FAQ: MDL-BDC24 & MDL-BDC

Jaguar Motor Controller Frequently Asked Questions

FRC 2012 Season



Black Jaguar (MDL-BDC24)



Gray Jaguar (MDL-BDC)

Not recommended for new designs (NRND)

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Product Features

Q1 What are the differences between the MDL-BDC24 and the MDL-BDC?

A

The MDL-BDC24 and MDL-BDC are different in the following ways:

Feature	MDL-BDC24	MDL-BDC (NRND)
Plastic enclosure	Black with red Texas Instruments logo	Gray with orange Luminary Micro logo
Control interfaces	■ Servo-style PWM ■ CAN (one 6P6C and one 6P4C connector) ■ RS232 serial port (the outside two pins of the 6P6C connector)	■ Servo-style PWM ■ CAN (dual 6P4C connectors)
Input voltage range across V+/V- inputs	6–30 V This allows the use of 24-V motors.	6–15 V
H-Bridge	Uses synchronous rectification	Does not use synchronous rectification
Terminal screws	These screws are intended to be removed.	These screws should not be removed. If removed, the screw leaves metal shavings inside the motor controller assembly which

Q2 Why did you add an RS232 serial port to the MDL-BDC24?

A The RS232 serial port was added to provide a low-cost connection to the CAN network. A robot controller without a CAN interface but with an RS232 interface is able to connect to an MDL-BDC24 device that bridges commands received on the serial interface to its CAN interface (while also serving as a motor controller).

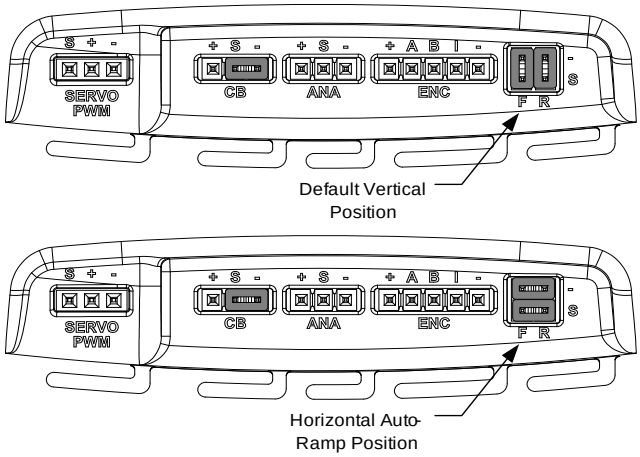
Q3	As an FRC team member or mentor, I thought we would be able to buy extra motor controllers for a discount from the standard resale price. How do I do this?
A	Additional motor controllers are available to FRC teams and mentors for an exclusive discount through TI's distribution partner, Digi-Key. The following link provides access to the discount program for FRC teams only: http://sales.digikey.com/dkes/FirstRoboticsCompetition.asp

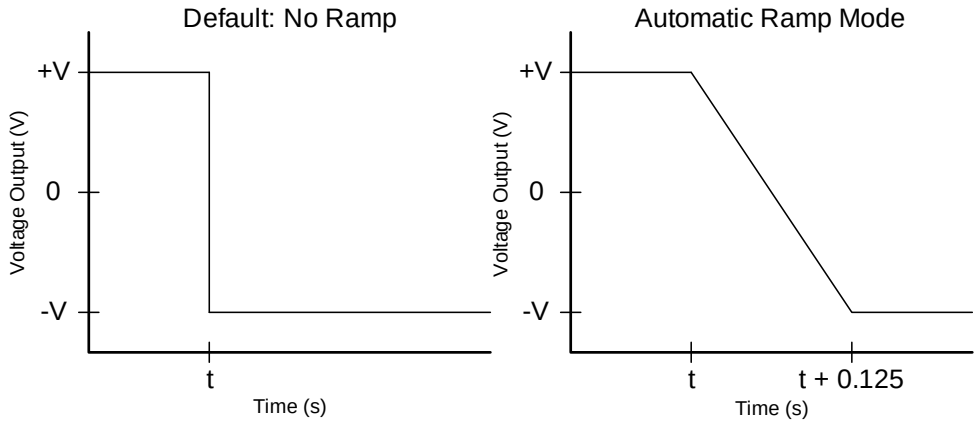
Automatic Ramp Mode

Q4	What is the Automatic Ramp mode?
A	Automatic Ramp mode is a feature introduced in the 2012 version of the Jaguar firmware (both black and gray Jaguar units) that, when activated, automatically ramps the output voltage to the motor at a preset ramp rate. Automatic Ramp mode is available regardless of the control mode: Servo PWM, CAN, or Serial. Automatic Ramp mode can be used as an alternative to programming a ramp function in the robot's code and/or as a quick fix during competition to remedy frequent current or voltage faults due to fast direction switching.

Q5	Which Jaguars have the Automatic Ramp mode?
A	Jaguars purchased or received during or after the 2012 season contain the Automatic Ramp mode in the factory default firmware. Older Jaguars can be updated to the latest firmware. See the Jaguar *Getting Started Guide* for more information.

Q6	We have mixed our new and old Jaguars together. How can we tell which Jaguars have the new firmware?
A	The new firmware performs a one-second fan test when power is first applied; older Jaguar firmware does not turn the fan on until the motor is driven. Listen for the fan spinning up as you apply power. You can also use the CAN or Serial interface to read the firmware version. The new firmware has the following version numbers: ■ Default from the factory: **8161 or greater** ■ FRC Trusted version (required to use the CAN interface for FRC): **greater than 92**

Q7	How do you access the Automatic Ramp mode?
A	With the Jaguar powered off, turn the two jumpers on the limit switch inputs from their default vertical position to a horizontal orientation (see below). Then, power on the Jaguar.  The limit switch inputs are checked once on power-up for the horizontal jumpers. When the horizontal jumpers are detected, the Jaguar enables the Automatic Ramp mode and then ignores the limit switch inputs. When the Automatic Ramp mode is enabled, the limit switch inputs cannot be used. Disabling the Automatic Ramp mode requires the jumpers to be in their default vertical position and the Jaguar to be power cycled.

Q8	What is the preset ramp rate?
A	The ramp rate is set to 524 steps per millisecond. There are 65,536 steps between full forward and full reverse, which means a 524 step/ms rate equates to a full-forward to full- reverse transition time of 0.125 seconds (see the graphs below).  At t, the user switches from full forward to full reverse.

Q9	Can we change the ramp rate for the Automatic Ramp mode?
A	No, the ramp rate is set to the preset value every time the mode is activated at power-up. A different ramp rate can be achieved by disabling the Automatic Ramp mode and either setting the internal ramp rate using the CAN or Serial interface, or by programming a ramp in your software running on the cRIO.

Q10	Can we update old Jaguars to the new firmware with the new mode?
A	Yes, you can update the firmware using one of the following methods: ■ Updating a Black Jaguar – Use BDC-COMM and the Serial interface – Use a 2CAN Ethernet-to-CAN bridge ■ Updating a Gray Jaguar – Use a Black Jaguar as a Serial-to-Can bridge with BDC-COMM – Use a 2CAN Ethernet-to-CAN bridge

Metal Debris and Misuse

Q11	Is metal debris really something to worry about?
A	Of course! By far the most common cause of Jaguar failures has been misuse, including metal debris. **Do not drill, file, or cut metal on the robot while any electrical component is present.** We suggest removing all electronics from the robot when metal is being modified in any way. However, removing the electronics does not guarantee debris-free electronics. Metal debris on the robot chassis can shake loose and fall into the electrical system. Before reinstalling the electronics, use a vacuum to clean up debris on the robot.

Q12	What if we can't remove the electronics from the robot while cutting metal?
A	It is often the case that the electronics are highly integrated into the robot or a quick modification must be made during competition and it is not feasible to remove the electronics before working on the robot. Protect the electronics as much as possible by following some of these suggestions: ■ Use blue painters tape to cover the Jaguar vents. ■ Use a tarp or a blanket to cover the electronics. Work carefully to avoid accidentally dumping debris over the electronics as you remove the tarp. Remove tarps carefully so that the debris is contained. ■ Use a vacuum to suck up any remaining debris. **Do not use compressed air which can scatter debris and push it into components.** Remember to remove any tape covering the Jaguar's air vents!

Q13	What if we accidentally get debris in our Jaguar?
A	Do not turn it on! Open the Jaguar to clean it out before turning it on. Follow these steps: 1. Remove the bottom shell by removing the four screws on the bottom of the Jaguar with a Phillips-head screwdriver. 2. Carefully remove the circuit board by slowly pressing the screw terminals through the top shell. Do not push too hard—the fan is attached to the top shell and the circuit board, and you can damage the fan by pulling too hard. 3. Press the white tab on the fan wire connector and gently pull the wire out of the circuit board connector (off-white in color). 4. Use a vacuum to clean out the circuit board and the plastic housing. 5. Reconnect the fan before reassembling the Jaguar. It is a good idea to clean your old Jaguars before reusing them. As always, when handling exposed electronic components, be sure to practice appropriate preventive measures to reduce the chance of Electrostatic Discharge (ESD).

Q14	When should we remove the Debris Warning stickers from our Jaguars?
A	In addition to reminding users about metal debris, the sticker acts as primitive barrier against debris entering the main air vent. The other air vents are still open and vulnerable to debris. Leave the sticker in place during robot construction as a reminder to team members to remove the electronics from the robot when metal is being cut, filed, or drilled. The sticker can remain in place during light robot testing to help reduce the chance of metal debris falling into the Jaguar while the robot is in motion—a time when debris tends to shake loose. Remove the sticker before heavy use, such as prolonged use at high or stall current and during competition. Also, remove the sticker if the Jaguar reports a Temperature Fault.

Q15	Won't the debris sticker restrict air flow and damage the Jaguar?
A	The sticker does block the main air intake vent. However, the Jaguar has a built-in temperature sensor that allows the Jaguar to monitor the temperature inside the case. The Jaguar indicates a Temperature Fault and turns off the output when the temperature is too high. The fault should trigger before damage occurs. Remove the sticker before running the robot during competition or other periods of heavy use regardless of whether you experienced temperature faults.

Q16	Can reversed polarity on the power connections damage a Jaguar?
A	**Yes! Reverse polarity will damage the Jaguar and may void your warranty.** Evidence of reverse polarity damage might not be apparent right away. When the reverse connection is corrected, the Jaguar may power up and operate correctly, however, the damage will worsen over time until the unit fails. There are many visual cues to help prevent reverse connection: ■ Raised lettering in the plastic: V+ and V- ■ Red and black screws ■ A warning sticker on newer model Jaguars The red and black screws can be removed and replaced incorrectly which makes the color coding useless. Always double-check your entire electrical system for reverse connections.

Q17	Can connecting power to the output side damage a Jaguar?
A	**Yes! Powering the output will damage a Jaguar and may void your warranty.** The Jaguar might not fail immediately, but the damage will worsen over time eventually leading to failure. There are a couple visual cues to help prevent reverse connection: ■ Raised lettering in the plastic: M+ for Motor+ and M- for Motor - ■ Green and white screws The green and white screws can be removed and replaced with the red and black screws which makes the color coding useless. Always double-check to make sure the Jaguars is correctly connected to power.

Q18	Because of a wiring mishap we connected a wire directly across the motor terminals and tried to run the Jaguar. The Jaguar no longer runs a motor. Isn't Jaguar supposed to have over-current protection?
A	Yes, the Jaguar has software-based over-current protection. However, the over-current protection is designed to prevent damage from a motor drawing too much current not a dead short. A dead short can create a huge current spike in a very short amount of time. If the spike is quick and large enough, the Jaguar cannot react fast enough to shut off the outputs. Whether or not you see a current fault depends on if the Jaguar was able to detect the spike. Damage also depends on magnitude and duration, so even if you see a current fault, the current spike might still be high enough to damage a Jaguar.

Faults

Q19	We notice that when we (accidentally) run our robot into a wall or obstacle and the robot is pushing really hard, the robot seems to shut down for a couple of seconds. Why does this happen?
A	The Jaguar modules have a self-protection feature that do not allow excessive current to be drawn. This feature protects both the motor and the motor controller from damage. The Jaguar module typically provides up to 40 A of continuous current to a heavily loaded motor. However, it is capable of providing much higher currents, but for shorter periods of time. Jaguar provides 60 A for up to two seconds and provides 100 A for approximately 0.2 s. The 2011 version of the Jaguar firmware provides a unique LED error code when this self-protection feature is tripped; the LEDs flash an repeating slow red then yellow sequence.

Q20	The Jaguars on our drive train are always current-faulting, especially when we change directions. Why can't the Jaguar handle this, is it broken?
A	This is usually indicative of a mechanical issue with the drive train. The Jaguar is designed to provide 40A continuously and 60A for a maximum of 2 seconds. The higher the current, the quicker the Jaguar current faults and turns off the outputs. There are many factors that increase the motor current including: ■ Too much friction – Sticking bearings – Misaligned sprockets and chain – Over-tensioned chain ■ High gear ratios ■ Rate of output change The effects of friction can make your motors draw much more current than they need to and can affect the efficiency and power of your robot. Examine your drive train and reduce the friction where possible. Extremely high gear ratios also make it easier for the motors to draw too much current or even stall. High gear ratios reduce the available torque and make it easy to stall the motor. Well-designed drive trains account for the torque required to move the robot and ensure that the motors can provide that torque at safe running currents. Finally, the rate at which you command the Jaguar to change output voltage can cause current spikes. When a new output value is set, the motor does not change instantly. Momentum in the drive train resists the change which causes a spike in the current. The worst spike usually happens when changing from full forward to full reverse at a high rate of speed. A simple output ramp can solve this problem easily and there are many ways to do it: ■ Program a ramp within your robot code ■ Adjust the internal ramp rate inside the Jaguar – This defaults to no ramp on power-up. – Access to this feature requires a CAN or Serial connection ■ Activate the Automatic Ramp feature – Activates by turning the limit switch input jumpers sideways – Sets the internal ramp to 524 steps per millisecond (full forward to full reverse in 0.125 seconds) – Requires the latest firmware – Jaguars shipped in 2012 have the latest firmware – Older Jaguars can be updated to the latest firmware using a CAN or Serial connection – See the Jaguar *Getting Started Guide* for more information

Q21	The Jaguars on our drive train are always voltage-faulting. How can we fix this problem?
A	The Jaguar constantly monitors the supplied voltage and indicates a voltage fault when it drops dangerously close to the level at which the Jaguar will turn off or reset, approximately 6 volts. Voltage drops can be caused many things, and often are a combination of several, including: ■ High current draw ■ Low battery charge ■ Aging battery ■ High resistance paths in the electrical system ■ Loose terminals and connectors The robot battery can supply a certain amount of current while maintaining a steady output voltage. As the current increases, the battery voltage drops. Many of the same issues that cause a high current spike also cause an associated drop in battery voltage (see the previous FAQ). Often, these spikes are short and barely noticeable with a standard volt meter, but the voltage drops can be very low and affect Jaguars ability to stay powered on. Amplifying the effect of current draw on the battery is the battery's charge level. A significantly discharged battery may still provide 12 V when unloaded, but as current draw increases, the battery voltage drops a lot quicker than a fully charged battery. In addition, aging batteries have a higher internal resistance. Because Voltage = Current x Resistance (V=IR), the higher the resistance, the lower the voltage for the same current. Resistive paths in your electrical system also contribute to voltage drops. As a wire's length increases, the resistance also increases. Therefore, minimize the length of the wires connecting your Jaguar to the Power Distribution Board. Loose terminals and connectors also increase the resistance in your electrical system—the better the fit, the lower the resistance.

Q22	Our Jaguars tend to temperature-fault every so often. What can we do to help this problem?
A	Keep the Jaguars well ventilated and make sure the vents are clear and open. Remove any tape or stickers that are protecting the Jaguars from debris.

CAN and Serial RS232 Interface

Q23	If I am not using the RS232 and/or CAN interface, what should we do with the unused interface?
A	We recommend putting electrical tape over the top of the connectors to prevent debris from getting into the connector. Please be careful not to cover the vent slots on the side of the Jaguar plastics when putting the tape in place. Two short 1" segments should be enough to cover the connectors while not obstructing the air flow venting, the status LED, or the PWM connector.

Q24	Is there anything you can do over CAN that cannot be done over the RS232 interface?
A	The MDL-BDC24 motor controller provides an RS232 interface that allows a robot controller with an RS232 port to send commands and get status over the serial port. The motor controller bridges between the RS232 and CAN interfaces so that any packet received on one interface is copied to the other with the exception of packets destined for the bridging device. The serial port bandwidth is lower than the native CAN bandwidth. Therefore, when using the serial-to-CAN bridging capabilities, the number of packets that can be exchanged is reduced to approximately 1/5th of the maximum number of packets on a CAN-only network.

Q25	My PC does not have an RS232 (COM) port, can I use a USB-to-RS232 adaptor?
A	Yes. These dongles are readily available. We have tested the Sabrent cable (SBT-USC1M) which is available from many retailers for approximately $11.

Q26	What is the performance of CAN? The serial to CAN bridge?
A	The CAN interface provided uses the 29-bit extended format message ID at a bit rate of 1 Mb/s. Assuming a typical bit-stuffing pattern, this combination allows in excess of 9,300 packets/s[a]. The RS232 interface runs at 115,200 baud (8-N-1), but unlike CAN is full duplex. Therefore, the number of packets expected to be transmitted on the RS232 network is between 1/10th to 1/5th of the peak CAN traffic.

a. See “A Comprehensive Guide to Controller Area Network”, W. Voss, Copperhill Technologies Corp. 2005.

Q27	What are CAN IDs?
A	Each MDL-BDC and MDL-BDC24 that is used on a CAN network must be assigned a unique ID before it can receive any commands. The ID assignment is up to the user; however, the following guidelines are recommended: • **Do not use ID 0 or 1.** ID 0 is reserved for broadcast packets on the CAN network. ID 1 is the default ID programmed into all motor controllers when they are tested and programmed at the factory. • **Program the ID into the motor controller before connecting it to the CAN network on the robot.** It is also a good idea to check the firmware version of the motor controller after assigning the ID in case an update is required. Use the bdc-comm PC utility to assign a CAN ID to an MDL-BDC or MDL-BDC24.

Q28	Where do I get CAN cables?
A	See the Jaguar *Getting Started Guide* for more information on making your own cables. CAN cables are very easy to make and quite inexpensive. The material cost of a 3-foot CAN cable is less than $0.50[a]. CAN cables are considerably less expensive than a similar length Servo (PWM) cable, are faster to make, and provide a locking tab. Pre-made cables and other CAN accessories are often sold by other FIRST suppliers.

a. This assumes the purchase of 100 feet of modular wire and a 10 or 100 pack of connectors. Frys #1930182 @ $0.99 (using 2 of 10) and #1544831 @ $6.99 (using 3 of 100) is $0.41.

Q29	How do I make a CAN cable?
A	Review thoroughly the detailed instructions in the Jaguar *Getting Started Guide* for making a CAN cable. A CAN cable is simple to make but you must be aware of the following: 1. Purchase 4-conductor modular wire (for example, Frys #1544831) and 6P4C modular connectors (for example, Frys #1930182). Note: If you are making an RS232/CAN cable, the process is slightly more involved, and you should follow the detailed instructions in the GSG. 2. Strip only the outer insulation from the modular wire. Do not strip the color-coded insulation from the enclosed wires. The modular connector pierces the insulation when crimped (that is, it is an insulation displacement connector). 3. The same pin on both connectors is attached to the same wire in the cable. If you insert the wire into both connectors, a correctly wired connection has the same wire colors in the same order on both connectors (that is, from left to right: yellow, green, red, and black on both connectors).

Q30	What are ‘synchronous updates’ and why would I need them?
A	Most `Set` commands (such as `VoltageSet`, `PositionSet`, and so on) have an optional byte in the payload that allows a robot controller to specify to the MDL-BDC and MDL-BDC24 that the command should not be executed immediately, but rather that the value passed in the payload should be stored and used at a later time when all motor controllers of a specific group are updated. The synchronous update command that follows a set of ‘Set’ commands allows the values provided to become active at the same time. This feature provides the same features as a Y servo (PWM) cable (splitter), except it can apply to more than just two controllers.

Limit Switches and Soft Limits

Q31	How do the limit switches work?
A	There are two limit switch headers, one labeled F and one R. Each header consists of two pins: one sense pin and one ground pin. The sense pin is pulled up to a positive voltage inside the motor controller. A normally-closed switch is connected across the ground and sense pins of each header thereby grounding the sense pin (low). If the switch is pressed and opens the circuit, the sense pin is disconnected from ground and the internal pull-up raises the voltage on the sense pin (high).

Direction of Desired Rotation	Limit Switch State/Sense Pin Voltage	
	Closed/Sense Pin Low	Open/Sense Pin High
Forward	Positive voltage	0 V
Reverse	Negative voltage	0 V

Q32	I do not plan to use limit switches. Can I remove the jumpers?
A	No. The jumpers are there to act as a limit switch in lieu of the switch being used. If you do not plan to use limit switches, leave the jumpers in place. If you remove the jumpers and cannot remember how to reinstall the jumpers, see the Jaguar *Getting Started Guide* to reinstall the jumpers. If you use a limit switch, you must remove the appropriate jumper and replace it with the limit switch circuit.

Q33	Can I have multiple limit switches independently limit a motor’s rotation?
A	Yes. Since the limit is signaled to the motor controller when the switch is open, a set of switches in series may be used. If any switch opens, the sense pin rises to a high state.

Q34	We want to use the limit switches. What part/supplier provides 1x2 headers that fit side-by side for use with the limit switches?
A	FCI offers part numbers 65039-035LF (housing) and 48248-000LF (receptacle), available from Digi-Key.

Q35	What are soft limits and how can I use them?
A	The motor controller allows the definition of two virtual (soft) limit switches. Soft limits can be used in position control mode. Each limit is defined by two components: the position value and the comparison direction. The direction specifies whether the limit is exceed if the current position value is *greater than* or *less than* the specified position value. Like limit switches, there are two soft limits so that a structure can be bounded on both sides. If the limit is exceeded, the motor controller behaves the same as it would if the physical limit switches were pressed. Soft limits are available only over CAN connections.

Q36	Instead of putting two connectors side by side, we would rather use just one connector for the limit switches. What part/supplier provides 2x2 headers for use with the limit switches?
A	FCI offers part numbers 65043-035LF (housing) and 48248-000LF (receptacle), available from Digi-Key.

Servo (PWM) Interface

Q37	My Jaguar (MDL-BDC or MDL-BDC24) is receiving a good Servo (PWM) signal, but it is not generating any voltage on the output (that is, my motor isn't turning). Is my Jaguar broken?
A	Probably not. The most likely reason for this occurrence is that the limit switch for Direction is open, or the jumper has been removed. A clue to this is the LED. If you are sending a Servo (PWM) signal, and the LED is flashing slowly red, it usually means that the Jaguar is experiencing a fault condition; the most common fault condition being the limit switch.

Q38	Do I need to calibrate the Servo (PWM) interface?
A	It depends. The motor controller has a calibration mode, and the need to calibrate depends on the Servo (PWM) signal range generated by the robot controller. For FRC users, the answer is probably not if you are using the cRIO system and a new motor controller. The default parameters of the motor controller are tuned for use with the cRIO. The calibration mode is provided if you want to use the motor controller with another source of Servo (PWM) signal that does not have the same range of pulse widths (for example, an older robot controller). Or, if you have calibrated your Jaguar (MDL-BDC) from a different source and move it back to a cRIO system, you must recalibrate.

Brake/Coast Interface

Q39	What is the best connection for a dynamic brake/coast interface?
A	If you are using the CAN interface, the brake/coast jumper setting may be overridden, and therefore no electrical interface to the brake/coast pins is necessary. Otherwise, if you are using a PWM (servo) interface, you can connect just the center pin of the brake/coast header to a digital source (for example, for FRC users the digital side car). Note that you should not connect a ground signal because you do not want this to act as a current return path to the battery. You want the current return path exclusively through the V- screw terminal.

Q40	We want to connect the Brake/Coast input to a robot controller and implement a dynamic Brake/Coast mechanism. What part/supplier provides a 1x3 header for use with the Brake/Coast input?
A	FCI offers part numbers 65039-034LF (housing) and 48248-000LF (receptacle), available from Digi-Key.

FAQ: MDL-BDC24 & MDL-BDC

Fixed-Point Values

Q41	What are fixed-point values?
A	Fixed-point is similar to floating point in that it expresses a non-integer value, but as its name implies, the decimal point position in the value is fixed. Fixed-point values are used in embedded systems programming when a floating-point unit is unavailable or the execution time of a floating-point library call is too slow. Most fixed-point values used in the motor controller are contained in a 32-bit integer and are a 16.16 format. This format uses 16 bits to represent the fractional value and 16 bits to represent the integer number. Note that the fractional value is limited to the granularity of $1/2^N$, where N represents the number of bits. In the case of 16.16 format, the smallest number that can be represented is approximately 0.000015.

Value	Fixed-Point Representation in 16.16 Format	Value Converted from Fixed-Point Representation Back to Floating-Point
1	0x00010000	1
2	0x00020000	2
0.5	0x00008000	0.5
0.19	0x000030A3	0.1899
Pi	0x0003243F	3.1415863

Fan

Q42	When we apply power to our Jaguar (MDL-BDC) module, the fan does not turn on. Is it broken?
A	Not necessarily. Unlike previous FRC speed controller solutions, the fan in a Jaguar module is set to turn on only when necessary. Jaguar turns the fan on when it is running a motor. By default, Jaguar does not turn the fan on until you start to drive. Jaguar turns the fan of when the module is not driving a motor and the internal temperature is safe in order to save valuable battery power.

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