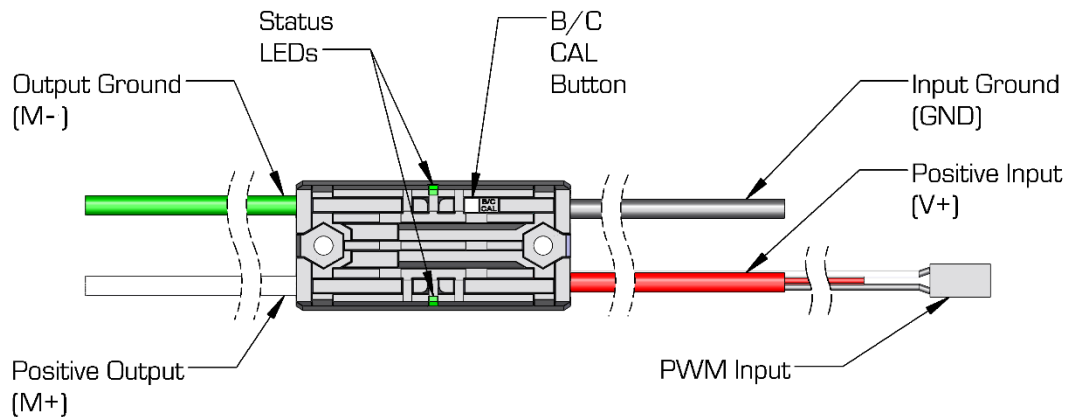


Getting Started – Victor SP

The Victor SP is a speed controller designed through collaboration between VEX Robotics (VEX.com) & Cross the Road Electronics (crosstheroadelectronics.com) that allows for fine control and high performance of brushed DC motors in competition robotics applications. The Victor SP handles high current loads with minimal voltage drop and heat generation. Its linear output and Brake/Coast options allow for precise motor control, making it well suited for all FRC motor applications from drivetrains to shooter wheels.

The lightweight aluminum case was designed using extensive Finite Element Heat Transfer (FEHT) modeling that led to a fully sealed design that makes fans optional. This, combined with a 3 sq. in footprint, a variety of built-in mounting options and super flexible, high strand count leads make installation a breeze.

The Victor SP at a Glance:



Victor SP Specs	
Outside Dimensions	2.5" x 1.125" x 0.875" [63.5mm x 28.58mm x 22.23mm]
Weight	0.20 lbf [0.09 kgf] (excluding wiring)
Nominal Voltage	12V
Min/Max Voltage	6-16V
Continuous Current	60A
Surge Current (2 sec)	100A
PWM Input Pulse (High Time)	1 - 2 ms Nominal 0.6-2.4ms max
PWM Input Rate (Period)	2.9-100ms
PWM Output Chop Rate (Switching Frequency)	15.625 kHz
Minimum Throttle (Deadband)	4%

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The power input & outputs of the Victor SP are indicated by markings on the housing as well as wire color as shown in the table below. All power input/output wires on the Victor SP are 600 strand minimum, 12AWG copper wire.

Wire	Case Marking	Wire Color	Wire Length ± 0.25in [6.35mm]
Positive Input	V+	Red	5.5in [139.7mm]
Input Ground	GND	Black	5.5in [139.7mm]
Positive Output	M+	White	5.5in [139.7mm]
Output Ground	M-	Green	5.5in [139.7mm]
PWM	None	White/Red/Black	17.25in [438.1mm]

Installing a Victor SP

Wiring a speed controller has never been easier than with the Victor SP. By following a few quick steps, your robot will be up and running in no time.

Wiring the Output

Connect the white wire to the M+ side of the motor and the green wire to the M- side of the motor using tightly crimped connectors. If the motor's inputs are not marked, the polarity of the input may be chosen by the user. Be sure to connect the output wires to motors with consistent polarity so each motor will rotate the same direction when given the same PWM signal. Reversing the output wire connections will result in the motor rotating the opposite direction when given the same PWM signal.

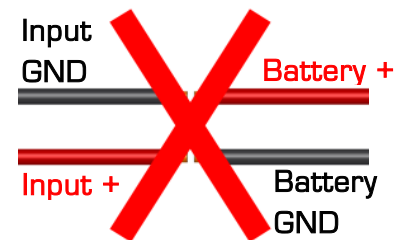
In many cases, the output leads of the Victor SP will not be long enough to reach the motor it is controlling, so an extension cable will be required. Extension cables should be made using appropriately sized wire and connected using properly crimped connectors.

Note: For the most robust connection, it is **highly** recommended that all connectors are crimped and soldered.

Wiring the Input



WARNING: TO MAXIMIZE PERFORMANCE, THE VICTOR SP DOES NOT INCLUDE REVERSE POLARITY PROTECTION. IF POWER IS APPLIED BACKWARDS, THE VICTOR SP MAY BE PERMANENTLY DAMAGED.



To power the Victor SP, connect the positive input (red) wire to the selected positive terminal of the Power Distribution Panel (PDP), and the input ground (black) wire to the corresponding ground terminal. In many cases, the Victor SP may be wired directly to the robot's PDP without extension cables – this is preferable since it reduces the number of electrical connections. If the robot's design does not allow for a direct connection to the PDP, extension cables may be used.

Getting Started – Victor SP

Always keep good electrical practices in mind when designing a robot's electrical system. The Victor SP's source voltage should never exceed 16V. In addition, a 40A or smaller breaker should be used in series with the Victor SP's positive input.

Wiring the PWM Input

The Victor SP's built-in Pulse Width Modulation (PWM) cable is used to control the device's output voltage. The built in PWM cable features a standard 3-pin (0.1 in pitch) female PWM connector that readily interfaces with many PWM controllers, such as the roboRIO and several VEX microcontrollers. The PWM signal used to control the Victor SP 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.

The pinout for the Victor SP's PWM cable is shown in the table below:

Wire Color	Wire Color
White	PWM Signal
Red	Not Used
Black	PWM Ground

Controlling a Victor SP with a NI roboRIO Controller:

To connect a Victor SP to the NI roboRIO controller, simply plug the Victor SP's attached PWM cable into the desired PWM header in the roboRIO's PWM output with the white (signal) wire on the "inside" of the controller. If an extension cable is needed to for the Victor SP 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 Victor SP with a VEX Microcontroller:

The Victor SP is compatible with the following VEX microcontrollers:

- VEXpro ARM9 Microcontroller
- VEX ARM® Cortex®-based Microcontroller
- VEX PIC Microcontroller V0.5

To connect a Victor SP with any of the above VEX microcontrollers, a standard 3-pin male-male header pin or a male-male 3-wire extension cable must be used.

If no extension cable is required for the Victor SP to reach the VEX microcontroller, insert a standard 3-pin male-male header into the Victor SP's female PWM cable and plug the cable into the desired motor port on the microcontroller with the white (signal) wire on the "inside" of the microcontroller.

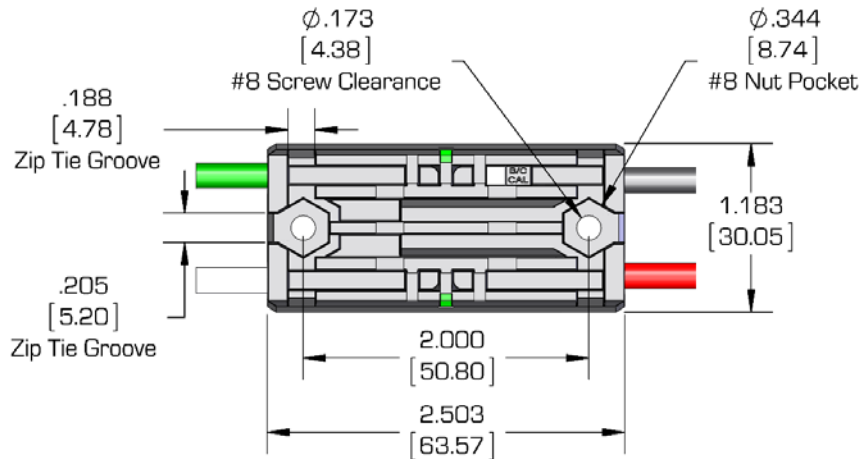
If an extension cable is needed for the Victor SP to reach the VEX microcontroller, a standard male-male 3-wire extension cable should be used. This type of extension cable is available from VEX Robotics as well as

Getting Started – Victor SP

many other online retailers. Connect the PWM extension cable to the Victor SP's PWM cable and plug the cable into the desired motor port on the VEX microcontroller with the white (signal) wire on the "inside" of the microcontroller.

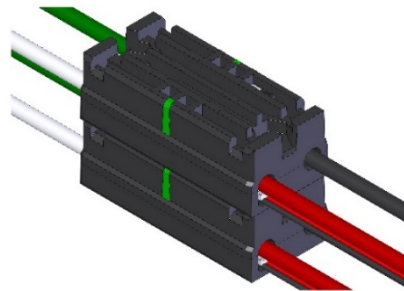
Note: The Victor SP's default calibration profile is configured for use with the roboRIO. To reconfigure it for use with a VEX microcontroller, follow the directions in the Calibration section.

Mounting the Victor SP



The Victor SP can be mounted using either (2X) #8-32 screws or zip-ties. The Victor SP's aluminum case is electrically isolated from the electronics, meaning it is safe to mount directly to a robot's frame!

The Victor SP's mounting location should be chosen to allow for adequate air flow around the heat fins and sides of the case. Any Victor SPs that are used for low-current applications may be stacked as shown below,



but Victor SPs used for high current applications, such as drivetrains, should be mounted individually.

For maximum heat dissipation it is recommended that the Victor SP be securely mounted to a robot's metal frame – this allows the robot to be used as a giant heat sink to aid in cooling.



CAUTION: IN RARE CIRCUMSTANCES, THE VICTOR SP MAY BECOME HOT DURING USE. USE CAUTION AROUND ANY VICTOR SP THAT HAS RECENTLY BEEN USED, ESPECIALLY ONES USED FOR HIGH CURRENT APPLICATIONS. IF PROTECTED BY A

Getting Started – Victor SP

40A BREAKER, THE VICTOR SP MAY BECOME HOT BUT WILL NOT BECOME HOT ENOUGH TO DAMAGE ITSELF.

Strain Relief

An important (yet frequently forgotten) aspect of wiring is strain relief. All electrical connections should be isolated from any pulling or tugging that may result in a poor connection. Once the Victor SP is fully wired, zip ties should be used to ensure that all electrical connections are protected.

Note: When zip-tying wires down, it is crucial to avoid sharp edges on the robot. Wires that are anchored to sharp edges can become worn over time and cause a short.

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 Victor SP's positive power input
- There are no short circuits on the Victor SP's output
- The PWM cable is correctly oriented (i.e. black to black & white to white)

Additional Information

Brake & Coast Modes

The Victor SP has two modes: Brake and Coast. When a neutral PWM signal is applied to the Victor SP in Brake mode, the motor 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 PWM signal is applied.

When a neutral PWM signal is applied to the Victor SP in Coast mode, Back-EMF will not be generated, so the motor's rotation will not be affected by the Victor SP.

Switching between Brake & Coast:

To switch between Brake and Coast mode, simply push the B/C CAL button at any time. The Victor SP 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 Victor SP.

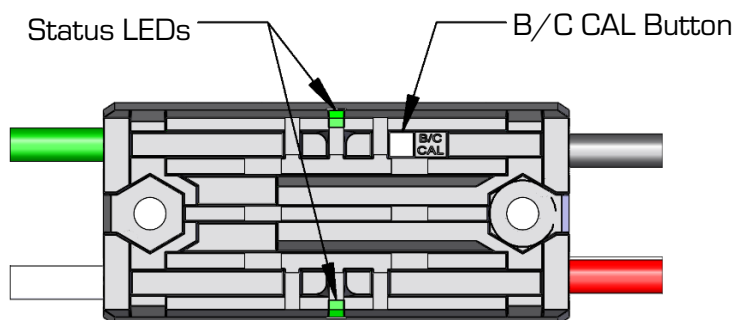
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Calibration

The calibration of a Victor SP is essentially the scale of PWM input signal to output voltage. Different controllers may have different “max” and “min” PWM signals that may not correspond to the same Victor SP outputs. Calibrating the Victor SP 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 Victor SP’s default calibration is compatible with the roboRIO control system.

To Calibrate the Victor SP:

- 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 Victor SP 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 Victor SP 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 Victor SP.

To Restore Default Calibration:

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

Getting Started – Victor SP

Blink Codes

Blink Codes During Calibration	
Status LEDs Blink Code	Victor SP State
Flashing Red/Green	Calibration Mode
Blinking Green	Successful Calibration
Blinking Red	Failed Calibration

Blink Codes During Normal Operation	
Status LEDs Blink Code	Victor SP State
Solid Orange	PWM Signal is within 4% of Neutral
Blinking Red	Reverse PWM Signal Applied - Blink speed is proportional to input
Solid Red	Full Reverse PWM Signal is applied
Blinking Green	Forward PWM Signal Applied - Blink speed is proportional to input
Solid Green	Full Forward PWM Signal is applied
Blinking Orange	No PWM Signal
LEDs Alternate Red/Orange	Damaged Hardware

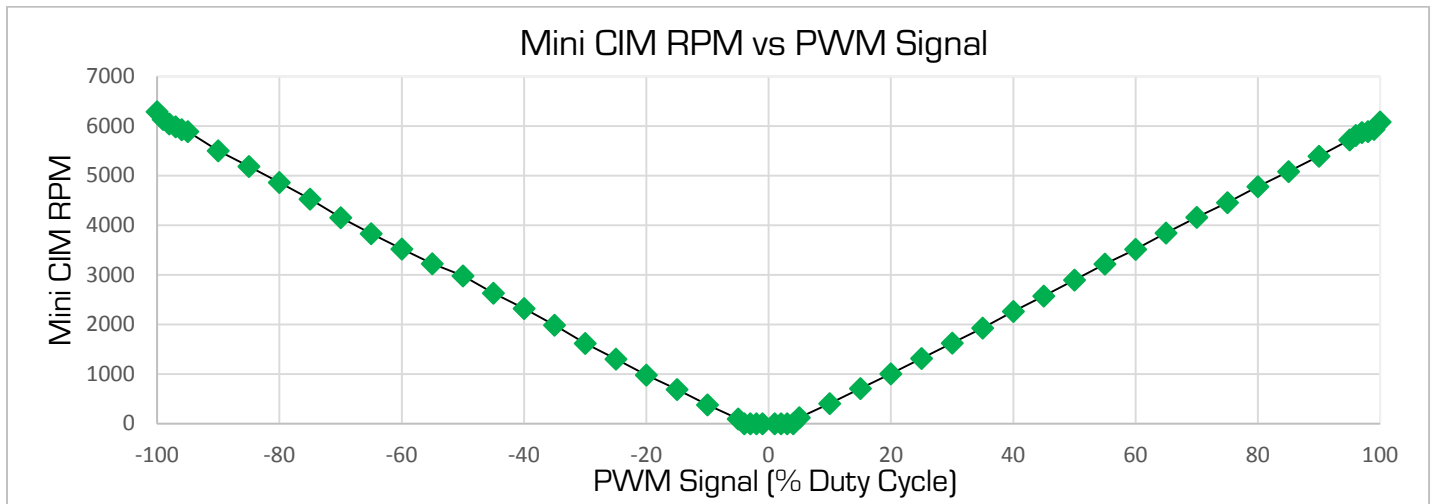
B/C CAL Button Blink Codes	
B/C CAL Button Color	Victor SP State
Solid Red	Brake Mode
Off	Coast Mode

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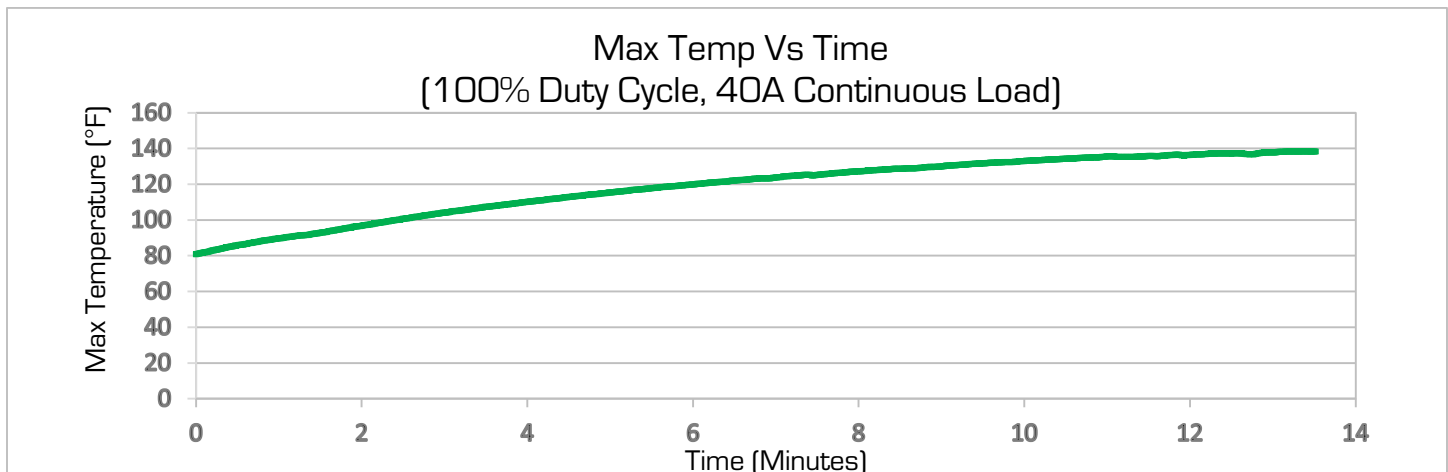
Performance Data

The Victor SP was designed to provide a predictable linear response over a wide range of PWM signals. To demonstrate its linearity, an experiment was performed by using a calibrated Victor SP controlled by a VEX Arm® Cortex®-based Microcontroller to drive a Mini CIM motor under no load. The PWM signal was varied from -100% to 100% at regular intervals. Finer intervals were measured near -100%, 0% and 100% duty cycle. During the test, the PWM signal and Mini CIM output were recorded and plotted, as shown below.

Note: This plot should only be used to evaluate the linearity of the Victor SP's output. This plot should not be used to predict a motor's behavior at a specific input signal.



To evaluate the Victor SP's thermal performance, a 40A load was applied using CIM motors and a dynamometer. Before the test, a thermocouple was attached to the bottom of the Victor SP (the warmest part of the case). The test was run for 10 minutes with temperature data being recorded at regular intervals then plotted, as shown below.



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Frequently Asked Questions:

Q: Is it possible to use more than one type of speed controller?

A: Yes, it is completely safe and acceptable to use multiple types of speed controllers on a single robot.

Q: Is it safe to mount a Victor SP directly to a robot's metal frame?

A: It's not only safe, it's recommended. The electronics inside the Victor SP are separated from the case by a minimum of two different layers of electrical insulation to prevent case shorts. Mounting a Victor SP to a robot's frame allows the robot to be used as a giant heat sink that will help keep the Victor SP cool.

Q: Does the Victor SP require a fan?

A: The Victor SP does not require a fan for typical FRC use but if the robot is being used for practice or many back to back matches it is a good idea to use a fan to cool the Victor SP to prevent accidental burns.

Q: What kind of electrical connectors should I use to connect wires to the Victor SP?

A: The choice of electrical connectors is left to the user. Electrical connectors used with the Victor SP 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 Victor SP be used with control systems other than the NI roboRIO?

A: Yes, the Victor SP may be used with any control system that is capable of PWM output.

Q: The center (red) PWM wire is not connected to the PWM connector, is this a problem?

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

Getting Started – Victor SP

Troubleshooting

Indication: No ORANGE Status LEDs on power up.

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

Possible Solutions:

1. Disconnect PWM cable.
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 Victor SP is damaged is to replace it with another Victor SP that is known to function properly.

CAUTION: Prior to replacing a potentially damaged speed controller, ensure that the wires connected to the output are not shorted and the input is not reversed. Also, verify that neither of the Victor SP's motor output leads are shorted to the chassis of the motor or the robot.

Indication: Flashing ORANGE Status LEDs on power up.

Problem: No PWM signal.

Possible Solutions:

1. Ensure the transmitter and receiver are powered ON.
2. The 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. Check for a good PWM signal by connecting a known good servo to the PWM extension 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 Victor SP.

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 center.

Getting Started – Victor SP

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 Victor SP are operating properly and there is no output, the Victor SP 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 Victor SP is damaged is to replace it with another Victor SP that is known to function properly.

CAUTION: Prior to replacing a potentially damaged speed controller, ensure that the wires connected to the output are not shorted and the input is not reversed. Also, verify that neither of the Victor SP's motor output leads are shorted to the chassis of the motor or 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 Victor SP are not operating properly and there is no output, the Victor SP 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 Victor SP do not illuminate at any joystick position.
3. Check the input at the Victor SP (+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 Victor SP is damaged is to replace it with another Victor SP that is known to function properly.

CAUTION: Prior to replacing a potentially damaged speed controller, ensure that the wires connected to the output are not shorted and the input is not reversed. Also, verify that neither of the Victor SP's motor output leads are shorted to the chassis of the motor or the robot.

Getting Started – Victor SP

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:

- 2014/08/18 - Beta Release
- 2014/11/05 - Initial Public Release
- 2015/02/05 - Blink Code Update