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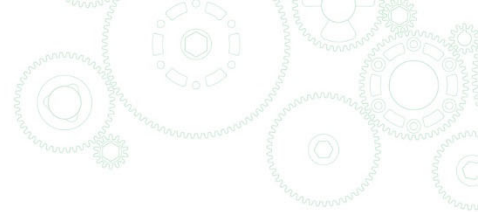
# Falcon 500 Motor User Guide

# FALCON 500

POWERED BY  
**TALON FX**



 [vexpro.com](http://vexpro.com)  [ctr-electronics.com](http://ctr-electronics.com)



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## Falcon 500 Features

The Falcon 500, powered by Talon FX, is a revolutionary new brushless motor for FRC! With an integrated motor controller and encoder, it raises the bar for motor and motor controller performance.

The Falcon 500 introduces many new and innovative features to the FIRST® Robotics Competition, some of which are the first of their kind in the FRC market.

These features will not only change the way teams think about motors, but will change the way teams interact with, use, and maintain them. The bottom line is the Falcon 500, powered by Talon FX, is changing competition as we know it.



Falcon 500, powered by Talon FX

### Brushless Is More

The Falcon 500 is a brushless motor, custom designed specifically for the FIRST Robotics Competition, through a collaboration between VEX Robotics and Cross the Road Electronics. Brushless motors are better than their brushed counterparts for a variety of reasons:

**More Reliable** – The brushes inside a brushed motor will inevitably fail. Over time these brushes deteriorate, leading to degraded performance. This is the reason why many FRC teams use new motors every year – regardless of whether they still work or not. In fact, some FRC teams have started replacing their brushed motors mid-season to make sure they're always getting the most out of their robot.

In theory, the bearings inside a brushless motor will be the first item to wear out. This means that brushless motors have a significantly longer life span than brushed motor.

**Cooler & More Efficient** – Since there are no brushes creating a torque load on the shaft, brushless motors produce more torque, making them more efficient.

**More Power Density** – Power density is how much mechanical power a motor can produce, relative to its size. Due to their design, brushless motors have a much higher power density that wouldn't be available in a similar sized brushed motor. This means that the Falcon 500, powered by Talon FX is smaller and lighter than most FRC legal brushed motors, while producing significantly more power.

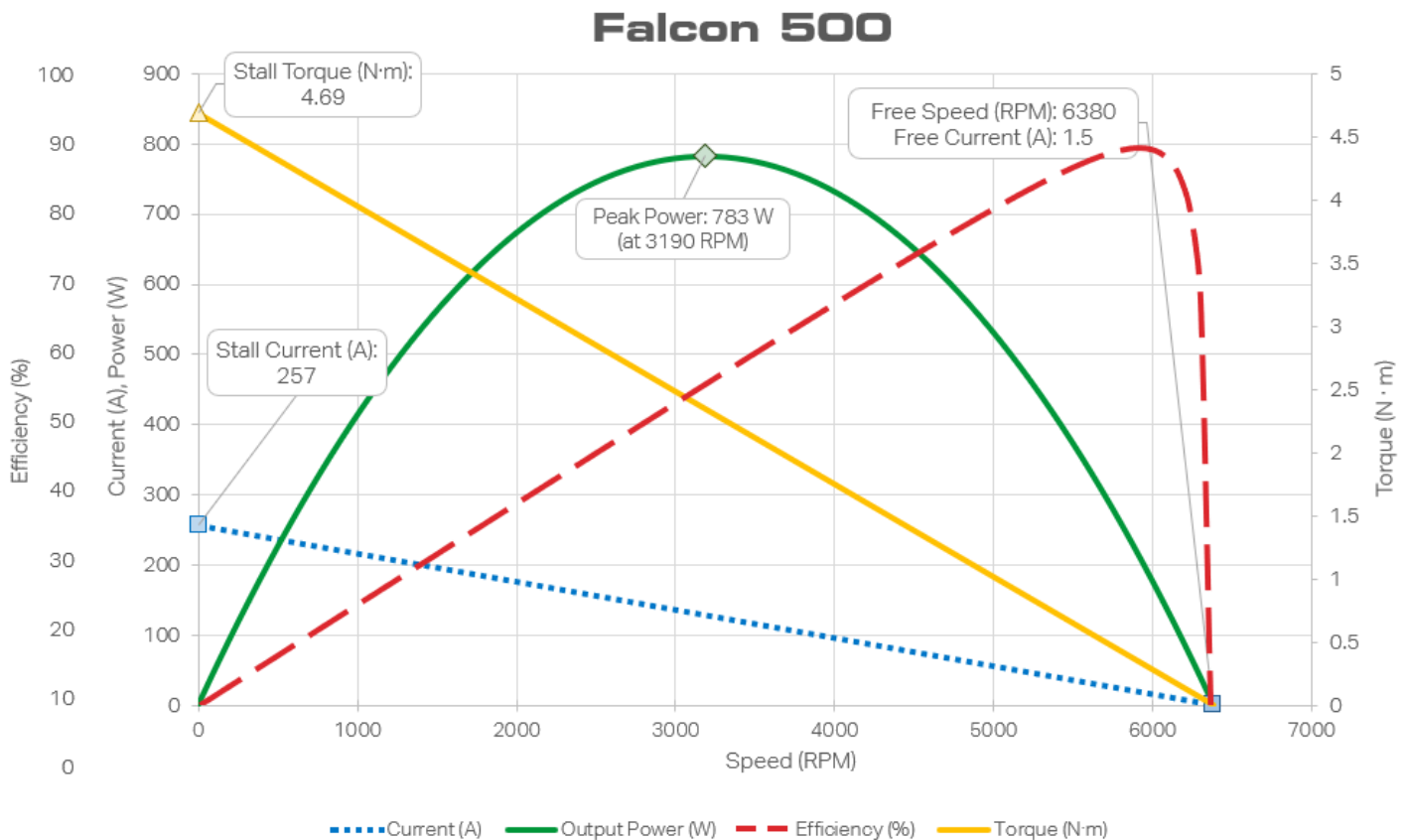
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## Power Up

The Falcon 500 produces just under 400W of Power at 40A and 12VDC. Without a doubt, it is the most powerful motor in FRC. At peak power the Falcon 500 can produce over 780W of power!

On top of this unprecedented power, the Falcon 500 is the most efficient motor in FRC, with a peak efficiency of 87%. In fact, the Falcon 500 is greater than 80% efficient across the entire FRC operating range (7A - 40A).

With this kind of power and efficiency, the Falcon 500 is the perfect motor for almost any FRC application. Don't rob your robot of valuable power and efficiency by using any other motor.



# Falcon 500 Motor User Guide

## Size & Packaging

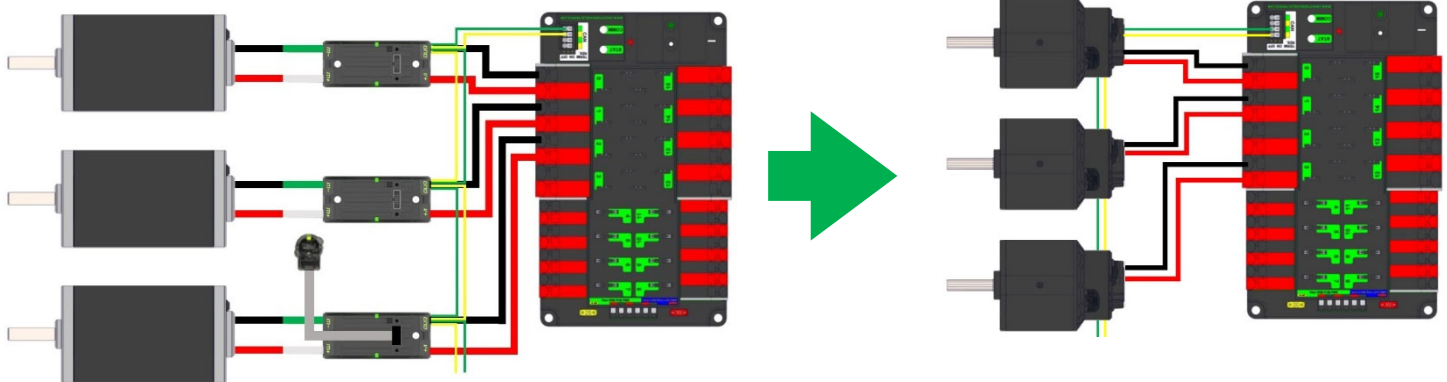
The Falcon 500 is smaller than a Mini CIM and just as light as a 775pro and Talon SRX. In fact, the Falcon 500 and Talon FX have one of the smallest volumes of any FRC motor and motor controller. Combine this with the Falcon 500's cutting edge power, and you have the best power-to-weight ratio of any FRC motor.

Motor	Total Weight (lbs)	% of Robot Weight (120 Lbs)	Power @ 20A	Power-To-Weight Ratio (W/lbs)
Falcon 500 + Talon FX	1.1	0.92%	203W	184.55
NEO + Spark Max	1.2	1.00%	202W	168.33
775pro + Talon SRX	1.1	0.92%	171W	156.88
BAG Motor + Talon SRX	1.1	0.92%	137W	124.55
Mini CIM + Talon SRX	2.4	2.02%	137W	56.61
CIM + Talon SRX	3.06	2.55%	157W	51.31



Above (Top to Bottom): CIM, Mini CIM, Falcon 500.

As teams have been trying to build smaller and smaller robots, fitting motor controllers has become a challenge. Since the Falcon 500 has an integrated Talon FX motor controller, this problem is a thing of the past. The Falcon 500 will dramatically change the way teams layout their robot's electronics and revolutionize their abilities to iterate their robot mid-season and mid-competition.



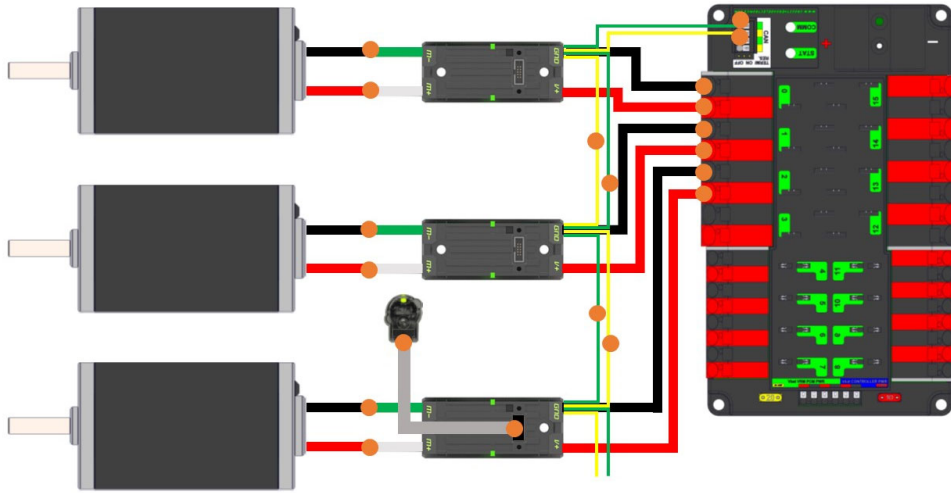
Above: (3x) CIM motors, (3x) Talon SRX, and (1x) Mag Encoder wired to a robot

Above: (3x) Falcon 500 motors wired to a robot

# Falcon 500 Motor User Guide

## Failure Point Reduction

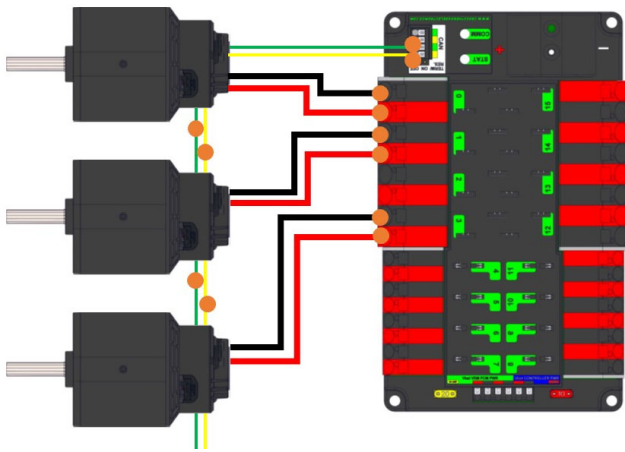
Each wire connection on a robot represents a possible failure point. A loose wire, a bad crimp, something plugged in backwards – all of these can lead to significant problems during a match. The Falcon 500 helps reduce the number of connections (failure points) by up to 50%. This means that your robot will be more robust than ever before. Simply plug in the Falcon 500 to your robot's power distribution system, connect it to CAN or PWM, and you're ready to go! Let's look at some examples:



The diagram to the left is what it would look like to wire (3x) CIM Motors and a Mag Encoder to your robot.

Each of the (20x) orange dots represent a connection that can fail, causing problems for your robot in the middle of a match.

**Above:** (3x) CIM motors, (3x) Talon SRX, and (1x) Mag Encoder wired to a robot. Each orange dot is a possible failure point in the wiring.



**Above:** (3x) Falcon 500 motors wired to a robot. Each orange dot is a possible failure point in the wiring.

The diagram to the left is what it looks like to wire (3x) Falcon 500 motors to your robot. Both diagrams have the same number of motors and sensor capability.

While the brushed motor example shows (20x) possible failure points, the Falcon 500 example has just (12x).

This is a significant reduction in the number of possible wiring problems that can exist on a robot by switching from common brushed motors to the Falcon 500.

What about other brushless options in FRC? Since the motor controller is integrated into the Falcon 500, so is the sensor and sensor wiring. This means that there is no sensor cable between the motor and controller that

can become unplugged during a match, eliminating more potential failures. In addition, the phase wiring between the controller and the motor is handled inside the Falcon 500. This makes it impossible for teams to mismatch the motor's phases with the motor controller's phases, eliminating even more failure points on a robot.

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### Talon FX

The Talon FX is built upon years of development in motor controller technology from Cross the Road Electronics. The Talon FX is the next evolution of the Talon family of motor controllers, which continues to be a leader in FRC motor controller technology.

# TALON FX



The Talon FX gives teams all the features they've come to expect from a Talon motor controller, including Follow Mode, limit switch feedback, and on-board motion control using Motion Magic.

One new feature added to the Talon FX is that a 2048 CPR Encoder is now built in. This means that when you buy a Falcon 500 you're not just buying a motor and motor controller. You're also buying a high-resolution encoder. For the first time in FRC history, a single product is giving teams access to world championship caliber motion control – out of the box, with no additional hardware needed.

Another change from the Talon SRX is that the Talon FX doesn't have a Talon data port and can't have an encoder plugged into it directly. However, teams can use a CAN-based encoder such as the Cross the Road Electronics CANCODER (P/N 19-676768) as an input sensor for Motion Magic.

### Reverse Polarity Protection

The single largest cause of failure in FRC motor controllers is reversing the polarity of the input power. This means a simple wiring mistake like wiring a motor controller backwards into the PDP (Power Distribution Power) or wiring a robot battery backwards can be a costly mistake for a team. The Falcon 500 is the first motor controller in FRC history to have reverse polarity protection built in. This means that if you do plug the Falcon 500 in backwards, the Talon FX isn't damaged or destroyed.

### Field Oriented Control (FOC)

The Talon FX is also capable of commutating the Falcon 500 using Field Oriented Control (FOC). This is different from trapezoidal commutation, which only energizes 2 of the motor's 3 phases at any given moment. With FOC, the Talon FX uses sinusoidal commutation to constantly energize all three phases.

### Phoenix API Compatible

The Talon FX is a Phoenix compatible device. This means that teams can program the Talon FX using their existing Phoenix-based code with only minor changes needed.

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### A Smart Motor for All Teams

The Falcon 500, powered by Talon FX has a built in 2048 CPR Encoder that teams can use to produce reliable motion control, out of the box. This is yet another game changer in FRC.

For the first time ever, teams of all skill and resource levels can have advanced motion control out of the box, without having to buy or setup additional hardware, or learn complicated programming concepts. Here's just some of the applications teams can do with a Falcon 500 and no additional sensor hardware:

**Measure distance driven on a drivetrain** - Use a Falcon 500 on a single speed drivetrain and get accurate distance measurement without the need of an external encoder. For 2-speed drivetrains, teams should still use an external encoder and an encoder, as the motor can't measure the difference in wheel speed between high and low gear.

**Position control on an arm or elevator** - Use a Falcon 500 on an arm or elevator to measure the position of an arm or elevator.

**Velocity control on a flywheel shooter** - Use a Falcon 500 to drive a flywheel shooter and use the integrated encoder to measure velocity.



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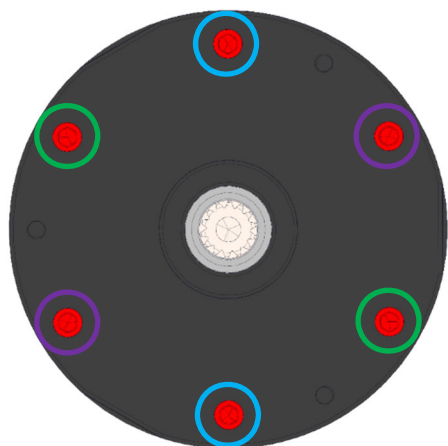
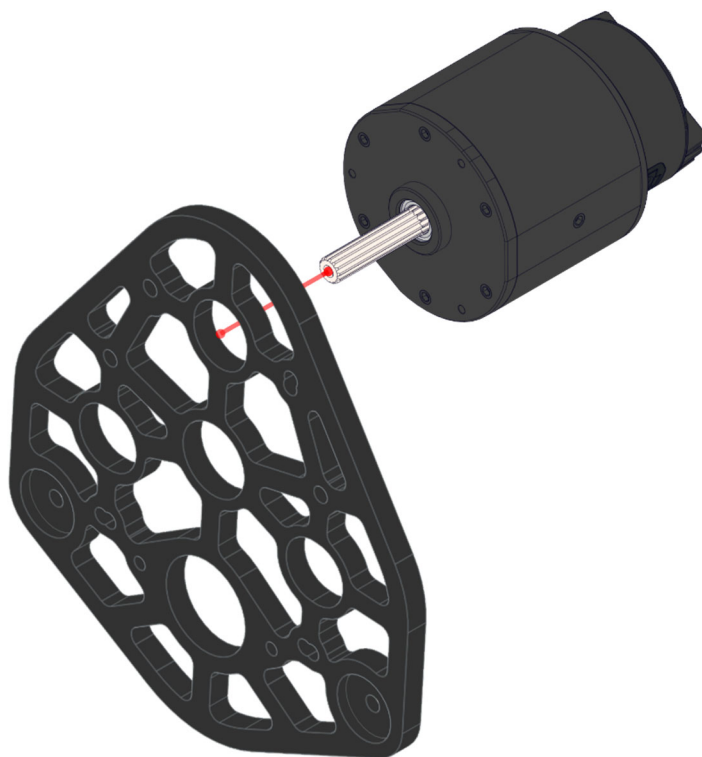
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### CIM Compatible

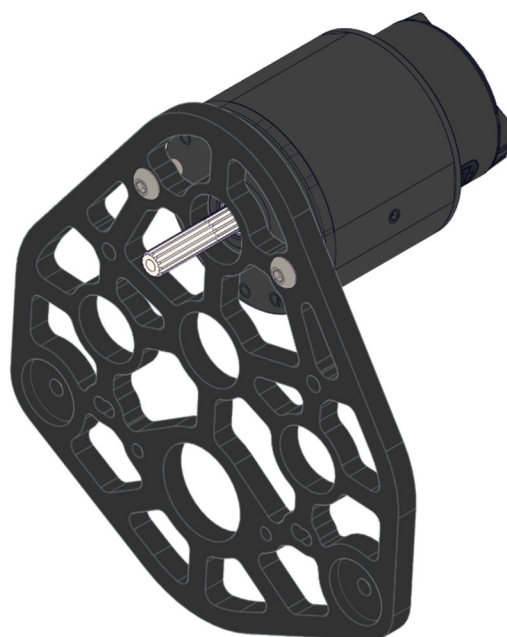
The Falcon 500 comes with (6x) #10-32 holes on a 2" bolt circle. This, combined with the motor's smaller diameter, means the Falcon 500 can be used anywhere a CIM or Mini CIM were used previously.

The extra #10-32 holes mean that teams have more freedom in the direction the wires and cooling port are facing in their application.

Out of the box, all mounting holes are 'plugged' with a #10-32 set screw. It is recommended that any unused mounting holes remain plugged to keep dirt and debris out of the motor chamber.



**Above:** A diagram showing the pairs of mounting holes on the Falcon 500



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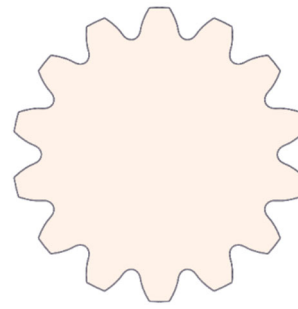
## Rethinking Motor Shafts

When making a game changing motor, why stop at performance? Since the beginning of FRC, teams have had to use keyed or press-fit motor shafts. While these are adequate, VEX and Cross the Road Electronics wanted to give teams a better option. The Falcon Shaft was developed to eliminate many common problems teams have with keyed and press-fit shafts.

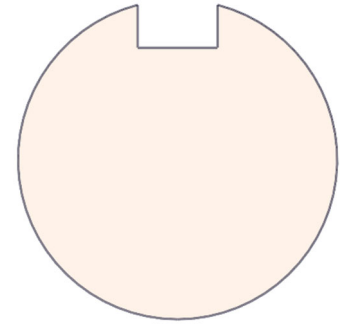
The Falcon Shaft is a new spline shaft designed specifically for FRC. Why are spline shafts better? First off, spline shafts have a higher torque capacity than a similar sized keyed shaft. This is because torque transfer is being spread across all the spline teeth, instead of a single key. This also helps with reversing loads where the force of instantly reversing the direction of the motor is absorbed by all the teeth instead of a single key.



Another small, but convenient detail of the Falcon Shaft is that it has a shoulder built into it which prevents items on the shaft from sliding past the face of the mounting boss. This prevents items on the shaft from rubbing against the inner and outer face of the output bearing. This also eliminates the need for teams to use spacers between the motor's output bearing and the gears and pulleys used on the shaft.

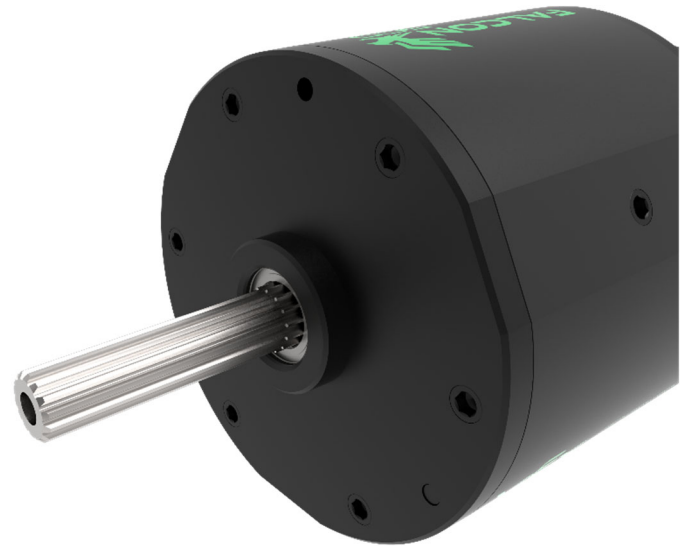


*Profile of Falcon 500  
Motor Shaft*



*Profile of CIM / Mini CIM  
Shaft*

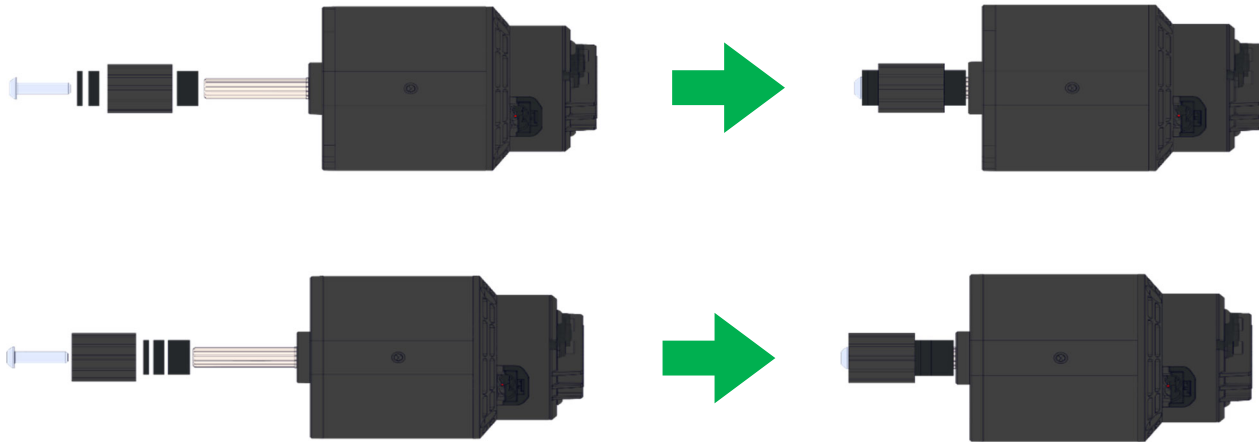
Not only is the Falcon Shaft designed to be stronger while eliminating keys, it is designed to make it even easier on FRC teams. One example of this is that the ends of the Falcon Shaft have a #8-32 tapped hole. This hole is used to retain items on the shaft, which means teams no longer need to use retaining clips or shaft collars to keep items on their motor shafts.



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Speaking of spacers, the Falcon 500 comes with a set of spacers that are specifically designed to help teams position items on their motor within a  $1/16"$ . This is meant to eliminate washer stacks and/or retaining clips to keep gears and pulleys positioned and retained on the motor shaft.

This system is designed so that [1x]  $1/16"$  spacer, [1x]  $1/8"$  spacer, [1x]  $1/4"$  spacer, and any Falcon bore pinion or pulley made by VEXpro will equal the length of the motor's shaft. Since this combination equals the length of the motor's shaft, you just need to put a #8-32 screw into the end of the motor to keep everything retained.



Pinions	Falcon 500 Compatible	CIM Shaft Compatible
8 Tooth Pinion	✓	✗
9 Tooth Pinion	✓	✓ (Press-fit Only)
10 Tooth Pinion	✓	✓
11 Tooth Pinion	✓	✓
12 Tooth Pinion	✓	✓
13 Tooth Pinion	✓	✓
14 Tooth Pinion	✓	✓

One of the biggest benefits of the Falcon Shaft being a spline shaft is that teams can now use smaller gears. The Falcon 500 is the only motor in FRC that allows teams to use as small as an 8T pinion on their drivetrain. This opens the door for teams to make smaller and lighter drivetrain gearboxes.

While press-fits have worked for teams, it's a non-trivial task that when done improperly, can damage motors. The spline eliminates this risk for all teams, while opening new design opportunities only available for teams using the Falcon 500.

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Lastly, the Falcon 500 is the first motor in FRC history that has a replaceable output shaft. In the past, a damaged or cut shaft was permanent. With the Falcon 500, teams now can replace the output shaft instead of replacing the entire motor.

There's also the option to replace the included long shaft with the "Falcon Motor Short Shaft" (217-6958). This shaft is already cut to the length needed to make the Falcon 500 work with a VersaPlanetary.



### Staying Cool Under Pressure

Heat buildup is a problem with any FRC motor. When heat builds up, the motor's internal resistance changes, which decreases its overall performance and efficiency. To combat this, teams have been using fans and freeze spray to try and cool their motors between matches. The Falcon 500 is the first motor in FRC to have a dedicated cooling port designed into the side of the motor. Teams can use this cooling port to connect a #10-32 push-to-connect pneumatic fitting. By using this, teams now have several options for actively cooling their motors. Some examples of how the cooling port can be utilized are:



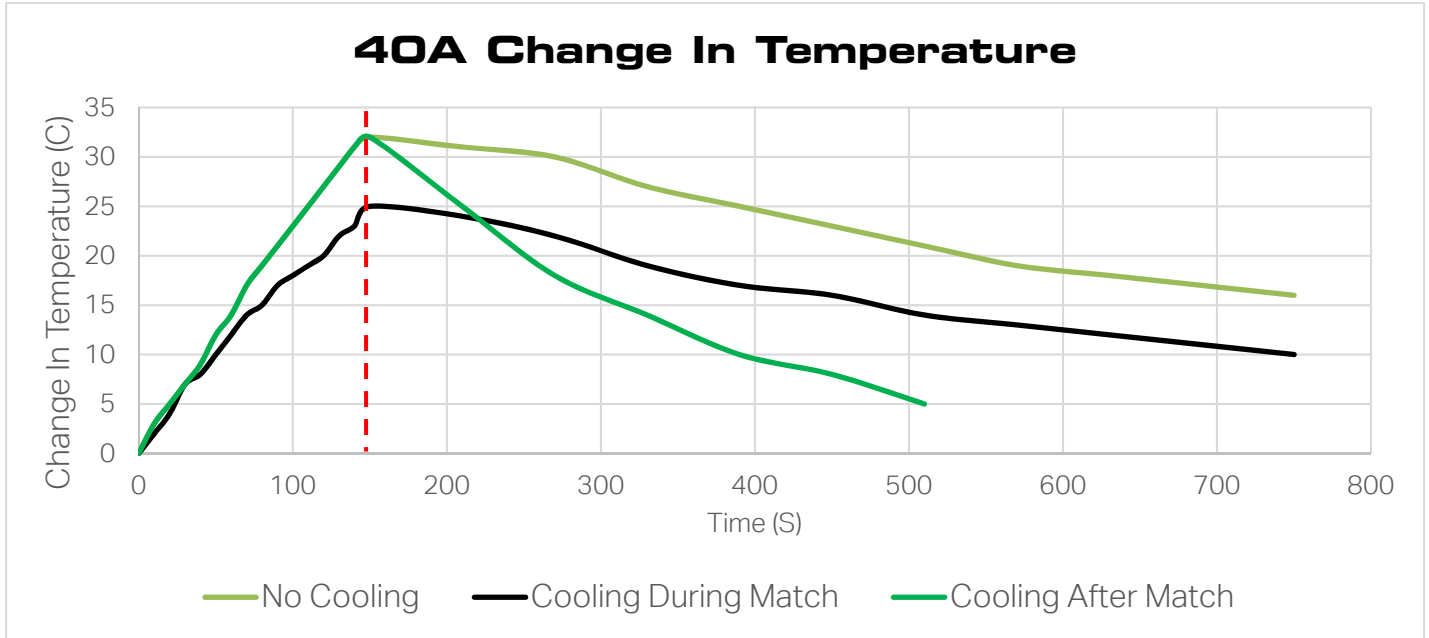
**Pneumatic Exhaust** - Plumb the exhaust from your pneumatic system to the Falcon 500(s). This way every time a cylinder is actuated, cool air is forced into your motors.

**Dedicated Air or Vacuum Pump** - Use a dedicated air or vacuum pump on your robot to force cool air into your Falcon 500(s).

**Off-Board Compressor** - Hook up an external air-source such as a shop compressor to push cool air into your motors after a match.

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Using the cooling port in a match can reduce heat by up to 29 °C (84 °F)<sup>1</sup>. Similarly, using the cooling port after a match can drop your motor's temperature by 27 °C (80 °F) in just 3 minutes – that's just half of a field timeout during the playoffs.



<sup>1</sup>30A @ 50% Duty Cycle

## Specifications

	Dimensions
<b>Dimensions</b>	60mm (2.36") Dia. X 81mm (3.18") Long
<b>Volume</b>	199.54 cm <sup>3</sup> (12.17 mm <sup>3</sup> )
<b>Weight</b>	1.1Lbs (0.49kg)
<b>Output Shaft</b>	14 Tooth, 0.5 Module Spline Shaft
<b>Mounting</b>	6x #10-32 On 2" Bolt Circle
<b>Cooling Port</b>	#10-32 On Side of Motor

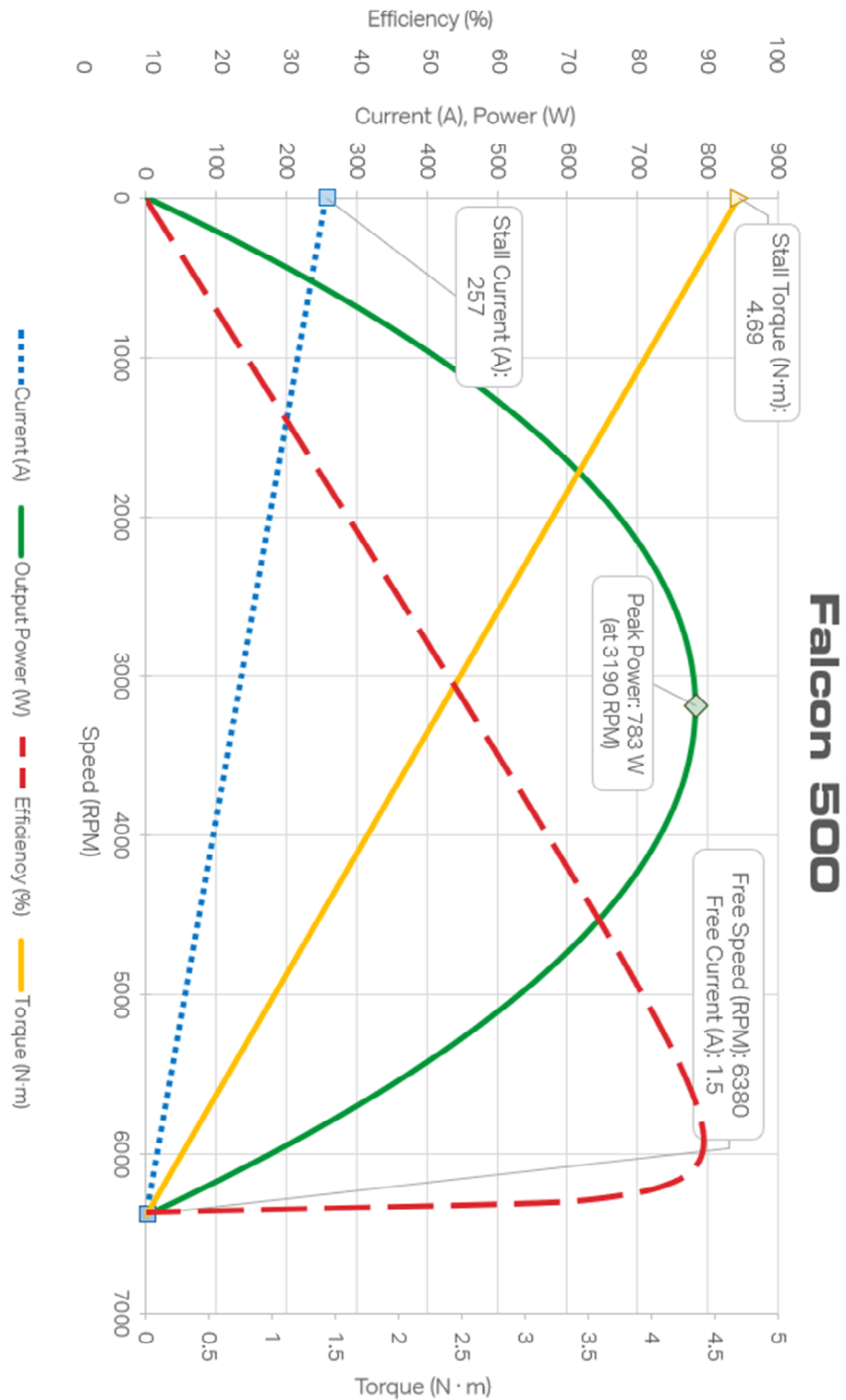
	Performance
<b>Free Speed RPM</b>	6380 RPM
<b>Free Current</b>	1.5A
<b>Stall Current</b>	257A
<b>Stall Torque</b>	4.69Nm
<b>Peak Efficiency</b>	87% (294W In)
<b>Power @ 40A / 12 VDC</b>	400W (83% Efficiency)
<b>Free Current</b>	1.5A
<b>Peak Power</b>	783W

Talon FX Specifications	
Nominal Voltage	12 VDC
PWM Input Pulse	1-2ms Nominal
PWM Input Rate	2.9-100ms
Minimum Throttle (Deadband)	Adjustable 0.1%-25% (4% Default)

Talon FX Inputs & Outputs	
Motor Interface	Integrated
Power	2x 12AWG Silicone Wires (Red & Black)
Communication	CAN / PWM
Direct Sensor Input	Yes, Over CAN Only
Limit Switch Input	2x Through 4 Pin JST Connector
Built-In Encoder Feedback	2048 CPR Encoder
Motion Magic	Yes, Using Built-In Encoder or CAN Sensor

Wire	Wire Color	Wire Length
Positive Input	Red	18in [457.2mm] ± 0.50in [12.70mm]
Input Ground	Black	18in [457.2mm] ± 0.50in [12.70mm]
CAN-High / PWM Signal	Yellow	18in [457.2mm] ± 0.50in [12.70mm]
CAN-Low / PWM Ground	Green	18in [457.2mm] ± 0.50in [12.70mm]

## Performance Data





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### General Warnings

Below are some warnings users should be aware of when working with the Falcon 500.

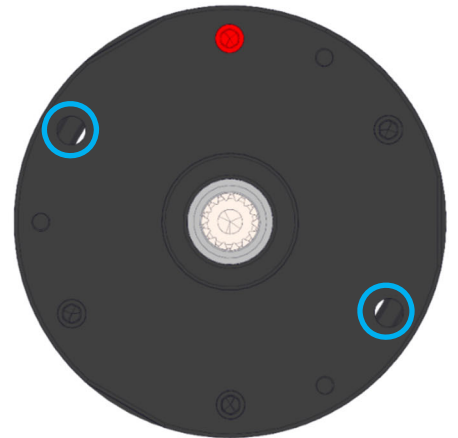
#### **Warning**

**DO NOT** remove the screws from the controller end cap. This can result in a loss of calibration between the motor and motor controller. A loss in calibration will result in decreased performance or permanently damage your Falcon 500.



#### **Warning**

When using the cooling port, make sure you remove the set screw from at least one additional mounting hole. This will prevent pressure from building up inside the motor. The extra hole will also help air flow through the motor, further assisting with the cooling process.



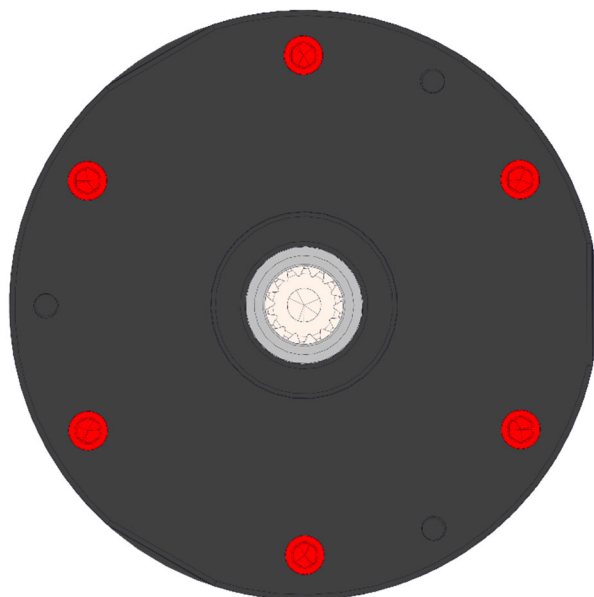
## Mounting a Falcon 500

The Falcon 500 comes with (6x) mounting holes so that teams have many options on the orientation of the wires and cooling port. To prevent dust and debris from entering the motor chamber of the Falcon 500, each mounting hole is plugged with a #10-32 set screw. It is recommended that any unused mounting holes remain plugged to continue preventing dirt and debris from entering the motor chamber.

**NOTE:** If you are using the cooling part, it is recommended that you remove a set screw from an additional mounting hole. This will prevent pressure from building up in the motor and assist with airflow through the motor.

### Step 1: Remove at least (2x) Set Screws from the Motor Mounting Holes

Using a 3/32" Hex Key, remove (2x) of the #10-32 set screws. If the Falcon 500 is being mounted on a gearbox as an alternative to a CIM / Mini CIM, the two screws should be 180° apart.

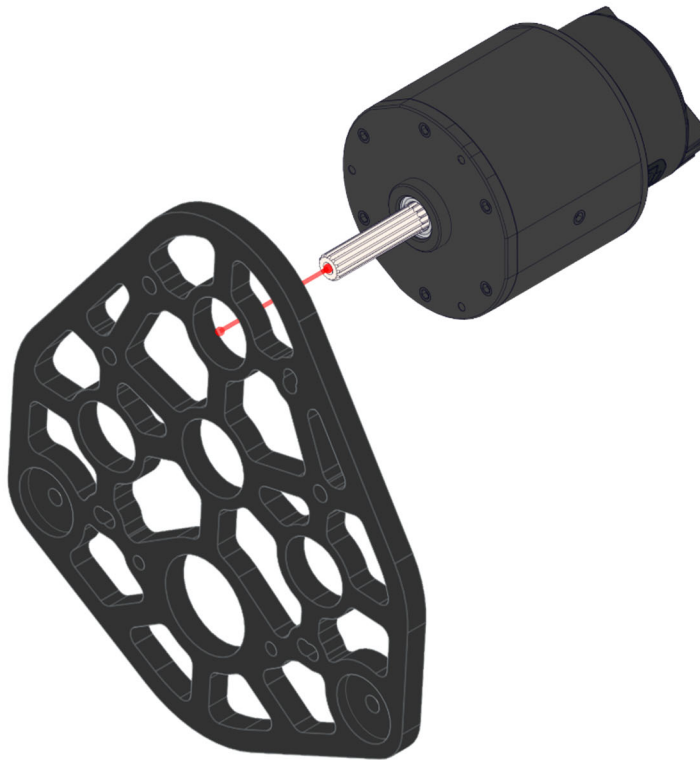


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### Step 2: Align Motor to Mounting Holes

Line up the (2x) open mounting holes on the motor to the mounting holes found wherever you can use a CIM.



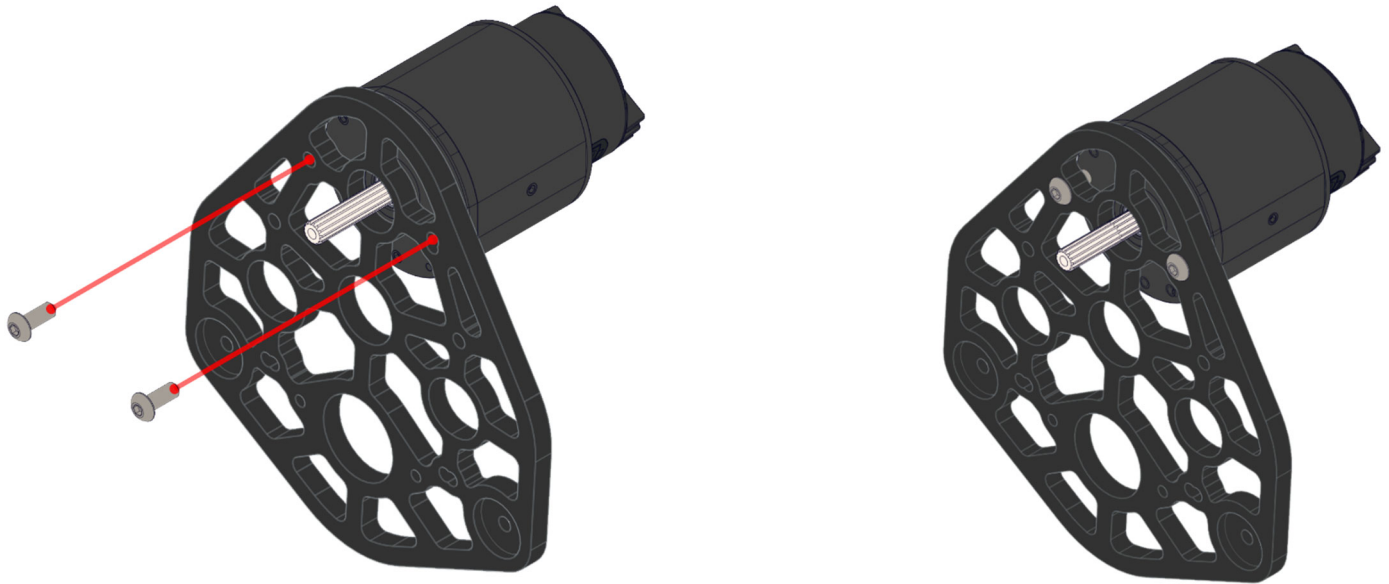
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### Step 3: Insert #10-32 Mounting Screws into Motor

Insert (2x) #10-32 screws through the mounting surface and into the motor. Secure the screws using a 9/64" hex key.

**NOTE:** Mounting screws can go a little over a 1/4" into the motor. Screws that protrude further than this may interfere with the motor's rotation.



## Wiring the Falcon 500

Wiring the Falcon 500 to a robot is easier than any other motor / motor controller in FRC. Similar to the Talon SRX and Victor SPX, the Talon FX can be controlled using either PWM or CAN. The PWM/CAN leads (green/yellow twisted pairs) on the Talon FX come with a 3 pin (0.1" pitch) connector pre-installed. One pair of leads has a female connector, the other has a male connector. This way, several Talon FX controllers can be daisy chained together on a CAN bus, or they can plug in directly to the roboRIO for PWM control.

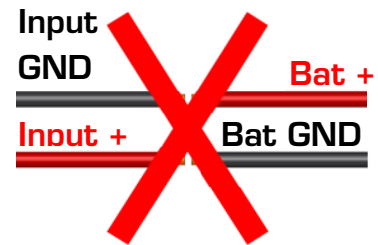
This section covers how to wire the Falcon 500, powered by Talon FX to your robot.

### Step 1: Connect the Talon FX to the robot's power distribution system

Connect the positive (red) wire to a positive terminal on the power distribution panel. Then connect the ground wire to a ground terminal on the power distribution panel. If possible, the Talon FX should be wired directly to the power distribution panel. This will reduce the number of electrical connectoins and potential failure points on the robot.

If the wires are too short, an extension cable will need to be used. Make sure any extension cables being used follow the most current FRC wiring rules.

**NOTE:** The Talon FX has built in reverse polarity protection. This ensures that the Talon FX isn't damaged in the event power polarity is reversed. However, the Talon FX will not function while polarity is reversed.



## Step 2: Connect the Talon FX to the robot's CAN bus network or PWM output

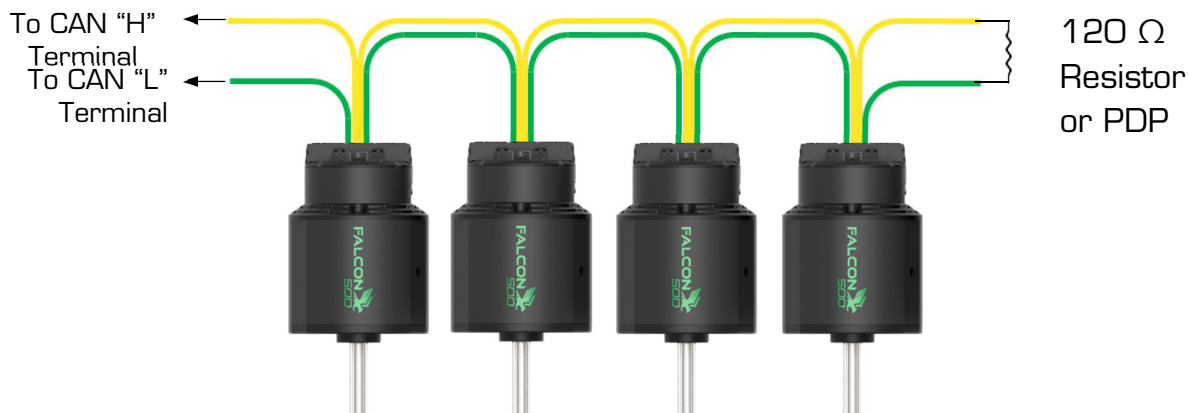
### CAN Instructions

Using the CAN bus to control the Talon FX allows users to take full advantage of all its features. To wire the CAN bus, connect a yellow signal wire to the CAN terminal marked "H" on the NI roboRIO and connect a green signal wire to the CAN terminal marked "L" on the NI roboRIO.

To connect additional Talon FXs, use the pre-installed connector to connect one Talon FX to another Talon FX. After your Talon FXs have been wired, there will be 2 remaining signal wires – connect these two wires using a 120  $\Omega$  resistor or to the CAN interface on the Power Distribution Panel (PDP) to properly terminate the cable end.

If the signal wires are too long, they can be cut shorter, but the end of the wire should be terminated with a tightly crimped connector to connect the signal wires green-to-green & yellow-to-yellow. For the best connection, it is **highly** recommended that each connector is crimped **and** soldered. The yellow and green wires should also be wrapped in a twisted pair fashion (not illustrated) to maximize tolerance to electrical noise.

**NOTE:** Signal wires of the same color are electrically identical – it does not matter which wire is used if the color is correct.



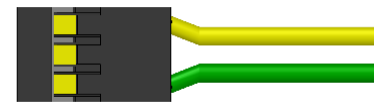
## PWM Instructions

Either of the Talon FX's built-in CAN bus wires can be used to control the device using PWM. In addition, one set of twisted pair wires have a male PWM connector while the other has a female PWM connector. This makes it easy to connect the Talon FX with many PWM controllers, such as the roboRIO and several VEX microcontrollers. The PWM signal used to control the Talon FX should be between 1-2ms in duration with a center (neutral) pulse of 1.5ms and a period between 2.9-100ms. The PWM period is how fast the robot controller can send a new PWM pulse. The amount of time between the rising edge of one PWM pulse to the next PWM pulse should not be less than 2.9ms or greater than 100ms.

Wire Color	Description	Traditional PWM Wire Color
Yellow	PWM Signal	White
Green	PWM Ground	Black



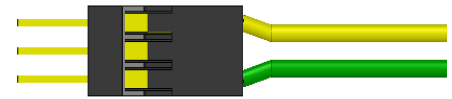
Standard Male 3-pin  
Extension Cable



Female 3-pin plug required  
for NI roboRIO



Standard female 3-pin  
Extension Cable



Male 3-pin plug required for  
some control systems

### Controlling a Talon FX with a NI roboRIO Controller:

To connect a Talon FX to the NI roboRIO controller, simply plug the Talon FX's attached female PWM connector into the desired PWM header in the roboRIO's PWM output with the yellow (signal) wire on the "inside" of the controller. If an extension cable is needed for the Talon FX to reach the roboRIO, a standard male-female 3-wire extension cable should be used – these extension cables are available from VEX Robotics as well as many other online retailers.

### Controlling a Talon FX with a VEX & CTRE Microcontrollers:

The Talon FX is compatible with the following VEX and Cross the Road Electronics microcontrollers:

Name (P/N)	Manufacturer Part Number	CAN / PWM	Male or Female Connector
V5 Robot Brain	VEX Robotics <i>276-4810</i>	PWM	Male
ARM® Cortex®-based Microcontroller	VEX Robotics <i>276-2194</i>	PWM	Male
Hero Development Board	CTR Electronics <i>16-728279</i>	CAN	None (Remove Connector)

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## Falcon 500 Motor User Guide

To connect a Talon FX with any of the above VEX microcontrollers, simply plug the Talon FX's male PWM connector into the desired motor port on the microcontroller with the white (signal) wire on the "inside" of the microcontroller.

If an extension cable is needed for the Talon FX to reach one of these microcontrollers, a standard male-female 3-wire extension cable should be used – these extension cables are available from VEX Robotics as well as many other online retailers.

**NOTE:** The Talon FX's default calibration profile is configured for use with the roboRIO. To reconfigure it for use with a VEX microcontroller, follow the directions in the Calibration section.

### Applying Power for the First Time

Before applying power for the first time, it is a good idea to double check the following:

- The red wire is connected to the positive source
- The black wire is connected to the source ground
- All electrical connections are secure and electrically isolated
- A 40A or smaller breaker is in series with the Talon FX's positive power input
- There are no short circuits on the Talon FX's output
- The CAN cable is correctly oriented (i.e. yellow to yellow for CAN bus & yellow to white for PWM)



## Installing Gears & Pulleys

The Falcon 500 comes with a spline shaft that eliminates the need to use keys and press-fits to transfer torque from the shaft to the gear or pulley. The end of the shaft has a #8-32 tapped hole which can be used to retain items on the shaft.

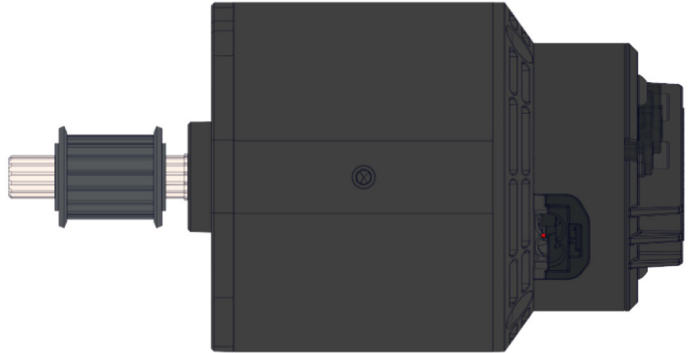
To help position items on the shaft, the Falcon 500 comes with a set of spacers. (1x) of each thickness spacer and (1x) of any gear or pulley made by VEX Robotics equals the length of the Falcon 500's shaft.

Below is a table that shows the order of gears/pulleys and spacers based on the desired distance from the end of the shaft.

Desired Distance from End of Shaft	First Item Installed on Shaft			Last Item Installed on Shaft
7/16"	Gear / Pulley	1/16" Spacer	1/8" Spacer	1/4" Spacer
3/8"	1/16" Spacer	Gear / Pulley	1/8" Spacer	1/4" Spacer
5/16"	1/8" Spacer	Gear / Pulley	1/16" Spacer	1/4" Spacer
1/4"	1/8" Spacer	1/16" Spacer	Gear / Pulley	1/4" Spacer
3/16"	1/4" Spacer	Gear / Pulley	1/16" Spacer	1/8" Spacer
1/8"	1/4" Spacer	1/16" Spacer	Gear / Pulley	1/8" Spacer
1/16"	1/4" Spacer	1/8" Spacer	Gear / Pulley	1/16" Spacer
0"	1/4" Spacer	1/8" Spacer	1/16" Spacer	Gear / Pulley

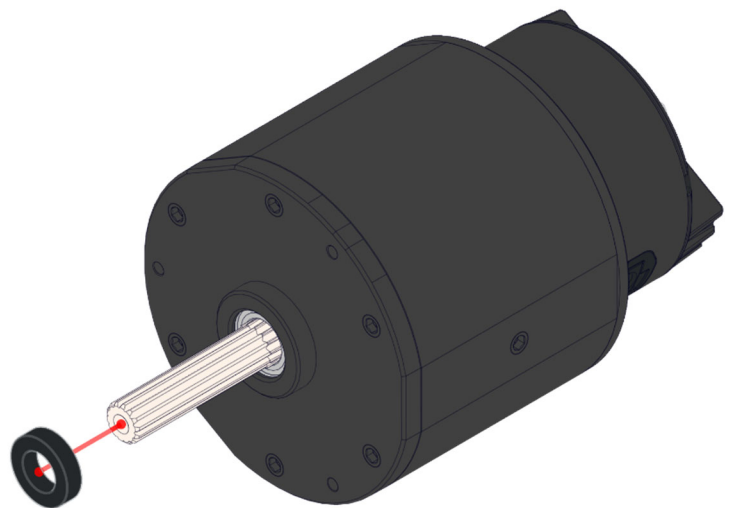
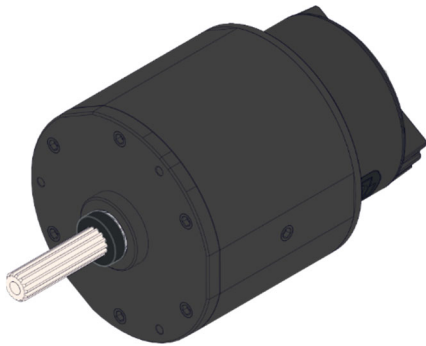
## Step 1: Determine the Approximate Location of the Gear/Pulley on the Shaft

Determine where you want your pinion and pulley to be located on the Falcon 500's spline shaft. In this example, we want the GT2 pulley to be 5/16" away from the end of the shaft.



## Step 2: Install Washers Between the Shaft's Shoulder and Gear (if necessary)

Based on the table at the beginning of this section, the first item installed on the shaft is a 1/8" thick spacer.

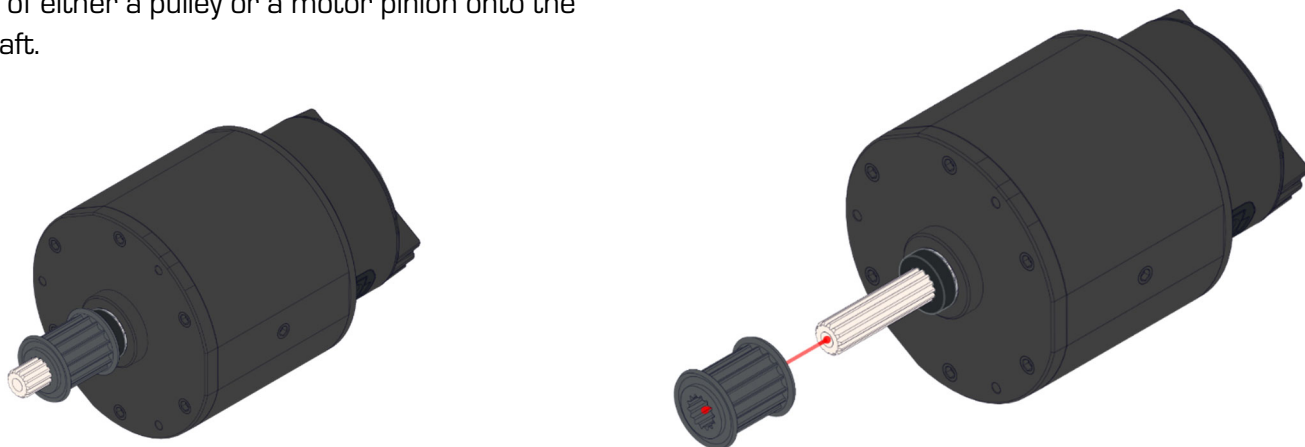


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## Falcon 500 Motor User Guide

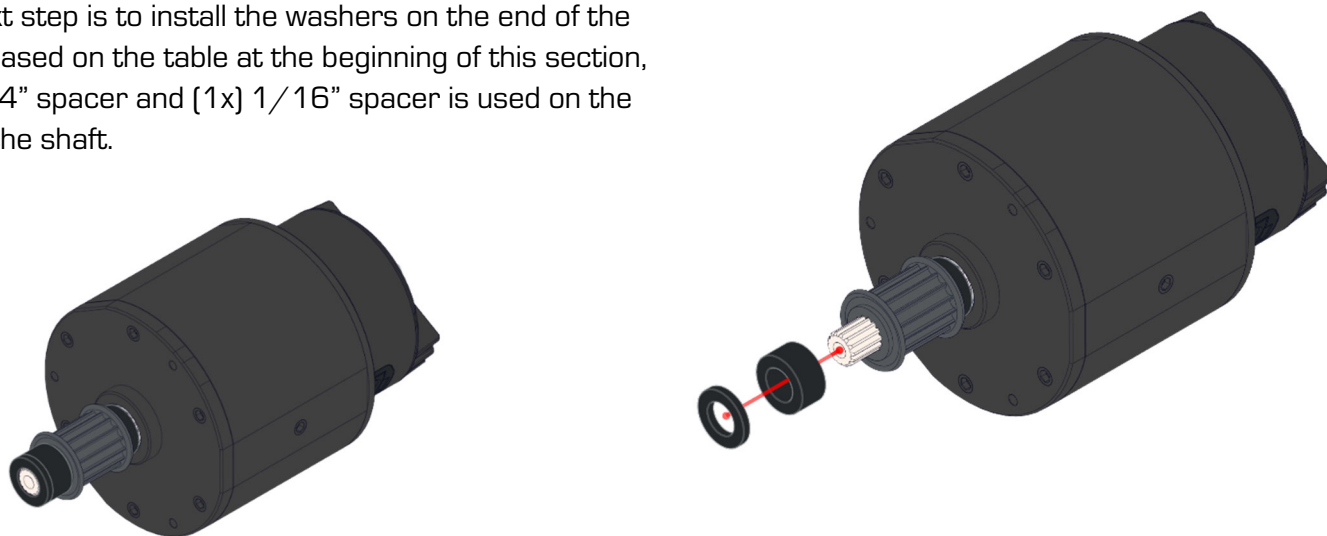
### Step 3: Install Gear/Pulley on Motor Shaft

Slide (1x) of either a pulley or a motor pinion onto the motor shaft.



### Step 4: Install Washers Between the Gear/Pulley and the End of the Shaft (if necessary)

The next step is to install the washers on the end of the shaft. Based on the table at the beginning of this section, (1x) 1/4" spacer and (1x) 1/16" spacer is used on the end of the shaft.



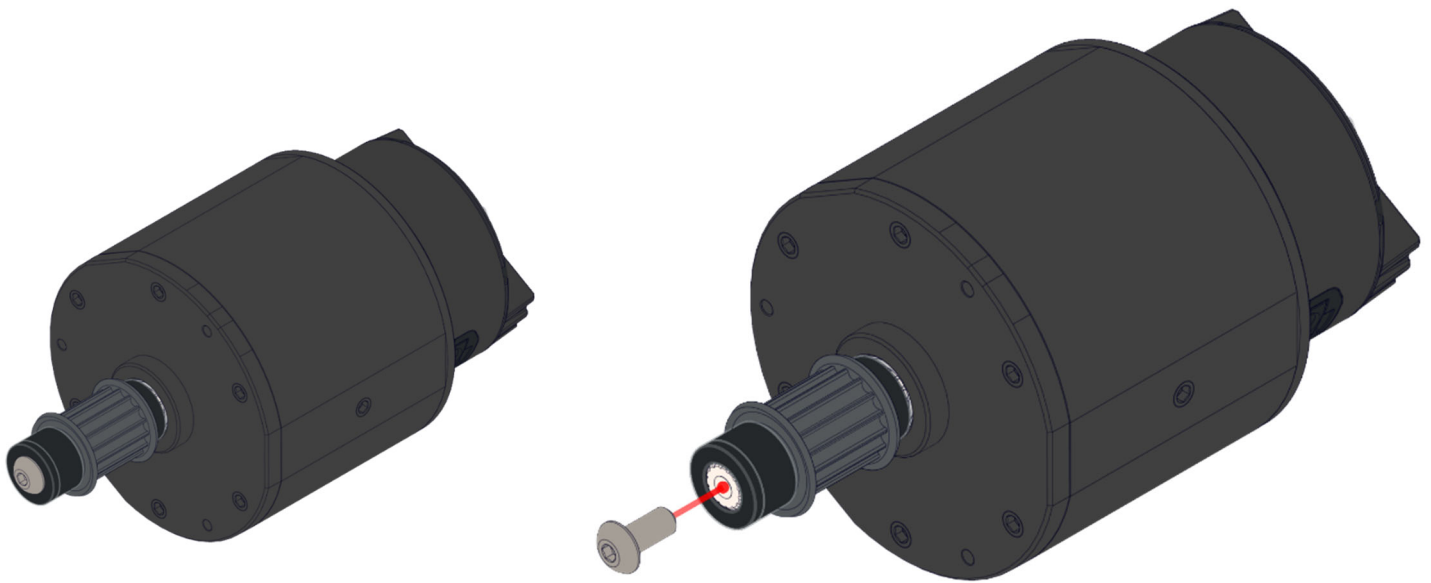
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## Falcon 500 Motor User Guide

### Step 5: Install Screw in the End of the Shaft.

Any #8-32 screw button head or socket head screw will work as a retaining screw. It's important to consider the application the motor is being used in so that you can still access the screw. This way if the screw needs to be tightened, or the gear needs to be replaced, the screw can still be accessed.

For example, if the end of the shaft is going to be accessible, we recommend using a #8-32 x 1/2" Star Drive Screw (P/N [276-4992](#)). However, if the end of the shaft isn't accessible, we recommend using a hex head screw (McMaster-Carr P/N [97763A177](#)).



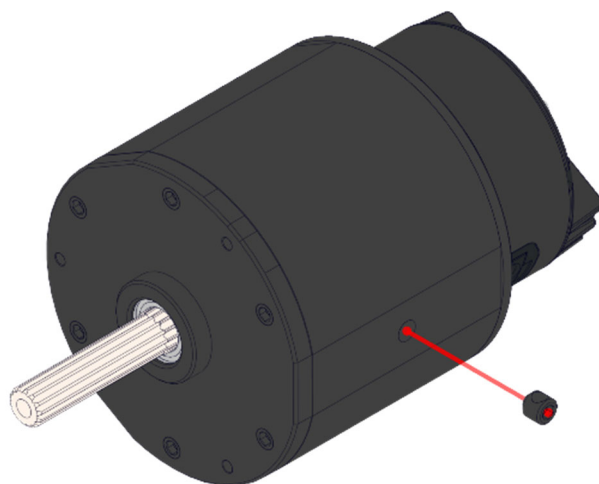
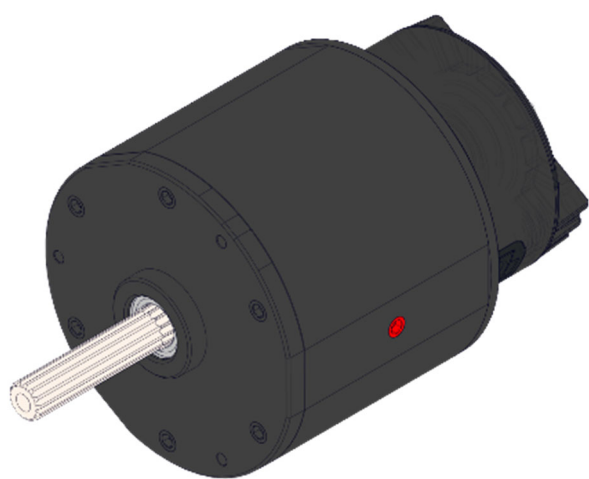
## Using the Falcon 500 Cooling Port

The Falcon 500 comes with a cooling port that can be used to force air through the motor chamber. This helps keep the motor cooler and therefore running more efficiently.

This section covers how to use the cooling port. Before using the cooling port, teams should read the most current robot construction rules to confirm that the method of using the cooling port is legal for the current season.

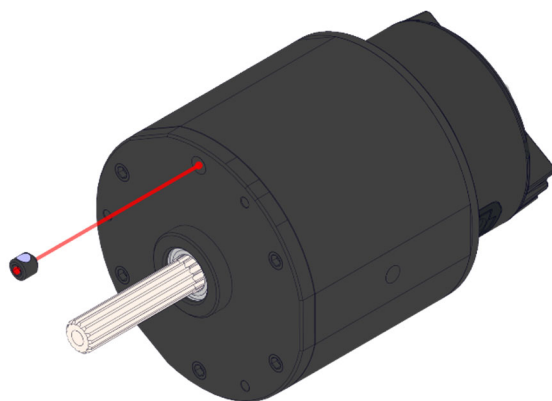
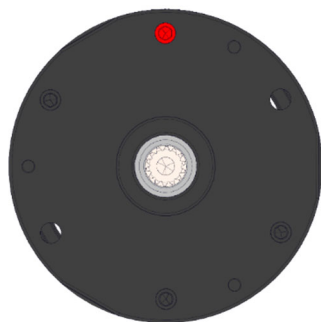
### Step 1: Remove the Set Screw from the Cooling Port

Using a 3/32" hex key, remove the #10-32 set screw from the Falcon 500's cooling port.



### Step 2: Remove at Least (1x) Additional Set Screw from a Mounting Hole

Use a 3/32" hex key to remove (1x) additional set screw from the front face of the Falcon 500.

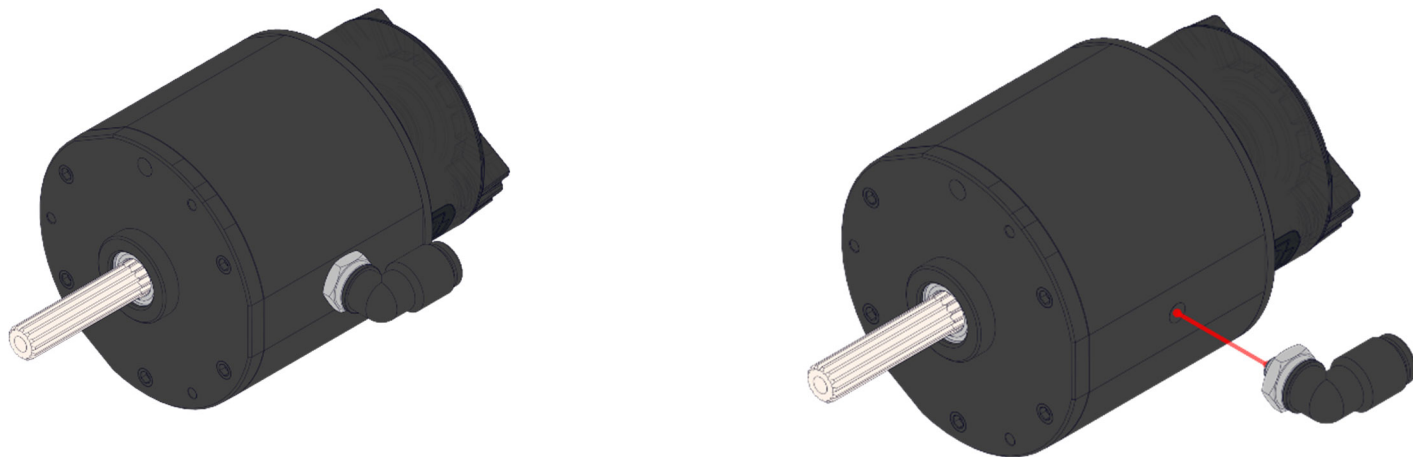


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## Falcon 500 Motor User Guide

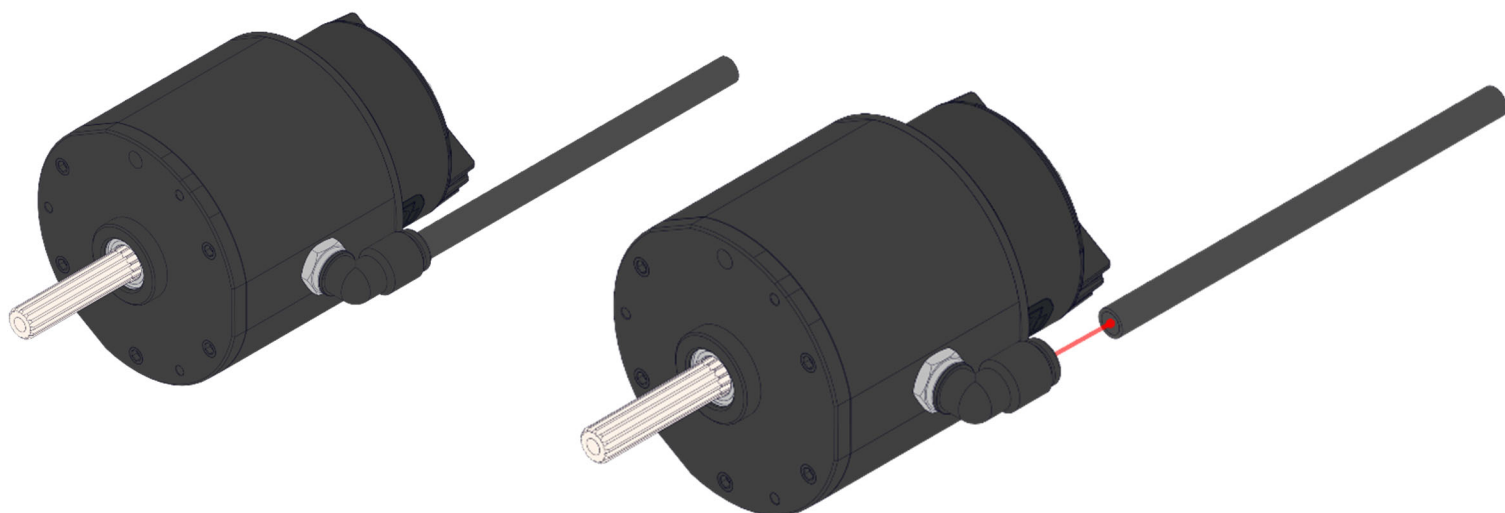
### Step 3: Install #10-32 Push-to-Connect Pneumatic Fitting

Use a 11mm wrench, screw a #10-32 pneumatic fitting into the Falcon 500's cooling port.



### Step 4: Connect Hose to Fitting

Connect pneumatic tubing to the pneumatic fitting from your air source.



## Changing the Output Shaft

The Falcon 500 gives teams the ability to change or replace the output shaft of the motor. If the motor's output shaft gets cut or damaged, teams can replace the original output shaft with a new output shaft. Similarly, if teams are using the Falcon 500 with the VersaPlanetary, there is a short shaft option (217-6958) that is already cut to the correct length.

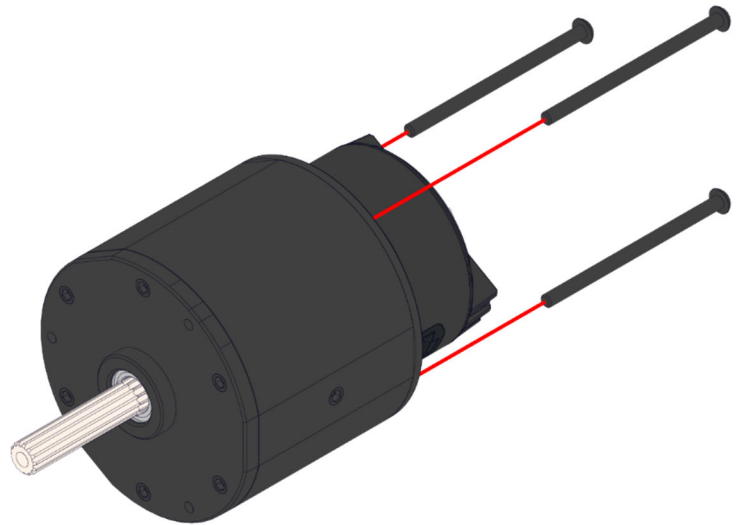
This section goes into detail about how to change the output shaft.

### Step 1: Remove the (3x) M3 Screws from the Back of the Motor Chamber

Use a T10 torx key to remove the (3x) M3 screws that secure the front end cap to the motor housing.

#### Note

T10 torx screw drivers are available from several local and online stores. We recommend McMaster-Carr P/N 5756A14.



#### Warning

**DO NOT** remove the screws from the controller end cap. This can result in a loss of calibration between the motor and motor controller. A loss in calibration will result in a loss of efficiency or function of your Falcon 500.



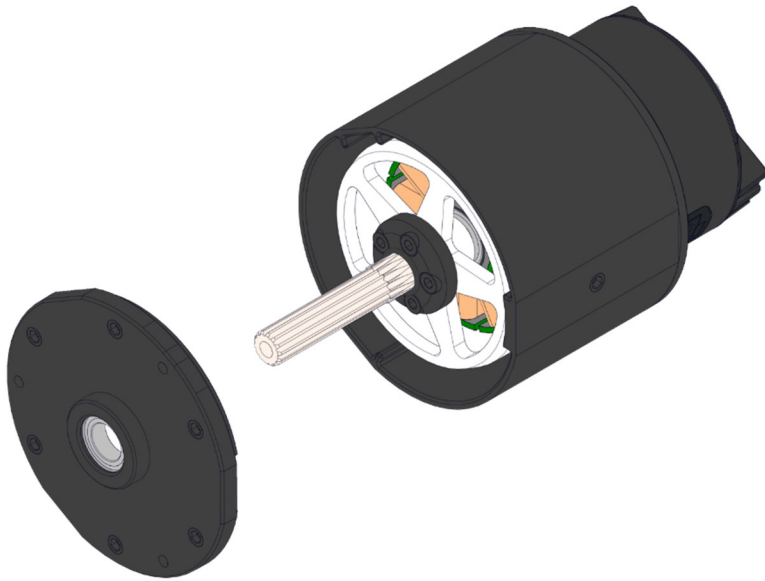
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## Falcon 500 Motor User Guide

### Step 2: Remove the Front End Cap from the Motor Chamber

Remove the front end cap from the motor housing.

**NOTE:** When removing the front end cap, make sure you remove the front end cap bearing as well.

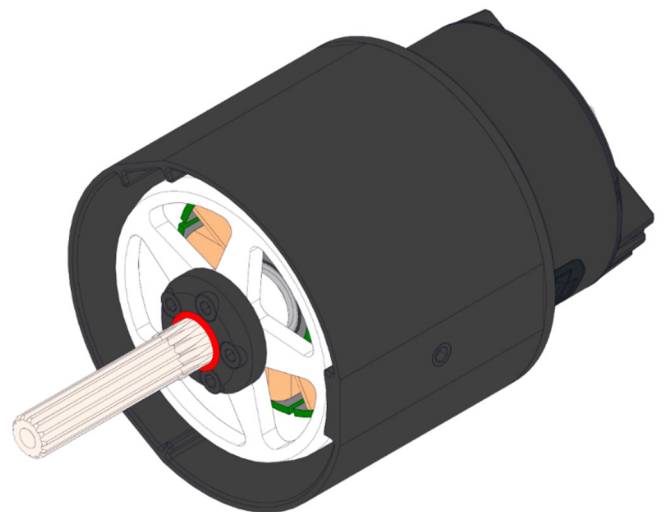


### Step 3: Remove the O-Ring from the Shaft

Remove the O-ring installed on the Falcon 500's shaft.

#### **Note**

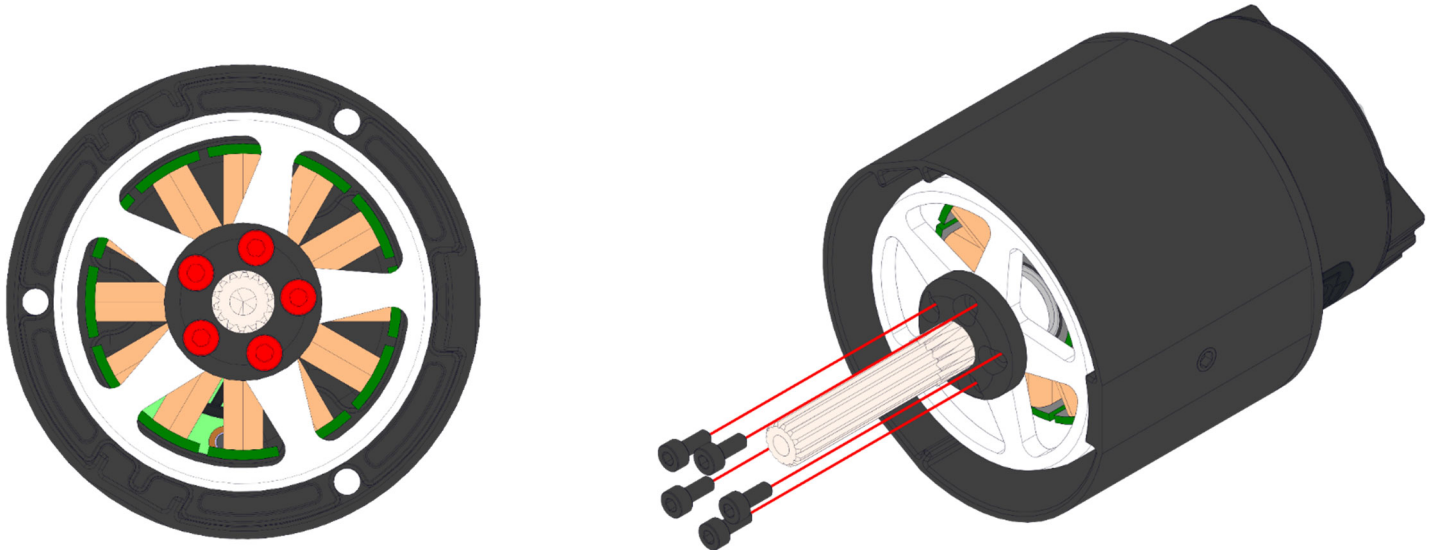
Do not discard the O-ring. This is an import part of the Falcon 500 assembly. If the O-ring is damaged or lost, a replacement O-ring can be purchased from McMaster-Carr (P/N [9262K442](#)).





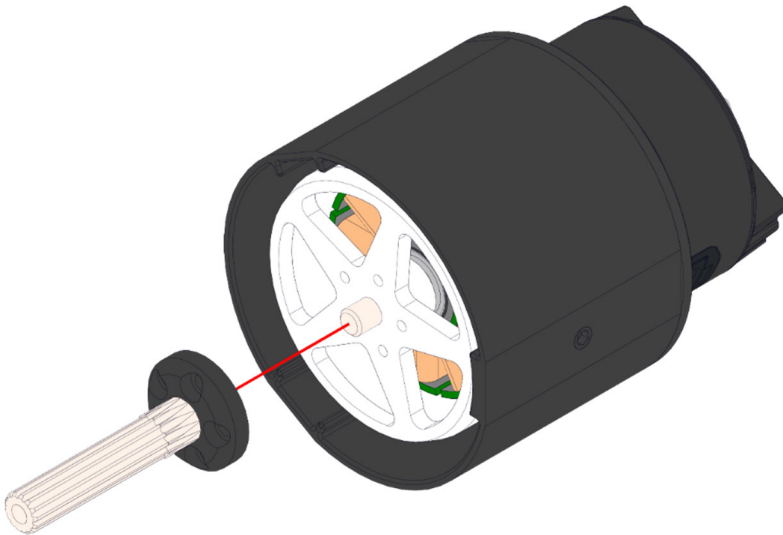
## Step 4: Remove the (5x) M2.5 Screws from the Flange of the Shaft

Use a 2mm hex key to remove the (5x) 2.5mm screws that secure the Falcon 500's output shaft to the motor assembly.



## Step 5: Remove the Shaft

Remove the output shaft from the Falcon 500.

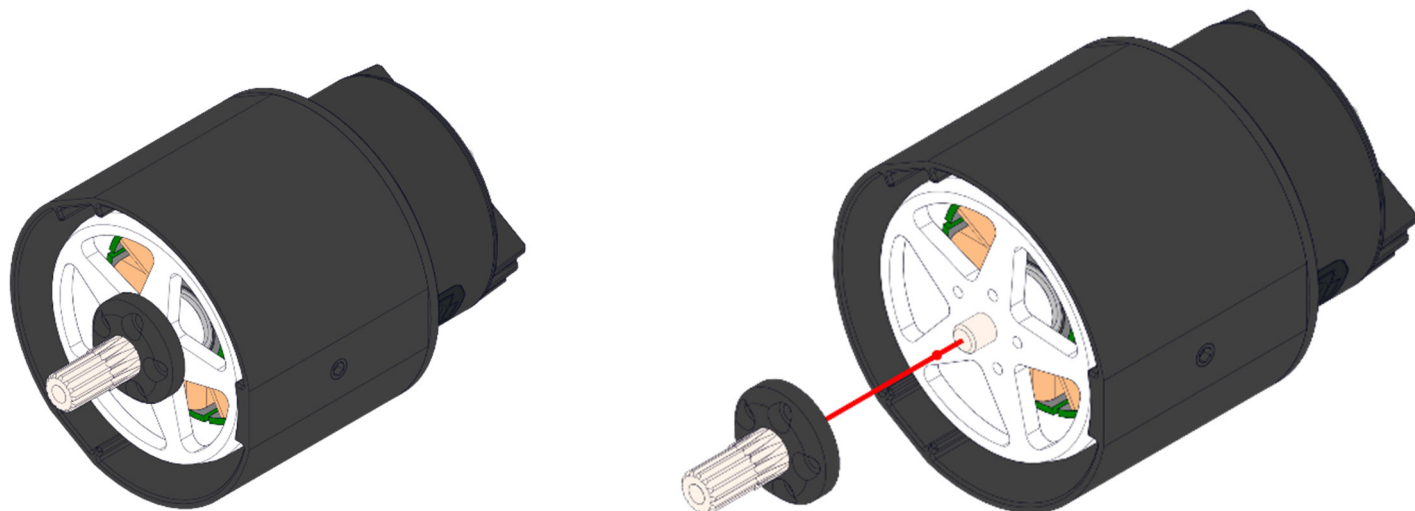


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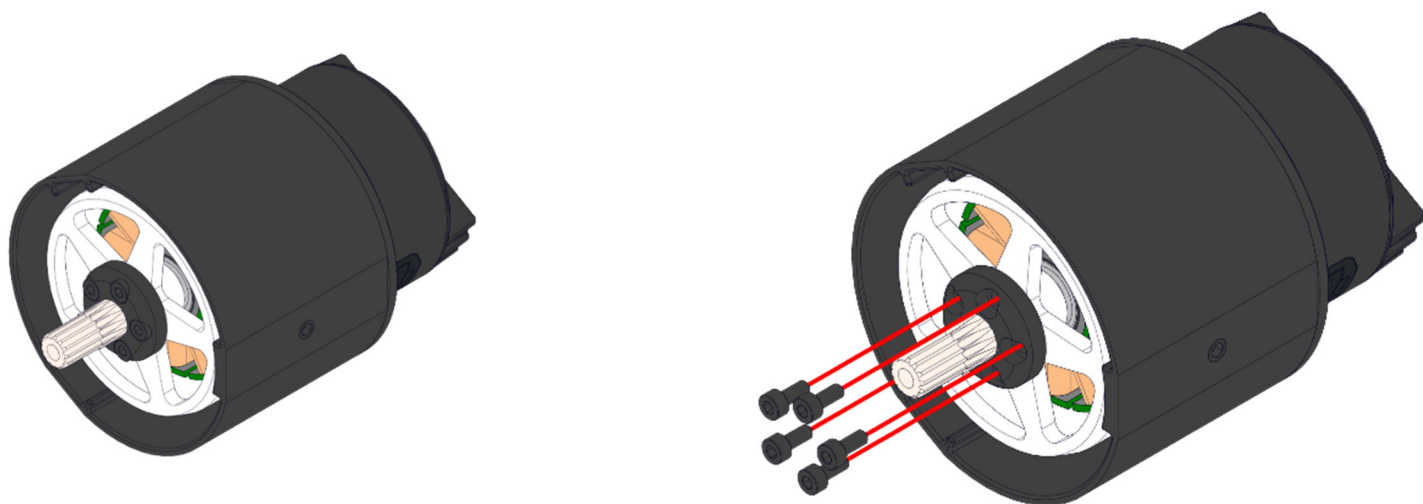
### Step 6: Place New Shaft on Motor

Slide the new output shaft onto the motor assembly.



### Step 7: Use (5x) M2.5 Screws to Secure the New Shaft to the Motor

Using a 2mm hex key and the (5x) 2.5mm screws that were removed in Step 4, secure the new output shaft to the rest of the motor assembly.

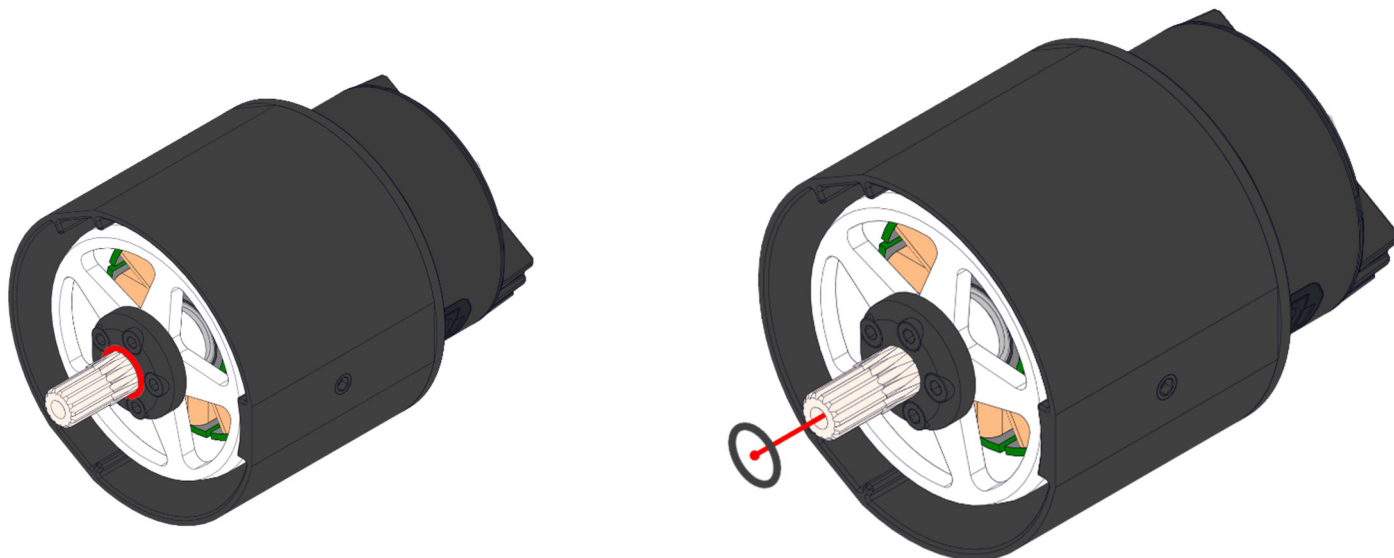


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## Falcon 500 Motor User Guide

### Step 8: Install the O-Ring

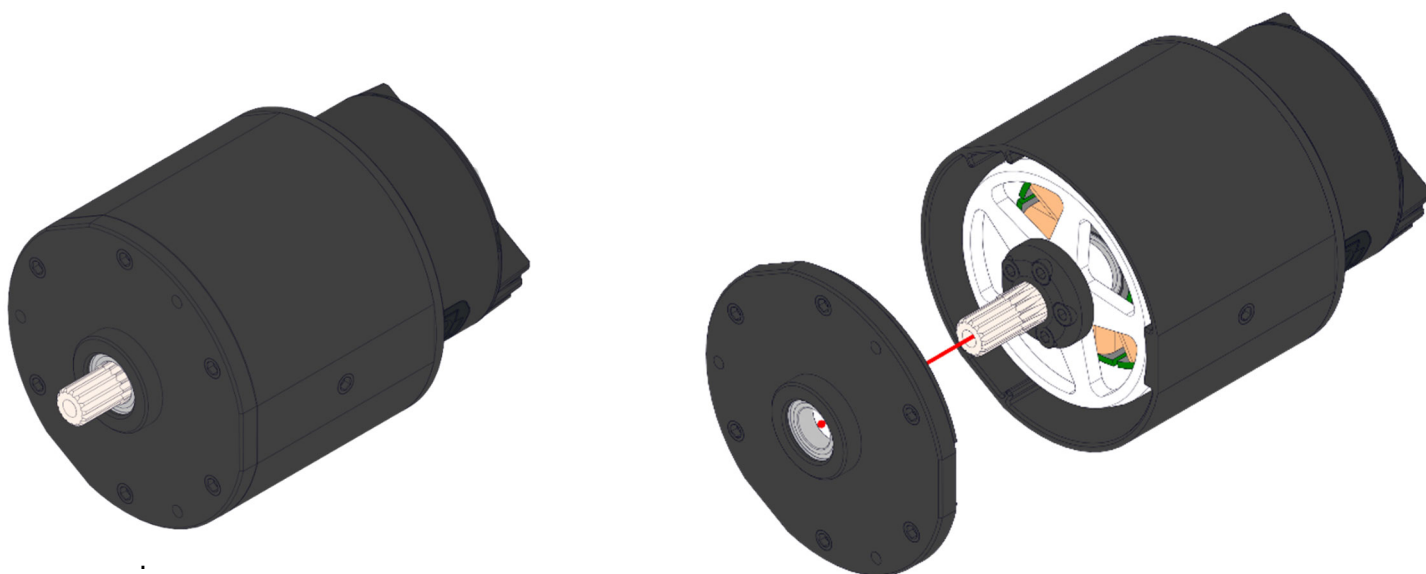
Slide the O-ring that was removed in Step 3 onto the newly installed output shaft.



### Step 9: Install the Front End Cap on the Motor Chamber

Reinstall the front end cap that was removed in Step 2.

**NOTE:** The front end cap is keyed to the sleeve of the motor chamber. If the end cap doesn't seat correctly, turn it 120° until it does.



## Step 10: Install (3x) M3 Screws into the Back of the Motor Chamber

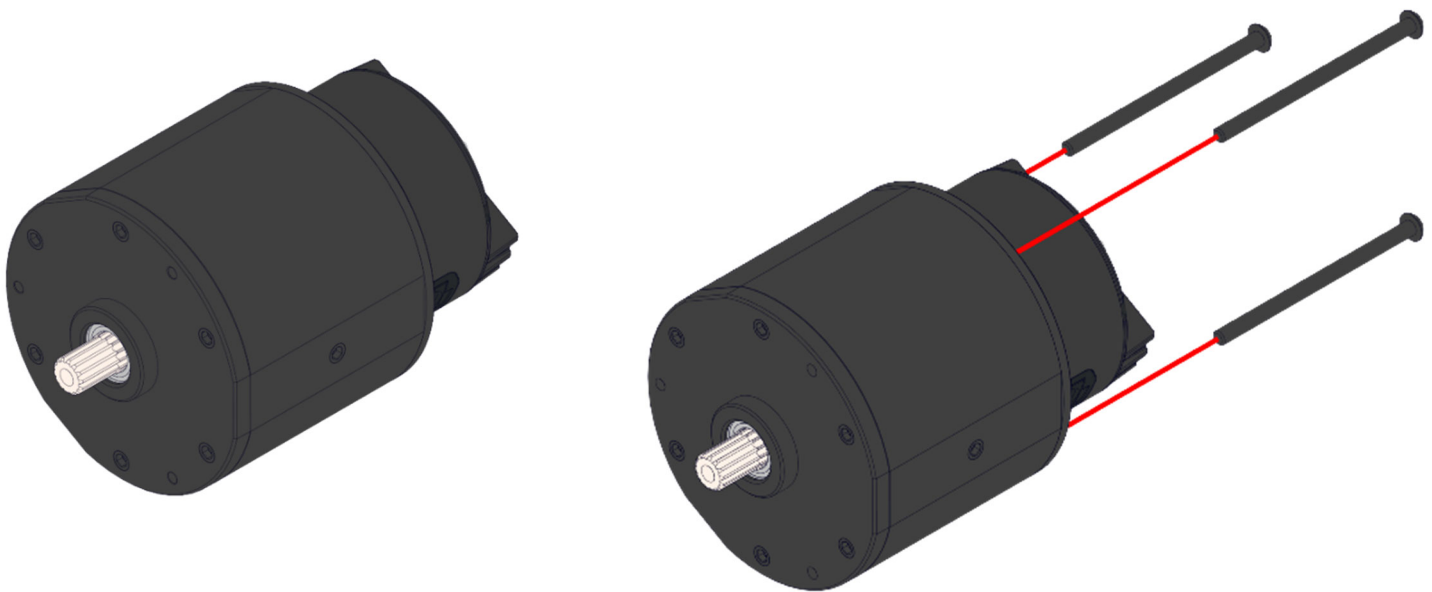
Use a T-10 star drive to reinstall the (3x) M3 screws that were removed in step 1, securing the front end cap to the rest of the motor assembly.

The M3 screws will be attracted to the side of the motor, making it difficult to thread them into the front end cap. Here's a tip to make this easier:

1. Push the (3x) M3 screws all the way through the housing.
2. Then line up an M3 screw with the corresponding M3 tapped hole on the front end cap.
3. Thread the M3 screw into the front end cap just 1-2 threads.
4. Repeat #2 and #3 until all three M3 screws are threaded into the end cap.
5. Push the front end cap so it's seated on the housing.
6. Tighten the (3x) M3 screws.

### **NOTE:**

After putting the Falcon 500 back together, check to make sure the shaft spins free by hand. If you feel any binding, the front end cap may not be properly aligned with the shaft or the motor chamber sleeve.



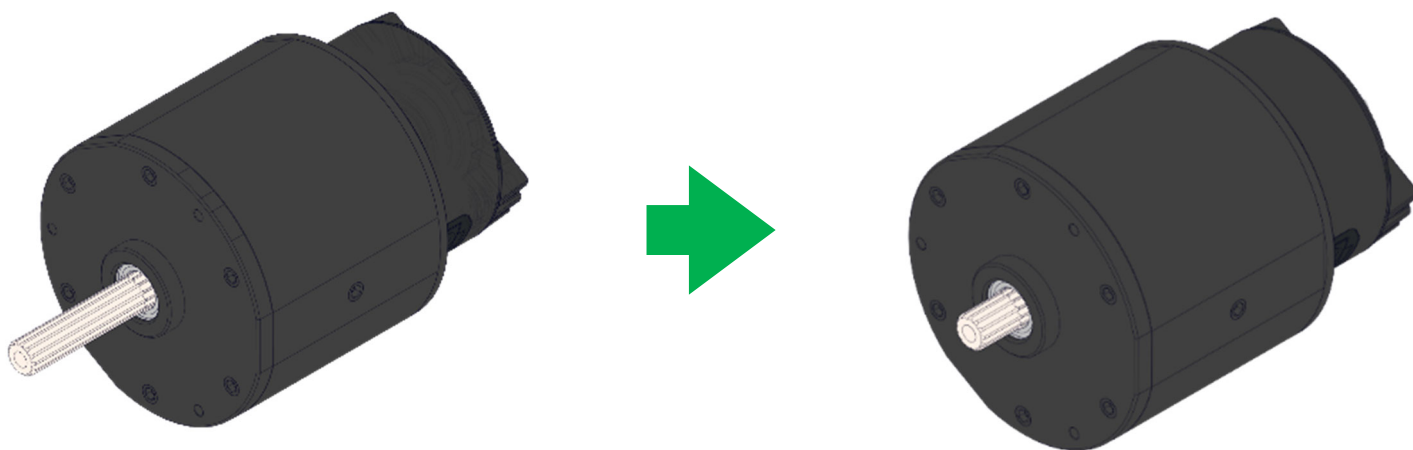
## Installing the Falcon 500 In A VersaPlanetary

The VersaPlanetary is a great option for teams looking to slow down their Falcon 500. Previously, if you wanted to use a CIM, Mini CIM or NEO, you would have to cut the shaft down to make it fit. This is a permanent modification. As was covered in the previous section, the Falcon 500's shaft can be replaced with a short shaft option. This short shaft is pre-cut to the correct length needed to use the Falcon 500 with the VersaPlanetary.

This section covers installing the Falcon 500 with a VersaPlanetary.

### Step 1: Replace the Long Output Shaft with a Short Output Shaft

Follow the instructions for changing the output shaft.

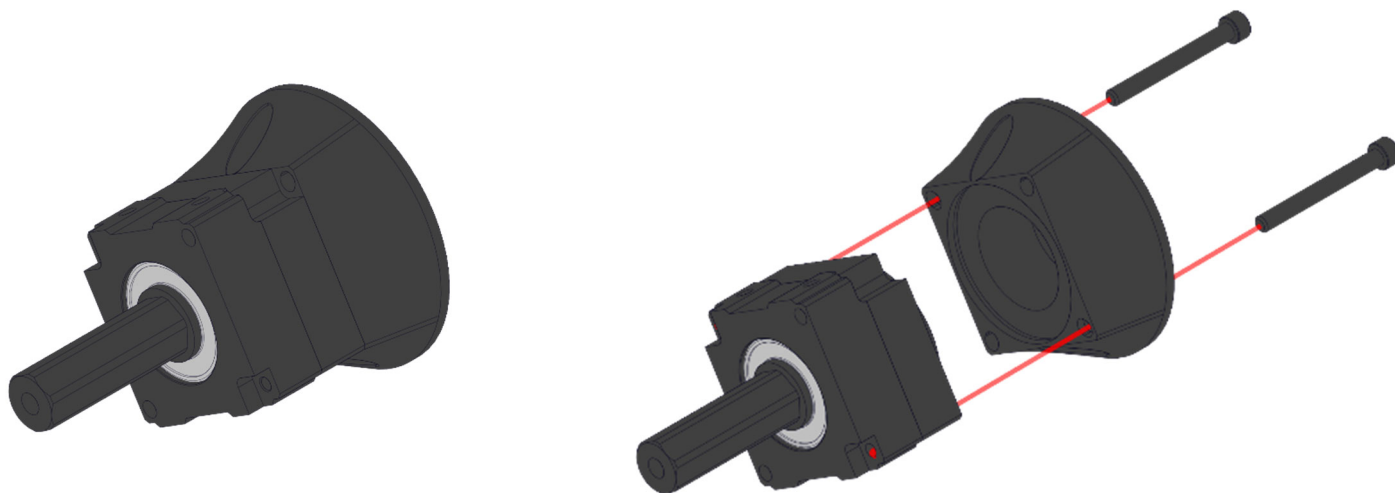


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## Falcon 500 Motor User Guide

### Step 2: Attach a CIM Adapter to the VersaPlanetary

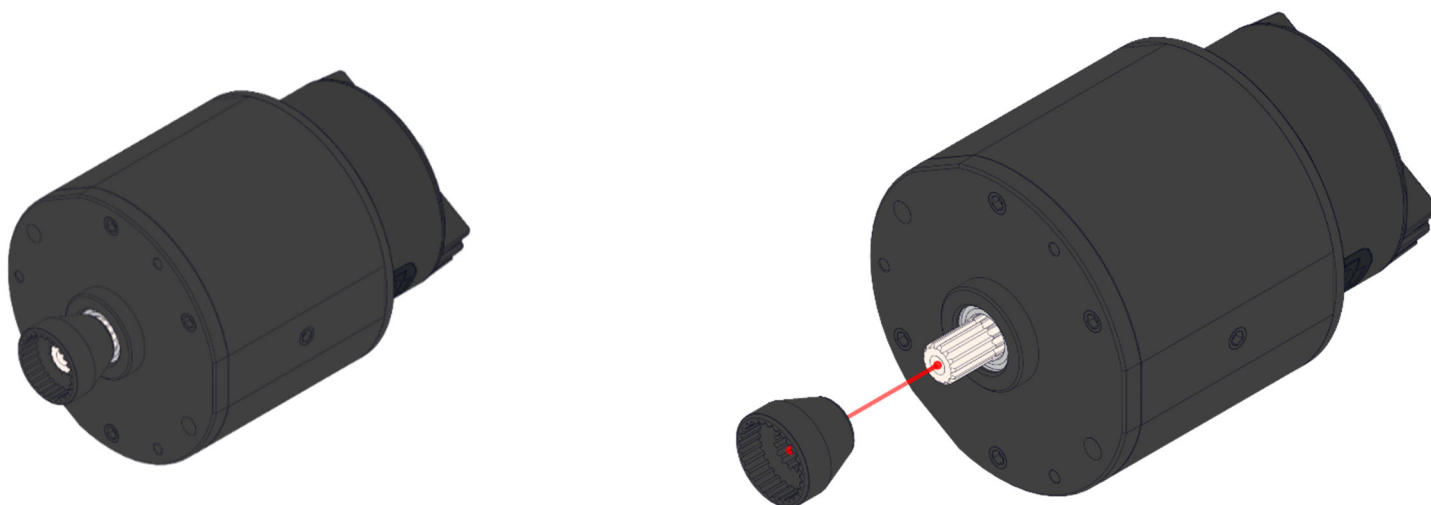
Follow the assembly instructions found in the [VersaPlanetary v2 User Guide](#) to assemble a VersaPlanetary with a CIM adaptor.



### Step 3: Slide a VersaPlanetary Coupler on the Falcon 500 Shaft

Slide the VersaPlanetary coupler designed for the Falcon 500 onto the Falcon 500's output shaft.

**NOTE:** There is no need to use a retaining screw when using the VersaPlanetary Coupler. The coupler will be constrained by the motor and the VersaPlanetary assembly.

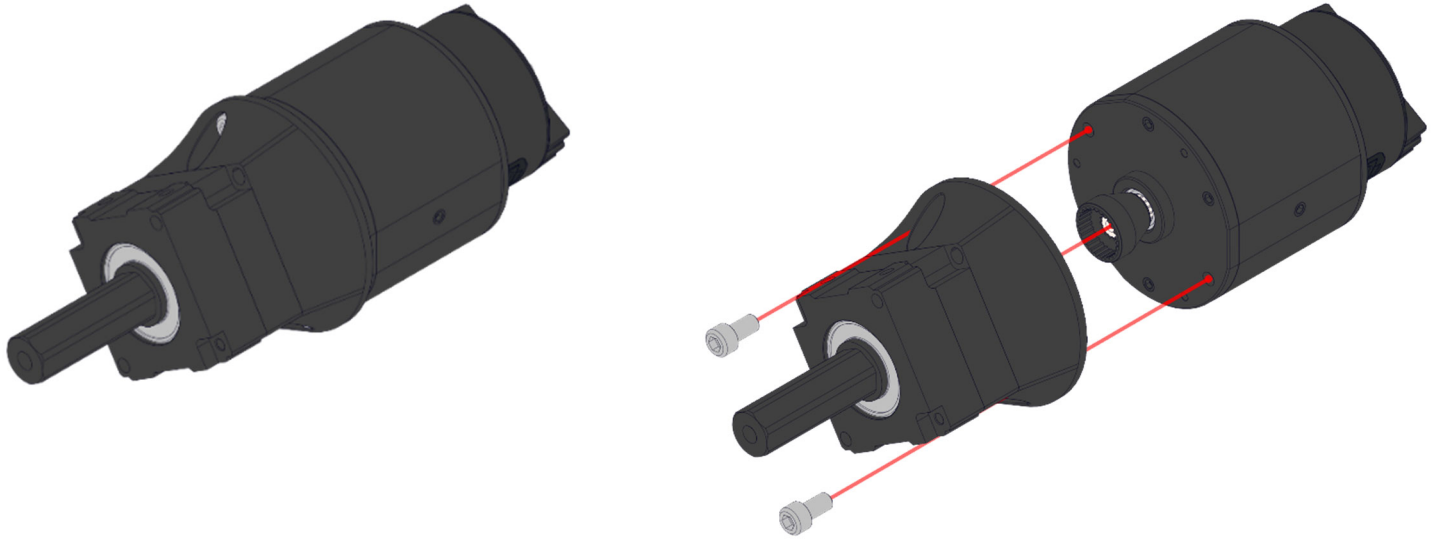


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## Falcon 500 Motor User Guide

### Step 4: Attach Motor to VersaPlanetary

Attach the Falcon 500 with a VersaPlanetary Coupler to the assembled VersaPlanetary with a CIM adaptor using (2x) #10-32. Secure them using a 5/32" hex key.



## Additional Information

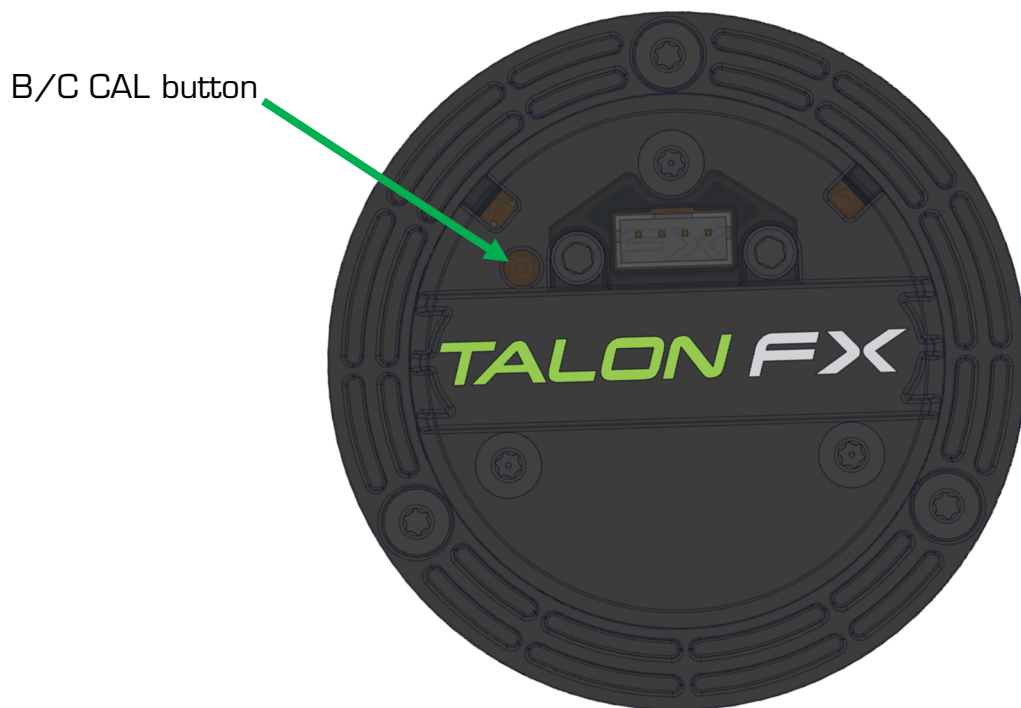
### Brake & Coast Modes

The Talon FX has two modes: Brake and Coast. When a neutral signal is applied to the Talon FX in Brake mode, the Falcon 500 will resist rotation, especially high-speed rotation. This is accomplished by essentially shorting the motor leads, which causes a Back Electromotive Force (Back-EMF) to resist the rotation of the motor. Brake mode does not have any effect when the motor is not rotating but can make a large difference in robot behavior when used on a motor attached to a high reduction gearbox. Brake mode does not impact performance when a non-neutral signal is applied.

When a neutral signal is applied to the Talon FX in Coast mode, Back-EMF will not be generated, so the Falcon 500's rotation will not be affected by the Talon FX.

### Switching between Brake & Coast:

To switch between Brake and Coast mode, simply push the B/C CAL button at any time. The Talon FX is in Brake mode when the button is illuminated red and Coast when the red light is turned off. Brake/Coast settings are saved even if power is removed from the Falcon 500.





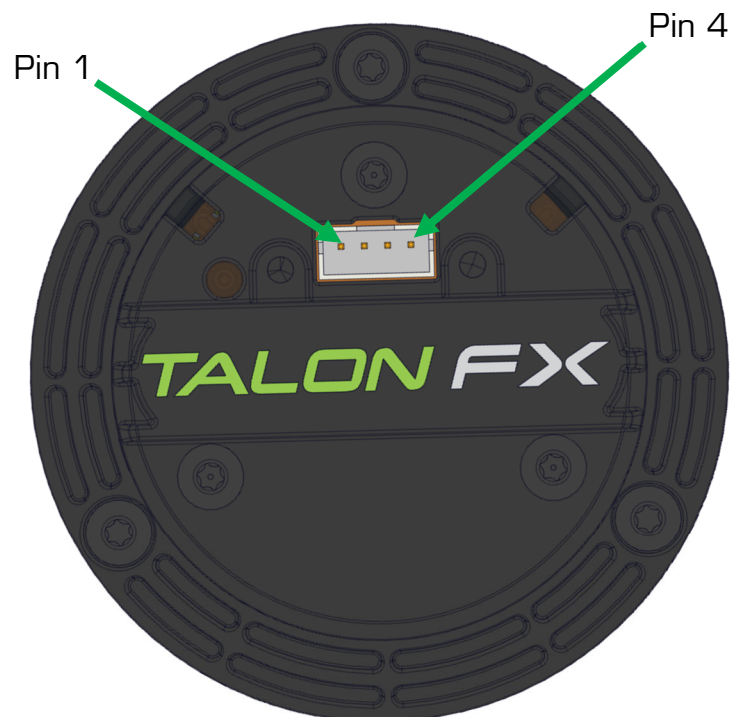
## Limit Switch Connector

The Talon FX has a limit switch connector on the back. This connector is a 4-pin JST PHR series connector. The purpose of this connector is so teams can disable the motor's ability to spin in a direction. For example, if a Falcon 500 is driving 'forward' and eventually triggers the 'forward' limit switch, then the motor will stop spinning in that direction. As long as the limit switch remains triggered, the motor will be able to spin 'forward'.

This is useful as a failsafe to preserve mechanisms on your robot in the event software fails.

Below is a pinout of the limit switch connector:

Pin	Description
1	Reverse
2	GND
3	GND
4	Forward

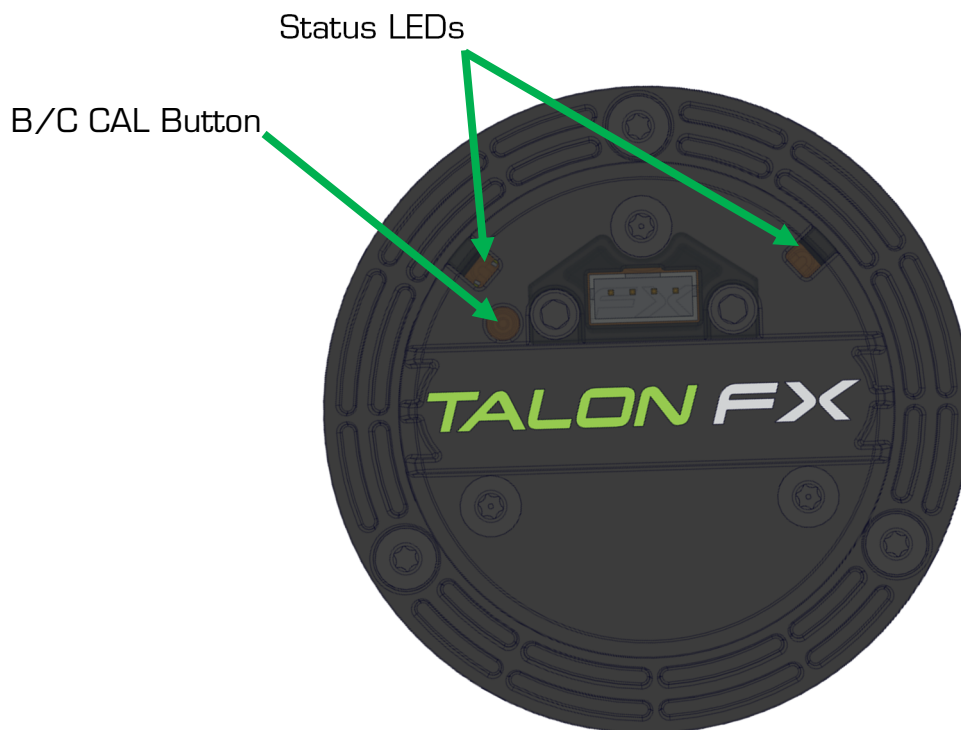


## Calibration

The calibration of a Talon FX is essentially the scale of input signal to output voltage. Different controllers may have different “max” and “min” signals that may not correspond to the same Talon FX outputs. Calibrating the Talon FX allows it to adjust for these differences so that a “max” signal results in a “max” output. Calibrating can also correct issues caused by joysticks or gamepads with off-center neutral outputs. The Talon FX’s default calibration is compatible with the roboRIO control system.

### To Calibrate the Talon FX:

- 1) Press and hold the B/C CAL button until the Status LEDs begin to rapidly blink red & green.

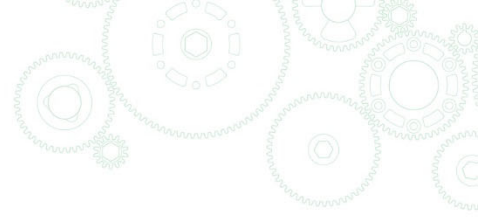


- 2) While holding the button, move the joystick (or other input signal) to full forward then to full reverse. This can be done multiple times. The Talon FX is looking for max & min PWM values during this step, so ensure that the joystick reaches its full max and full min.
- 3) Release the joystick and allow it to return to neutral. After the joystick is in the neutral position, release the B/C CAL button.
- 4) If the Talon FX was calibrated properly, the status LEDs will blink green several times. If the calibration failed, the status LEDs will blink red and the previous calibration will be kept.

**NOTE:** Calibration profiles are saved even if power is removed from the Talon FX.

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### To Restore Default Calibration:

- 1) Remove power from the Talon FX
- 2) Hold down the B/C CAL button
- 3) While holding down the button, restore power to the Talon FX
- 4) Continue holding the button until the status LEDs blink green, then release the button

## Blink Codes

## Blink Codes During Calibration

Status LEDs Blink Code	Talon FX State
Flashing Red/Green	Calibration Mode
Blinking Green	Successful Calibration
Blinking Red	Failed Calibration

## Blink Codes During Normal Operation

LEDs	Colors	Talon FX State
Both	Blinking Green	Forward throttle is applied. Blink rate is proportional to Duty Cycle
Both	Blinking Red	Reverse throttle is applied. Blink rate is proportional to Duty Cycle
None	None	No Power is being applied to Talon SRX
LEDs Alternate <sup>1</sup>	Off/Orange	CAN Bus detected, robot disabled
LEDs Alternate <sup>1</sup>	Off/Slow Red	CAN/PWM is not detected
LEDs Alternate <sup>1</sup>	Off/Fast Red	Fault Detected
LEDs Alternate <sup>1</sup>	Red / Orange	Damaged Hardware
LEDs Strobe "towards" (M+) <sup>2</sup>	Off/ Red	Forward Limit Switch or Forward Soft Limit
LEDs Strobe "towards" (M-) <sup>2</sup>	Off/ Red	Reverse Limit Switch or Reverse Soft Limit
LED1 Only	Green / Orange	In Bootloader

## B/C CAL Button Blink Codes

B/C CAL Button Color	Talon FX State
Solid Red	Brake Mode
Off	Coast Mode

- 1) LEDs alternate - Status LEDs are different colors at all times. The (2X) LEDs will swap colors when blinking.
- 2) (1X) Status LED will blink followed shortly by the other with a long pause before repeating. The "direction" of the blink indicates the Talon SRX's current state.

## Frequently Asked Questions

### Q: Why Are Torx / Star Drive Screws Used on the Falcon 500?

A: Traditional hex keys, as well as the screws they're used on, are susceptible to stripping. This is especially true the smaller the hex key gets as well as with button head screws. Torx / Star Drive screws are much harder to strip and therefore, teams won't have to be as concerned about stripping screws if they need to open up the motor chamber.

### Q: Is it safe to mount the Falcon 500 directly to a robot's metal frame?

A: Yes. In fact, mounting the Falcon 500 to metal on your robot will act as a heatsink and help keep it running cooler.

### Q: Is it safe to mount the Falcon 500 directly to plastic?

A: Yes. While it's not ideal for cooling, the Falcon 500 will work when it's mounted to plastic.

### Q: Does the Falcon 500 Require A Fan?

A: The Falcon 500 does not require a fan for typical FRC use. However, if the robot is being used for practice or many back to back matches, it is a good idea to use the Falcon 500's cooling port to cool the motor.

### Q: What kind of electrical connectors should I use to connect wires to the Falcon 500 / Talon FX?

A: The choice of electrical connectors is left to the user. Electrical connectors used with the Talon FX should be designed for use with 12AWG wire and tightly crimped. For the best electrical connection, it is highly recommended that wire connectors are soldered to the wire they are crimped on.

### Q: Can the Falcon 500 be used with control system other than the NI roboRIO?

A: Yes, the Falcon 500, powered by Talon FX may be used with any control system that is capable of PWM output or CAN bus.

### Q: Does the Falcon 500 work with either CAN or PWM?

A: Yes. The Falcon 500 can be controlled through either CAN or PWM. However, CAN is required to take advantage of the Talon FX's smart features like Motion Magic.

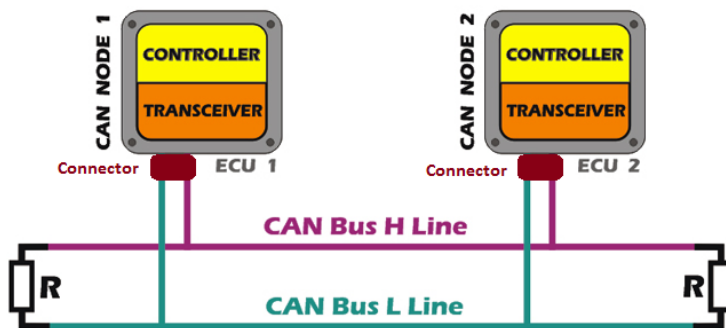
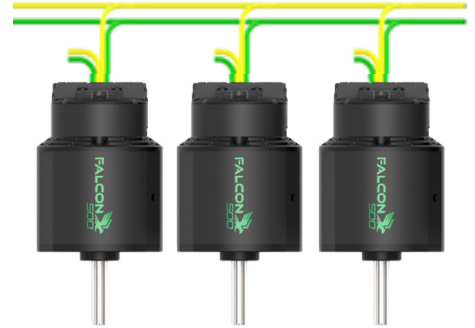
### Q: There isn't a wire connected to the center (red) PWM wire on the .1" servo connector, is this a problem?

A: No. The center (red) PWM wire is typically +5V that can be used to power PWM devices. The Talon FX is powered by the 12V input and does not require PWM power.

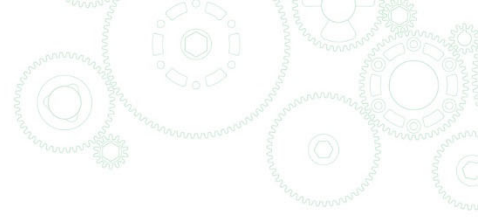
### Q: What CAN bus topologies are recommended?

**A:** The Talon FX is intended to be used in the **daisy chain fashion**. Additionally, FRC Teams should always confirm what is considered “legal” per the latest FRC competition rules.

Alternatively, the CAN bus may be wired in the fashion commonly seen in the automotive industry, where a single harness is made (with proper termination resistor at each of the two ends). Each module can “tap” into the primary bus harness (crimp, connector, soldered, etc.) with a cable stub (maximum length of one foot).



In the automotive industry, this is accomplished with a cable design that has the cable stubs designed in with end-connectors at various places in the cable.



As documented in the DW CAN bus specification, both daisy chain or a designed master cable harness meets the specification's documented topology (diagram below).

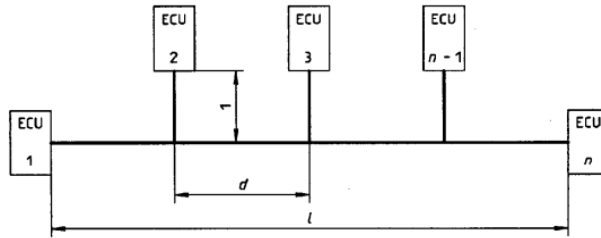


Figure 22 — Wiring network topology

Table 15 — Network topology parameters

Parameter	Notation	Unit	Value			Conditions
			min.	nom.	max.	
Bus length	L	m	0		40	
Cable stub length <sup>1)</sup>	l	m	0		0,3	Bit rate: 1 Mbit/s <sup>2)</sup>
Node distance	d	m	0,1		40	

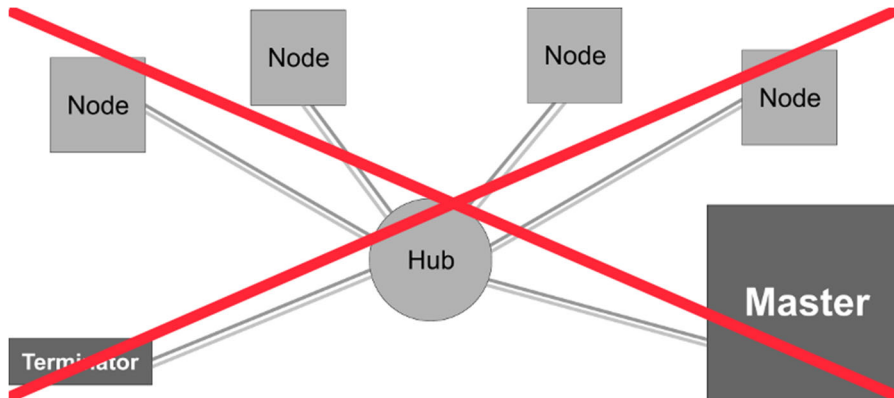
1) Dependent on the topology, the Baud rate, and the slew rate deviations from 120 Ω may be possible. It is, however, necessary to check the applicability of other resistor values in each case.

2) At bit rates lower than 1 Mbit/s the bus length may be lengthened significantly. Depending on *l*, the bit rate and internal capacitances of the individual ECUs, other network topologies with changed lengths *l* and *d* may be used. In this case the influence of occurring cable resonator waves on the bit representation on the bus line should be carefully checked by measurements of  $V_{diff}$  at each ECU (see also table 8, note 3).

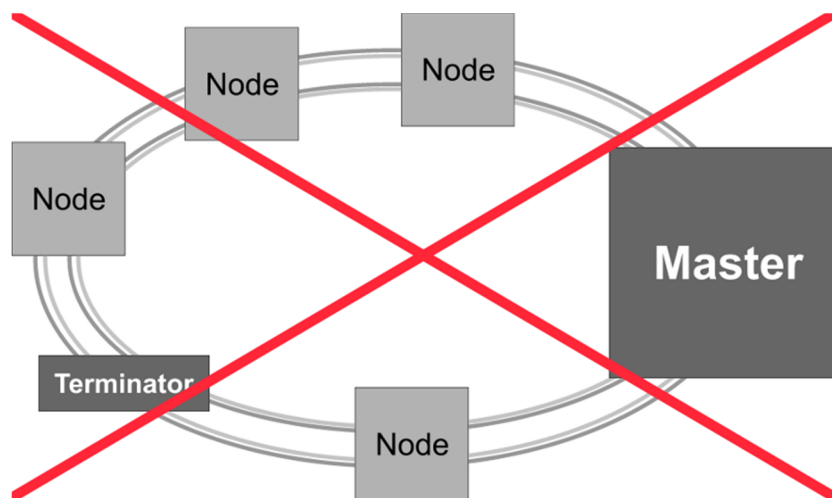
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Star topology is **not** recommended. This use case is not common, nor is it suggested in the DW CAN bus specification. This nonstandard implementation requires careful study and analysis of the candidate bus cable, which is typically beyond the capabilities of a typical FRC team.

This topology may be used when performing basic testing on a bench-setup with a small network (few modules and short cable travel). However, this use case should not be construed as evidence guaranteeing that star topology is a robust solution. Star topology is not a robust general solution to be relied on for critical applications.



Ring topology is **not** recommended. This use case is not common, nor is it suggested in the DW CAN bus specification. This nonstandard implementation requires careful study and analysis of the candidate bus cable, which is typically beyond the capabilities of a typical FRC team.





## Troubleshooting

**Indication: No ORANGE Status LEDs on power up.**

Problem: Input power issue or joystick trim tab off center.

Possible Solutions:

1. Disconnect CAN cable(s).
2. If Status LEDs remains off, check +V or GND connections for voltage and proper polarity.
3. If Status LEDs blink ORANGE, the speed controller is probably damaged. The final test to determine if the Falcon 500 / Talon FX is damaged is to replace it with another Falcon 500 / Talon FX that is known to function properly.



**CAUTION:** PRIOR TO REPLACING A POTENTIALLY DAMAGED FALCON 500 / TALON FX, ENSURE THAT THE WIRES CONNECTED TO THE OUTPUT ARE NOT SHORTED AND THE INPUT IS NOT REVERSED. ALSO, VERIFY THAT THE POWER LEADS OF THE TALON FX ARE NOT SHORTED TO THE CHASSIS OF THE ROBOT.

**Indication: Flashing ORANGE Status LEDs on power up.**

Problem: No CAN/PWM signal.

Possible Solutions:

1. Ensure the transmitter and receiver are powered ON.
2. The CAN/PWM cable may be improperly connected. Check wire color-coding at each end. Check that the connector is not offset by a pin at the receiver end.
3. If using PWM, check for a good PWM signal by connecting a known good servo to the PWM cable. If the servo does not move, this can indicate either:
  - a. A faulty microcontroller
  - b. An improperly connected cable
  - c. A bad PWM cable

**NOTE:** The servo requires that voltage be present on the center pin of the PWM cable. This connection is not required for the TalonFX.

**Indication: Flashing RED Status LEDs after calibration.**

Problem: Calibration Failed.

Possible Solutions:

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1. Inadequate travel in either the forward or reverse direction. Repeat the calibration procedure and move the joystick further forward and/or further reverse.
2. The joystick trim is not centered. Neutral cannot be extremely far from center.

**Indication: No power output from the speed controller although the Status LEDs work.**

Problem: Possible internal damage.

Possible Solutions:

If the Status LEDs on the Talon FX are operating properly and there is no output, the Talon FX may be internally damaged. This condition is typically caused by a short circuit on the output or there has been an over-current condition that caused a failure.

Check the following:

1. Ensure the Status LEDs are changing between ORANGE, RED, and GREEN with joystick movement.
2. Disconnect the motor and check the output (M+ to M-) with a voltmeter. The meter should read between +/- battery voltage with corresponding full range joystick movement. If the Status LEDs are working properly and the outputs are not working properly, the speed controller is probably damaged. The final test to determine if the Falcon 500 / Talon FX is damaged is to replace it with another Falcon 500 / Talon FX that is known to function properly.

**CAUTION:** PRIOR TO REPLACING A POTENTIALLY DAMAGED FALCON 500 / TALON FX, ENSURE THAT THE WIRES CONNECTED TO THE OUTPUT ARE NOT SHORTED AND THE INPUT IS NOT REVERSED. ALSO, VERIFY THAT THE TALON FX'S POWER LEADS ARE NOT SHORTED TO THE CHASSIS OF THE ROBOT.



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**Indication:** No power output from the speed controller and the Status LEDs do NOT work.

**Problem:** No input power or possible internal damage.

**Possible Solutions:**

If the Status LEDs on the Talon FX are not operating properly and there is no output, the Talon FX may be internally damaged. This condition is typically caused by no input power or a reversed polarity on the input.

Check the following:

1. Disconnect the output wires.
2. Ensure the Status LEDs on the Talon FX do not illuminate at any joystick position.
3. Check the input at the Talon FX (+BATTERY to GND) with a voltmeter. If the Status LEDs are not working properly and the input is good, the speed controller is probably damaged. The final test to determine if the Falcon 500 / Talon FX is damaged is to replace it with another Falcon 500 / Talon FX that is known to function properly.



**CAUTION:** PRIOR TO REPLACING A POTENTIALLY DAMAGED FALCON 500 / TALON FX, ENSURE THAT THE WIRES CONNECTED TO THE OUTPUT ARE NOT SHORTED AND THE INPUT IS NOT REVERSED. ALSO, VERIFY THAT THE TALON FX'S POWER LEADS ARE NOT SHORTED TO THE CHASSIS OF THE ROBOT.

## What's Included

Picture	Description	QTY	Replacement Part Number
	Falcon 500, powered by Talon FX	1	217-6515
	1/16" Thick Falcon Shaft Spacer	6	217-6937
	1/8" Thick Falcon Shaft Spacer	4	217-6937
	1/4" Thick Falcon Shaft Spacer	2	217-6937
	Extension Cable Retaining Clip	1	276-4128

## FCC Compliance Statement (United States):

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

- (1) This device may not cause harmful interference, and
- (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

## ICES-003 Compliance Statement (Canada):

This Class B digital apparatus complies with Canadian ICES-003.

Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

## Revision History:

2019/10/25 – Initial Public Release

217-6515-751

## Falcon 500 Motor User Guide

### Support

Please send any questions, comments, or concerns to VEX Robotics:

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