

# FAQ: MDL-BDC & MDL-BDC24



## Jaguar / Black Jaguar Frequently Asked Questions FRC 2010 Season



### Product Models

<b>Q</b>	What are MDL-BDC and MDL-BDC24?
<b>A</b>	MDL-BDC and MDL-BDC24 are brushed DC motor controllers designed by Luminary Micro (now a part of Texas Instruments). MDL-BDC was the first BDC controller designed by Luminary Micro and was supplied to <i>FIRST</i> for the 2009 <i>FIRST</i> Robotics Competition as the “Jaguar” motor controller. MDL-BDC24 is a redesigned version of the MDL-BDC.

<b>Q</b>	Why did you redesign the MDL-BDC?
<b>A</b>	Some of the components used in the MDL-BDC are no longer available for purchase, and so those components had to be replaced. Because the design was being changed, some enhancements were added, including the 24V operation and the RS232 serial port.

<b>Q</b>	How is MDL-BDC24 different than MDL-BDC?															
<b>A</b>	MDL-BDC and MDL-BDC24 are different in the following significant ways:															
	<table border="1"> <thead> <tr> <th>Difference</th> <th>MDL-BDC</th> <th>MDL-BDC24</th> </tr> </thead> <tbody> <tr> <td>Plastic enclosure</td> <td>Grey with orange Luminary Micro logo</td> <td>Black with red Texas Instruments logo</td> </tr> <tr> <td>Control Interfaces</td> <td>Servo-style PWM CAN (dual 6P4C connectors)</td> <td>Servo-style PWM CAN (one 6P6C and one 6P4C connector) RS232 serial port (the outside two pins of the 6P6C connector)</td> </tr> <tr> <td>Maximum input voltage across V+/V- inputs</td> <td>15 V</td> <td>30 V. This allows the use of 24 V motors.</td> </tr> <tr> <td>HBridge</td> <td>Does not use synchronous rectification</td> <td>Uses synchronous rectification</td> </tr> </tbody> </table>	Difference	MDL-BDC	MDL-BDC24	Plastic enclosure	Grey with orange Luminary Micro logo	Black with red Texas Instruments logo	Control Interfaces	Servo-style PWM CAN (dual 6P4C connectors)	Servo-style PWM CAN (one 6P6C and one 6P4C connector) RS232 serial port (the outside two pins of the 6P6C connector)	Maximum input voltage across V+/V- inputs	15 V	30 V. This allows the use of 24 V motors.	HBridge	Does not use synchronous rectification	Uses synchronous rectification
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<b>Q</b>	Why did you add an RS232 serial port to the MDL-BDC24?
<b>A</b>	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).

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<b>Q</b>	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?
<b>A</b>	Additional motor controllers are available to FRC teams and mentors for a discount exclusively through Texas Instruments' distribution partner, Digi-Key. Here is your FRC exclusive order link to place an order for a discounted motor controller: <a href="http://sales.digikey.com/dkes/FirstRoboticsCompetition.asp">http://sales.digikey.com/dkes/FirstRoboticsCompetition.asp</a> .

## Mechanical

<b>Q</b>	Do you have any recommendations regarding the air vents?
<b>A</b>	Yes, please do not cover them up! Jaguar draws air through the top vent and expels it out the side vents. If any of these vents are blocked, it reduces the airflow through the unit and affects the cooling of the power transistors (MOSFETs). Similarly, we also recommend against placing Jaguar (MDL-BDC) modules directly next to each other (touching) so as to reduce any conflicting airflow.

## Interfaces

<b>Q</b>	For the 2010 FRC competition, will <i>FIRST</i> allow the use of CAN and all of the interfaces and features provided on the MDL-BDC and MDL-BDC24 motor controllers?
<b>A</b>	TI works very closely with <i>FIRST</i> to design and produce a motor controller with great features. However, it is completely up to <i>FIRST</i> to decide what features of an MDL-BDC or MDL-BDC24 motor controller may be used.

<b>Q</b>	If I am not using an interface, what should we do with it?
<b>A</b>	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.

## CAN and Serial RS232 Interface

<b>Q</b>	Is there anything you can do over CAN that can't be done over the RS232 interface?
<b>A</b>	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, and therefore when using the serial to CAN bridging capabilities, the number of packets that could be exchanged is reduced to approximately 1/5 <sup>th</sup> of the maximum of a purely CAN network.

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<b>Q</b>	My PC doesn't have an RS232 (COM) port, can I use a USB to RS232 adaptor?
<b>A</b>	Yes. These dongles are readily available. We've tested the Sabrent cable (SBT-USC1M) which is available from many retailers for approximately \$10.

<b>Q</b>	What is the performance of CAN? The serial to CAN bridge?
<b>A</b>	<p>The CAN interface provided uses the 29-bit extended format message ID at a bit rate of 1 Mb/s. Assuming a normal bit stuffing pattern, this combination allows in excess of 9,300 packets/s<sup>1</sup>.</p> <p>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 1/10<sup>th</sup> and 1/5<sup>th</sup> of the peak CAN traffic.</p>

<b>Q</b>	What are CAN IDs?
<b>A</b>	<p>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.</p> <p>The ID assignment is up to the user; however, the following guidelines are recommended:</p> <ol style="list-style-type: none"><li>1. 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're tested and programmed at the factory.</li><li>2. 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.</li></ol> <p>The best way to assign a CAN ID to an MDL-BDC or MDL-BDC24 is using the bdc-comm PC utility.</p>

<b>Q</b>	Where do I get CAN cables?
<b>A</b>	You are expected to make your own cables. They are very easy to make and quite inexpensive. The material cost of a 3 foot CAN cable is less than \$0.50 <sup>2</sup> . CAN cables are considerably less expensive than a similar length Servo (PWM) cable, are faster to make, and provide a locking tab.

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<sup>1</sup> See "A Comprehensive Guide to Controller Area Network", W. Voss, Copperhill Technologies Corp. 2005.

<sup>2</sup> This assumes the purchase of 100 feet of modular wire and a 10 or 100 pack of connectors. Fry's #1930182 @ \$0.99 (using 2 of 10) and #1544831 @ \$6.99 (using 3 of 100) is \$0.41.



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**Q** How do I make a CAN cable?

**A** The Getting Started Guide (GSG) provides this detail. It is recommended that you review the material in this document thoroughly.

However, a CAN cable is simple to make if you are aware of the following:

1. You need some 4-conductor modular wire (e.g. Frys #1544831) and 4P4C modular connectors (e.g. Frys #1930182). Note that if you're making an RS232/CAN cable, the process is slightly more involved, and it is recommended that you see the instructions in the GSG.
2. You only need to strip 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 (i.e. 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 (e.g. from left to right: yellow, green, red, and black on both connectors).

**Q** What are 'synchronous updates' and why would I need them?

**A** Most 'Set' commands (e.g. VoltageSet, PositionSet, etc.) 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

**Q** 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	0V
Reverse	Negative voltage	0V

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<b>Q</b>	I don't plan to use limit switches. Can I remove the jumpers?
<b>A</b>	No. The jumpers are there to act as a limit switch in lieu of the switch being used. If you do not plan on using limit switches, leave the jumpers in place. If you remove the jumpers and cannot remember how to reinstall the jumpers, please refer to the 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.

<b>Q</b>	Can I have multiple limit switches independently limit a motor's rotation?
<b>A</b>	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.

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

<b>Q</b>	What are soft limits and how might I use them?
<b>A</b>	<p>The motor controller allows the definition of two virtual (soft) limit switches. Soft limits can be used in position control mode.</p> <p>Each limit is defined by two components: the position value and the comparison direction. The direction specifies whether the limit is exceeded 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 may be bounded on both sides.</p> <p>If the limit is exceeded, the motor controller behaves exactly the same as it would if the physical limit switches were pressed. Soft limits are available only over CAN connections.</p>

<b>Q</b>	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?
<b>A</b>	FCI offers part numbers 65043-035LF (housing) and 48248-000LF (receptacle), available from Digi-Key.

## Servo (PWM) Interface

<b>Q</b>	My Jaguar (MDL-BDC or MDL-BDC24) is receiving a good Servo (PWM) signal, but it is not generating any voltage on the output (i.e. my motor isn't turning). Is my Jaguar broken?
<b>A</b>	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're 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.

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<b>Q</b>	Do I need to calibrate the Servo (PWM) interface?
<b>A</b>	<p>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.</p> <p>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 (e.g. 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.</p>

## Brake/Coast Interface

<b>Q</b>	What is the best connection for a dynamic brake/coast interface?
<b>A</b>	<p>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.</p> <p>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 (e.g. for FRC users the digital side car). Note that you shouldn't hook up 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.</p>

<b>Q</b>	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?
<b>A</b>	FCI offers part numbers 65039-034LF (housing) and 48248-000LF (receptacle), available from Digi-Key.

## Faults

<b>Q</b>	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. What gives?
<b>A</b>	The Jaguar (MDL-BDC) modules have a self protection feature that does not allow excessive current to be drawn. This feature protects both the motor and the motor controller from damage. The Jaguar (MDL-BDC) module normally 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.

## Fixed-Point Values

**Q** What are fixed-point values?

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

**A**

## Fan

**Q** When we apply power to our Jaguar (MDL-BDC) module, the fan does not turn on. Is it broken?

Not necessarily. Unlike previous FRC speed controller solutions, the fan in Jaguar (MDL-BDC) is controlled to turn on only when necessary. Jaguar (MDL-BDC) turns the fan on when it is running a motor. By default, Jaguar (MDL-BDC) does not turn the fan on until you start to drive. Jaguar (MDL-BDC) turns the fan off when the module is not driving a motor and the internal temperature is safe. This feature saves battery power, and (as you know) every little bit of conservation helps!

**A**



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Texas Instruments  
108 Wild Basin Rd., Suite 350  
Austin, TX 78746  
Main: +1-512-279-8800  
Fax: +1-512-279-8879  
<http://www.ti.com/stellaris>

