Jaguar Motor Controller

Getting Started Guide

Table of Contents

Chapter 1: Introduction to Jaguar

This document provides a complete description of how to use Jaguar in both Networked and Servo control modes.

Additional information can be found in the Jaguar data sheets, as well as in related application notes.
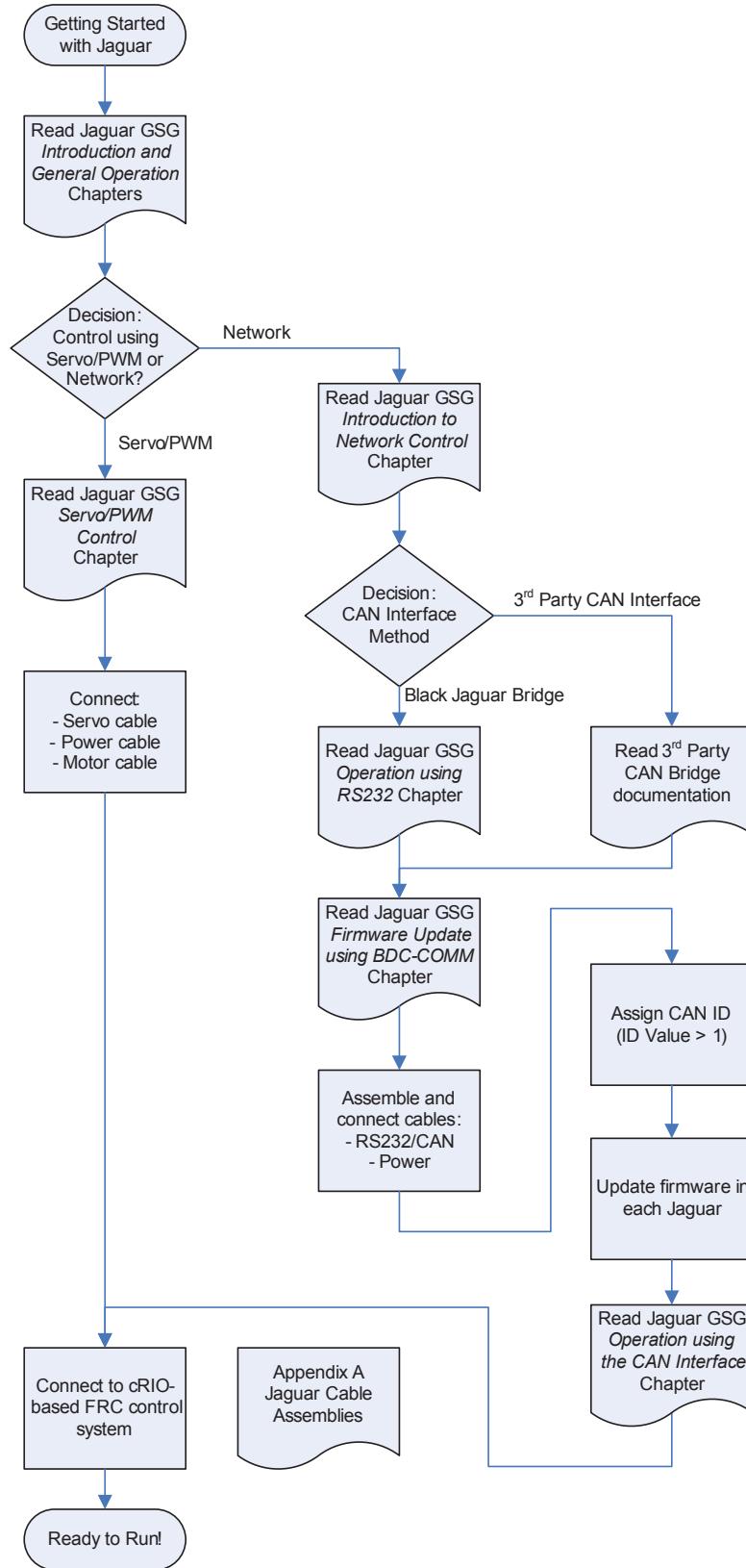
Figure 1-1. Jaguar Motor Controller

The flowchart in Figure 1-2 provides an overview of the process of developing with the Jaguar. We suggest checking off each step as it is completed.

Figure 1-2. Jaguar Development Process

```
                    Getting Started
                     with Jaguar
                          │
                          ▼
                   Read Jaguar GSG
                   Introduction and
                   General Operation
                       Chapters
                          │
                          ▼
                     Decision:                    Network
                   Control using  ──────────────────────────┐
                   Servo/PWM or                              │
                     Network?                                ▼
                          │                           Read Jaguar GSG
                     Servo/PWM                        Introduction to
                          │                           Network Control
                          ▼                               Chapter
                   Read Jaguar GSG                           │
                     Servo/PWM                               ▼
                       Control                          Decision:           3rd Party CAN Interface
                       Chapter                        CAN Interface  ────────────────────────────┐
                          │                              Method                                   │
                          │                                 │                                     │
                          ▼                         Black Jaguar Bridge                           │
                       Connect:                             │                                     ▼
                     - Servo cable                          ▼                              Read 3rd Party
                     - Power cable                   Read Jaguar GSG                        CAN Bridge
                     - Motor cable                   Operation using                       documentation
                          │                          RS232 Chapter                                │
                          │                                 │                                     │
                          │                                 ▼                                     │
                          │                          Read Jaguar GSG                              │
                          │                          Firmware Update                              │
                          │                          using BDC-COMM          Assign CAN ID        │
                          │                             Chapter              (ID Value > 1)        │
                          │                                 │                      │              │
                          │                                 ▼                      ▼              │
                          │                          Assemble and          Update firmware in     │
                          │                          connect cables:        each Jaguar           │
                          │                           - RS232/CAN                 │               │
                          │                           - Power                     ▼               │
                          │                                                Read Jaguar GSG        │
                          ▼                                                 Operation using        │
                     Connect to cRIO-    Appendix A                        the CAN Interface       │
                     based FRC control   Jaguar Cable                          Chapter            │
                       system            Assemblies                                                │
                          │
                          ▼
                     Ready to Run!
```

Features

The Jaguar offers a variable speed control for 12 V and 24 V brushed DC motors at up to 40 A continuous current. The motor control module includes high performance Controller Area Network (CAN) connectivity and a rich set of control options and sensor interfaces, including analog and quadrature encoder interfaces. The high-frequency PWM on the Jaguar enables DC motors to run smoothly and quietly over a wide speed range. The module uses highly optimized software and a powerful 32-bit Stellaris® microcontroller to implement open-loop speed control as well as closed-loop control of speed, position, or motor current.

The Jaguar provides the following features:

• Quiet control of brushed DC motors
  – 15 kHz PWM frequency

• Three options for Speed control
  – Industry-standard R-C servo type (PWM) interface
  – Controller Area Network (CAN) interface
  – RS232 serial interface

• CAN communication
  – Multicast shared serial bus for connecting systems in electromagnetically noisy environments
  – 1M bits/s bit rate
  – CAN protocol version 2.0 B
  – Full configurability of module options
  – Real-time monitoring of current, voltage, speed, and other parameters
  – Firmware update

• RS232 serial communication
  – Bridges RS232 port to a CAN network
  – Directly interfaces to a PC serial port or National Instruments cRIO

• Automatic Output Ramp mode

• Status LED indicates Run, Direction, and Fault conditions

• Motor brake/coast selector

• Limit switch inputs for forward and reverse directions

• Quadrature encoder input (QEI)
  – Index input
  – 5 V supply output to encoder

• Analog input
  – Accepts 10 k potentiometer or 0-3 V input

• Screw terminals for all power wiring

• Headers (0.1 inch pitch) for all control signals

Warnings

> **WARNING – Be aware of the following warnings. Failure to heed warnings can result in damage to the module or invalidation of the module warranty.**

- Mount the Jaguar module so that the vents in the top and sides of the unit are not restricted in any way. Maintain a clearance of at least ½ inch between modules.

- Reverse wiring is unprotected; doing so voids the Jaguar module's warranty. Do not exceed the absolute maximum supply voltage (30 V_{DC})

- Doing so causes permanent damage to the module.

- Protect Jaguar from all situations where debris could enter through ventilation slots or connector openings.

Chapter 2: General Operation

This chapter describes the general operation of the Jaguar motor control module. Figure 2-1 shows the key features of the Jaguar motor control. Table 2-1 provides a key to the status LED.

Figure 2-1. Jaguar Key Features
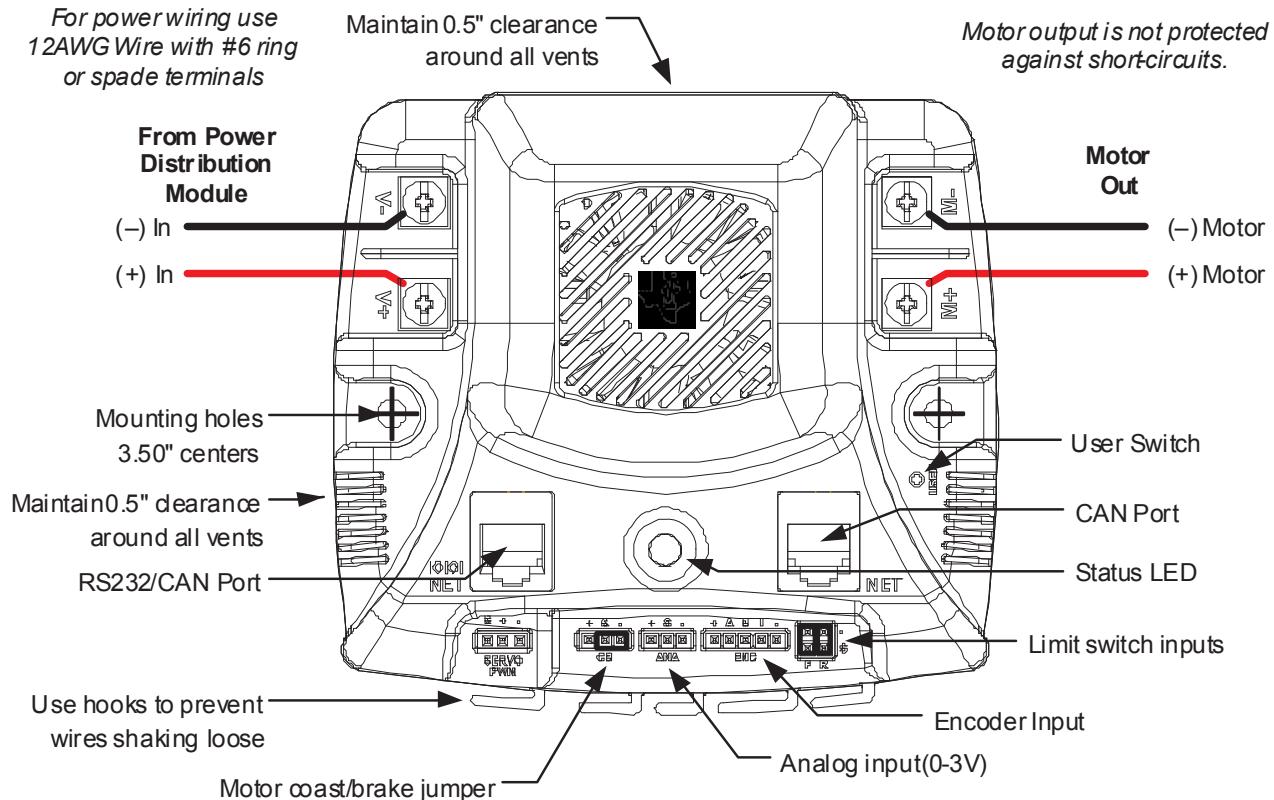
Table 2-2. Status LED

LED State	Module Status
Normal Operating Conditions	
Solid Yellow	Neutral (speed set to 0)
Fast Flashing Green	Forward
Fast Flashing Red	Reverse
Solid Green	Full-speed forward
Solid Red	Full-speed reverse
Fault Conditions	
Slow Flashing Yellow	Loss of servo or Network link
Fast Flashing Yellow	Invalid CAN ID
Slow Flashing Red	Voltage, Temperature, or Limit Switch fault condition
Slow Flashing Red and Yellow	Current fault condition

LED State	Module Status
Calibration Conditions	
Fast Flashing Red and Green	Calibration mode active
Fast Flashing Red and Yellow	Calibration mode failure
Slow Flashing Green and Yellow	Calibration mode success
Slow Flashing Red and Green	Calibration mode reset to factory default settings success
Other Conditions	
Slow Flashing Green	Waiting in CAN Assignment mode

Operating Modes

The Jaguar can be controlled using either the Servo-style PWM Input or the CAN interface. Table 2-3 compares the capabilities of each control method.

Table 2-4. Control Method Comparison

	Control Method	
	Servo-Style PWM input	CAN/RS232C Interface
Open-Loop Speed Control	Yes	Yes
Closed-Loop Speed Control	No	Yes
Analog Position Control	No	Yes
Encoder Position Control	No	Yes
Configurable Parameters	No	Yes
Voltage, Current Measurement	No	Yes
Automatic Output Ramp	Yes	Yes
Limit Switches	Yes[a]	Yes[b]
Coast/Brake Feature	Yes	Yes[b]
Firmware Update	No	Yes

a. Limit switch inputs are disabled when in Automatic Ramp mode.
b. By default, the jumper sets coast/brake. Network commands can over-ride the jumper setting.

Jaguar supports the simultaneous use of CAN for monitoring and the Servo-style input for speed.

Fault Conditions

A slow flashing Red LED indicates that the Jaguar detected one of the following fault conditions:

• Power supply under-voltage

• Over temperature

• Limit switch activated in the current direction of motion

A slow flashing Red and Yellow LED indicates the following fault condition:

• Over current

When a fault condition occurs, the motor shuts down and the LED indicates a fault state during the fault condition and for 3 seconds after the fault cause is cleared (except for the limit switch fault, which is cleared instantly). A slow flashing Yellow LED indicates that the Jaguar is not receiving a valid control signal. A fast flashing Orange LED indicates an invalid CAN ID.

Jaguar Motor Controller Getting Started Guide

Coast/Brake Jumper

The coast/brake signal controls the dynamics of the drive signal to the motor. When set to brake, the Jaguar is able to achieve greater deceleration and holding torque because it decays regenerative current from the motor. The coast/brake signal can be set with a jumper or controlled by a signal from a digital source. A single wire connected to the center (S) pin, is recommended. Do not connect to the + pin (+3.3 V) of this connector as any mis-wiring could damage the Jaguar.

The coast/brake jumper setting can be overwritten when using the CAN/RS232 interface.
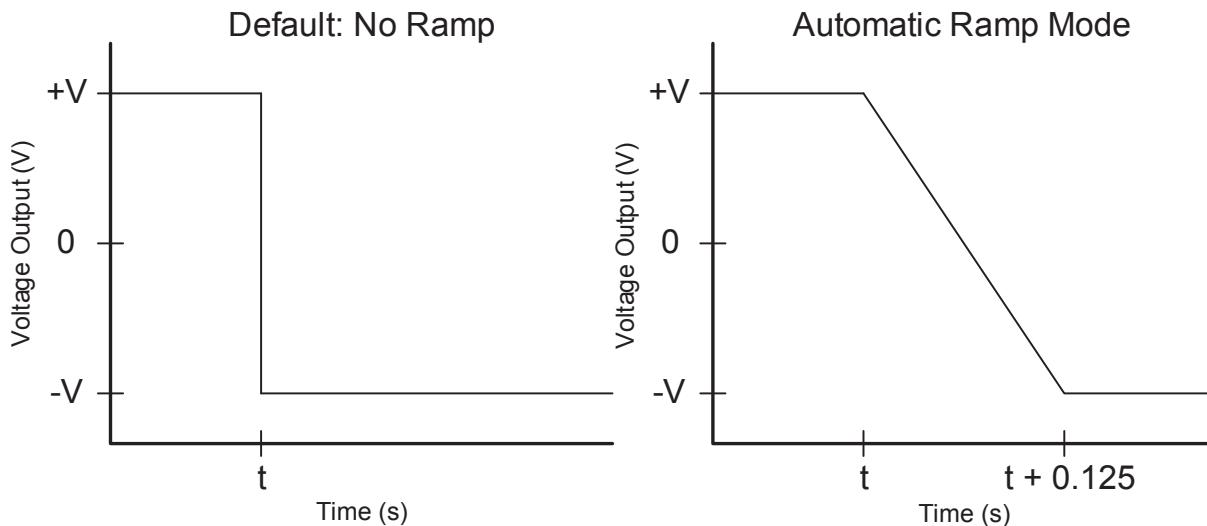
Power and Motor Wiring

The Overview diagram (Figure 2-1 on page 7) shows motor and power connections to the Jaguar. For power wiring, use 10-12 AWG wire terminated with #6 ring or spade terminals. The control is not protected against reverse polarity or short-circuits.

Automatic Ramp Mode

The Automatic Ramp mode, when activated, automatically ramps the output voltage to the motor at a preset ramp rate. This new feature is designed to reduce the current spikes associated with rapid direction changing. The preset ramp rate is set to 524 steps per millisecond. With 65,536 steps between full forward and full reverse, a 524 step/ms rate equates to a full-forward to full- reverse transition time of 0.125 seconds. See Figure 2-2 for an example.

Figure 2-2. Sample of Voltage Output with and without Ramp
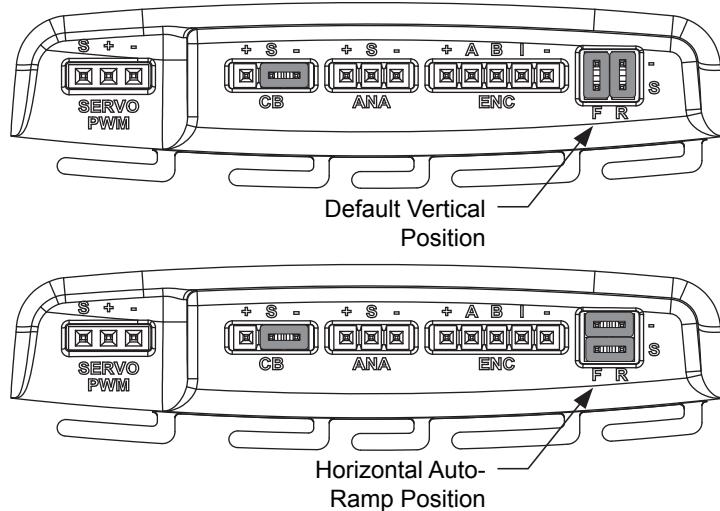
NOTE: At t, the user switches from full forward to full reverse.

Jaguar Motor Controller Getting Started Guide

The rate is set only once when the Jaguar is powered on. It can be changed, but only by CAN or Serial communication.

The Automatic Ramp mode is accessible regardless of the control mode being used; Servo PWM, CAN, or Serial. With the Jaguar powered off, turn the two jumpers on the limit switch inputs from their default vertical position, to a horizontal orientation (see Figure 2-3). Then, power on the MDL-BDC24.

Figure 2-3. Automatic Ramp Mode Jumper Positions

Default Vertical Position

Horizontal Auto-Ramp Position

The limit switch inputs are checked once on power-up for the horizontal jumpers. When detected, the Jaguar enables the automatic ramp and then ignores the limit switch inputs.

NOTE: When Automatic Ramp mode is enabled, the limit switch inputs cannot be used.
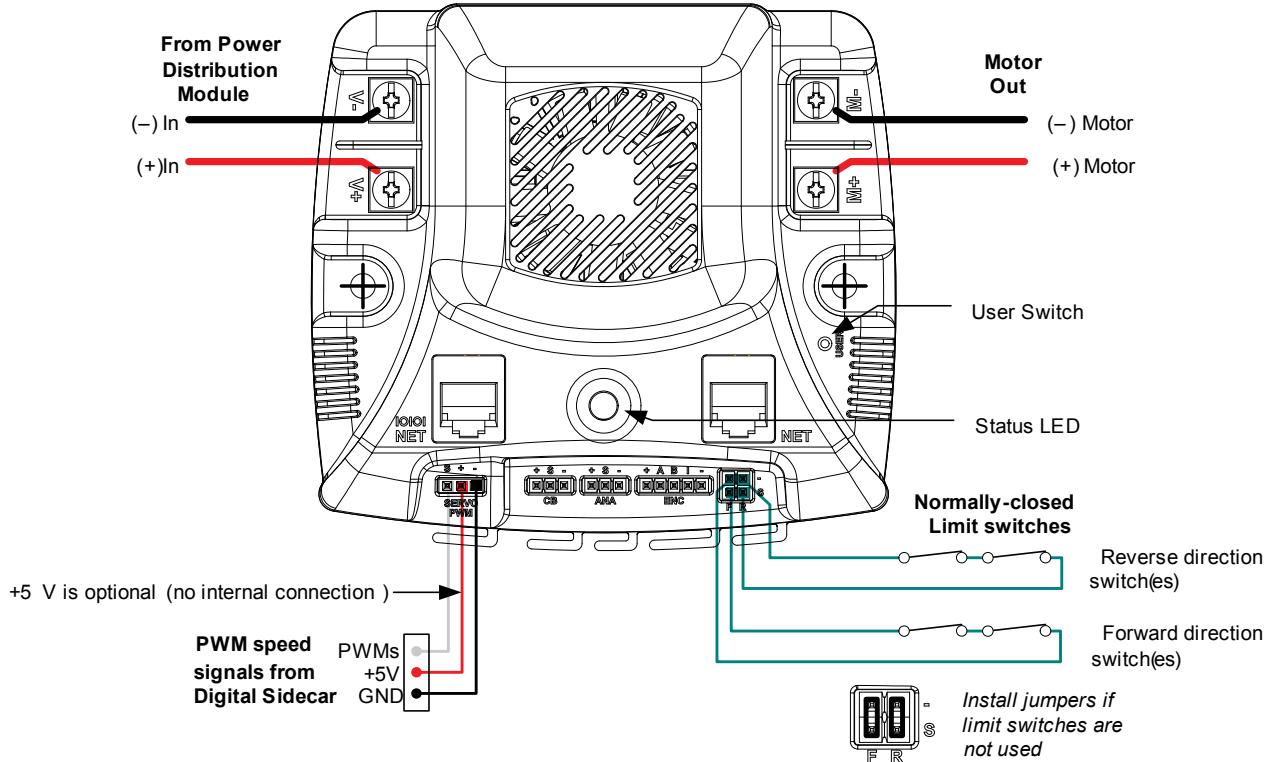
Disabling the Automatic Ramp mode requires the jumpers to be in their default vertical position and the Jaguar to be power cycled.

Chapter 3: Servo/PWM-based Control

The Jaguar supports open-loop speed and direction control through a servo-style PWM input. Figure 3-1 shows the servo-wiring details.

Figure 3-1. Wiring for Servo-style PWM Control

Servo-Style PWM Speed Control Input

The servo PWM input controls the open-loop motor speed and direction. The digital signal must meet the timing and voltage requirements listed in the Jaguar specifications. The center pin (+) has no internal connection. Because the signal is optically isolated, both the signal (S) and GND (-) pins must be connected to the signal source.

The servo-style PWM input is optically isolated. All other control inputs are non-isolated and are referenced to the power supply (-).

Calibrating the PWM Input

To accommodate variation in the timing of the supplied signal, Jaguar has a calibrate feature that sets new values for full-forward, full-reverse and points in between. Calibration is normally only required in applications where the PWM source has uncertainties due to analog radio links or other variables. Direct digital sources are unlikely to require calibration.

Jaguar Motor Controller Getting Started Guide

To calibrate the servo-style PWM input for a specific range, connect a PWM source, then:

1. Hold down the USER switch with a straightened paper clip for 5 seconds.
2. The LED flashes Red and Green to indicate Calibration mode.
3. Instruct the controller to send a full-forward signal for one or more seconds.
4. Instruct the controller to send a full-reverse signal for one or more seconds.
5. The LED flashes Green and Yellow quickly to indicate a successful calibration.

The Jaguar samples these signals and centers the speed range and neutral position between these limits. A calibration failure signals if an out-of-range signal is detected. This condition is indicated by flashing the LED Red and Yellow.

Chapter 4: Introduction to Network-Based Control

The jaguar supports CAN-based control, configuration and firmware updates. The Jaguar also supports the same command set over RS232.

Network Security and System Safety

The factory default network protocol allows for very flexible control networks with all commands being accepted and executed without restriction. However, a vulnerability is that faulty software has the potential to send errant messages. To address the possibility that motors could run when they are not supposed to, a special set of trusted commands have been added. This capability is supported in an FRC-specific firmware update. The Jaguar must have updated firmware if it is to be used with CAN or RS232 communication in an FRC competition.

Trusted Mode (FIRST Robotics Competition feature)

Each Jaguar module expects to see a trusted message from the Host every 100 ms. If a trusted message is not received, the Jaguar will shut down the motor output until trusted communication is restored.

Trusted communication relies on a proprietary protocol that defines a dynamic message token, known only to the host driver and a specific Jaguar.

Non-FIRST users should use the factory-default firmware (available in source form) which does not implement trusted communication.
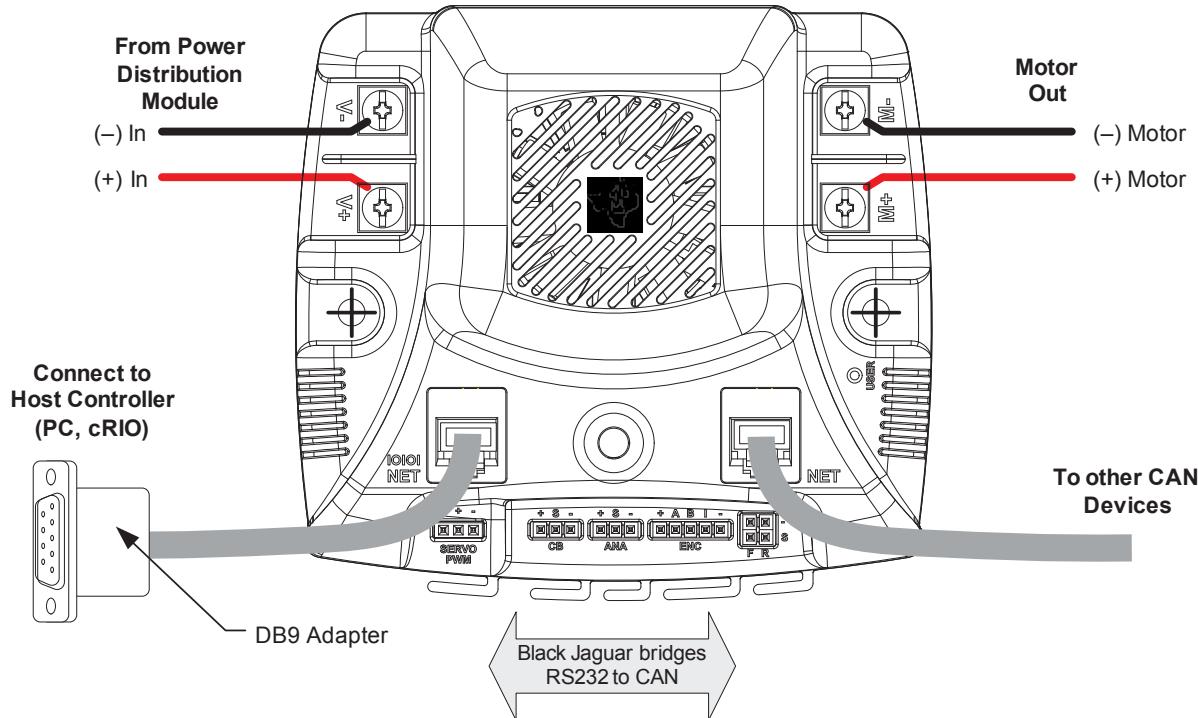
Chapter 5: Operation using the RS232 Interface

The Jaguar supports a full set of network control and configuration functions over a standard RS232C serial interface. The command protocol is essentially the same as the protocol used on the CAN interface allowing the Jag u a r to automatically bridge all commands between the RS232 and CAN interfaces.

RS232 signals are implemented on the left-side NET connector, which has a special IOIOI annotation as shown in Figure 5-1.

Figure 5-1. Jaguar Bridges for RS232 to CAN
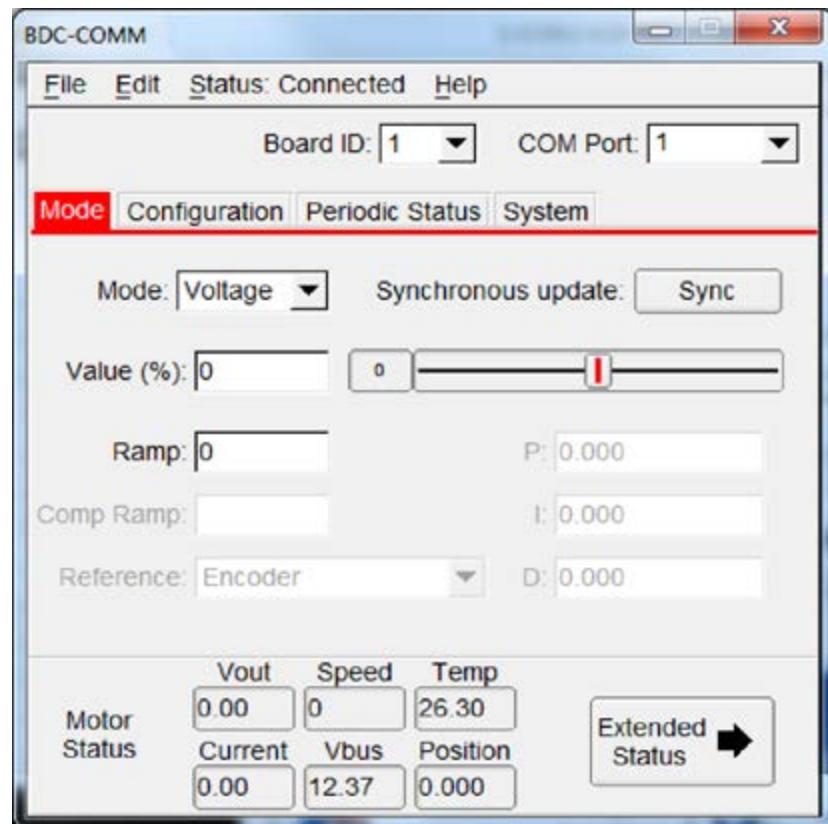
See Appendix A, "Jaguar Communication Cables," on page 23 for details of the RS232 cable assembly. The recommended DB9 adapter design contains an integrated CAN terminator.

BDC-COMM Application Overview

BDC-COMM is a Windows application for configuring and controlling a Jaguar network using a PC's RS232 serial port. It is also a convenient tool for performing firmware updates. BDC-COMM requires the use of an Jaguar to bridge RS232 to CAN. Figure 5-2 on page 15 shows the main GUI window of the BDC-COMM application. For more information on using the BDC-COMM application, see the ***BDC-COMM Application User's Guide***.

Figure 5-2. BDC-COMM GUI Main Window

Chapter 6: Firmware Update Using BDC-COMM

Firmware update capability allows VEX Robotics to provide new software, in binary format that contains feature enhancements and bug fixes.

Special firmware releases have been created for FRC 2013. This firmware update must be installed prior to using RS232 or CAN-based control. Firmware update is optional for Servo/PWM control.

Firmware update requires RS232 and CAN cables, at least one Jaguar, the binary file, a PC with an RS232 port, and a 12 V power source.

The **BDC-COMM** Application User's Guide contains additional detail on using the tool for firmware update as well as other configuration and control functions.

Important Information
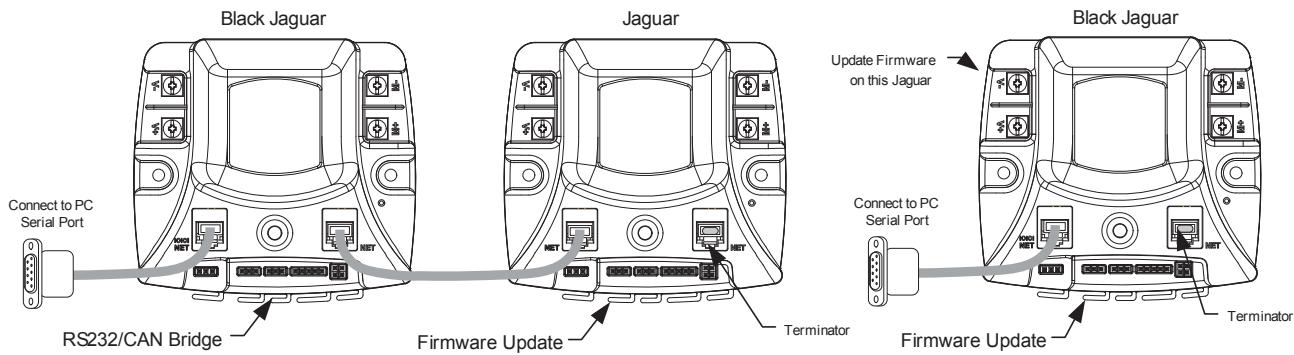
Observe the following precautions when updating firmware:

• We strongly recommend connecting only one Jaguar to the network at a time.
• Use the correct binary file.

Step 1: Hardware Setup

• Connect an Jaguar to a PC following the information in Chapter 5, "Operation using the RS232 Interface" on page 13.
• Apply power. The LED on the Jaguar(s) flash yellow indicating loss-of-link.

Figure 6-1. Valid Configurations for Firmware Update

Jaguar Motor Controller Getting Started Guide

Step 2: Run BDC-COMM

• Run BDC-COMM.EXE.

• The LED on the Jaguar(s) should now be solid yellow indicating a valid network link. If the LED is not solid yellow, check all network connections as well as the BDC-COMM Com Port setting.

• A valid link must be established before proceeding to the next step.

Step 3: Assign Unique CAN ID

• If two modules are connected, each must have a unique CAN ID. The factory default CAN ID is 1.

• Assign the Jaguar modules the ID > 1 so that new Jaguar modules from the factory do not operate on your robot.

• Using the BDC-COMM application, select the System tab and enter a new ID (a unique number from 2..63).

• Click "Assign." The LED on the module(s) starts flashing green.

• Press the USER button on the module that is to receive the new ID. This must be done within 5 seconds or the operation times out.

• The module's LED blinks the number of times that corresponds to the ID if assignment was successful (for example, if you assign the unique ID number of 5, the LED blinks five times).

• A fast-flashing yellow LED indicates an invalid CAN ID. This can occur if an attempt is made to reassign an ID that is already in use.

Step 4: Update Firmware

• A valid link must be established before proceeding. Ensure that the LED indicates solid yellow. It might be necessary to reconnect to the CAN network to synchronize the trusted link.

• Select the board ID that you want to update using the "Board ID" menu.

• Select File > Update Firmware from the top menu bar.

• Browse to locate the appropriate binary file:

• Click OK and then click Update.

• A progress bar displays the firmware update progress.

• When the firmware update completes, reconnect bdc-comm to the network to re-establish a link.

The System tab in BDC-COMM displays the firmware version.

Chapter 7: Closed-Loop Control Options

A network-controlled Jaguar supports several types of closed-loop control through an internal PID controller.

• Constant-current control

• Position control using an encoder

• Position control using a potentiometer

• Speed control

Only one mode can be used at a time.
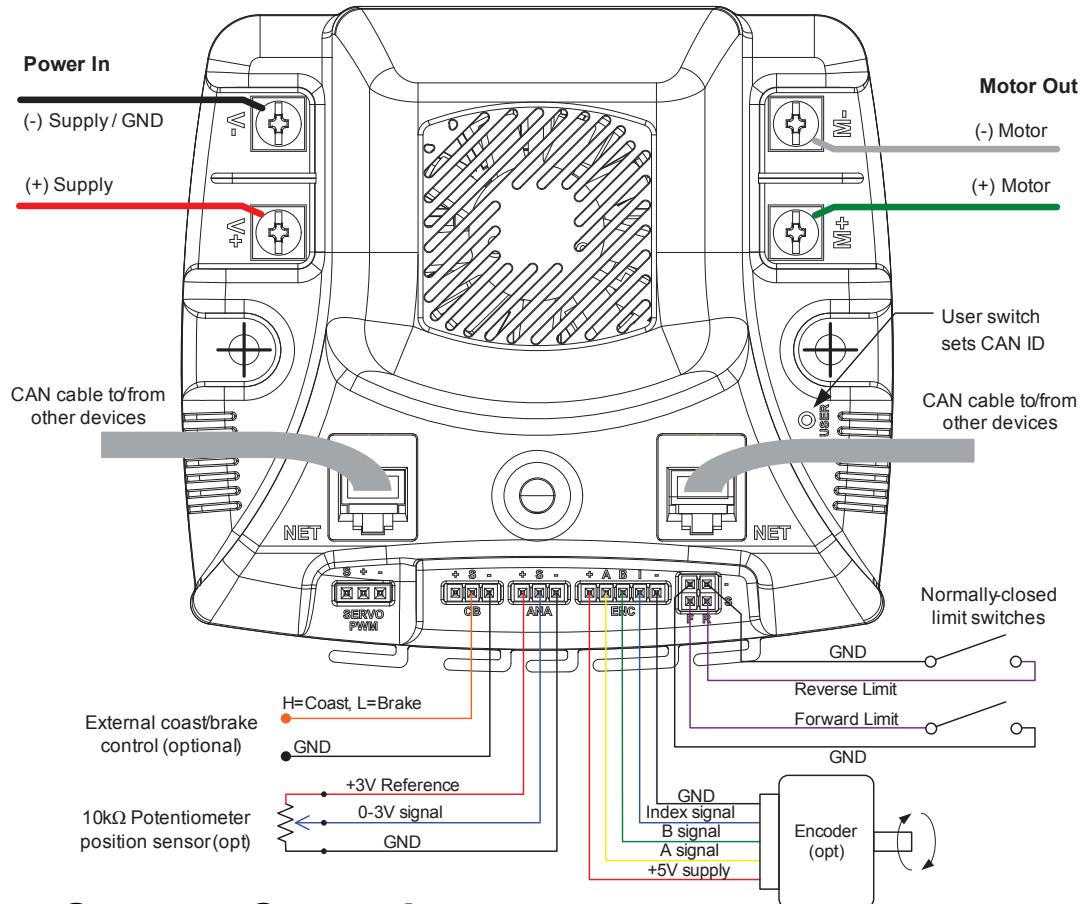
For each control mode, refer to API, VI, or tool documentation for information on which commands to use for configuration.

Wiring

All closed-loop mode, except for constant-current control, require an external sensor. Figure 7-1 shows an advanced wiring configuration using the CAN interface. The diagram shows wiring for position sensing using both a position potentiometer and a quadrature encoder. Although two sensor types are shown, the MDL-BDC software supports control and monitoring of only one sensor at a time.

Figure 7-1. Advanced Wiring Diagram

Constant Current Control

The Jaguar defaults to voltage control, but in some applications current (ampere) control is a more useful parameter. In this mode, the Jaguar's internal current sensor is used to complete a constant-current control loop. The capabilities of this mode are a function of the motor's parameters and the electrical specification for the module as listed in the data sheet. A small DC motor might not be suitable for use with the Jaguar's constant-current mode. No additional wiring is needed for constant current control.

Position Control using an Encoder

In position control mode, the Jaguar accepts position commands over the network, and then use an internal PID controller to autonomously move the motor to the specified position.

The QEI software position count changes on each pulse of the Encoder A input. For example, a 360° movement of a 100 pulse-per-revolution (PPR) encoder results in a 100-count change in the position value. PPR is sometimes referred to as the number of lines that an encoder has.

The relationship between the Encoder B input and the Encoder A input determines whether the position counter increments or decrements.

An edge on the Index ("I") input resets the position counter to zero.

The jaguar supports a wide range of shaft encoders. Encoder electrical parameters are detailed in the corresponding data sheets.

If the P, I and D parameters are positive (or zero), the Jaguar expects that a forward condition (+ voltage on White terminal, - voltage on Green) generates increasing counts on the encoder interface. Increasing counts occur when the rising (or falling) edge of the A input leads the rising (or falling) edge of the B input.

If the P, I and D parameters are negative (or zero), the Jaguar expect that a forward condition (+ voltage on White terminal, - voltage on Green) generates decreasing counts on the encoder interface. Decreasing counts occur when the rising (or falling) edge of the B input leads the rising (or falling) edge of the A input.

See Figure 7-1 on page 19 for wiring information. For reliable operation, keep encoder wiring short and route it away from noise sources. The encoder inputs are not electrically isolated.

Position Control Using a Potentiometer

Position control can also be implemented with a single or multi-turn potentiometer. Potentiometers with continuous rotation are not supported.

The Jaguar contains a built-in bias pin for use with 10 k potentiometers. If another potentiometer value or analog source is used, it must have a 0-3 V range.

If the P, I and D parameters are positive (or zero), Jaguar expects that a forward condition (+ voltage on White terminal, - voltage on Green) generates an increasing voltage on the analog input.

If the P, I and D parameters are positive (or zero), Jaguar expects that a forward condition (+ voltage on White terminal, - voltage on Green) generates a decreasing voltage on the analog input.

The analog input is not electrically isolated.

Speed Control

Speed control can be implemented with either an encoder or with a simple tachometer sensor. If a tachometer sensor is used (such as a gear-tooth sensor), then the signal should be connected to the Encoder 'A' input signal, with the 'B' and 'I' input left unconnected.

The speed set-point is defined in revolutions per second. Adjust the encoder-lines parameter if the sensor generates more than one pulse per revolution.

Chapter 8: Operation Using the CAN Interface

Controller Area Network (CAN) provides a powerful interface for controlling one or more Jaguar modules. Jaguar has a 6P6C socket and a 6P4C socket for daisy-chaining modules using standard cables. Each end of the CAN network should be terminated with a 100 resistor.

The CAN protocol used by Jaguar includes the following capabilities:

• Firmware update over CAN

• Read supply voltage, motor voltage, temperature and current

• Set and read motor voltage or target position

• Set control mode to speed or position

• Configure parameters

• Enable features such as closed-loop speed and position control.

• Trusted communication with keep-alive commands for fail-safe operation

CAN IDs

Each Jaguar on the CAN bus is accessed using an assigned ID number. The ID defaults to 1, but should be changed to a unique value from 2 to 63 by following the ID Assignment procedure. The procedure is detailed in Step 3 of the firmware update procedure in Chapter 6, "Firmware Update Using BDC-COMM", page 17.

At the network protocol level, ID assignment involves the following:
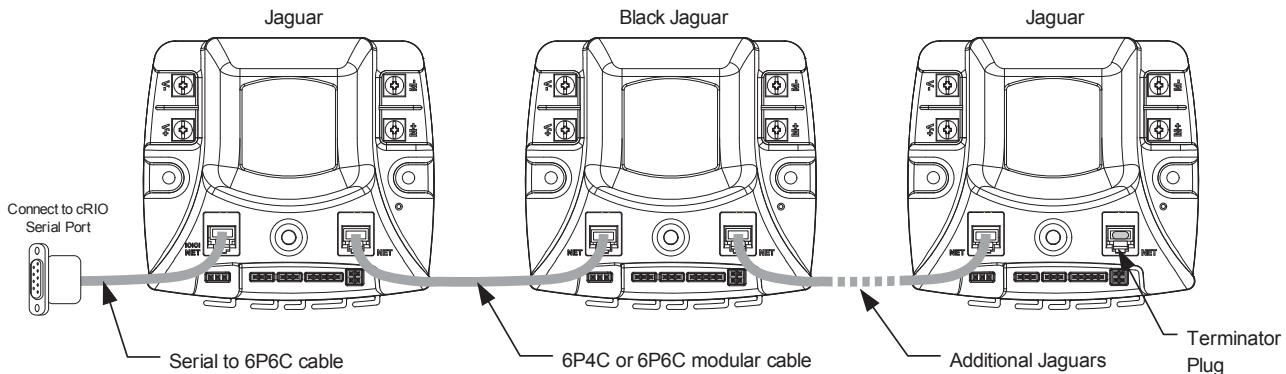
1. The Host sends Assign ID + number command to all Jaguar modules.
2. Pressing the USER switch on a Jaguar informs that particular module to accept the previously specified ID number and save it to non-volatile memory. The operation times out if a switch is not pressed within 5 seconds.
3. The Jaguar with the new ID assignment sends out a message to let all Jaguar modules know that the ID assignment is complete. Normal operation resumes.

CAN Network

A CAN network consists of one or more Jaguar modules, an interface or bridge, and a host controller. Figure 8-1 shows a typical configuration.

Jaguar Motor Controller Getting Started Guide

Figure 8-1. CAN Network Topology

CAN cabling follows a daisy-chained topology using modular cable. Table 8-1 lists network parameters.

Table 8-1. CAN Wiring Parameters

Parameter	Value	Notes
Maximum Nodes	16	A node is defined as a device on the CAN network. This includes all Jaguar modules and any device that sends and receives CAN messages. If you use the Black Jaguar as a bridge, all Jaguar modules (gray or black, including the Bridge) count as nodes, but the computer (or CRIO) does not since it is sending messages over the serial port.
Total Cable Length (maximum)	20 ft / 6.1m	Tip: Start with this length of bulk cable and cut all segments from it to ensure compliance.
Termination Resistance	100	At each end of the network.
Cable Type	4 or 6 conductor modular cable. 28 or 26 AWG.	

See Appendix A, "Jaguar Communication Cables," on page 22 for cable and terminator assembly instructions.

Control Options for Networked Jaguar Modules

The Host controller on a Jaguar network requires a software driver to implement the CAN communication protocol. Protocol details are available from the Jaguar pages at www.vexrobotics.com/vexpro.

The following Host tools/APIs/Virtual Instruments are available:

• BDC-COMM is a Windows application for configuring, testing, and performing firmware upgrades.

• LabView VI

• Java API

• C++ API
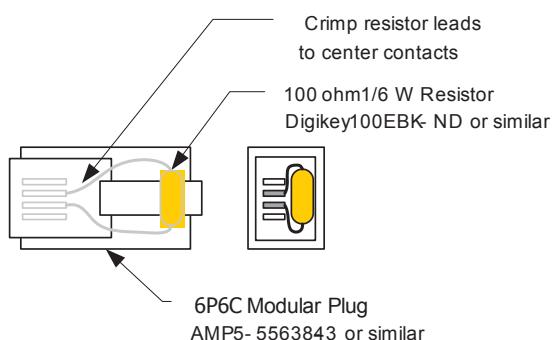
Appendix A: Jaguar Communication Cables

CAN Terminator

Because the CAN signals operate at high bit rates (1 MBPS), a terminator is required at each end of the network. A simple network might work with a single terminator, but this is not recommended for normal use. The termination resistor is also important for returning the CAN signaling levels to the recessive state when no nodes are transmitting. Figure A-1 shows the recommended terminator construction.

**Figure A-1. CAN Terminator Plug**
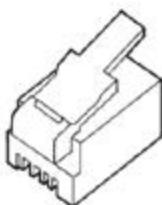
CAN Cable
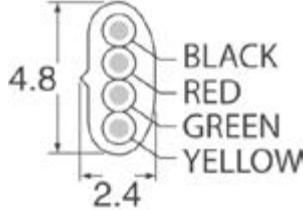
Use CAN cables to daisy-chain the network between Jaguar modules. Standard off-the-shelf modular 6P6C cables can be used. Cables must be "straight-pinned," which means Pin 1 > 1, Pin 2 > 2, and so on. This is also referred to as a reverse-cable because the tabs on the connectors are on the opposite sides of the cable. The CAN cable needs only 4 conductors, but it is acceptable to use a 6-conductor cable and plugs. A suitable 6-ft off-the-shelf 6P4C cable is Digikey Stock No. A2662R-07-ND.

Figure A-2 shows the materials needed to build custom-length CAN cables. Apart from a modular plug crimp tool, no special tools are required.
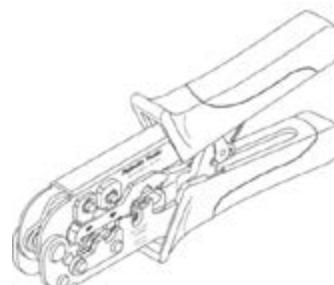
Figure A-2. Materials Needed to Assemble Custom-Length 6P4C Cable

Modular plug for stranded flat - oval cable
AMP P/No. 5-641335
Digikey Stock No. A9092-ND

Modular cable – 4 conductor
Assmann Elect. AT-K-26-4-S/100-R
Digikey Stock No. A0043R-100-ND

Modular cable – 4 conductor
Assmann Elect. AT-K-26-4-S/100-R
Digikey Stock No. A0043R-100-ND
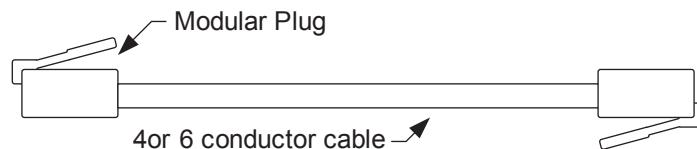
CAN Cable Assembly

Follow these steps to complete cable assembly (shown in Figure A-3):
1. Cut modular cable to length
2. Use the crimp to strip the outer jacket from each end of the cable.
3. Insert wires into the modular plug and load into crimper.
4. Close crimper to complete the connections and secure the cable.

Figure A-3. Completed Cable Assembly

Modular Plug

4or 6 conductor cable

CAN Cable Pin Assignments

Plug	Wire Color	Jaguar Use
1	Black	-
2	Red	CAN H
3	Green	CAN L
4	Yellow	GND

RS232 Cable

Figure A-4 shows the materials needed to build the RS232 cable. Apart from a soldering-iron, no special tools are required.

Figure A-4. Materials Needed to Assemble RS232 Cable Components

Resistor 100Ω 1%
panasonic ERO-S2PHF1200
Digikey Stock No. P100CACT-ND

Heatshrink Tubing 1/8" diameter
Digikey Stock No. Q2F018B-ND

Modular adapter
6P6C to DB-9 Female
CUI P/No AMK-0003
Digikey Stock No. 046-0003-ND

Modular cord
6 contact 6 conductor, reversed
Assman Elect. AT-S-26-6/B-7/R-R
Digikey Stock No. 046-0003-ND

RS232 Cable Assembly

Follow these steps to complete cable assembly (shown in Figure A-4):

1. Take the Modular Adapter and cut the black wire as short as possible. This wire is unused.
2. Cut off the terminals on the Red and Green wires. Strip then solder the Red and Green wires to the 100 resistor. Use a section of heat shrink to protect the resistor and solder connections.
3. Insert remaining terminals into the DB9 receptacle. Pin numbers are indicated on the plastic connector body.
   – White/Pin 3
   – Blue/Pin 2
   – Yellow/Pin 5
4. Slide the back-shell over the connector, then insert the modular cable to complete the assembly.

RS232 Cable Pin Assignments

6P6C	Wire Color	Jaguar Use	PC Use	DB9 Pin
1	White	RXD	TXD	3
2	Black	-	-	-
3	Red	CAN H	-	-
4	Green	CAN L	-	-
5	Yellow	GND	GND	5
6	Blue	TXD	RXD	2

External References

The following references are also useful for working with the Jaguar:

• The *Jaguar Data Sheet* contains detailed electrical specifications and connector details.

• The *Jaguar User's Guide* provides instructions on how to use the BDC-COMM GUI and command line applications to control Jaguar networks.

• *Jaguar FAQ*