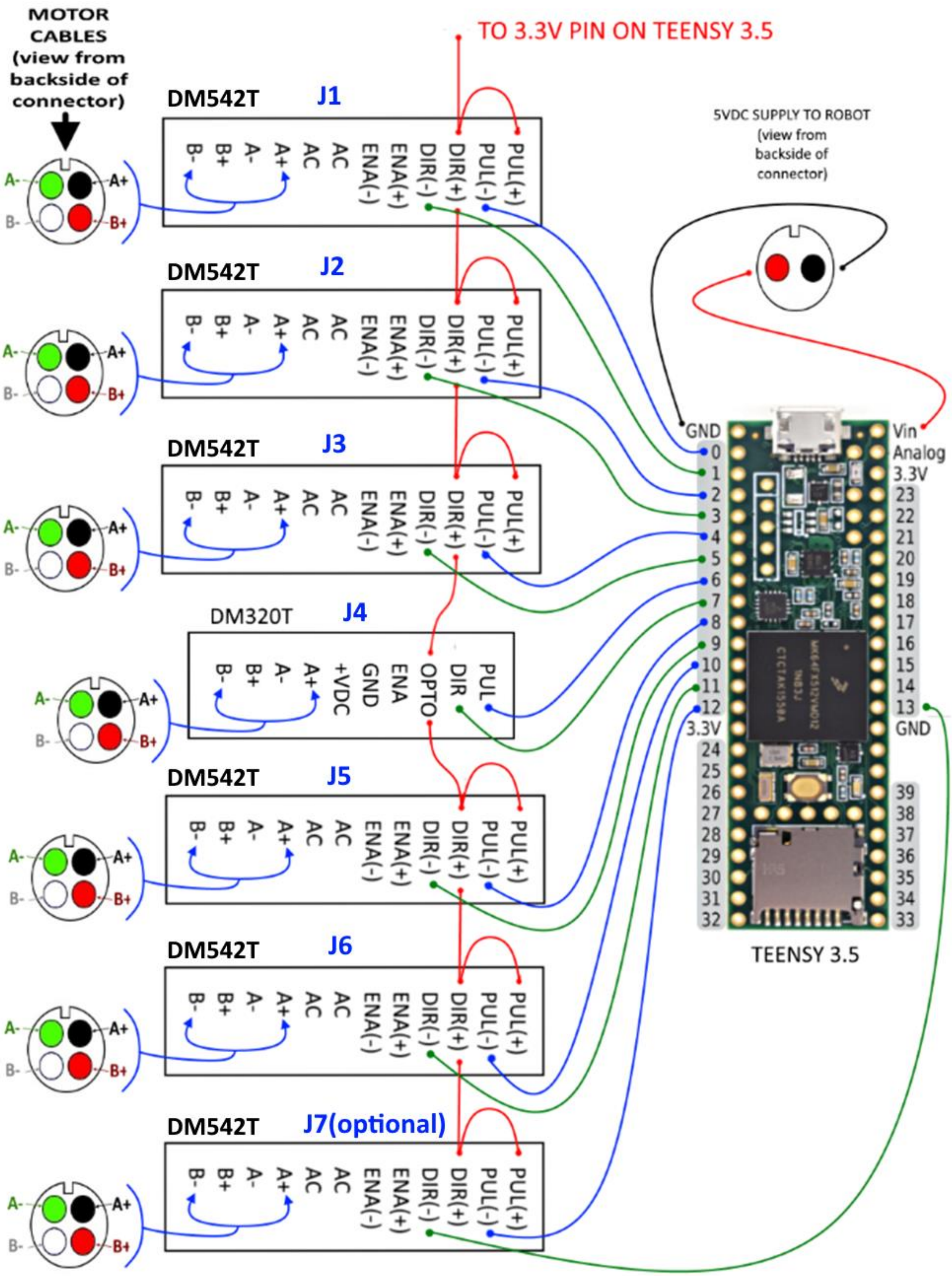
J6 – (DM542T):
SW1 = ON SW2 = ON SW3 = ON SW4 = OFF
SW5 = OFF SW6 = ON SW7 = ON SW8 = ON

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

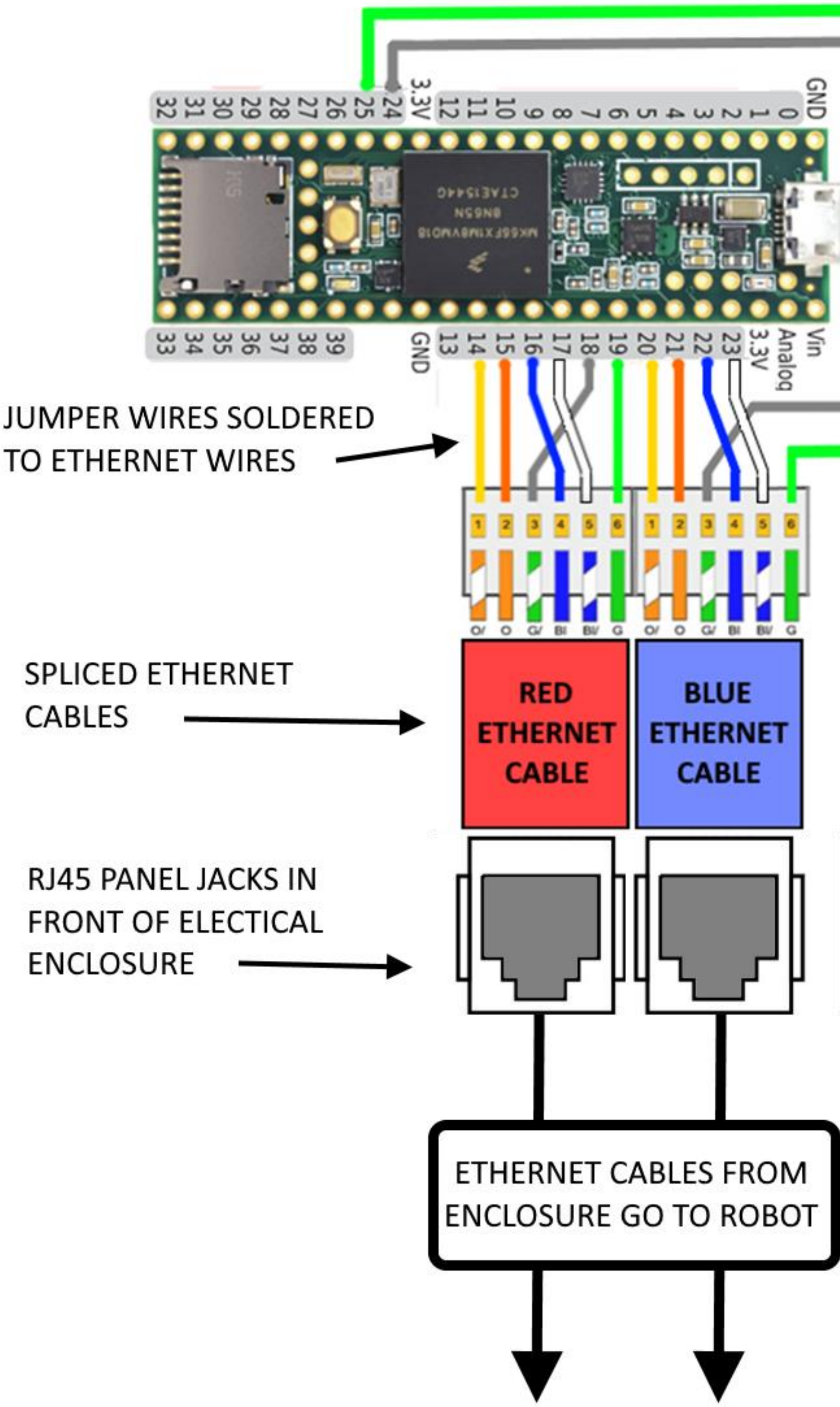
CHAPTER 4

SCHEMATICS

Wiring for Drivers and Teensy 3.5

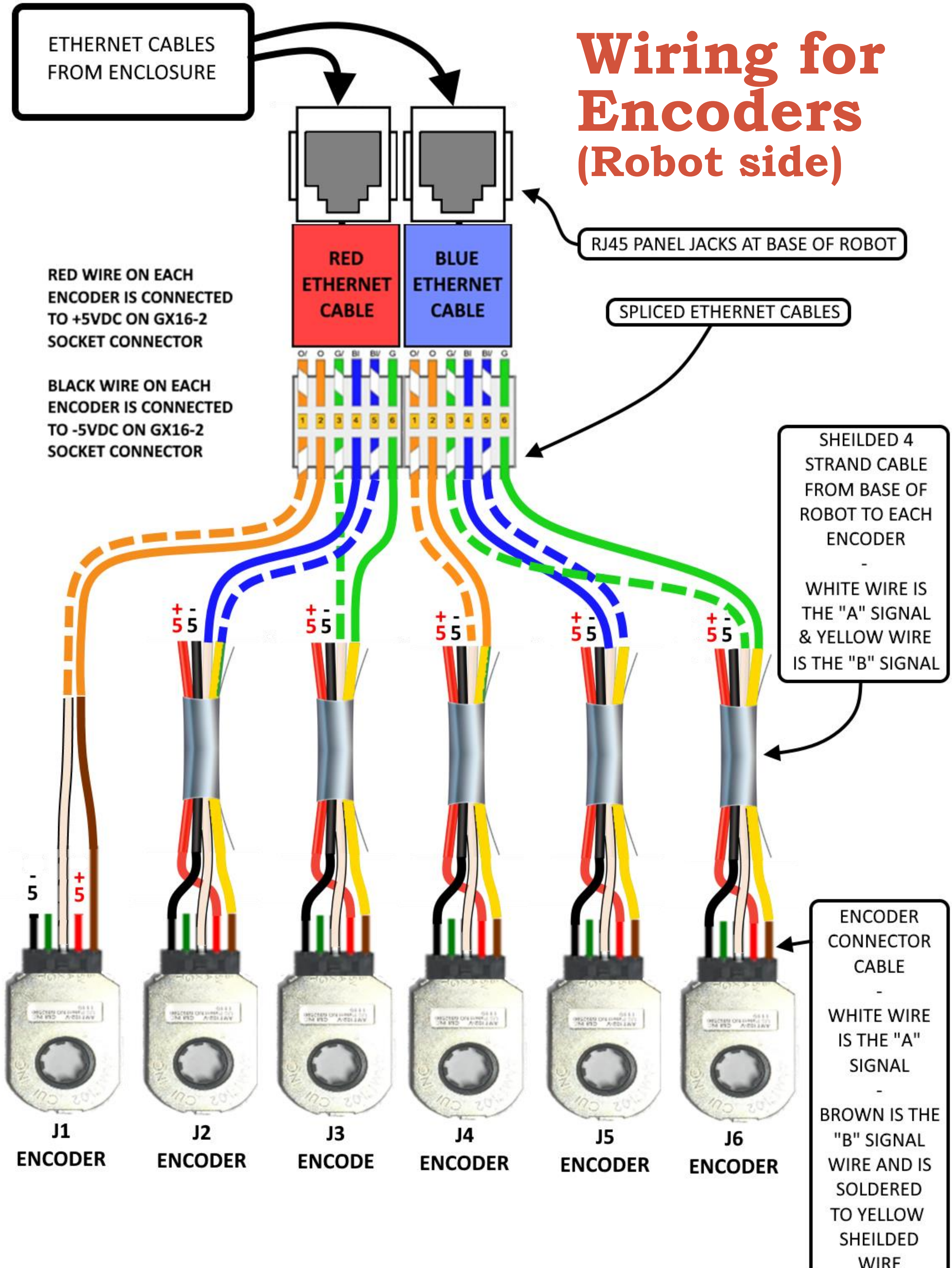


Wiring for Encoders
(Enclosure side)

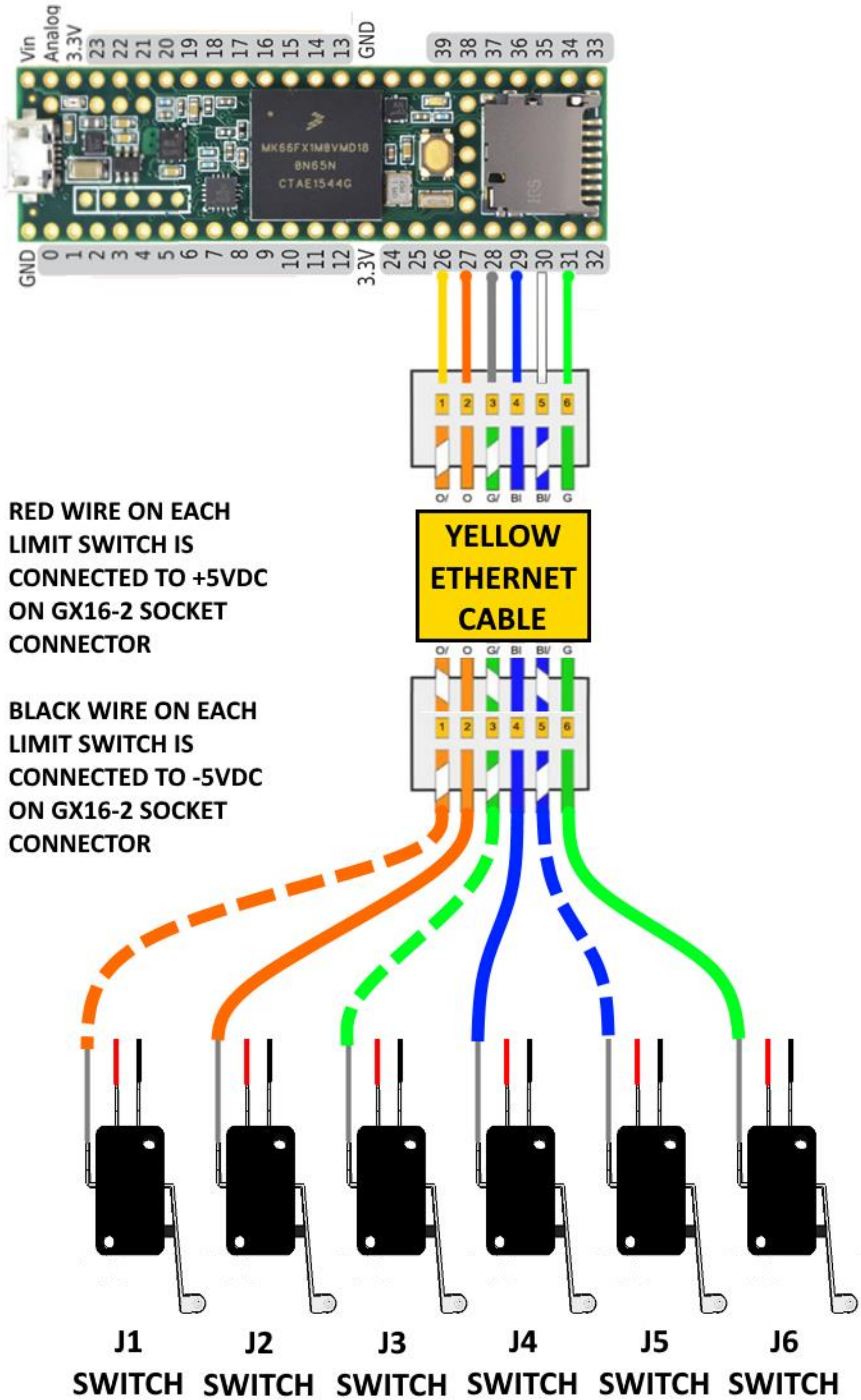


NOTE:
Teensy 3.5 must share a ground connection with 5vdc power supply and Arduino Mega 2560

Wiring for Encoders (Robot side)



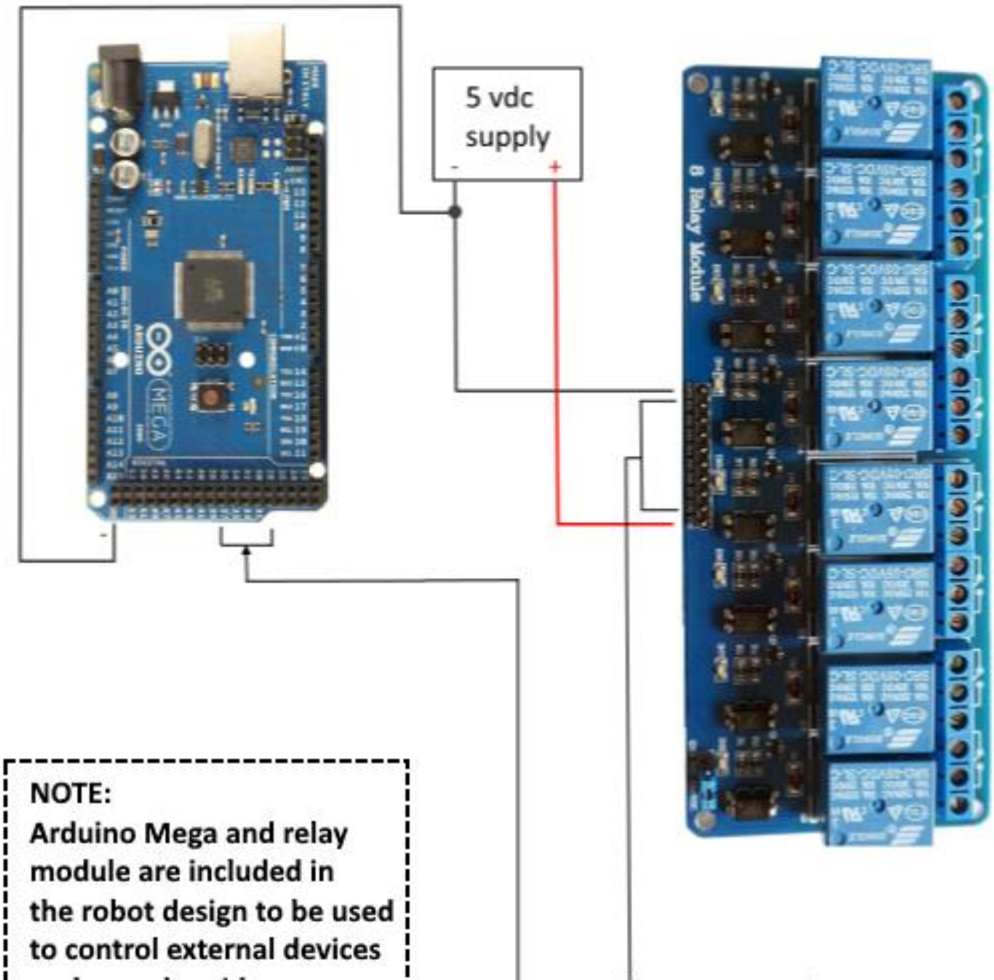
Wiring for Limit Switches



RED WIRE ON EACH LIMIT SWITCH IS CONNECTED TO +5VDC ON GX16-2 SOCKET CONNECTOR

BLACK WIRE ON EACH LIMIT SWITCH IS CONNECTED TO -5VDC ON GX16-2 SOCKET CONNECTOR

Wiring for Arduino Mega 2560



NOTE:
Arduino Mega and relay module are included in the robot design to be used to control external devices such as solenoids or robot grippers.

IN1 to arduino pin **28**
IN2 to arduino pin **29**
IN3 to arduino pin **30**
IN4 to arduino pin **31**
IN5 to arduino pin **32**
IN6 to arduino pin **33**
IN7 to arduino pin **34**
IN8 to arduino pin **35**

Connection NORMAL

A+	A-	B+	B-
Black	Green	Red	Blue

Connection J5

A+	A-	B+	B-
Red	Brown	Yellow	Green

Note that the wire colors for the J5 motor are different from the other motors.

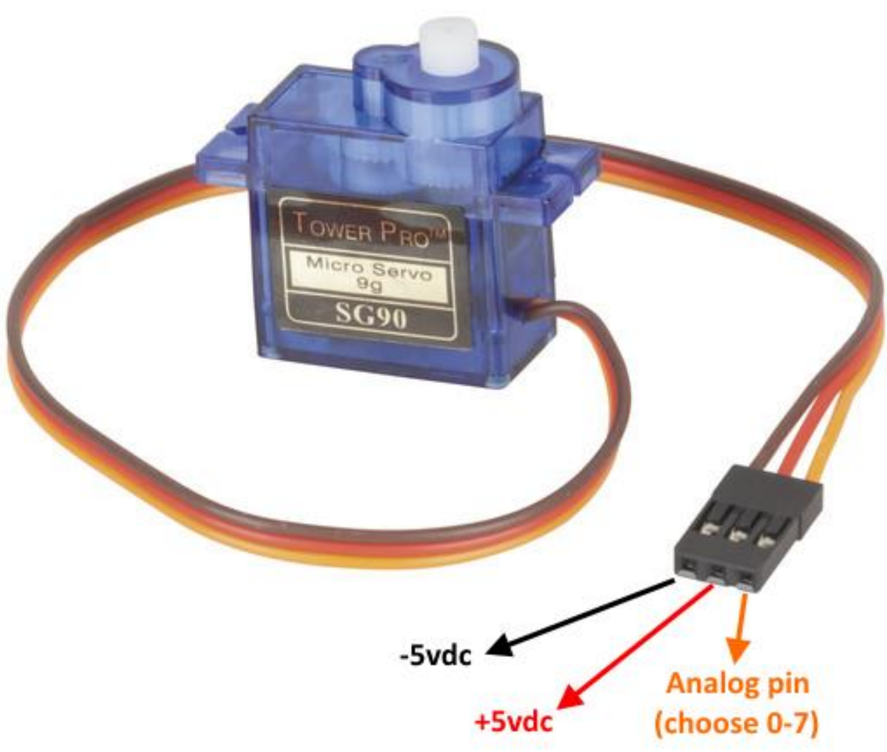
In the robot assembly chapter the steps for connecting each motor will show how to connect each color wire.

CHAPTER 5

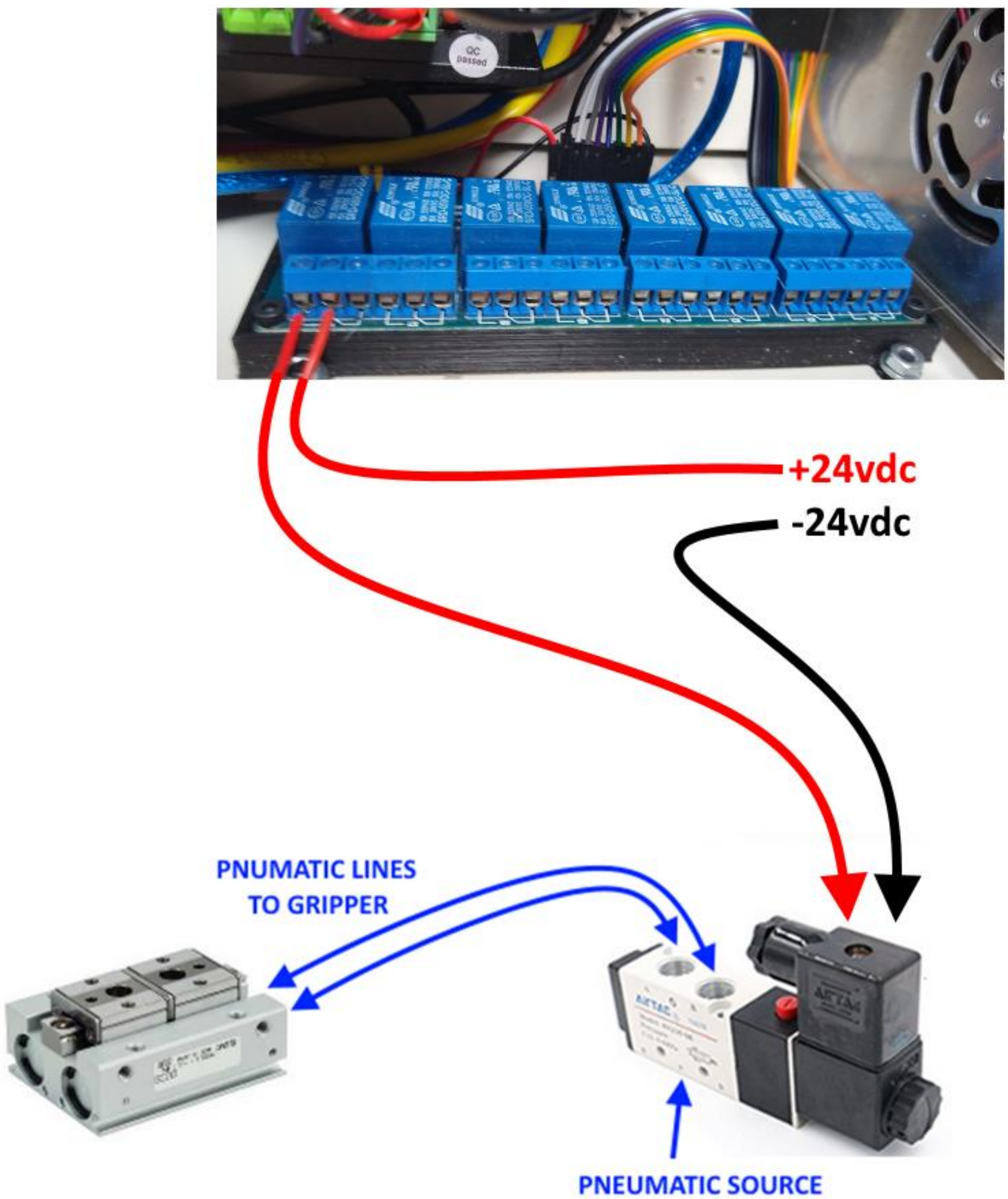
ROBOT GRIPPERS

The recommended gripper for the AR3 robot is the SMC model MHF2-8D shown in the Bill of Materials. 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.

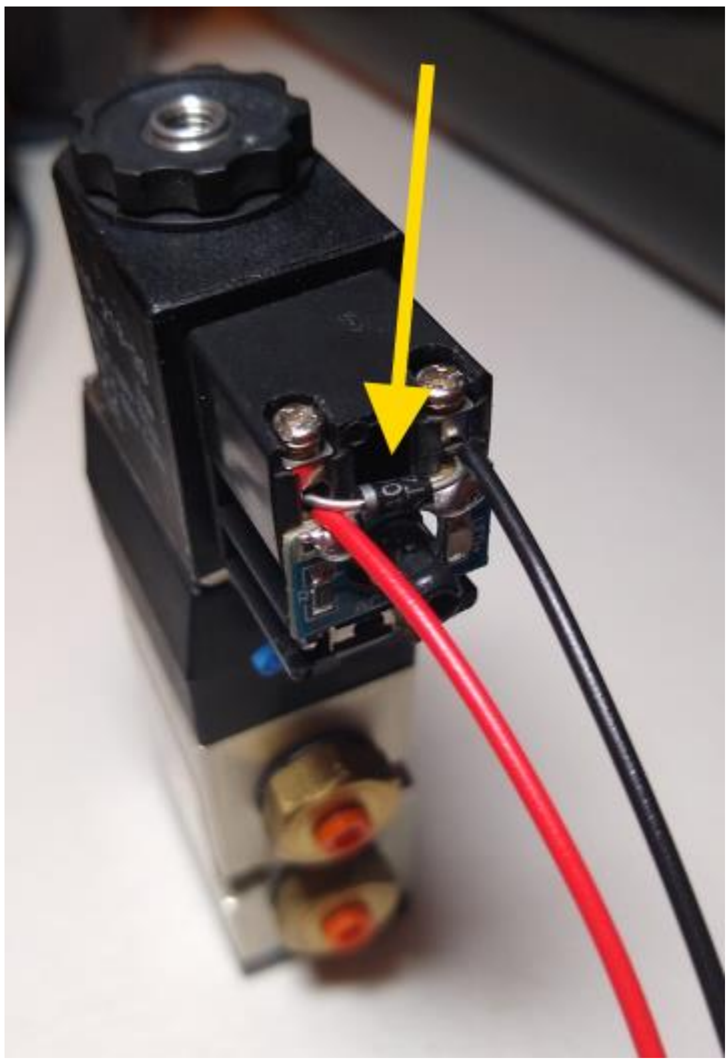
If using a servo gripper you would connect your servo to one of the Arduino analog pins 0 through 7 and then use the "Servo" position command button to control your gripper.



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.



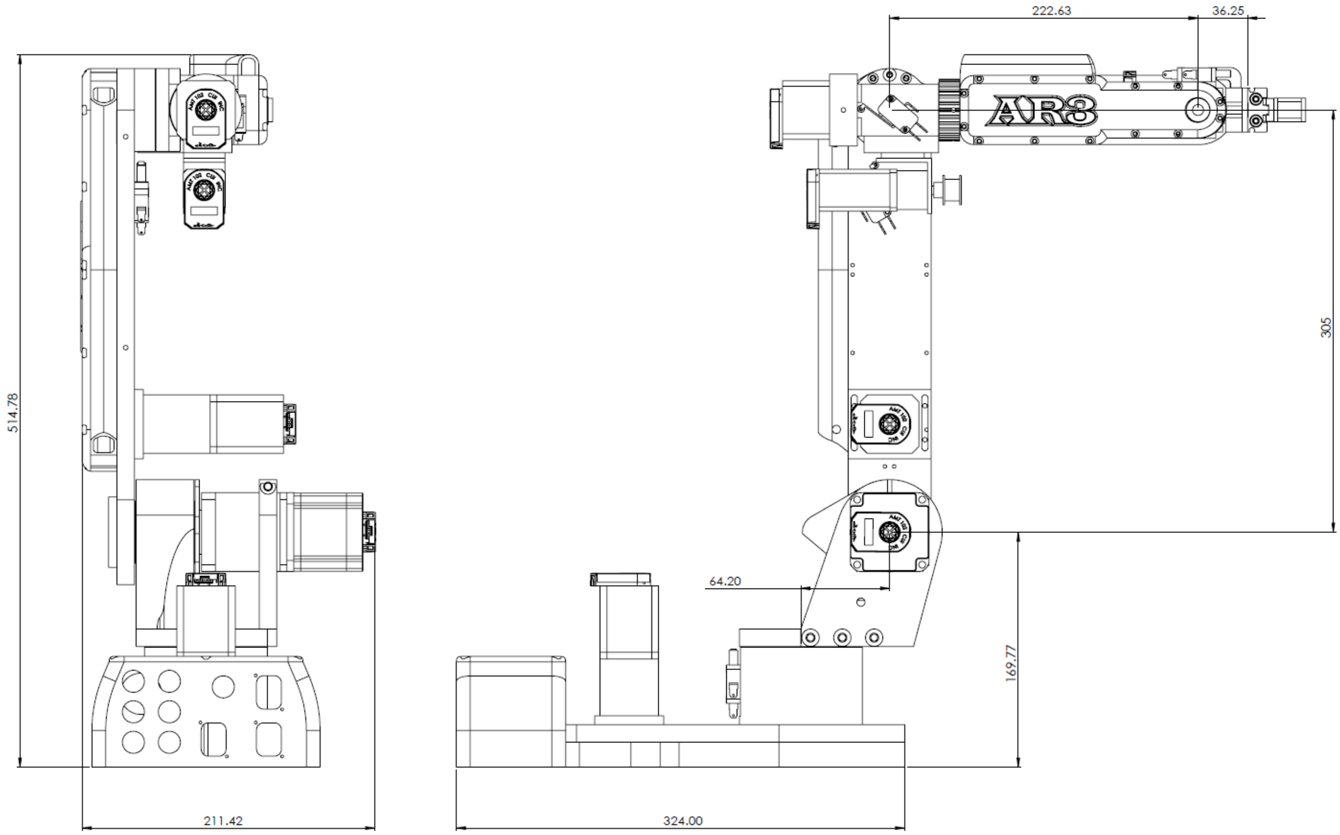
Solenoid valves for controlling pneumatic grippers tend to interrupt the serial connection to the controller. If you find the Teensy or Arduino are losing connection when the solenoid valve actuates install a flyover diode across the solenoid terminals (revers bias).



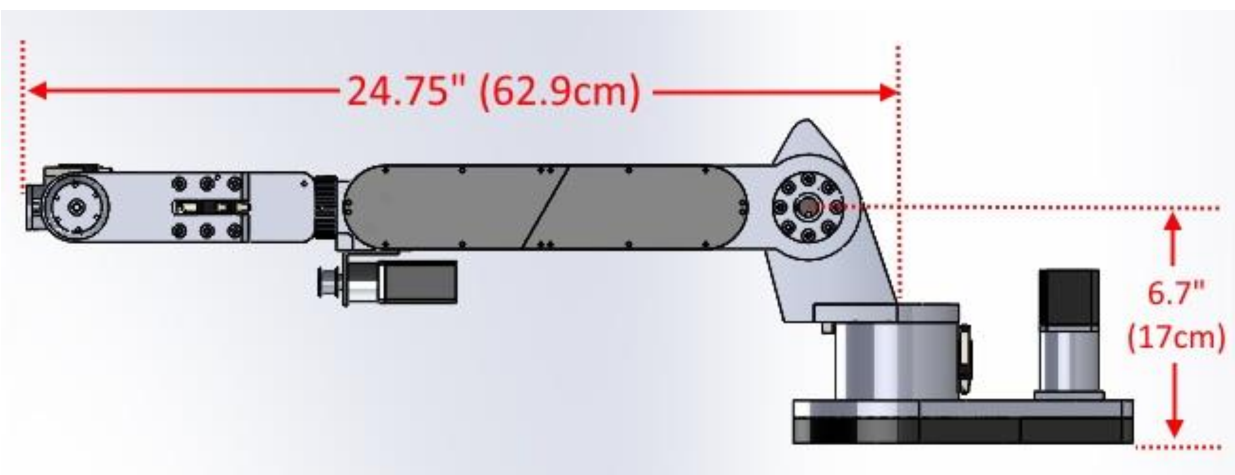
https://en.wikipedia.org/wiki/Flyback_diode

CHAPTER 6

ROBOT SPECIFICATIONS


222.63
36.25
AR3
305
64.20
169.77
514.78
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

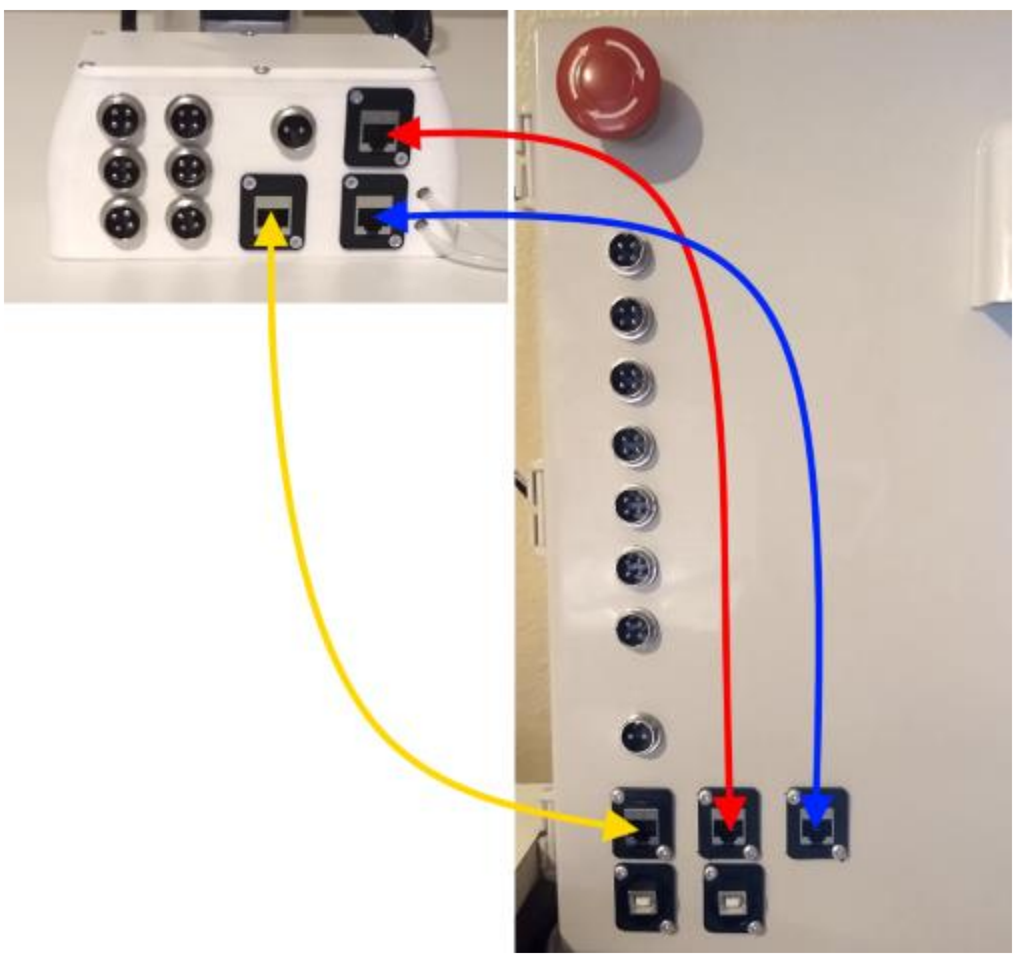
STARTUP PROCEEDURE

AR3 Robot Startup & Troubleshooting

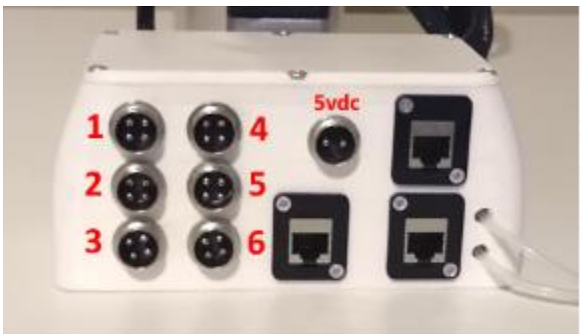
Before powering up your control box double check all connections per the wiring schematic. Check continuity on all wires and connectors for each motor, encoder and limit switch. It is imperative that all wire connectors are crimped or soldered carefully and checked with a volt meter.

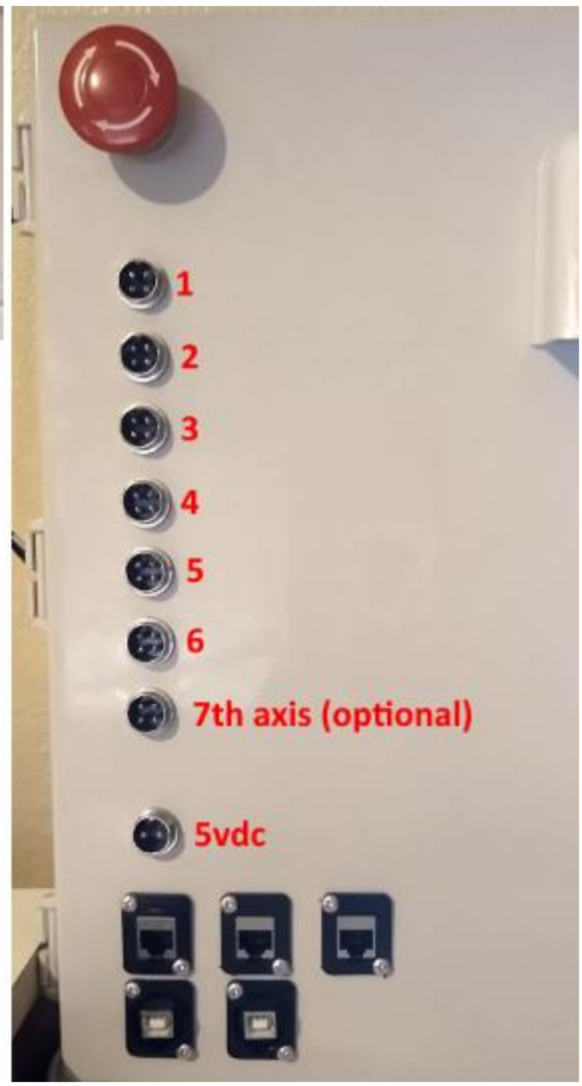
It is recommended that you plug in each of the (3) Ethernet cables prior to plugging in the USB port for the Teensy 3.5.

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:

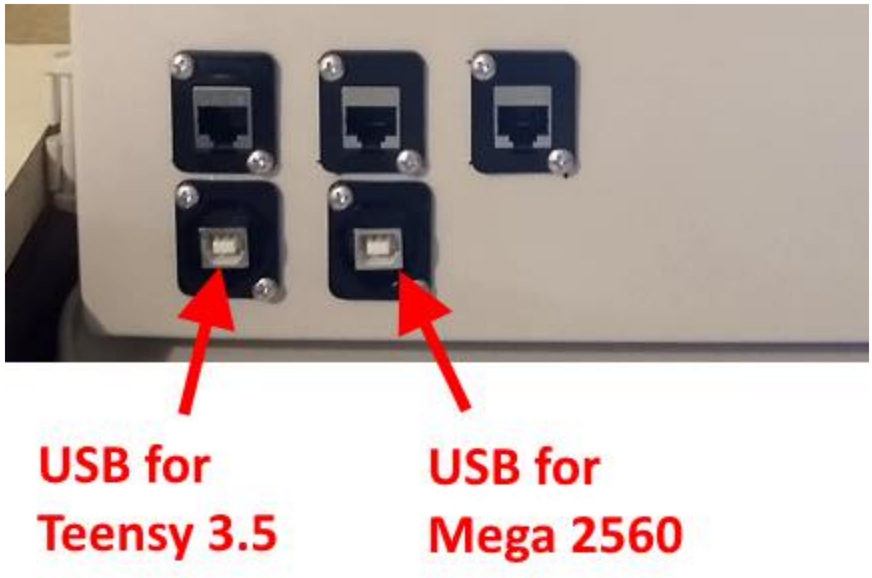


Connect the motor extension cables and 5vdc power cables from the control enclosure to the robot base as corresponds to the numbers shown below.





Connect (2) USB cables from PC to enclosure as shown below.



Please review this video on the startup and software installation:

[AR3 Startup Video]

As shown in the setup video follow the instruction on this page to install the Teensyduino loader software:

https://www.pjrc.com/teensy/td_download.html

Install the latest version of the Arduino IDE that is supported by Teensyduino:

https://www.arduino.cc/en/main/software

Download and install the ARCS_teensy_sketch onto the teensy 3.5 board.

Download and install the ARCS_Arduino_sketch onto the Mega 2560 board.

Download and open the ARCS control software then set the com ports on the main controls tab for both the teensy 3.5 and the Arduino Mega 2560.

Before attempting to auto calibrate the robot jog each axis using joint mode a small amount in each direction.

Verify each joint is jogging the correct direction per the joint direction drawings at the end of this document.

If a particular joint jogs the same direction regardless of pressing the + or – direction buttons you likely have a wiring issue with the direction wire from the Arduino to the driver.

If a joint does not move at all but others do you likely have an issue with the step wire from the Arduino to the driver.

Do not use the auto calibrate button the first time, calibrate each joint one at a time using the individual joint calibration buttons.

Have your hand on the E-Stop button the first time so that you can stop the robot and cut power if there is an issue with each limit switch and the robot tries to overdrive the joint.

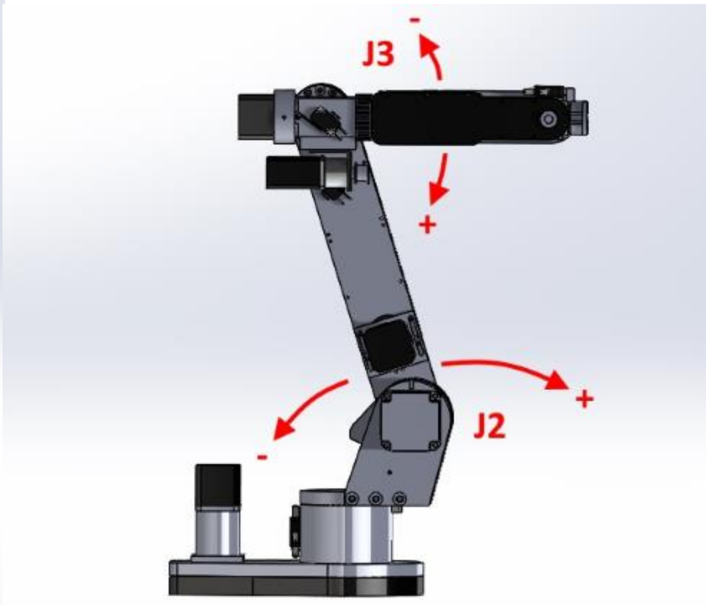
You can also manually trigger the switch with your finger before the robot contacts the switch to give you extra time to hit the E-Stop in the event there is a wiring issue and robot doesn't stop moving when the switch is made.

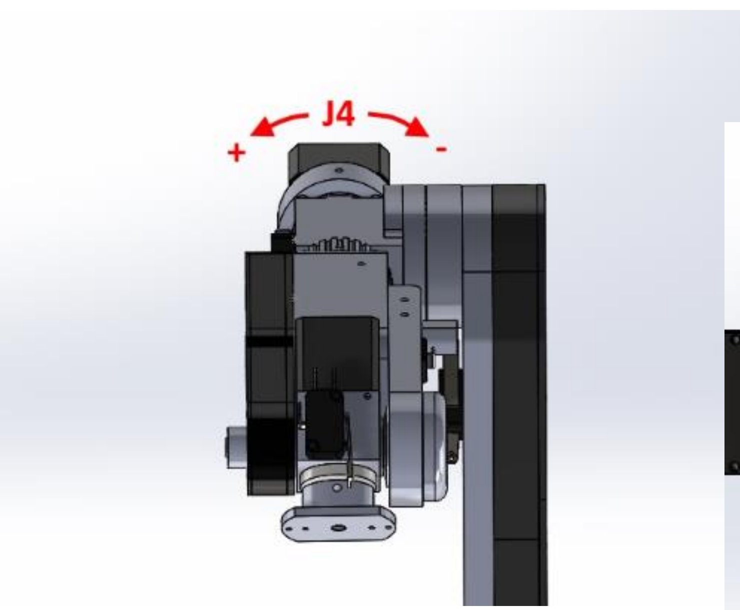
Once all joints and switches are verified to be stopping and calibrating you can then use the auto calibrate to calibrate all joints at the same time.

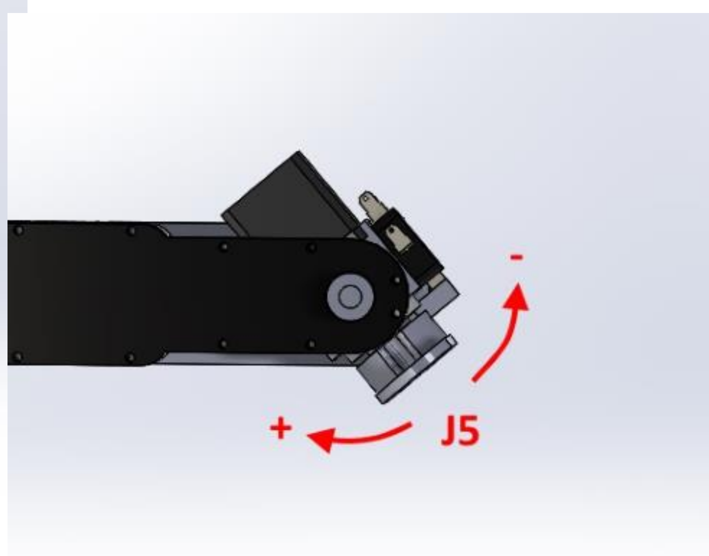
Once your robot is jogging correctly and calibration is complete you can now begin using and programming your robot. Please review each of the tutorial on this page:

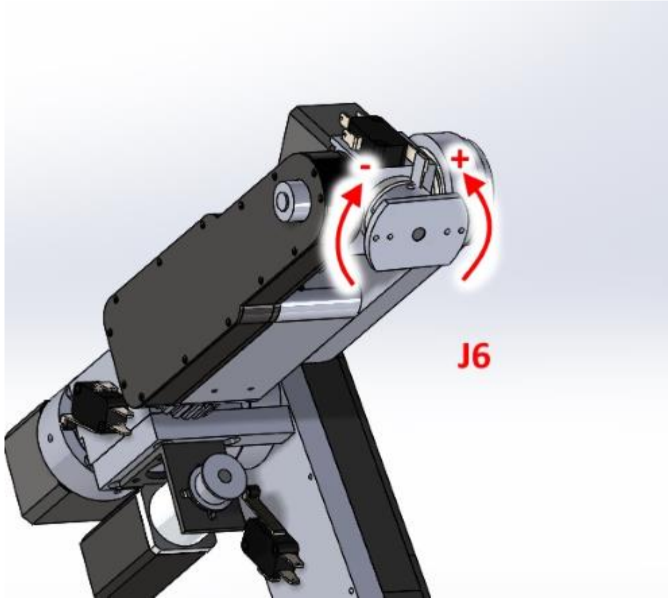
https://www.anninrobotics.com/tutorials


-
+
J1


-
J3
+
+
J2
-


J4
+
-


-
+
J5


-
+
J6

CHAPTER 8
ROBOT PROGRAMMING

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

1. COMMUNICATION

Determine which com port your Teensy 3.5 and Arduino Mega 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. When jogging in joint mode You can also jog the robot in individual motor steps by checking the "Jog joint in steps" radio button. 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 AR2 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.

c. fine calibration

This feature allows you to set a reference position, so you can check how true your calibration is given an event where you have a bent limit switch or must replace a part of the robot. For example, you can jog the robot to some reference position that you know, perhaps with the robot holding a pointer and going to a known spot, you could then press "teach fine calibration position" to save this position. Then later you can press "Go to fine calibration position" to return to the originally taught position and check accuracy. If its off, you can jog the robot in small steps to the correct calibration position and then press "execute fine calibration" and your calibration will be adjusted to the original reference position.

d. Direction Defaults

the calibration defaults are set to the side of the axis that the limit switch is mounted on. If for example you were building your own custom robot you could change these values to change the direction the robot drives each axis to the calibration limit switch. there are 6 values - one for each joint and they can only be a "0" or "1" for negative direction or positive direction.

The motor direction outputs work in the same way and allow you to change to motor drive direction from clockwise to anticlockwise if you are building a custom robot and your mechanics require a motor to spin the other way. again, there are 6 values - one for each joint and they can only be a "0" or "1" for negative direction or positive direction.

e. Robot Calibration Values
The calibration values allow you to input the freedom of motion for each joint and the number of stepper motor steps to make that stroke happen. If building your own custom robot, you could change these values to match your custom range of motion and stepper gearing.

f. DH parameters - these are the Denavitt Hartengberg parameters used to calculate the kinematics of the robot given the length and orientation of each arm. Please see my videos on kinematics and calibration before building your own custom robot and applying these values.

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

CHAPTER 9

OPEN LOOP VERSION (AR2)

There are a couple reasons one might want to build an open loop version of this robot. You may have already built the AR2 and would like to upgrade your wiring as well as covers and spacers to the AR3 version without the expense of purchasing dual shaft motors, or you may want to save some money and not incur the added cost of the encoders. If you would like to build the open loop version of the AR3 you can do so by following the instructions below:

- Follow chapter 2 on the robot assembly but skip each step that involves the installation or wiring of the encoders.
- The 5vdc wire bundles would only have 6 wires instead of 12.
- Build the AR2 electrical enclosure as shown in the AR2 manuals but add the 5vdc GX16-2 aviation plug to your to your enclosure as shown in this manual. You would wire +5vdc and -5vdc from the 5vcd power supply to the GX16-2 plug.
- Install and run the AR2 software as well as the AR2 arduino sketch for the Arduino Mega as shown in the AR2 instructions.