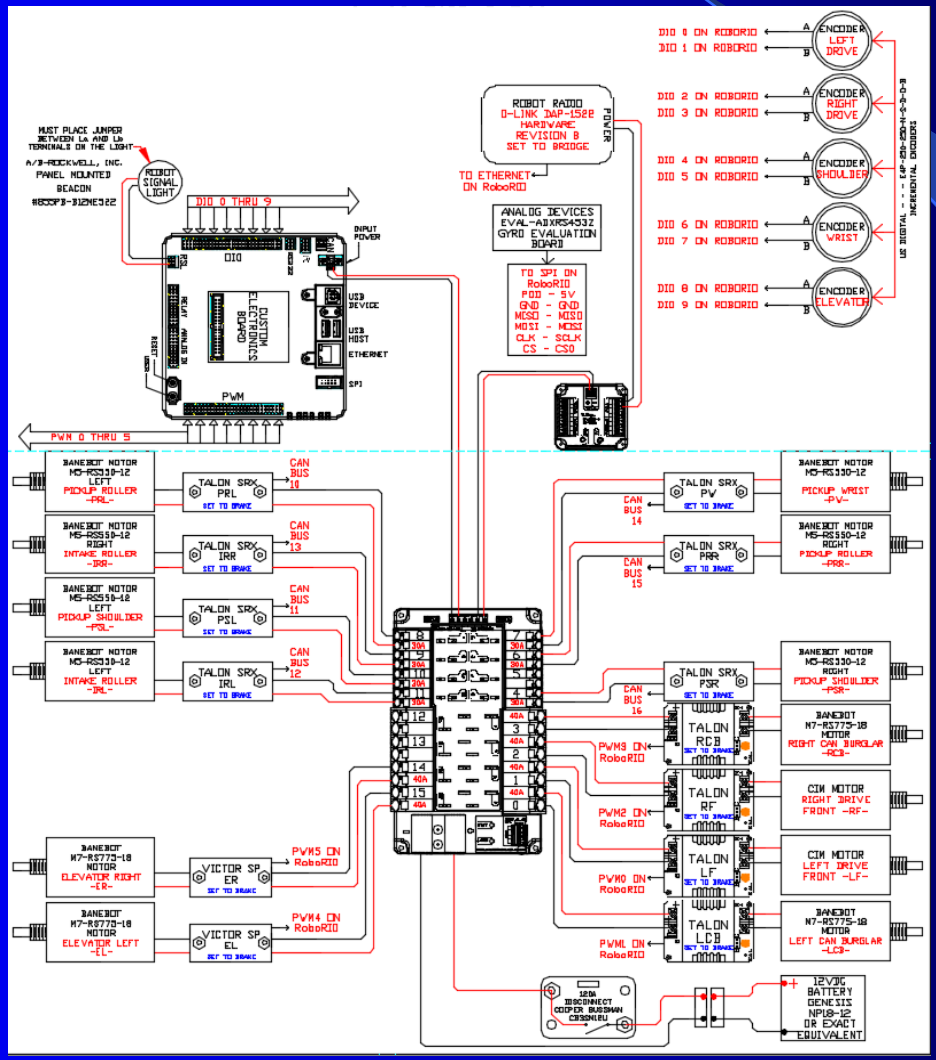
2015
Electrical Design and Wiring for FIRST Robotics Competition

Information Presented by:

- Spenser Adams – Team #67 Electrical Mentor/Teacher
- Lee Arms – Team #67 Electrical Mentor
- Gina Sweet – Team #67 Electrical Mentor
- Russ Sweet – Team #67 Electrical Mentor

Robot Schematic Document When Wiring a Team 67 Robot



Programming Assignment Sheet to Inform Code Writers about Team 67's Robot Wiring

Motor Type	Motor Assignment	PD Circuit Breaker	Controller Type	Controller Name	RoboRIO Connection	Comments	Coast/Brake
CIM	Left Drive-Front	40 Amp (PDP01)	Talon SR	LF	PWM 0	MOTOR LF	Brake
M7-RS775-18	Left Can Burglar	40 Amp (PDP00)	Talon SR	LCB	PWM 1	MOTOR LCB	Brake
CIM	Right Drive-Front	40 Amp (PDP02)	Talon SR	RF	PWM 2	MOTOR RF	Brake
M7-RS775-18	Right Can Burglar	40 Amp (PDP03)	Talon SR	RCB	PWM 3	MOTOR RCB	Brake
M7-RS775-18	Elevator - Left	40 Amp (PDP15)	Victor SP	EL	PWM 4	MOTOR EL	Brake
M7-RS775-18	Elevator - Right	40 Amp (PDP14)	Victor SP	ER	PWM 5	MOTOR ER	Brake
M5-RS550-12	Pickup Shoulder - Left	30 Amp (PDP10)	Talon SRX	PSL	CAN BUS 11	MOTOR PSL	Brake
M5-RS550-12	Pickup Shoulder - Right	30 Amp (PDP04)	Talon SRX	PSR	CAN BUS 16	MOTOR PSR	Brake
M5-RS550-12	Pickup Wrist	30 Amp (PDP07)	Talon SRX	PW	CAN BUS 14	MOTOR PW	Brake
M5-RS550-12	Pickup Roller - Left	30 Amp (PDP08)	Talon SRX	PRL	CAN BUS 10	MOTOR PRL	Brake
M5-RS550-12	Pickup Roller - Right	30 Amp (PDP06)	Talon SRX	PRR	CAN BUS 15	MOTOR PRR	Brake
M5-RS550-12	Intake Roller - Left	30 Amp (PDP11)	Talon SRX	IRL	CAN BUS 12	MOTOR IRL	Brake
M5-RS550-12	Intake Roller - Right	30 Amp (PDP09)	Talon SRX	IRR	CAN BUS 13	MOTOR IRR	Brake

Digital Input	Feedback Data	RoboRIO DIO Connection
Encoder Out A	Left Side Drive	D0
Encoder Out B	Left Side Drive	D1
Encoder Out A	Right Side Drive	D2
Encoder Out B	Right Side Drive	D3
Encoder Out A	Shoulder	D4
Encoder Out B	Shoulder	D5
Encoder Out A	Wrist	D6
Encoder Out B	Wrist	D7
Encoder Out A	Elevator	D8
Encoder Out B	Elevator	D9

Analog Input	Feedback Data	RoboRIO AIO Connection
Potentiomer AI0	Left Side Can Burglar	AI0
Potentiomer AI1	Right Side Can Burglar	AI1

Miscellaneous	Power Input	Comments
RoboRIO Power	[V] & [C] input connections	from dedicated Controller power on Power Distribution Panel
Voltage Regulator Module	12V IN	from dedicated VRM power on Power Distribution Panel
Robot Radio	from Voltage Regulator Module (VRM)	connected to 5V @ 2A connections
		signal connection to RoboRio Ethernet connection
Robot Signal Light	RSL Connection on RoboRIO	La to Lb jumper installed for steady operation
Gyro Evaluation Board	This is wired to the MXP port on the RoboRIO	

Connection Notes:
PWM 0 through PWM 5 in PWM Connections on the RoboRIO
CAN BUS from RoboRIO, ended on Power distribution Board with Termination "ON"
D 0 through D 9 in DIO Connections on the RoboRIO

Update - Revision Notes
Notes for4/7/2015 items:
Added Left & Right Side Can Burglar Motor
Added Left & Right Side Can Burglar Motor Potentiometers
Added Gyro Evaluation Board
Removed the Left & Right Side Bun Extension Motors

Warning!

Never, Never, wire with power applied!

- -

Always make sure that the positive and negative power leads are wired correctly!

(Have another person check that they are correct)

- -

Always make sure that the control cables (PWMs, etc.) are connected correctly!

(Have another person check that they are correct)

Electronic Standards used by Team #67
Wire Color and Dress

- Red wires are positive DC voltage
- Black wires are negative DC voltage
- Chassis must not be used as a conductor
- Install electrical and control wiring so that it is ***laid out logically*** and contained with jacketing, tie wraps, spiral tubing, shrink tubing or lacing cord
- Protect your electrical control system from other robots

NOTE: FIRST allows other colors of wires to be used – The listed standard is that used by Team #67

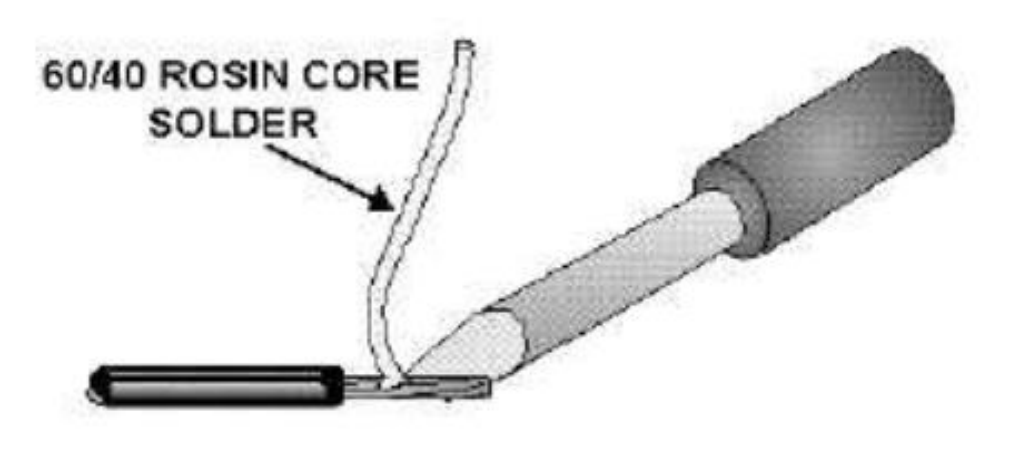
Electronic Standards used by Team #67 Wire Gauge and Type

Use only stranded wire with a high strand count for flexibility

- Use 6 AWG wire for battery and main disconnect breaker power
- Use 12 AWG wire for all motor power
- Use 18 AWG wire for all other power wiring except:
  - Use premade standard RC PWM cables for motor control
  - Use premade cables for items like the Wireless Radio, Robot Signal Light or purchased CAN bus cables
  - Self-made CAN bus cable is 20AWG wire (Low-Green and High-Yellow)
- All stranded wires should be tinned. See the next slide.
  - Tin a wire by applying the tip of a heated, cleaned and primed soldering iron to the stripped wire for a short time and then apply a small amount of 60/40 rosin core solder to the wire. Solder flows into the wire to fill the wire with solder.

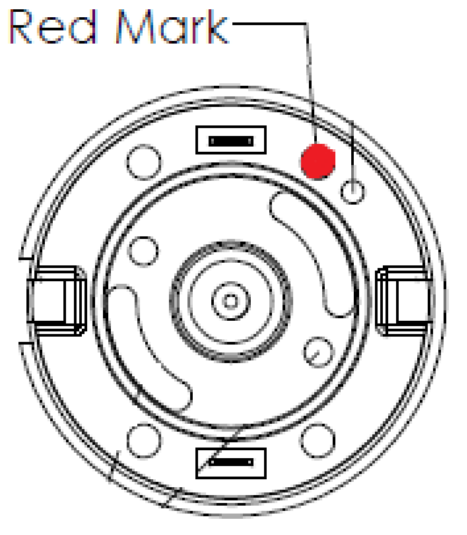
NOTE: FIRST allows other wire sizes to be used and does not require the wires to be tinned – The listed standard is that used by Team #67

How to Tin Stranded Wire



- Strip the wire to the desired length.
- Heat the soldering iron to the heat level needed for the wire size. Larger wires require a hotter soldering iron to complete the tinning process.
- Make sure that the tip of the soldering iron is clean and pre-tinned.
- Hold the soldering iron tip and solder together on the wire until a very small amount of solder begins to flow.
- Move the soldering iron to the opposite side of the wire and flow a small amount of the solder into the strands of wire until half of the exposed length of the conductor is covered.

Team #67
Motor Wiring



- All motors, with the exception of servo motors, are wired with terminals/connectors from the Anderson PowerPole PP15/45 product line
  - Red 12 AWG Wire to Red Connector
  - Black 12 AWG Wire to Black Connector
- Some motors have a red and black wire connected directly to the internal connections
- Some motors have a red mark near an external terminal that is connected to the internal connections
  - Connect a 12 AWG red wire to this terminal
  - Connect the 12 AWG black wire to the other terminal

2015 FRC POWER SYSTEM

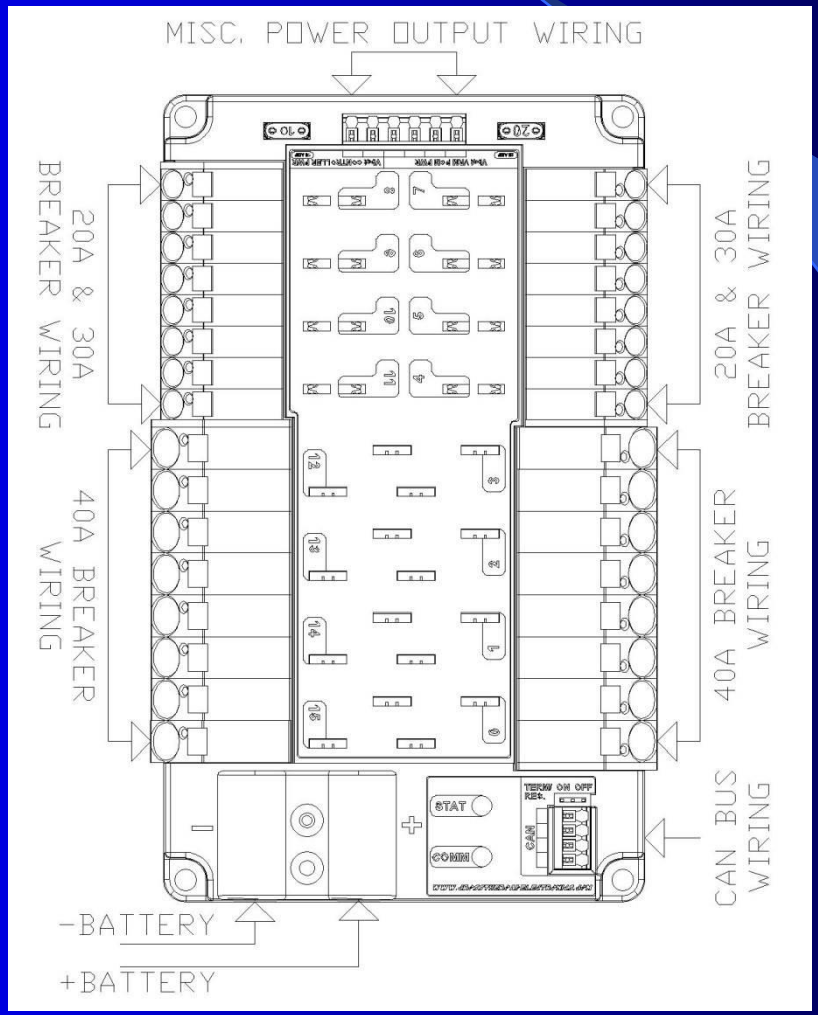
Power System Components

Cooper Bussmann
CB185-120
Main Disconnect
120A Circuit Breaker

Anderson
SB50 (Red)
Power Connector

Yuasa
NP18-12B
Battery

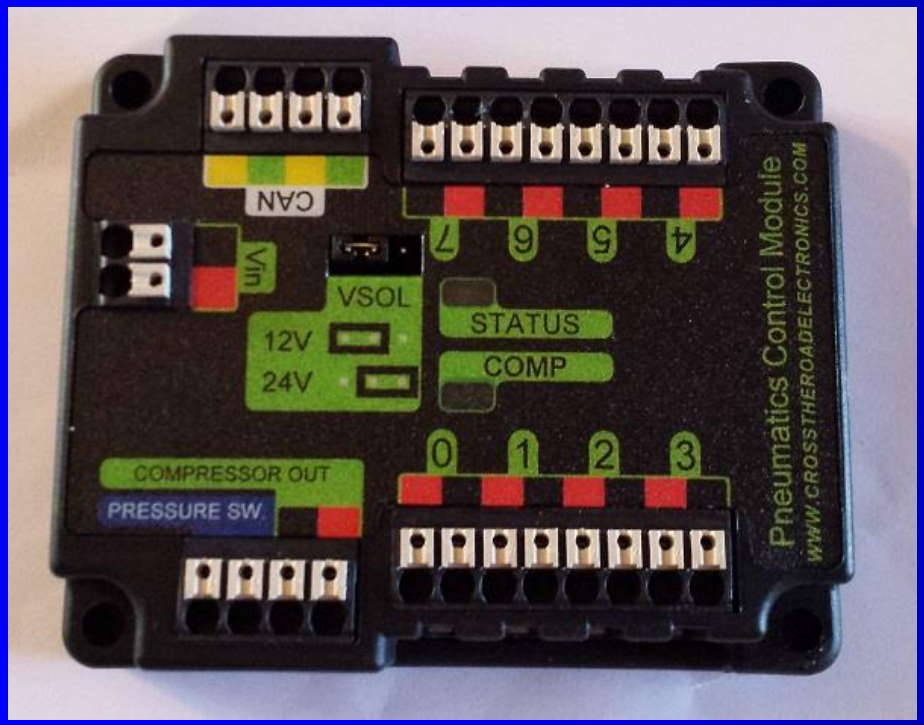
Power Distribution Panel from Cross the Road Electronics



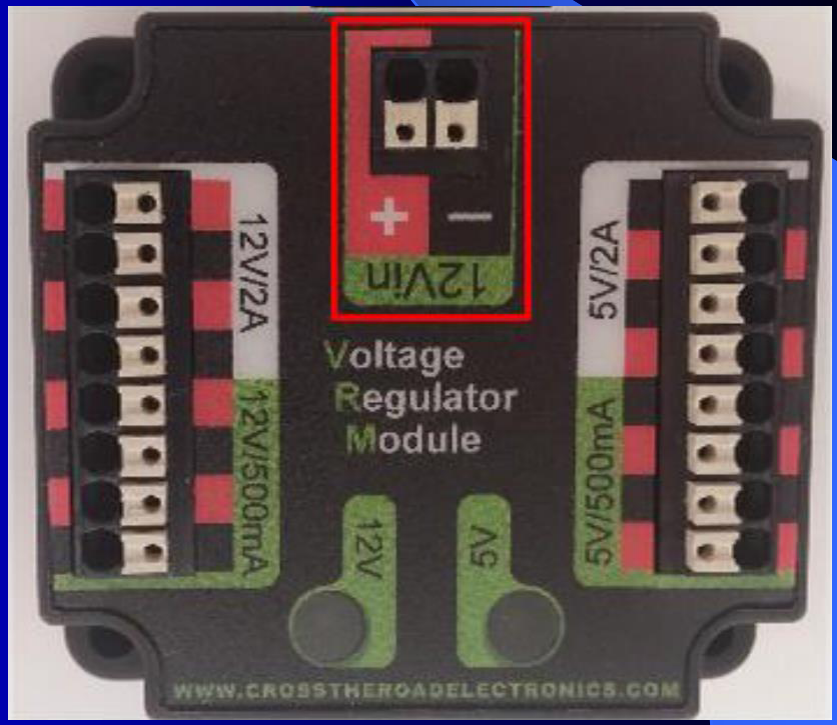
Circuit Breakers

Interface Modules from Cross the Road Electronics

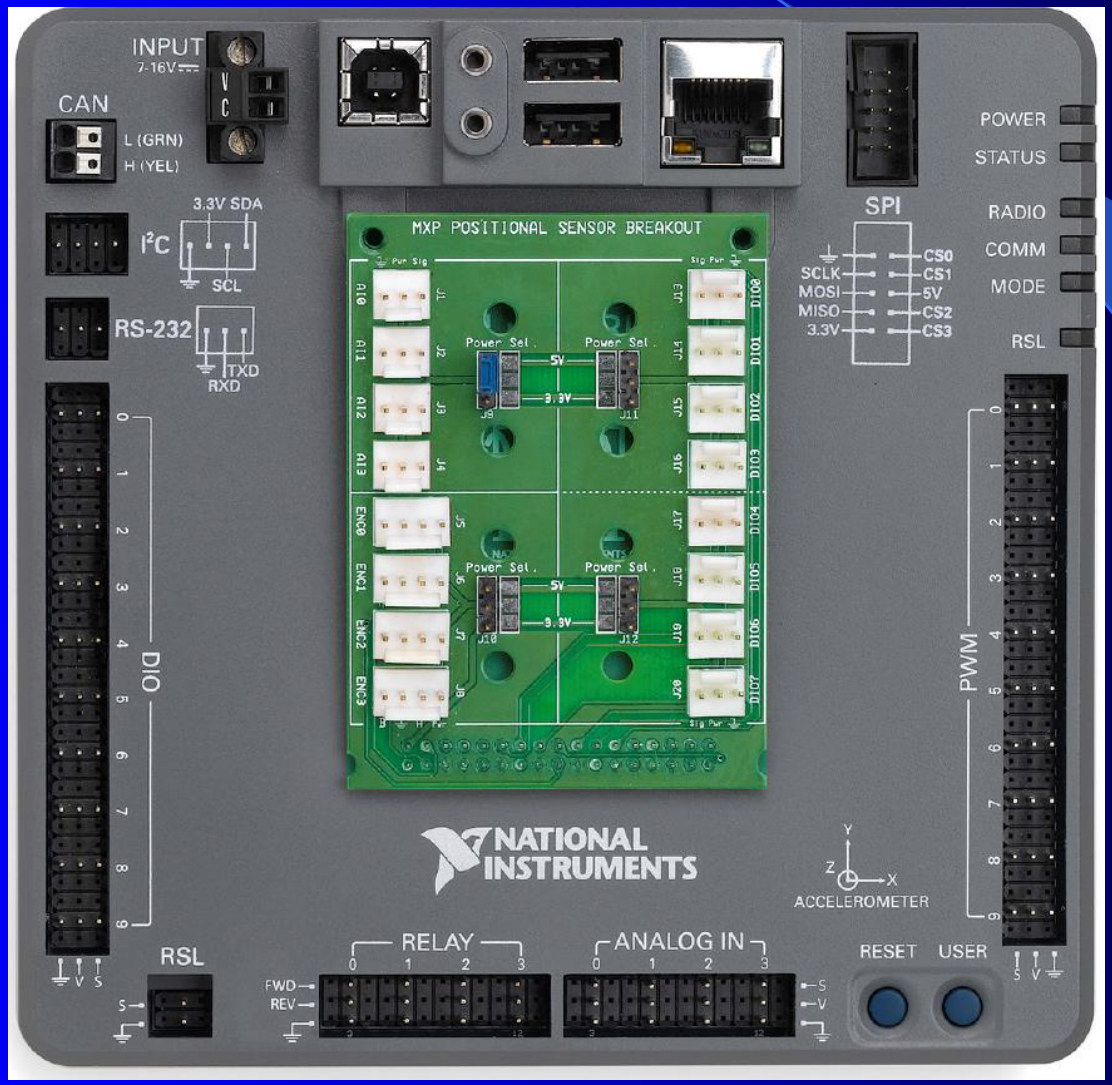
Pneumatics Control Module



Voltage Regulator Module



National Instruments RoboRIO Controller with MXP Expansion Board



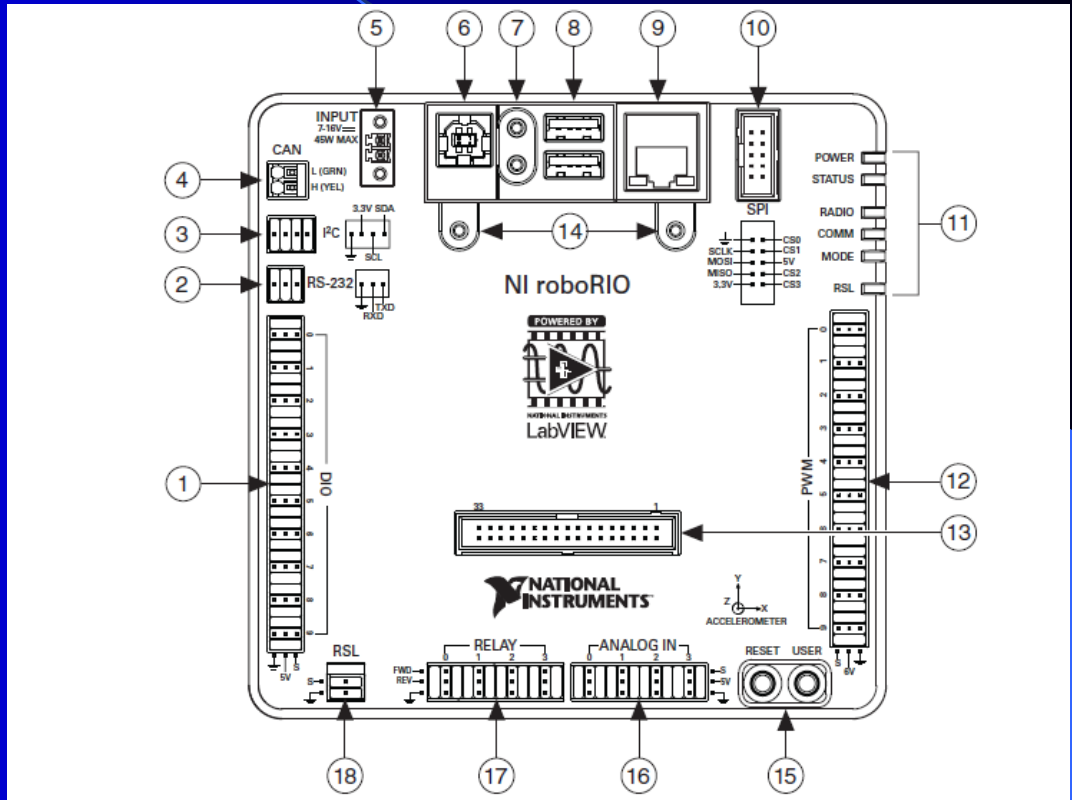
National Instruments RoboRIO Controller Features

1-DIO Ports:

- DIO Connections 0 thru 9 as shown and DIO connections 0 thru 13 on the MXP all have 40 kΩ pullup resistors to 3.3 V
- DIO connections 14 and 15 on the MXP have 2.2 kΩ pullup resistors to 3.3 V

2-RS-232 Port:

- RS-232 is a common serial interface connection.
- NI RoboRIO has one UART (Universal Asynchronous Receiver/Transmitter) connected the RS-232 port.
- The UART lines on the MXP are electrically identical to DIO lines 0 to 13 on the MXP. UART.RX and UART.TX have 40 kΩ pullup resistors to 3.3 V.
- The RS-232 lines are compliant with TIA/EIA-232-F voltage levels.



1	Digital input and output (DIO) port	10	Serial peripheral interface bus (SPI) port
2	RS-232 port	11	LEDs
3	I²C port	12	Pulse-width modulation (PWM) port
4	CAN port	13	myRIO Expansion Port (MXP)
5	Power connector	14	MXP retention mount
6	USB Device port	15	User and Reset buttons
7	USB Host retention mount	16	Analog input (AI) port
8	USB Host ports	17	Relay port
9	Ethernet port	18	Robot signal light (RSL) port

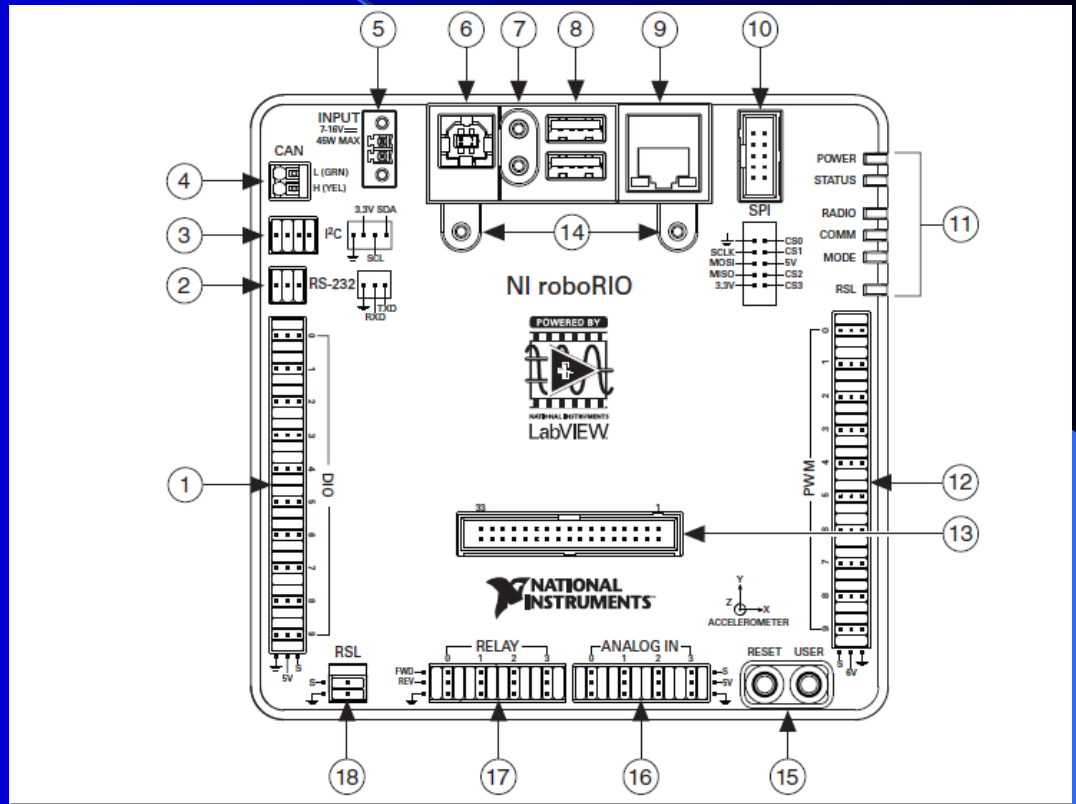
National Instruments RoboRIO Controller Features

3-I2C Port

- I²C is a serial interface used to connect I²C slave devices

4-CAN Port:

- Controller Area Network (CAN bus) is a vehicle bus standard designed to allow microcontrollers and devices to communicate with each other in applications without a host computer
- It is a message based protocol, designed originally for multiplex electrical wiring within automobiles, but is also used in many other contexts.
- The CAN bus used with the RoboRIO MUST be terminated at each end with 120 Ω resistors. One of the 120 Ω termination resistors is internal to the RoboRIO.



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National Instruments RoboRIO Controller Features

5-Power Connector:

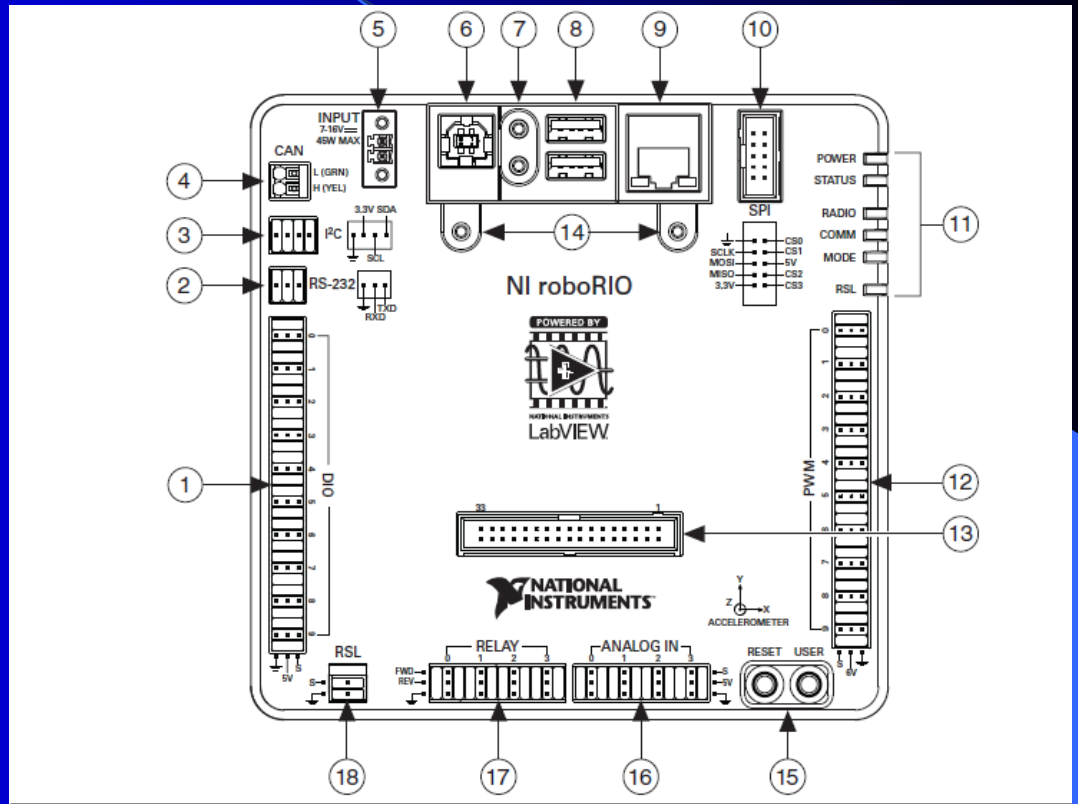
- Uses COMBICON Power Connector and MUST be connected directly to the Vbat CONTROLLER PWR connection on the Power Distribution Panel

6-USB Device Port:

- Universal Serial Bus (USB) device port is used to deploy and debug code by connecting a USB cable from the USB device port on the NI RoboRIO to a computer.

8-USB Host Ports support these items:

- Web cameras that conform to the USB Video Device Class (UVC) protocol.
- Machine vision cameras that conform to the USB3 Vision standard and are backward compatible with the USB 2.0 specification.
- Basler ace USB3 cameras, USB Flash drives and USB-to-IDE adapters formatted with FAT16 and FAT32 file systems.



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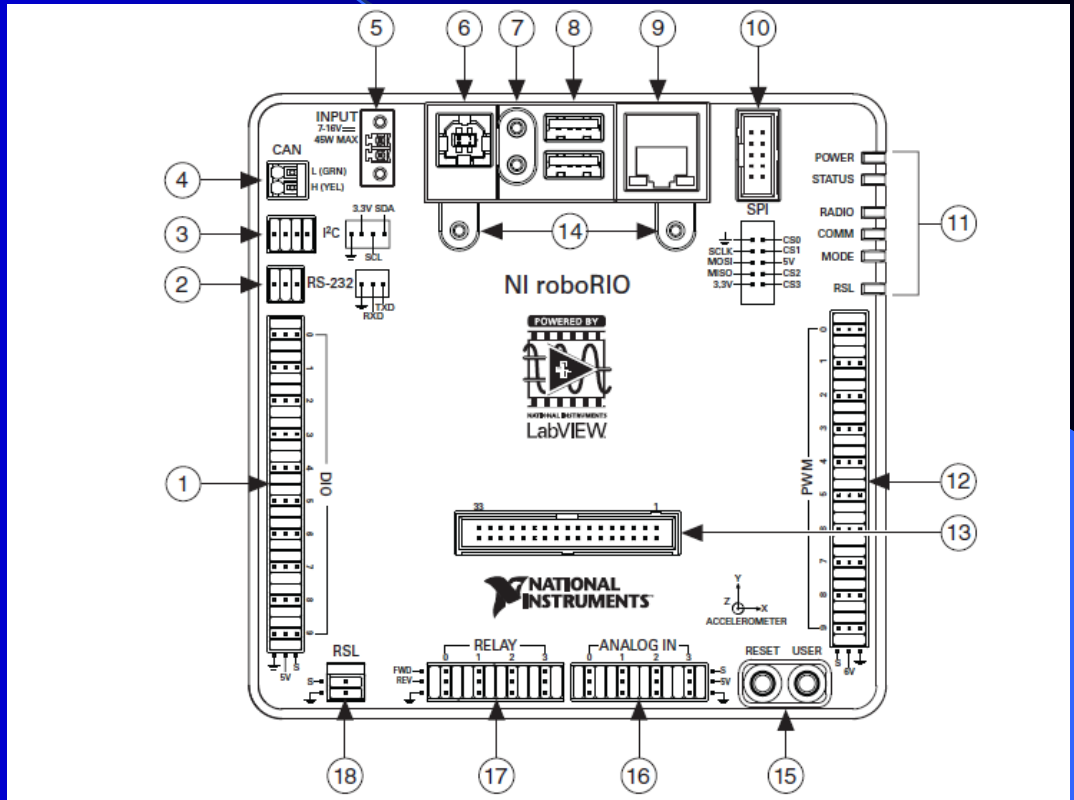
National Instruments RoboRIO Controller Features

9-Ethernet Port

- Used to connect to an Ethernet network.
- Use a standard Category 5 (CAT-5) or better shielded, twisted-pair Ethernet cable to an Ethernet hub, router, or directly to a computer.
- Do not use a cable longer than 30 meters.
- Port attempt to connect using a DHCP (Dynamic Host Configuration Protocol) connection.

10-SPI Port:

- Serial Peripheral Interface (SPI) is an interface bus commonly used to send data between microcontrollers and small peripherals such as shift registers, sensors and SD cards.
- Uses separate clock and data lines, along with a select line to choose the device which is being communicated with.



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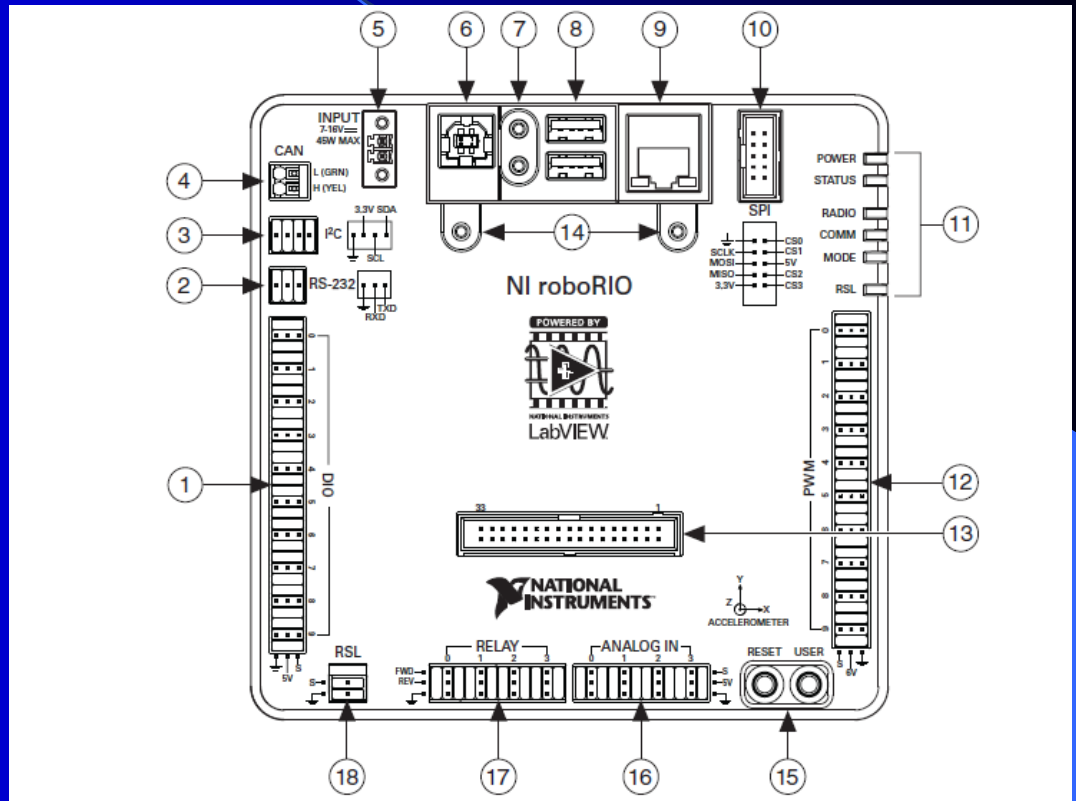
National Instruments RoboRIO Controller Features

11-LEDs

- Used to indicate conditions of various functions of the RoboRIO They include:
  - POWER LED
  - STATUS LED
  - RADIO LED
  - COMM LED (Communication)
  - MODE LED
  - RSL LED (Robot Signal Light)
- The LEDs have various states and colors that indicate various conditions and functions. These are defined in the NI RoboRIO user manual

12-PWM Ports

- PWM Connections 0 thru 9 as shown have 6 V on the center pin which can be used to power servo motors
- Shared PWM Connections 0 thru 9 on the MXP expansion Port only has 5 V power
- All PWM signal connections have a 40 kΩ pulldown resistors to ground



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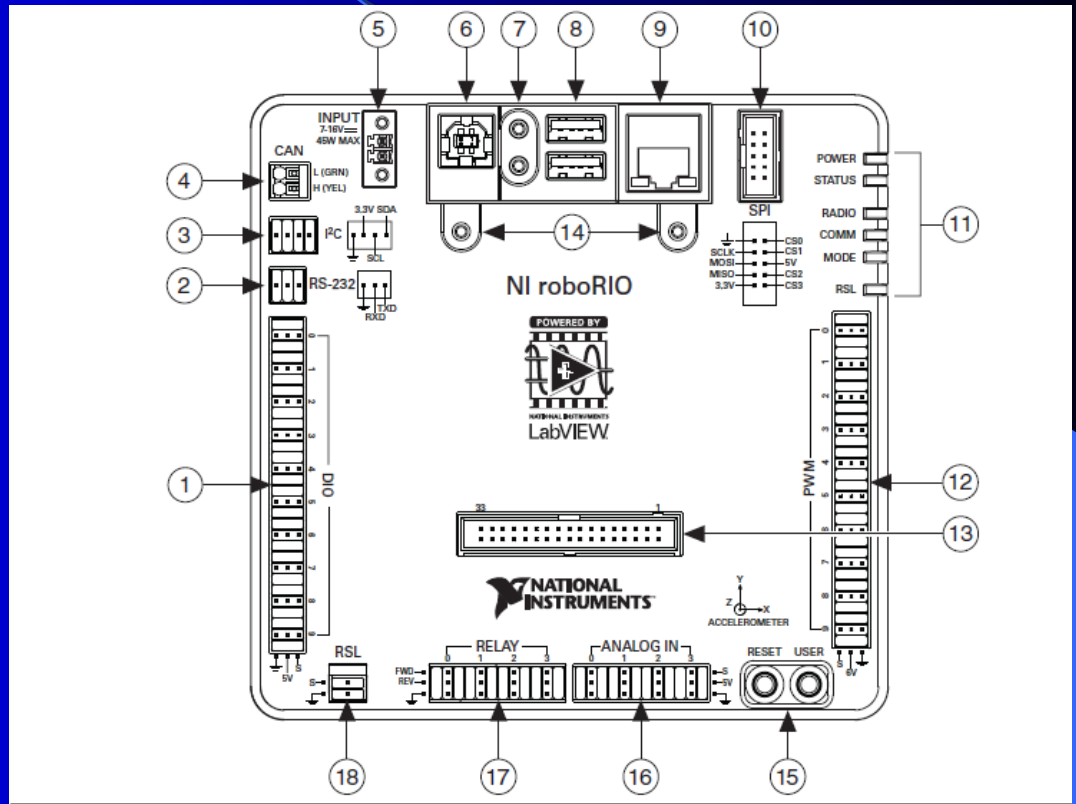
National Instruments RoboRIO Controller Features

13-MXP Connector

- Also called Custom Electronics Port
- Allows access to signals in addition to those available on the standard interface. The signals include :
  - +3.3 V
  - +5 V
  - Analog Ground (1 Ports)
  - Digital Ground (7 Ports)
  - Analog Input (4 ports)
  - Analog Output (2 Ports)
  - DIO (16 Shared Ports)
  - PWM (10 Shared Ports)
  - SPI (1 Shared Port)
  - I2C (1 Shared Port)
  - UART Receive (1 Port)
  - UART Transmit (1 Port)
- Various board configurations are available for teams to buy to get to these signals or a team can manufacture a board using info furnished by National Instruments.



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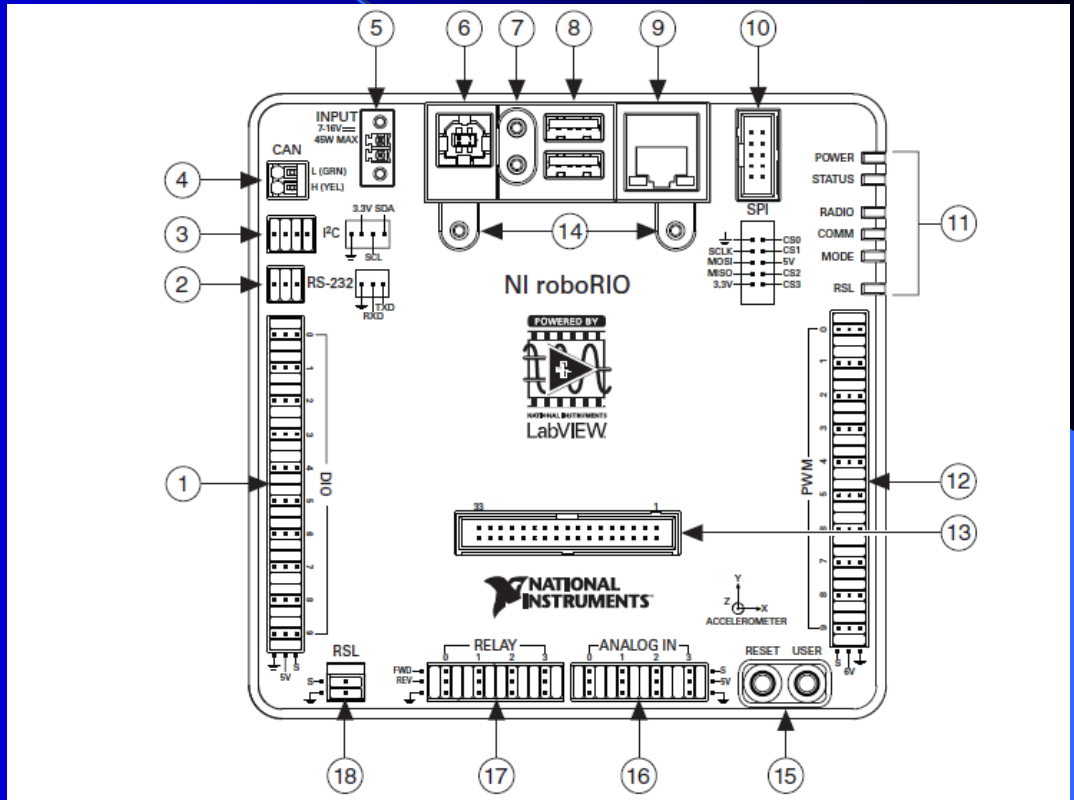
National Instruments RoboRIO Controller Features

15-User and Reset Buttons

- **User Button**
  - Produces a logic TRUE when depressed and a logic FALSE when not
- **Reset Button**
  - Pressing and releasing the Reset button restarts the processor and the FPGA (Field-programmable gate array)
  - Pressing and holding the Reset button until the status LED lights (about five seconds) and then releasing the Reset button restarts the processor and the FPGA and forces the RoboRIO into a safe mode.
  - In safe mode, it launches only the services necessary for updating configuration and installing software.
  - In the safe mode, communicate by using the RS-232 serial port.



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National Instruments RoboRIO Controller Features

16-Analog Input Ports:

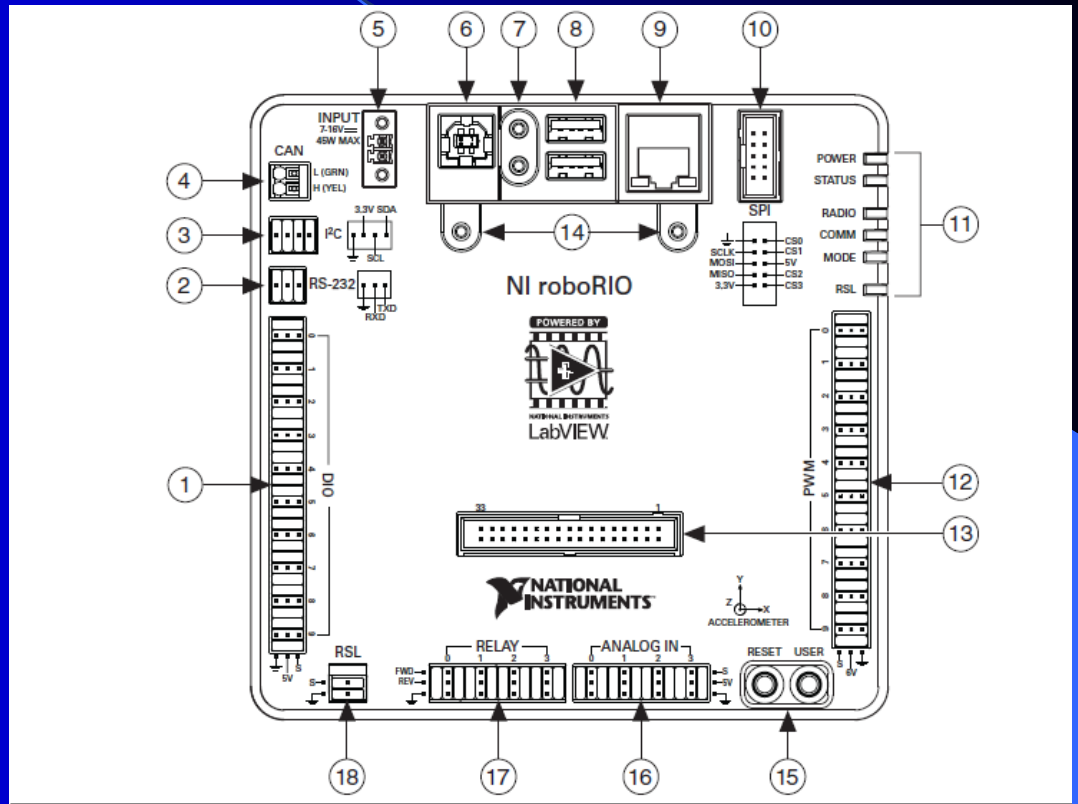
- Four single-ended channels can be used to measure 0-5 V signals
- Channels are multiplexed to a single analog-to-digital converter (ADC) that samples all channels (including MXP).

17-Relay Ports:

- Relay ports all have 40 kΩ pulldown resistors to ground. There are 4 Forward controls and 4 Reverse controls.

18-RSL (Robot Signal Light Port):

- Switched power output to drive RSL when RSL is enabled. The voltage level depends on the connected input voltage. RSL current is limited at 120 mA.
- Wiring goes to an LED, so the polarity of the output is important.



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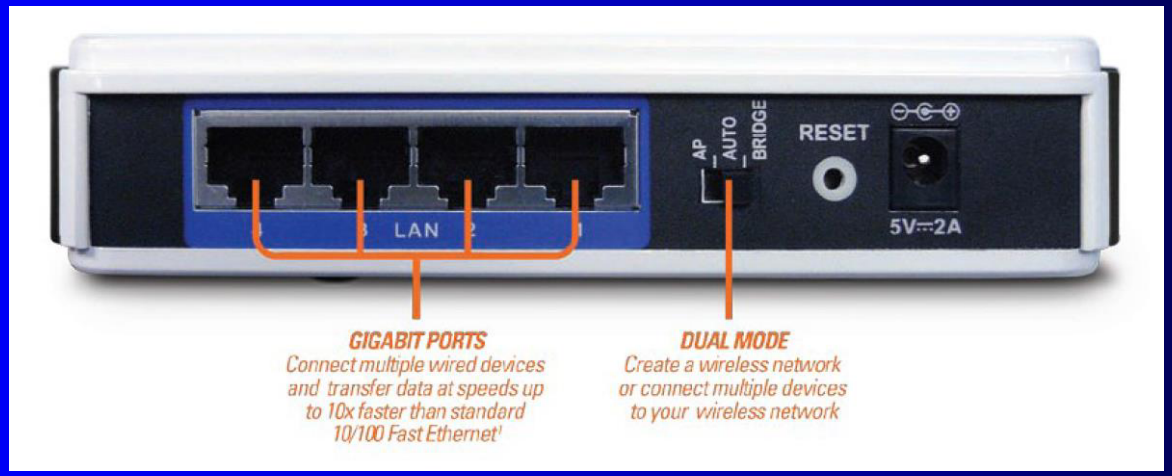
D-Link DAP-1522
(Revision B)
Wireless Bridge

- One D-Link DAP-1522 (revision B), configured with the appropriate encryption key for your team number at each event, is the only permitted device for communicating to and from the ROBOT during the matches.
  - Power must be supplied by the 5V/2A output of a Cross the Road Electronics Voltage Regulator Module (VRM) and must be the only load connected to those terminals.
  - Signal must be connected to the RoboRIO Ethernet port via a CAT5 or CAT6 Ethernet cable. Team 67 uses: CAT6 Shielded Patch Cord Molded with Boot & Bubble. It used stranded, shielded, twisted pair cable.
  - Wireless Bridge must be mounted such that the diagnostic lights are visible to ARENA personnel.
  - Make sure the DAP-1522 has the Mode switch set to the “Bridge” position before going on the field for any match.
- Wiring configuration is shown on a later slide.

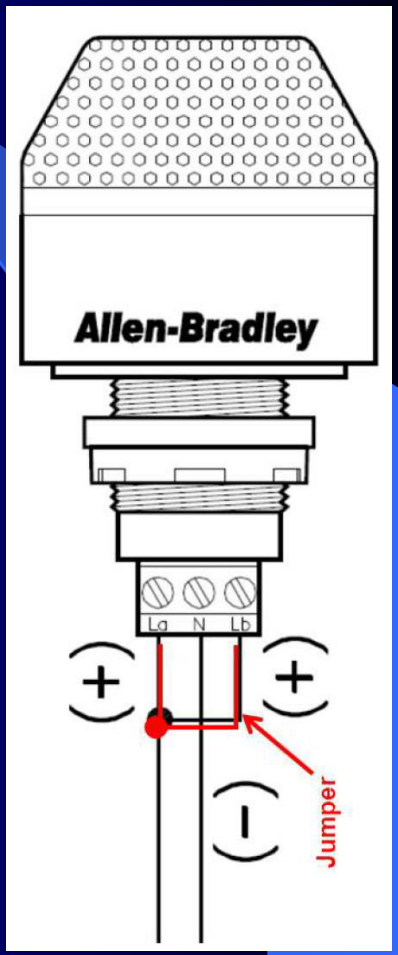
D-Link DAP-1522
(Revision B)
Wireless Bridge



D-Link DAP-1522
(Revision B)
Wireless Bridge Wiring

Robot Signal Light Info and Wiring

- ROBOTS must use at least one (1), but no more than two (2) diagnostic ROBOT Signal Lights (RSL)
- The only acceptable RSL is Rockwell #855PB-B12ME522. Rockwell is the new owner of Allen Bradley products.
- RSL MUST be:
  - Mounted on the ROBOT such that it is easily visible while standing three (3) feet in front of the ROBOT
  - Wired for solid light operation by placing a jumper between the “La” and “Lb” terminals on the light’s removable connector.
  - Connected to the “RSL” terminals on the RoboRIO. A red wire needs to be connected from the leads that have the jumper wire to the “S” terminal on the RSL connector of the RoboRIO. A black wire is connected from the “N” pin on the RSL to the terminal with the Ground symbol on the RSL connector of the RoboRIO.



Motor Controller Wiring Notes used by Team #67

ALL Motor Controllers

Power Input Wiring

- **ALW**AYS make sure that the +POWER INPUT wiring (Spikes or Speed Controllers) have the Red wire (+ DC Voltage) to the positive input terminal and the -POWER INPUT wiring (Spikes or Speed Controllers) have the Black wire (- DC Voltage) to the negative input terminal
  - If the POWER INPUT WIRING is connected in reverse, the motor controller is very likely to be PERMANENTLY DAMAGED immediately when the power is applied to it
  - + DC Voltage connections are marked with 12V, +V, V+, or +
  - - DC Voltage connections are marked with GND, -V, V-, or -

NOTES: -FIRST allows other colors of wires to be used – The listed standard is that used by Team #67 (See next slide for FIRST standards)

-Special wiring is required when wiring a Servo motor. This is defined on a later slide.

FIRST acceptable wire gauges and colors

- **Legal Wire Colors for use on robots per 2015 Competition/Game manual**
  - Red, yellow, white, brown, or black-with-stripe on the positive (e.g. +24VDC, +12VDC, +5VDC, etc.) connections.
  - Black or blue for the common or negative side (-) of the connections.
  - Wires that are originally attached to legal devices are considered part of the device and by default legal.
- **Legal Wire Gauges for use on robots per 2015 Competition/Game manual**

Application	Minimum Wire Size
31 – 40A protected circuit	12 AWG (2.052mm)
21 – 30A protected circuit	14 AWG (1.628mm)
6 – 20A protected circuit	18 AWG (1.024mm)
Between the PDP dedicated terminals and the VRM or PCM	18 AWG (1.024mm)
Compressor outputs from the PCM	18 AWG (1.024mm)
Between the PDP and the roboRIO	22 AWG (0.645mm)
VRM 2A circuits	22 AWG (0.645mm)
≤5A protected circuit	22 AWG (0.645mm)
roboRIO PWM port outputs	26 AWG (0.404mm)
SIGNAL LEVEL circuits (i.e. circuits which draw ≤1A continuous and have a source incapable of delivering >1A, including but not limited to roboRIO non-PWM outputs, CAN signals, PCM Solenoid outputs, VRM 500mA outputs and Arduino outputs)	28 AWG (0.321mm)

Motor Controller Wiring Notes used by Team #67

ALL Motor Controllers Power Output Wiring

- Output wiring of the motor controllers is always marked to accommodate output consistency
- The positive output connection on all controllers is labeled M+
- The negative output connections on all controllers is labeled M-

➢ The output of the controller can be wired in a forward direction (M+ to M-) or a reverse direction (M- to M+) with no damage to the motor control device. The only affect will be the motor will run in the opposite direction

NOTES: -The normal wiring configuration used by Team #67 is to wire all motor controllers in a forward direction (M+ to M-). If needed, Team #67 typically reverses motor rotation in the programmed software code.

- If two motors are controlled using the same PWM line and need to run in an opposite direction, then one motor would be wired in reverse.

Motor Controller Wiring Notes

Control Signal Wiring to a Motor Controller

- **Spike Motor Control Wiring**
  - Connect the Spike using a standard RC PWM cable.
  - Connect the Black wire to the B PWM connection on the Spike and the other end to the Ground symbol on a selected Relay connection of the NI RoboRIO

The Spike will function and display the control LEDs as listed in this table:

INPUTS		OUTPUTS			
Fwd(Wht)	Rev(Red)	M+	M-	Indicator	Motor Function
0	0	GND	GND	Orange	OFF / Brake Condition (default)
1	0	+12v	GND	Green	Motor rotates in one direction
0	1	GND	+12v	Red	Motor rotates in opposite direction
1	1	+12v	+12v	Off	OFF / Brake Condition

Notes:

1. 'Brake' refers to the dynamic stopping of the motor due to the shorting of the motor inputs. This condition is not optional when going to an off state.
2. The INPUT Fwd and Rev are defined as follows: 0 (Off) and 1 (On).

Typical Spike Motor Controller Wiring to NI RoboRIO

Typical Servo Motor Wiring to NI RoboRIO

2015 Motor Speed Controllers available for FRC robots

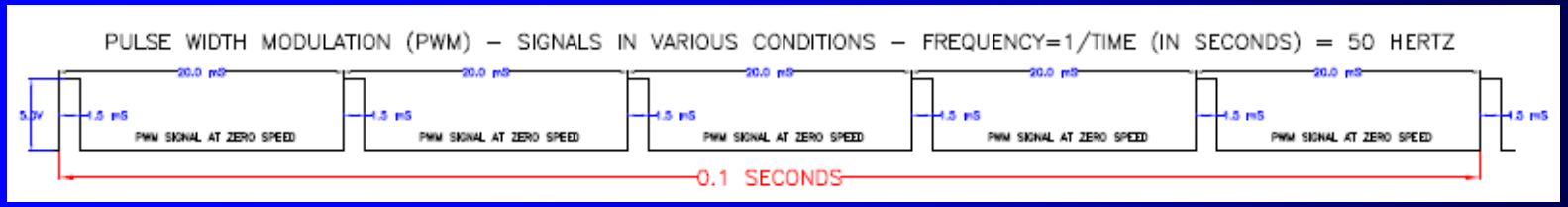
Not used by Team #67	Not used by Team #67	Used by Team #67	Used by Team #67	Used by Team #67
Texas Instruments Jaguar	VEX Robotics Victor 884 Or Victor 888	Cross the Road Electronics Talon SR	Cross the Road Electronics Talon SRX	Cross the Road Electronics Victor SP

Motor Speed Controller Control Signals

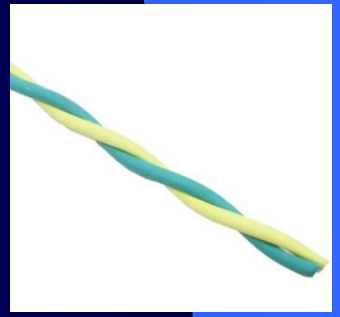
PWM and CAN bus Description

PWM Cables

- PWM – Pulse Width Modulation
  - PWM is a modulation technique used to encode a message into a pulsing signal. This is a 0 to 5VDC binary motor control signal with a 1.0mS to 2.0mS pulse width. This will be detailed on the next slide. This will proportionally control the Motor Speed Controller from full forward speed to full reverse speed. The Motor Controller Speed will be at zero motion (neutral state) when the pulse width is 1.5mS.



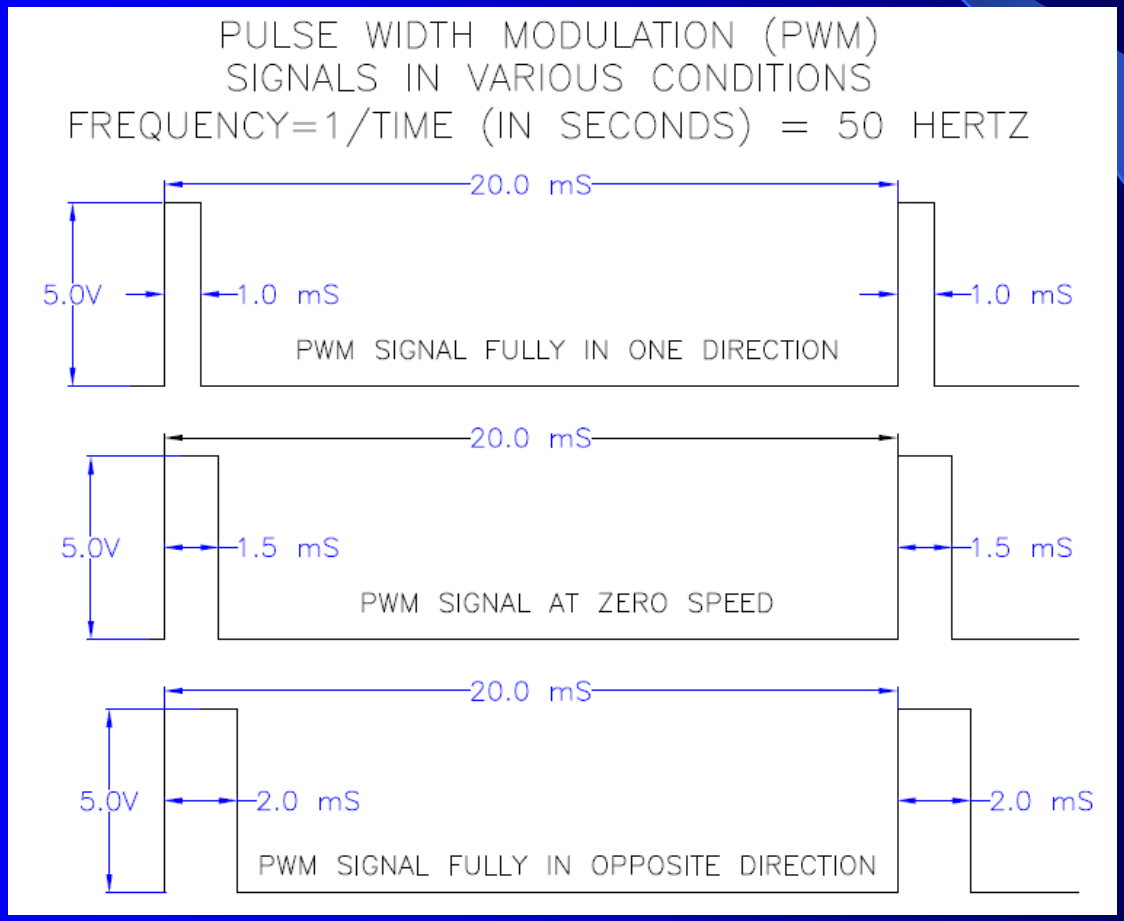
CAN Cable



- CAN bus is a multi-master serial bus standard for connecting Electronic Control Units (known as nodes). Two or more nodes are required on the CAN network to communicate. All nodes are connected to each other through a two wire bus. The bus MUST be terminated at each end with 120 Ω resistors. The RoboRIO has an internal 120Ω resistor to complete one end of the termination.

Motor Speed Controller Control Signals

PWM – Pulse Width Modulation – More Detailed Graphic



Motor Speed Controller Wiring Notes

Control Signal Wiring to Motor Speed Controllers

- **Victor 888, Talon SR or Victor SP use ONLY PWM Motor Control Wiring**
  - Connect the Victor 888 using a standard RC PWM cable. Connect the Black wire to the B PWM connection on the Victor 888 and the other end to the Ground symbol on a selected PWM connection on the NI RoboRIO.
  - Connect the Talon SR using a standard RC PWM cable. Connect the Black wire to the B PWM connection on the Talon SR and the other end to the Ground symbol on a selected PWM connection on the NI RoboRIO.
  - The Victor SP has a standard RC PWM cable attached directly to the device. Connect the Black wire from the Victor SP to the Ground symbol on a selected PWM connection on the NI RoboRIO. The PWM cable length connected to the Victor SP is 17.8 inches. If the cable is too short, an extension can be added.

Motor Speed Controller Wiring Notes (continued)

Control Signal Wiring to Motor Speed Controllers

- Talon SRX or Jaguars can use either PWM or CAN bus Motor Control Wiring
  - These devices MUST NOT be connected to both the PWM and CAN bus
- To connect the Talon SRX to the PWM control, wire the cable attached directly to the device by using either of the green wires as the ground wire (normally black wire) and either of the yellow wires as the signal wire (normally white wire). Insulate the unused green and yellow wires. Then connect the green wire to the Ground symbol on a selected PWM connection on the NI RoboRIO.
- To connect the Jaguar to the PWM control, use a standard RC PWM cable. Connect the Black wire to the - PWM connection on the Jaguar and the other end to the Ground symbol on a selected PWM connection on the NI RoboRIO.
- CAN bus wiring on these two devices is detailed in three slides later in this presentation.

Typical Motor Speed Controller Wiring using PWM Control

Typical Motor Speed Controller Wiring using CAN bus Control

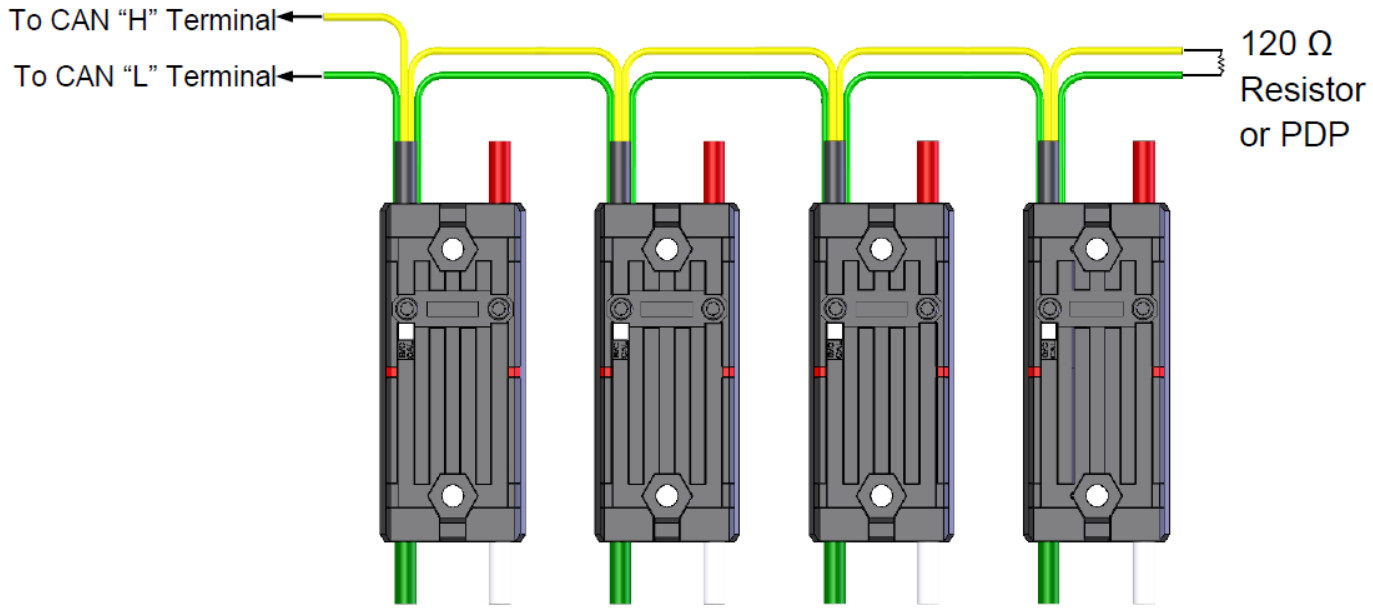
Closeup Of PDP CAN bus Termination

Motor Speed Controller Wiring notes (continued)

CAN bus Control Signal Wiring with end Termination

Motor Speed Controller Wiring notes (continued)

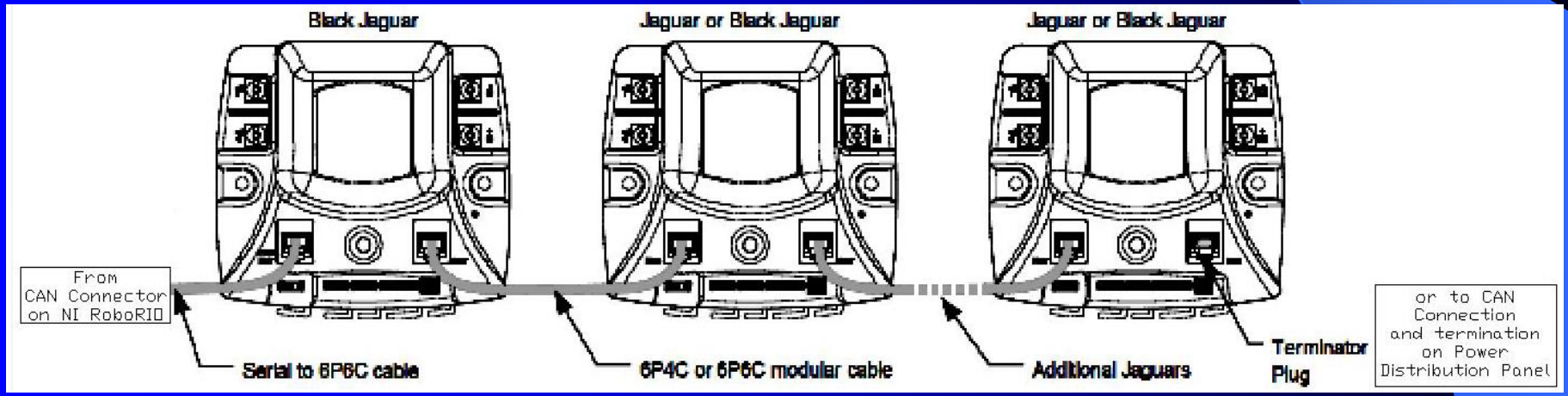
CAN bus Control Signal Wiring to Talon SRX Motor Speed Controller



After all of the Talon SRXs have been wired, there will be 2 remaining signal wires – connect these two wires using a 120 Ω resistor or to the CAN interface on the Power Distribution Panel (PDP) to properly terminate the cable end.

Motor Speed Controller Wiring Notes (continued)

CAN bus Control Signal Wiring to Texas Instruments Jaguar Motor Speed Controller



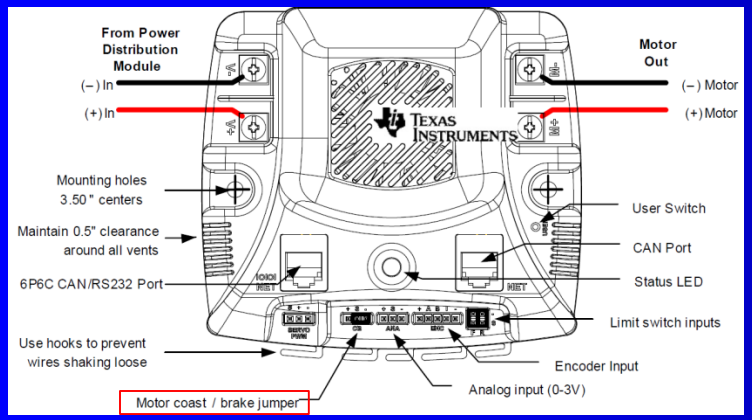
Motor Speed Controller Wiring Notes (continued)

Motor Speed Controllers Brake/Coast Mode

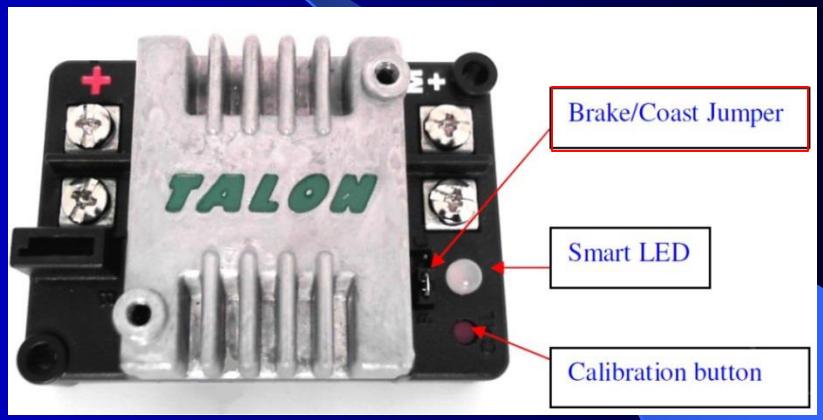
- The Coast/Brake mode selects the dynamic behavior of the motor controller when decelerating or stopping.
- In the Coast mode, the motor controller allows the current in the motor to decay slowly, providing a more gradual deceleration.
- In the Brake mode, the motor controller uses switching to oppose current generated by the motor which results in much faster deceleration. The brake setting also provides some additional holding capability in the stopped position.
- On the Jaguar, Victor 888 and the Talon SR, the Brake/Coast mode is set using a jumper. CAN bus network commands can override the jumper setting on the Jaguar.
- On the Victor SP and Talon SRX, the Brake/Coast mode is set by pressing the B/C Cal pushbutton. When the status light is solid red, the controller is in the Brake mode. When the status light is off, the controller is in the Coast mode. The CAN bus network commands can override the jumper setting on the Talon SRX.

Motor Speed Controller wiring notes used by Team #67 (continued)

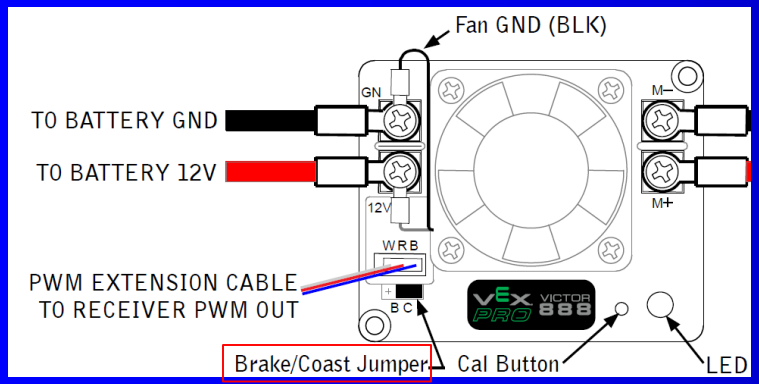
Motor Speed Controllers Mode Jumper/Button Locations



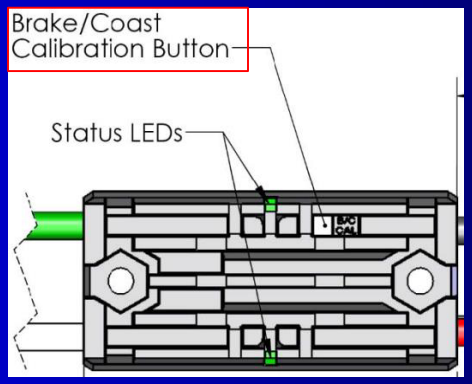
Texas Instruments Jaguar



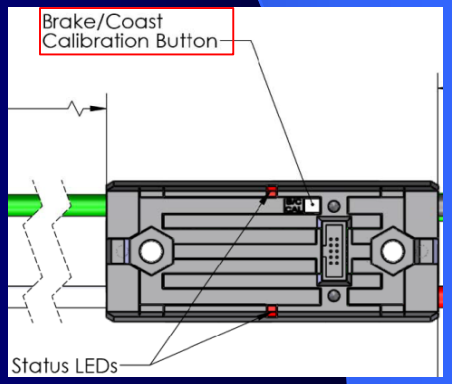
Talon SR



Victor 888



Victor SP



Talon SRX

Motor Speed Controller wiring notes used by Team #67 (continued)

Motor Speed Controllers PWM Calibration Function

- The PWM calibration of a motor controller determines how to scale the PWM input signal to output voltage. Different motor controllers may have different “max” and “min” PWM signals that may not correspond to all of the motor controller outputs. Calibrating the motor controller 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 motor controllers used by FIRST teams have a default calibration that is compatible with the NI RoboRIO control system.
- The PWM calibration procedure is different for each of the motor controllers used by FIRST teams. There is a procedure defined in each of the motor controller’s user guides and there is a definition of the visual display that indicates when the procedure was successful or when the procedure has failed.

Motor Speed Controller wiring notes used by Team #67 (continued)

Motor Speed Controllers
CAN bus interface connections

- The Talon SRX and the Jaguar motor controllers that are wired to use the CAN bus have direct connectivity and a set of control options for multiple sensor interfaces. These can include analog inputs (such as potentiometers, etc.) and digital inputs (such as encoders, switches, etc.).
- Sensors can be connected directly to the Talon SRX via the Data Port. The Talon SRX supplies the voltage and ground to the sensor devices. Do not supply external voltages or ground into the Data Port. The Data Port accepts a 2x5 0.05 inch pitch keyed cable that is available from many online retailers as well as VEX Robotics.
- Sensors can be connected directly to the Jaguar MDL-BDC via the ANA, ENC and the FR connectors. These are used for Closed Loop Control of the Jaguar. The MDL-BDC software supports control and monitoring of only one sensor at a time.

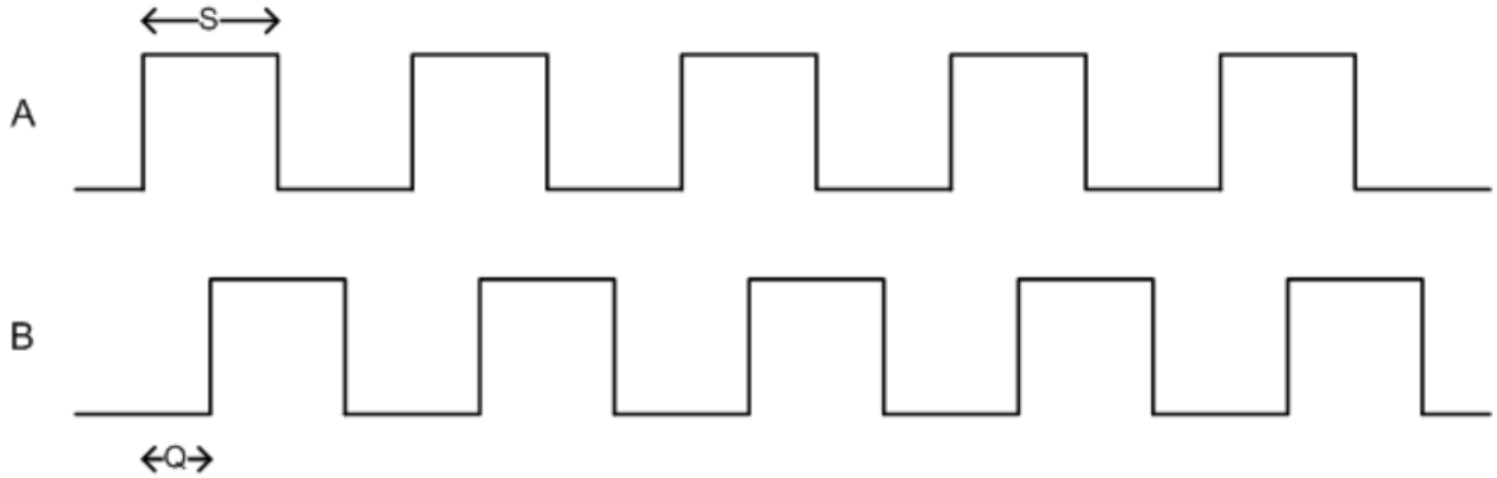
- Sensors -
Encoder Wiring to NI RoboRIO

Common FIRST Encoder - US Digital E4P-250-250-N-S-D-D-B

- E4P-250-250-N-S-D-D-B is a miniature incremental encoder that provides a quadrature output signal with these features:
  - 250 pulses per revolution (per phase)
  - ¼” (0.250”) mounting hole
  - No index
  - Single ended output
  - Default cover with no hole
  - Default base
  - Bulk packaging
- Phase A leads Phase B signals by 90° when encoder is rotating clockwise (shown in the next slide)
- Use a US Digital CA-MIC4-SH-NC-(# of Feet) cable to connect the encoder. It has a 4-Pin Micro Connector with an Unterminated, Shielded Cable that is wired as shown in a later slide

- Sensors -
Encoder Output Signals

Common FIRST Encoder - US Digital E4P-250-250-N-S-D-D-B



Parameter	Typ.	Max.	Units
Symmetry, S	180 ± 16	180 ± 75	electrical degrees
Quadrature Delay, Q	90 ± 10	90 ± 60	electrical degrees

(1) A leads B for clockwise shaft rotation, B leads A for counter clockwise shaft rotation viewed from the cover/label side of the encoder.

- Sensors -

Encoder Wiring to NI RoboRIO

- Sensors -

Switch Wiring to NI RoboRIO

- Sensors -
Team 67's
Potentiometer Information

Rotary Potentiometer

Linear Potentiometer

- Always use linear taper devices
- Always use resistance values between 10kΩ and 100kΩ
- Independent linearity tolerance must be <2% (lower = more accurate)
- Use conductive plastic element technology for infinite resolution
- Rotary potentiometers come in single turn or multiple turn configurations

- Sensors -

Potentiometer Wiring to NI RoboRIO

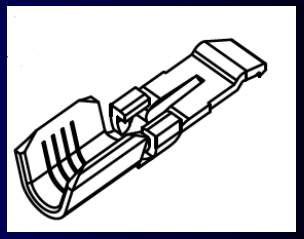
- Sensors -

Rockwell Light Sensor to NI RoboRIO

Crimp Terminals used by Team #67

- **Team #67 only uses uninsulated crimp terminals in these types and sizes:**
  - Butt Splice Connectors - (12-10 AWG)
  - Butt Splice Connectors - (22-18 AWG)
  - Quick Disconnect - ¼" Female - (12-10 AWG)
  - Quick Disconnect - ¼" Female - (12-10 AWG) - 90°
  - Quick Disconnect - ¼" Male - (12-10 AWG)
  - Ring Terminals - #6 Screw (12-10 AWG)
  - Ring Terminals - #6 Screw (22-18 AWG)
  - Ring Terminals - #6 Screw (26-22 AWG)
  - Ring Terminals - ¼" Screw (6 AWG)
  - Ring Terminals - ¼" Screw (12-10 AWG)
  - Fork Terminals - #6 Screw (12-10 AWG)
  - Fork Terminals - #6 Screw (22-18 AWG)
  - Anderson PowerPole Terminals #261G2-LPBK
  - Anderson SB-50 Connector Terminal - (6 AWG)
- **Barrel Crimp terminals are always covered with shrink tubing**

Butt Splice Connectors



Power Pole Terminal

Female Quick Disconnect Terminal

90° Female Quick Disconnect Terminal

Male Quick Disconnect Terminal

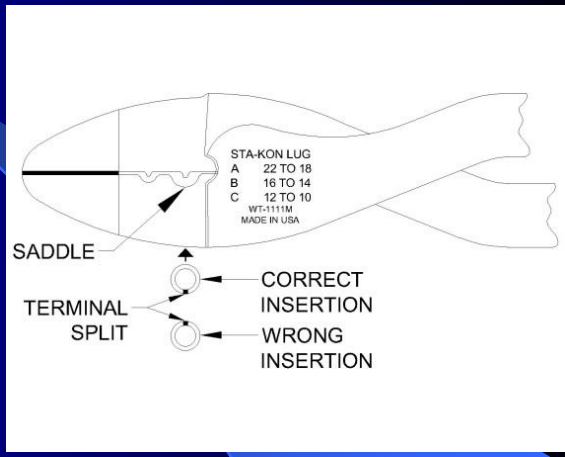
Fork Terminal

Ring Terminal

SB-50 Terminal

Crimping Tools for Electrical Work on a Robot

- Always use the correct tool that is designed to crimp the type of terminals and the wire size being crimped.
- Always set the split side of the crimp barrel into the saddle side of the crimpers
- Strip wire to the correct length. Correct length is defined for each type of crimp terminal. Wire insulation must touch the barrel, but must not be inserted into the crimp barrel.



MSC Industrial Supply Co.
#03131315 (21 ¼" long)
2-8 AWG terminal crimper
For battery terminals

Thomas and Betts #W111M
22-10 AWG (13" long)
uninsulated terminal crimper
for barrel terminals

Powerwerx TRIcrimp
Crimpers for Terminals
Used in PowerPole Connectors

Shrink Tubing used by Team #67

- Team #67 normally uses 2:1 shrink ratio tubing in these colors and sizes:
  - Red – $^{3}/_{32}$” , $^{1}/_{8}$”, , $^{1}/_{4}$”, $^{3}/_{8}$” and $^{1}/_{2}$” diameter
  - Black – $^{3}/_{32}$” , $^{1}/_{8}$”, , $^{1}/_{4}$”, $^{3}/_{8}$” and $^{1}/_{2}$” diameter
  - Green – $^{1}/_{4}$” diameter
  - Yellow – $^{1}/_{4}$” diameter
  - White – $^{3}/_{32}$” diameter
- Nominal cut length is ¾”, but length varies with specific application
- Team 67 uses colored electrical tape for insulation repairs or places that shrink tubing can not be used

Tools for Electrical Work on a Robot

Wire Strippers – Good Choices

- Always use the correct wire stripper for the size (AWG) and the type (stranded or solid) of wire being stripped
- Make sure the wire stripper being used has a sharp cutting tool

Ideal #45-121
T-6 T-Stripper
16-26 AWG stranded wire

Ideal #45-124
T-8 T-Stripper
8-16 AWG stranded wire

Klein Kurve® #11053
Wire Cutter/Stripper
6-12 AWG stranded wire

Tools for Electrical Work on a Robot

- Heat Gun – No open flame devices are allowed in the pit area at any competition.
- Wago tool or long slotted screwdriver to insert wires into spring loaded terminals
  - Needed on RoboRIO controller, PDP, PCM and VRM

SparkFun Heaterizer
#XL-3000 heat gun

Wago Tool
No longer available
Similar to Kohler tool

Snap On Screwdriver
0.32” Flat Tip
14 5/32" long

Battery Charger used by Team 67

AndyMark, Inc. #AM-2026

Lead Acid Battery Charger, 3 Bank, 6 Amp, Dual Pro RS3 with SB-50A Connectors

Battery Power Items to Check Before Going to the Competition Field

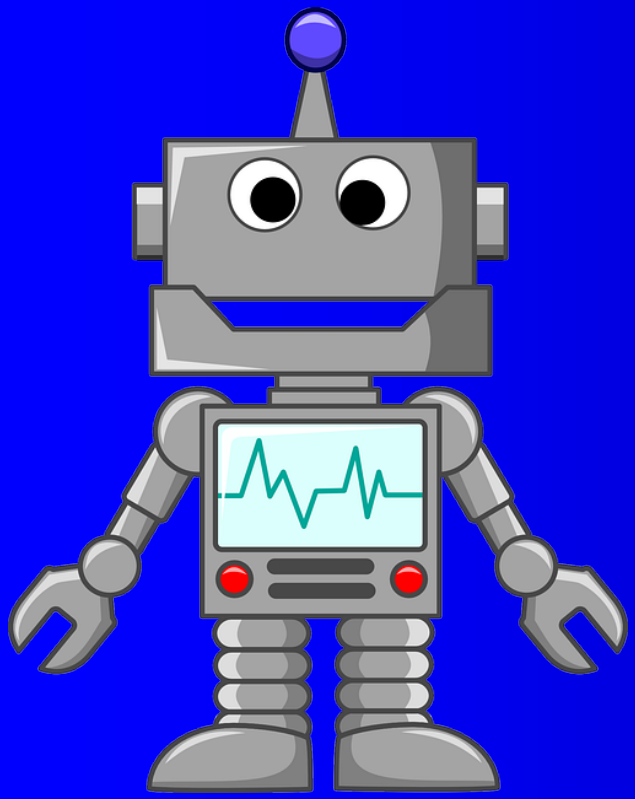
Always!

- Don't forget to install a fully charged battery
- Check the battery condition by measuring it with a Cross the Road Electronics Battery Beak
  - → Plug it into the Anderson SB-50 connector, turn ON the Battery Beak and make sure the orange portion of the display shows STATUS: Good and CHARGE: ≥ 110%
- Make sure the battery is PROPERLY SECURED
- Verify that the battery terminals are fully insulated
- Make sure the power connector is fully engaged

Thanks for much information which was found at these locations

- Andymark, Inc.
  - → http://www.andymark.com/
- Cross the Road Electronics
  - → http://www.ctr-electronics.com/
- FIRST website
  - → http://www.USFIRST.org/
- National Instruments
  - → https://decibel.ni.com/content/community/academic/student_competitions/frc
- VEX Robotics
  - → http://www.vexrobotics.com/
- Miscellaneous manufacturer's websites for datasheets and information
- Chief Delphi forums for community information
- Much good reference information can be found at http://team358.org/files/programming/ControlSystem2015-2019/
- 2006 PowerPoint presentation by Chris Noble (Team 1018 [at that time]) and Darrell Noble (Team 71 [at that time])

Very Important Closing Comments



→A neat robot is a safe, reliable robot!

→Read ALL of the Rules and ALL of the game manual and follow the rules completely.

- If you're not sure, ask your mentor, the FIRST organization advisors and/or another team.
  - ➢ Remember, the only bad question is the one you don't ask!