# Other KoP Item Resources

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# Other KoP Item Resources

# Control

# VMX-pi Vision/Motion Processor & Robotics Controller

**Kauai Labs**

***Build Better Robots®***

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.

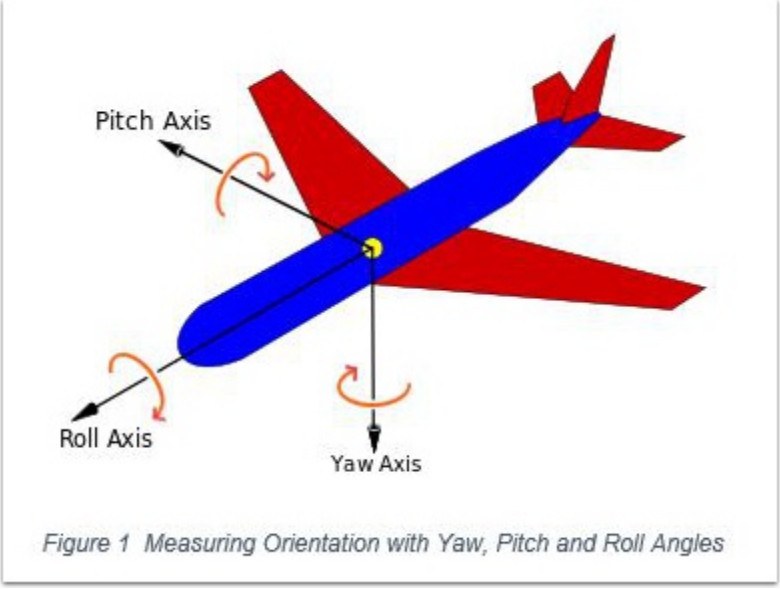



*Figure 1  Measuring Orientation with Yaw, Pitch and Roll Angles*

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.

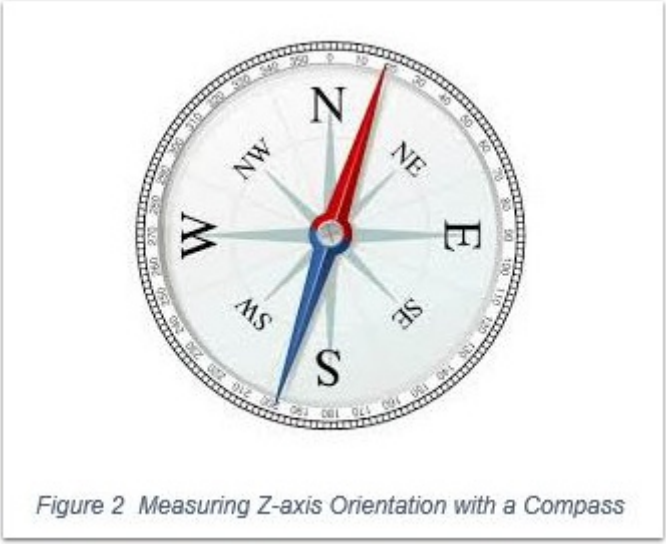



*Figure 2 Measuring Z-axis Orientation with a Compass*

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:

# Other KoP Item Resources

| 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 |
| 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.

# Other KoP Item Resources

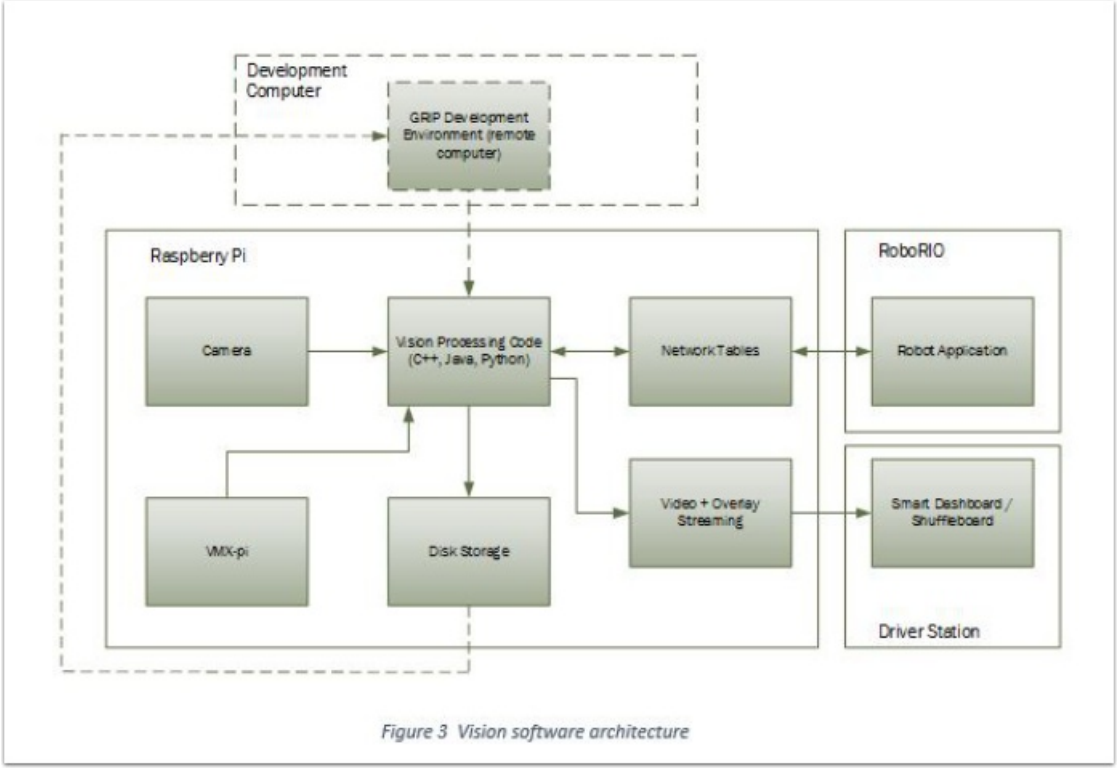



*Figure 3 Vision software architecture*

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

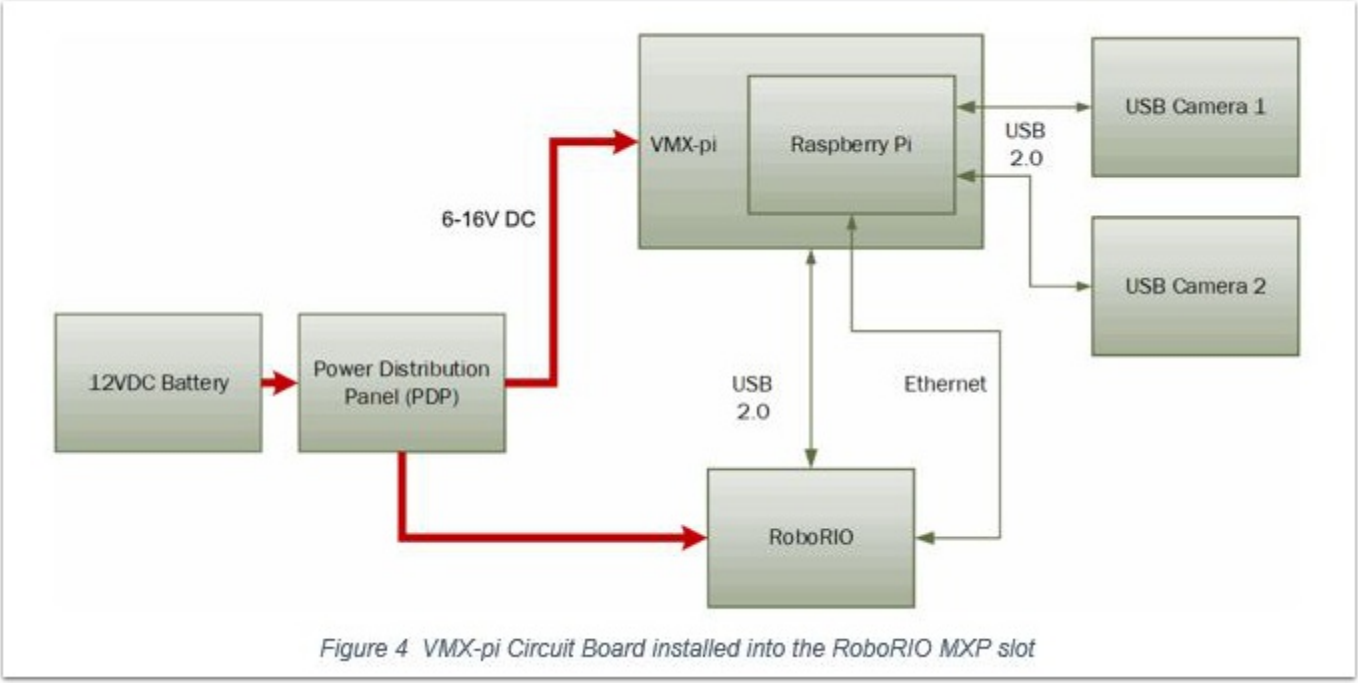



*Figure 4 VMX-pi Circuit Board installed into the RoboRIO MXP slot*

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.

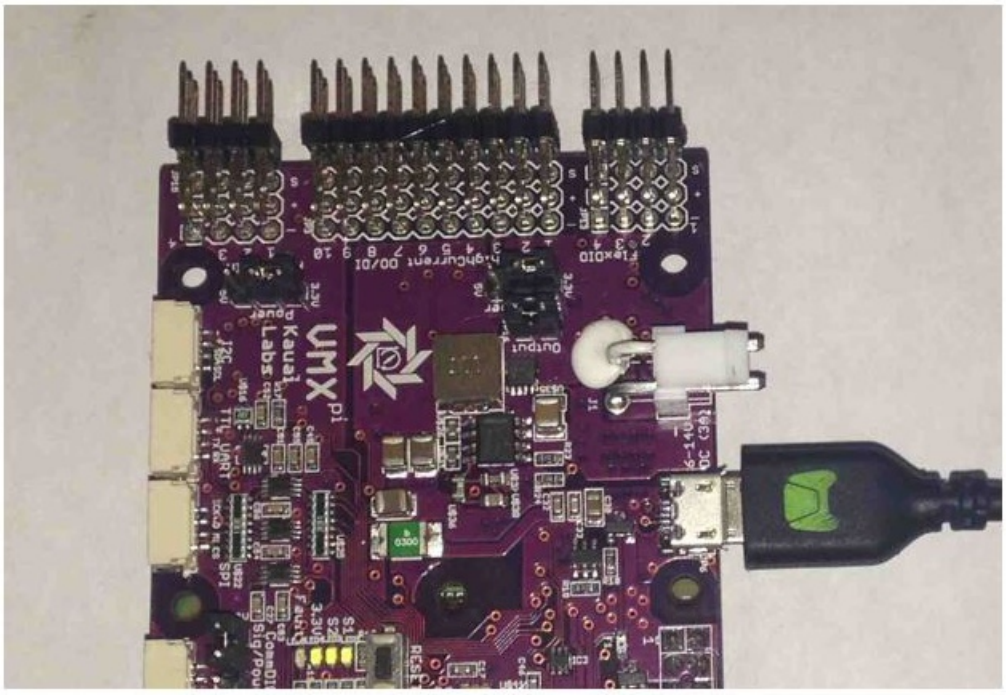


*Figure 5  VMX-pi USB connection for configuration and IMU data access*

## 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)

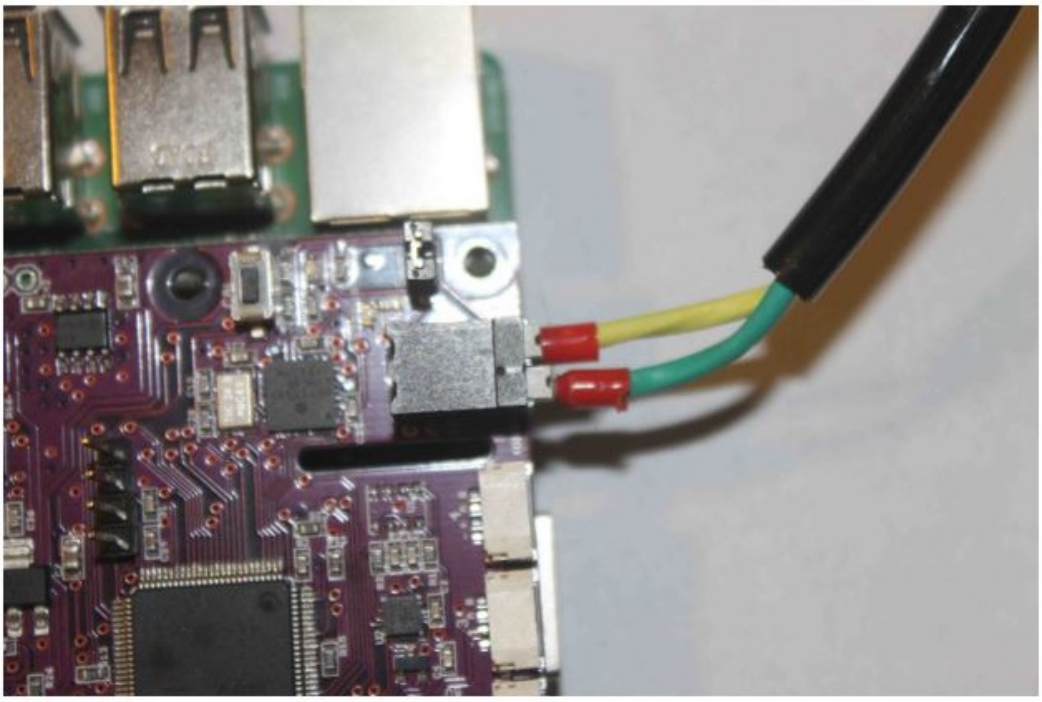


*Figure 7 Connecting VMX-pi to the CAN Bus*

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.

# Other KoP Item Resources

## 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.

# Other KoP Item Resources

## 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

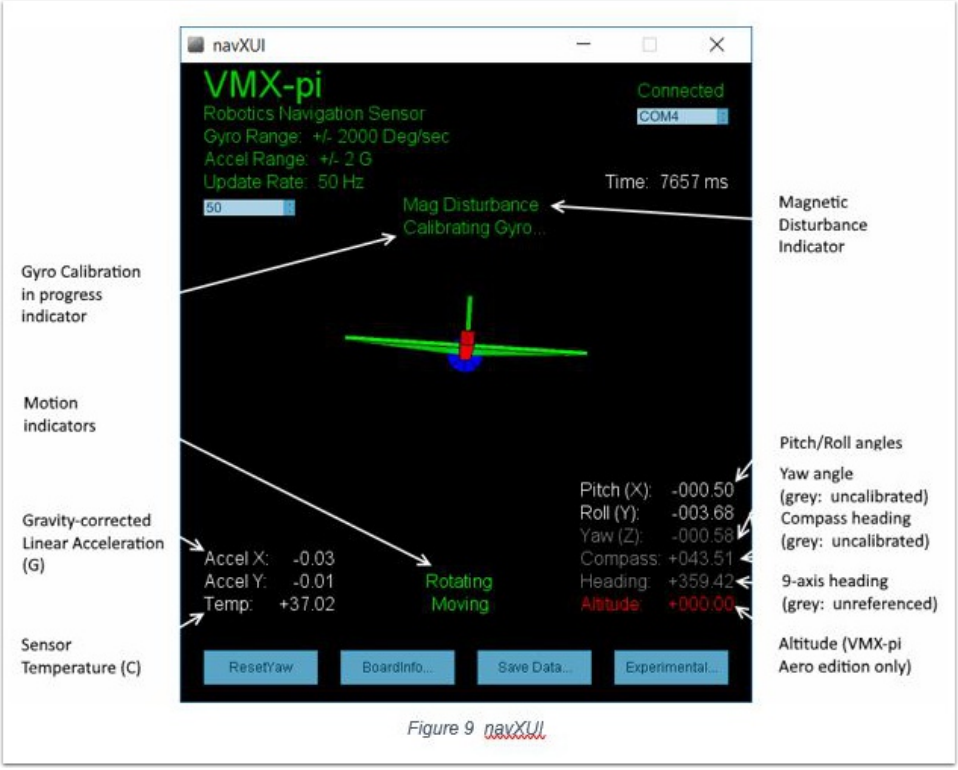



*Figure 9 navXUI*

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.

# Other KoP Item Resources

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

# 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.

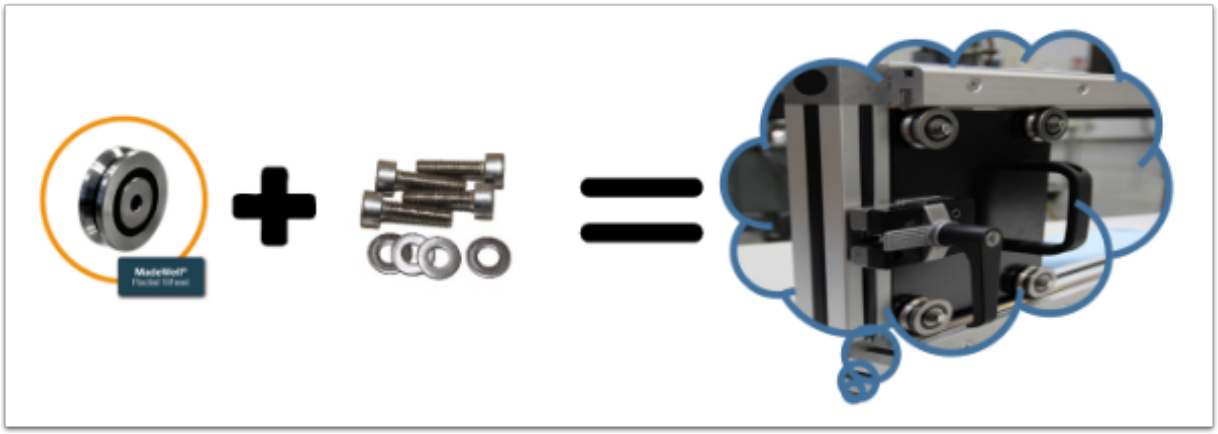
# Other KoP Item Resources

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!

# Other KoP Item Resources

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

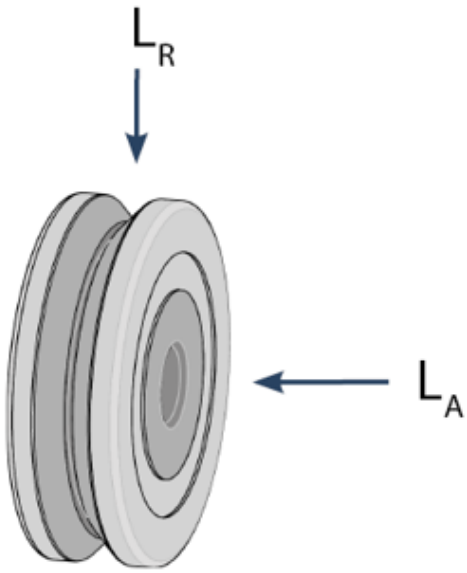
| TECHNICAL SPECIFICATIONS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SIZE | STOCK CODE | MATERIAL | OUTSIDE DIAMTER (D) | WHEEL WIDTH (W) | BORE DIAMETER (B) | VEE RADIUS INSIDE (VRI) | INNER RADIUS (C) | OUTER RADIUS (E) | WEIGHT (g) |
| 1 | W1RX | AISI 52100 Carbon steel | Ø0.771 [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]

# Other KoP Item Resources

### 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

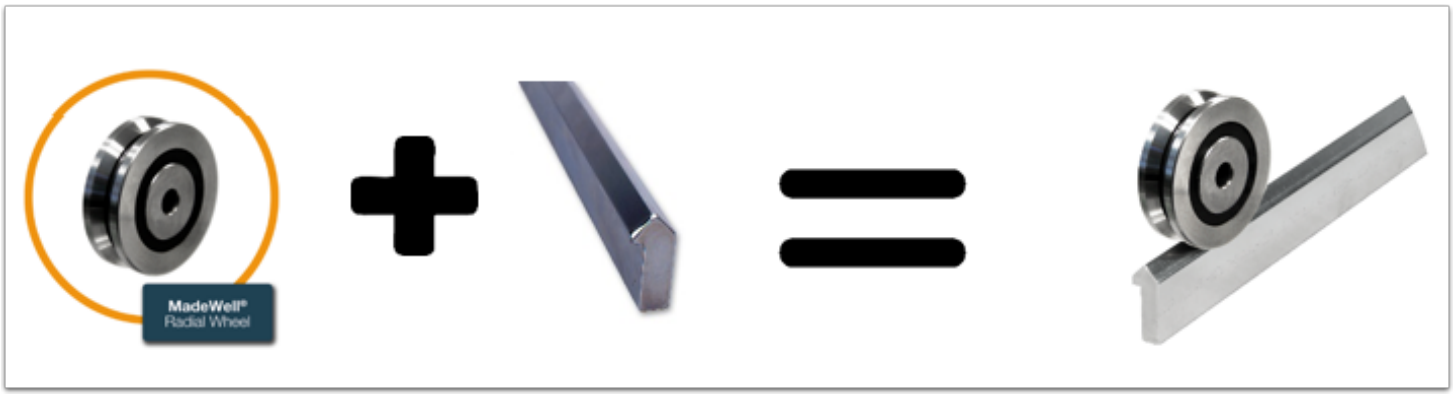
### What is DualVee track made of?

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.

# Other KoP Item Resources




**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.

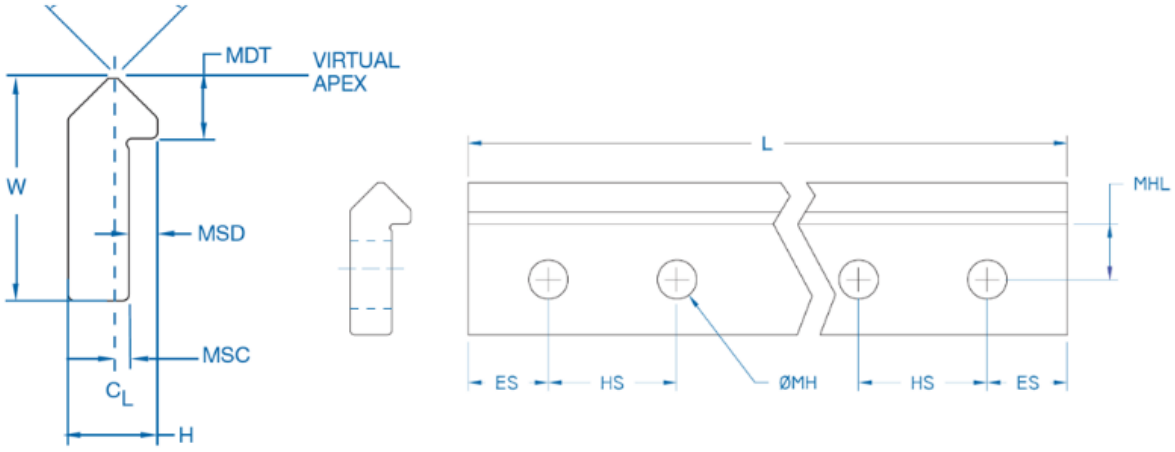
# Other KoP Item Resources

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.

**Drilled and Undrilled Dimensions**

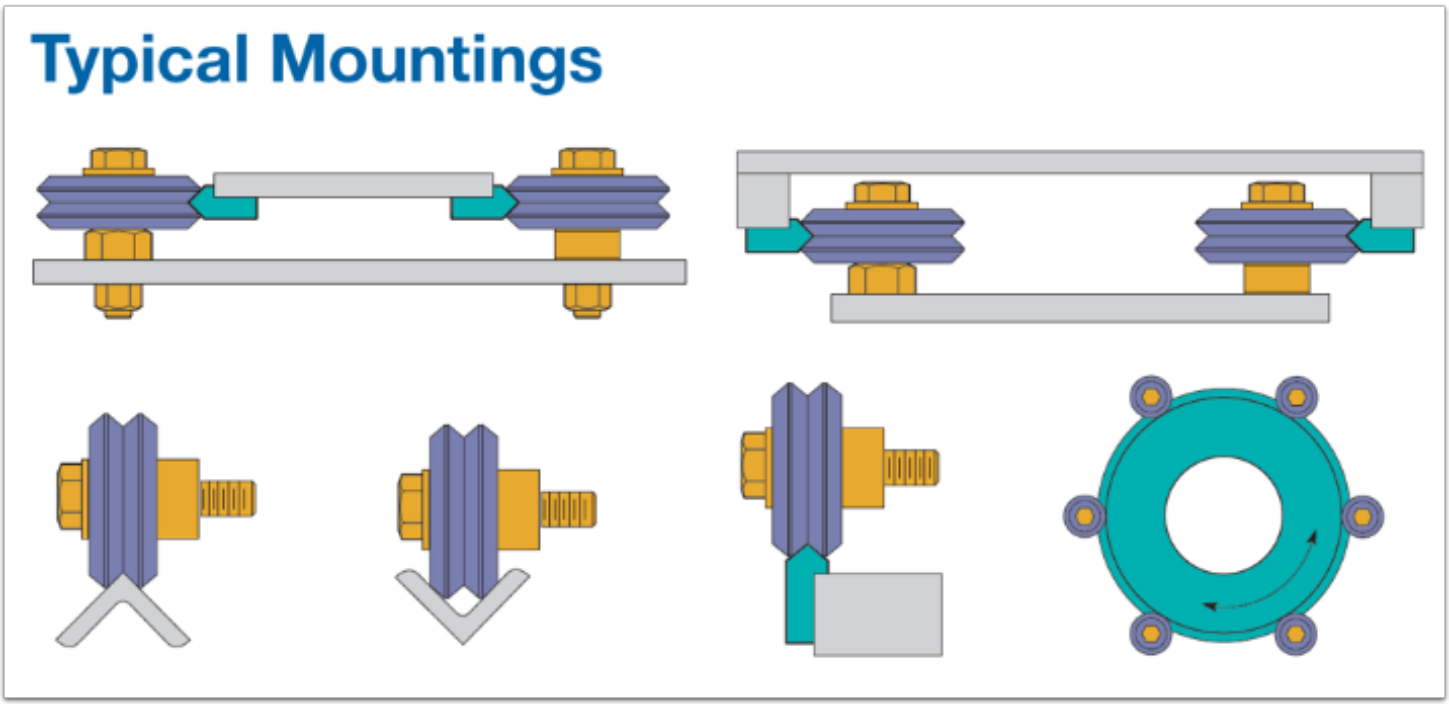
| Size | Width | Height | Mounting Shoulder Location | Mounting Shoulder to Center Line | Mounting Shoulder Depth | Drilled Track Hole Dimensions | | | | Weight |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | End Hole Spacing | Hole to Hole Spacing | Hole Size Thru (Diameter) | Mounting 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 |



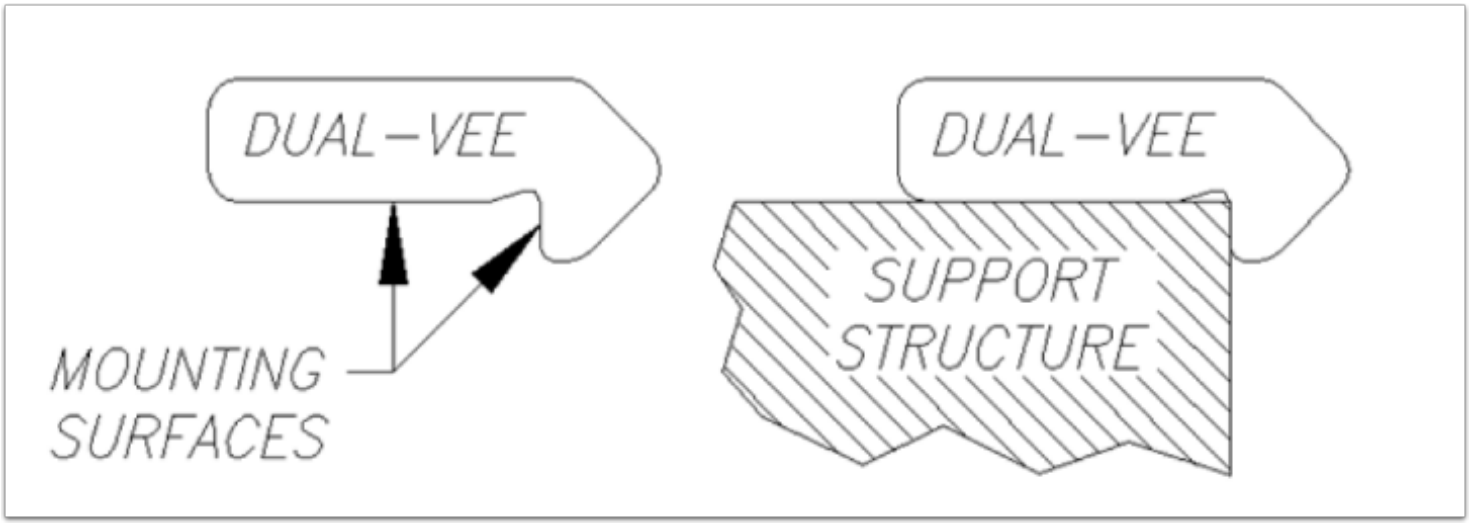

### Any other recommendations?

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.

# Other KoP Item Resources



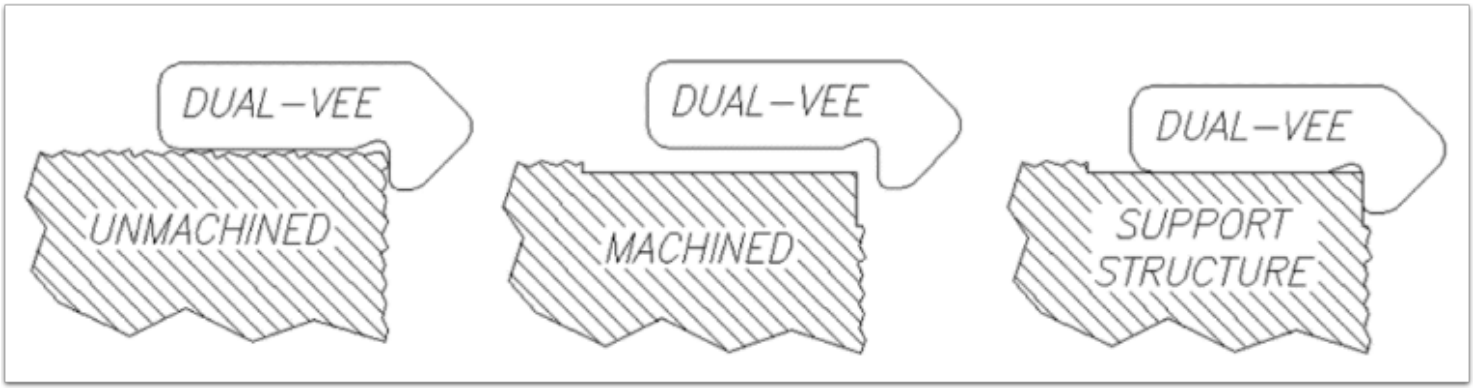

DualVee track is designed with an integrated shoulder and mounting surface. These surfaces are to be utilized when mounting DualVee track to your support structure or in your case, robot frame.



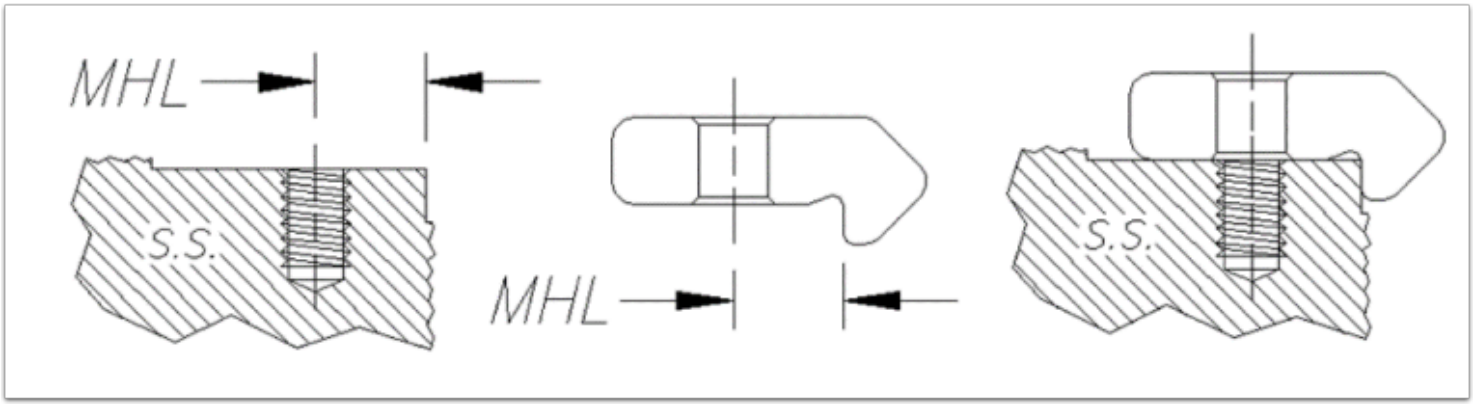

Pay special attention to the track mounting surface because small variations in things like flatness, parallelism and even perpendicularity may result in your wheel not running the way you want it to.

# Other KoP Item Resources

Our recommendation is to use a machined register on the support structure (robot frame) in the track mounting locations.

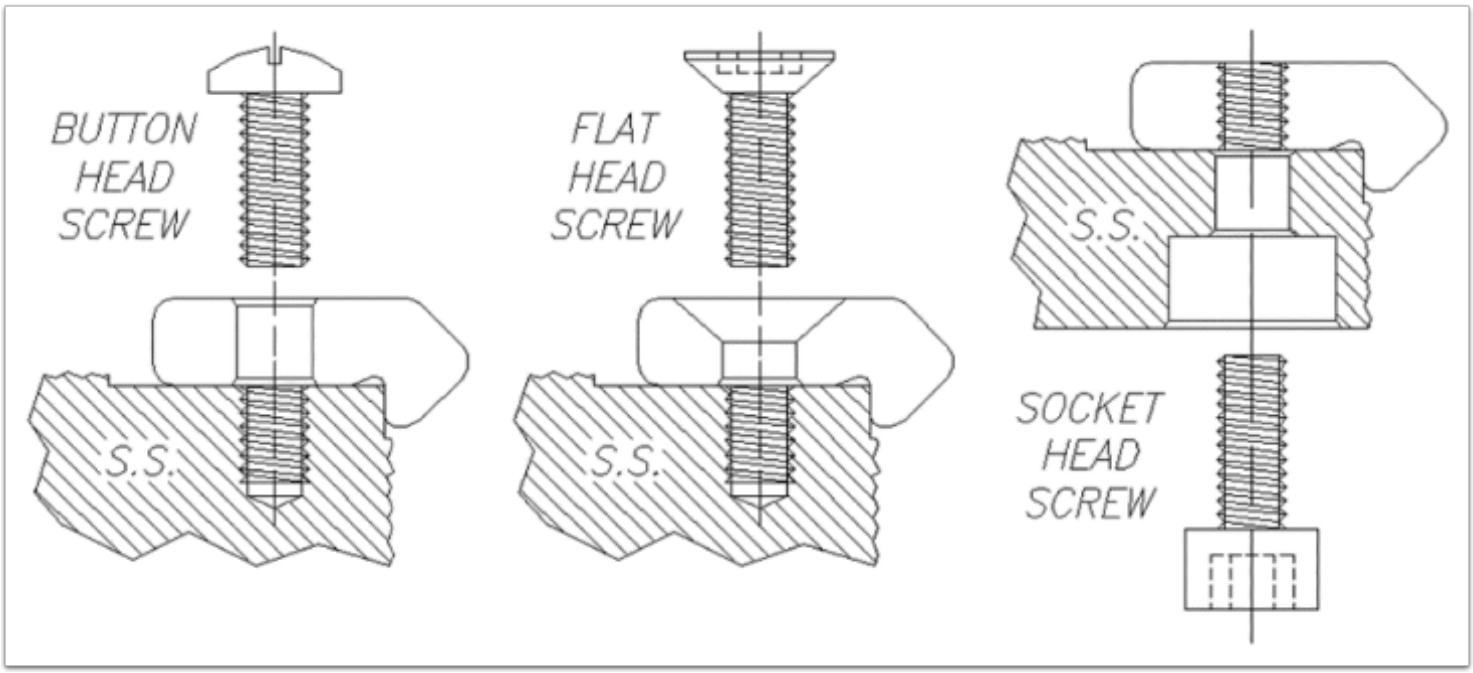



Machining for the track mounting fasteners can also be completed during support member machining. Through hole locations have been standardized on all sizes of DualVee track with dimensions originating from the locating soldier. The catalog dimension “MHL” can be referenced for support structure design.




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.

# Other KoP Item Resources



# 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)**

# Other KoP Item Resources

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

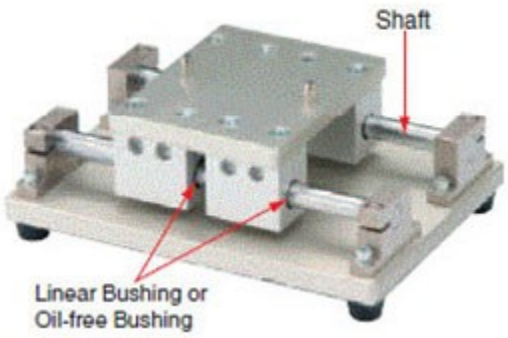
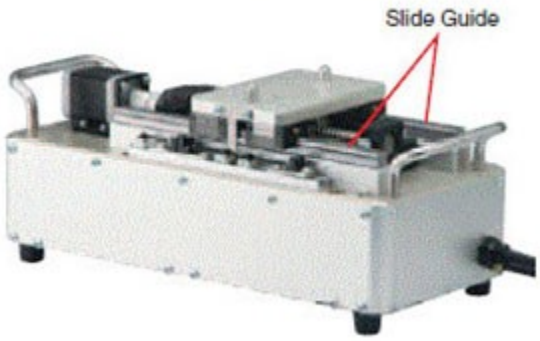



**Photo 2** Example of Slide Guide use



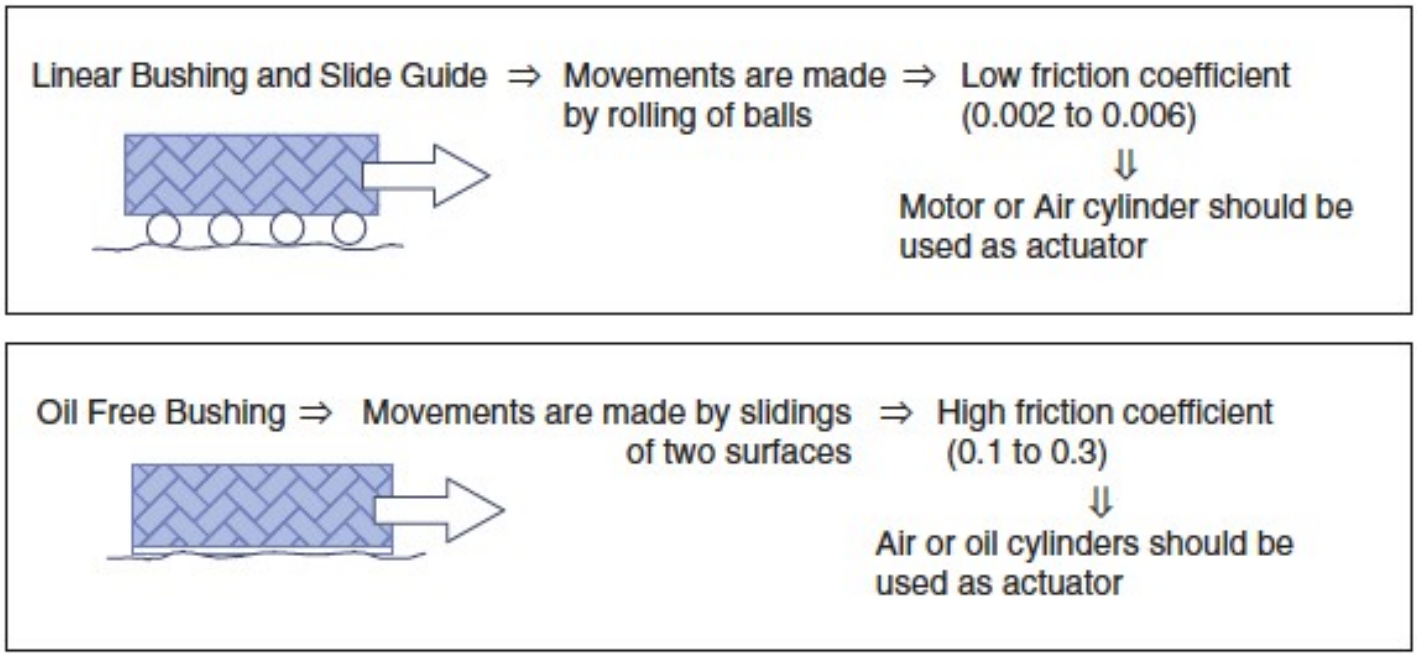

*Linear Bushing, Oil free Bushing ⇒ Shaft supported at both ends ⇒ Light to medium load Slide Guide ⇒ Fixed rail on base⇒ Light to heavy load*

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)*

# Other KoP Item Resources

**Figure 1** Contact and load distribution of Linear Bushing

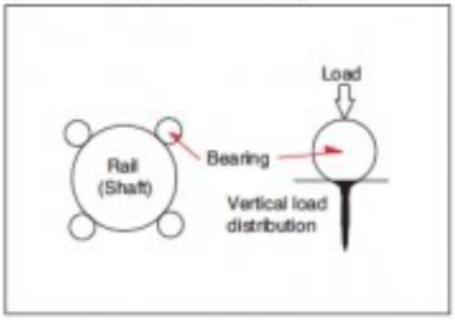
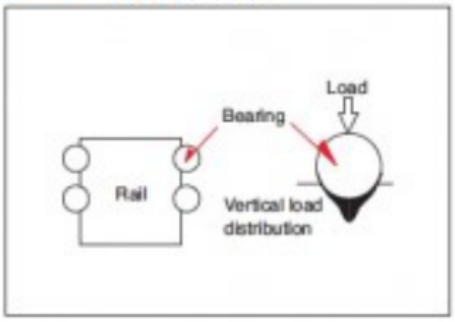



**Figure 2** Contact and load distribution of Slide Guide



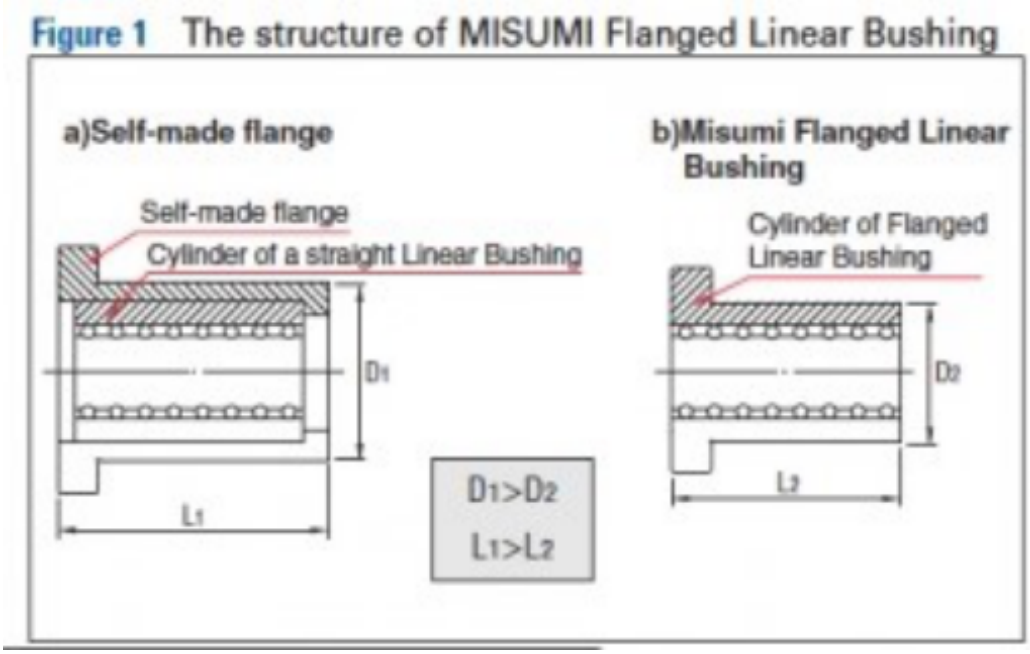

*Linear motion ⇒ Point contact ⇒ Concentrated vertical load distribution ⇒ Not applicable for heavy load*

*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.

# Other 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).

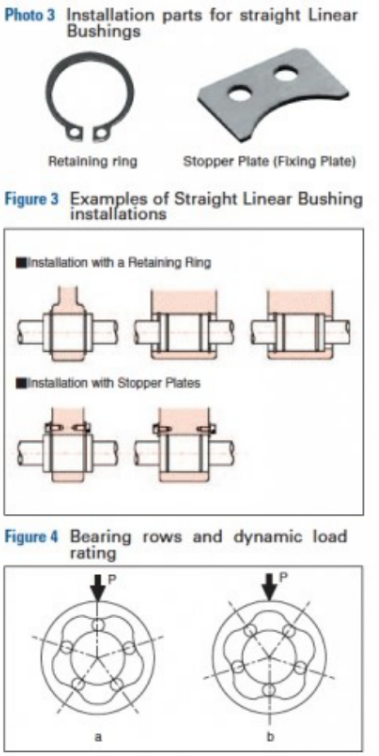
As shown in Figure 2, depending on the design, Linear Bushings can either move while Shafts are fixed, or be stationary (fixed) while Shafts are in motion.

- 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.

# Other KoP Item Resources




**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.

# Other 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.

# Motors

# Bosch Seat Motor

## Specification Sheet

2016-12-21_spec_sheet_-_Bosch_FRC_motor_6_004_.pdf

## CAD File

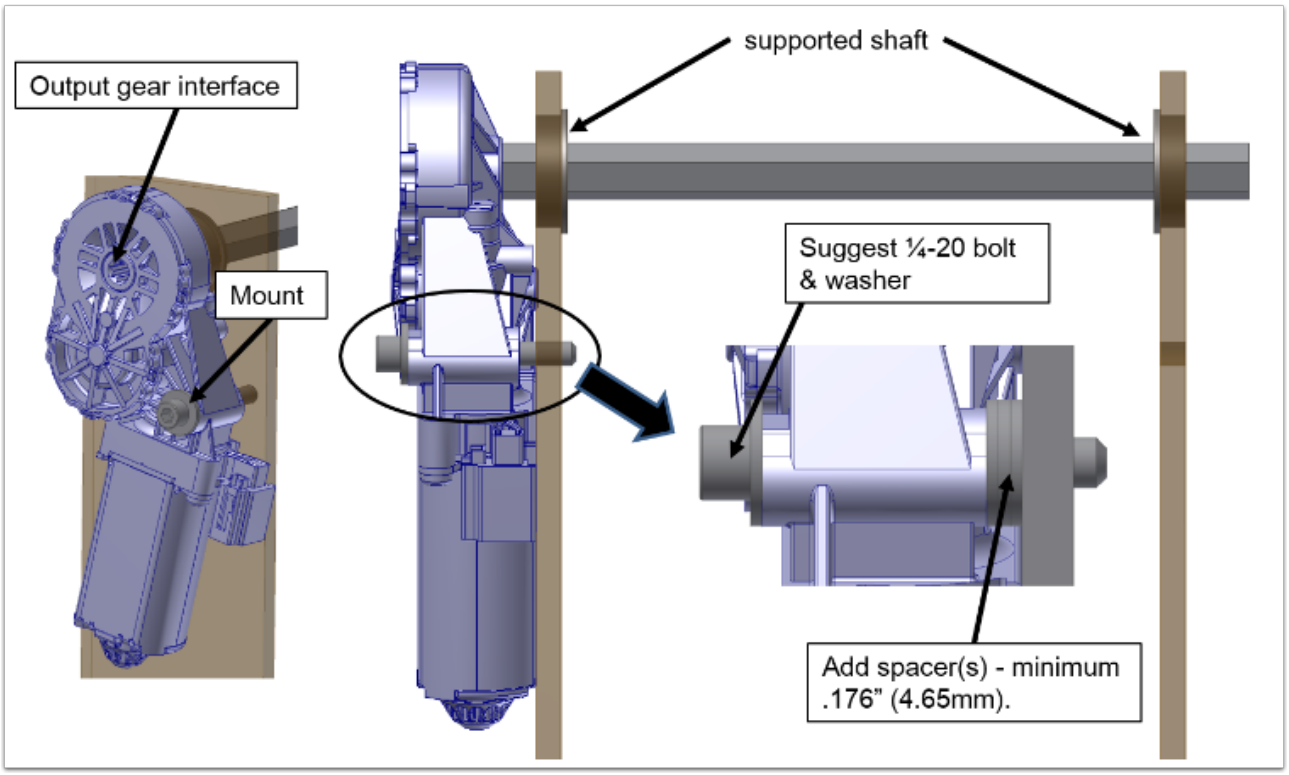
FRC_Bosch_motor_V2_6_004_RA3_194-06.zip

## Motor Mounting & Shaft Support: Suggested

Motor relies on two solid mounting points:

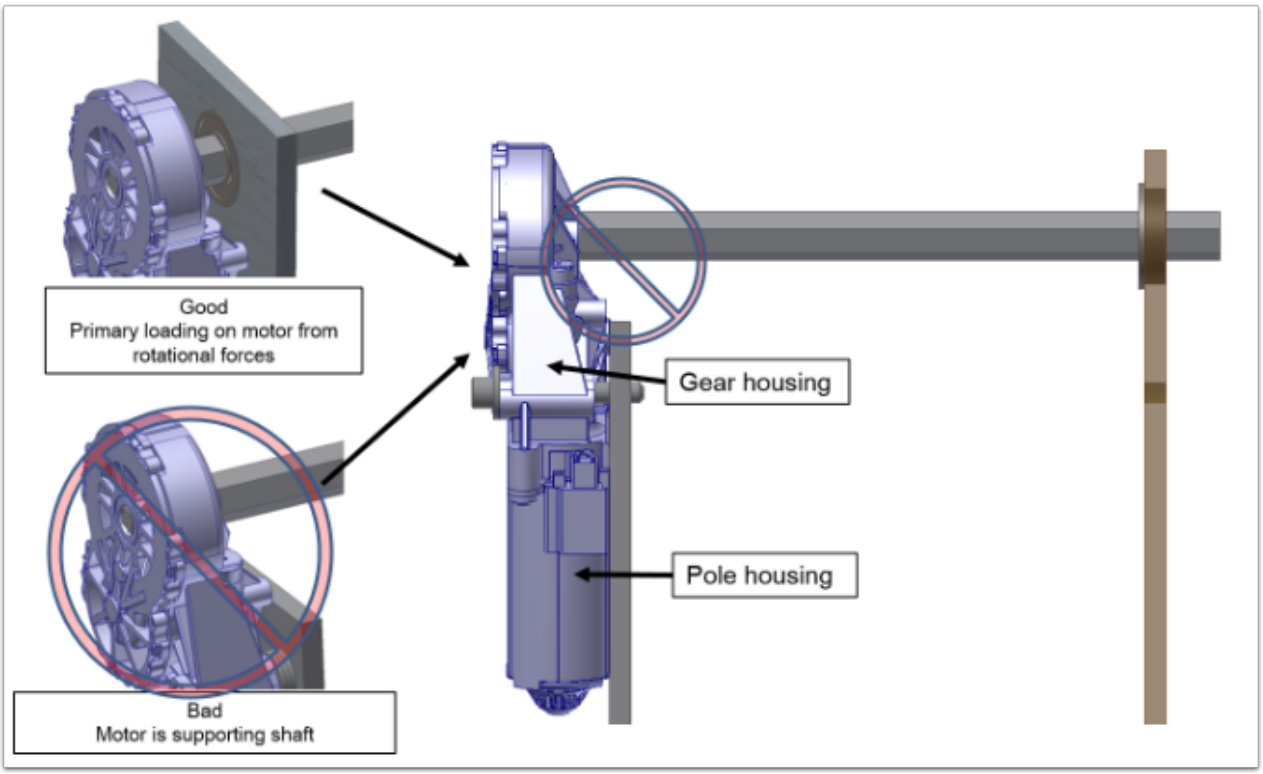
1. output gear interface and
2. oval mounting hole.

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.



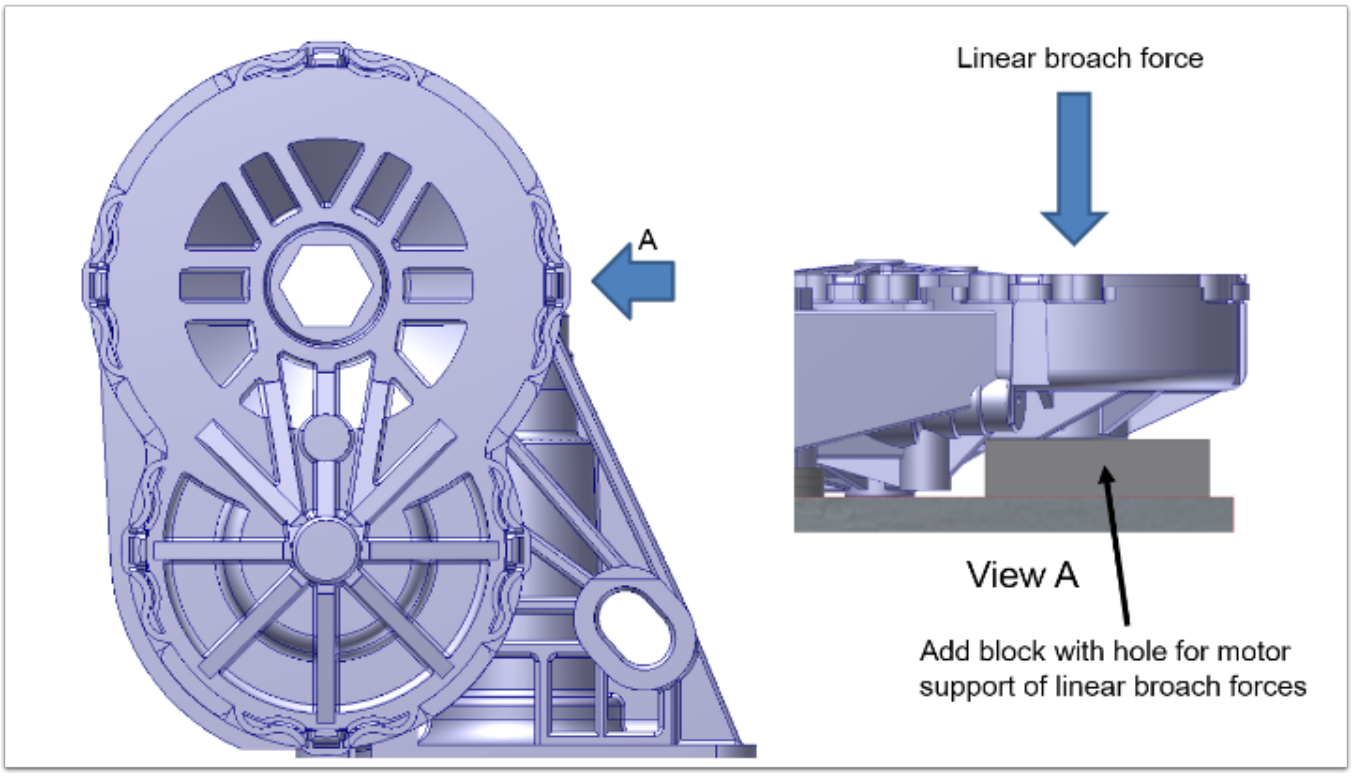

## Motor Mounting & Shaft Support: Things to Avoid

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.



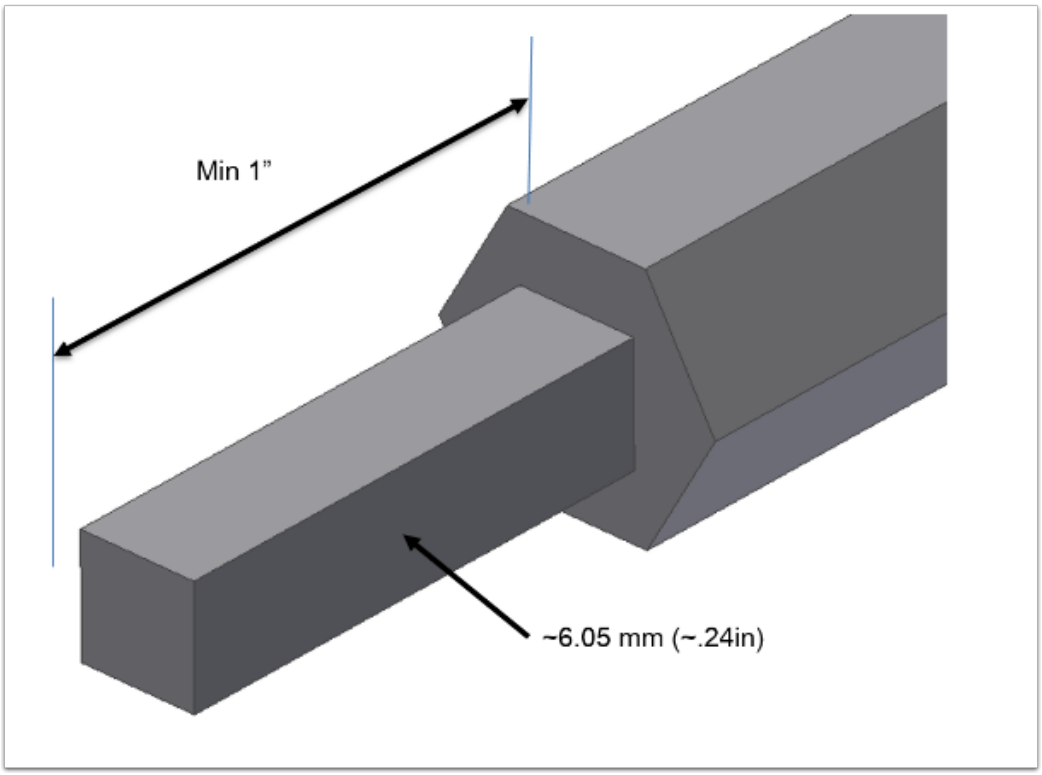

## Subtractive Manufacturing Option: Mill Hex Shaft

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).

# Other KoP Item Resources



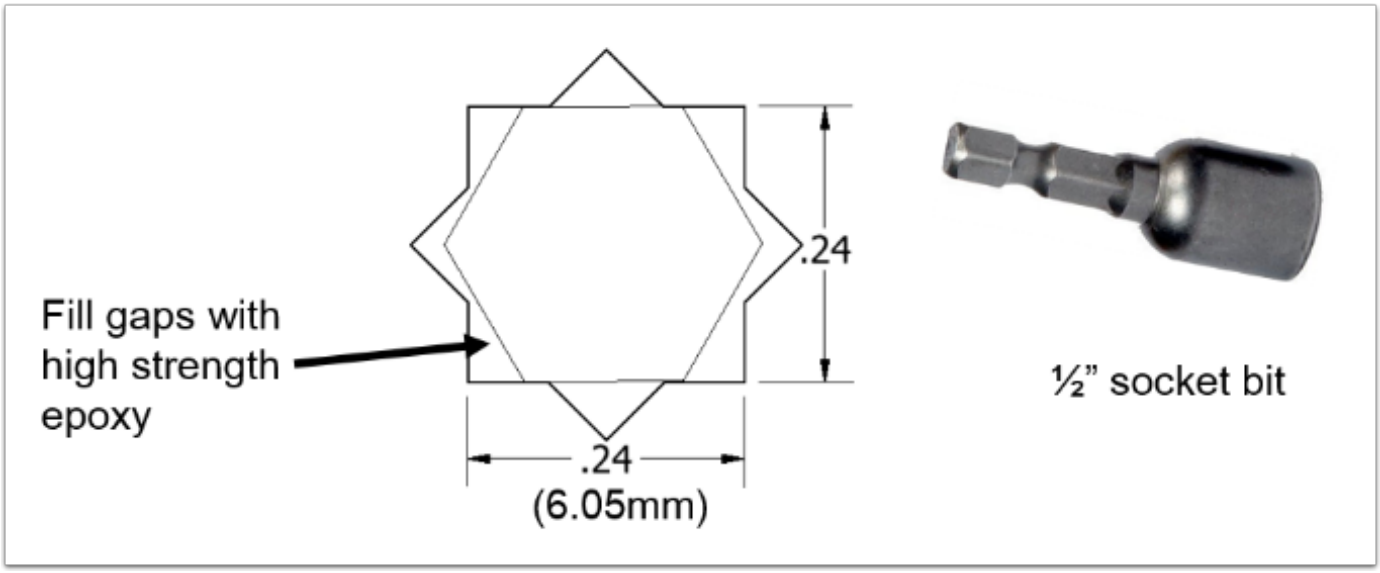

## Off-the-Shelf Options for Output Interface

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.

# Other KoP Item Resources

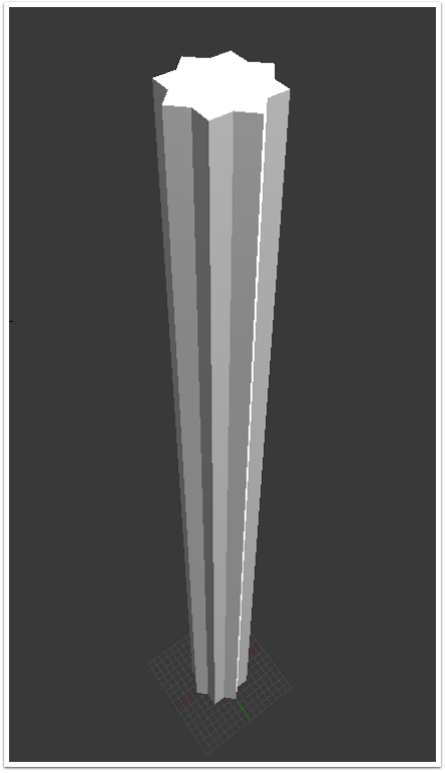
Utilize a ½" socket bit.  It interfaces nicely with ½" hex stock or a 5/16" bolt head/nut.  The hex portion will fit snugly in the star interface but will not support the required max torque. Adding JB weld or other strong epoxy in this gap is an option. This has not been validated so be sure to leave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




# Output Options: 3D Printable Options

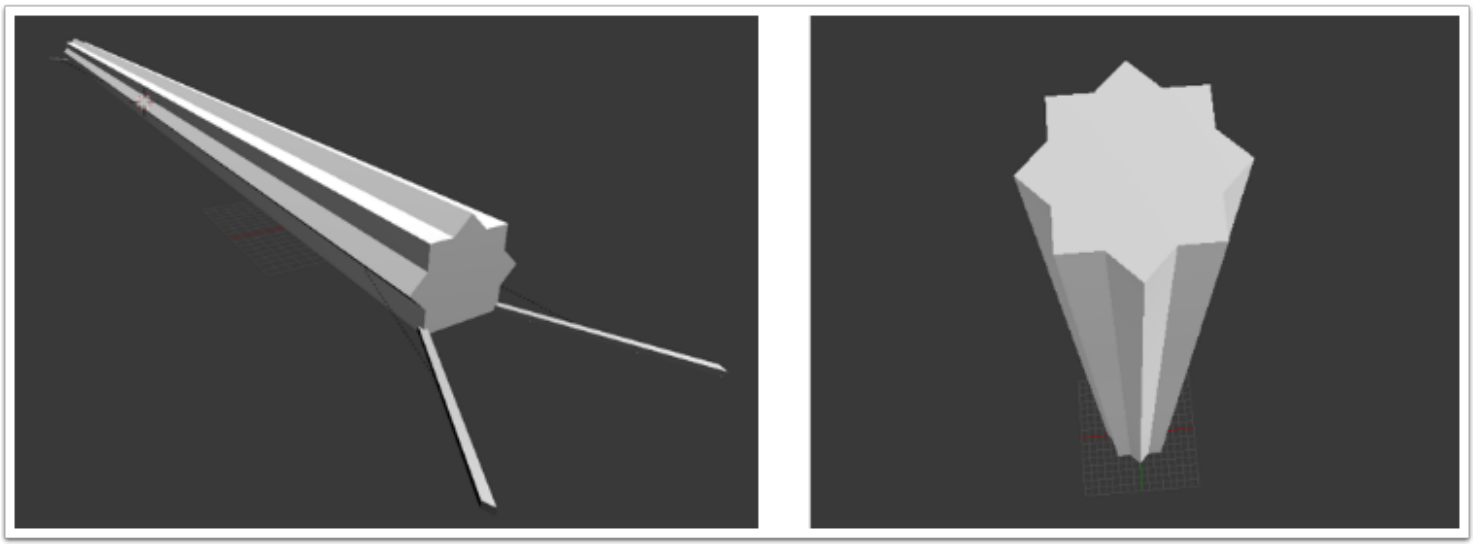
- Teams with access to a 3D printer may also consider printing a custom interface to meet their specific needs.
- Depending on the choice of material, however, this interface may not be as strong as some of the previous options.
- For fused-filament printers, additional care is required to ensure that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

# Other KoP Item Resources

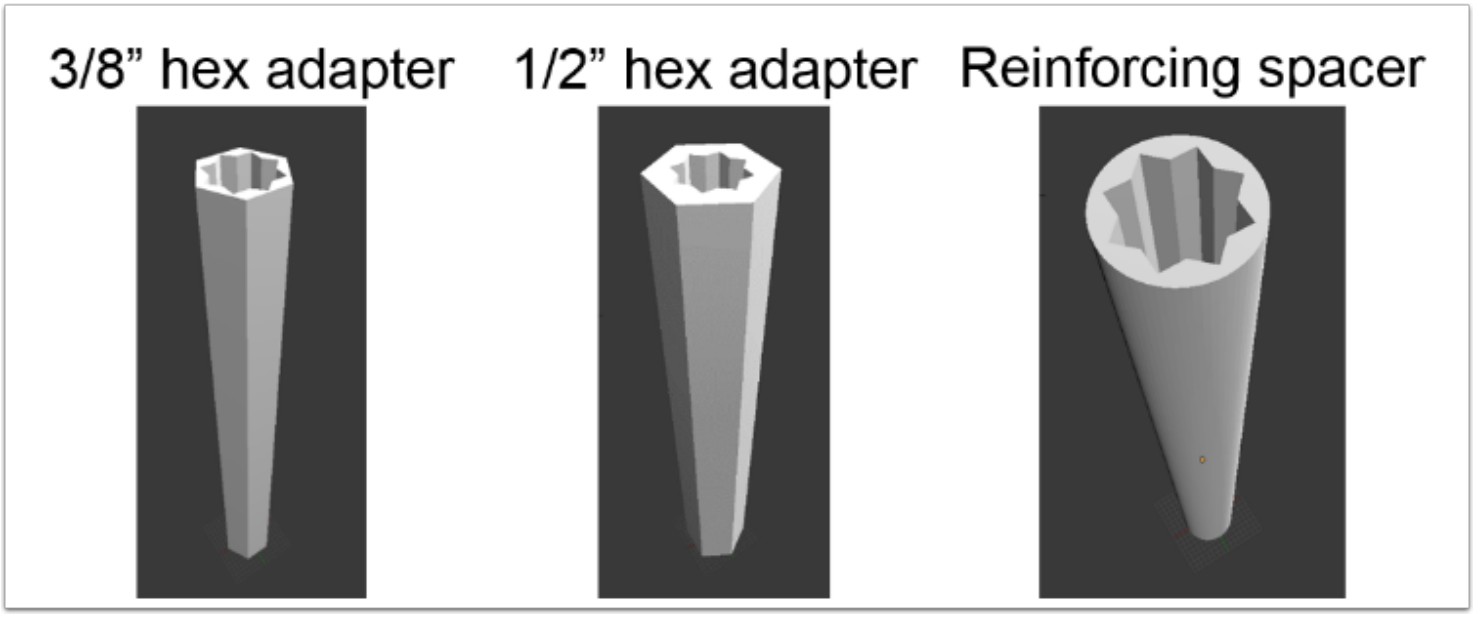


- For printing horizontally, consider removing one of the star teeth; this will allow the spline to lay flat.
- Also consider adding “whiskers” or “mouse ears” where appropriate; these features improve adhesion to the print bed, which helps to minimize warping.
- For printing vertically, remember to 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.

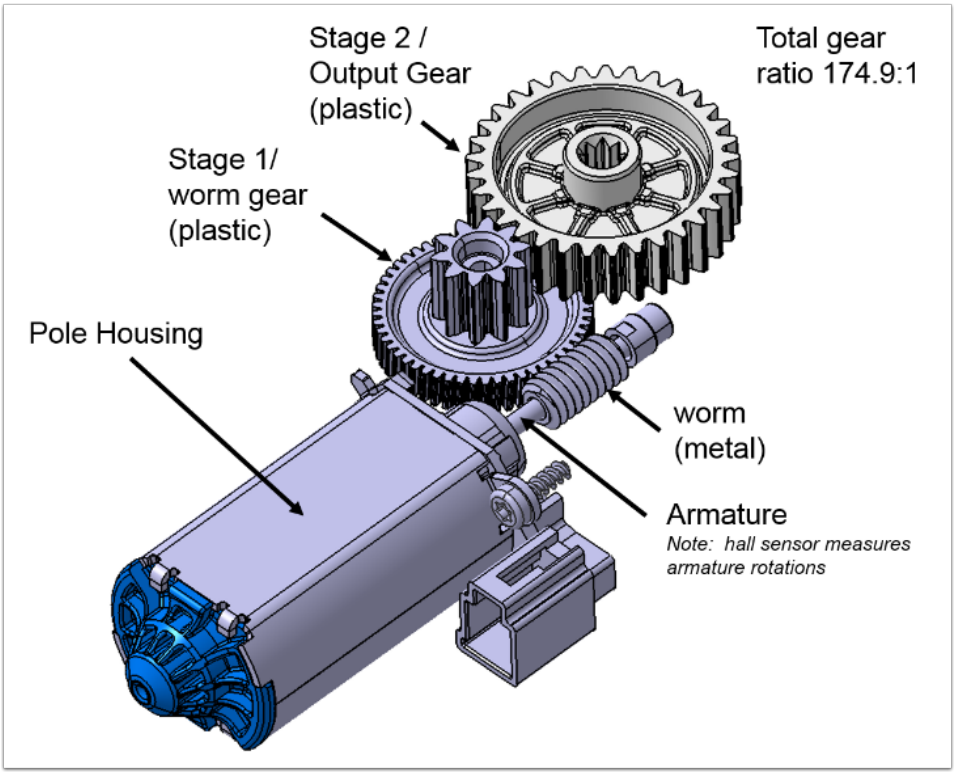
# Other KoP Item Resources



- 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



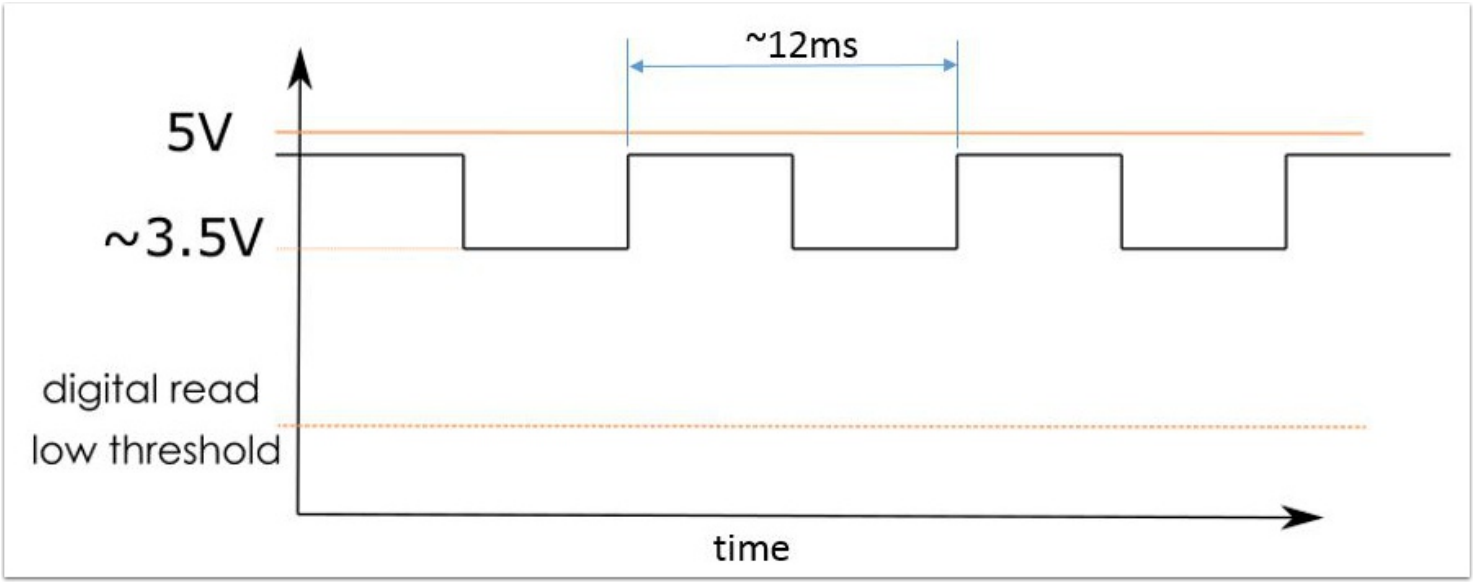

## Design Consideration Summary

- 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

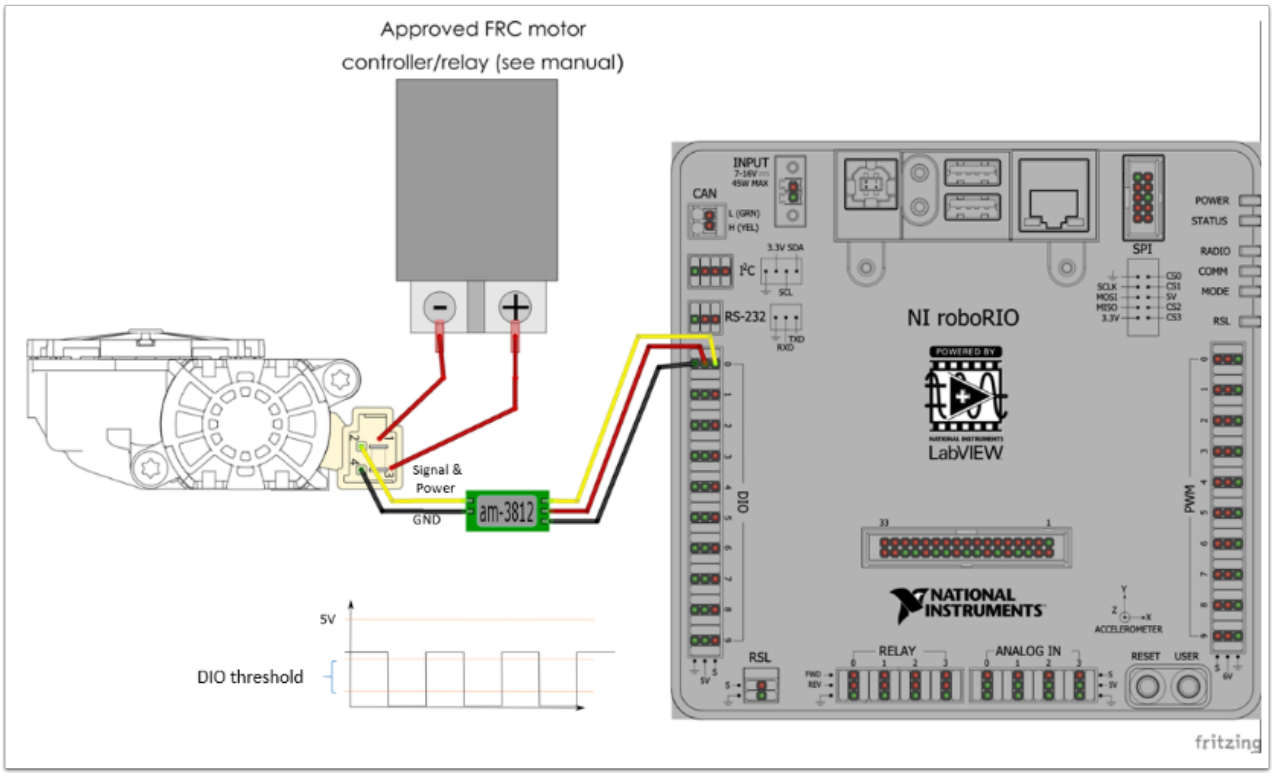
The basic circuit interface with RoboRio is shown below.

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.



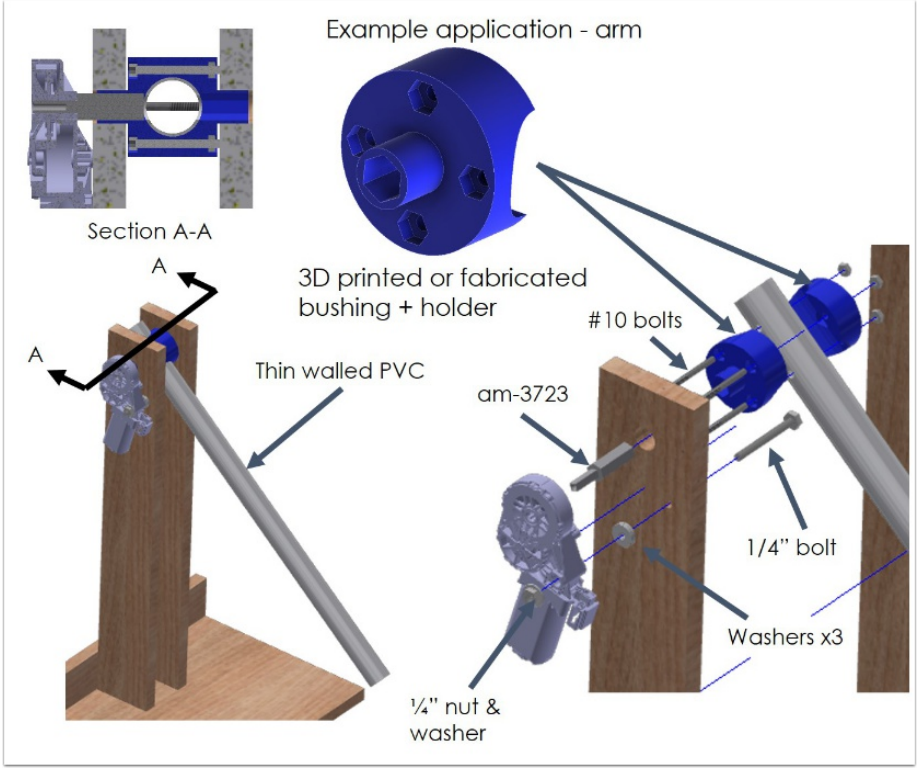

In order to get the step to drop below the digital read threshold, a simple circuit is used (image below includes an adapter for reading DIO) . A kit can be purchased from AndyMark that performs this function (am-3812).

# Other KoP Item Resources

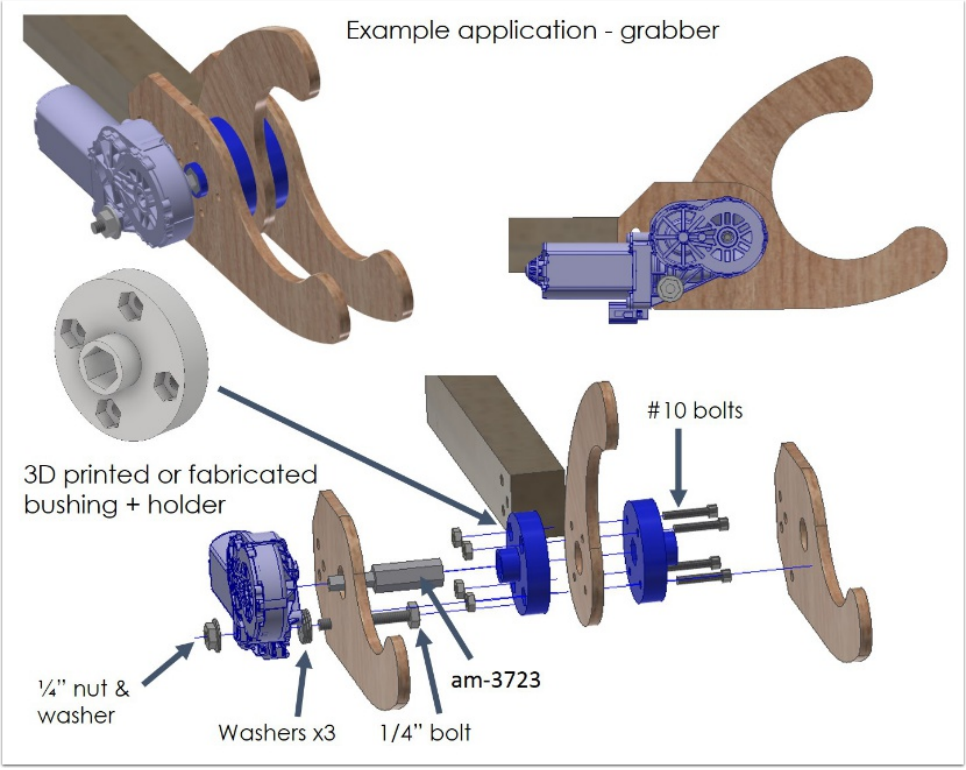


# Other KoP Item Resources

## Sample Applications



# Other 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

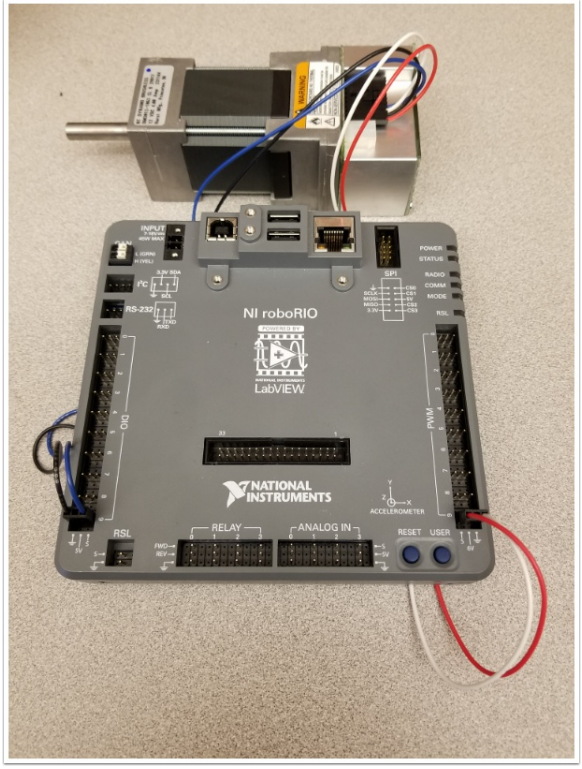
The Dynamo BLDC Motor comes with a 2 pin harness with red and black wires for powering the device. Plug the connector into the receptacle on the back of the device (it's keyed, so it will only go one way). Connect the other end directly to one of the <30A breaker slots on the PDP, or use quick disconnects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

# Other KoP Item Resources

## 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.

# Other KoP Item Resources


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:

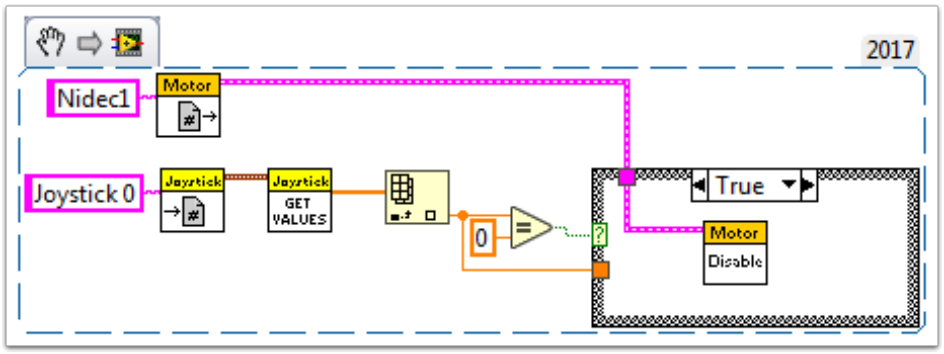
```
double value;
NidecBrushless motor = new NidecBrushless(0,0);


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)

# Other KoP Item Resources

## 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

# Pneumatics

# FESTO Solenoid Valve

## Basic Valve Data

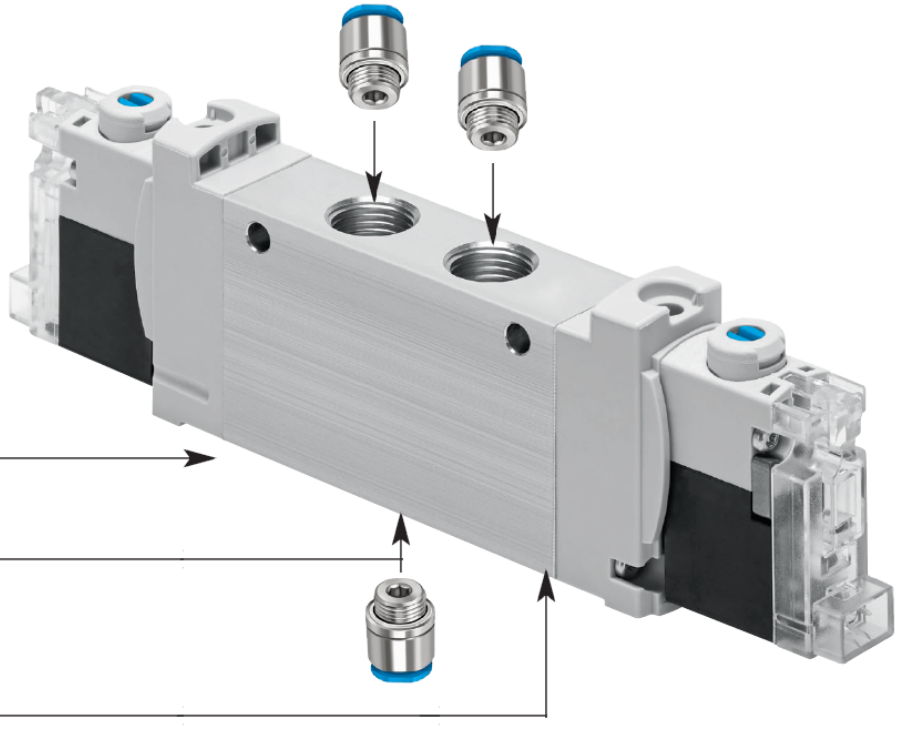
The VUVG-LK10-B52-T-M7-1H2L-S is a 5/2 dual solenoid piloted valve. The valve has M7 ports and is operated with a 24V DC signal. The maximum air flow is 13.4 cfm. The weight of the valve including the fittings and cables is 0.2 lbs.

**Typical Pneumatic Connection**
The pneumatic connection for typical cylinder would be as follows:

**Port 4** - To cylinder back end (insert fitting here)
**Port 2** - To cylinder front end (insert fitting here)

**Port 5** - Exhaust from port 4 (to atmosphere)
**Port 1** - Pressure supply (insert fitting here)

**Port 3** - Exhaust from port 2 (to atmosphere)



## 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.

# Other KoP Item Resources

## 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.

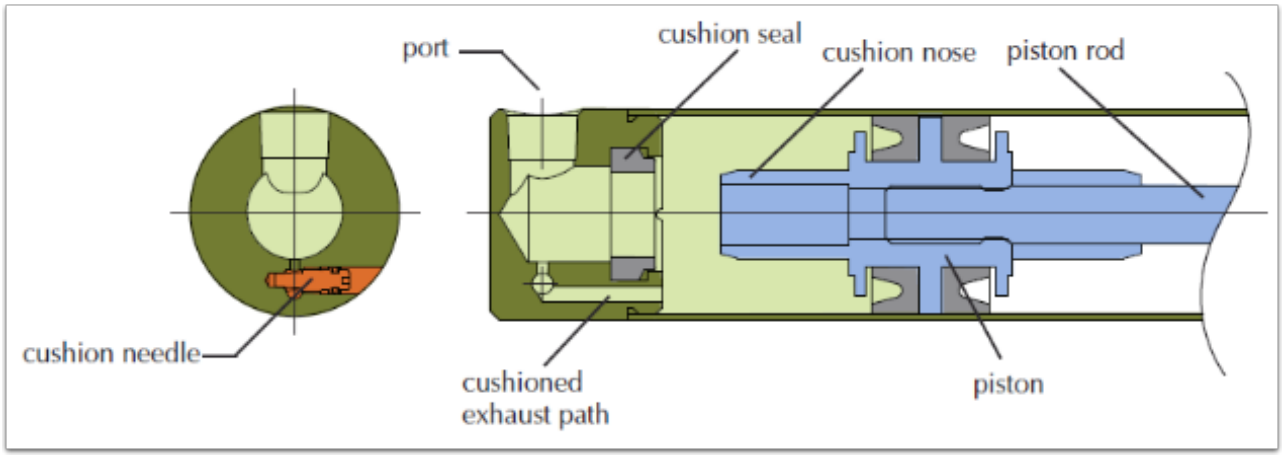
# Position & Speed Control Options for Pneumatic Cylinders (from Clippard)

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

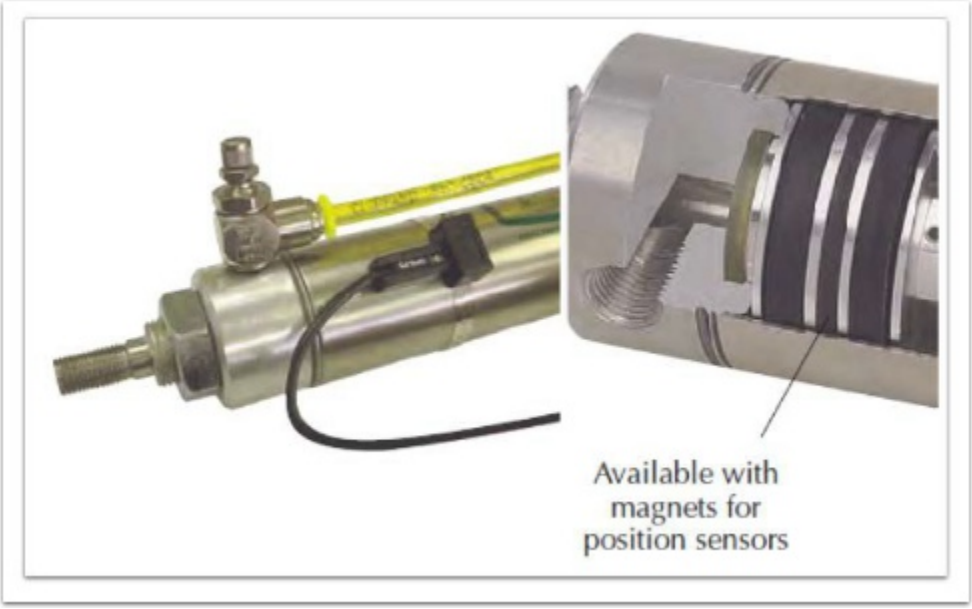
This option allows the cylinder to slow down at the end of stroke. It is valuable for reducing vibration and noise common with sudden metal to metal stops.



# Other KoP Item Resources

## 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.

# Other KoP Item Resources

## 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.

# Sensing

# CUI Inc - AMT10 Encoder

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

Photo: CUI, Inc.

# Other KoP Item Resources

## 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's AMT10 encoder series here.

## Installing the Encoder

Need help mounting CUI's AMT encoder? Watch the video below with step-by-step instructions that demonstrate the simplicity of mounting the AMT10 series encoder to a DC motor.

## FAQs

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

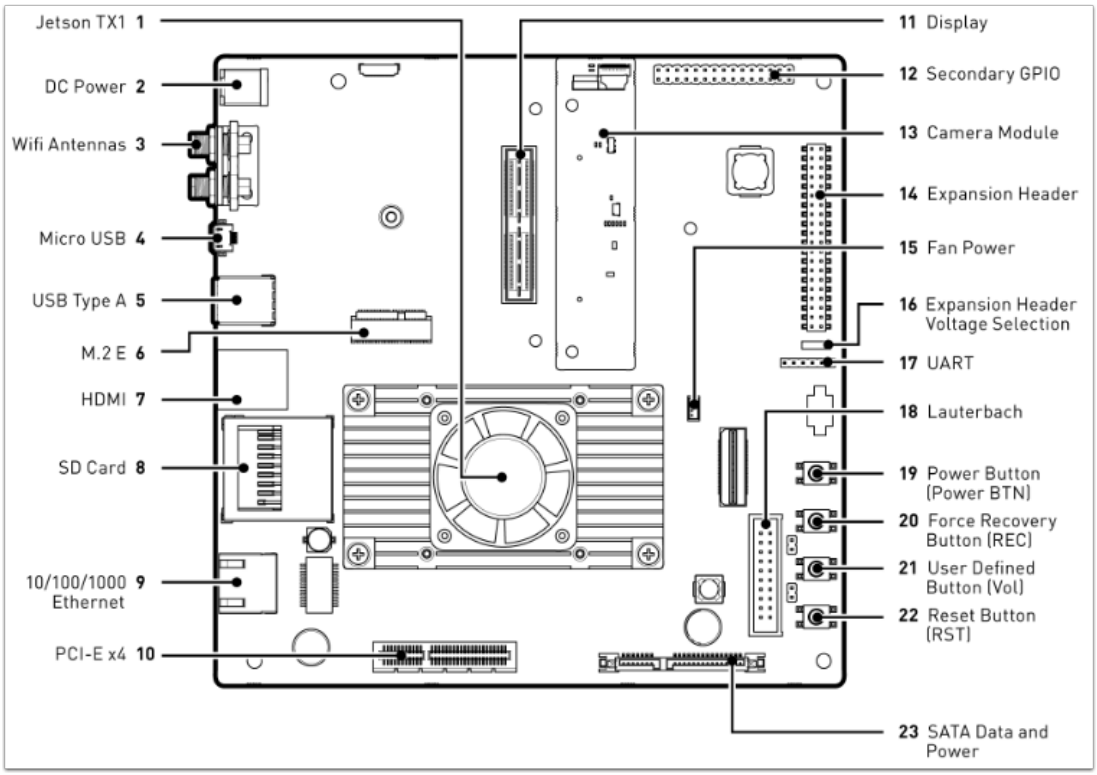
## Suggestions?

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



# Other KoP Item Resources

## 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.

# Other KoP Item Resources

## 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

# 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.

# Other KoP Item Resources

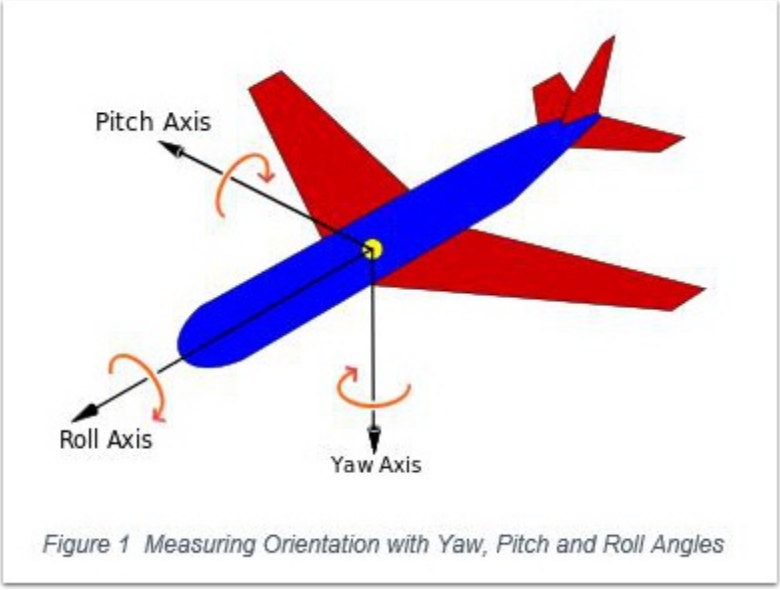



*Figure 1 Measuring Orientation with Yaw, Pitch and Roll Angles*

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 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.

# Other KoP Item Resources

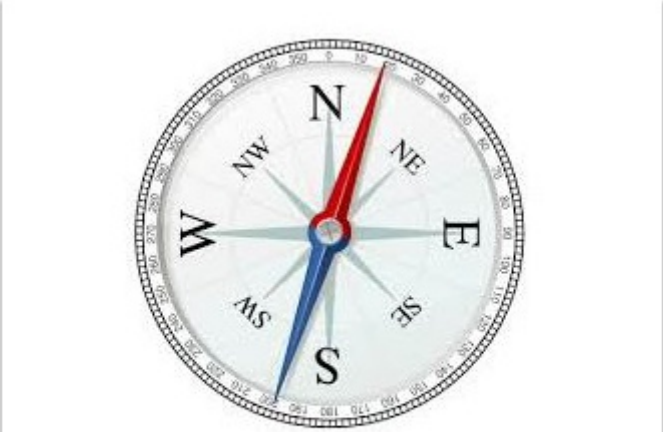



*Figure 2 Measuring Z-axis Orientation with a Compass*

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

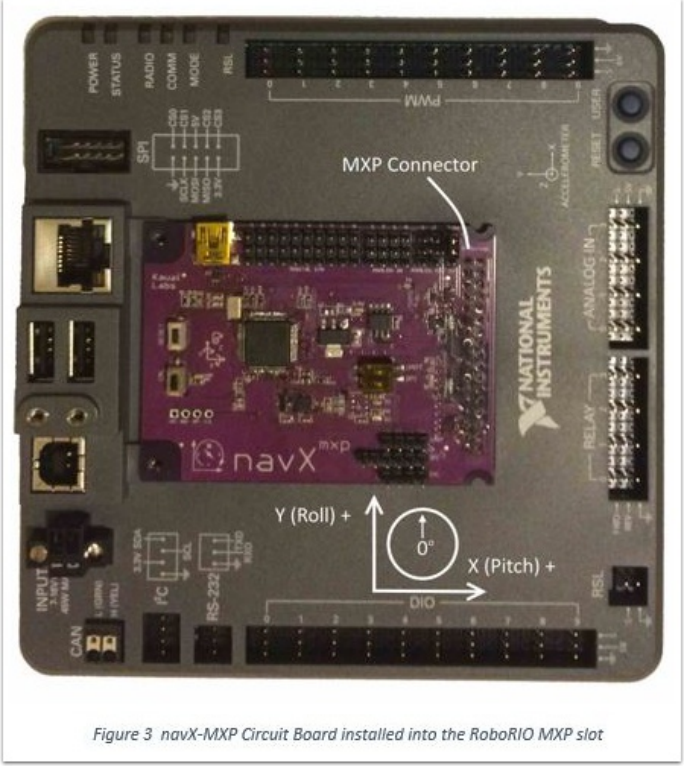



*Figure 3 navX-MXP Circuit Board installed into the RoboRIO MXP slot*

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

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.

# Other KoP Item Resources

## Enclosure


*Figure 5 navX-MXP enclosure*

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.

# Other KoP Item Resources

## 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.

## Learning More

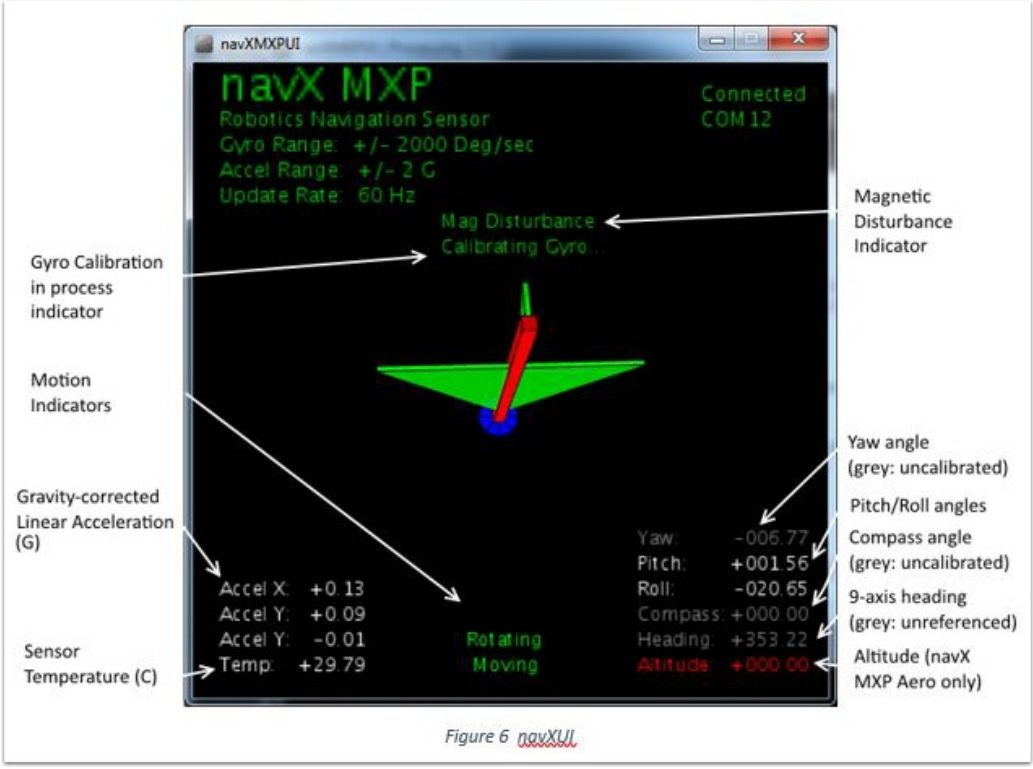



*Figure 6 navXUI*

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.

# Other KoP Item Resources

## 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.

# Software

# IBM Bluemix

Does your FRC team want to explore new ways to develop applications? Java, Web, Mobile, Node Red, IoT, Cognitive computing, and other technologies are available through the IBM Bluemix platform for your teams to explore. Check out the “Library” page under the resources tab on blue mix and get started.

The promotion code provided to FRC teams will allow each FRC team 12 month access to IBM’s Bluemix cloud computing platform. This will allow you to explore and create applications using the Bluemix platform.

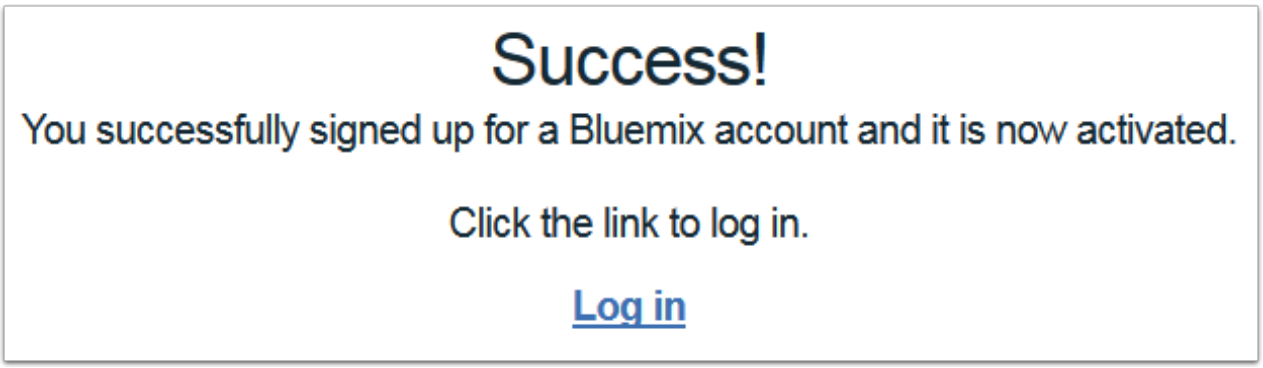
1. Sign up for a Bluemix account:

This initial account will be valid for 30 days and allow access for 2GB of runtime and memory to run apps. The promocode you will generate in the following steps will extend your account an additional 365 days!!

Go here to create an account https://ibm.biz/FRC-Bluemix

2. Confirm your Bluemix account: Check your email for a validation link from “The Bluemix Team”. Click on the Button

3. **Verify account was created:** You should see the following message in your browser if your account was created successfully:

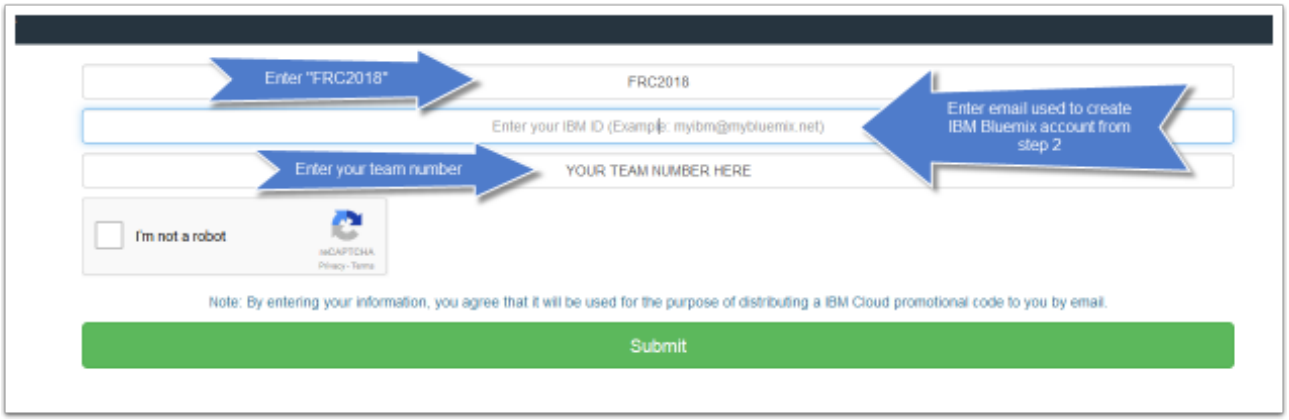



4. Go to this website and generate a promocode to extend your account to 12 months. http://promocodes.mybluemix.net/

**Event Name** = FRC2018

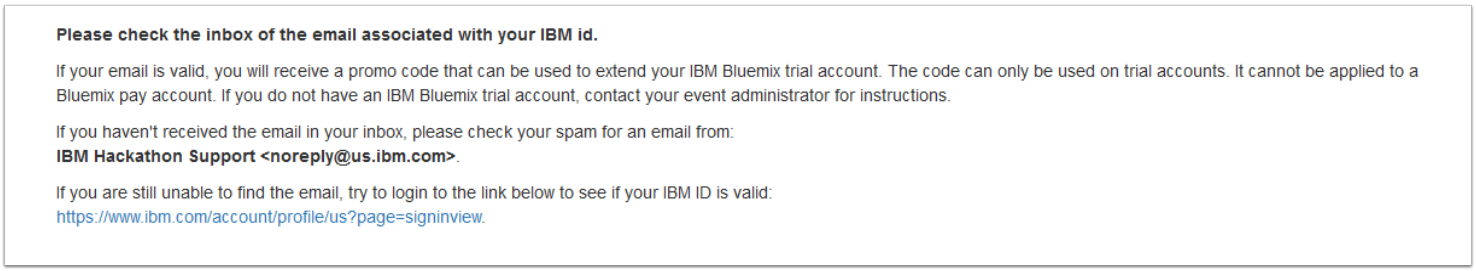
**IBM ID** = The email address you used to create your Bluemix account

**Team name** = Team Number of your FRC team.




5. **Verification of promocode being generated:** You should be directed to a page with the following message :

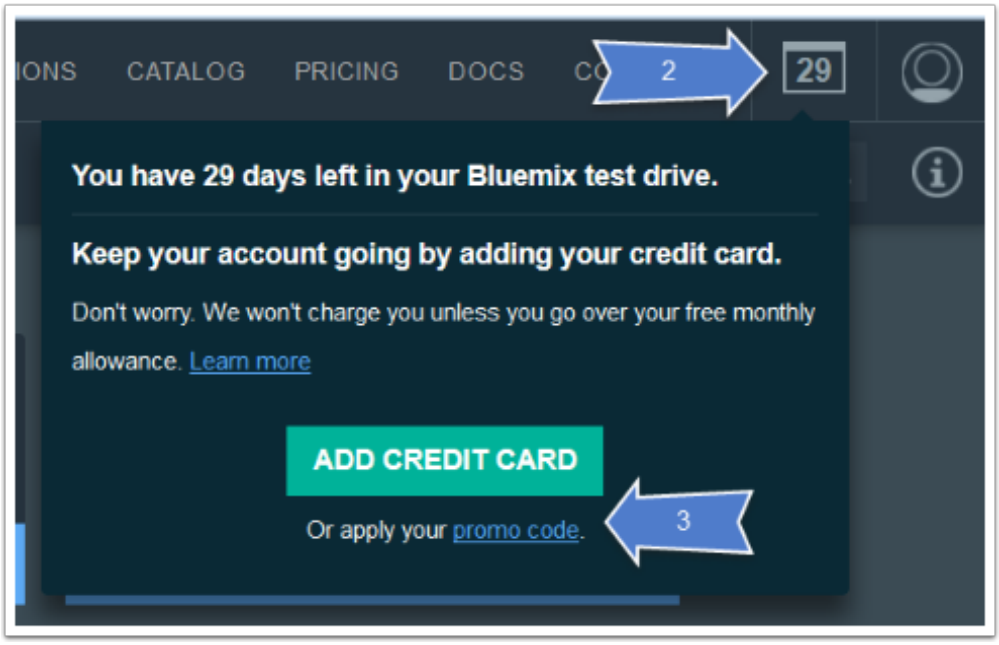
# Other KoP Item Resources




6. Obtain your specific promocode: Open your email and find the promocode in the email sent to you from *IBM Hackathon Support*

7. Log in to Bluemix: Log into your new Bluemix account here : https://console.ng.bluemix.net/

8. Apply promo code screen: After logging into Bluemix, select the box in the upper right corner that has a number. This number represents the number of days left in your free trial period. We are going to extend your account for an additional 365 days :) It is labeled with the blue #2 arrow below. This will open another window for you to click on "apply promo code". Click on "apply promo code" and enter the promocode that was included in the email sent to you. (see screen shots below)

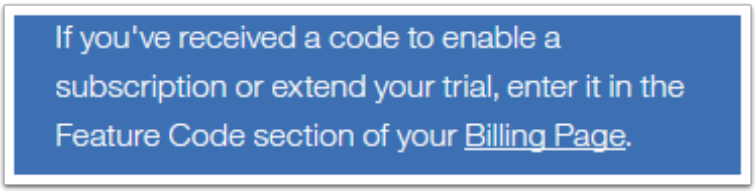



9. Apply the promocode : Copy the promocode from your email into the window shown below.

# Other KoP Item Resources


Hit apply. This will extend your trial period for an additional 365 days.

**10. If you are using an account created last year, you will be directed to a new page to upgrade your account.** Please select the link for "Billing Page" on that screen and you will be taken to a page to enter the new promocode.




11. Learn:

1. BLuemix landing page: https://console.ng.bluemix.net/#/store
2. IBM Bluemix youtube playlist: https://www.youtube.com/playlist?list=PL78F74113FAACEA34
3. Bluemix Docs for all the Bluemix Services : https://console.ng.bluemix.net/docs/
4. IBM Developerworks recipes : https://developer.ibm.com/recipes/
5. Student Hackaton Starter kit: https://developer.ibm.com/students/hackathon-starter-kit/
6. Boiler Plates: https://console.ng.bluemix.net/catalog/?category=blueprints

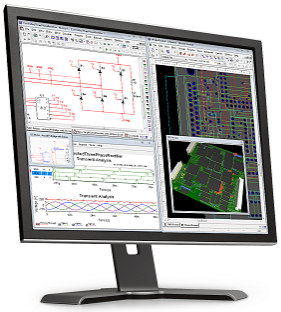
12. SHARE:

Make something cool, and let us know by tweeting #IBMFIRST

# 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.

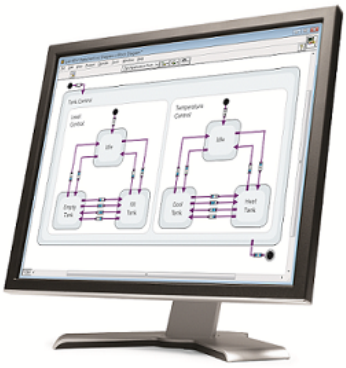
Expansion Board Developer Guide for roboRIO

Download Multisim & Ultiboard

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

# Other 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.

Download
LabVIEW Statechart Module

# Wiring & Connections

# APP Powerpole Connectors

## PP14 to PP45 (the "small" ones)

Specification Sheet

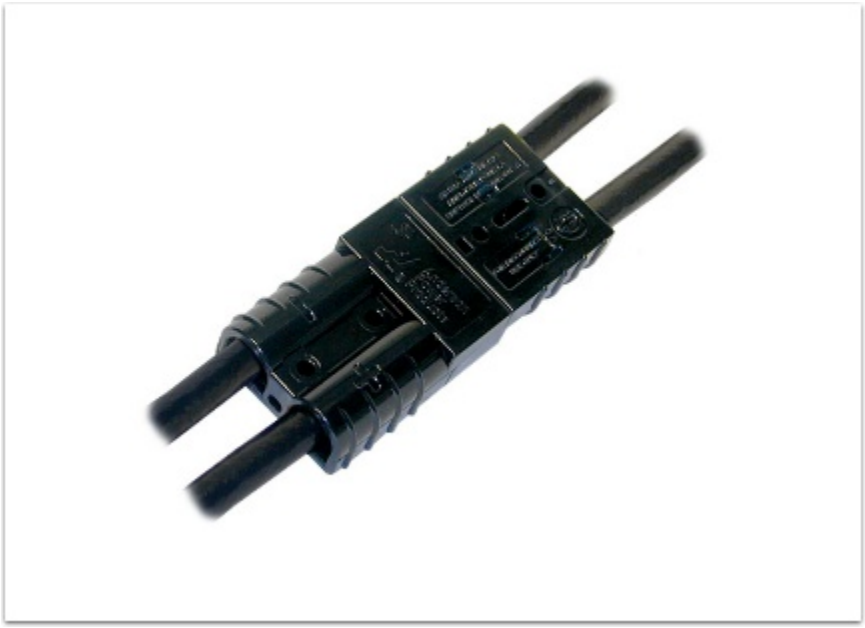
ds-pp1545-1.pdf

Assembly Instructions

Powerpole_Assembly_Instructions.pdf

# Other KoP Item Resources

## 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.