KoP Item Resources

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Control

VMX-pi Vision/Motion Processor & Robotics Controller

When combined with a Raspberry Pi (purchased separately), the VMX-pi Vision/Motion Processor & Robotics Controller provides an accurate, easy-to-use way ***measure motion***, to ***process video***, ***interface to external sensors*** and ***monitor your RoboRIO*** – using libraries designed and tested to operate on a RoboRIO-based robot.

Note: VMX-pi is also capable for use as a Robot controller including control of actuators (e.g., servos, motors, relays, pneumatics) via Digital Output and Digital Communication protocols like CAN. However, VMX-pi's control functionality is not historically legal for use with actuators used in FRC competitions (please consult the "Robot" section of the FRC Game Manual for details) – but it's great for building an off-season robot! For more information on VMX-pi robot control features, please visit VMX-pi online.

Power Supply and Management:

VMX-pi provides power to your Raspberry Pi, and comes with cables with secure, locking connectors so you can easily connect them to the Power Distribution Panel on your robot, or to a standard "Wall-wart" when developing software. VMX-pi's power management will keep your Raspberry Pi running even when the robot battery voltage gets low.

Motion Processing:

VMX-pi includes a navX-Technology self-calibrating Inertial Measurement Unit (IMU) and an Attitude/Heading Reference System (AHRS). Motion-processing capabilities enable you to improve your autonomous and teleoperated programs by adding intelligent features including:

- Driving in a straight line
- Rotating automatically to a specific angle

- Field-oriented drive
- Automatic Balancing
- Motion Detection
- Collision Detection

Vision Processing:

The Raspberry Pi (especially when combined the VMX-rtk Robotics Toolkit) provides an inexpensive, powerful platform for processing, recording to disk and streaming video to the FRC Driver station. Vision-processing capabilities enable you to improve your autonomous programs by performing target detection and calculations of distance and angle target. VMX-pi provides an integrated power supply for your Raspberry Pi, making it simple to add a Raspberry Pi to your robot. And the Raspberry Pi SD Card makes a great place to store competition video recorded by the robot.

Real-time Clock:

VMX-pi's onboard battery-backed Real Time Clock keeps track of current date and time – even when not connected to an external power source. This allows logging on your robot with useful timestamps, and can also be used to synchronize streams of data from multiple robots.

Interface to Sensors:

VMX-pi provides I/O capabilities very similar to the RoboRIO – making it useful for interfacing to external sensors (e.g., the Sparkfun QWIIC Connect family of I2C sensors), as well as the RoboRIO CAN bus. On a FRC robot, these features can be integrated into your robot application (by sending information from VMX-pi to the RoboRIO over the network via NetworkTables). VMX-pi can also be used to unobtrusively monitor the behavior of a FRC robot for debugging and analyzing robot performance.

Motion Processing overview

VMX-pi includes a navX-Technology Inertial Measurement Unit (IMU), and includes 6 sensors which measure inertial motion: 3 accelerometers measuring acceleration (in units of Standard Gravity [g]) and 3 gyroscopes measuring Rotational Speed (in units of degrees per second).

Additionally, through a process called "Motion Processing", VMX-pi intelligently combines the 6-axis inertial sensing data to create a measurement of relative 3D orientation.

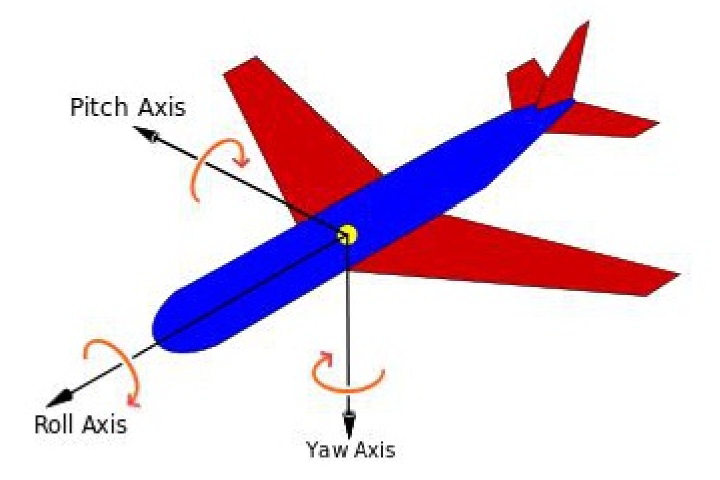

Figure 1 Measuring Orientation with Yaw, Pitch and Roll Angles

IMUs are typically used to measure aircraft orientation, but are also very useful for controlling a robot. IMUs measure rotation of an object around the Z-axis (known as "Yaw"), the X-axis (known as "Pitch") and the Y-axis (known as "Roll").

Pitch and Roll angles are absolute (tied to the earth's surface); 0 degrees means "flat" with respect to the earth.

However, IMU Yaw angles are ***relative*** - not tied to any direction (like North on a Compass). Therefore, your robot application must decide where 0 degrees is. Usually, FRC robots treat the "head" of the field (the direction driver's face) as 0 degrees.

For more information, please visit the [VMX-pi Terminology page](#).

Digital Compass and Attitude/Heading Reference System (AHRS)

VMX-pi's navX-Technology also includes 3 magnetometer sensors, which measure magnetic fields (in units of Tesla). By measuring the earth's magnetic field, VMX-pi provides a digital compass – which is a different way of measuring the Z ("Yaw") axis.

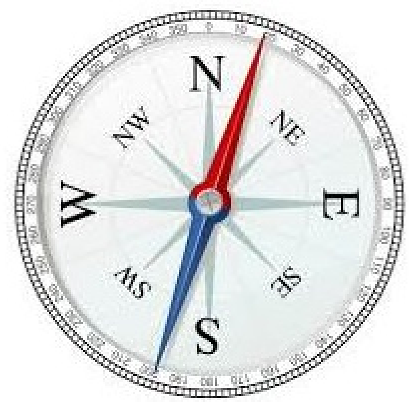

Figure 2 Measuring Z-axis Orientation with a Compass

And by intelligently fusing the digital compass with the gyroscope/accelerometer data, VMX-pi can create a measurement of absolute 3D orientation.

Note: Earth's magnetic field is actually very weak when compared to the magnetic field generated by a nearby motor; for this reason it can be difficult to get accurate digital compass readings on a FRC robot. For this reason, using the VMX-pi AHRS is an advanced feature best suited for teams who have the time to learn about how to calibrate the VMX-pi digital compass and also how to deal with magnetic disturbances.

Vision software overview

Useful Vision software for FRC robots is comprised of multiple features:

Feature	Description
Acquisition	Retrieves camera images so they can be processed by software
Processing	Detects objects of interest in camera images, and calculates metrics(e.g., distance and angle) about those objects
Streaming	Allows drivers to see what the robot sees, in real-time and during amatch

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Feature	Description
Recording	Stores video of a match recorded by the robot for later viewing
Overlays	Textual information display on video useful to Streaming viewers anddebugging of Processing algorithms

VMX-pi's VMX Robotics Toolkit contains OpenCV and the WPI cscore and ntcore libraries - and enables your Raspberry pi to integrate your vision processing algorithm (e.g., as generated from the WPI GRIP tool) into your robot application. The VMX Robotics toolkit includes source code demonstrating each of the features and how to incorporate them into your robot's Vision software.

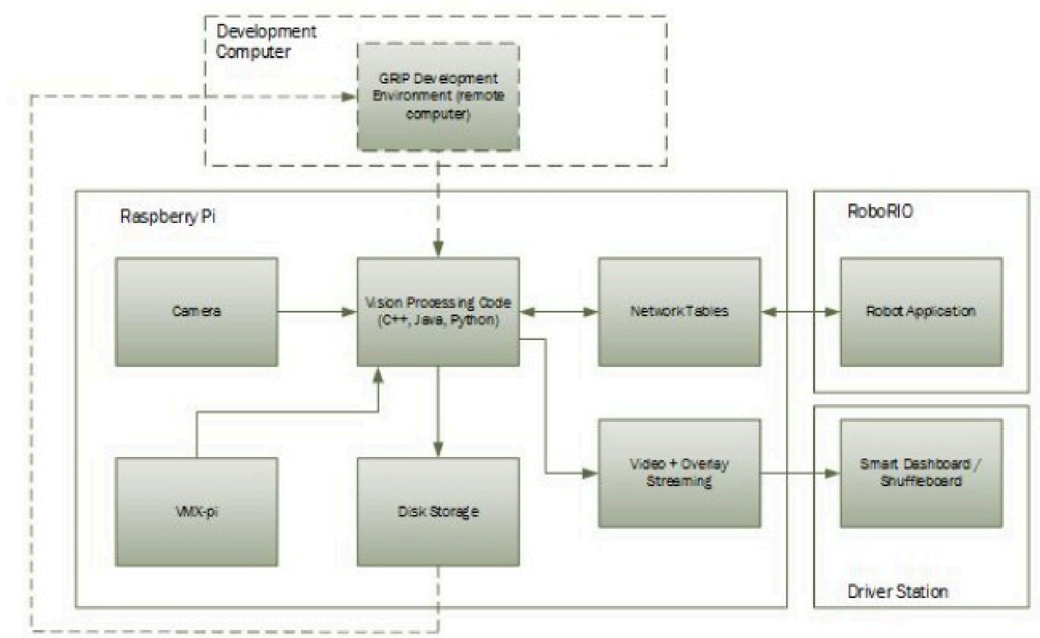


Figure 3 Vision software architecture

The Vision software architecture diagram depicts how the various vision components work together. The dotted lines represent the activities that occur during development & debugging; the remaining components are used during practice matches and competition.

Please visit the VMX-rtk Online examples, which includes examples of these features and how to combine them into FRC vision co-processing application running on the Raspberry Pi connected to VMX-pi.

CAN Bus Monitoring overview

VMX-pi's integrated CAN bus interface allows you to monitor the robot CAN Bus from the Raspberry Pi. If you are interested in writing applications to monitor the can bus, please see the can_bus_monitor examples which demonstrate how to write software that access some of the CAN bus devices typically found on a FRC robot.

Note: In addition to monitoring a CAN bus, VMX-pi is also capable of transmitting CAN bus control commands. However, VMX-pi's control functionality is not historically legal for use to control CAN actuators used in FRC competitions (please consult the "Robot" section of the FRC Game Manual for details).

Assembly with Raspberry Pi

The first step is to assemble your Raspberry Pi 3 and VMX-pi, as shown at VMX-pi online.

Kauai Labs has created the VMX Robotics Toolkit, available for purchase at the Kauai Labs Store. This is a high-quality SD Card for your Raspberry Pi with many pre-installed software tools for FRC robotics, and also has approximately 16GB of extra space for storing videos taken on your robot during practice or competition. Instructions are also available at VMX-rtk online to build your own SD card image, however Kauai Labs recommends the VMX Robotics Toolkit SD card – which was created to save you the time and trouble of creating your own SD card.

VMX-pi comes with a battery cable for connecting to the Power Distribution Panel; VMX-pi also comes with a "Wall-Wart" cable for powering VMX-pi and your Raspberry Pi when not on a FRC robot. You will need to purchase a standard Wall-wart (between 6-16 VDC output, up to 3 Amps, with a center-positive connector with an inner diameter of 2.1mm and an outer diameter of 5.5mm. These are available online at many stores for under $10.

FRC Robot Installation Overview

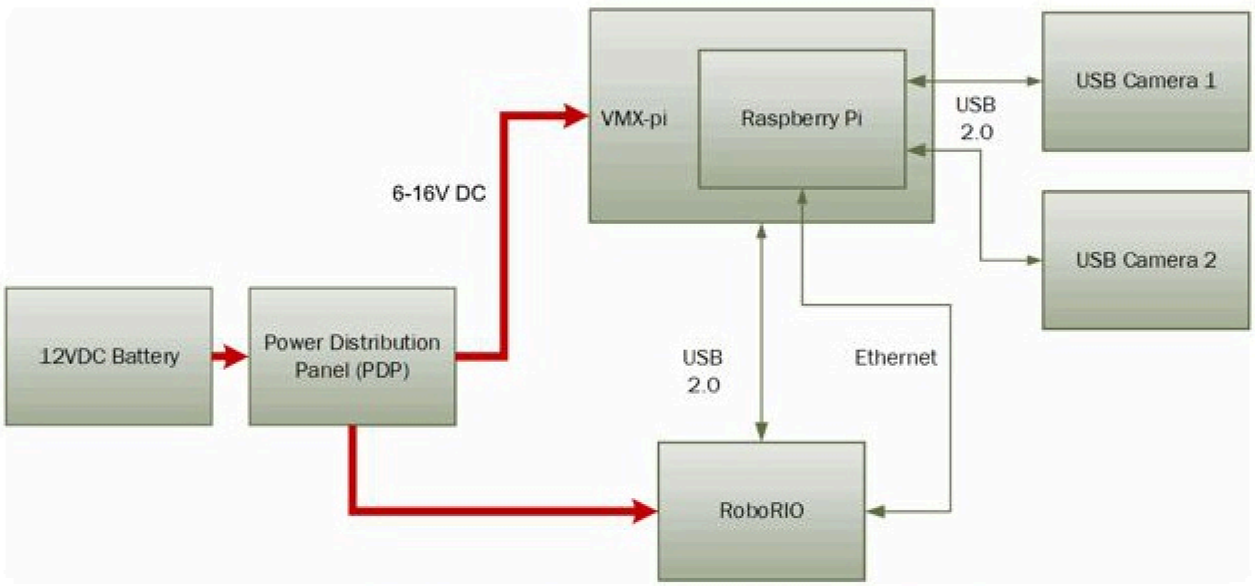


Figure 4 VMX-pi Circuit Board installed into the RoboRIO MXP slot

VMX-pi can be easily connected to a robot, connecting power from the Power Distribution Panel (PDP), Ethernet and/or USB from the RoboRIO, and (if vision processing is used), connecting cameras to the Raspberry Pi USB Ports (or to the Raspberry Pi camera connector if using the Raspberry Pi Camera). This only takes a few minutes.

If using the Standoffs to mount VMX-pi, connect the Standoffs to the chassis or other large surface of the robot; if using the VMX-pi enclosure, mount the enclosure to the robot chassis via the mounting holes at the four corners. In either case, if using IMU data, it is important to mount VMX-pi firmly so that it moves as a unit with your robot chassis.

NOTE: When connecting VMX-pi to your FRC robot for use in competition, be sure to disable the Raspberry Pi Wifi, to avoid Wifi interference.

USB (if accessing IMU data directly from the RoboRIO)

If connecting VMX-pi to the RoboRIO to acquire IMU data – or to a Windows computer to run the navXUI and other tools on Windows - use a USB micro cable. The USB Micro cable is connected to the usb connector near the power connector, as shown below.

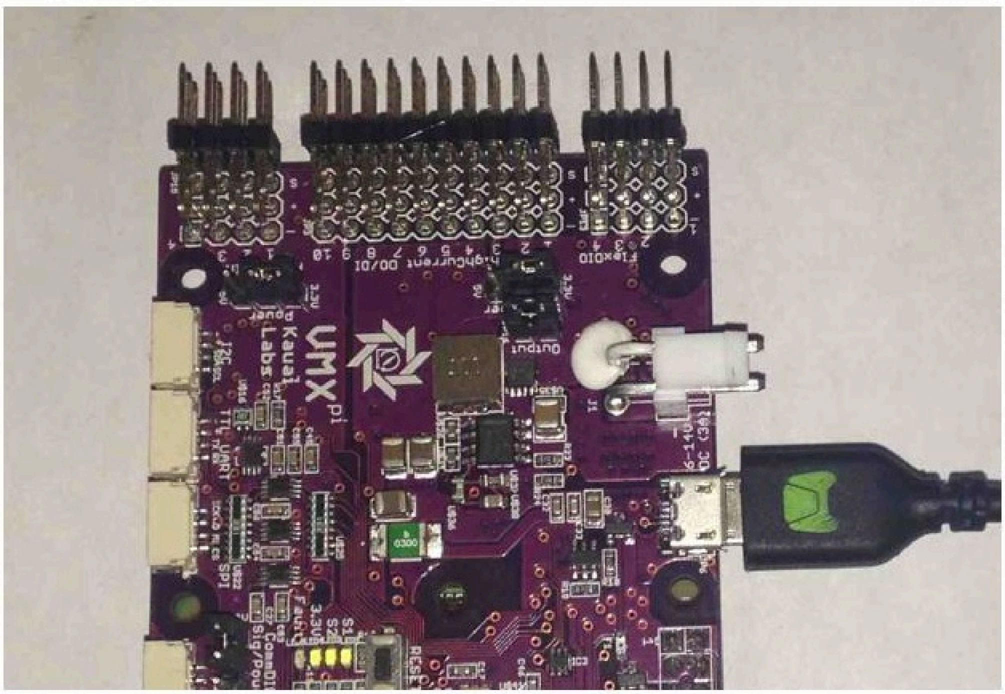


Figure 5 VMX-pi USB connection for configuration and IMU data access

Ethernet (if accessing Vision processing or other data via NetworkTables)

Figure 6 Connecting VMX-pi to the CAN Bus

If connecting VMX-pi to the RoboRIO to communicate data over Ethernet, connect an Ethernet cable to the RJ45 (Ethernet) connector on your Raspberry Pi connected to the VMX-pi. Connect the other end to the Robot network, either on the Wifi radio (e.g.,OpenMesh) or a separate ethernet switch connected to the radio.

CAN (if accessing CAN bus data)

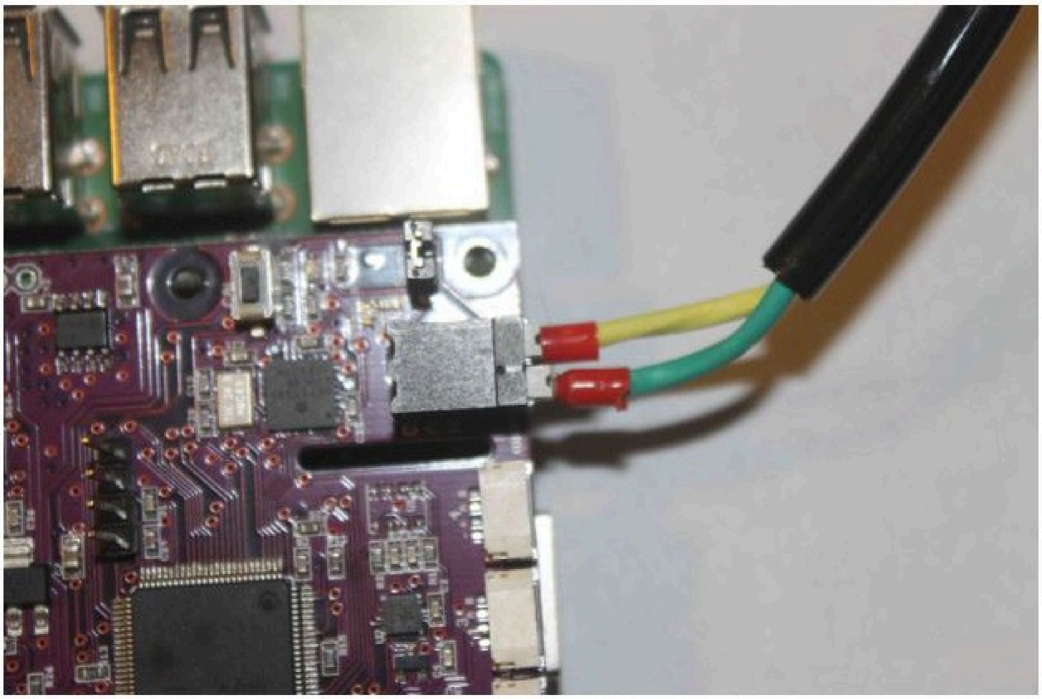


Figure 7 Connecting VMX-pi to the CAN Bus

If connecting VMX-pi to the RoboRIO to acquire CAN data, connect a CAN cable (as supplied in the Kit of Parts) to the Weidmuller connector on the VMX-pi. The use of ferrules (the red plastic portion of these connectors is visible in the photo above) is highly recommended to ensure a secure electrical connection.

Enclosure

Figure 8 VMX-pi enclosure

An enclosure is recommended to protect the VMX-pi and Raspberry Pi circuit boards from excessive handling, "swarf", electrostatic discharge (ESD) and other elements that can potentially damage them.

Visit the VMX-pi Enclosure page to either purchase an enclosure for VMX-pi or to download a 3D-printable design file.

RoboRIO Software Installation

To access VMX-pi IMU data from your RoboRIO robot application, install the VMX-pi Libraries for RoboRIO.

If using NetworkTables to exchange data between VMX-pi and RoboRIO, Network Tables support on the RoboRIO is already installed with the FRC software releases; on the Raspberry Pi, NetworkTables is available (for C++, Java and Python) on the VMX-rtk SD Card Image.

Using VMX-pi

Example RoboRIO robot examples for accessing the VMX-pi's navX-technology IMU data are available in C++, Java and Python.

Example programs for developing vision processing for Raspberry Pi will be available online at the KauaiLabs website soon after kickoff in the "Raspberry Pi" example section.

Visit the VMX-pi Examples page for a description of each example and details on how to use it with your chosen programming language. This page also includes other examples of how to develop robot applications when using VMX-pi as a robot controller.

Learning More

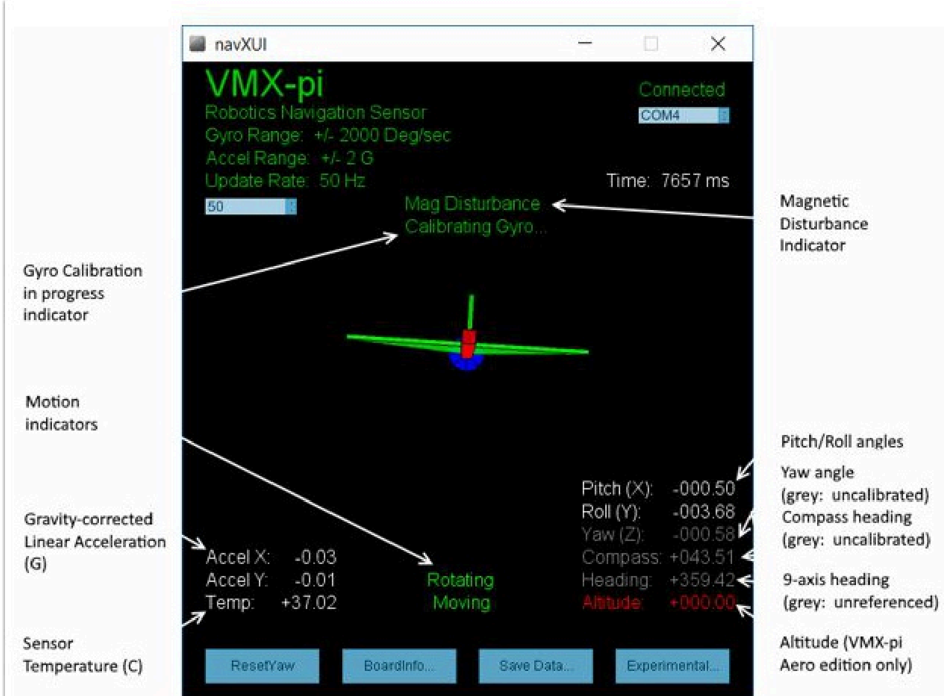


Figure 9 navXUI

To learn more about how the VMX-pi navX-technology IMU works, you can use navXUI, which runs on a Windows PC connected via USB to the VMX-pi and demonstrates all of the VMX-pi features.

navXUI also provides a way to save VMX-pi data to a file so you can analyze it. navXUI can even run simultaneously with your RoboRIO robot application.

Best Practices

If you want to get the most out of your VMX-pi and achieve results similar to those of the top FRC teams, the VMX-pi Best Practices is just for you. These guidelines will help you avoid common pitfalls and achieve the highest possible accuracy.

Getting Help

If you have trouble with VMX-pi, please visit the VMX-pi support page; you can join the VMX-pi newsgroup or contact technical support for help.

Mechanical Guides, Blocks, Bearings

Linear Motion 101: Guide Wheels and Track

So you've entered the *FIRST*® Robotics Competition, congrats!! But now the real work begins, but don't worry we are here to help. One of the biggest challenges that you may be facing is designing. Designing your robot and laying out the processes and tools that you will need to build it.

Linear motion is likely something you've heard of, but is also likely something you aren't too familiar with. To make a long story short, linear motion and its components are what makes machines move. Whether your robot needs to lift something off the ground or move something from one place to another it all falls into the realm of linear motion.

Basic Components of Linear Motion

Think of components as the ingredients of linear motion!

- Guide Wheel
- Track

This guide is focused on the basics of MadeWell guide wheels and DualVee track so you know everything you need to in order to start building your robot.

Questions and Answers: MadeWell Radial Guide Wheel Edition

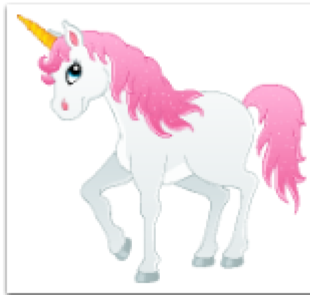
So, what are MadeWell Radial Wheels?

Quick answer, they are ball bearing guide wheels that can make just about anything move in just about any environment, quickly.

Longer answer, they are industrial, precision ground guide wheels with 90° vee running surfaces that were designed for linear motion applications. They are made of high quality carbon or stainless steel and were engineered to move heavy loads at high speeds (up to 5.5m/s or about 12mph).

They can move stuff, so what? Why should I care?

Touché! Guide wheels are made to move stuff, but not all guide wheels are created equal. MadeWell wheels are special. Not a unicorn eating rainbow ice cream kind of special, but the kind of special where you can use them in your robot and the tools you use to make your robot.

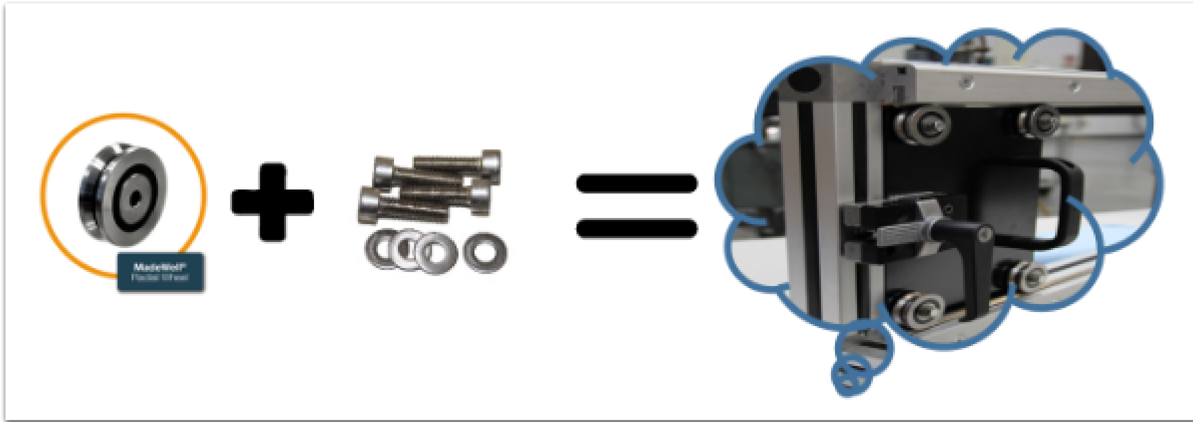


Need some ideas on where we recommend you throw your MadeWell wheels?

- Robot work stand
- Robot sliding electronics board
- Workshop
- **YOUR ROBOT**
- Moving element for sliding robot into loading crate for transport
- A bearing guide for cables or wires

Is it hard to attach these MadeWell wheels? I have kind of limited resources and time.

You are in luck my friend, MadeWell wheels are super easy to attach to things. All you need is a simple screw, a washer and a MadeWell wheel.



You said I need a simple screw to mount the wheels……. can you be a little more specific?

Of course!

RECOMMENDED MOUNTING HARDWARE			
WHEEL SIZE	STOCK CODE	SCREWS	MOUNTING SPACERS
1	W1RX W1RSSX	M5	M5 DIN 433
2	W2RX W2RSSX	1/4"	SAE type A 1/4"
3	W3RX W3RSSX	M8 or 5/16"	M8 DIN 125 SAE type A 5/16"

Okay, so what are the technical specs for MadeWell wheels?

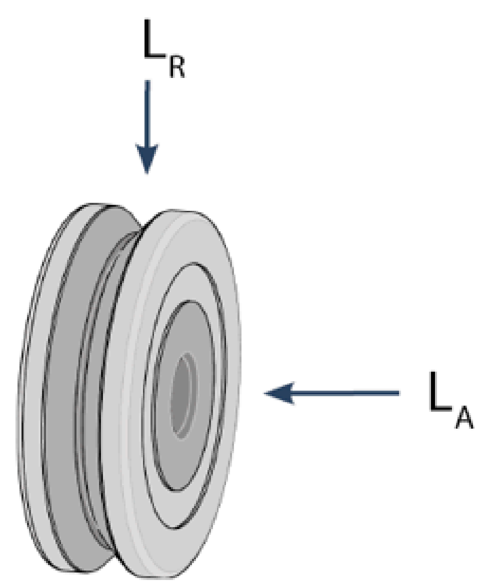
Great question, how do you build anything without measurements, right?

TECHNICAL SPECIFICATIONS									
SIZE	STOCK CODE	MATERIAL	OUTSIDE DIAMTER (D)	WHEEL WIDTH (W)	BORE DIAMETER (B)	VEE RADIUS INSIDE (VRI)	INNER RADIUS (C)	OUTER RADIUS (E)	WEIGHT (g)
1	W1RX	AISI 52100 Carbon steel	Ø0.771 [Ø19.58]	0.274 [6.96]	Ø 0.201 +/-.002 [Ø5.11+/-0.51]	.313 [7.94]	0.012 [0.30]	0.012 [0.30]	10
	W1RSSX	AISI 440C Stainless steel							
2	W2RX	AISI 52100 Carbon steel	Ø1.210 [Ø30.73]	0.383 [9.73]	Ø 0.251 +/- .002 [Ø6.38+/-0.51]	.500 [25.4]	0.020 [0.51]	0.024 [0.61]	38
	W2RSSX	AISI 440C Stainless steel							
3	W3RX	AISI 52100 Carbon steel	Ø1.803 [Ø45.80]	0.551 [14.00]	Ø 0.316 +/- .002 [Ø8.026 +/-0.51]	.750 [19.05]	0.024 [0.61]	0.024 [0.61]	122
	W3RSSX	AISI 440C Stainless steel							

* Values are in inches [millimeters]

What about load capacities?

LOAD RATINGS				
WHEEL SIZE	WORKING RADIAL LOAD CAPACITY L_R		WORKING AXIAL LOAD CAPACITY L_A	
	N	lbf	N	lbf
1	670	151	138	31
2	1500	337	320	72
3	3700	832	800	180



Well, I really like the wheels. Now what?

You can get MadeWell wheels through the Bishop Wisecarver website using your *FIRST* voucher. MadeWell wheels come in either carbon steel or stainless steel and must be purchased in sets of four. Click here to navigate to the website!

Okay, so now that you have a better understanding of how you can use guide wheels in your build let's get you better acquainted with the 1,2, 3s of DualVee track.

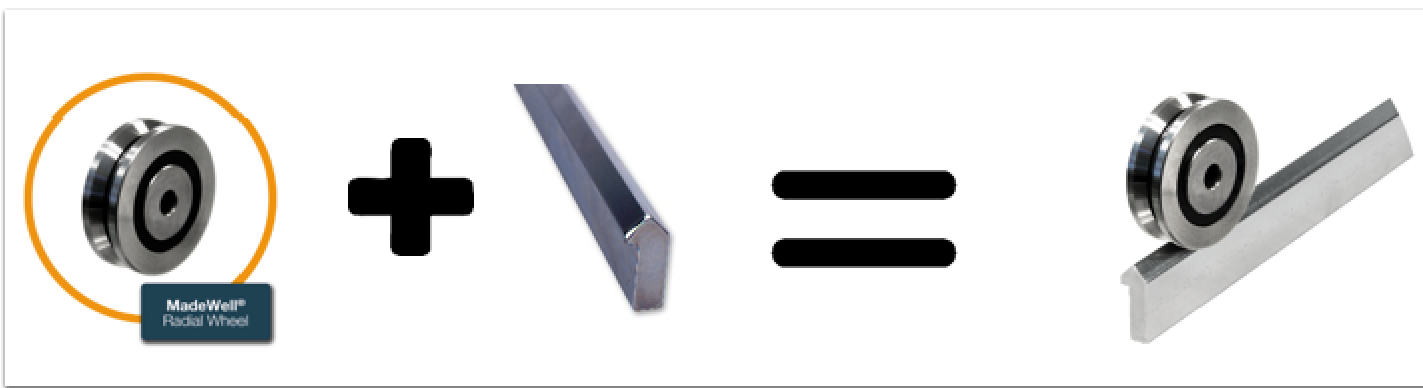
Questions and Answers: DualVee Track Edition

What is DualVee track made of?

DualVee track is made of either AISI 1045 carbon steel of AISI 420 stainless steel and you can get it hardened or unhardened.

I don't get it; how can you use DualVee track with MadeWell guide wheels?

Although DualVee track was designed to work with DualVee wheels it actually is able to be used with any 90° vee guide wheel, which includes MadeWell wheels.



Why do I want DualVee Track so much?

Cutting right to the chase, I respect that.

First, DualVee track is induction hardened which is something you really will care about if you are relying on your machine to move accurately and smoothly every time you use it.

Second, DualVee track's design gives it two super flat and super accurate running surfaces. This means that you could have two different wheels running at the same time on the same piece of track!!

Thirdly, DualVee track arrives treated, milled, polished and ready to be cut, drilled and mounted however you need to. Minimal effort for maximum usability!

Wait, how do I cut DualVee track?

The best way to cut DualVee track is to use an abrasive chop saw. I know, there are so many types but to make your life easier an abrasive disk saw will cut right through steel.

If you don't happen to have an abrasive chop saw handy and you also don't have to make too many cuts, a simple hand hack saw will do the job too!

Another way to cut DualVee track would be to use a milling machine and a carbide end mill. Milling machines are really useful for trimming the ends of track to precise measurements.

Since we're talking about how-to, how do I drill DualVee track?

The heat treatment that is used on the vee surfaces of track often goes a little past the vee onto what we call the "track heal." This is the longer surface where you can find the embossed lettering. Most of this area is unhardened. You can drill your mounting holes into this section very easily using HSS (high speed steel) drill bits or just about anything harder like cobalt or carbide.

To safely drill the rest of the DualVee track, make sure that the track materials are securely clamped in a vise and use a drill press or a milling machine. You can drill through holes in the track and use bolts to attach it to a base or you can drill tap threads into the track and attach it to a base with through holes. You can have it your way, kind of like Burger King.

Keep in mind that when drilling, some of the material may be somewhat harder than the soft treated area. Also, **DO NOT USE A HAND DRILL** (cordless). Safety first, always. Here are some drilling recommendations for your track.

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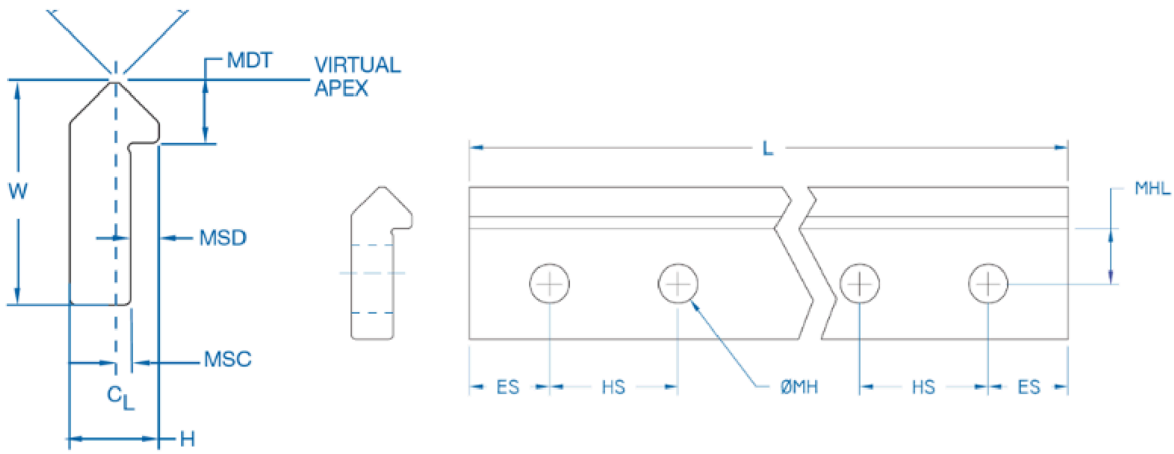
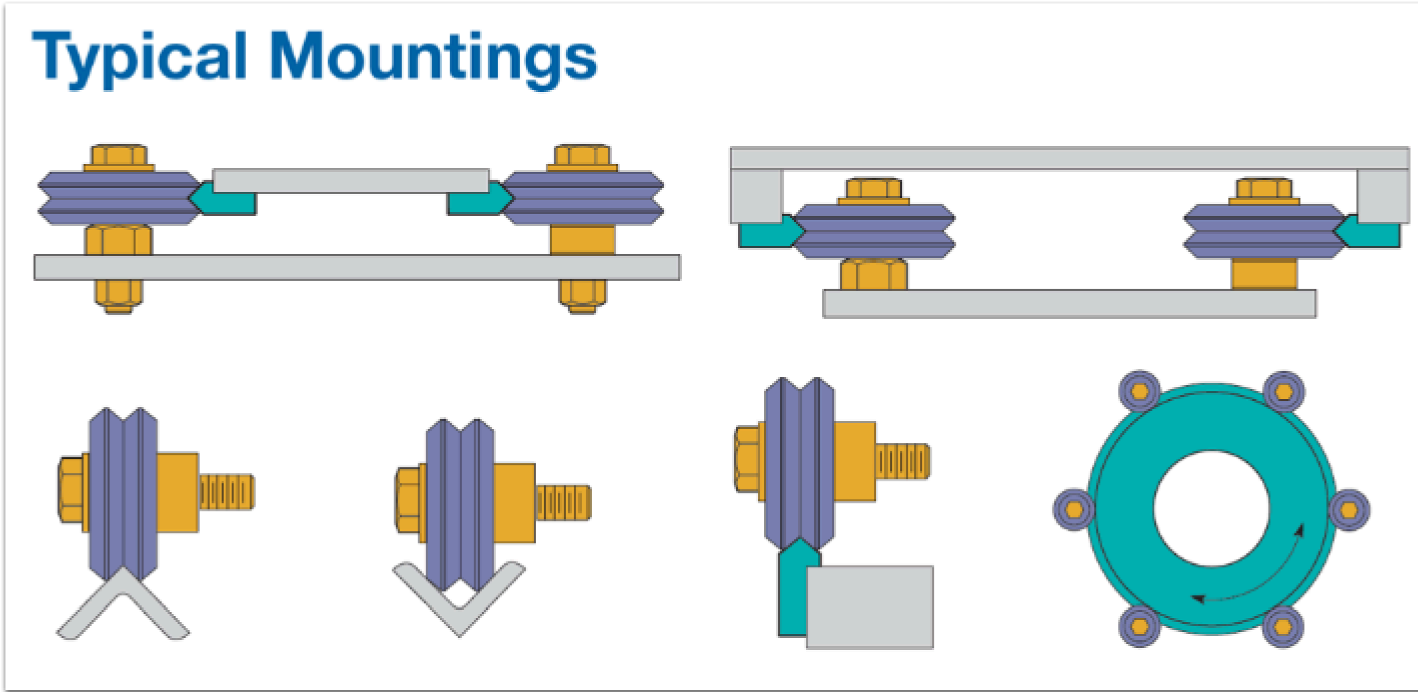
Drilled and Undrilled Dimensions

Size	Width	Height	Mounting Shoulder Location	Mounting Shoulder to Center Line	Mounting Shoulder Depth	Drilled Track Hole Dimensions				Weight
						End Hole Spacing	Hole to Hole Spacing	Hole Size Thru (Diameter)	Mounting Hole Location	
	W	H	MDT	MSC	MSD	ES	HS	MH	MHL	(lbs./ft)
1	.437	.187	.125	.031	.062	.250	2.000	.156	.156	.183
2	.625	.250	.187	.031	.094	.315	3.000	.203	.219	.343
3	.875	.343	.250	.062	.109	.375	3.000	.281	.313	.690
4	1.062	.437	.312	.093	.125	.500	4.000	.344	.375	1.100

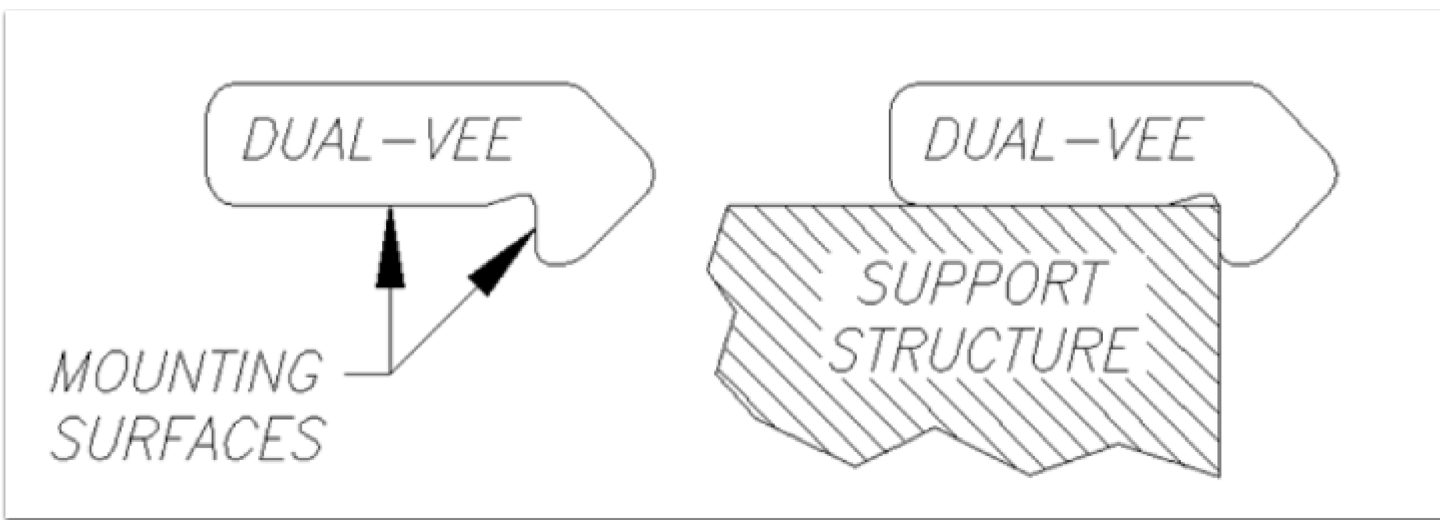


Any other recommendations?

Yeah!! When it comes to mounting DualVee track it truly is dealer's choice. There are number of options including everything from the kind of screw you'd prefer to the mounting orientation of the track. Just in case your drawing a blank on the specifics of how you want to mount your track, here a couple of recommendations to get you warmed up.



DualVee track is designed with an integrated shoulder and mounting surface. These surfaces are to be utilized when mounting DualVee track to your support structure or in your case, robot frame.



Pay special attention to the track mounting surface because small variations in things like flatness, parallelism and even perpendicularity may result in your wheel not running the way you want it to. Our recommendation is to use a machined register on the support structure (robot frame) in the track mounting locations.

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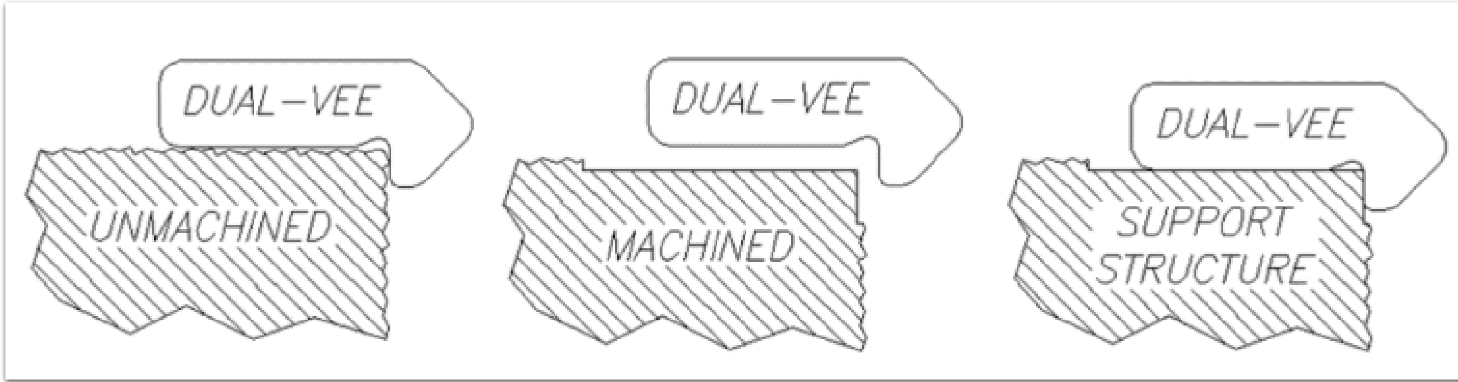
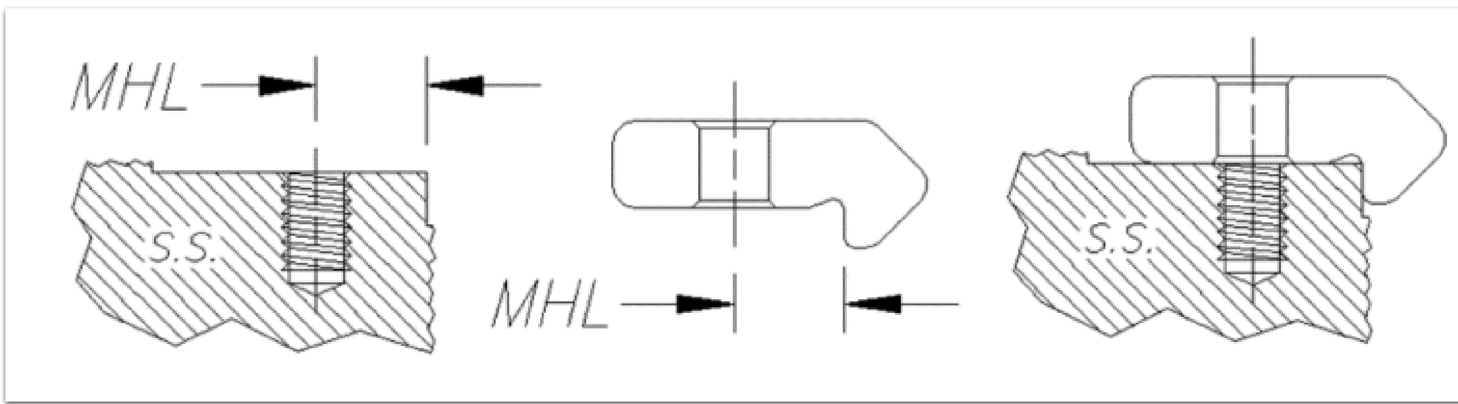
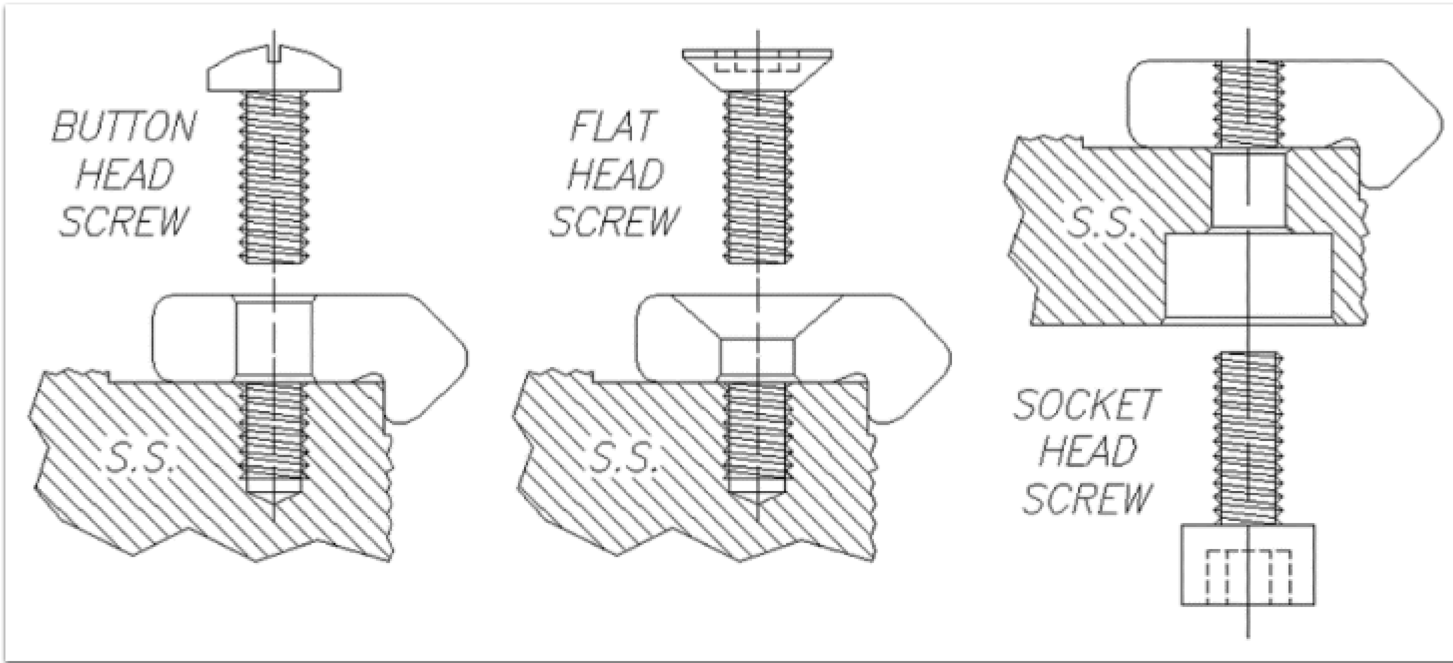


Machining for the track mounting fasteners can also be completed during support member machining. Through hole locations have been standardized on all sizes of DualVee track with dimensions originating from the locating soldier. The catalog dimension “MHL” can be referenced for support structure design.



Custom fasteners and hole locations other the ones specified in the catalog “MHL” can be accommodated for a variety of fastening methods. Common DualVee track hole and fastener combinations include clearance holes for screws, through holes with countersinks, and through threads.


BUTTON
HEAD
SCREW
S.S.
FLAT
HEAD
SCREW
S.S.
S.S.
SOCKET
HEAD
SCREW

Linear Bushings

Mastering Linear Bushings by: MISUMI USA

Linear motion products are the most commonly used motion elements in the automation of transfer, locating, and assembly machinery. Here, three types of linear guides, Linear Bushing, Slide Guide, and Oil Free Bushing will be compared and explained.

Comparison of Linear Motion Products Characteristics

The characteristics of the three types of linear motion products are shown in the table below.

Type	Load Capacity	Friction Coefficient	Guidance Accuracy	Environmental Conditions	Ease of Maintenance
Linear Bushing	Medium	Low	Medium to High	Medium	Medium to High
Linear Slide Guide	High	Low	High	Medium	Medium to High
Oil Free Bushing	Medium	High	Medium	High	High

The Characteristics and Structure of Linear Motion

It is important to first understand the differences in performance based on the load capacity of the component. A machine using Linear Bushings or Oil Free Bushings, which moves on a shaft where both-ends are supporting a heavy load, can elastically deform the Shaft. **(See Photo 1)**.

In the case of vertical linear motion mechanisms, the Shaft does not need to support the load of the unit, thus load capacity can be ignored. Linear Slide Guides have excellent load capacity because the unit moves on rails assembled on the base plate. **(See Photo 2)**

Photo 1 Example of Linear (or Oil-Free) Bushing use

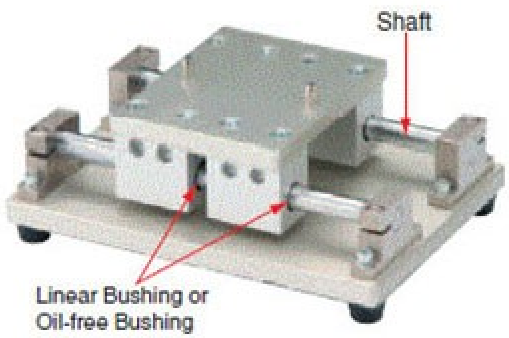
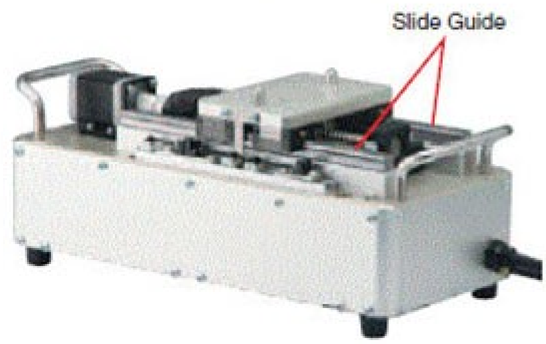


Photo 2 Example of Slide Guide use



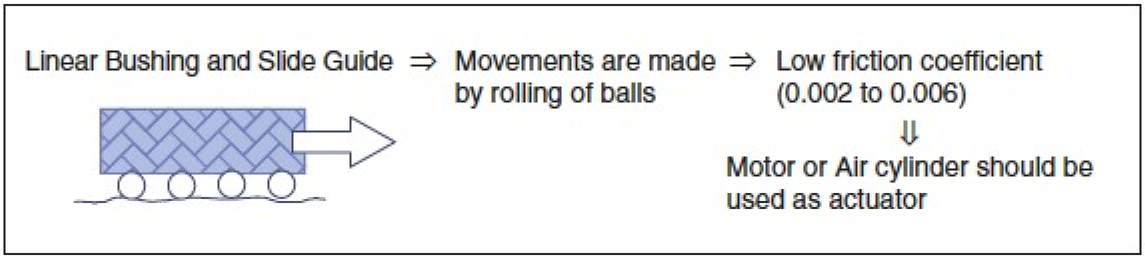
Linear Bushing, Oil free Bushing ⇒ Shaft supported at both ends ⇒ Light to medium load Slide Guide ⇒ Fixed rail on base⇒ Light to heavy load

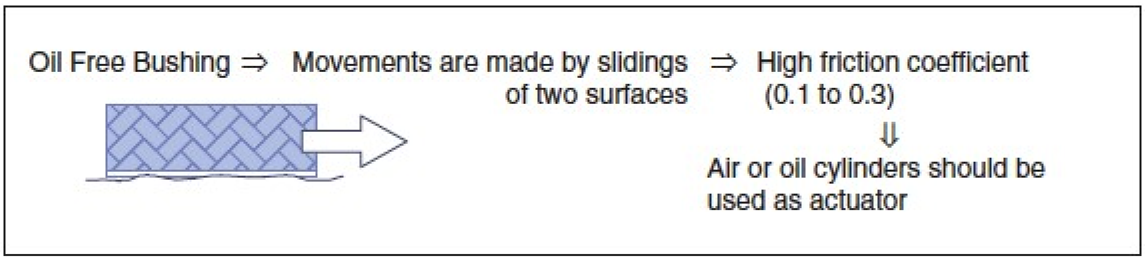
Another important factor to consider is the difference in performance related to the coefficient of friction. In Linear Bushing and Linear Oil Free Bushings utilize two surfaces sliding against each other, which result in higher friction.

Low friction ⇒ low frictional force ⇒ low turning torque⇒ Rotary motion can be turned into linear motion easily

High friction ⇒ high frictional force ⇒ high turning torque or thrust force is required ⇒ Linear Cylinder is recommended

**Note – The value of friction coefficient can influence the capacity of an actuator and heat generation during movement. Oil Free Bushings are inappropriate because of heat dissipated by continuous high-speed operation. In the case of using Air Cylinders, speed control of the start / stop is not possible. Mechanisms such as Shock Absorption Dampers need to be set to stop the speed softly. It can shorten the cycle time.*





The next factor to consider is that of guide accuracy when the performance depends on the clearance of bearing and rail/shaft. In some instances, shafts are used for the rail with a Linear Bushing. The fit between Shafts and bushing is clearance fit (when g6 tolerance Shaft is used we have normal clearance, when h5 tolerance Shaft is used we have smaller clearance fit). Another application might use a Linear Guide as the profile rail (or track rail) and bearing block (or slide unit). Fit ranges from 0-3μm for Clearance Fit types to -3-0 μm for Preload types. An Oil Free Bushing is used with a Shaft, where the clearance is larger than a Linear Bushing therefore guide precision is lower.

Note – Because of the raceway design, steel balls inside linear ball guides can have 2 or 4 contact points. This allows even distribution of complex load. Steel balls inside Linear Bushing have only one (or single) contact point with the Shaft, which results in centered load distribution. (See **Figure 1 and **Figure 2**)*

Figure 1 Contact and load distribution of Linear Bushing

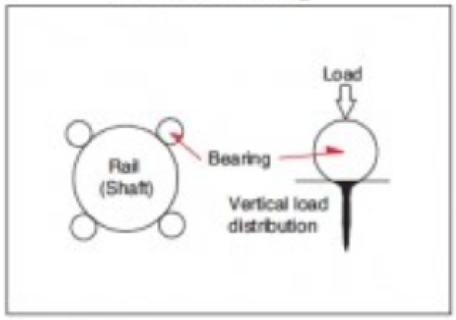
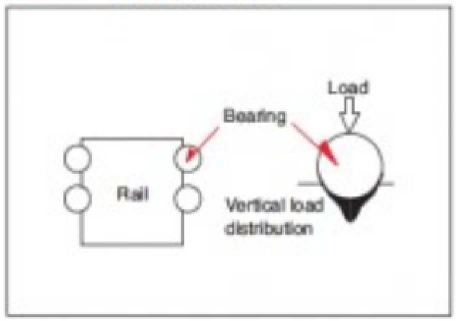


Figure 2 Contact and load distribution of Slide Guide



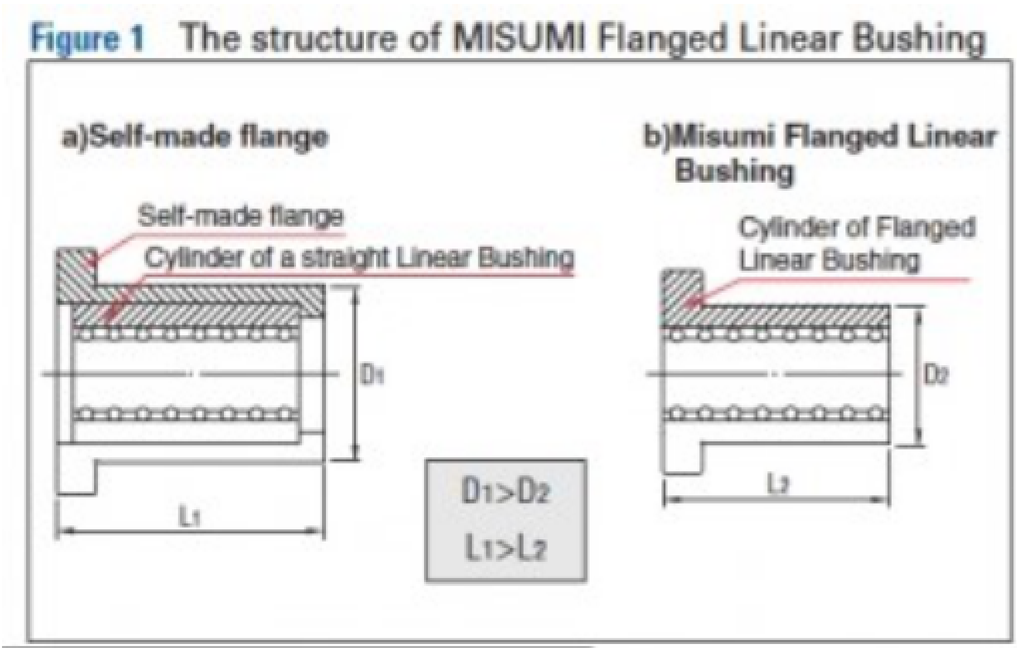
Linear motion ⇒ Point contact ⇒ Concentrated vertical load distribution ⇒ Not applicable for heavy load

Slide guide ⇒ Surface contact ⇒ Distributed vertical load distribution ⇒ Applicable for heavy load

Finally, consider environmental conditions and ease of maintenance. The performance difference depends on the materials used. Linear Bushings and Linear Slide Guides maintain long term reliability with the use of lubricating grease. Therefore, they are not applicable to be used in an environment that exceeds the environmental specs the grease. Oil Free Bushings provide higher performance because they do not require the use of lubricating grease.

KoP Item Resources

Straight (**Photo 1**) and flanged bushings (**Photo 2**) share a similar structural design. The main advantage of using flanged Linear Bushing lies in its compact design (**Figure 1**) as the integrated structure saves space. The outer cylinder flange allows direct mounting of the bushing and allows flanged bushings to maintain higher load capacity than standard Linear Bushings. A hardened, precision flanged outer cylinder (housing), made out of chrome steel or corrosion resistant steel, is advanced in its quality, and lower in cost compared to "self-made" flanged housing.



Choosing Between a Straight and Flanged Linear Bushing

The following factors should be considered when making Linear Bushing selections.

- Decide whether force will be applied to the Linear Bushing. Choose a flanged type if the Linear Bushing must bear force.
- Decide how much space is available on the surface to which the Linear Bushing is to be attached. (Refer to part 3)

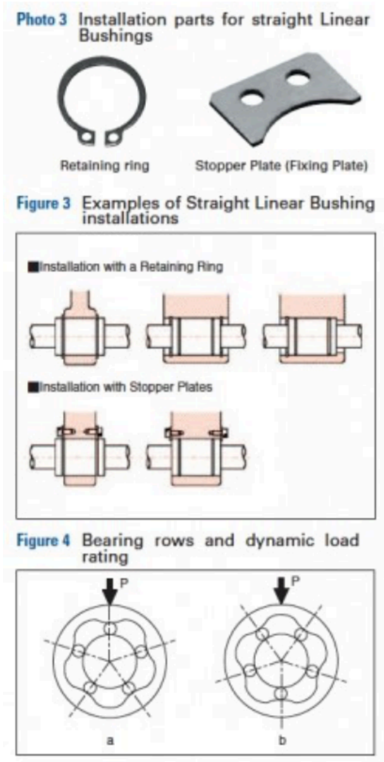
The Linear Bushing in the component a) receives inertia force from the moving component, therefore the Linear Bushing must be firmly screwed to the housing. As for component b), an Air Cylinder moves the Shaft in the Linear Bushing. The Retaining Ring fixing the Linear Bushing only receives the frictional force from the Shaft. Therefore, a compact design using a straight type is fine. The same can be said for c).

As shown in Figure 2, depending on the design, Linear Bushings can either move while Shafts are fixed, or be stationary (fixed) while Shafts are in motion.

- X-axis: If the Linear Bushing moves, use the Flanged type bushings.
- Y & Z-axis: For fixed Linear Bushing, use Straight type with Retaining Ring or Stopper Plate.

How to Install Linear Bushings

To fix a Straight Linear Bushing, using Retaining Ring or Stopper Plate (Fixing Plate as shown in photo 3) see
Figure 3.



Notes on installation angle: Load rating of Linear Bushing varies according to the load position on the circumference. Linear Bushing, usually has 4-6 rows/ball tracks that are set on even angle. When installing, if possible, avoid positioning Linear Bushing so that the ball track is under direct load (Figure 4), otherwise that row will directly bear the load (Figure 4a).

For example, Figure 4 shows a Linear Bushing with 5 rows. The variance of dynamic load rating is as follows:

right figure ÷ left figure.

Therefore, angle load should be installed as in the right picture.

Static Load Rating

Right figure a ÷ left figure b=1.46

Dynamic Load Rating

Right figure a ÷ left figure b=1.19

For further examples of linear bushings, check out these application examples from our application Library called inCAD library.

KoP Item Resources

- No.000086 Two-Step Shutter
- No.000208 Table Lifter

If you have any further questions, please contact our engineering support team at engineering@misumiusa.com.

Triangle Bearings

How to Assemble Your Bearing

The following is available in your Kit of Parts:

2	**BD1508P**		½" Bore Size
2	**FM1508P**		½" Bore Size

Breakdown:

2	**Flange Mounting (4050)**		Length: 2.313" Width: 1.125" Bolt to Bolt: 1.75" Bolt Hole Diameter: .281"
2	**Pillow Block Top Mounting (3688)**		Length: 2.313" Height: 1.12" Bolt to Bolt: 1.75" Bolt Hole Diameter: 0.375"
2	**Pillow Block Bottom Mounting (3687)**		Length: 2.313" Width: 0.438" Bolt Hole Diameter: 0.375"
4	**Sintered Iron Bearing Ball (1508P)**		Bore Size: ½" Outside Diameter: 1.0" Width: 0.5"

How to assemble Triangle's Miniature Two Bolt Flange

Equipment Needed:

- Triangle part #4050 Two Bolt Flange Mounting
- Triangle Part #1508P Sintered Iron Bearing - 1/2" Bore
- Two - 1/4 - 2- bolts
- Small or adjustable wrench
- A plug gauge or something similar that is smaller than the bearing's bore
- 1/2" shaft
- gloves

Step 1:

Put on your gloves and grab the two bolt flange mount, bearing and plug gauge.

Step 2:

Place the Bearing sideways into the mount so it isn't completely flat.

Step 3:

Put the plug gauge (or other tool you are using) into the bore of the bearing

Step 4:

Place your right hand on the bottom of the mount and put your left hand on the top of the mount.

Step 5:

While keeping your hands in this position, push opposite sides until the bearing is fully in the mount and aligned.

Step 6:

When the two bolt flange is fully assembled into the mount, place it on the mounting area of your product. Make sure your mounting holes are 1.75" apart.

Step 7:

Fasten your two bolts into each mounting hole and tighten them with your wrench. Tighten with your wrench until the flange is completely secured onto your product.

Step 8:

Place a 1/2" shaft into the bore of the bearing. Ensure the shaft can move axially.

How to Assemble Triangle's Miniature Pillow Block Bearing

Equipment needed:

- Triangle part #3668 Top Pillow Block Mount
- Triangle Part #3687 Bottom Pillow Block Mount
- Triangle Part #1508P Sintered Iron Bearing – ½" Bore
- Two - 1/4 - 2- bolts
- Small or adjustable wrench
- 1/2" shaft

Step 1:

Take the iron bearing and put it into the top of the top pillow block mounting.

Step 2:

While still holding together the top pillow block mount and bearing, grab the bottom of the pillow block mount and place it at the bottom of the other two parts and snap them together to complete the assembled pillow block bearing.

Step 3:

Place the assembled pillow block bearing onto the mounting area of your product. Make sure that your mounting holes are 1.75" apart.

Step 4:

Fasten your bolts into each mounting hole and tighten them with your wrench.

Step 5:

After the pillow block is fastened onto your product, make sure the product is securely on and tighten more if needed.

Step 6:

Place the ½" shaft into the bore of the bearing. Make sure it rotates axially.

For more information or questions please contact us!

Phone: 920-235-3710

Email: info@triangleoshkosh.com

website: www.triangleoshkosh.com

Motors

Bosch Seat Motor

Specification Sheet

PDF 2016-12-21_spec_sheet_-_Bosch_FRC_motor_6_004_.pdf

CAD File

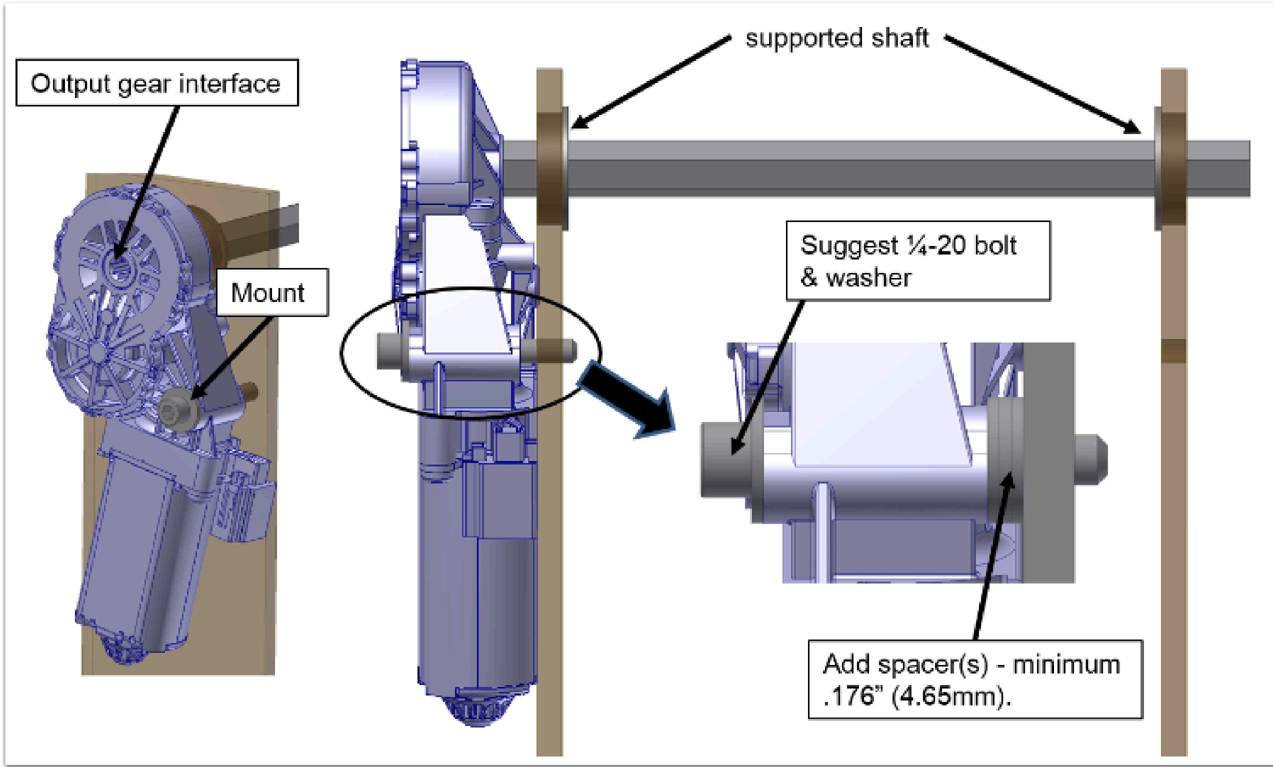
ZIP FRC_Bosch_motor_V2_6_004_RA3_194-06.zip

Motor Mounting & Shaft Support: Suggested

Motor relies on two solid mounting points:

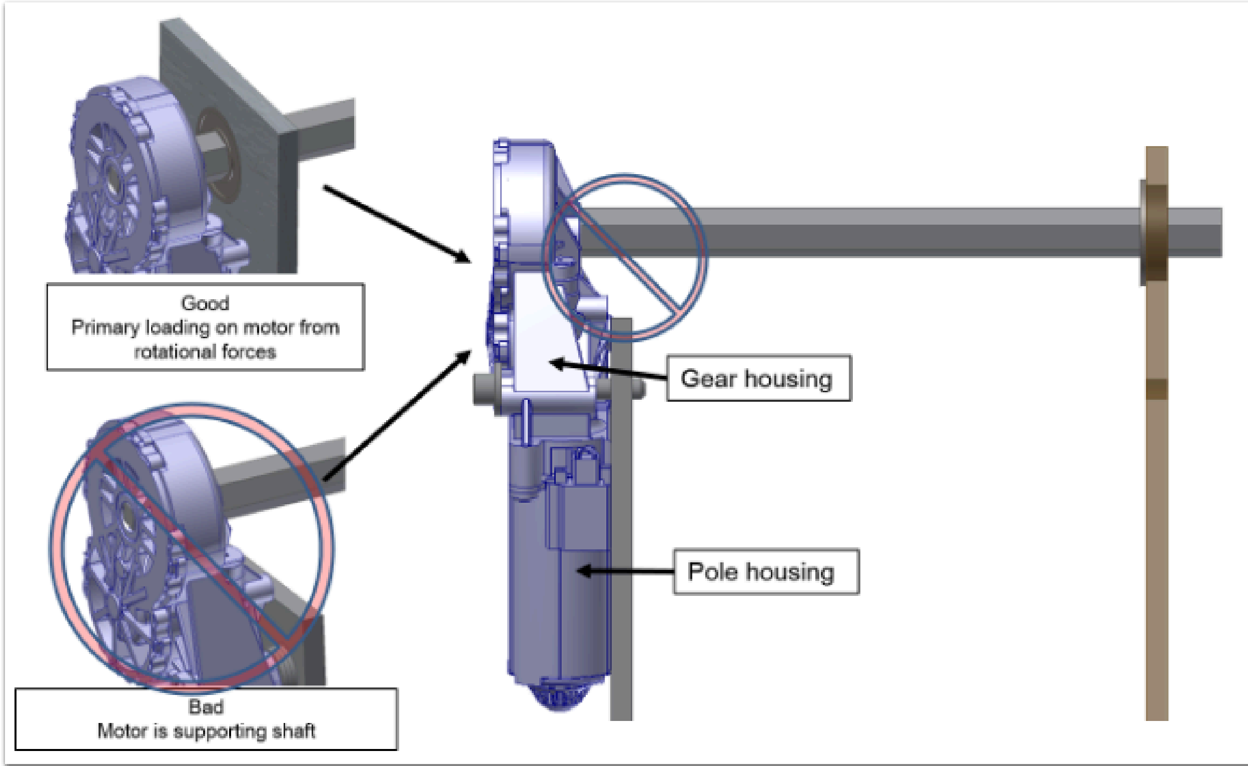
1. output gear interface and
2. oval mounting hole.

Make sure shaft is fully supported and does not rely on motor as support. A ¼" bolt fits very well in the mount slot but make sure you use a washer to help distribute the bolt clamping load.



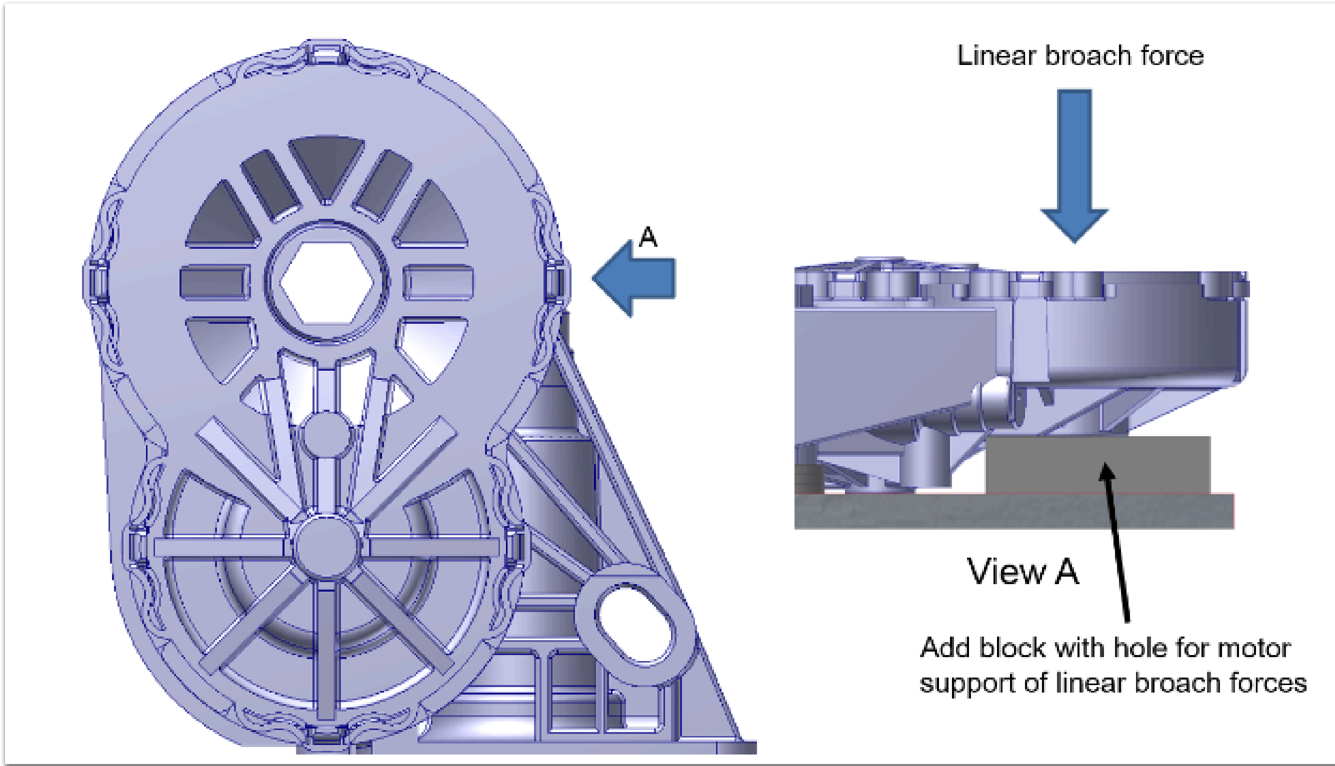
Motor Mounting & Shaft Support: Things to Avoid

Avoid mounting in any other way such as clamping or bracing the pole housing/gear housing, etc. Also, minimize multidirectional loading on the motor by fully supporting the shaft so external loads on the motor are primarily in the rotational direction.



Subtractive Manufacturing Option: Hex Broach

Use a linear broach to cut out a 3/8” hex. Make sure gear is supported during this operation. Do not remove gear. Cover is not meant to be removed and will most likely damage the cover latches which affects motor function and durability.

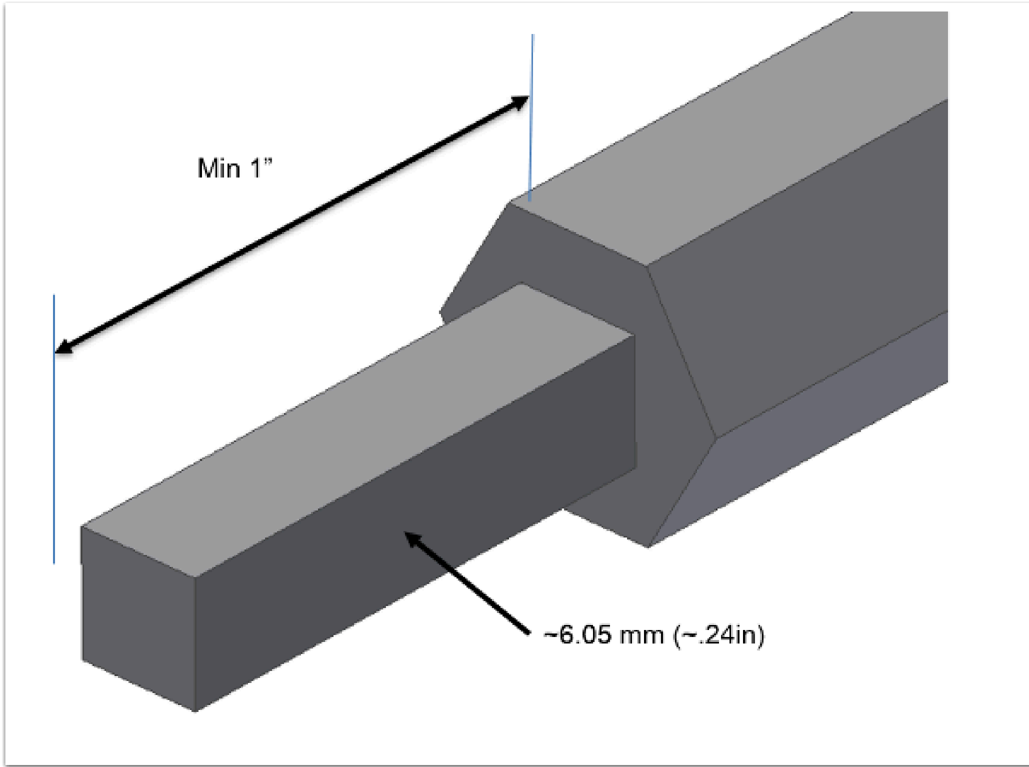


Subtractive Manufacturing Option: Mill Hex Shaft

Mill square profile from ½" or 3/8" hex shaft stock. Suggest a slight interference fit so there is a solid connection and no gap. Also best to keep at least 1" in length for max interface with plastic motor output gear.

Note: This solution has been known to fail using an aluminum shaft; suggest either for very low torque applications or utilize a steel shaft.

A similar design will be available for purchased from AndyMark (am-3723).

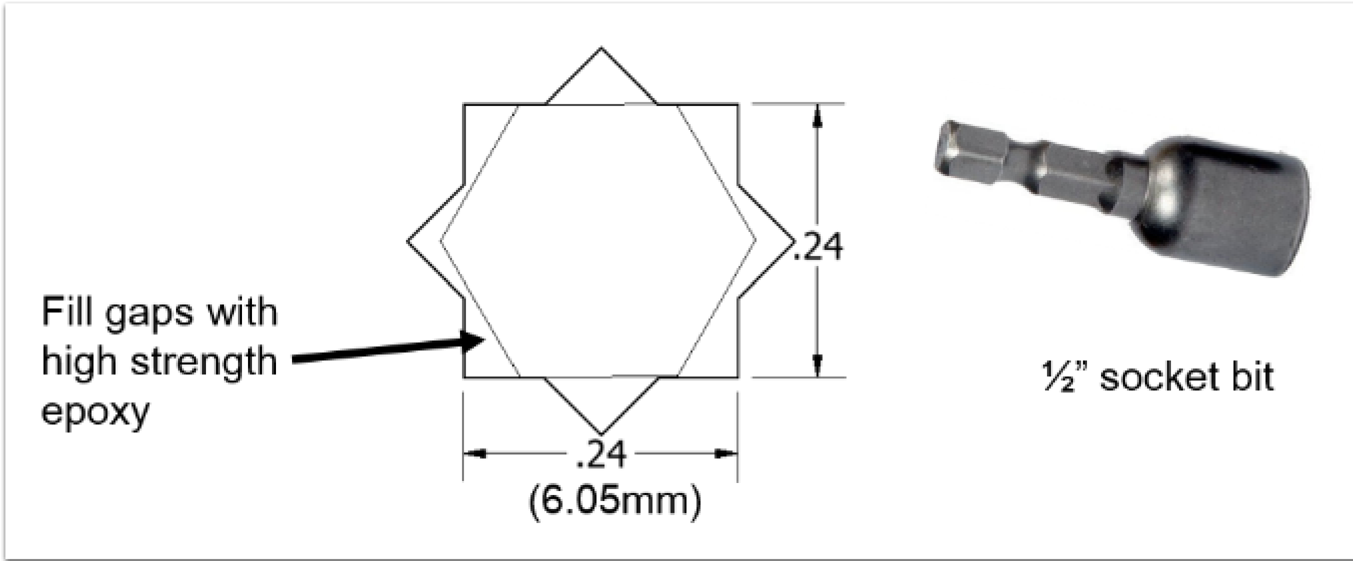


Off-the-Shelf Options for Output Interface

Get Creative. The star output is basically two squares rotated 45°. Here's a few suggested starting options that you can find at most home improvement stores. Keep in mind these are only suggestions and have not been confirmed yet for durability.

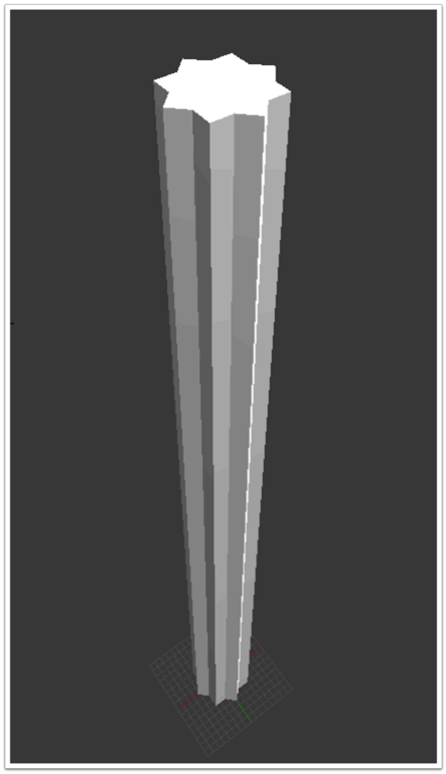
¼" standard square fittings in a toolbox are a tad too big, but with some grinding could be made to fit. With a bit of searching you may be able to find a part with a closer fit.

Utilize a ½" socket bit. It interfaces nicely with ½" hex stock or a 5/16" bolt head/nut. The hex portion will fit snugly in the star interface but will not support the required max torque. Adding JB weld or other strong epoxy in this gap is an option. This has not been validated so be sure to leave time to test for durability.



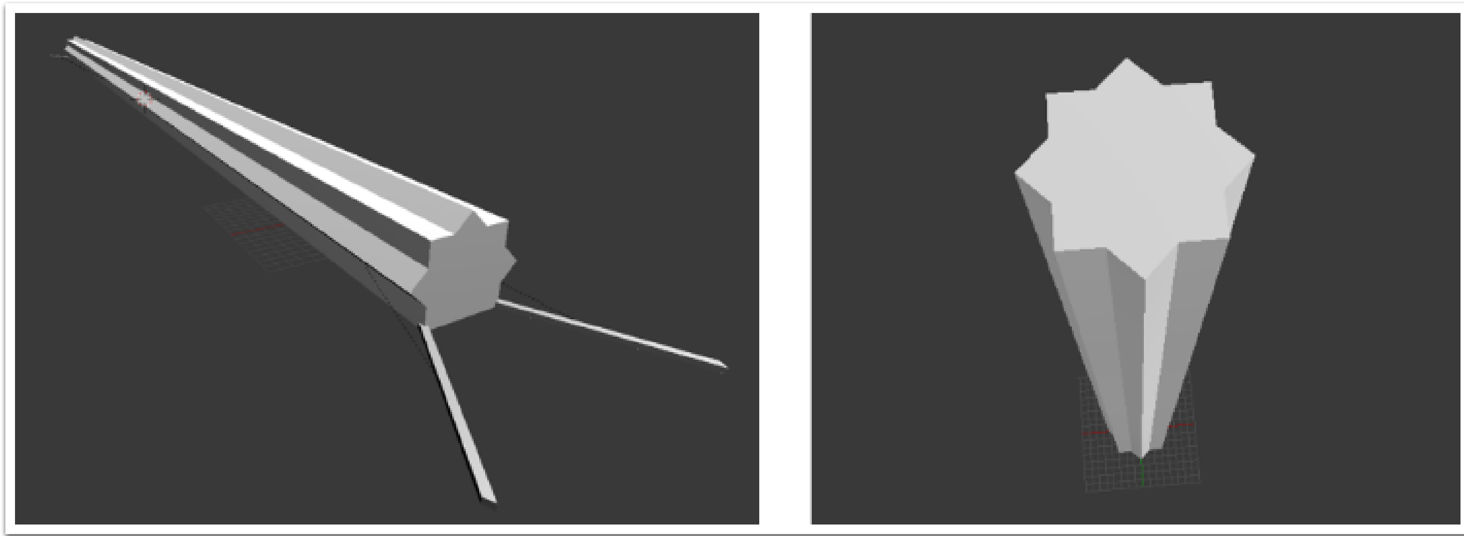
Output Options: 3D Printable Options

- Teams with access to a 3D printer may also consider printing a custom interface to meet their specific needs.
- Depending on the choice of material, however, this interface may not be as strong as some of the previous options.
- For fused-filament printers, additional care is required to ensure that the final product remains strong without sacrificing dimensional accuracy.
- This shaft can be recreated by drawing two overlapping 6mm squares, and extruding the result.

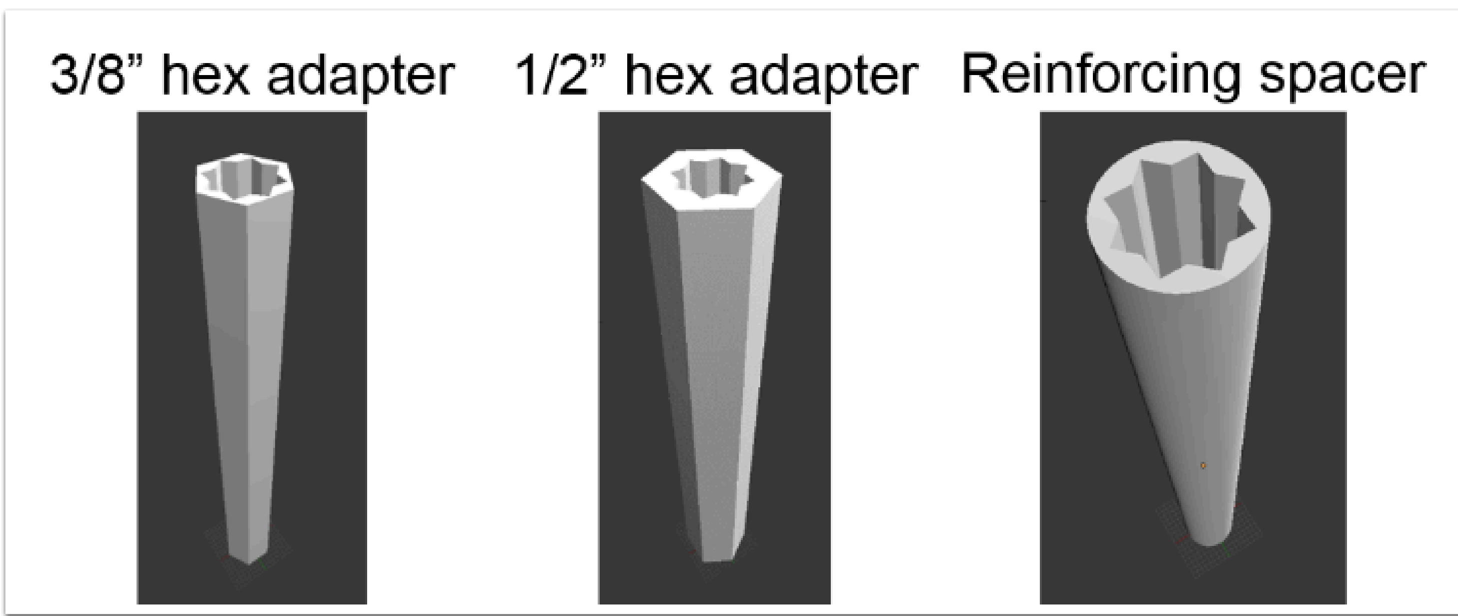


- For printing horizontally, consider removing one of the star teeth; this will allow the spline to lay flat.
- Also consider adding “whiskers” or “mouse ears” where appropriate; these features improve adhesion to the print bed, which helps to minimize warping.
- For printing vertically, remember to use thicker-than-usual print layers; this helps to improve adhesion between layers of the print.
- We recommend printing the spline longer than necessary; any excess length is easy to cut off later.

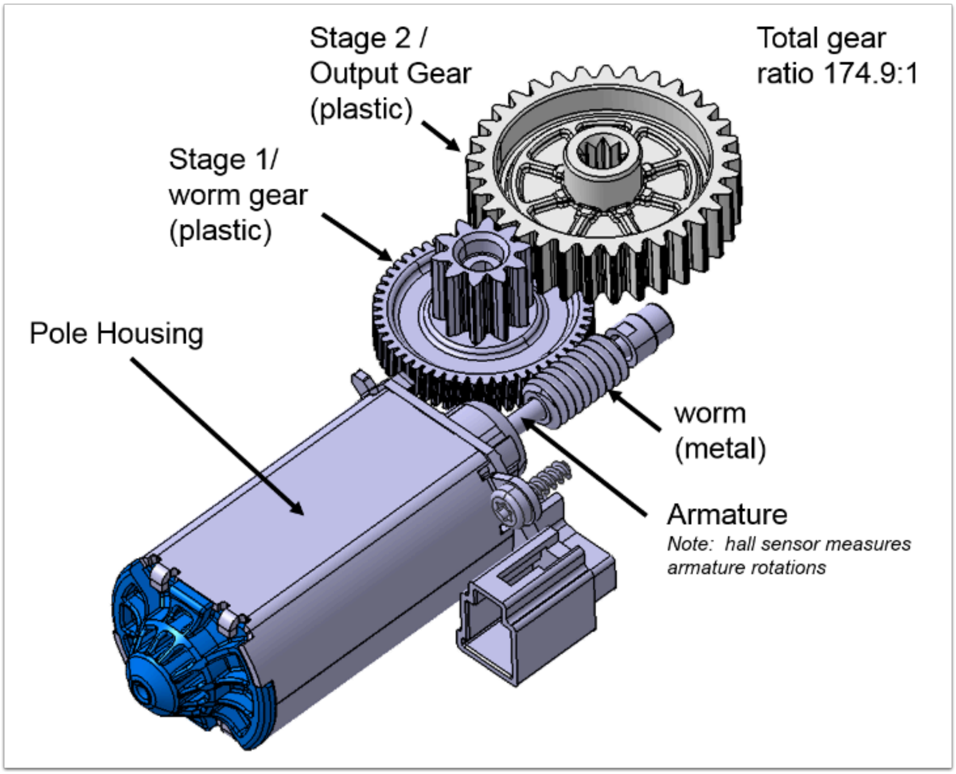
KoP Item Resources



- Once you have a functional spline shaft, it's easy to convert that 8-pointed spline into a standard FRC drive shaft.
- These adapters may be recreated by scaling up the original spline profile from 6mm squares to 6.05mm (fused-filament printers may require additional clearance).



Detail: Gear Housing & Gear Cover Removed



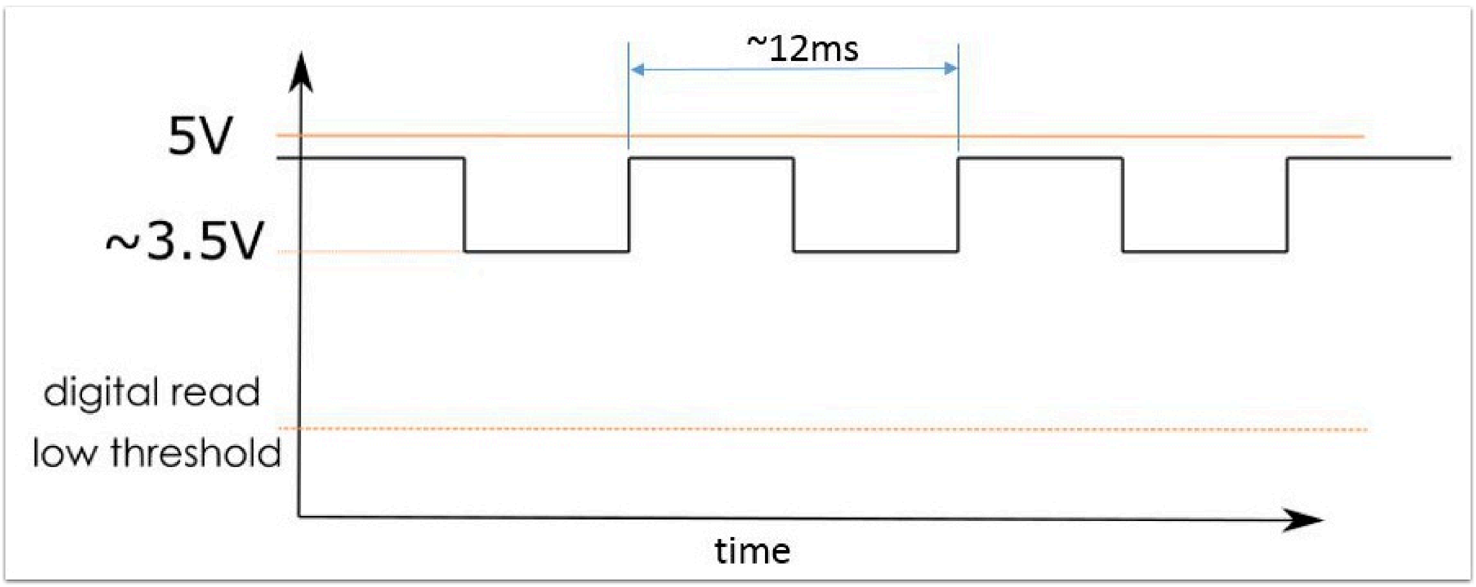
Design Consideration Summary

- Make sure there is a tight fit between motor output gear and the interface to what is being driven. Slight interference is preferred.
- Motor has a built in thermal switch if it is overloaded for an extended time. This will reset automatically once internal temperature returns to acceptable limits.
- Avoid multi directional forces on output gear (ie side loading from unsupported shaft). Gears are very robust if forces are primarily in rotational direction.
- Expect there will be a few degrees or more of inaccuracy in sensing angular position due to free play with motor internal gears, plastic creep, and tolerances in the mechanism you are driving.
- Since this is a slow moving motor it is an option is to use bushings instead of bearings for shaft support of the mechanism that is being driven.

Hall Circuit Interface

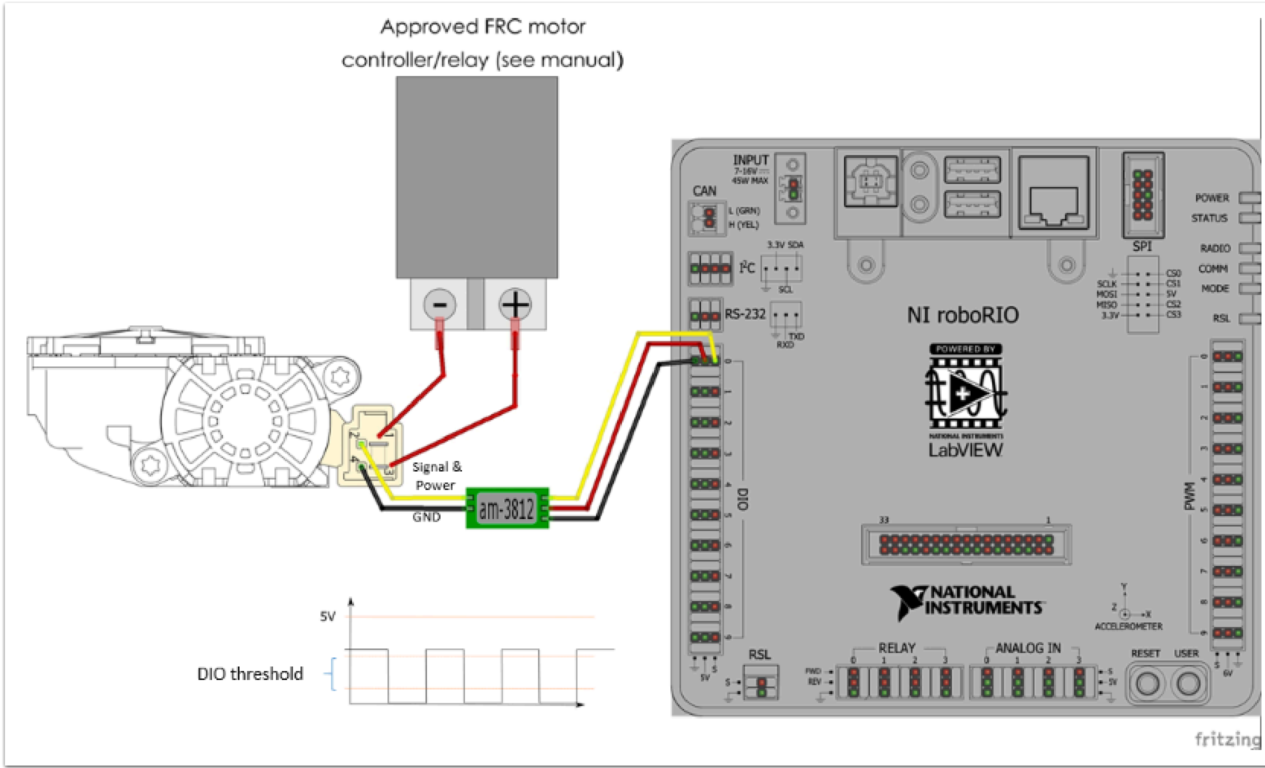
The basic circuit interface with RoboRio is shown below.

The hall circuit in the motor causes a voltage drop for each armature rotation. The square wave output and voltage drop is dependent on the voltage input to the circuit. As wired per the figure above, a typical output is show below. Due to the voltage not dropping low enough, the signal cannot be read by the DIO on the RoboRio. Motor input 12V free speed gives ~12ms pulse.

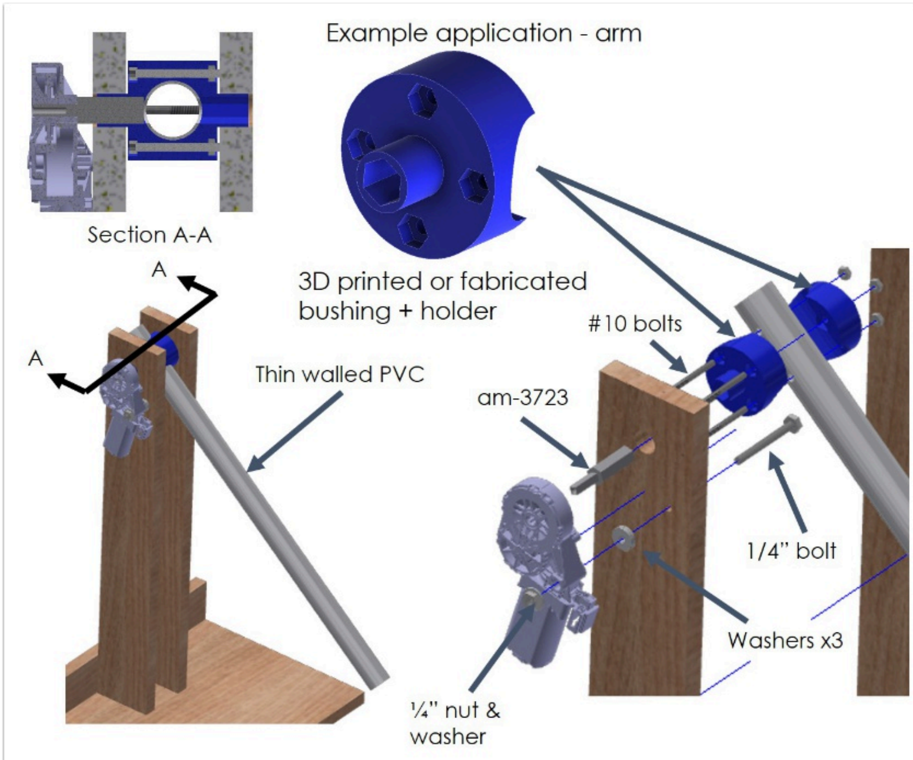


In order to get the step to drop below the digital read threshold, a simple circuit is used (image below includes an adapter for reading DIO) . A kit can be purchased from AndyMark that performs this function (am-3812).

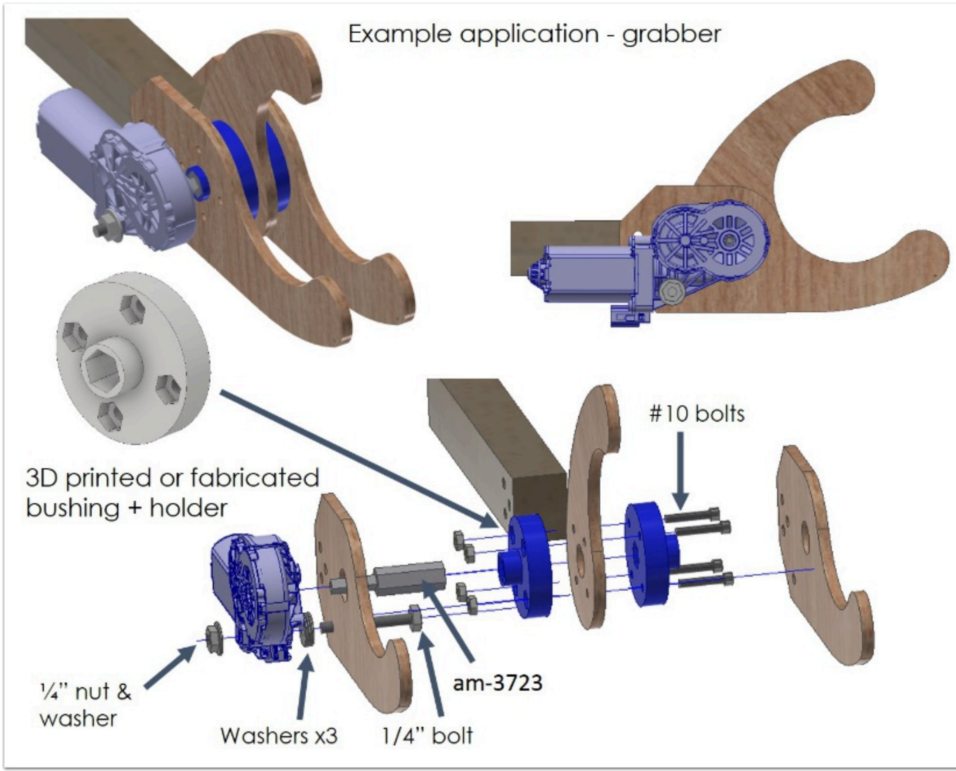
KoP Item Resources



Sample Applications



KoP Item Resources



Nidec Dynamo BLDC Motor with Controller

The Nidec Dynamo BLDC Motor with Controller is a 12V DC brushless motor/controller combo. This article discusses how to connect it to, and control it with, the FRC Control System and links to some additional resources on the Dynamo and brushless technology.

What is a Brushless Motor?

Never heard of brushless motors? No problem! Since its inception, *FIRST* Robotics Competition has allowed only brushed motors. However, brushless motors are widely used in many industries! For more information about the difference between the two, check out this link

Nidec Dynamo BLDC Motor Datasheet

Want more specifics on the currents, torques, and other important details about the Nidec Dynamo BLDC Motor? The Specification Sheet should have what you are looking for.

Want more detail on the pinout of the connectors, connector part numbers, or other info about the controller? Try the Controller Datasheet.

Both documents can be found on the Downloads tab of the Andymark page for the motor: https://www.andymark.com/Dynamo-p/am-3740.htm

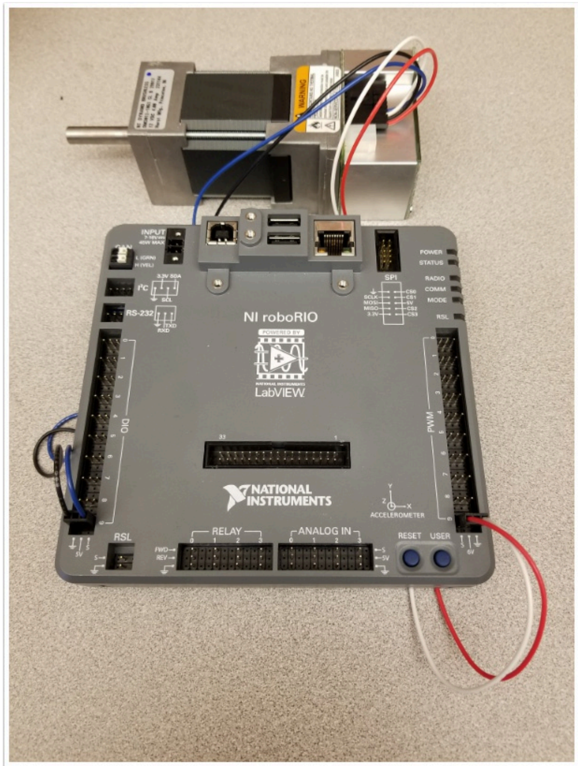
Wiring the Dynamo BLDC Motor

Power Wiring

The Dynamo BLDC Motor comes with a 2 pin harness with red and black wires for powering the device. Plug the connector into the receptacle on the back of the device (it's keyed, so it will only go one way). Connect the other end directly to one of the <30A breaker slots on the PDP, or use quick disconnects or other connectors to extend the wires to reach the PDP location on your robot.

> While the provided small gauge wires are exempt from the wire gauge rules as "Wires that are recommended by the device manufacturer", any extensions you connect may not be.
>
> The wires are sized appropriately for the current the device draws, however you may wish to acquire and use a smaller breaker (in the 6-10A range) in the PDP slot for this device to provide additional protection for the device and wiring.

Signal Wiring



The Dynamo BLDC Motor Controller requires two signal connections to the roboRIO:

- The connector with the blue wire should connect to a DIO connector on the roboRIO, with the blue wire corresponding to the (S)ignal pin (towards the inside of the roboRIO).
- The connector with the red wire should connect to a PWM connector on the roboRIO with the red wire corresponding to the (S)ignal pin (towards the inside of the roboRIO).

The connector that plugs into the Dynamo BLDC Motor Controller is keyed, so no need to worry about plugging it in backwards.

If you need to extend the signal connections of the Dynamo controller, regular PWM extension cables can be used (take care to note which color of the PWM cable connects to which color of the Dynamo cable).

Programming the Dynamo BLDC Motor with Controller

The library software in each of the three languages has dedicated code for the Dynamo BLDC Motor with Controller that will handle the coordination between the PWM connection (used for Enable) and the DIO connection (used to send a non-servo PWM to control speed and direction). In C++ and Java you will find this in the "NidecBrushless" class. In LabVIEW select "Nidec Brushless" from the dropdown of the MotorControlOpen VI (found in the Actuators->Motors palette).

Application Note: Disconnected DIO Behavior

⚠ With the layout of the existing wiring harness, disconnecting the DIO signal will cause the device to run in full reverse whenever the robot is enabled. **Note that disabling the robot will still properly disable the device.**

For users that would like to mitigate this issue, two possibilities are provided below (the mitigation in the Application Note: Motor Whine section is a partial mitigation to this issue)

Modifying the Wiring Harness

To mitigate the issue of partially uncontrolled operation if the DIO connector were to become disconnected, a minor modification to the wiring harness can be made. By swapping the black and white wires (so the connectors are red/black and blue/white) a disconnection of the DIO connector will instead disable the device. This swap can be made with a small flathead screwdriver or other sharp object as detailed below.

To remove the wire from the connector:

1. Grasp the wire to remove firmly between your fingers and apply gentle pressure, pulling it away from the connector.
2. Using a small flat screwdriver or other sharp object, gently depress the latch through the window in the connector until the pin slides free.

Repeat these actions for the white wire from the other connector.

To insert the pin into the connector:

1. Ensure that the wires are not tangled.
2. Locate the latch on the pin and face it towards the window on the connector
3. Slide the pin fully into the connector until the latch engages.
4. Gently attempt to pull the wire back out to ensure it has seated properly.

If the wire does not remain in the connector in step 4:

1. Try inserting the wire again, making sure that it is seated fully into the connector
2. If that does not work, try using a small pair of pliers or jeweler's screwdriver to gently pry the latch slightly further away from the pin body, then re-insert

Application Note: Motor Whine

The default behavior of the library code when commanded with a neutral (0) signal is to leave the device enabled and send a neutral signal. This causes the device to emit a high pitched whine (and also leaves it susceptible to the "Disconnected DIO issue described above). The code is written in this way because disabling the device has two side-effects:

- The device will coast when it is disabled as opposed to being actively driven to 0 speed
- The tachometer output, if wired (see note below), will be deactivated. If the device is moving due to momentum or external forces, these tach pulses will be missed.

If you wish to disable the device when commanded neutral, a description of how to do so in LabVIEW and C++\Java is provided below.

C++\Java

In C++ and Java, explicitly calling the stopMotor() method will physically disable the device by turning off the roboRIO PWM signal. The next time set() is called, the device will be re-enabled. Note that this is different than the behavior of the disable() method which requires an explicit enable() call before the device will be re-enabled.

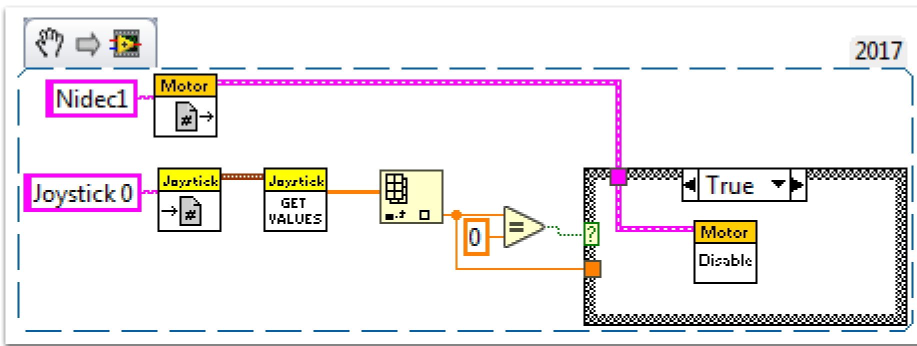
To integrate this into your code, wherever you would call set(), you can replace it with a call similar to the following:

```
double value;
NidecBrushless motor = new NidecBrushless(0,0);



if(value == 0) {
  motor.disable();
} else {
  motor.set(value);
}
```

If you want to instead disable when the value is close to zero (a deadband), simply change the comparison from value == 0 to Math.abs(value) < ### where ### is your desired deadband size (a number between 0 and 1)

LabVIEW

In LabVIEW, the Motor Disable VI can be used to disable the device. The next time the Set Output VI is called, the device will be automatically re-enabled. The snippet below shows an example of how you might use this to disable the device when the commanded speed is 0. To instead use a deadband, replace the = VI with an Absolute Value and Less Than VI. The False case of the case structure contains a Motor Set Output VI that uses the passed in orange wire to set the motor speed.



Application Note: Tachometer output

The Nidec BLDC Motor with Controller contains a built-in tachometer that is not wired in the provided wiring harness. This is a 5V level signal suitable for plugging directly into the roboRIO and using with the Counter classes/VIs. You may either use code to assume direction or use the direction pin provided from the device. More information about the pinouts of the signal connector and connector parts that could be used to populate the tachometer and direction pins can be found in the Controller Datasheet located on the Downloads tab of the Andymark page for the motor: https://www.andymark.com/Dynamo-p/am-3740.htm

Johnson Electric PLG Motor

Basic Overview

Figure 1: PLG motor + 1/2" Hex Adapter

This PLG motor (Power Lift Gate) is used in automotive applications to open and close the lift gate in SUV's etc. In most applications the motor drives a lead screw that provides translational motion. An adapter to convert the motor output to a ½" Hex, standard to FRC teams, is provided. This can also be fabricated but requires precision. Additional parts will be offered for sale through AndyMark.

Quick reference information:

- Weight (including adapter): 250g (.55 lbs)

KoP Item Resources

- Nominal free speed ~450RPM, Nominal Stall torque ~4.5Nm
- Gear reduction = 2 stage planetary. Total reduction is 22.2:1.
- Max current 26Amps
- Dual Hall output available for speed and directional feedback. See provided drawing.
- There are 44.4 hall pulses per one rotation of the output.
- CAD step model can be downloaded here
- Motor Drawing can be downloaded here
- Drawing of hex interface adapter can be downloaded here
- CAD files for 3D printed mount can be downloaded here

Utilizing the hall sensors is optional if teams need motor feedback. It is not required for motor operation.

Performance

Motor performance can vary from motor to motor. The limit line represents the range the motor could vary across the population. It is always best to plan for worst case performance when sizing the motor.

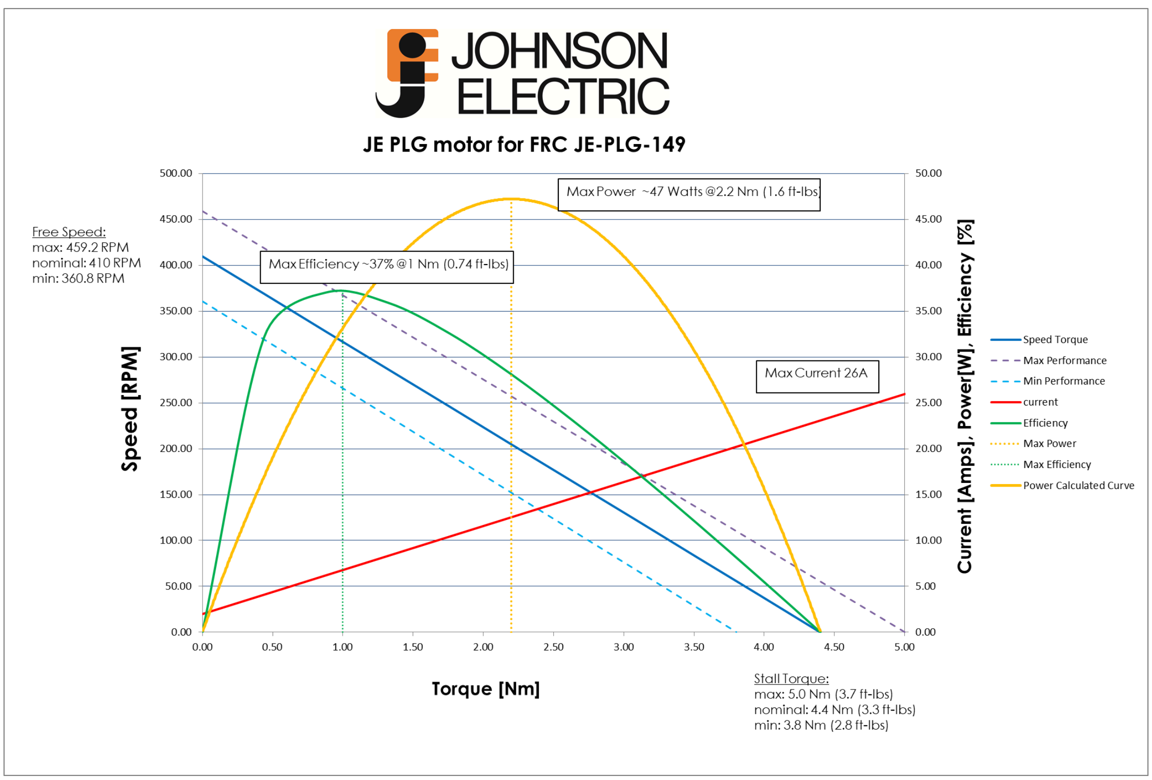
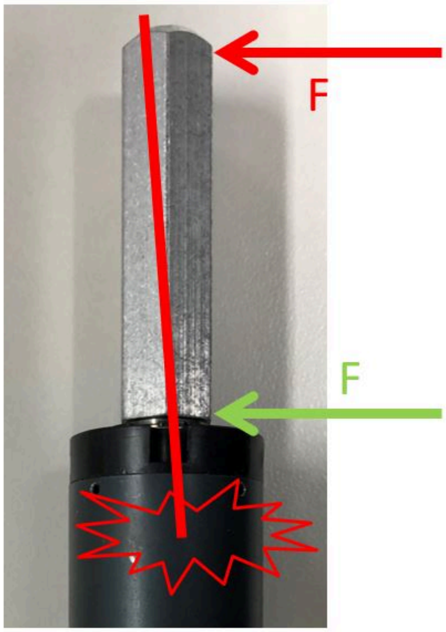


Figure 2: JE-PLG-149 performance curve



Planetary gearboxes can be easily damaged with side loads far from input

Suggest to add support

Electrical connection

An FRC approved motor controller is required to interface with this motor. Refer to the latest version of the rules for restrictions and requirements. Only the black and red wires are needed for motor operation. The 4 hall wires (Brown, Yellow, Green and Blue) are optional if teams would like motor feedback and are not required for motor operation.

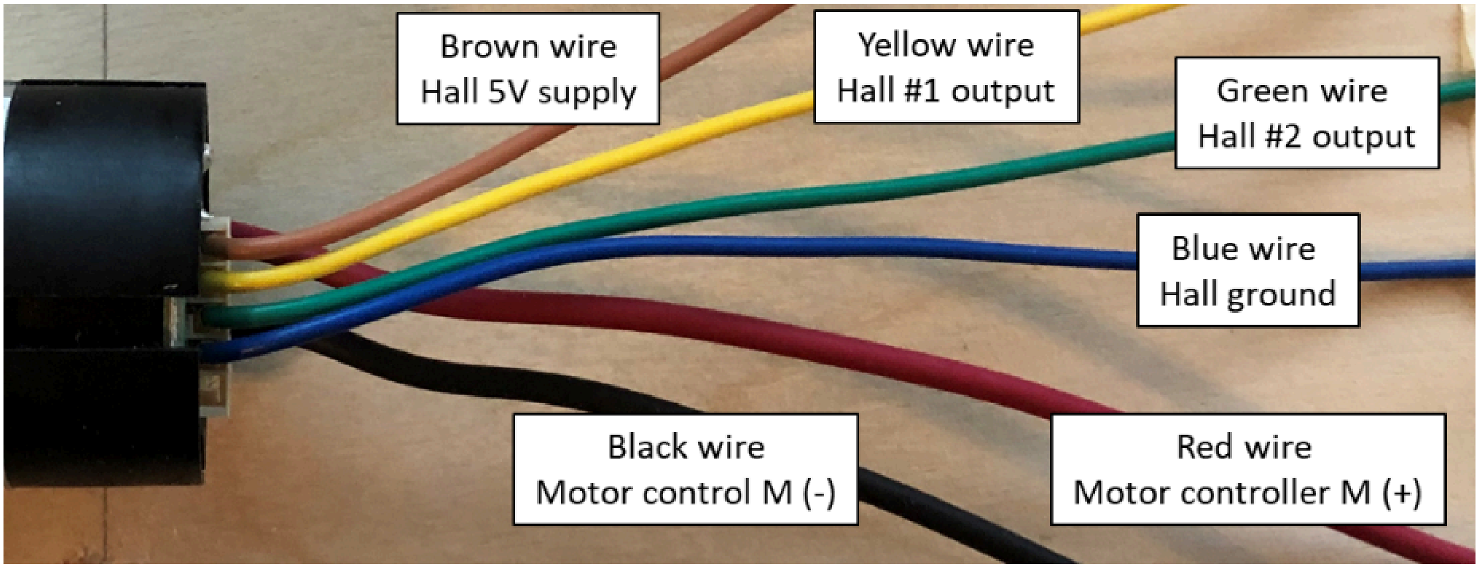


Figure 3: Wire labeling quick reference. The 4 hall wires are not required for motor operation.

The following figure represents a minimum hookup configuration for motor operation. If directional control is not required it is an option to use an FRC approved relay module instead of a motor controller. It is best to connect M+ and M- as shown in order to assure expected motor direction based on drawing.

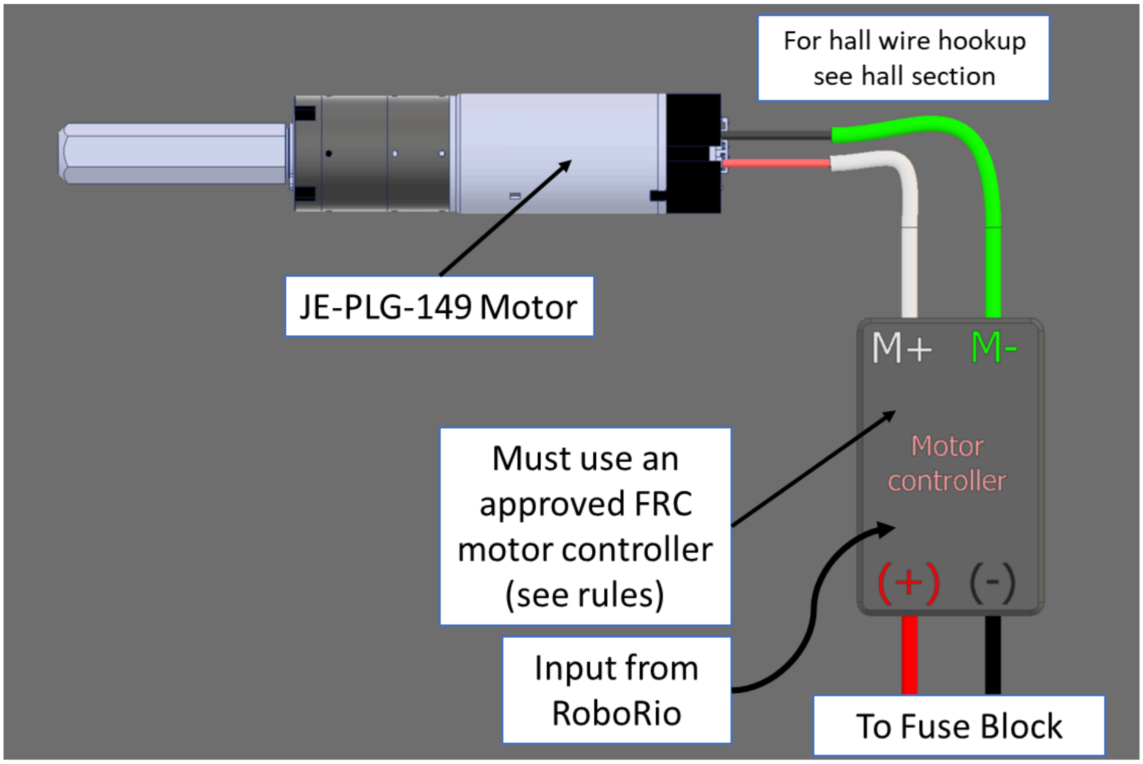


Figure 4: Electrical hookup - See FRC manual

Hall interface

Two hall sensors are available to provide feedback on direction of rotation. If the signal for the hall sensor 1 rises before hall sensor 2 then direction is Clockwise.

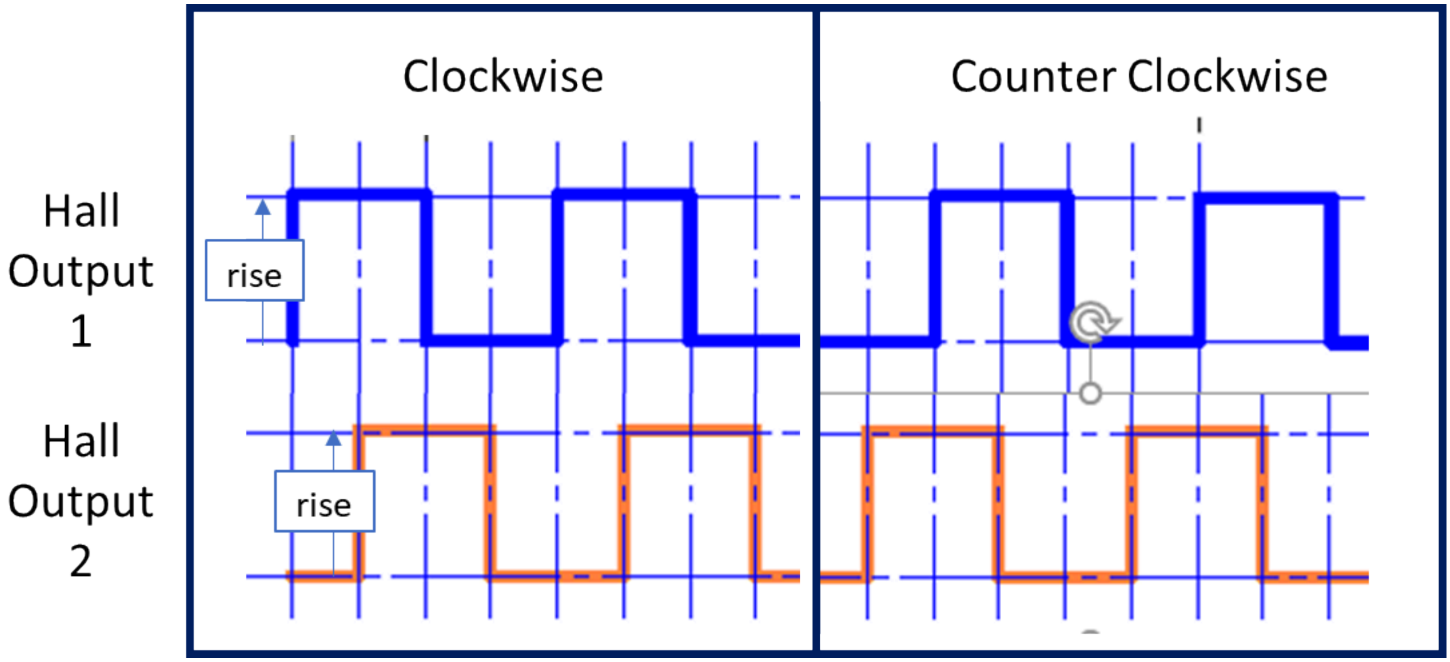
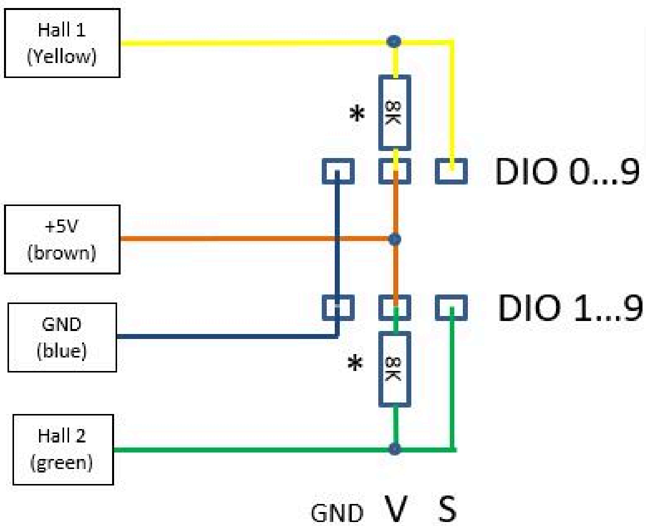


Figure 5: Reading motor direction from hall output

Speed and location can be obtained from output from either hall sensor. There will be 44.4 pulses per 1 revolution of the output. A pullup resistor of 1Kohm is required at each hall output (See drawing)

KoP Item Resources



* <u>Note</u>: Due to integrated pullup resistance in RoboRio an 8K resistor in parallel (as shown) is recommended. If not connecting to the RoboRio a 1K pullup should be used.

Motor Mounting Option 1

(Minimum Machining – ie handtools)

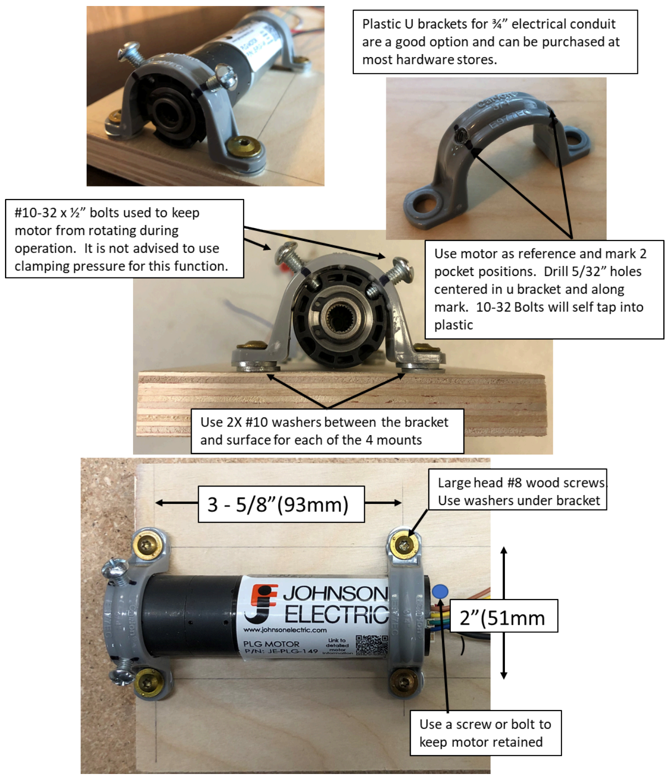


Figure 6: Motor mounting with minimal machining

Motor Mounting Option 2

(Medium Manufacturing – ie drill press)

The detail described in this section is best fabricated with wood, UHMW, or similar plastic material and represents a recommended minimum size. It is suggested to use a drill press to assure hole precision and to drill the large motor pockets with a 1-1/8” (28mm) Forstner bit. This bit is available at most hardware stores but is typically not found in Forstner bit kits. It is a worthwhile purchase as it is also useful for drilling bearing holes in softer materials.

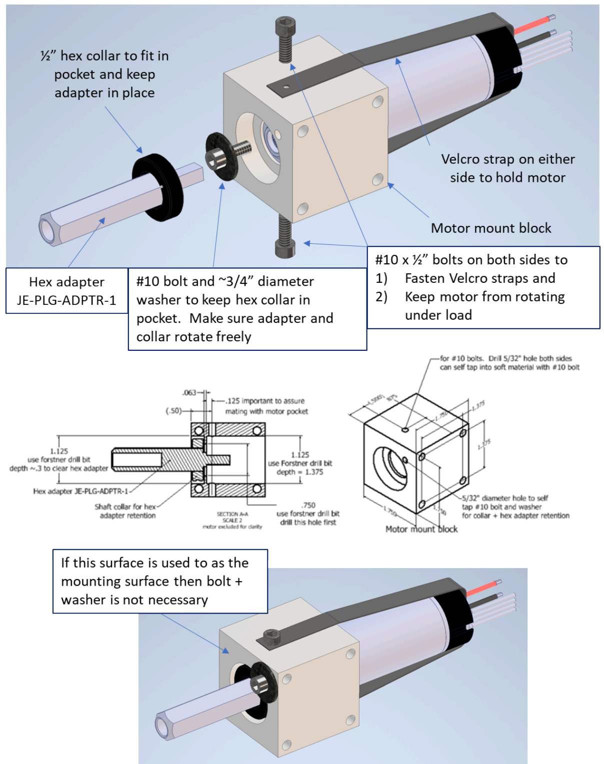


Figure 7: Motor mounting option #2

Figure 8: Forstner bit - 1-1/8" (28mm) is usually not a standard size

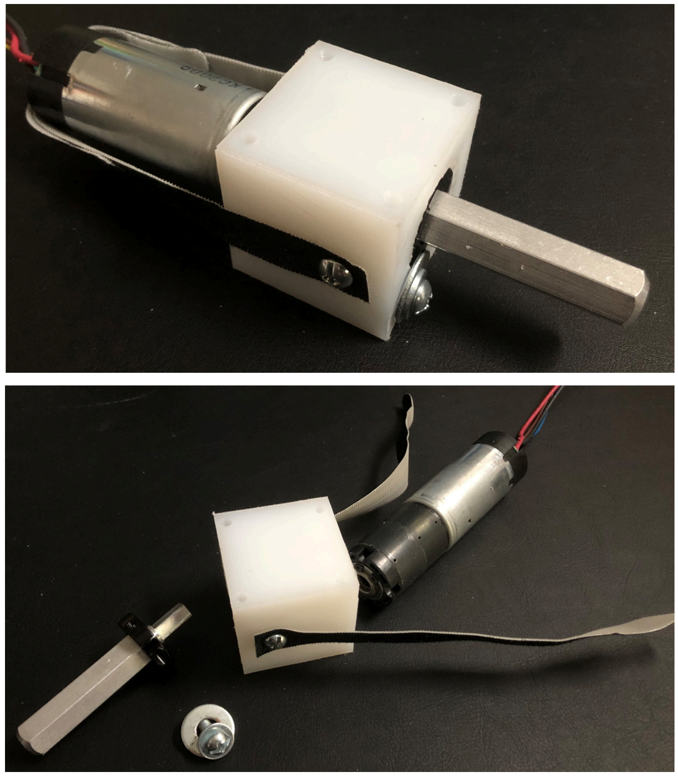


Figure 9: Fabricated part using UHMW, hook and loop straps, etc

Motor Mounting option 3

(3D printed)

A design optimized for 3D printing with the FDM process can be downloaded for those that have this capability. There are also many online resources for getting 3D printed parts made. PLA material can be used or other higher strength material if preferred. The figure below shows best orientation during printing to optimize strength and avoid supports.

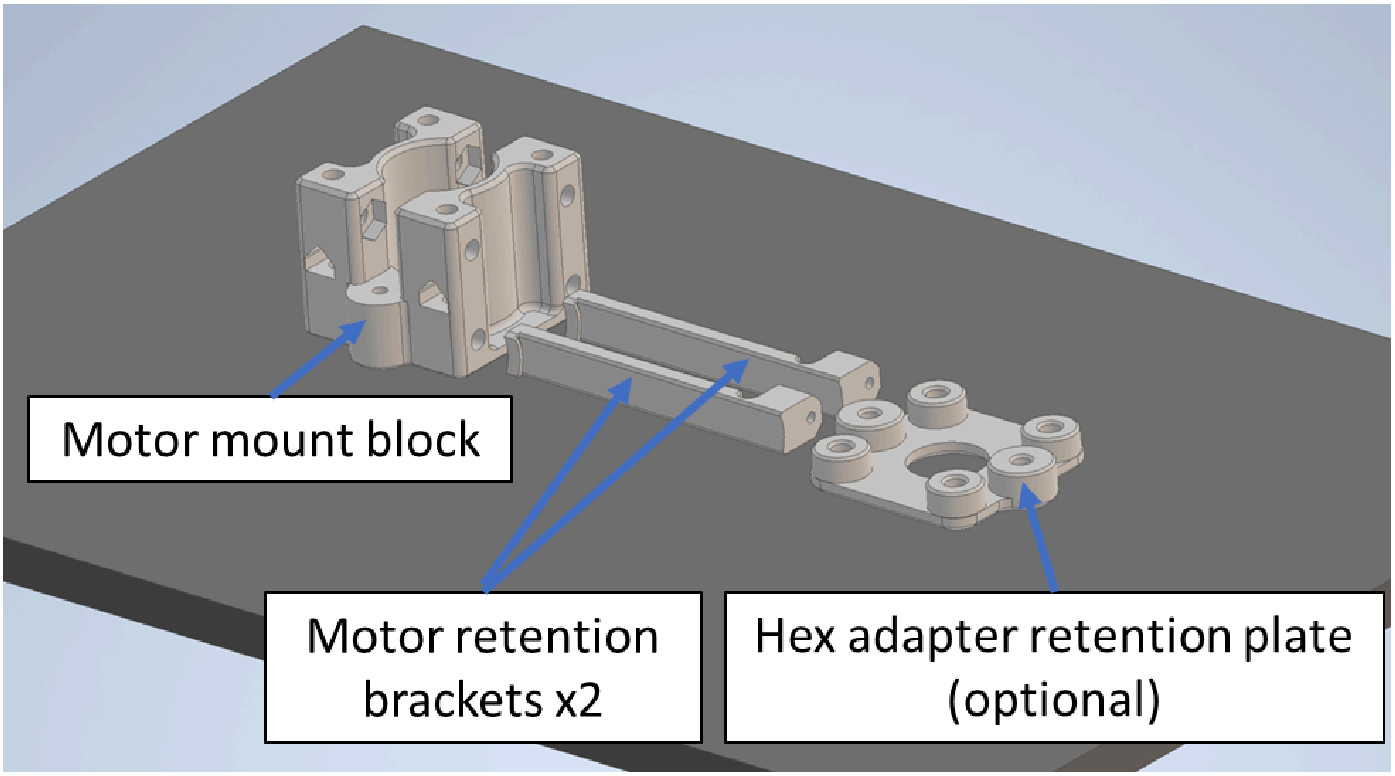


Figure 10: Build parts in this orientation to avoid supports and optimize strength

There are several features on the mount block for motor retention and mounting options. Pockets are provided to hold nuts allowing the option for shorter bolts. See figure below.

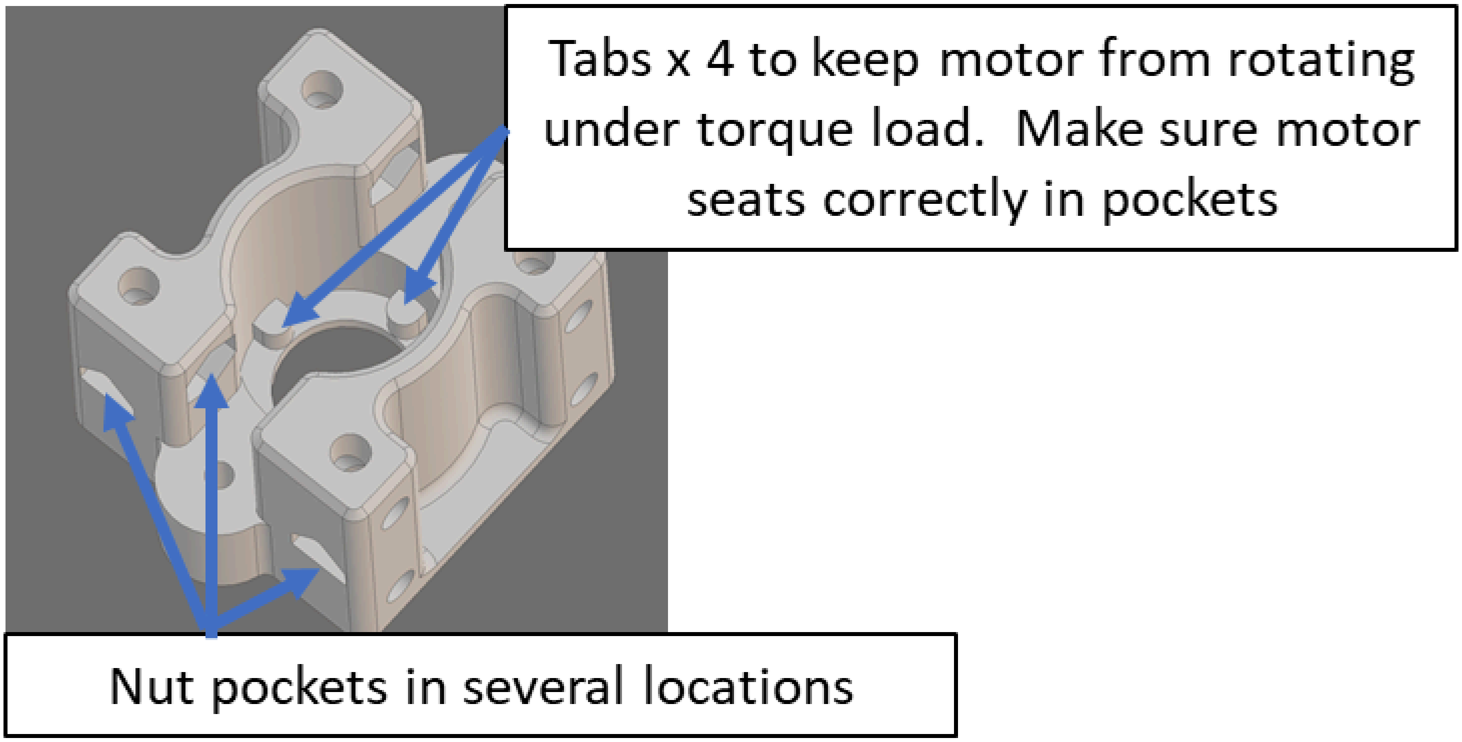


Figure 11: Motor mount block

If the hex adapter is not supported in the direction of the arrow shown, then a retention plate & ½" hex collar can be used to keep the adapter from falling out. Do not rely on friction to hold it in place. This may loosen over time. See figure below.

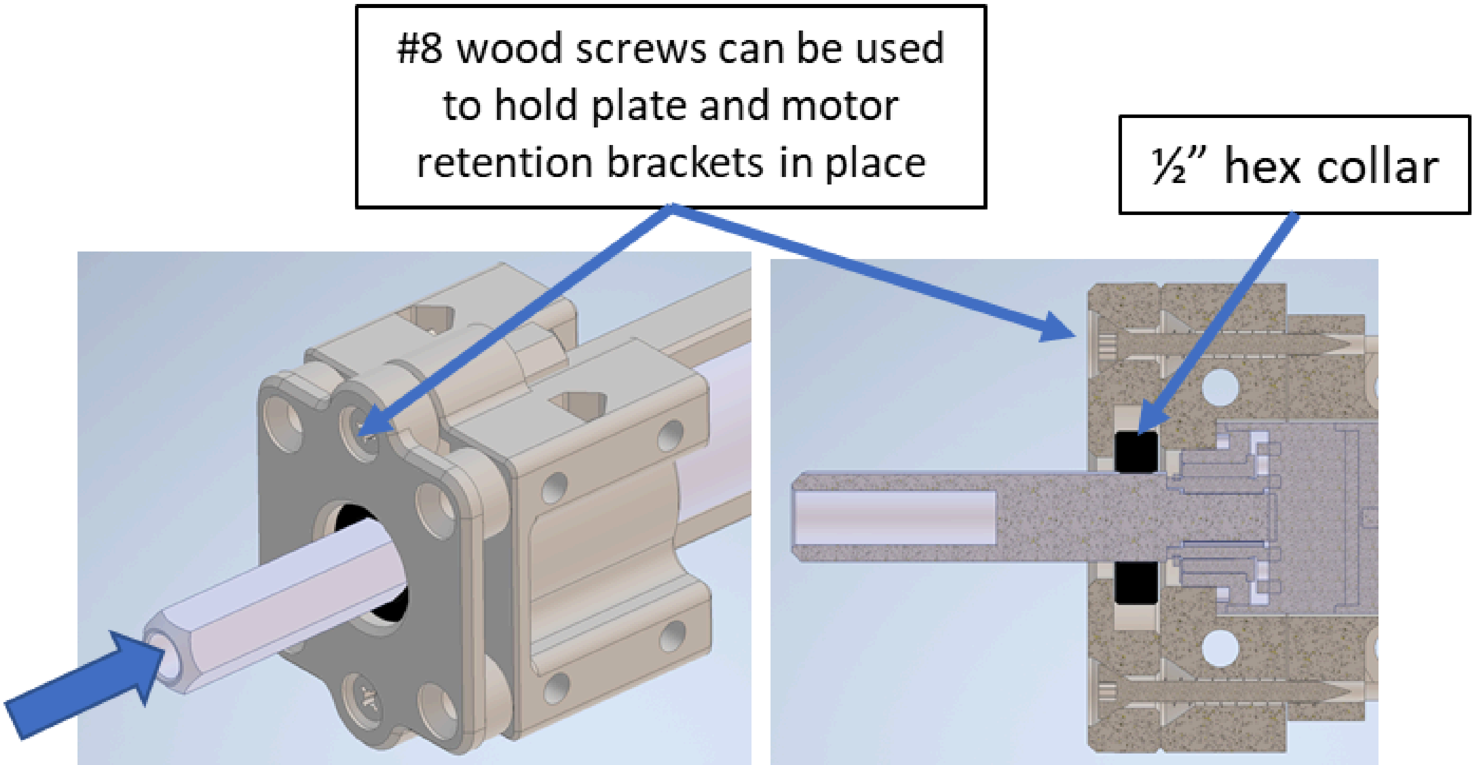


Figure 12: Hex adapter retention plate is needed if the adapter is not held

The motor should be supported with 2 retention brackets. The end should hook onto the plastic motor cap and #8 wood screws through the motor mount block will tap into the bracket hole to hold in place. A pocket in the motor retention bracket is provided so the mount holes are not restricted.

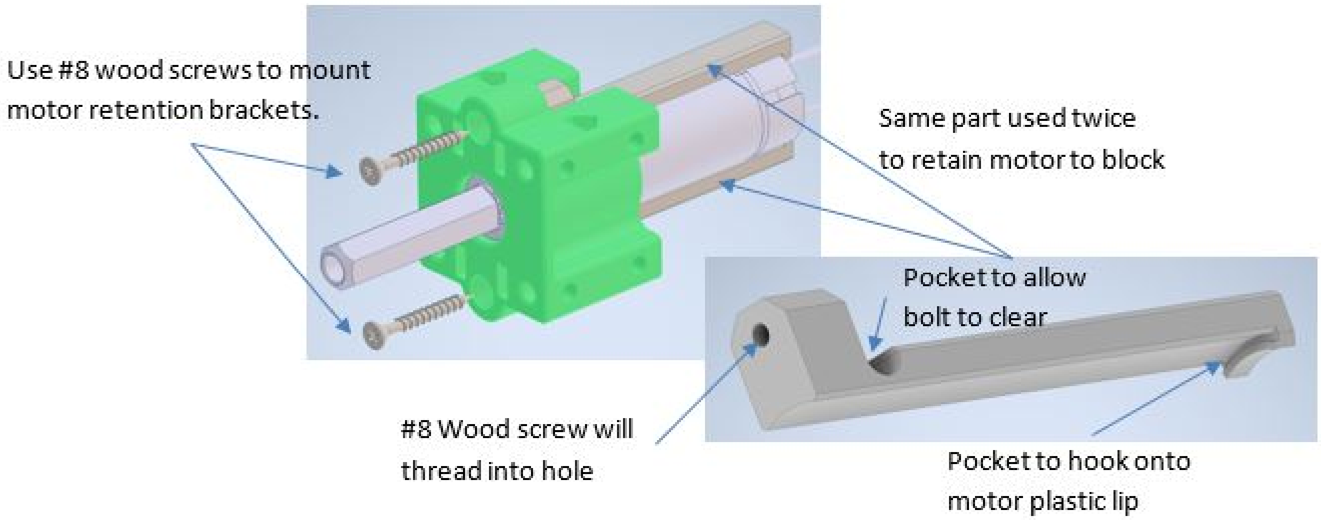
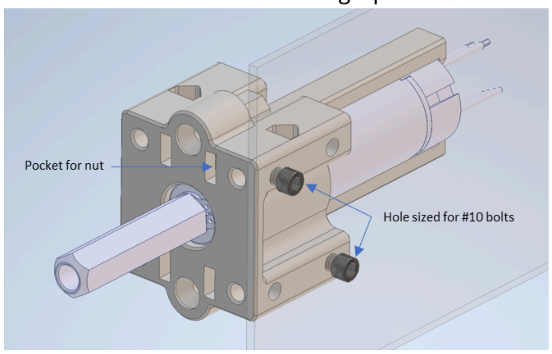


Figure 13: motor retention bracket mounting

There are two orientations that can be used for mounting. An option is available to use shorter bolts by adding a nut to the pocket. Minimum of two #10 bolts should be used in a diagonal configuration. If desired, teams can opt to use all four mounts.

KoP Item Resources

Side face mounting option



Output face mounting option

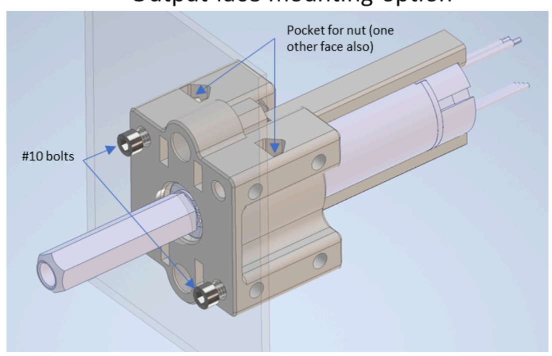


Figure 14: Mounting options

2020-02-12_JE-PLG-149_R2.PDF

2019-12-20_JE-PLG-ADPTR-1_R1.PDF

2019-12-30_JE-PLG-149_with_adapter_R1.stp

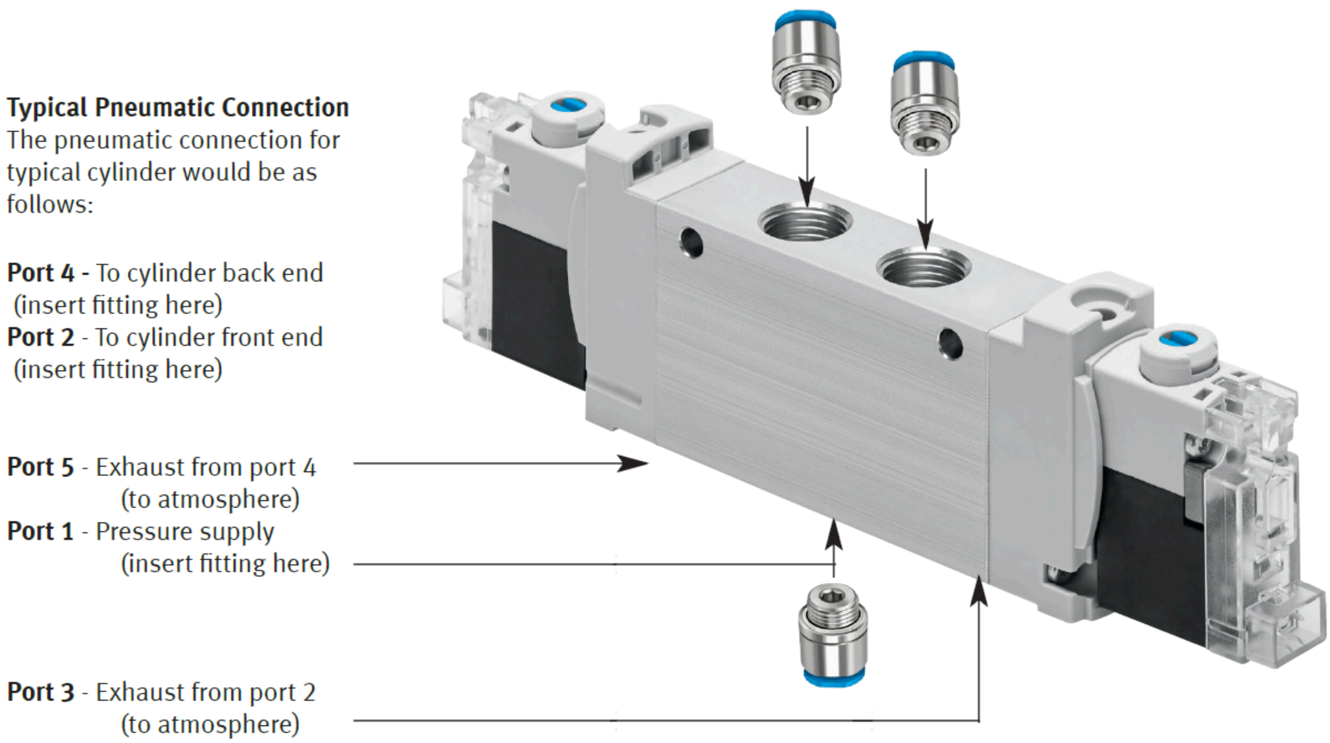
2020-01-09_PLG_motor_mount.stp

Pneumatics

FESTO Solenoid Valve

Basic Valve Data

The VUVG-LK10-B52-T-M7-1H2L-S is a 5/2 dual solenoid piloted valve. The valve has M7 ports and is operated with a 24V DC signal. The maximum air flow is 13.4 cfm. The weight of the valve including the fittings and cables is 0.2 lbs.



Electrical Connection

Attach one end of each cable to a +24V DC signal and the other to a 0V DC signal.

When the valve is switched on the LED will turn on.

Wiring

- Red: +24V DC
- Black: 0V DC

Operation

To extend the cylinder, activate coil 14 for at least 30 mSec. To retract cylinder activate coil 12 for at least 20 mSec. Following the activation time the coil can be deactivated without switching positions. Verify that both coils are not activated simultaneously. A minimum of 25 psi should be supplied Port 1.

Manual Override

To operate the valve without electrical current depress the blue button for a temporary time or depress and turn to maintain the activation. The valve will not return to original state unless it receives an electrical signal at the coil or manual override operation.

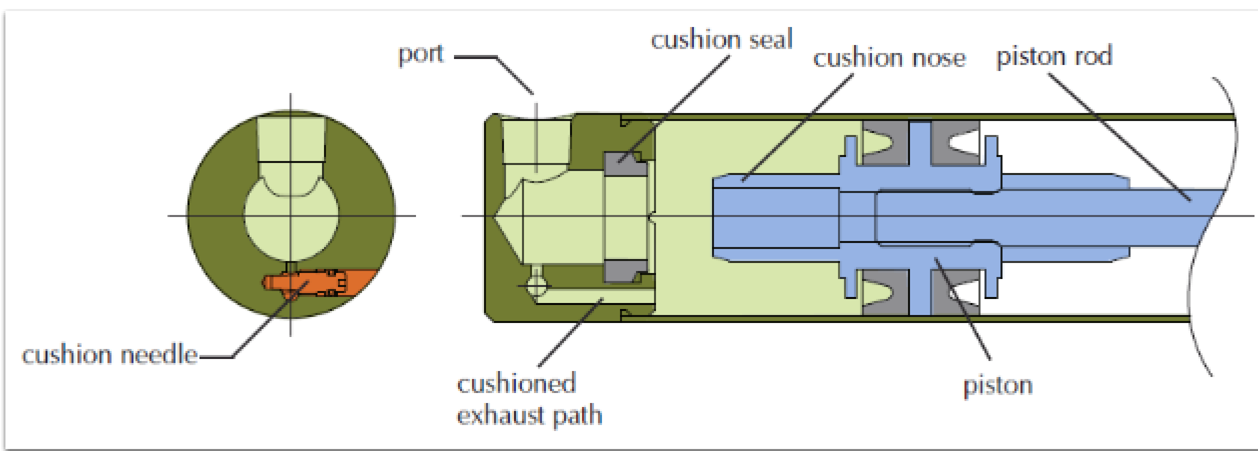
Position & Speed Control Options for Pneumatic Cylinders (from Clippard)

Pneumatic cylinders' speed and power advantages make this technology a valuable player in many applications. Where they can fall short is the controllability of position and variable speeds. Electronic drives and motors have the advantage of better controllability, but usually come with more complexity and a high price.

Here are a few ways to better control the position and speed(s) of your pneumatic actuator.

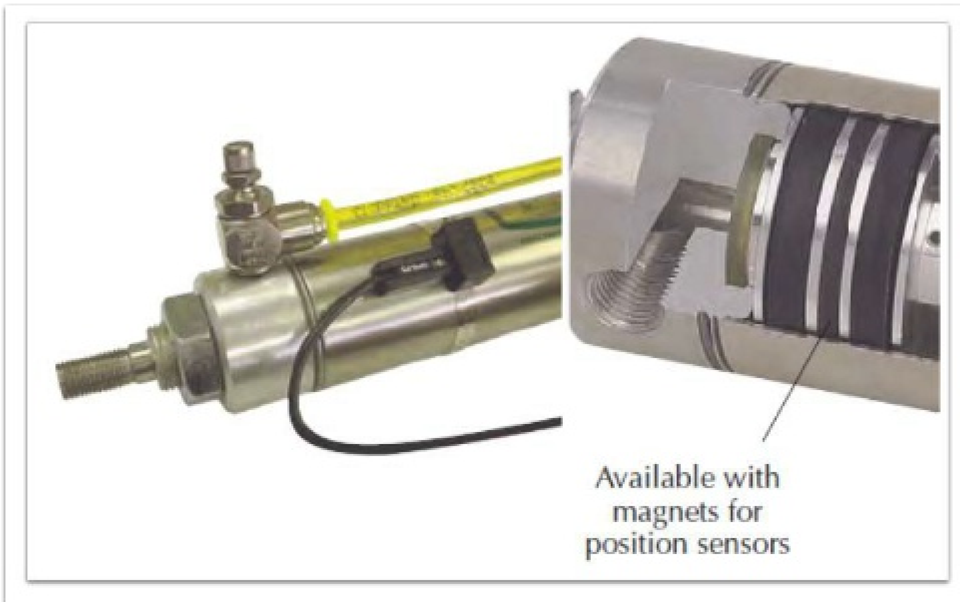
Cushion Cylinders

This option allows the cylinder to slow down at the end of stroke. It is valuable for reducing vibration and noise common with sudden metal to metal stops.



Magnetic Cylinder Pistons

Magnetic Cylinder pistons offer the ability to detect stroke position with reed or GMR switches. Knowing the position of the cylinder can allow the users to switch exhaust flow paths or pressure to vary speed or direction.



Flow Control Valves

Flow control and needle valves allow adjustment of the speed of a cylinder.

Quick Exhaust Valves

The primary function of a quick exhaust vale is to increase cylinder speed. This also enables the use of smaller directional valves and longer control lines.

Pilot Operated Check Valves

These valves provide control functions with cylinders and with other control circuits.

PHD Cylinders

PHD Cylinder: General Overview

Series OCG Cylinder Start-up Procedure

OCG-Information.pdf

Former Season FRC Application Examples

Robot Quick Build

Robot Quick Build Overview

Robot Quick Build Sessions (RQBS) are sessions held (typically) right after kickoff to help teams jump-start their season by getting the base chassis put together with the help of veteran mentors.

The instructions used for RQBS can also be seen as sort of a "Quick start" guide to building your robot even if you did not attend one of these sessions.

Requred Materials

- **Tools:** The AM14U chassis documentation has a list of tools necessary for mechanical assembly. For electrical wiring and board installation you will need:
  - Wago Tool or other medium flat-head screwdriver
  - Very small flat-head screwdriver and Philips head screwdriver
  - 5mm Hex key (3/16" may work if metric is unavailable, but use carefully) and a 1/16" hex key
  - Wire cutters, strippers, and crimpers
  - 7/16" box end wrench or nut driver
  - 6 AWG wire crimper or vise to crimp compression lugs for the battery, PDP and 120A breaker.
  - USB A male to USB B male cable for imaging and programming the roboRIO
  - Tool to cut 1/4"- 1/2" plywood board to appropriate size
  - Drill with 3/16" drill bit and Philips head bit
- **Materials:** In addition to what is contained in the KoP, you will need:
  - ¼" – ½" Plywood control board (for exact sizes, see Installing Electrical Board for RQBS)
  - Pan Philips Head Machine Screws with nuts for electrical board attachment. Note: The AM14U kit may have a small number of extra
    - Option 1 requires (8) 10-32 x 1in and (4) 10-32 x 1.5in
    - Option 2 requires (4) 10-32 x 1in

Basic Steps

The basic steps to get a running robot using the Robot Quick Build style are:

- Assemble AM14U chassis (this can be done in parallel with wiring below)
- Cut electronics Board

- Wire electronics board according to Wiring the FRC Control System until you reach the red text telling you to stop (after installing Circuit Breakers)
- Install Electronics Board on Robot
- Finish Wiring

Quick Build complete! Proceed to Getting Started with the Control System (skip wiring) to get your Control System up and running to program your robot.

Installing Electrical Board for RQBS

Electrical Board Options

There are two options provided for Robot Quick Build electrical boards with 4 sizes provided for each.

- Option 1 - This option uses two thin strips to support a rectangular board above the top of the chassis.
- Option 2 - This option uses a board wit a U-shaped cutout to accommodate the battery box when mounting inside the chassis.

Sizes:

- Testing - This size accommodates the chassis if assembled un-cut. This is the recommended configuration for Kickoff Quick Builds where teams do not yet have enough information about their design to make a decision about robot sizing. **Note: This size is not a competition legal robot size**
- The other 3 options correspond to the cut chassis sizes described in the AM14U documentation.

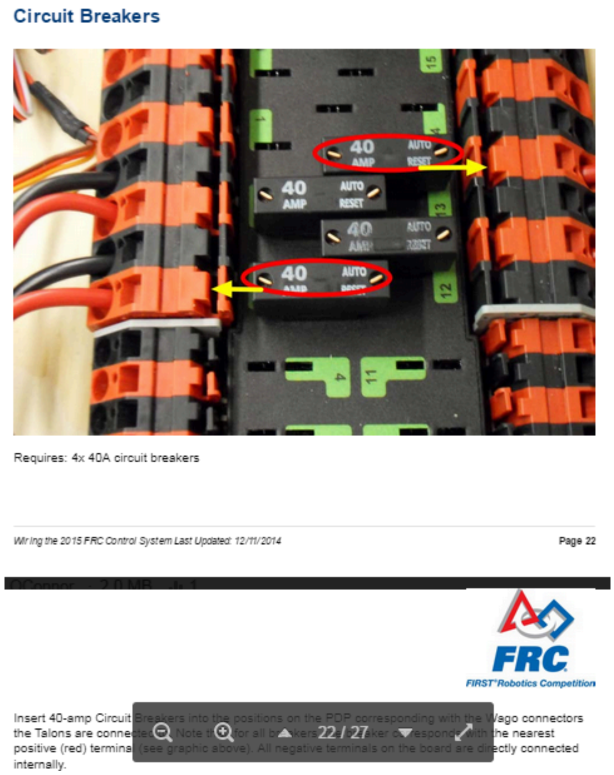
Download the Zip file below and choose one of the options for your robot.

QuickBuildElectricalBoards.zip

AM14U preparation

Unlike prior years it is recommended to complete the AM14U chassis construction prior to installing the electronics. This is true for either "option".

Electrical board preparation



Circuit Breakers

Requires: 4x 40A circuit breakers

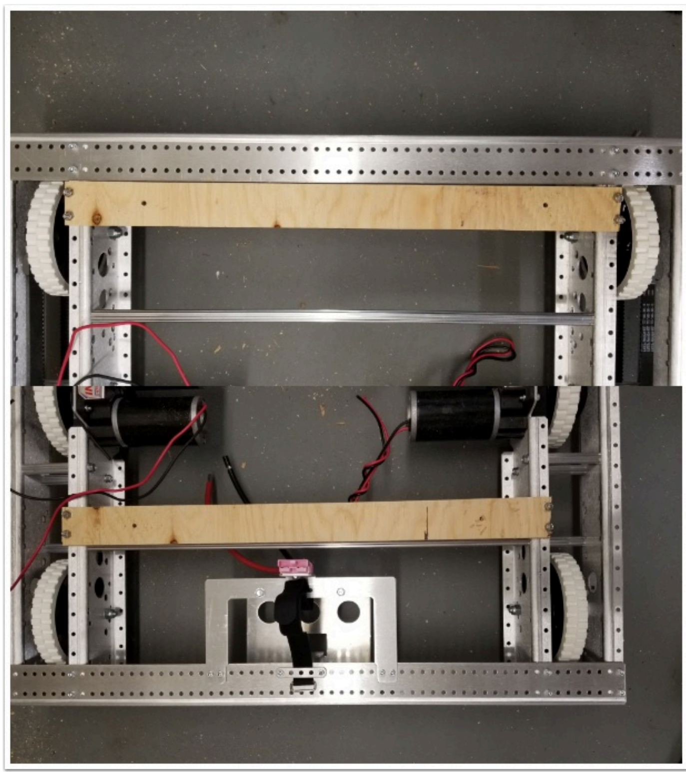
Wiring the 2015 FRC Control System Last Updated: 12/11/2014 Page 22

Insert 40-amp Circuit Breakers into the positions on the PDP corresponding with the Wago connectors the Talons are connected ... positive (red) terminal (see graphic above). All negative terminals on the board are directly connected internally.

Complete the ["Wiring the FRC Control System"]() assembly instructions up to and including the circuit breakers step.

Option 1 Installation

Support Strips

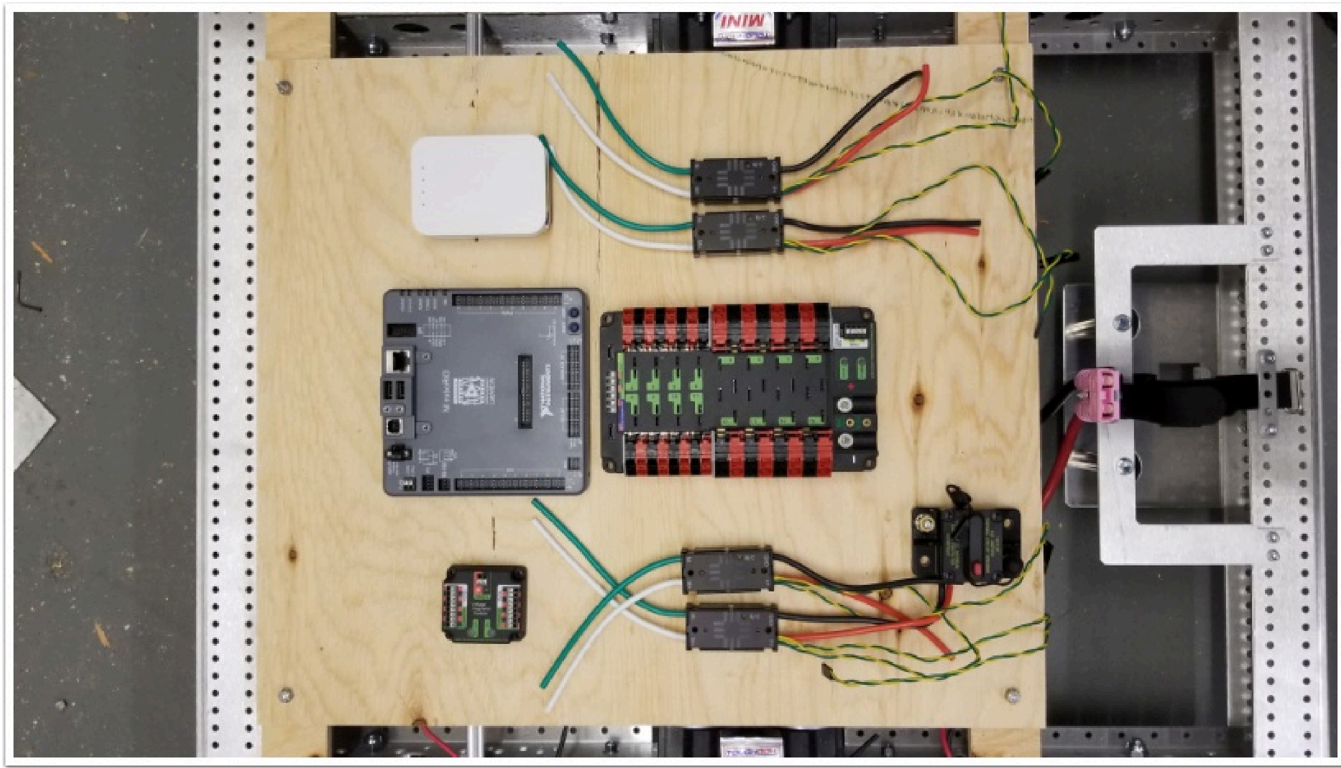


Requires: drill, 3/16" drill bit, (8) 10-32 x 1" pan philips head machine screw, (8) 10-32 nylock nuts, philips head screw driver, wrench

Locate the 2 support strips on the chassis as shown: Flush with the front rail on the front of the robot, 6 holes forward on the back on the robot (the back of the board is approximately centered on the churro tube).

Drill holes in the support boards matching the chassis holes (it's recommended to mark/punch the holes from below, then remove the board to drill) and fasten using 10-32 machine screws.

Main Board

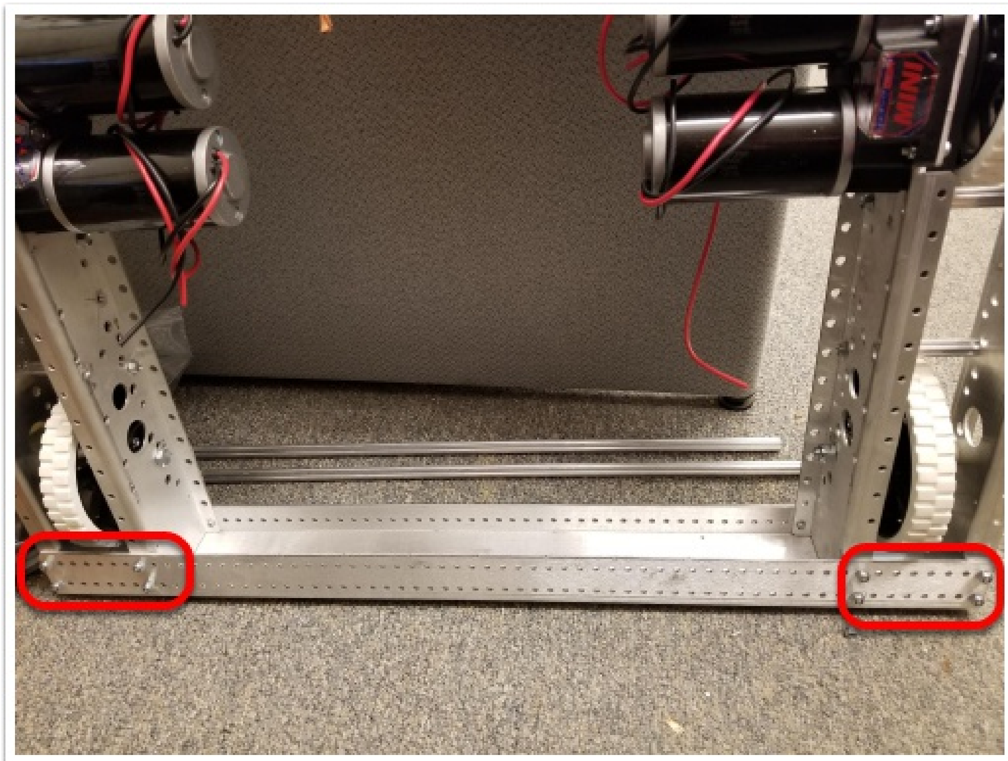


Requires: drill, 3/16" drill bit, (4) 10-32 x 2" pan Philips head machine screw, (4) 10-32 nylock nuts, Philips head screw driver, wrench

Locate the main board above the support strips as shown. Near each corner, match drill a hole through both pieces of wood. Secure with 10-32 hardware.

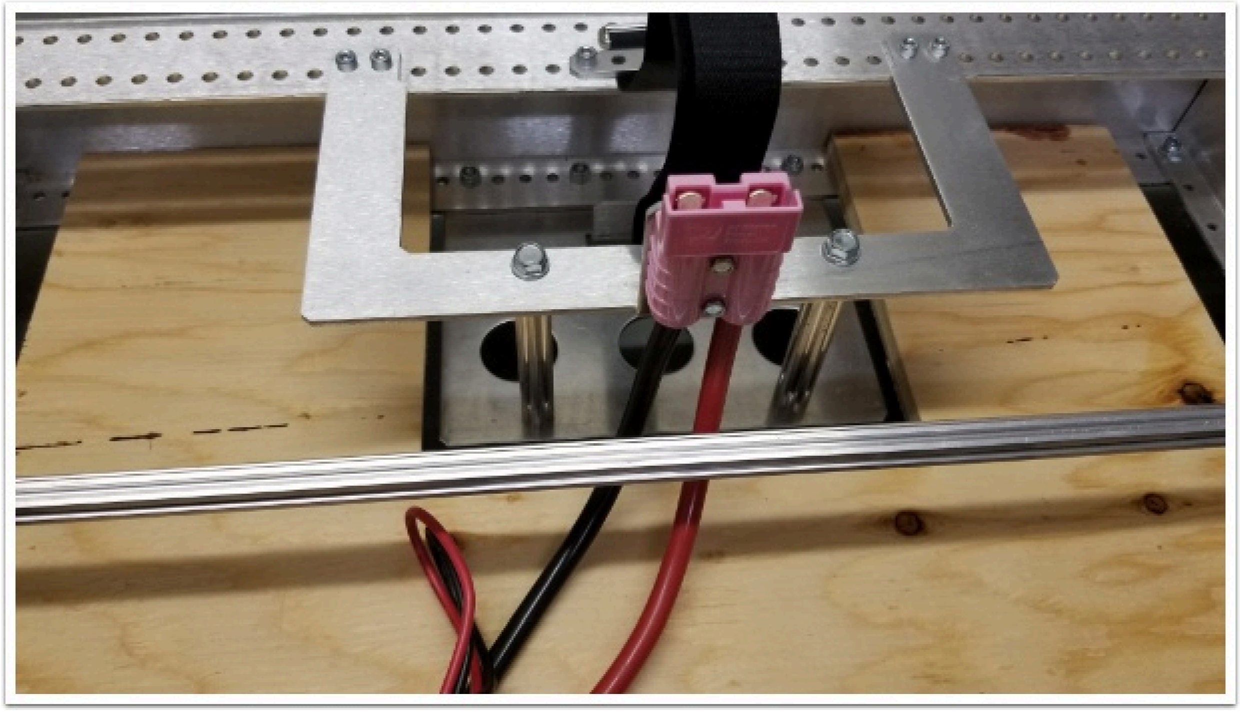
Option 2 Installation

Remove chassis front



Remove the front channel from the chassis by removing all fasteners (top and bottom) and sliding the channel away from the remaining chassis pieces.

Board placement



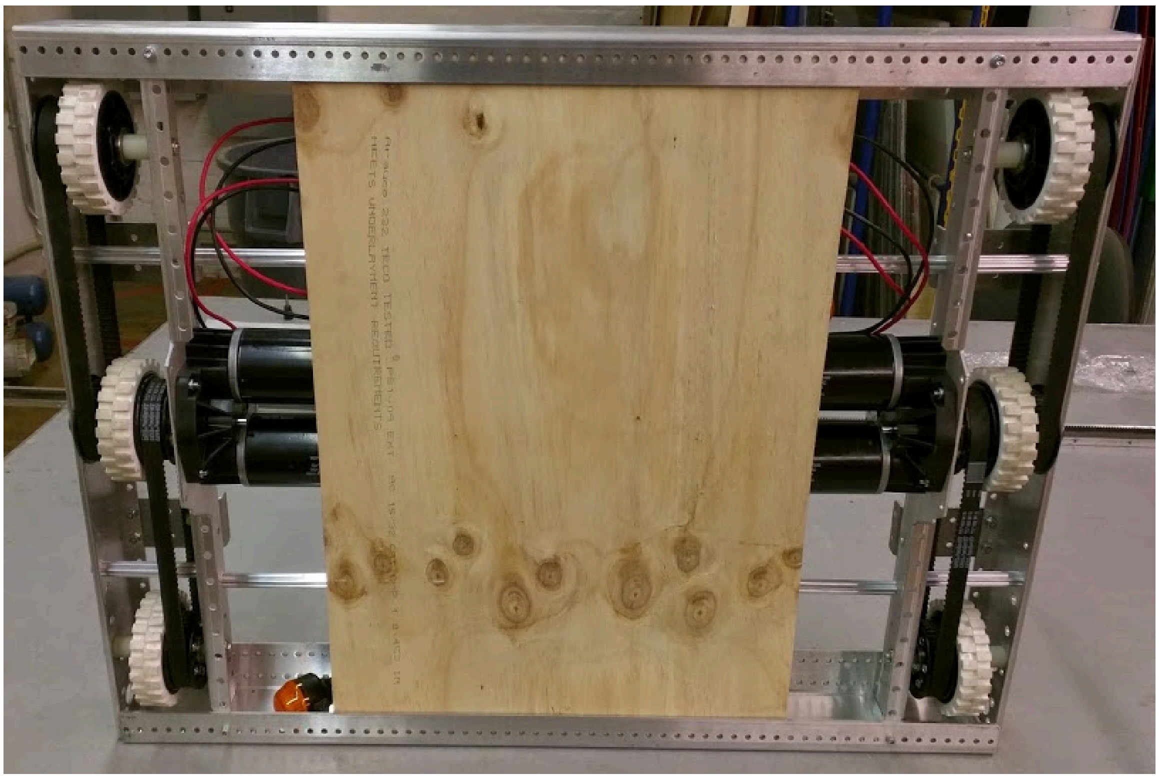
Insert the board into the chassis so the U-shaped cutout surrounds the battery tray.

Re-attach front rail

Re-attach front rail of chassis.

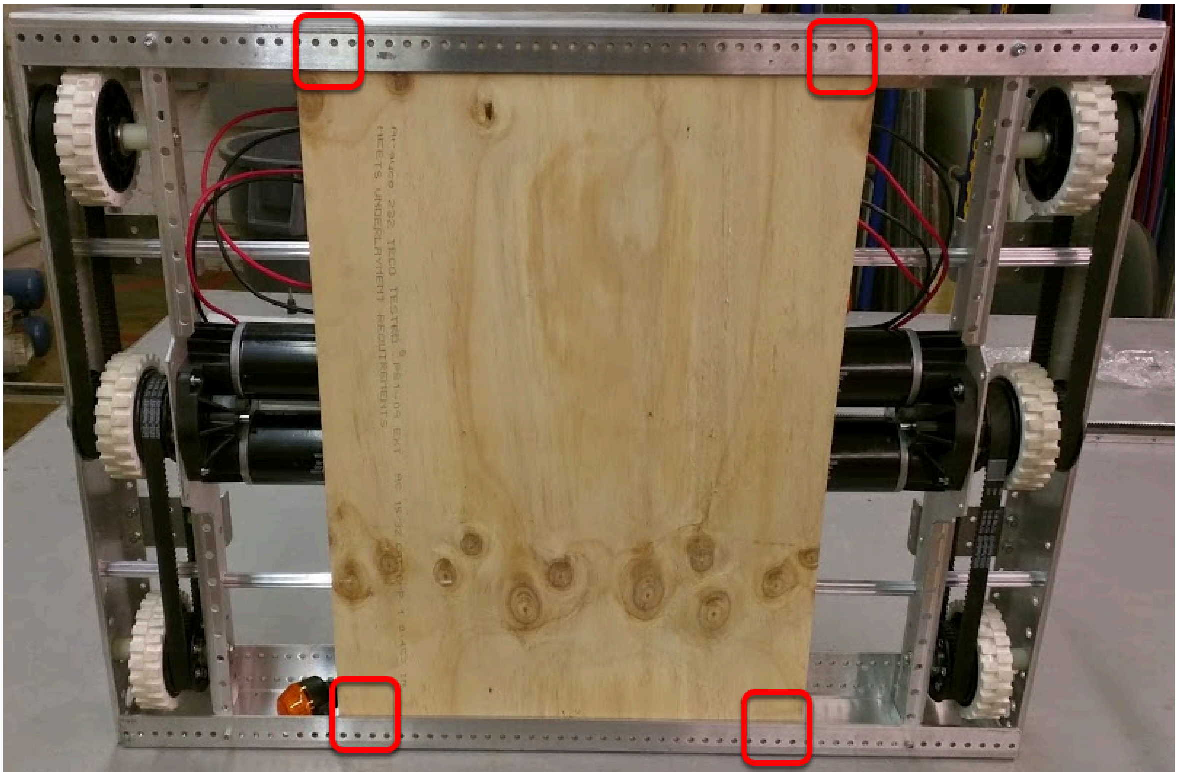
Securing the electrical board

Chassis orientation



Flip the drive base so that the bottom of the electrical board is exposed.

Drilling holes



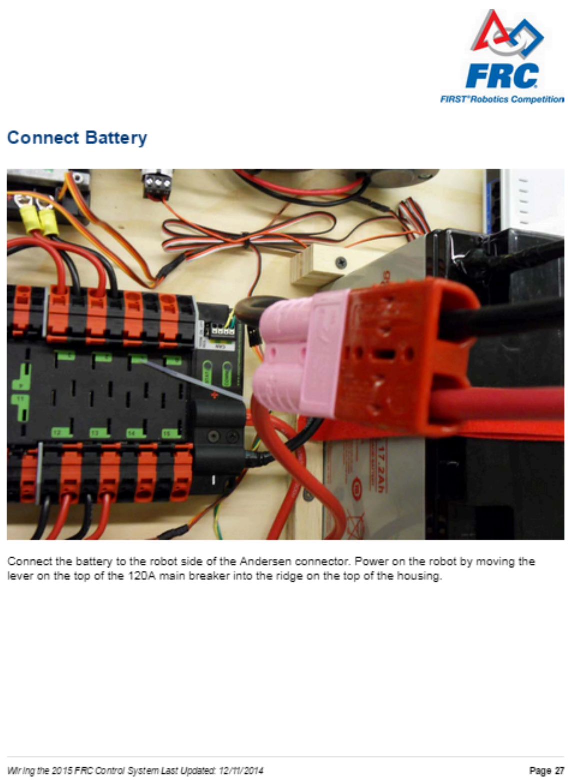
Requires: drill, 3/16" drill bit

Drill 4 holes in the corners of the electrical board using a 3/16" drill bit and the hole pattern on the end rails as a guide.

Installing fasteners

Insert 4, 10-32 x 1" Philips pan head machine screws from the bottom of the electrical board through both the end rail and the board. Secure them from the top with 4, 10-32 nylock nuts.

Electrical board wiring


Connect Battery

Connect the battery to the robot side of the Andersen connector. Power on the robot by moving the lever on the top of the 120A main breaker into the ridge on the top of the housing.

Wiring the 2015 FRC Control System Last Updated: 12/11/2014 Page 27

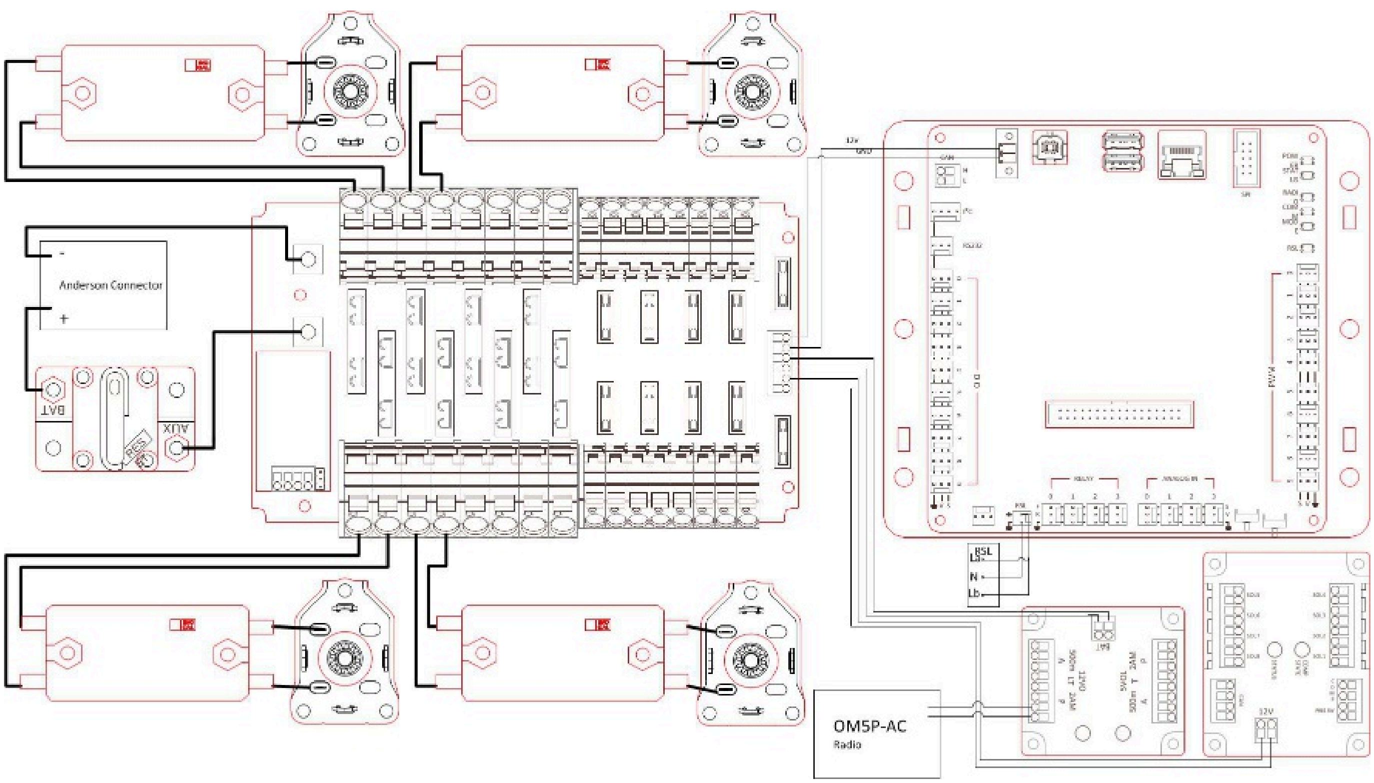
Complete the remaining steps in the ["Wiring the FRC Control System"]() (motor power and battery connections)

Wiring the FRC Control System

This document details the wiring of a basic electronics board for bench-top testing.

Some images shown in this section reflect the setup for a Robot Control System using Spark motor controllers. Wiring diagram and layout should be similar for other motor controllers. Where appropriate, a second set of images shows the wiring steps for using PWM controllers with integrated wires.

Gather Materials



Locate the following control system components and tools

- Kit Materials:
    - Power Distribution Panel (PDP)

  - roboRIO
  - Pneumatics Control Module (PCM)
  - Voltage Regulator Module (VRM)
  - OpenMesh radio (with power cable and Ethernet cable)
  - Robot Signal Light (RSL)
  - 4x Victor SPX or other speed controllers
  - 2x PWM y-cables
  - 120A Circuit breaker
  - 4x 40A Circuit breaker
  - 6 AWG Red wire
  - 10 AWG Red/Black wire
  - 18 AWG Red/Black wire
  - 22AWG yellow/green twisted CAN cable
  - 16x 10-12 AWG (yellow) ring terminals (8x quick disconnect pairs if using integrated wire controllers)
  - 2x Andersen SB50 battery connectors
  - 6AWG Terminal lugs
  - 12V Battery
  - Red/Black Electrical tape
  - Dual Lock material or fasteners
  - Zip ties
  - 1/4" or 1/2" plywood

- Tools Required:
  - Wago Tool or small flat-head screwdriver
  - Very small flat head screwdriver (eyeglass repair size)
  - Philips head screw driver
  - 5mm Hex key (3/16" may work if metric is unavailable)
  - 1/16" Hex key
  - Wire cutters, strippers, and crimpers
  - 7/16” box end wrench or nut driver

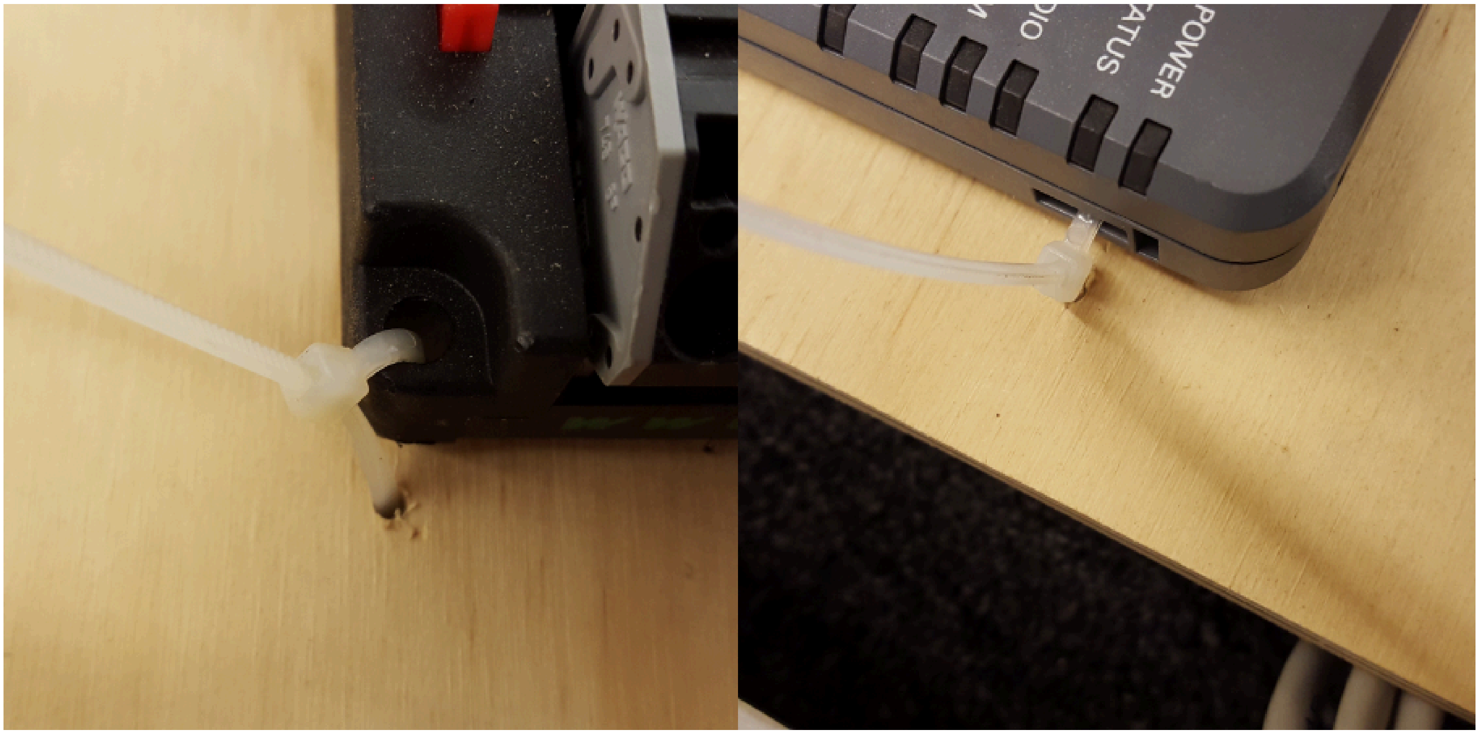
Create the Base for the Control System

For a benchtop test board, cut piece of 1/4” or 1/2" material (wood or plastic) approximately 24" x 16". For a Robot Quick Build control board see the supporting documentation for the proper size board for the chosen chassis configuration.

Layout the Core Control System Components

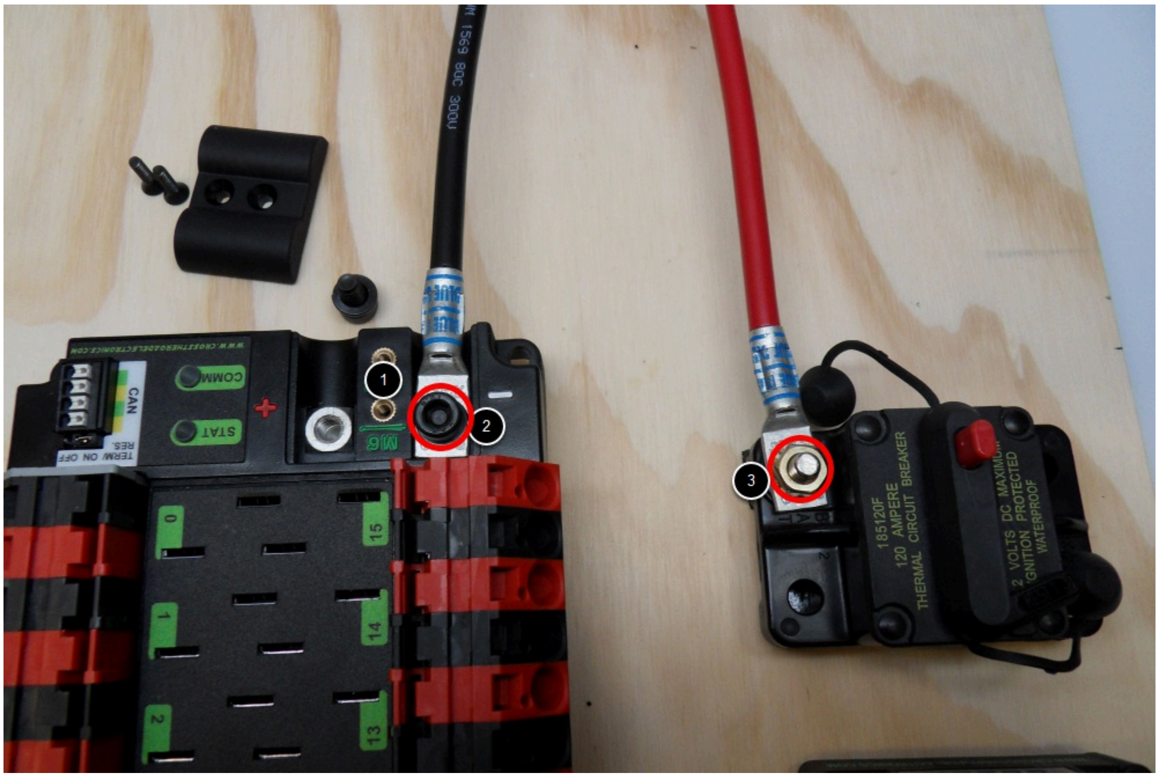
Layout the components on the board. One layout that should work is shown in the images above.

Fasten components



Using the Dual Lock or hardware, fasten all components to the board. Note that in many FRC games robot-to-robot contact may be substantial and Dual Lock alone is unlikely to stand up as a fastener for many electronic components. Teams may wish to use nut and bolt fasteners or (as shown in the image above) cable ties, with or without Dual Lock to secure devices to the board.

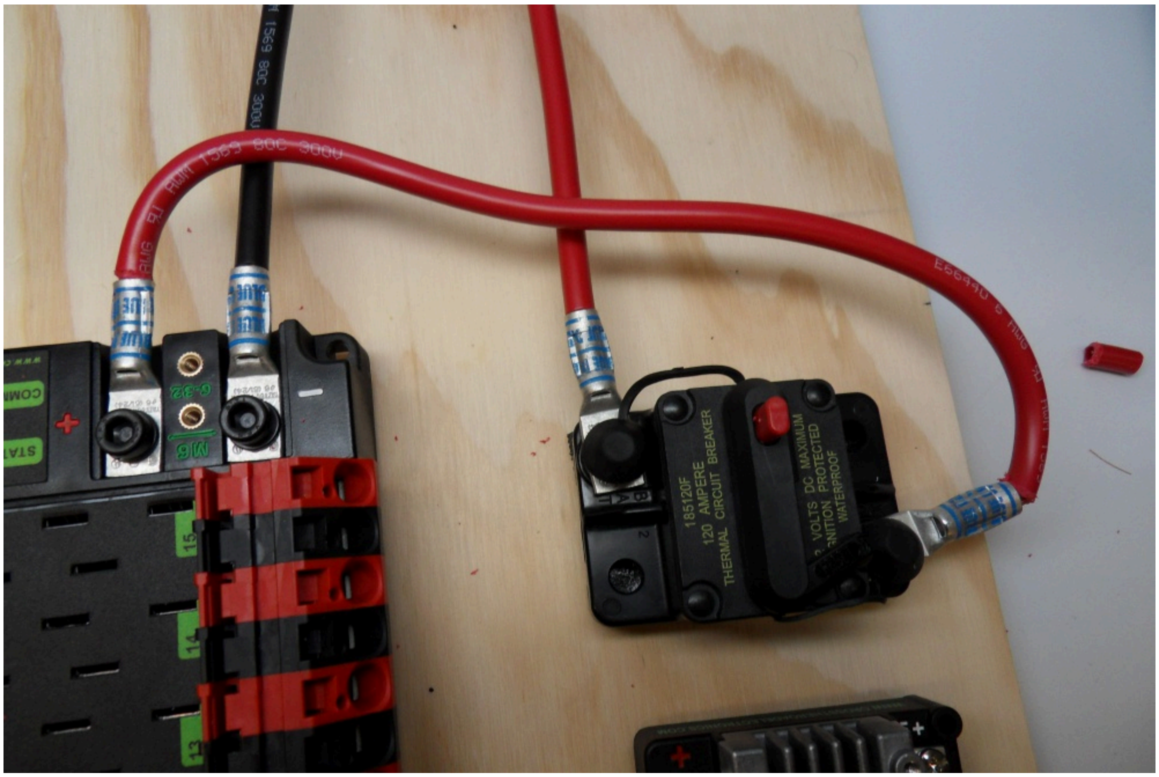
Attach Battery Connector to PDP



Requires: Battery Connector, 6AWG terminal lugs, 1/16" Allen, 5mm Allen, 7/16" Box end

1. Attach terminal lugs to battery connector.
2. Using a 1/16" Allen wrench, remove the two screws securing the PDP terminal cover.
3. Using a 5mm Allen wrench (3/16" will work if metric is not available), remove the negative (-) bolt and washer from the PDP and fasten the negative terminal of the battery connector.
4. Using a 7/16" box end wrench, remove the nut on the "Batt" side of the main breaker and secure the positive terminal of the battery conenctor

Wire Breaker to PDP

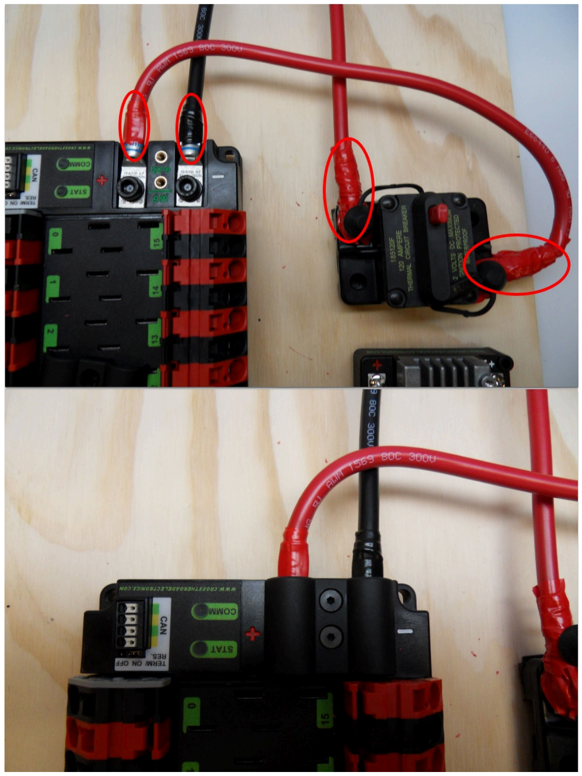


Requires: 6AWG red wire, 2x 6AWG terminal lugs, 5mm Allen, 7/16" box end

Secure one terminal lug to the end of the 6AWG red wire. Using the 7/16" box end, remove the nut from the "AUX" side of the 120A main breaker and place the terminal over the stud. Loosely secure the nut (you may wish to remove it shortly to cut, strip, and crimp the other end of the wire). Measure out the length of wire required to reach the positive terminal of the PDP.

1. Cut, strip, and crimp the terminal to the 2nd end of the red 6AWG wire.
2. Using the 7/16" box end, secure the wire to the "AUX" side of the 120A main breaker.
3. Using the 5mm, secure the other end to the PDP positive terminal.

Insulate PDP connections



Requires: 1/16" Allen, Electrical tape

1. Using electrical tape, insulate the two connections to the 120A breaker. Also insulate any part of the PDP terminals which will be exposed when the cover is replaced. One method for insulating the main breaker connections is to wrap the stud and nut first, then use the tape wrapped around the terminal and wire to secure the tape.
2. Using the 1/16" Allen wrench, replace the PDP terminal cover

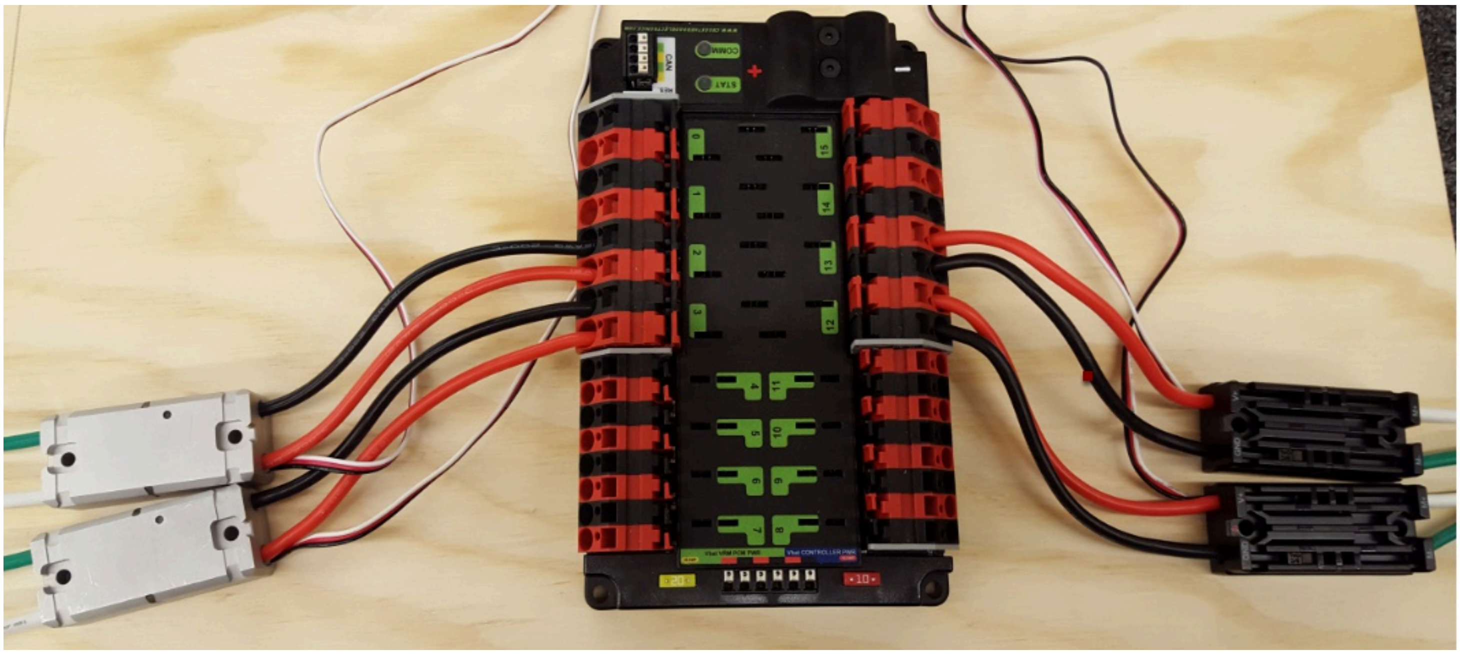
Wago connectors

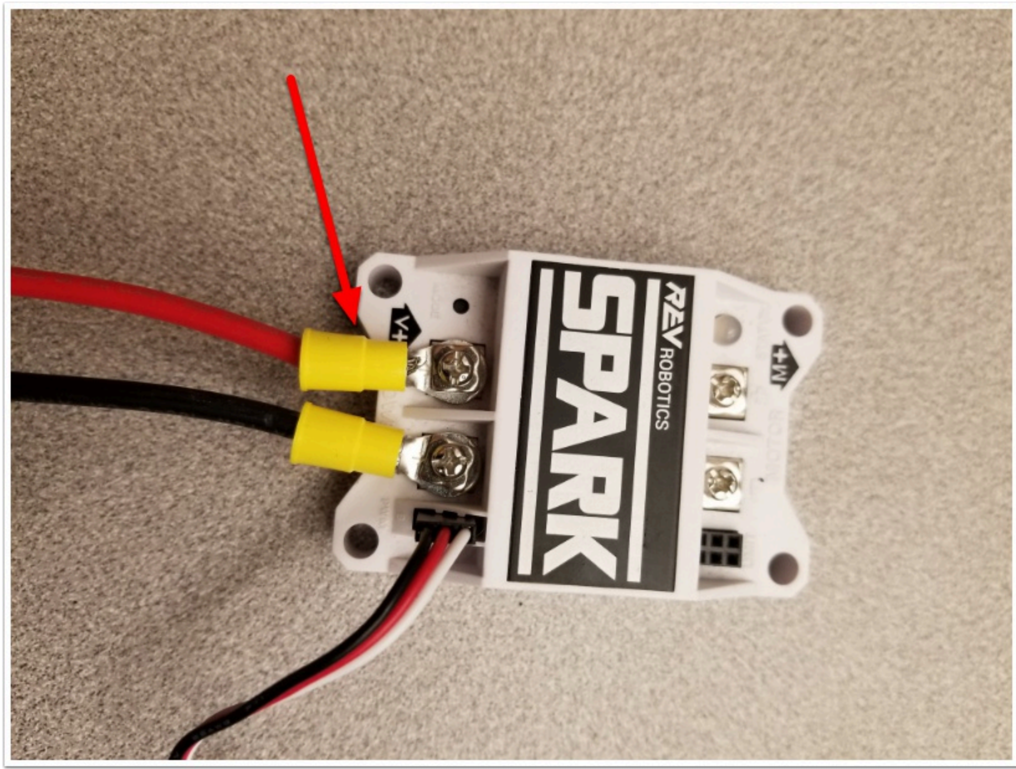
The next step will involve using the Wago connectors on the PDP. To use the Wago connectors, insert a small flat blade screwdriver into the rectangular hole at a shallow angle then angle the screwdriver upwards as you continue to press in to actuate the lever, opening the terminal. Two sizes of Wago connector are found on the PDP:

- Small Wago connector: Accepts 10AWG-24AWG, strip 11-12mm (~7/16")
- Large Wago connector: Accepts 6AWG-12AWG, strip 12-13mm(~1/2")

To maximize pullout force and minimize connection resistance wires should not be tinned (and ideally not twisted) before inserting into the Wago connector.

Motor Controller Power





Requires: Wire Stripper, Small Flat Screwdriver, 10 or 12 AWG wire, 10 or 12 AWG fork/ring terminals (terminal controllers only), wire crimper

For Victor SPX or other wire integrated motor controllers (top image):

1. Cut and strip the red and black power input wires wire, then insert into one of the 40A (larger) Wago terminal pairs.

For terminal motor controllers (bottom image):

1. Cut red and black wire to appropriate length to reach from one of the 40A (larger) Wago terminal pairs to the input side of the speed controller (with a little extra for the length that will be inserted into the terminals on each end)
2. Strip one end of each of the wires, then insert into the Wago terminals.
3. Strip the other end of each wire, and crimp on a ring or fork terminal
4. Attach the terminal to the speed controller input terminals (red to +, black to -)

Weidmuller Connectors

The correct strip length is ~5/16" (8mm), not the 5/8" mentioned in the video.

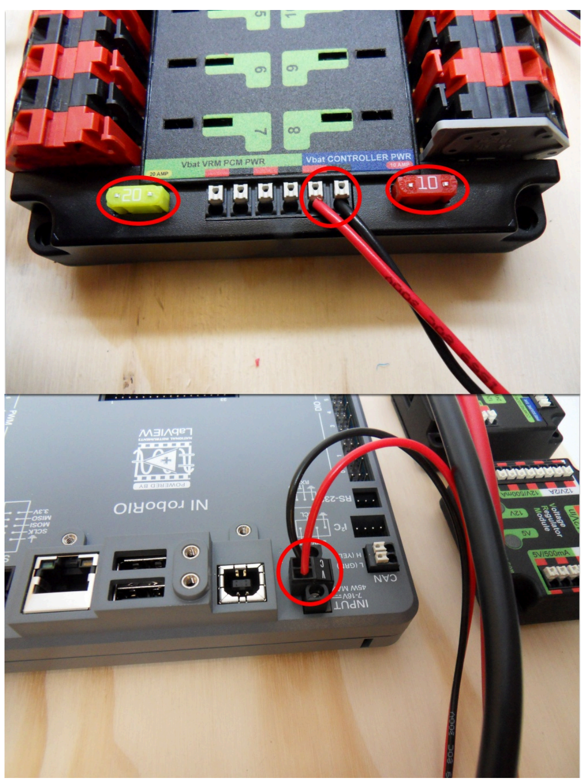
A number of the CAN and power connectors in the system use a Weidmuller LSF series wire-to-board connector. There are a few things to keep in mind when using this connector for best results:

- Wire should be 16AWG to 24AWG (consult rules to verify required gauge for power wiring)
- Wire ends should be stripped approximately 5/16"
- To insert or remove the wire, press down on the corresponding "button" to open the terminal

After making the connection check to be sure that it is clean and secure:

- Verify that there are no "whiskers" outside the connector that may cause a short circuit
- Tug on the wire to verify that it is seated fully. If the wire comes out and is the correct gauge it needs to be inserted further and/or stripped back further.

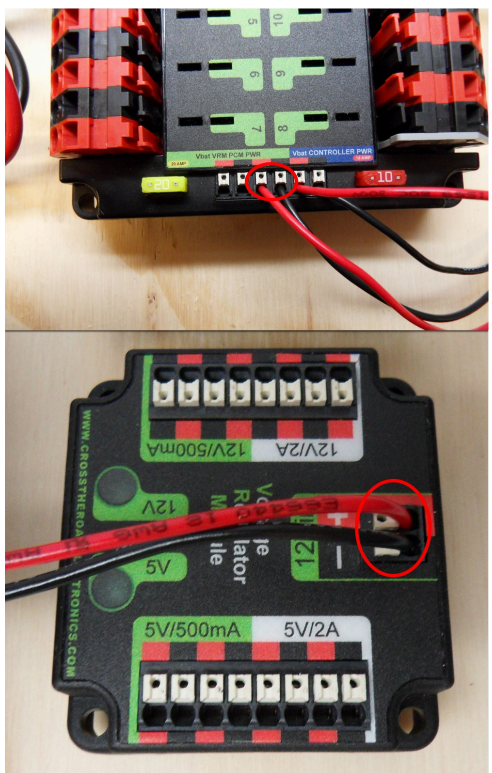
roboRIO Power



Requires: 10A/20A mini fuses, Wire stripper, very small flat screwdriver, 18AWG Red and Black

1. Insert the 10A and 20A mini fuses in the PDP in the locations shown on the silk screen (and in the image above)
2. Strip ~5/16" on both the red and black 18AWG wire and connect to the "Vbat Controller PWR" terminals on the PDB
3. Measure the required length to reach the power input on the roboRIO. Take care to leave enough length to route the wires around any other components such as the battery and to allow for any strain relief or cable management.
4. Cut and strip the wire.
5. Using a very small flat screwdriver connect the wires to the power input connector of the roboRIO (red to V, black to C). **Also make sure that the power connector is screwed down securely to the roboRIO.**

Voltage Regulator Module Power

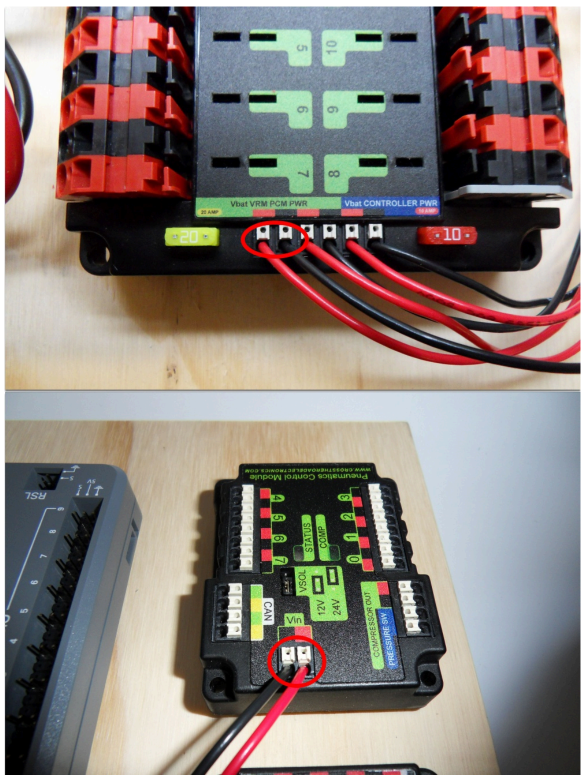


Requires: Wire stripper, small flat screwdriver (optional), 18AWG red and black wire

1. Strip ~5/16" on the end of the red and black 18AWG wire.
2. Connect the wire to one of the two terminal pairs labeled "Vbat VRM PCM PWR" on the PDP.

3. Measure the length required to reach the "12Vin" terminals on the VRM. Take care to leave enough length to route the wires around any other components such as the battery and to allow for any strain relief or cable management.
4. Cut and strip ~5/16" from the end of the wire.
5. Connect the wire to the VRM 12Vin terminals.

Pneumatics Control Module Power (Optional)



Requires: Wire stripper, small flat screwdriver (optional), 18AWG red and black wire

Note: The PCM is an optional component used for controlling pneumatics on the robot.

1. Strip ~5/16" on the end of the red and black 18AWG wire.
2. Connect the wire to one of the two terminal pairs labeled "Vbat VRM PCM PWR" on the PDP.
3. Measure the length required to reach the "Vin" terminals on the VRM. Take care to leave enough length to route the wires around any other components such as the battery and to allow for any strain relief or cable management.
4. Cut and strip ~5/16" from the end of the wire.
5. Connect the wire to the VRM 12Vin terminals.

Radio Power and Ethernet

DO NOT connect the Rev passive POE injector cable directly to the roboRIO. The roboRIO MUST connect to the female end of the cable using an additional Ethernet cable as shown in the next step.

Requires: Small flat screwdriver (optional), Rev radio PoE cable

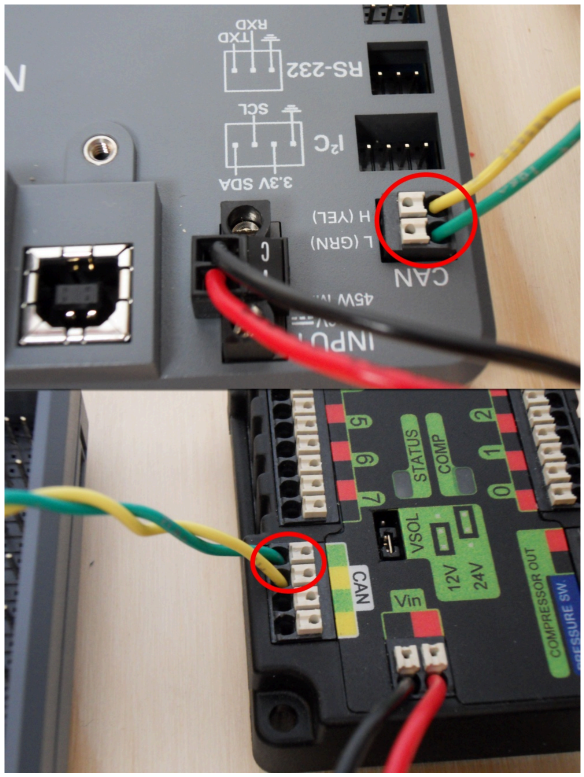
1. Insert the ferrules of the passive PoE injector cable into the corresponding colored terminals on the 12V/2A section of the VRM.
2. Connect the male RJ45 (Ethernet) end of the cable into the Ethernet port on the radio closest to the barrel connector (labeled 18-24v POE)

RoboRIO to Radio Ethernet

Requires: Ethernet cable

Connect an Ethernet cable from the female RJ45 (Ethernet) port of the Rev Passive POE cable to the RJ45 (Ethernet) port on the roboRIO.

RoboRIO to PCM CAN

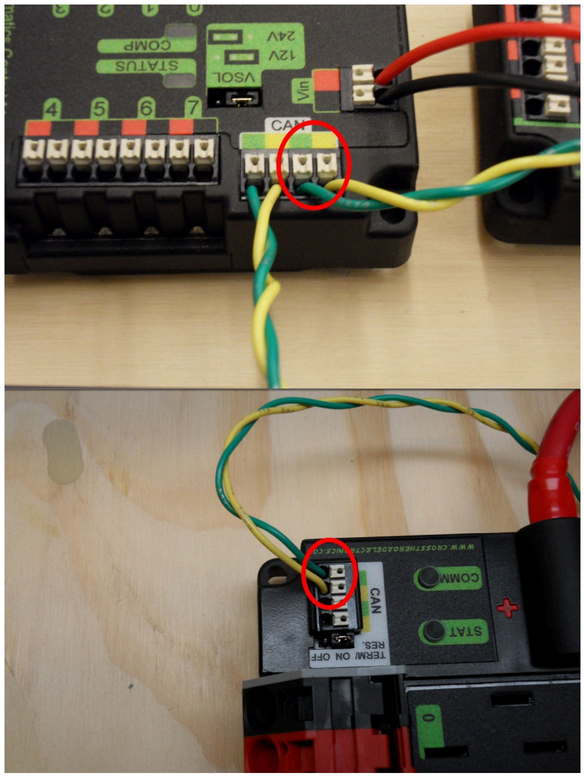


Requires: Wire stripper, small flat screwdriver (optional), yellow/green twisted CAN cable

Note: The PCM is an optional component used for controlling pneumatics on the robot. If you are not using the PCM, wire the CAN connection directly from the roboRIO (shown in this step) to the PDP (show in the next step).

1. Strip ~5/16" off of each of the CAN wires.
2. Insert the wires into the appropriate CAN terminals on the roboRIO (Yellow->YEL, Green->GRN).
3. Measure the length required to reach the CAN terminals of the PCM (either of the two available pairs). Cut and strip ~5/16" off this end of the wires.
4. Insert the wires into the appropriate color coded CAN terminals on the PCM. You may use either of the Yellow/Green terminal pairs on the PCM, there is no defined in or out.

PCM to PDP CAN



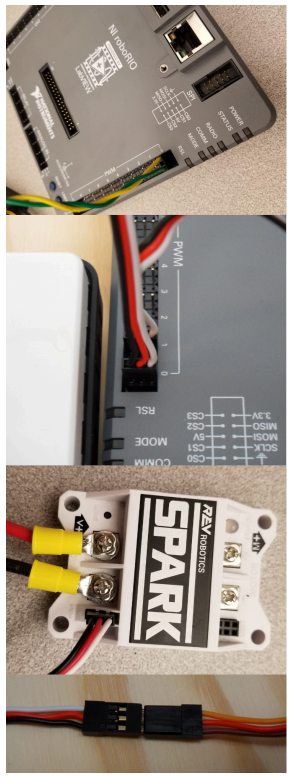
Requires: Wire stripper, small flat screwdriver (optional), yellow/green twisted CAN cable

Note: The PCM is an optional component used for controlling pneumatics on the robot. If you are not using the PCM, wire the CAN connection directly from the roboRIO (shown in the above step) to the PDP (show in this step).

1. Strip ~5/16" off of each of the CAN wires.
2. Insert the wires into the appropriate CAN terminals on the PCM.
3. Measure the length required to reach the CAN terminals of the PDP (either of the two available pairs). Cut and strip ~5/16" off this end of the wires.
4. Insert the wires into the appropriate color coded CAN terminals on the PDP. You may use either of the Yellow/Green terminal pairs on the PDP, there is no defined in or out.

Note: The PDP ships with the CAN bus terminating resistor jumper in the "ON" position. It is recommended to leave the jumper in this position and place any additional CAN nodes between the roboRIO and the PDP (leaving the PDP as the end of the bus). If you wish to place the PDP in the middle of the bus (utilizing both pairs of PDP CAN terminals) move the jumper to the "OFF" position and place your own 120 ohm terminating resistor at the end of your CAN bus chain.

PWM Cables



Requires: 4x PWM cables (if using non-integrated wire controllers), 2x PWM Y-cable (Optional)

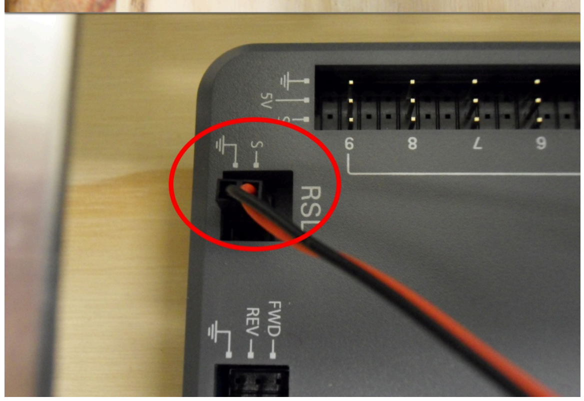
Option 1 (Direct connect):

1. Connect the PWM cables from each controller directly to the roboRIO. For Victor SPX's and other PWM/CAN controllers, the green wire (black wire for non-integrated controllers) should be towards the outside of the roboRIO. For controllers without integrated wires, make sure the controller side of the black wire is located according to the markings on the controller. It is recommended to connect the left side to PWM 0 and 1 and the right side to PWM 2 and 3 for the most straightforward programming experience, but any channel will work as long as you note which side goes to which channel and adjust the code accordingly.

Option 2 (Y-cable):

1. Connect 1 PWM Y-cable to the PWM cables for the controllers controlling one side of the robot. The brown wire on the Y-cable should match the green/black wire on the PWM cable.
2. Connect the PWM Y-cables to the PWM ports on the roboRIO. The brown wire should be towards the outside of the roboRIO. It is recommended to connect the left side to PWM 0 and the right side to PWM 1 for the most straightforward programming experience, but any channel will work as long as you note which side goes to which channel and adjust the code accordingly.

Robot Signal Light

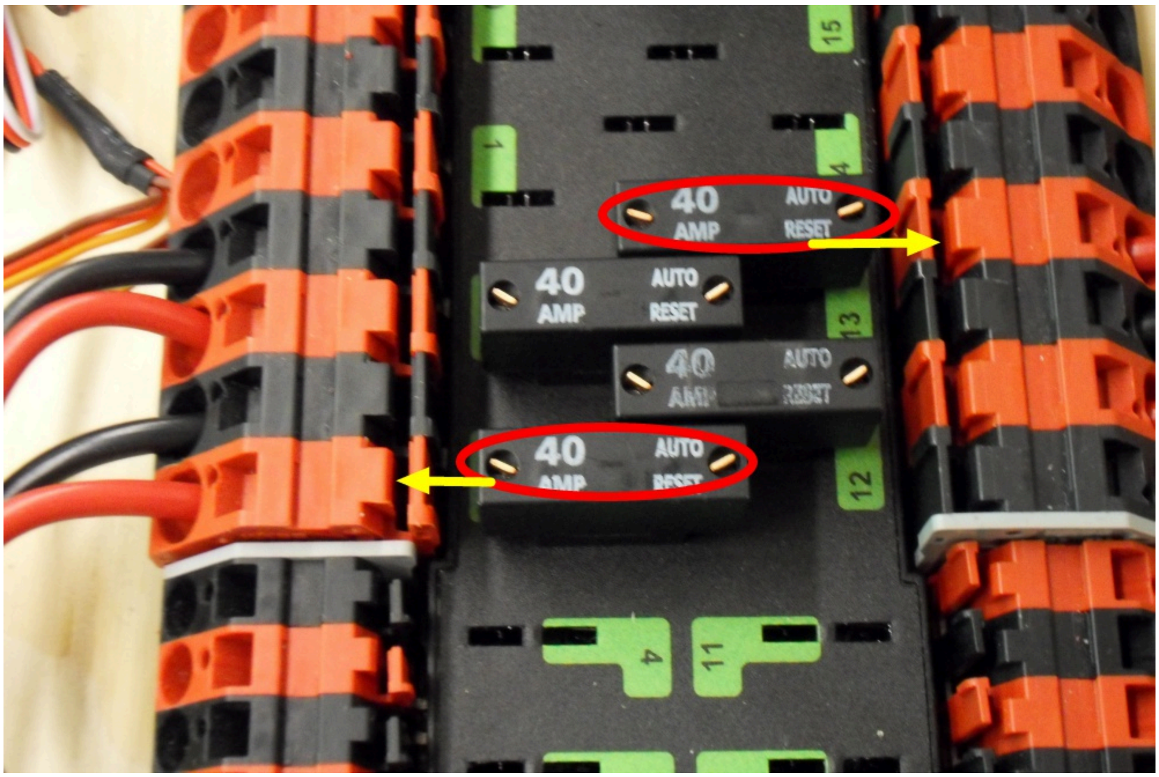


Requires: Wire stripper, 2 pin cable, Robot Signal Light, 18AWG red wire, very small flat screwdriver

1. Cut one end off of the 2 pin cable and strip both wires
2. Insert the black wire into the center, "N" terminal and tighten the terminal.
3. Strip the 18AWG red wire and insert into the "La" terminal and tighten the terminal.
4. Cut and strip the other end of the 18AWG wire to insert into the "Lb" terminal
5. Insert the red wire from the two pin cable into the "Lb" terminal with the 18AWG red wire and tighten the terminal.
6. Connect the two-pin connector to the RSL port on the roboRIO. The black wire should be closest to the outside of the roboRIO.

You may wish to temporarily secure the RSL to the control board using zipties or Dual Lock (it is recommended to move the RSL to a more visible location as the robot is being constructed)

Circuit Breakers

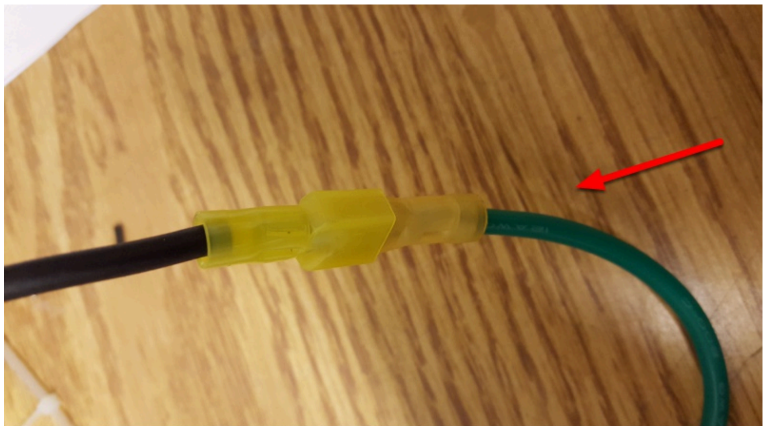


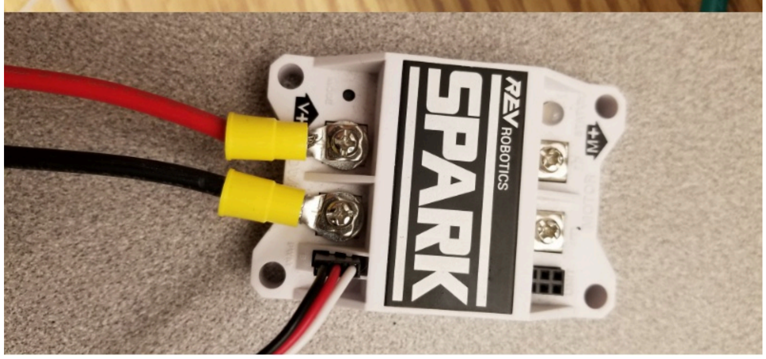
Requires: 4x 40A circuit breakers

Insert 40-amp Circuit Breakers into the positions on the PDP corresponding with the Wago connectors the Talons are connected to. Note that, for all breakers, the breaker corresponds with the nearest positive (red) terminal (see graphic above). All negative terminals on the board are directly connected internally.

If working on a Robot Quick Build, stop here and insert the board into the robot chassis before continuing.

Motor Power





Requires: Wire stripper, wire crimper, phillips head screwdriver, wire connecting hardware

For each CIM motor:

1. Strip the ends of the red and black wires from the CIM

For integrated wire controllers (including Victor SPX):

1. Strip the white and green wires from the controller
2. Connect the motor wires to the controller output wires (it is recommended to connect the red wire to the white M+ output). The images above show examples using quick disconnect terminals.

For Sparks or other non-integrated-wire controllers:

1. Crimp a ring/fork terminal on each of the motor wires.
2. Attach the wires to the output side of the motor controller (red to +, black to -)

STOP

STOP!!

Before plugging in the battery, make sure all connections have been made with the proper polarity. Ideally have someone that did not wire the robot check to make sure all connections are correct.

- Start with the battery and verify that the red wire is connected to the positive terminal
- Check that the red wire passes through the main breaker and to the + terminal of the PDP and that the black wire travels directly to the - terminal.
- For each motor controller, verify that the red wire goes from the red PDP terminal to the Talon input labeled with the red + (not the white M+!!!!)
- For each device on the end of the PDP, verify that the red wire connects to the red terminal on the PDP and the red terminal on the component.
- **Make sure that the orange Passive PoE cable is plugged directly into the radio NOT THE roboRIO! It must be connected to the roboRIO using an additional Ethernet cable.**

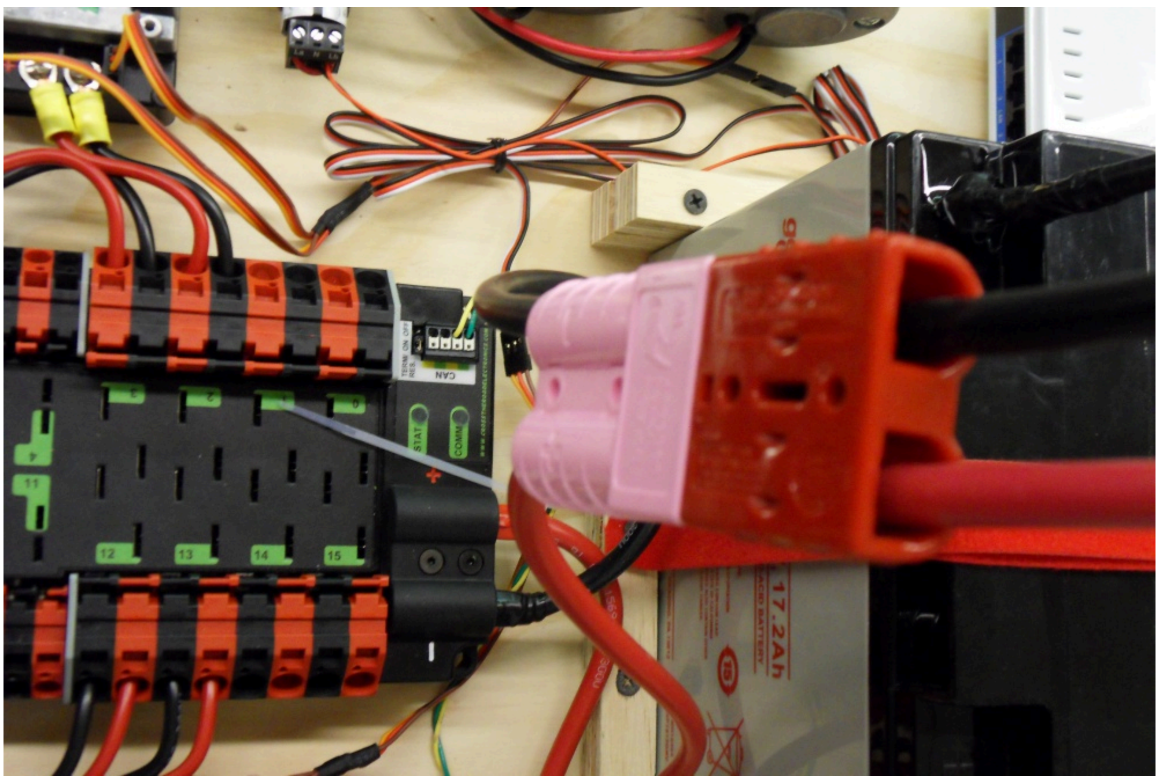
It is also recommended to put the robot on blocks so the wheels are off the ground before proceeding. This will prevent any unexpected movement from becoming dangerous.

Manage Wires

Requires: Zip ties

Now may be a good time to add a few zip ties to manage some of the wires before proceeding. This will help keep the robot wiring neat.

Connect Battery



Connect the battery to the robot side of the Andersen connector. Power on the robot by moving the lever on the top of the 120A main breaker into the ridge on the top of the housing.

Sensing

Analog Devices' Sensors

Analog Devices has put together user guides for all of their FRC offerings. You can read more about how to use these boards by going to www.analog.com/first.

CUI Devices - AMT10 Encoder

CUI DEVICES

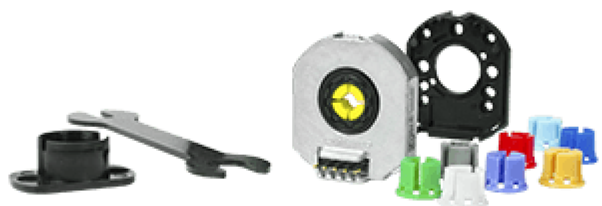
What Is It?

An encoder is a sensor and an essential part of the motion control feedback loop. The encoder can be used to provide precise position, rotation and speed feedback information for your robot. It can be used to measure the rate and count of rotations, how fast a shaft on your robot is turning (RPM), as well as how far something connected to the rotary shaft has traveled.

Teams have used these encoders in the past on the wheels of the robot to monitor speed, precisely control wheel movement and to count wheel rotations. Additionally, the encoders have been used on lifting mechanisms to control lifting speed as well as measure the lift height.

The AMT10 encoders, donated by CUI Devices, utilize capacitive technology to measure rotary motion. Using the DIP switch on the back of the encoder, these encoders can be quickly and easily set to any one of 16 different resolutions, allowing for maximum versatility within your robot design. Additionally, the encoder has an index pulse (Z), occurring once per rotation. This index pulse is ideally suited for determining motor or shaft RPM.

CUI Devices' AMT10 encoders were made available through *FIRST* Choice and additional AMT parts/accessories are readily available through Digi-Key Electronics at www.digikey.com.



How are They in the Kit of Parts?

There were/are a limited number of these encoders available in the *FIRST* Choice area of the Kit of Parts system.

- AMT103 Base, PN AMT-B1-S
- AMT103 Cable Assembly, 5-pin, 5 x 22AWG, 1 ft., PN CUI-435-1FT
- AMT103 Cable Assembly, 5-pin, 5 x 22AWG, 6 ft., PN CUI-3934-6FT
- AMT103 Wide Base, PN AMT-B1-W
- Modular Incremental Encoder Kit, AMT10 Series, Axial, PN AMT103-V

For spare or additional encoders, please visit Digi-Key.

Datasheet

View technical specifications and drawings for CUI Devices' AMT10 encoder series here.

Installing the Encoder

Need help mounting CUI Devices' AMT encoder? Visit their mounting instructions page for more information.

Improper Mounting

Improper mounting is the leading cause of poor performance or incorrect readings with the AMT10 encoder. Please reference the video above and other resources or feel free to contact amtsupport at cuidevices dot com for help with troubleshooting any errors.

FAQs

Have questions about CUI Devices' AMT encoder series? Check to see if these frequently asked questions about the product and technology might have your answer.

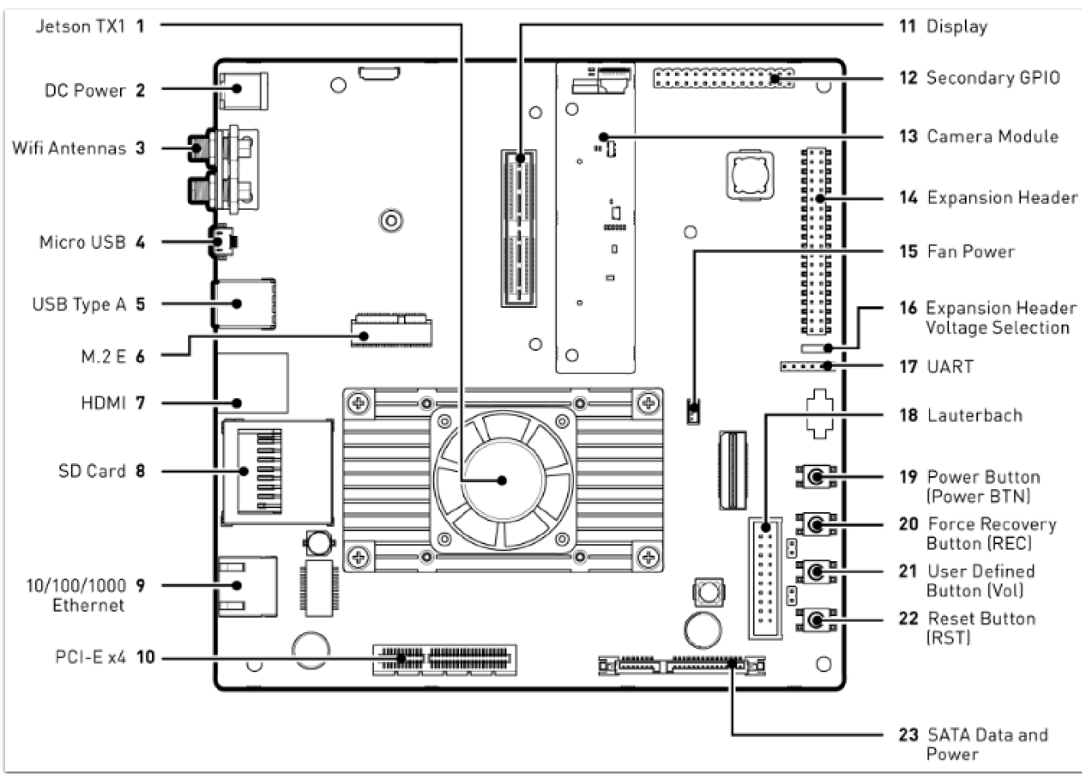
Suggestions?

If you have any helpful tips or tricks in using this item in *FIRST* Robotics Competition applications, please send them to frcparts at firstinspires dot org. Thank you!

Jetson TX1 Developer Kit

Here are some resources for using the Jetson TX1 for *FIRST* Robotics Competition.

Jetson TX1 Developer Kit Line Art



Instructional Videos

Getting Started

1. Unbox your Jetson and get setup (see video below).
2. Join our Embedded Developer Program and download JetPack to get the latest software and tools.

Unboxing the NVIDIA Jetson TX1 Developer Kit

Get an inside view of the new NVIDIA Jetson TX1 DevKit. It is the newest member of the Jetson platform., with even more performance and power efficiency than its predecessor, the Jetson TK1.

Embedded Deep Learning with Jetson

Watch this free webinar to get started developing applications with advanced AI and computer vision using NVIDIA's deep learning tools, including TensorRT and DIGITS.

OpenCV on NVIDIA Jetson: Episode 1: CV Mat Container

Learn to work with mat, OpenCV's primary container. You'll learn memory allocation for a basic image matrix, then test a CUDA image copy with sample grayscale and color images.

Double Your Deep Learning Performance with JetPack 2.3

Learn how to double your deep learning performance with JetPack 2.3. This all-in-one package bundles and installs all system software, tools, optimized libraries and APIs, along with providing examples so developers can quickly get up and running with their innovative designs. Key features include TensorRT, cuDNN 5.1, CUDA 8 and multimedia API.

For more video tutorials, visit us here.

Documentation

Note: Some downloads require NVIDIA Embedded Developer Program membership. Not a member? Join the Embedded Developer Program for free here.

- Jetson TX1 Developer Kit Product Sheet PDF
- Jetson TX1 Developer Kit 3D CAD Step Model
- Multimedia Guide
- Jetson TX1 Thermal Design Guide

NVIDIA Jetson Community

Have questions or issues about your Jetson TX1 Developer Kit?

Visit our Jetson TX1 Developer Forum

1. If you aren't already a member, join now. * Be sure to include your FRC team number.
2. Click on "Create Topic"
3. Make sure to explain that you are from FIRST Robotics. A community member or seasoned NVIDIA person can help with your issues.

GitHub Resource

Explore code samples, tutorials and more on our Getting Started with Deep Learning GitHub Repo.

More Information

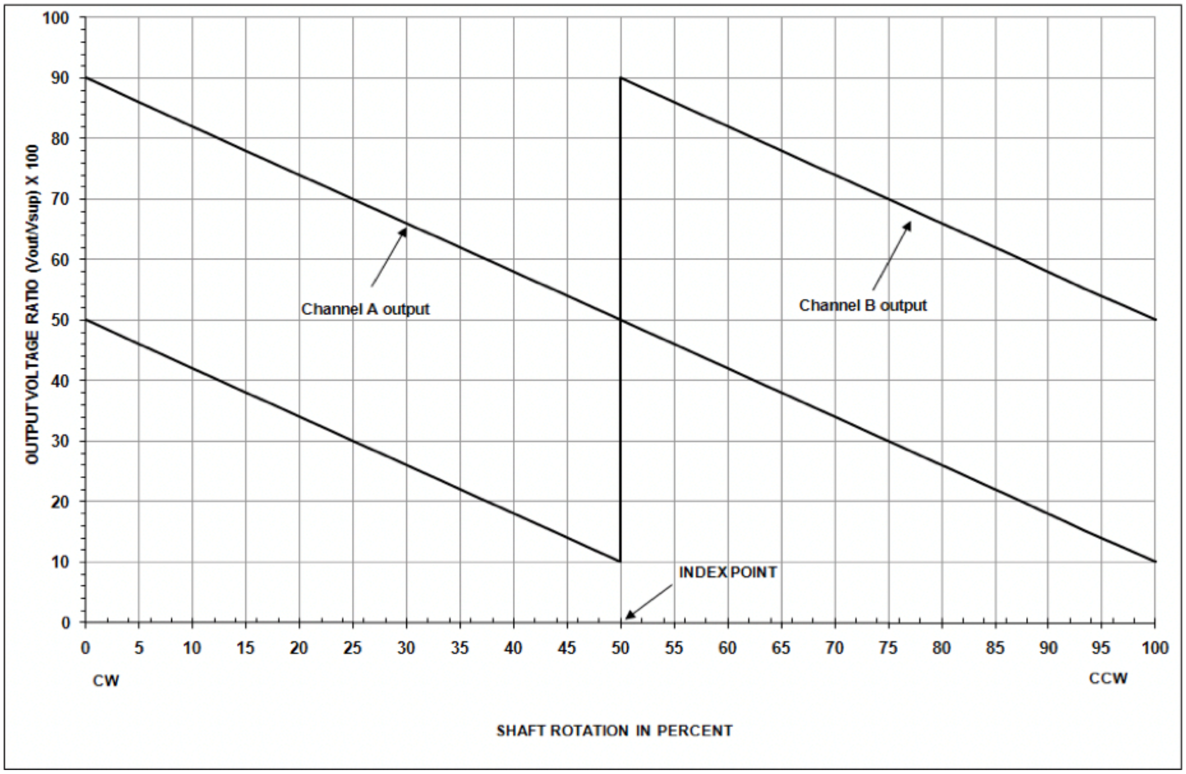
For more information, visit:

- NVIDIA Jetson and FIRST Robotics page
- Jetson Wiki

John Deere Encoder (RE321826)

Application Information

RE321826 is a Hall Effect dual output analog sensor. It is designed to be used in rugged environments typically encountered on agricultural, construction, and forestry machines. Each channel is independently powered. The output of the two channels are 180 degrees out of phase so when one channel is transitioning from minimum to maximum output the other channel is at the midpoint of its output. Monitoring both channels provides uninterrupted continuous rotational position information.



Electrical Characteristics

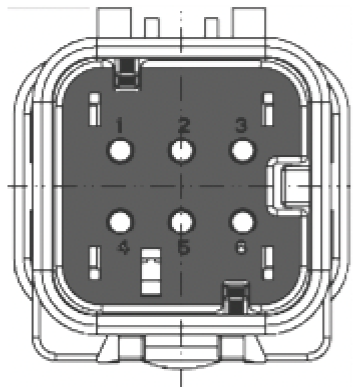
- Supply voltage: 5 V +/- 0.25 V
- Supply current: 16 mA per channel maximum
- Reverse voltage protection: 10 V maximum
- The analog voltage output operates between 10% and 90% of the 5V reference.

Connector

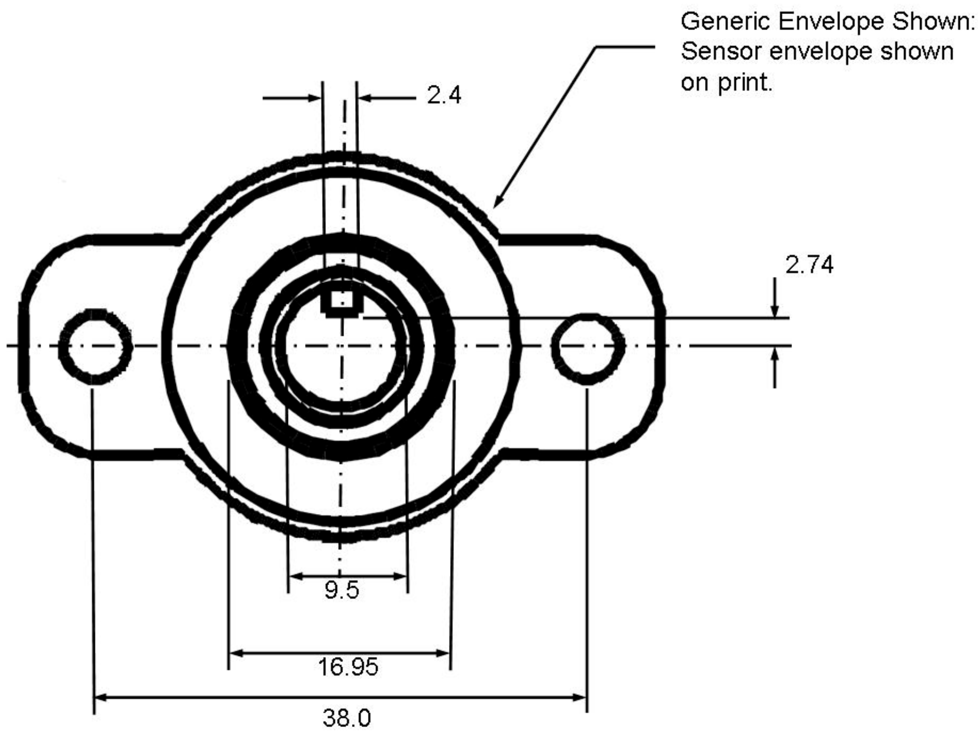
Unit contains an embedded AmpSeal 16 6-position Tyco 776434-1 (JD 57M9753) with gold pins Tyco 638078-1 (JD 57M9810) compatible connector that mates with Tyco 776433-1 (JD 57M9750) or Tyco 776531-1 (JD 57M9786) with gold sockets Tyco 776492-1 (JD 57M9806) or Tyco 1924464-1 (JD 57M9808).

KoP Item Resources

	Channel A	Channel B
Ground	1	4
Signal	2	5
Supply	3	6



Physical Characteristics



(dimensions in mm)

The unit is actuated by a 9.5mm (⅜") diameter shaft with a 2.4mm (3/32") keyway. The shaft included in the kit is a proper fit or a shaft can be made using typical ⅜" keyed shaft in steel or aluminum. The included R86457 bracket can be used as a guide for the shaft.

navX-MXP

Kauai Labs
Build Better Robots®

Measuring motion/orientation, improving your autonomous and tele-operated software, and expanding roboRIO I/O

The navX-MXP Robotics Navigation Sensor provides an accurate, easy-to-use way to measure motion and 3D orientation of any object (for instance, your robot chassis or a robotic arm).

These capabilities enable you improve your autonomous and teleoperated programs by adding intelligent features including:

- Driving in a straight line
- Rotating automatically to a specific angle
- Field-oriented drive
- Automatic Balancing
- Motion Detection
- Collision Detection

navX-MXP is both a self-calibrating Inertial Measurement Unit (IMU) and an Attitude/Heading Reference System (AHRS).

navX-MXP is simple to install on a roboRIO, and includes roboRIO I/O expansion features.

Inertial Measurement Unit (IMU)

navX-MXP is an Inertial Measurement Unit (IMU), and includes 6 sensors which measure inertial motion: 3 accelerometers measuring acceleration (in units of Standard Gravity [g]) and 3 gyroscopes measuring Rotational Speed (in units of degrees per second).

Additionally, through a process called “Motion Processing”, navX-MXP intelligently combines the 6-axis inertial sensing data to create a measurement of relative 3D orientation.

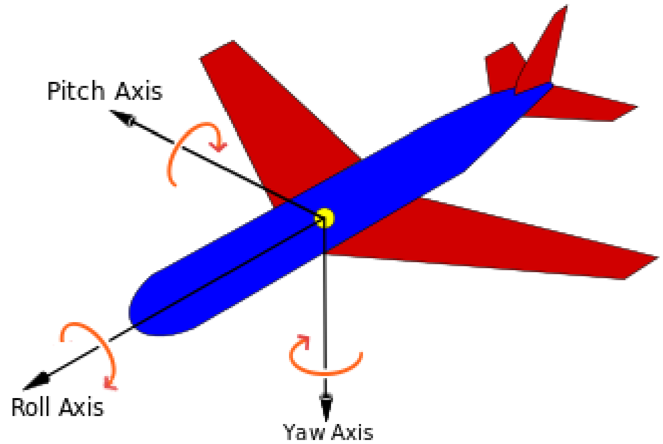


Figure 1 Measuring Orientation with Yaw, Pitch and Roll Angles (Photo credit: Creative Commons License v. 3.0, More Info: https://commons.wikimedia.org/wiki/File:Yaw_Axis.svg, Source: Wikimedia Commons, the free media repository, Author: Auawise

IMUs are typically used to measure aircraft orientation, but are also very useful for controlling a robot. IMUs measure rotation of an object around the Z-axis (known as "Yaw"), the X-axis (known as "Pitch") and the Y-axis (known as "Roll").

Pitch and Roll angles are absolute (tied to the earth's surface); 0 degrees means "flat" with respect to the earth.

However, IMU Yaw angles are ***relative*** - not tied to any direction (like North on a Compass). Therefore, your robot application must decide where 0 degrees is. Usually, FRC robots treat the "head" of the field (the direction driver's face) as 0 degrees.

For more information, please visit the navX-MXP Terminology page.

Digital Compass and Attitude/Heading Reference System (AHRS)

navX-MXP also includes 3 magnetometer sensors, which measure magnetic fields (in units of Tesla). By measuring the earth's magnetic field, navX-MXP provides a digital compass which is a different way of measuring the Z ("Yaw") axis.

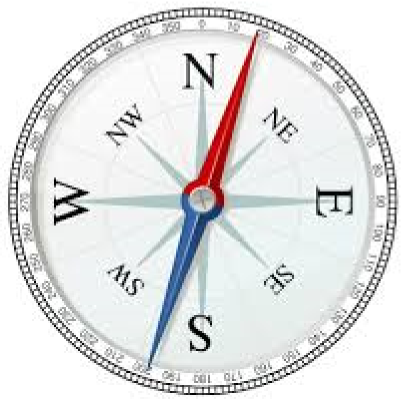


Figure 2 Measuring Z-axis Orientation with a Compass (Photo credit: Creative Commons Zero 1.0 Public Domain License, More Info: https://openclipart.org/detail/236412/simple-compass, Source: OpenClipArt.org, Author: alexg)

And by intelligently fusing the digital compass with the IMU can create a measurement of absolute 3D orientation.

Note: Earth's magnetic field is actually very weak when compared to the magnetic field generated by a nearby motor; for this reason it can be difficult to get accurate digital compass readings on a FRC robot. For this reason, using the navX-MXP AHRS is an advanced feature best suited for teams who have the time to learn about how to calibrate the navX-MXP digital compass *and also how to deal with magnetic disturbances.*

roboRIO Hardware Installation

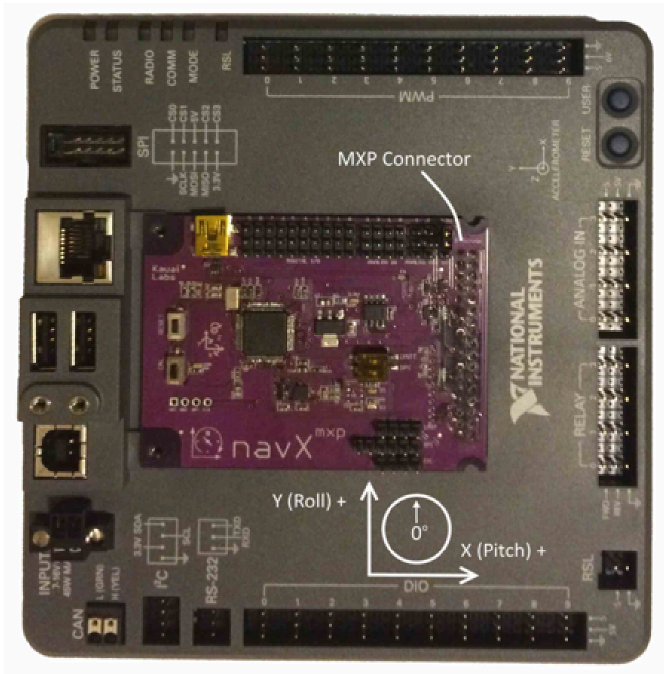


Figure 3 navX-MXP Circuit Board installed into the RoboRIO MXP slot (Photo credit: Kauai Labs)

The navX-MXP can be easily connected to a National Instruments roboRIO MXP port. This only takes about 5 seconds and provides a stable, secure base for the onboard sensors that is aligned to the axes of your robot. Two screws are provided with navX-MXP to secure the circuit board to the roboRIO. More information may be found on the navX-MXP roboRIO installation page.

USB (optional, or to connect to your vision co-processor)

Figure 4 USB Mini-B Cable (Photo Credit: Kauai Labs)

A secondary configuration possibility is to connect navX-MXP to a roboRIO or another computer via USB possible because *data from navX-MXP flows simultaneously to the MXP connector and the USB port*. Some teams have connected the navX-MXP USB port to a co-processor in order to integrate navX-MXP sensor measurements into their vision processing. To support access to USB-based navX-MXP data from a Linux-based co-processor, a Linux library was developed by Team 900 (Zebracorns) and is available here.

NOTE: As further described in the navX-MXP Best Practices, a USB cable connected to your roboRIO can also provide a secondary power supply in case of roboRIO brownout.

Enclosure

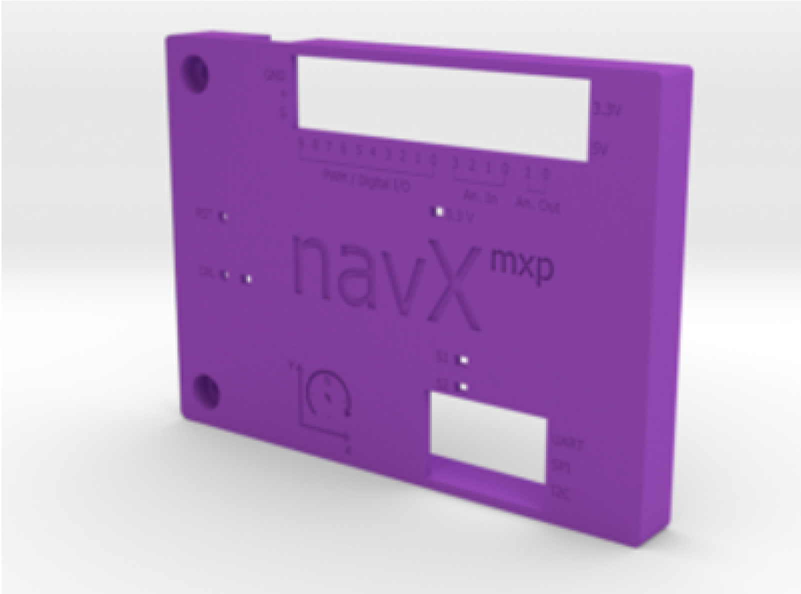


Figure 5 navX-MXP enclosure (Photo Credit: Kauai Labs)

An enclosure is recommended to protect the navX-MXP circuit board from excessive handling, “swarf”, electrostatic discharge (ESD) and other elements that can potentially damage navX-MXP.

Visit the navX-MXP Enclosure page to either purchase an enclosure for navX-MXP or to download a 3D-printable design file.

roboRIO Software Installation

To access navX-MXP from your roboRIO robot application, install the navX-MXP Libraries for roboRIO.

Using navX-MXP

Many example programs are available for navX-MXP in C++, Java and LabVIEW. Visit the navX-MXP Examples page for a description of each example and details on how to use it with your chosen programming language.

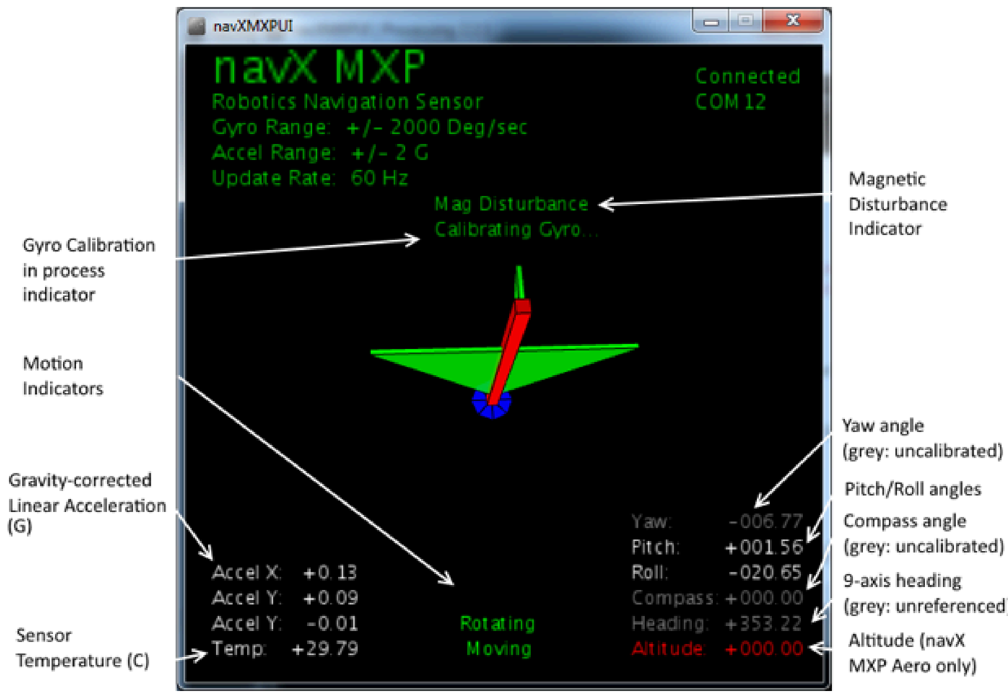


Figure 6 navXUI (Photo Credit: Kauai Labs)

Learning More

To learn more about how navX-MXP works, you can use navXUI, which runs on a Windows PC connected via USB to the navX-MXP and demonstrates all of the navX-MXP features. navXUI also provides a way to save navX-MXP data to a file so you can analyze it. navXUI can even run simultaneously with your roboRIO robot application.

Best Practices

If you want to get the most out of your navX-MXP and achieve results similar to those of the top FRC teams, the navX-MXP Best Practices is just for you. These guidelines will help you avoid common pitfalls and achieve the highest possible accuracy.

Getting Help

If you have trouble with navX-MXP, please visit the navX-MXP support page; you can join the navX-MXP newsgroup or contact technical support for help.

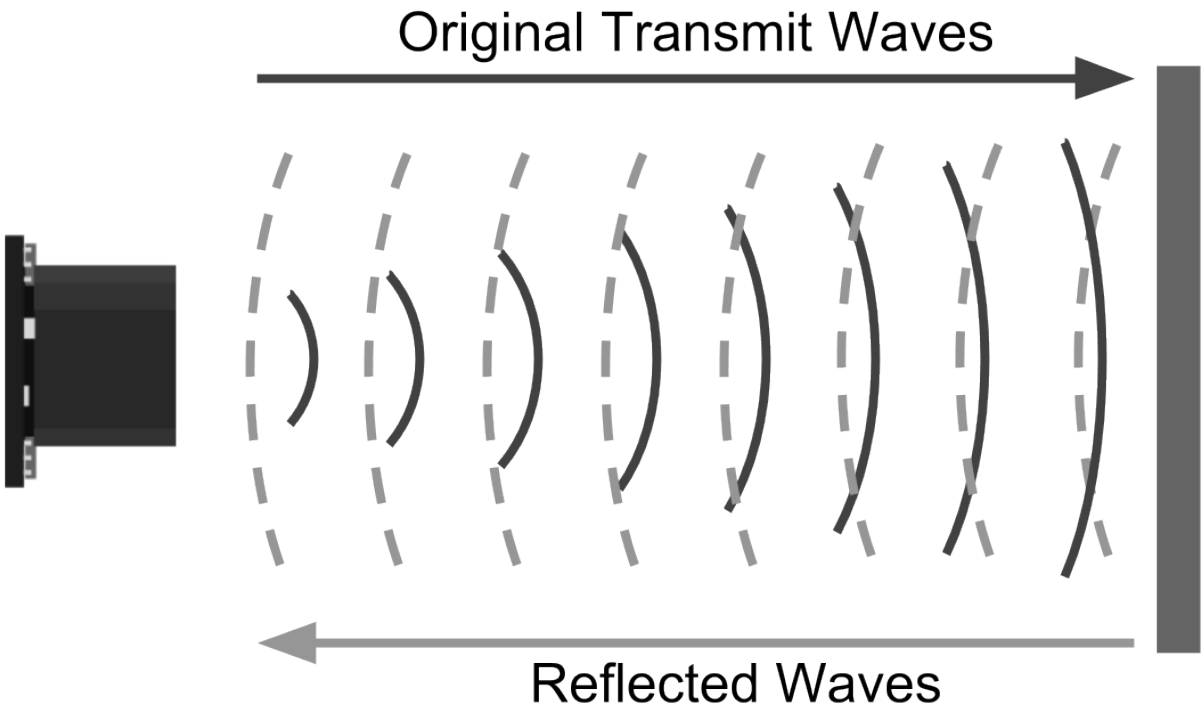
MB1013 HRLV-MaxSonar-EZ Ultrasonic Sensor Set-up Guide

Below we have a tutorial to help you get started with the MaxBotix MB1013 ultrasonic sensor! This will hopefully give you a basic understanding of how ultrasonic sensors work and will help you set up your ultrasonic sensor to read analog voltage.

Take a look at this sensor's data sheet for more information on the sensor's specs!

How Ultrasonics work

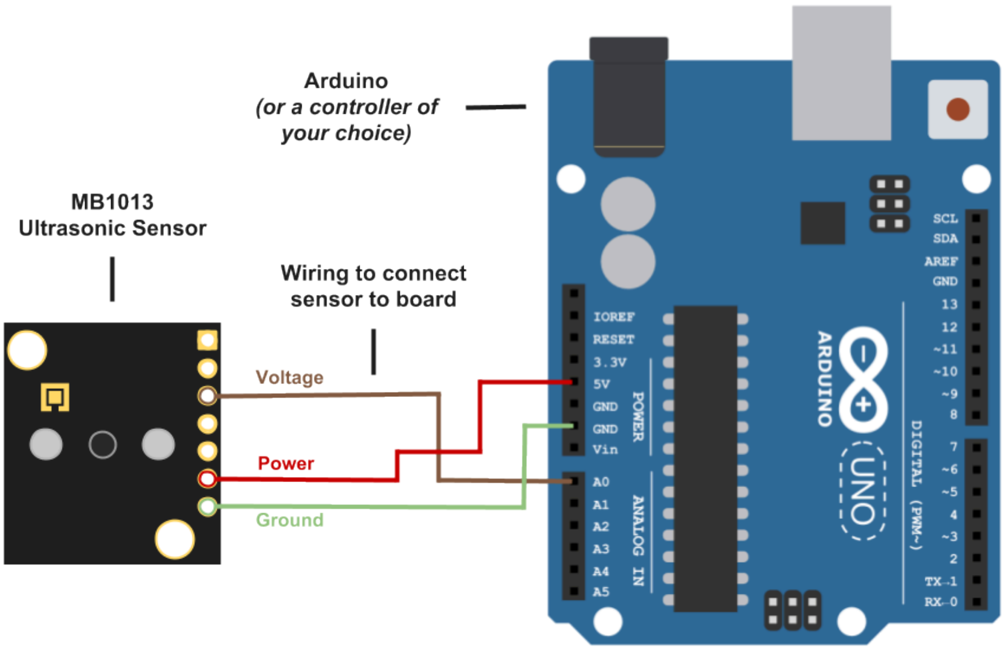
Using sound, the ultrasonic rangefinder measures distance for you. The diagram below shows how the sensor sends and receives the sound waves. It measures the distance using the time it takes for the sound wave to leave, reflect off of a surface or object, and travel back to the sensor.



Using Your Ultrasonic Sensor in your Project

1. HOOK UP CONTROLLER

We used an Arduino in this example, but you can use another controller and program of your choice.



2. INSTALL SOFTWARE

Install *Arduino Sketch* coding software onto your PC. This is where you type the code you want to compile and send to the Arduino board.

3. SET UP YOUR SENSOR WITH ARDUINO

Plug your Arduino into the USB cable and into your computer. Once you upload Arduino, you can then compile and activate the code.

4. COMPILE AND RUN CODE

The code below will allow you to read distance in centimeters. Compile and run this code to obtain real-time distance measurements to the closest object. (Please note: this code is not only for Arduino and will run on most controllers)

```
const int anPin = 0;

long anVolt, cm;
```

```
void setup() {
  Serial.begin(9600);
}


void read_sensor(){
  anVolt = analogRead(anPin);
  cm = anVolt/2;
}


void print_range(){
  Serial.print("Range = ");
  Serial.print(cm);
  Serial.print(" cm ");
  Serial.print('\n');
}

void loop() {
  read_sensor();
  print_range();
  delay(100);
}
```

How This Helps You

How can you use this information? Glad you asked! There are quite a few applications in which this becomes very useful.

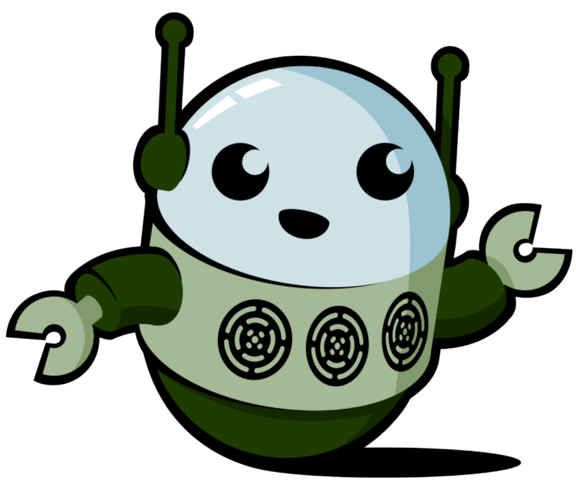
One, distance to objects data is extremely useful for the autonomous section of the contest. Your robot can actually use the distance when navigating to help avoid objects.

Another use is if you need to perform an action when your robot is a certain distance from an object. You can use the information to make the robot perform better and much more quickly even during the remote-controlled section of the contest.

Also, as good as Lidar sensors are, only ultrasonic sensors can reliably detect certain surfaces such as glass. Transparency and color of objects have no effect on if an ultrasonic sensor can see an object. This is especially useful if you don't know what kind of environment your robot will be operating in.

Need More Help?

If you find yourself in need of more information about the MaxSonar sensor and your project, we at MaxBotix are more than happy to help you. Please call us at (218)454-0766 or email our technical support team at techsupport@maxbotix.com.

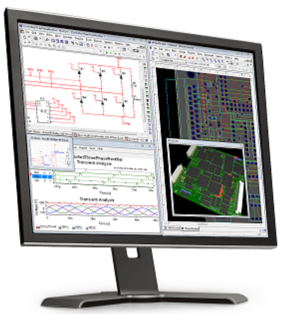


Software

Multisim, Ultiboard, and Statechart Module

All FRC teams can use the FRC LabVIEW serial number included in their Kick Off Kit to activate Multisim, Ultiboard, and Statechart Module. These are all great tools that can help you during build season. See below to learn more and download.

Use Multisim and Ultiboard to Prototype, Test, and Build Circuit Boards



Multisim is an industry-standard, best-in-class SPICE simulation environment. It is the cornerstone of the NI circuits teaching solution to build expertise through practical application in designing, prototyping, and testing electrical circuits. Learn more about Multisim here.

Ultiboard enables efficient layout and routing of PCB designs. Integration with NI Multisim allows seamless transfer of schematics to layout. Learn more about Ultiboard here.

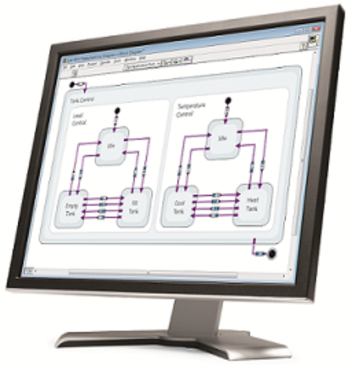
More technical resources for Multisim and Ultiboard.

Expansion Board Developer Guide for roboRIO

Note: If you'd like to use these tools before FRC kick off, you can download from the link above and use it for a 45 day trial.

Use LabVIEW Statechart Module to Simplify Code with High Level Abstraction

KoP Item Resources

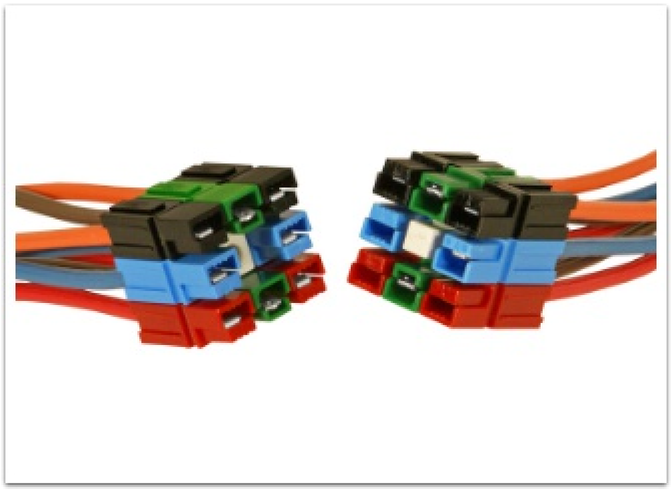


Statechart Module is a LabVIEW add-on that provides a high level of abstraction for designing applications using states, transitions, and events. This helps to keep code organized, scalable, well documented, and easy to read. You can deploy these applications to roboRIO. Learn more about State Chart Module here.

Wiring & Connections

APP Powerpole Connectors

PP14 to PP45 (the "small" ones)



Specification Sheet

ds-pp1545-1.pdf

Assembly Instructions

Powerpole_Assembly_Instructions.pdf

SB50 (the "large" ones)

Specification Sheet

ds-sb50.pdf

Assembly Instructions

SB_Assembly_Instructions.pdf

Connector Crimping & Preventative Maintenance

CRIMPING___MAINTENANCE.pdf

How to Mate a Flat Wiping Contact

See Anderson Power Products' video on how to make a flat wiping contact here.

Other

FIRST Bumper Logo

1. Iron setting on high
2. Thin cloth in between transfer backing and iron
3. Apply pressure and iron in a circular motion
4. Check by peeling back. If it comes off cleanly, you're done; if not, keep ironing checking frequently.

Robot Mechanisms: A Curriculum Developed for Robotics Competitions

Siemens hopes you enjoy taking these short, self-paced classes to get a better understanding of the basics of robotics: mechanisms and motion.