You Can do CAN: CAN Bus on a Budget

A 2011 hardware guide on making CAN bus possible for under $50

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One of the new technologies available to FIRST teams this year, 2011, is CAN bus. CAN bus is an alternative to PWM for wiring Jaguar speed controllers. CAN capabilities have been present since 2009 and legal for use since 2010. But in 2011, the bulk of the required hardware comes out of the box. For my team, 2783, this provided an incentive to give the technology a spin. This document is a collection of what we found works on the hardware end of things.

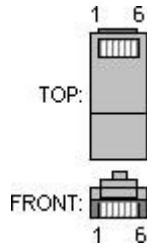
CAN bus has many advantages over PWM. PWM is a point to point connection, while CAN is a bus. Anybody who has done PWM wiring will tell you how confusing masses of PWM wires can be; CAN only requires one wire to the cRIO and from there, it is a daisy-chain of jaguars. In addition, with CAN, Jaguars can be wired in any order (with one exception, explained later). CAN strings can also be tested by way of a computer, making troubleshooting even less of a challenge. CAN bus uses 6 and 4 wire oval cable, which is generally more durable than wire used in PWM wiring. In addition, the RJ-12 plugs used by CAN bus have a locking clip, while PWM plugs do not have any lock.

CAN bus currently has two legal implementations. The first one is the Cross the Road Electronics 2CAN adapter. It provides the full, 1 Mbit, connection in an easy to wire format. However, it has a major drawback; it costs nearly $200. For teams on a budget like my own, this cost reduces the gain by using CAN. Luckily, there is a second option; the Texas Instruments MDL-BDC24, more commonly known as the “black” jaguar. In 2011, they come as part of the Kit of parts, making CAN bus an even more attractive technology to FIRST teams.

To use the black jaguar for CAN, you first need to buy some things, most of which my team found at low prices at monoprice.com. You will need: (monoprice.com product codes in **Bold)**

- some RJ-12 (6P6C) plugs **7270** and 6 wire cable **943**
- either more RJ-12 plugs/cable or RJ-11 (6P4C) Plugs and 4 wire cable
- a 6P crimping tool **7035**
- female DB9 to RJ-12 adapters **1150** and a pin pusher **2884** OR the serial cable from the 2009 KOP
- 100Ω resistors
- a computer with Microsoft Windows and a serial port (or usb to serial adapter) **2276**
- an unbent paperclip

The first thing you need to do is make the serial to rj-12 adapter and a terminator. For this, refer to the following charts and diagrams:



(from pinouts.ru)

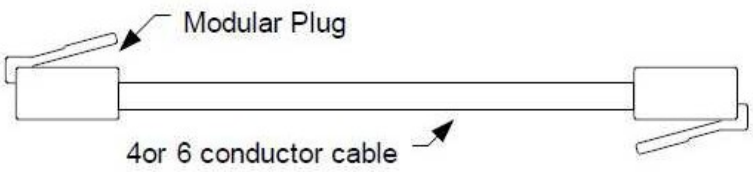
rj-12 (serial)	serial pin	serial cable color	gray adapter color	terminator
1	3	orange	blue	NC
2	NC	NC	NC	
3	100Ω		green	100Ω
4	100Ω		red	100Ω
5	5	green	black	NC
6	2	red	white	

For the serial cable, you will want to have at least two, as they are used both to connect to the cRIO and to connect the Jaguars to your computer. There are two ways to make a the cables. The first and best way is to use a DB9 to RJ12 adapter. The ones from monoprice.com have a backwards from normal pinout, which the chart above reflects. To make the adapter, use the copper end of the pin pusher to insert the blue wire into pin 3 of the serial (they are marked on the adapter), black to pin 5, and white to pin 2. then, snip the pins off the red and green wires and solder between them a 100Ω resistor. The yellow wire can be snipped and left to hang.

However, if you are inpatient like I was waiting for the parts to come in and you have the white serial cable from the 2009 KOP, two 100Ω resistors and a RJ-12 cable, you can make two cables out of that. To do so, cut the serial cable. You will only need the orange, green, and red cables. Also, snip the 6 connector cable so about 1-3” is past the plug. The middle two wires (3 and 4) get the 100Ω resistor, pin 1 goes to orange, pin five to green, and pin 6 to red. Be sure to tape or heat shrink all 5 solder joints.

You also need to make a terminator, preferably two or more. All it is is an RJ12/11 plug with the middle two pins connected by a 100Ω resistor. The way that TI recommends to make the terminator is to crimp a resistor straight to the plug. However, the way I find works best is to crimp in two wires to the plug (or use a snipped off two wire phone cord) and solder the resistor to those. Again, electrical tape or heat shrink is your friend.

Last, you need to make your CAN wires. They are four or six wire cables with an RJ-12/11 on each end. It is a “through cable”; pin 1 goes to pin 1 and so on. Four wire cords are not, so if you recycle a few ones with broken clips, be sure you cut them and crimp you own plugs on them. You will also find that when properly made, if you hold the cable without twisting it, one plug will be upside down:



(from the black jaguar manual)

The next step is to prepare the jaguars for use. You will need to go to luminary micro's jaguar homepage and download the BDC-COMM program and the jaguar firmware. Then, you will connect the serial adapter to the the left CAN jack on a black jaguar. Plug a terminator into the other jack. Power the jaguar (an old Buss 2008 power board with a battery leads is a good choice). Connect the serial cable to the computer, and run the program. In the board ID box, you should see a number; if not, then your cable/terminator is bad or your COM port is set wrong.

In the program, go to file and then update firmware. In the dialog box, hit the "..." button and find where you extracted the firmware. Be sure you get the right firmware; there is a black jaguar file and a gray jaguar file. Then select update.

In the program, you also need to reset the ID of the jaguar. All Jaguars come with an ID of 1, so to make a chain work, you need to change the ID. To do so, take an unbent paperclip and insert it into the "user switch" on the jaguar, located on the right side, below the right mounting hole. In the program, go to the system tab and in the "new board ID" box, enter the new ID (2-63) and select assign. Within 5 seconds, push the user button with the paperclip.

You need to do this with all jaguars. The black ones use the same process as above; the gray ones use the same but with a black jaguar connected (and powered) and a CAN cable connecting the black jaguar to the gray jaguar and a terminator on the unused port of the gray jaguar (be sure to use the gray jaguar firmware!). You also should somehow mark the ID on the jaguar (little numbered stickers helps).

You can also test your string with the program as well. That's what the "mode" tab is for. You can use the slider to change the voltage being sent by the jaguar. You can even test more than one jaguar at once. All of the limit switch, potentiometer, and encoder inputs and the voltage and temperature on the jaguar can be monitored from this tab as well.

Before you can wire all of your jaguars on the robot, you need to do a couple things to the cRIO. First, you need to update the firmware on the cRIO and when doing so, select the black jaguar option (this installs the necessary driver on the cRIO). After doing that, the "CONSOLE OUPUT" DIP switch needs to be switched to off on the cRIO.

Finally, the wiring on you robot can be done. You can be very flexible on your wiring order as long as the first jaguar is a black one and you connect the serial adapter from the cRIO to the first black jaguar's left port. From there, either port is fair game for in/out, and you order can be whatever you want. Be sure to put a terminator on the last jaguar's unused port.

A last note to the programmers: Whatever language you are using, you need to modify your code to use CAN. The things you will need are at the FIRST forge.

Good luck to all who are reading this document with you decision to use CAN bus on your robot. You will probably enjoy the experience.