
FALCON
500
POWERED BY
TALON FX

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FALCON 500 FEATURES

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

The Falcon 500 introduced 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.

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 lifespan than brushed motors.

Cooler & More Efficient

Since there are no brushes creating a torque load on the shaft, brushless motors produce more torque, making them more efficient. This higher efficiency not only means the motor is producing more power, it means less heat is being generated. By producing less heat, a brushless motor can operate for longer at a given power than a brushed motor.

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.

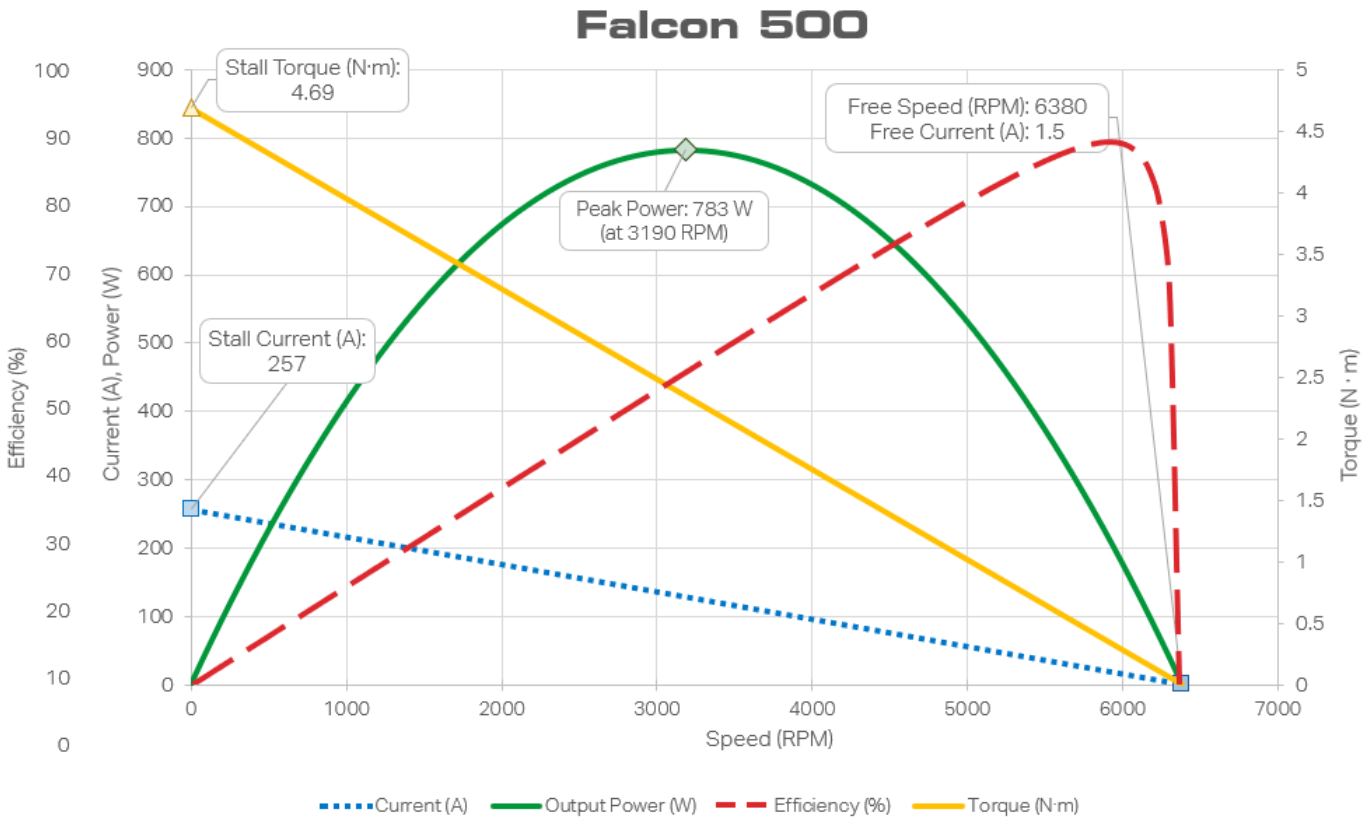
POWER UP

When using trapezoidal control, the Falcon 500 produces just under 400W of Power at 40A and 12VDC. Without a doubt, it is the most powerful motor in the FIRST Robotics Competition. At peak power the Falcon 500 can produce over 780W of power in trapezoidal control!

FRC teams won't be able to use all 780W due to limitations of their robot's power distribution system. The higher peak power does mean that when used on an FRC robot, the motor will be operating at a lower area of the power curve (further to the right in the graph below). By operating at a lower area of the power curve, the motor will be more efficient.

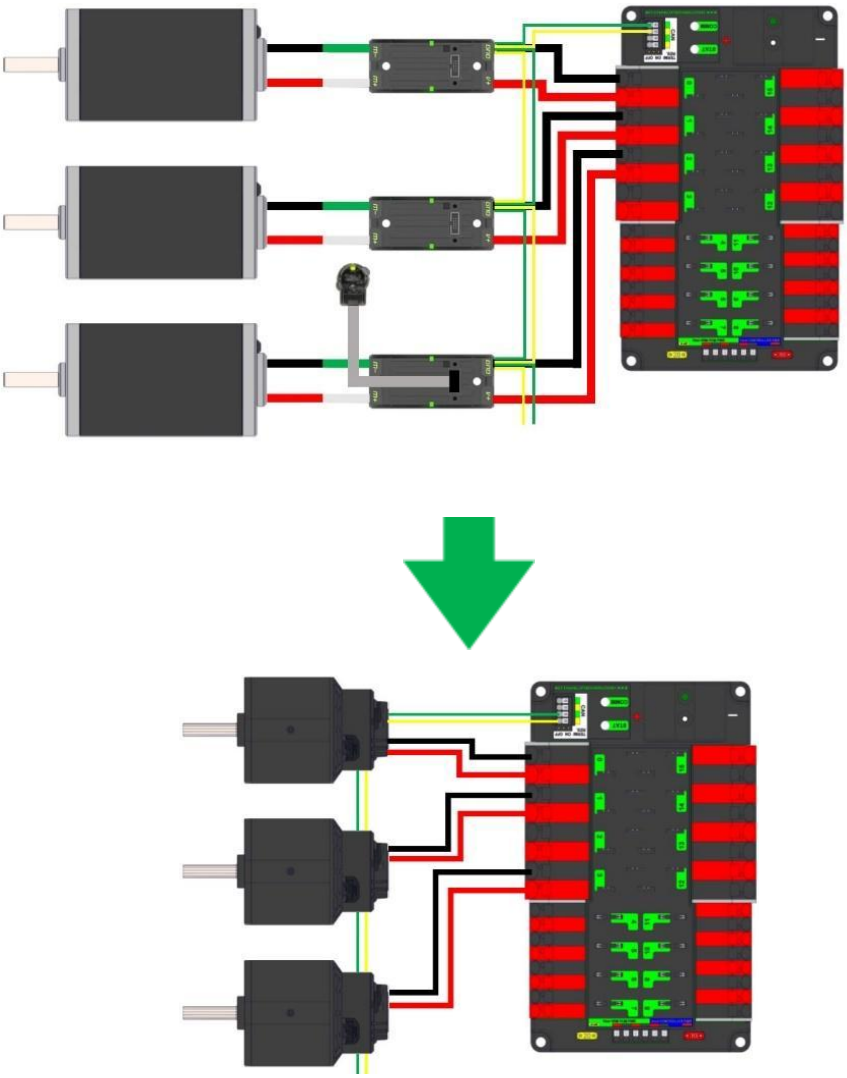
On top of this unprecedented power, the Falcon 500 is the most efficient motor in FRC, with a peak efficiency of 87% in trapezoidal control, and 89% in sinusoidal control. In fact, the Falcon 500 is greater than 80% efficient across the entire FRC operating range (7A – 40A) - the best of any motor in FRC.

With this kind of power and efficiency, the Falcon 500 is the perfect motor for almost any FRC application.



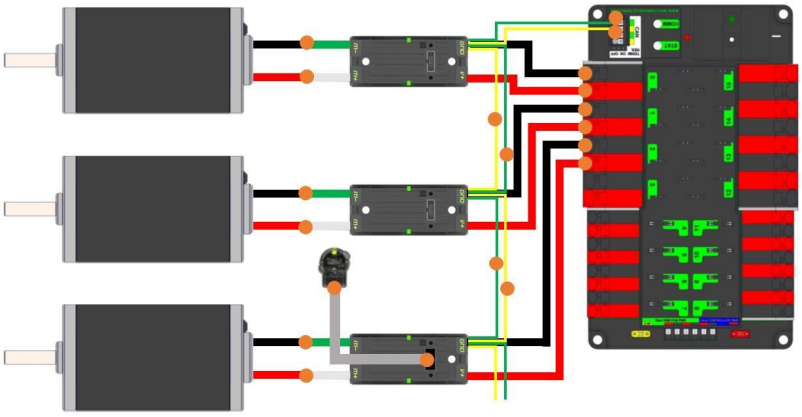
SIZE & PACKAGING

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 dramatically changes the way teams layout their robot's electronics and revolutionizes their abilities to iterate their robot mid-season and mid-competition.



FAILURE POINT REDUCTION

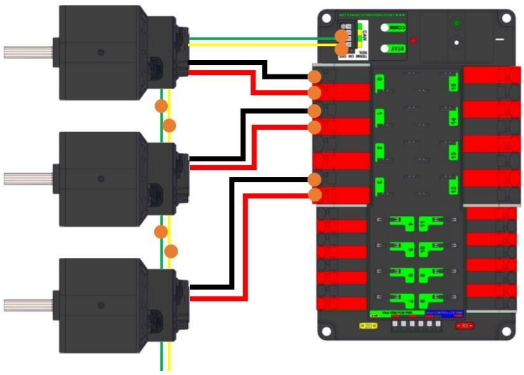
Each wire connection on a robot represents a possible failure point. A loose wire, a bad crimp, something plugged in backwards – all of these can lead to significant problems during a match. The Falcon 500 helps reduce the number of connections (failure points) by up to 50%. This means that your robot 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.

The diagram to the right 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.

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.

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.

The Talon FX also has a 2048 CPR encoder built-in to the controller. 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.

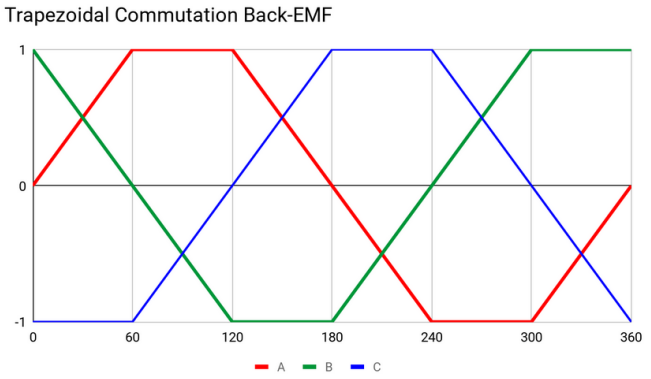
Though the Talon FX does not have a Talon data port like its predecessor, the Talon SRX, teams can use a CAN based encoder such as the Cross the Road Electronics CANCODER (P/N 19 676768) as an input sensor for Motion Magic.

REVERSE POLARITY PROTECTION

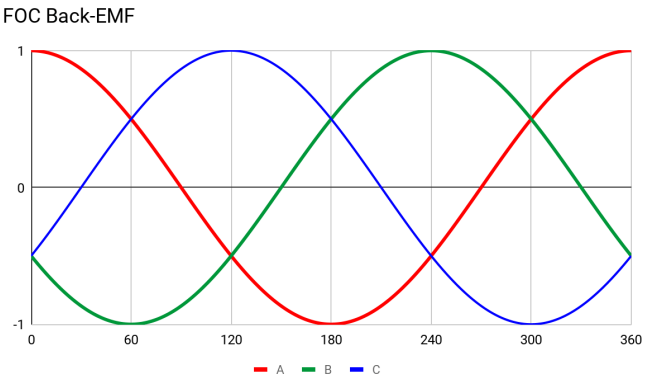
The single largest cause of failure in FRC motor controllers is reversing the polarity of the input power. This means a simple wiring mistake like wiring a motor controller backwards into the PDP (Power Distribution Power) or wiring a robot battery backwards can be a costly mistake for a team. The Falcon 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.



Energizing all three phases prevents the drop in torque that occurs when phases switch from on to off with trapezoidal commutation. This increases the motor's torque output, which increases the power output of the motor.



A Falcon 500 running on FOC can produce up to 15% more power than a Falcon 500 running on standard trapezoidal commutation.

FOC is only available when using the motor with a Phoenix Pro licensed Talon FX or CANivore. For more information on Field Oriented Control, see the information on Phoenix Pro.

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.

STALL WHISTLE

When the Falcon 500 begins to stall, it will whistle an audible tone to inform the user of this event.

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.

Teams of all skill and resource levels can have advanced motion control out of the box, without having to buy or set up 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.

THERMAL PROTECTION

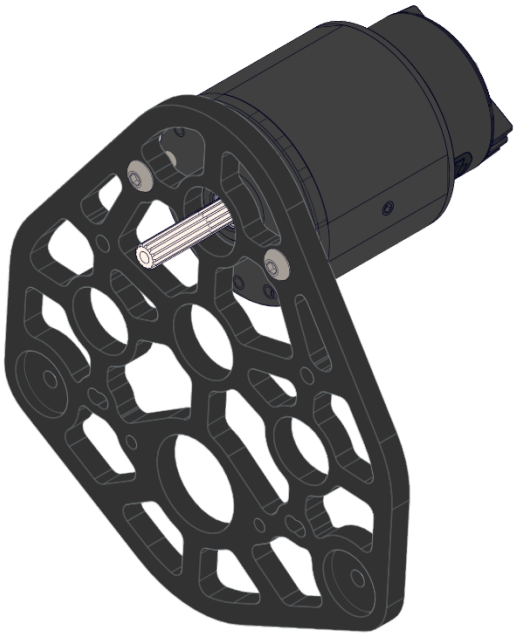
Another innovative feature of the Falcon 500 and Talon FX is the ability for the controller to protect itself and the motor from exceeding its temperature rating. When the Falcon 500 approaches its temperature rating, the motor enters a thermal shutoff to prevent itself from permanently damaging itself. This helps extend the life of the motor and protects teams' investment in the Falcon 500.

The motor and controller are designed to run at 40A continuously for at least 5 minutes before reaching thermal shutoff. When the motor returns to a safe temperature, the motor will resume operation.

CIM COMPATIBLE

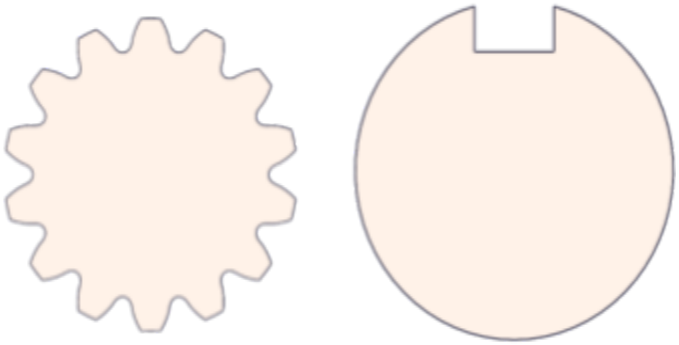
The Falcon 500 comes with (6x) #10-32 holes on a 2” bolt circle. This, combined with the motor’s smaller diameter, means the Falcon 500 can be used anywhere a CIM or Mini CIM were used previously.

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



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.



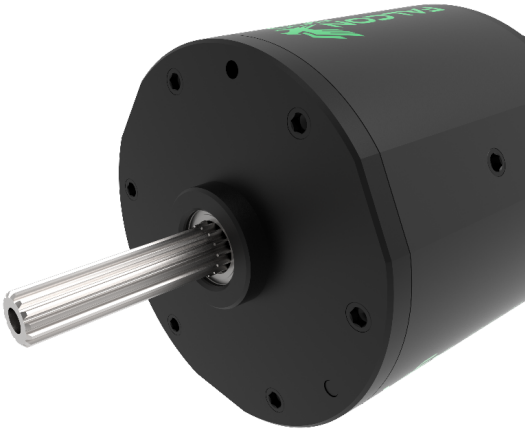
Profile of Falcon 500 Motor Shaft

Profile of CIM / Mini CIM Shaft

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.

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.

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.



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.

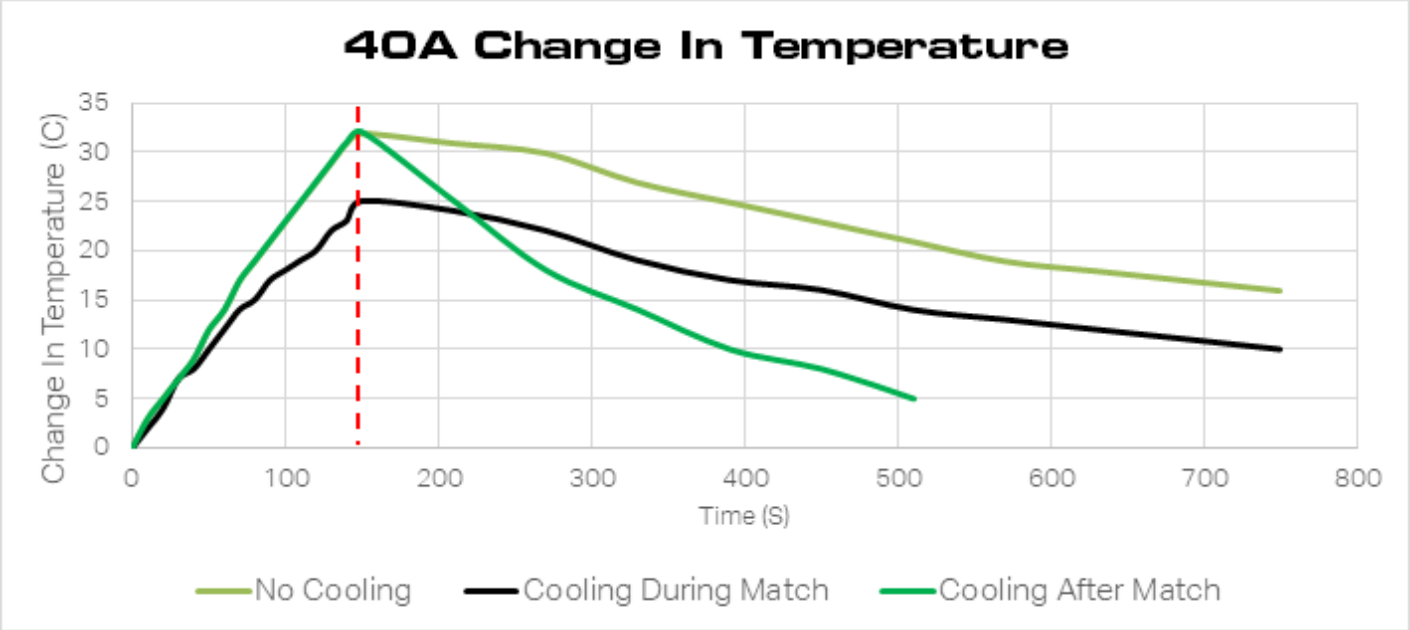
While press-fits have worked for teams, it's a non-trivial task that when done improperly, can damage motors. The spline eliminates this risk for all teams, while opening new design opportunities only available for teams using the Falcon 500. Lastly, the Falcon 500 is the first motor in FRC history that 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 v3" (217-8907). 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.

Using the cooling port in a match can reduce heat by up to 29°C (84°F)[1]. 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.



SPECIFICATIONS

	DIMENSIONS
Dimensions	60mm (2.36”) Dia. X 89.9mm (3.54”) Long
Weight	1.25Lbs (0.56kg)
Output Shaft	14 Tooth, 0.5 Module Spline Shaft
Mounting	6x #10-32 On 2” Bolt Circle
Cooling Port	2x #10-32 On Side of Motor

	TRAPEZOIDAL	FOC
Free Speed RPM	6380 RPM	6079 RPM
Free Current	1.5A	1.5A
Stall Current	257A	304A
Stall Torque	4.69Nm	5.84Nm
Peak Efficiency	87%	89%
Power @ 40A / 12 VDC	400W (83% Efficiency)	420W (85% Efficiency)
Peak Power	783W	929W

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 LIMIT SWITCH INPUT THRESHOLDS	
Logic High Min Voltage	2.64 V
Logic Low Max Voltage	0.66 V

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]

FALCON 500 v3 MECHANICAL IMPROVEMENTS

In the interest of improving the user experience and performance of the Falcon 500, there have been some mechanical updates to the motor from its prior revisions. Starting with motors sold in Late 2022, longtime users will note that there are some minor differences to the Falcon 500 motors than what they're used to. It is important to note that because of these updates, the Falcon 500 v3 is slightly longer and heavier than prior revisions. Take this into consideration when designing mechanisms to use this motor

HOUSING ASSEMBLY

For the previous revisions of Falcons (v1 and v2), the motor was assembled with long M3 screws from the controller end of the motor through to the faceplate. These screws were challenging to line up for reassembly. To make assembly and reassembly easier, the motor is now assembled by having (3x) M2.5 socket head cap screws attach the faceplate to the sleeve and (3x) M2.5 socket head cap screws attach the sleeve to the motor/controller.

SECOND COOLING PORT

Some teams who used the cooling port during practice requested a second cooling port so that they could network motors together, pushing air through several motors with a single inlet. A second #10-32 cooling port was added to the sleeve so that teams could attach two pneumatic fittings (an inlet and an outlet).

NEW OUTPUT SHAFT DESIGN

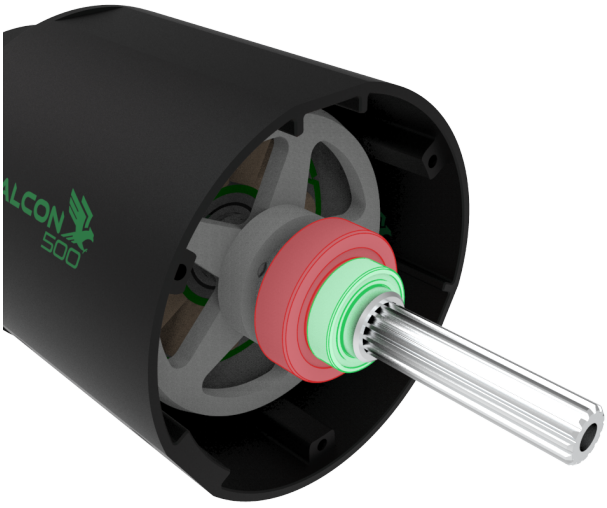
Falcon 500 v1 and v2 used (5x) M2.5 screws to attach the shaft to the motor's rotor and transfer torque. In a review of production failures of v1 and v2 motors, we found that consistently applying loctite to screws was a problem.

The Falcon 500v3 features a redesigned shaft interface. Torque is now transferred through a female spline on the rotor. The shaft is retained in the mechanical assembly of the motor, eliminating the need for any screws hidden inside the motor. No more loctite. No more worrying about screws loosening and not being able to see them.

The new shaft design also features a longer shoulder, which has better press-fit engagement. Finally, the spline is pinned into the shoulder sleeve to make sure that shaft can't be pulled out of the motor.

BLIND MOTOR MOUNTING HOLES

The Falcon 500 v3 features a new faceplate design that has blind mounting holes. This prevents teams from inserting a long screw into the motor and jamming the rotor.



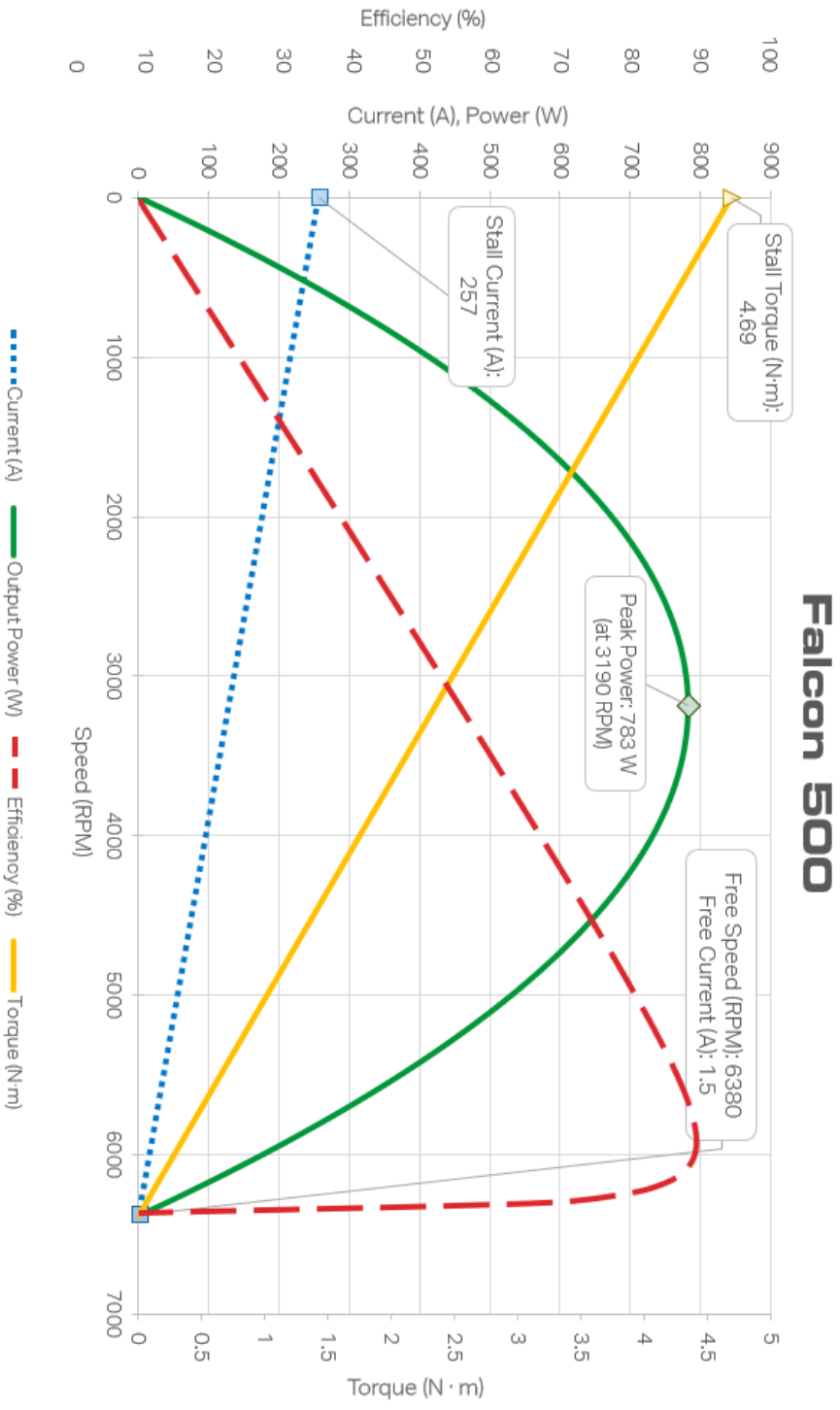
DUAL OUTPUT BEARINGS

To help make the new shaft interface possible, the Falcon 500 v3 features two output bearings. In addition, the bearings are larger with a higher load rating than the single output bearing used in v1 and v2.

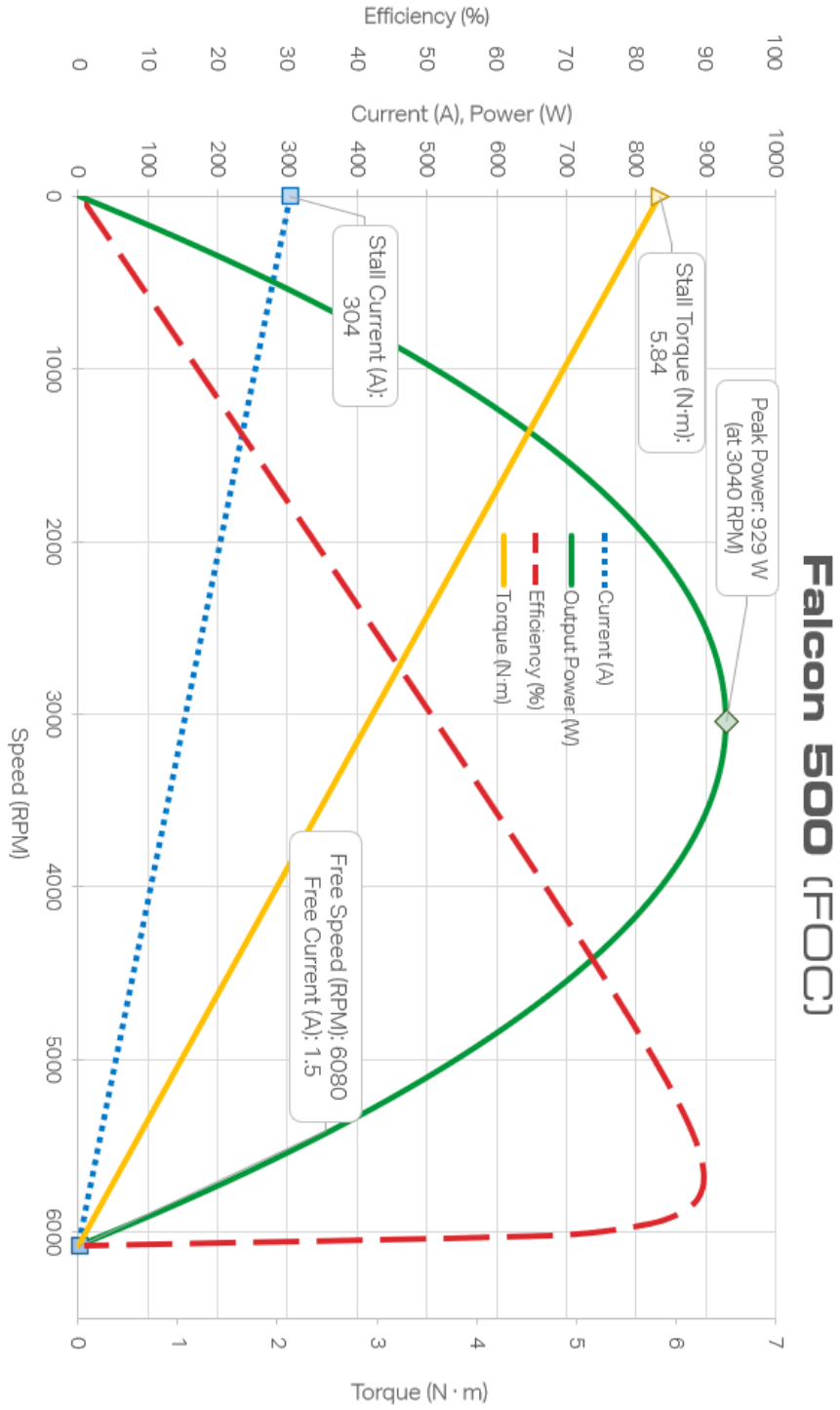
MECHANICAL CHANGE LOG

Revision	Mechanical Changes	Sell Dates
v1	• Initial Release	Oct 2019-Dec 2020
v2	• Motor assembly screws changed to stainless to prevent sticking to the rotor during assembly. • #10-32 set screws removed from faceplate. • #10-32 set screw in cooling port replaced with button head. • M2.5 shaft retention screws changed from 2mm drive to T8 torx drive. • Washer added between output shaft flange and output bearing to prevent rubbing. • Shaft color changed to black.	Dec 2020-Dec2022
v3	• Changed motor assembly method (50mm long M3 screws are now shorter M2.5 screws that thread into the sleeve) • Removed M2.5 screws for shaft retention. • Added female spline bushing to front of motor to transfer torque to output shaft. • Changed output shaft to have longer sleeve. Shaft now pinned to flange instead of brazed. • Output shaft is now retained by the assembly of the motor. • Increased size of output bearing. • Added second output bearing for better support of the output shaft. • Added second cooling port to allow motors to be plumbed through a single inlet. • Mounting holes on the face plate is now blind to prevent long screws from locking the rotor. • Shafts are changed back to silver	Dec 2022-Present

PERFORMANCE DATA (TRAPEZOIDAL)



PERFORMANCE DATA (FOC)

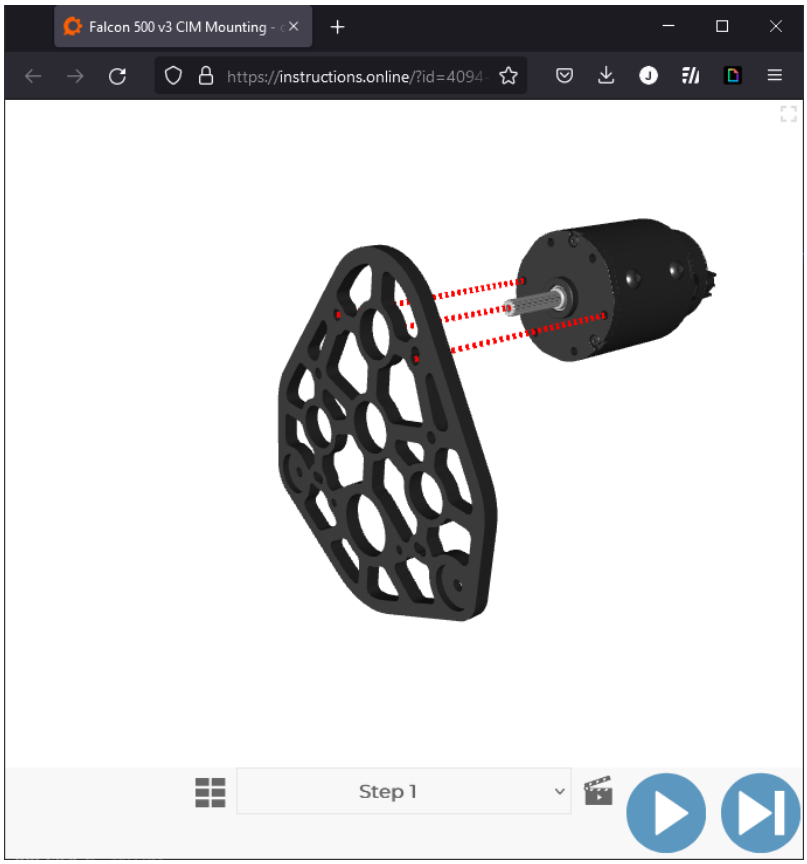


GENERAL WARNINGS

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 and will void the warranty. A loss in calibration will result in decreased performance or permanently damage your Falcon 500. Once the end cap is removed the Falcon 500 can no longer be put back into its original state due to the loss of calibration.*

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.



Digital instructions for installing gears and pulleys on the output shaft are available online here.

Note: *Instructions can be viewed on desktop and mobile devices.*

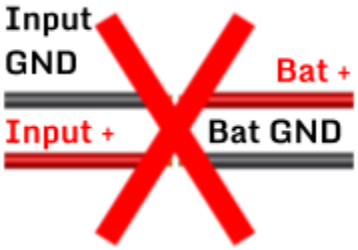
WIRING THE FALCON 500

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"[2.54mm] 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 connections 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

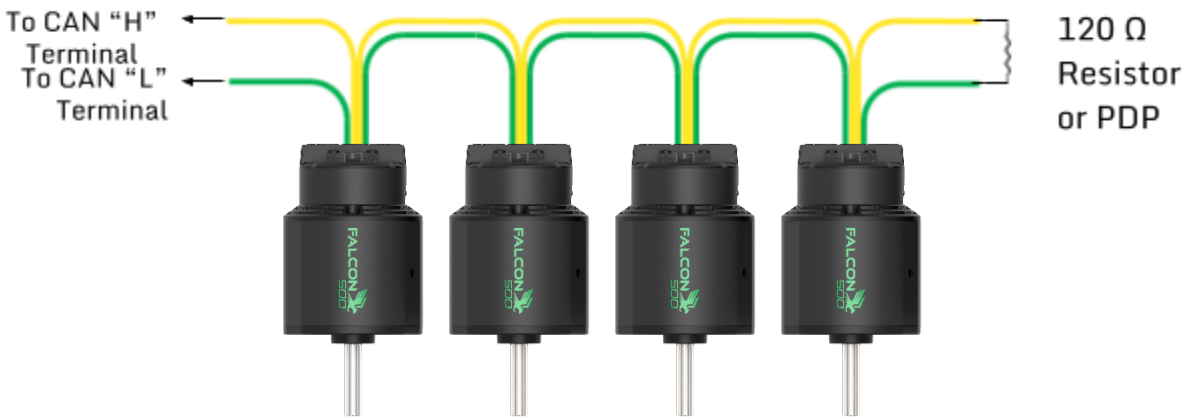
CAN INSTRUCTIONS

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 Ω 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.*

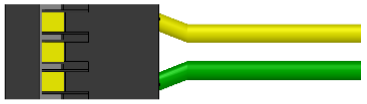


PWM INSTRUCTIONS

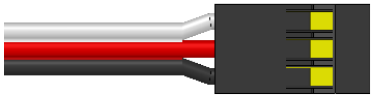
WIRE COLOR	DESCRIPTION	TRADITIONAL PWM WIRE COLOR
Yellow	PWM Signal	White
Green	PWM Ground	Black

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.

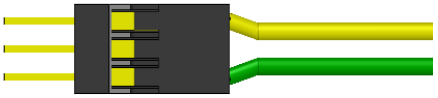
Standard Male 3-pin Extension Cable



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 / *276-4810*	PWM	Male
ARM® Cortex®-based Microcontroller	VEX Robotics / *276-2194*	PWM	Male
Hero Development Board	CTR Electronics / *16-728279*	CAN	None (Remove Connector)

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:

1. The red wire is connected to the positive source
2. The black wire is connected to the source ground
3. All electrical connections are secure and electrically isolated
4. A 40A or smaller breaker is in series with the Talon FX's positive power input
5. There are no short circuits on the Talon FX's output
6. 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.

Digital instructions for installing gears and pulleys on the output shaft are available online here.

Note: *Instructions can be viewed on desktop and mobile devices.*

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

USING THE FALCON 500 COOLING PORT

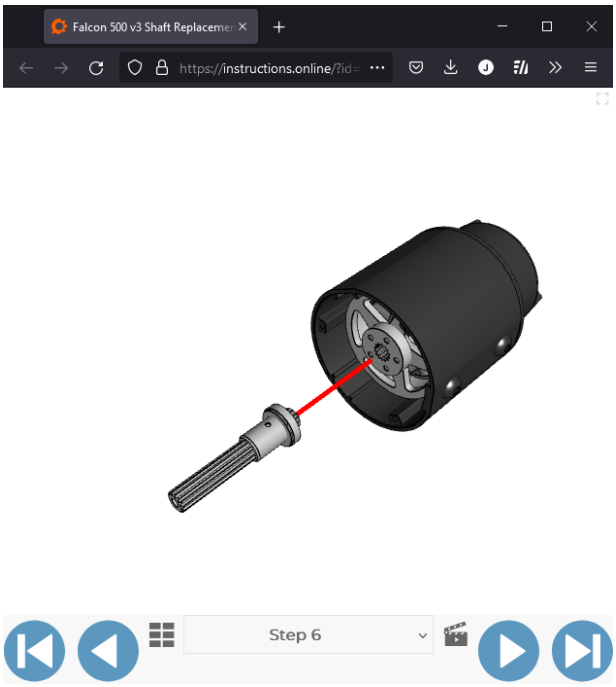
The Falcon 500 comes with a cooling port that can be used to force air through the motor chamber. This helps keep the motor cooler and therefore running more efficiently.

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.

Digital instructions for using the cooling port are available online here.

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 (217-8907) that is already cut to the correct length, or a medium length shaft (217-8908)

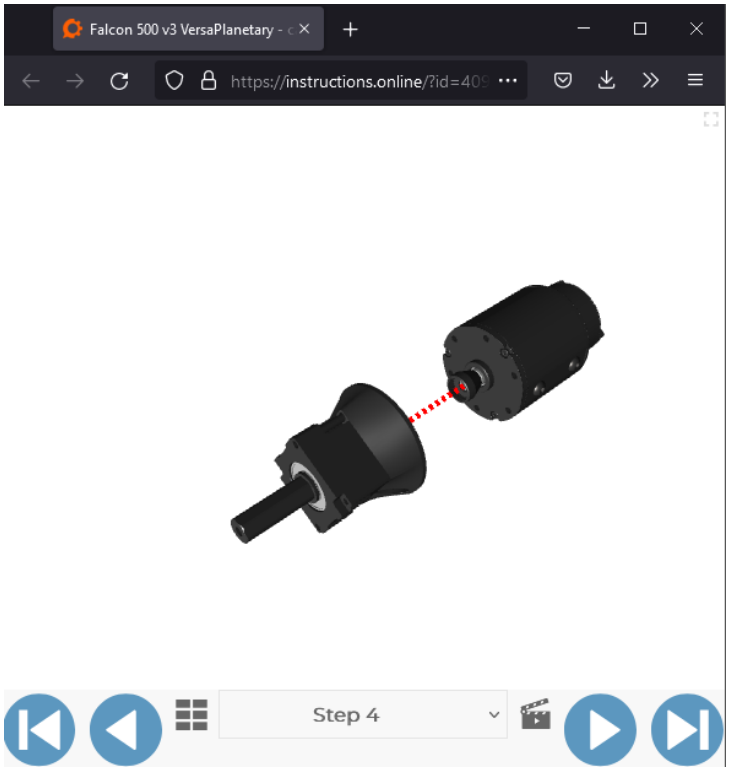


Digital instructions for changing and replacing the output shaft are available online here.

Note: *Instructions can be viewed on desktop and mobile devices.*

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.



Digital instructions for installing a Falcon 500 onto a VersaPlanetary are available online here.

Note: *Instructions can be viewed on desktop and mobile devices.*

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 not be able to spin 'forward'.

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

The Talon FX provides a pull-up to 3.3v on the reverse and forward pins, so typically an external pull-up is not needed. The default setting of "Normally Open" ensures an "out of the box" Talon FX allows motor-output even if no limit switch is connected.

See the Software Reference Manual to change the default Limit Switch behavior from "Normally Open".

Below is a pinout of the limit switch connector:

PIN	DESCRIPTION
1	Forward
2	GND
3	GND
4	Reverse

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.*

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**
	Calibration Mode
	Successful Calibration
	Failed Calibration
BLINK CODES FOR UNLICENSED PHOENIX PRO TALON FX	
	Device has Phoenix Pro firmware and is unlicensed. Either connect this device to a Phoenix Pro licensed CANivore, apply a Phoenix Pro device license, or change firmware to use Phoenix v5.

BLINK CODES DURING NORMAL OPERATION		
LEDs	**Colors**	**Talon FX State**
	Blinking Green	Forward throttle is applied. Blink rate is proportional to Duty Cycle
	Blinking Red	Reverse throttle is applied. Blink rate is proportional to Duty Cycle
	None	No Power is being applied to Talon SRX

BLINK CODES DURING NORMAL OPERATION (CONTINUED)		
LEDs	**Colors**	**Talon FX State**
	Off/Orange (Alternating)	Talon FX is Disabled Phoenix is not running in Robot Controller or Robot Controller is missing from bus
	Off/Orange (Simultaneous)	Talon FX is Disabled Phoenix is running in Robot Controller
	Off/Slow Red	CAN/PWM is not detected
	Red / Orange	Damaged Hardware

BLINK CODES DURING NORMAL OPERATION (CONTINUED)		
LEDs	**Colors**	**Talon FX State**
	Off/ Red	Forward Limit Switch or Forward Soft Limit
	Off/ Red	Reverse Limit Switch or Reverse Soft Limit
	Green / Orange	In Bootloader
	Off/ Orange	Thermal Fault / Shutoff

B/C CAL BUTTON BLINK CODES	
B/C CAL Button Color	**Talon FX State**
Solid Red	Brake Mode
Off	Coast Mode

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 a 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.

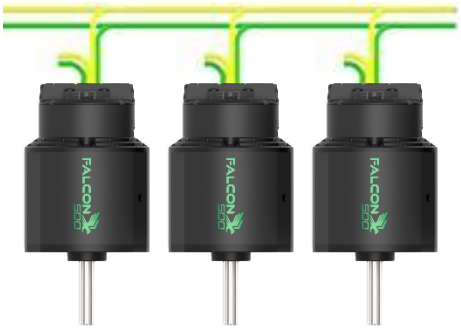
Q: Does the Falcon 500 work with either CAN or PWM?

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?

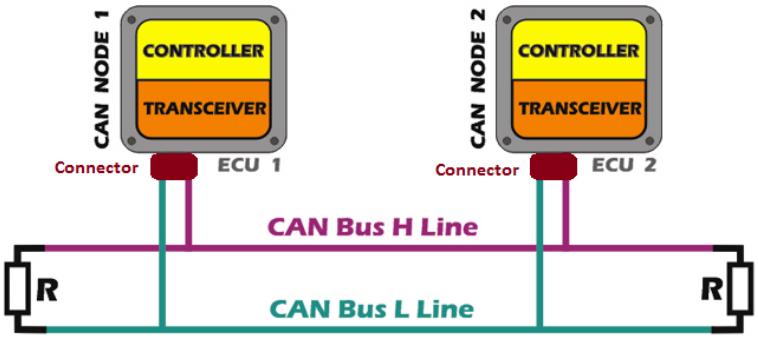
A: No. The center (red) PWM wire is typically +5V that can be used to power PWM devices. The Talon FX is powered by the 12V input and does not require PWM power.

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).

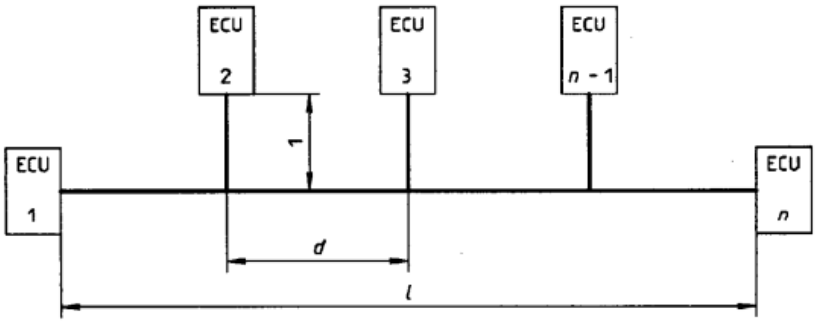


Figure 22 — Wiring network topology

Table 15 — Network topology parameters

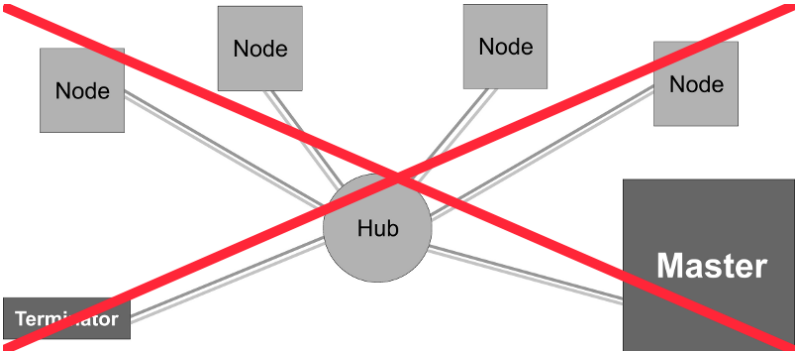
Parameter	Notation	Unit	Value			Conditions
			min.	nom.	max.	
Bus length	L	m	0		40	
Cable stub length[1)]	l	m	0		0,3	Bit rate: 1 Mbit/s [2)]
Node distance	d	m	0,1		40	

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.

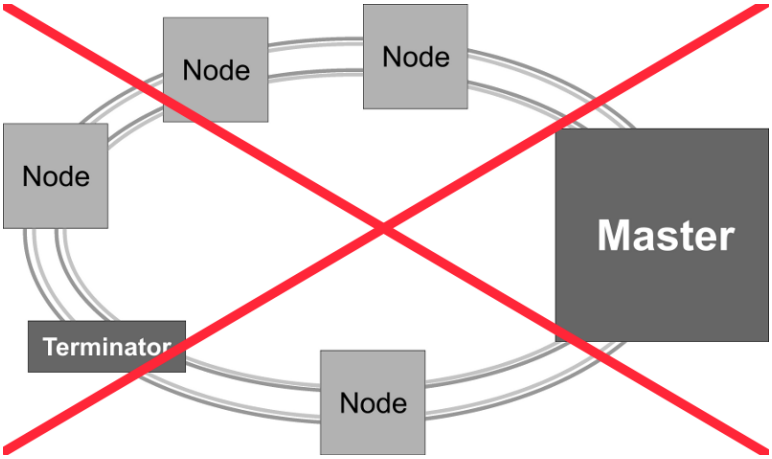
2) At bit rates lower then 1 Mbit/s the bus length may be lengthened significantly. Depending on *l*, the bit rate and internal capacitances of the individual ECUs, other network topologies with changed lengths *l* and *d* may be used. In this case the influence of occurring cable resonator waves on 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).

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 remain 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:

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 the 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 POWER LEADS OF THE TALON FX ARE NOT SHORTED TO THE CHASSIS OF THE ROBOT.*

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:

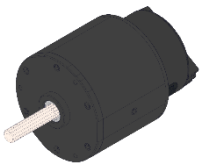
If the Status LEDs on the Talon FX are not operating properly and there is no output, the Talon FX may be internally damaged. This condition is typically caused by no input power or a reversed polarity on the input.

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.

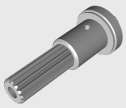
***CAUTION**: PRIOR TO REPLACING A POTENTIALLY DAMAGED FALCON 500 / TALON FX, ENSURE THAT THE WIRES CONNECTED TO THE OUTPUT ARE NOT SHORTED AND THE INPUT IS NOT REVERSED. ALSO, VERIFY THAT THE POWER LEADS OF THE TALON FX ARE NOT SHORTED TO THE CHASSIS OF THE ROBOT.*

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

SPARE PARTS

To help with maintenance of the motors, and prevent simple mechanical failures from making motors unusable, VEX will make Spare Parts for the Falcon 500 v3 Available.

PICTURE	DESCRIPTION	PART NUMBER
	Falcon 500 Short Shaft v3	217-8907
	Falcon 500 Medium Shaft v3	217-8908
	Falcon 500 Long Shaft v3	217-8909
	Falcon 500 v3 Replacement Front Plate	217-8935
	Falcon 500 v3 Replacement Housing Sleeve	217-8936
	Falcon 500 v3 Replacement Bearing Kit	217-8937

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

DATE	COMMENTS
10/25/2019	Initial Public Release
01/07/2021	General Edits And Corrections
02/03/2021	Updated For V2 Falcon
01/24/2022	Updated Limit Switch Orientation. Other Enhancements.
11/30/2022	Updated For V3 Falcon
2/10/2023	Update Blink Code table & clarified disclaimer for removing the end cap
2/15/2023	Updated Limit Switch Information

SUPPORT

Please send any questions, comments, or concerns to VEX Robotics and/or Cross The Road Electronics:

VEX ROBOTICS	CROSS THE ROAD ELECTRONICS
Sales: sales@vex.com **Support:** prosupport@vex.com **Phone:** 1-903-453-0802 **Fax:** 1-214-722-1284 **Office Hours:** 7am – 5pm CST (Monday-Friday)	**Sales:** sales@ctr-electronics.com **Support:** support@ctr-electronics.com **Phone:** 1-586-207-1387 **Office Hours:** 9am - 5pm EST (Monday-Friday)