2017 Control System Hardware

Last Updated: 01-18-2017

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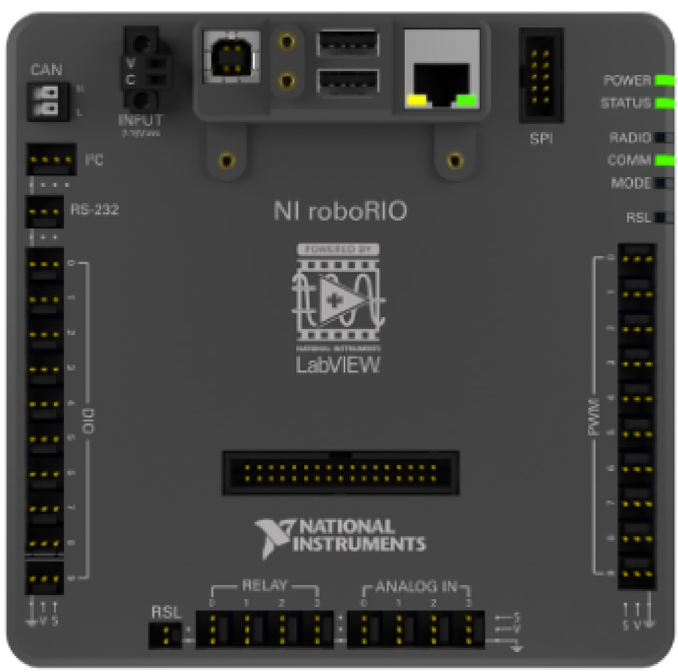
General Hardware

2017 FRC Control System Hardware Overview

The goal of this document is to provide a brief overview of the hardware components that make up the 2017 FRC Control System. Each component will contain a brief description of the component function, a brief listing of critical connections, and a link to more documentation if available. Note that for complete wiring instructions/diagrams, please see the Wiring the 2017 Control System document.

National Instruments roboRIO

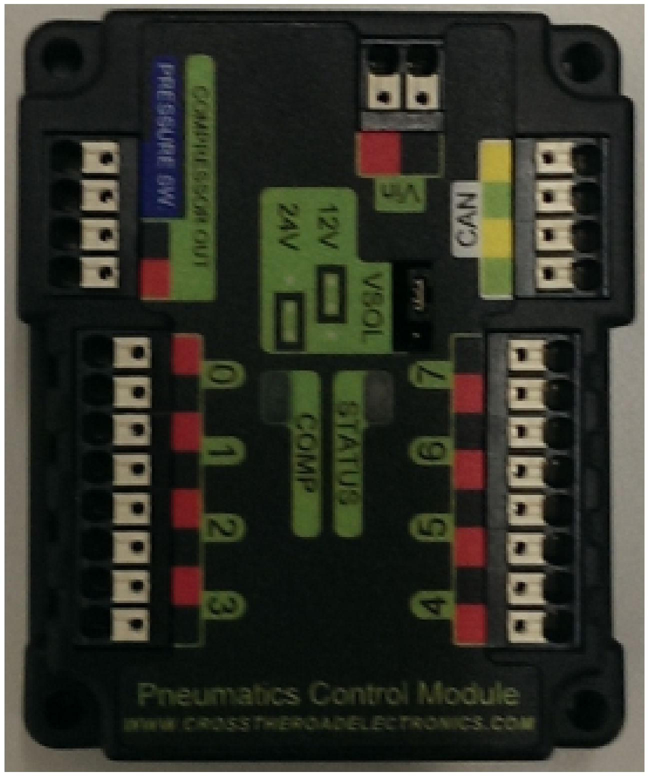


The NI-roboRIO is the main robot controller used for FRC. The roboRIO includes a dual-core ARM Cortex™-A9 processor and FPGA which runs both trusted elements for control and safety as well as team-generated code. Integrated controller I/O includes a variety of communication protocols (Ethernet, USB, CAN, SPI, I2C, and serial) as well as PWM, servo, digital I/O, and analog I/O channels used to connect to robot peripherals for sensing and control.The roboRIO should connect to the dedicated 12V port on the Power Distribution Panel for power. Wired communication is available via USB or Ethernet. Detailed information on the roboRIO can be found in the roboRIO User Manual.

Power Distribution Panel

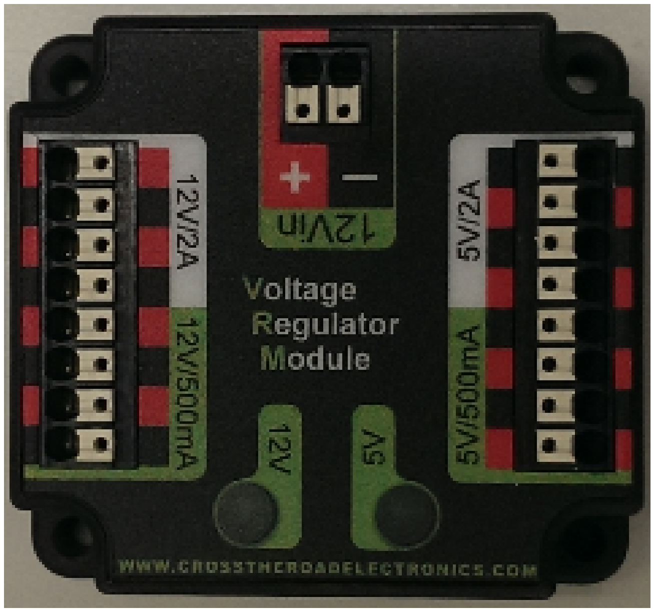
The Power Distribution Panel (PDP) is designed to distribute power from a 12VDC battery to various robot components through auto-resetting circuit breakers and a small number of special function fused connections. The PDP provides 8 output pairs rated for 40A continuous current and 8 pairs rated for 30A continuous current. The PDP provides dedicated 12V connectors for the roboRIO, as well as connectors for the Voltage Regulator Module and Pneumatics Control Module. It also includes a CAN interface for logging current, temperature, and battery voltage. For more detailed information, see the PDP User Manual.

Pneumatics Control Module



The PCM is a device that contains all of the inputs and outputs required to operate 12V or 24V pneumatic solenoids and the on board compressor. The PCM is enabled/disabled by the roboRIO over the CAN interface. The PCM contains an input for the pressure sensor and will control the compressor automatically when the robot is enabled and a solenoid has been created in the code. The device also collects diagnostic information such as solenoid states, pressure switch state, and compressor state. The module includes diagnostic LED’s for both CAN and the individual solenoid channels. For more information see the PCM User Manual.

Voltage Regulator Module

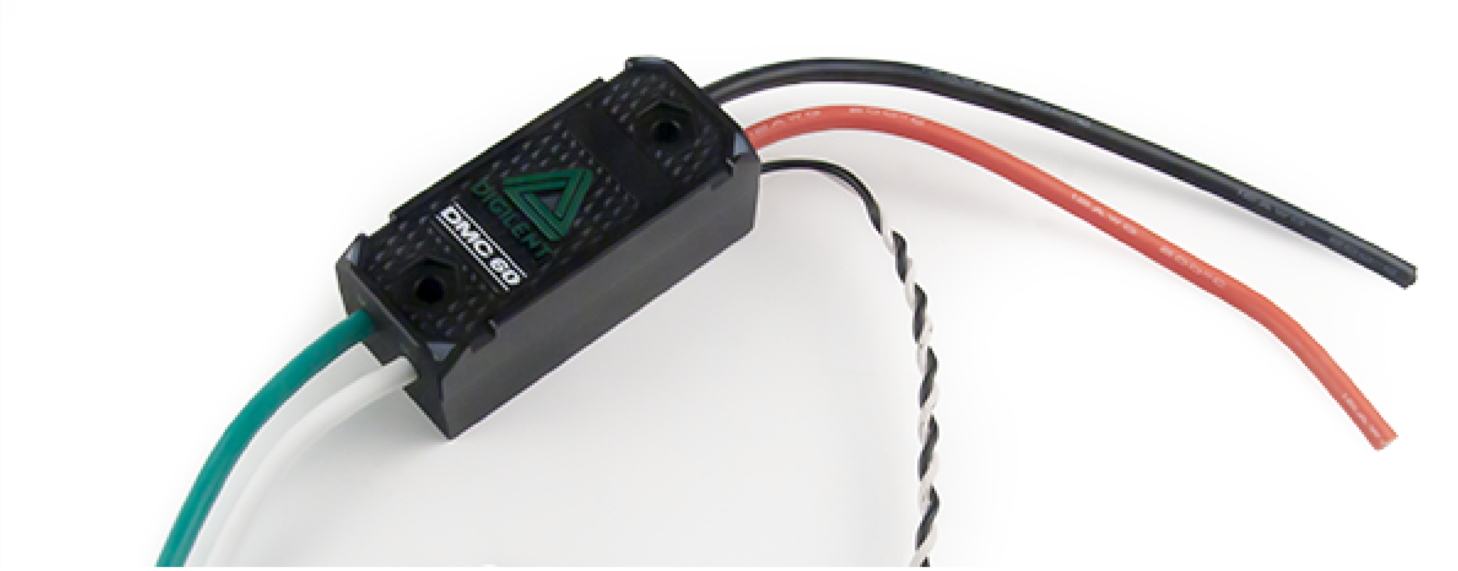


The VRM is an independent module that is powered by 12 volts. The device is wired to a dedicated connector on the PDP. The module has multiple regulated 12V and 5V outputs. The purpose of the VRM is to provide regulated power for the robot radio, custom circuits, and IP vision cameras. Note: The two connector pairs associated with each label have a combined rating of what the label indicates (e.g. 5V/500mA total for both pairs not for each pair). The 12V/2A limit is a peak rating, the supply should not be loaded with more than 1.5A continuous current draw. For more information, see the VRM User Manual.

Motor Controllers

There are a variety of different motor controllers which work with the FRC Control System and are approved for use. These devices are used to provide variable voltage control of the brushed DC motors used in FRC. They are listed here in alphabetical order.

DMC-60 Motor Controller



The DMC-60 is a PWM motor controller from Digilent. The DMC-60 features integrated thermal sensing and protection including current-foldback to prevent overheating and damage, and four multi-color LED indicators frequency to indicate speed, direction, and status for easier debugging. For more information, see the DMC-60 reference manual: https://reference.digilentinc.com/dmc-60/reference-manual

Jaguar Motor Controller

The Jaguar Motor Controller from VEX Robotics (formerly made by Luminary Micro and Texas Instruments) is a variable speed motor controller for use in FRC. The Jaguar can be controlled using either the PWM interface or over the CAN bus. The Black Jaguar can also be used to convert from RS232 (from the BDC-Comm PC program) to the CAN bus. The Jaguar should be connected using one of these control interfaces and powered from the Power Distribution Panel. For more information, see the Jaguar Getting Started Guide, Jaguar Datasheet and Jaguar FAQ on [this page](#).

SD540B and SD540C Motor Controllers

The SD540 Motor Controller from Mindsensors is a variable speed motor controller for use in FRC. The SD540B is controlled using the PWM interface. The SD540C is controllable over CAN. Limit switches may be wired directly to the SD540 to limit motor travel in one or both directions. Switches on the device are used to flip the direction of motor travel, configure the wiring polarity of limit switches, set Brake or Coast mode, and put the device in calibration mode. For more information see the Mindsensors FRC page: http://www.mindsensors.com/68-frc

SPARK Motor Controller

The SPARK Motor Controller from REV Robotics is a variable speed motor controller for use in FRC. The SPARK is controlled using the PWM interface. Limit switches may be wired directly to the SPARK to limit motor travel in one or both directions. The RGB status LED displays the current state of the device including whether the device is currently in Brake mode or Coast mode. For more information, see the REV Robotics SPARK product page: http://www.revrobotics.com/product/spark/

Talon Motor Controller

The Talon Motor Controller from Cross the Road Electronics is a variable speed motor controller for use in FRC. The Talon is controlled over the PWM interface. The Talon should be connected to a PWM output of the roboRIO and powered from the Power Distribution Panel. For more information see the [Talon User Manual.]()

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Talon SRX

The Talon SRX motor controller is a CAN-enabled "smart motor controller" from Cross The Road Electronics/VEX Robotics. The Talon SRX has an electrically isolated metal housing for heat dissipation, making the use of a fan optional. The Talon SRX can be controlled over the CAN bus or PWM interface. When using the CAN bus control, this device can take inputs from limit switches and potentiometers, encoders, or similar sensors in order to perform advanced control such as limiting or PID(F) closed loop control on the device. For more information see the Talon SRX User Manual.

Note: CAN Talon SRX has been removed from WPILib. See this blog for more info and find the CTRE Toolsuite installer here: http://www.ctr-electronics.com/control-system/hro.html#product_tabs_technical_resources

Victor 888 Motor Controller / Victor 884 Motor Controller

The Victor 888 Motor Controller from VEX Robotics is a variable speed motor controller for use in FRC. The Victor 888 replaces the Victor 884, which is also usable in FRC. The Victor is controlled over the PWM interface. The Victor should be connected to a PWM output of the roboRIO and powered from the Power Distribution Panel. For more information, see the Victor 884 User Manual and Victor 888 User Manual.

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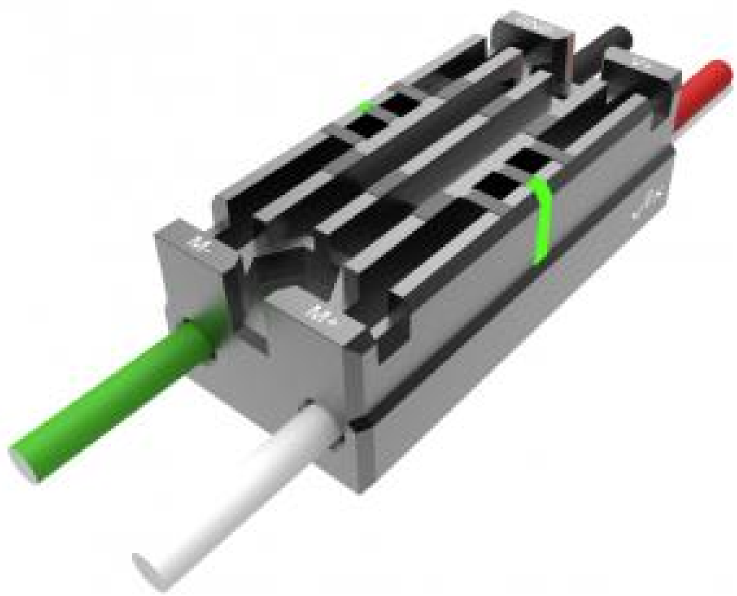
Victor SP



The Victor SP motor controller is a PWM motor controller from Cross The Road Electronics/VEX Robotics. The Victor SP has an electrically isolated metal housing for heat dissipation, making the use of the fan optional. The case is sealed to prevent debris from entering the controller. The controller is approximately half the size of previous models. For more information, see the Victor SP User Manual.

Spike H-Bridge Relay

The Spike H-Bridge Relay from VEX Robotics is a device used for controlling power to motors or other custom robot electronics. When connected to a motor, the Spike provides On/Off control in both the forward and reverse directions. The Spike outputs are independently controlled so it can also be used to provide power to up to 2 custom electronic circuits. The Spike H-Bridge Relay should be connected to a relay output of the roboRIO and powered from the Power Distribution Panel. For more information, see the Spike User's Guide.

Servo Power Module

The Servo Power Module from Rev Robotics is capable of expanding the power available to servos beyond what the roboRIO integrated power supply is capable of. The Servo Power Module provides up to 90W of 6V power across 6 channels. All control signals are passed through directly from the roboRIO. For more information, see the Servo Power Module webpage.

Axis M1013/M1011/206 Ethernet Camera

The Axis M1013, M1011 and Axis 206 Ethernet cameras are used for capturing images for vision processing and/or sending video back to the Driver Station laptop. The camera should be wired to a 5V power output on the Voltage Regulator Module and an open ethernet port on the robot radio. For more information, see Configuring an Axis Camera and the Axis 206, Axis M1011, Axis M1013 pages.

Microsoft Lifecam HD3000

The Microsoft Lifecam HD3000 is a USB webcam that can be plugged directly into the roboRIO. The camera is capable of capturing up to 1280x720 video at 30 FPS. For more information about the camera, see the Microsoft product page. For more information about using the camera with the roboRIO, see the Vision Processing section if this documentation.

OpenMesh OM5P-AN or OM5P-AC Radio

Either the OpenMesh OM5P-AN or OpenMesh OM5P-AC wireless radio is used as the robot radio to provide wireless communication functionality to the robot. The device can be configured as an Access Point for direct connection of a laptop for use at home. It can also be configured as a bridge for use on the field. The robot radio should be powered by one of the 12V outputs on the VRM and connected to the roboRIO controller over Ethernet. For more information, see Programming your radio for home use and the Open Mesh OM5P-AN product page.

The OM5P-AN is no longer available for purchase. The OM5P-AC is slightly heavier, has more cooling grates, and has a rough surface texture compared to the OM5P-AN.

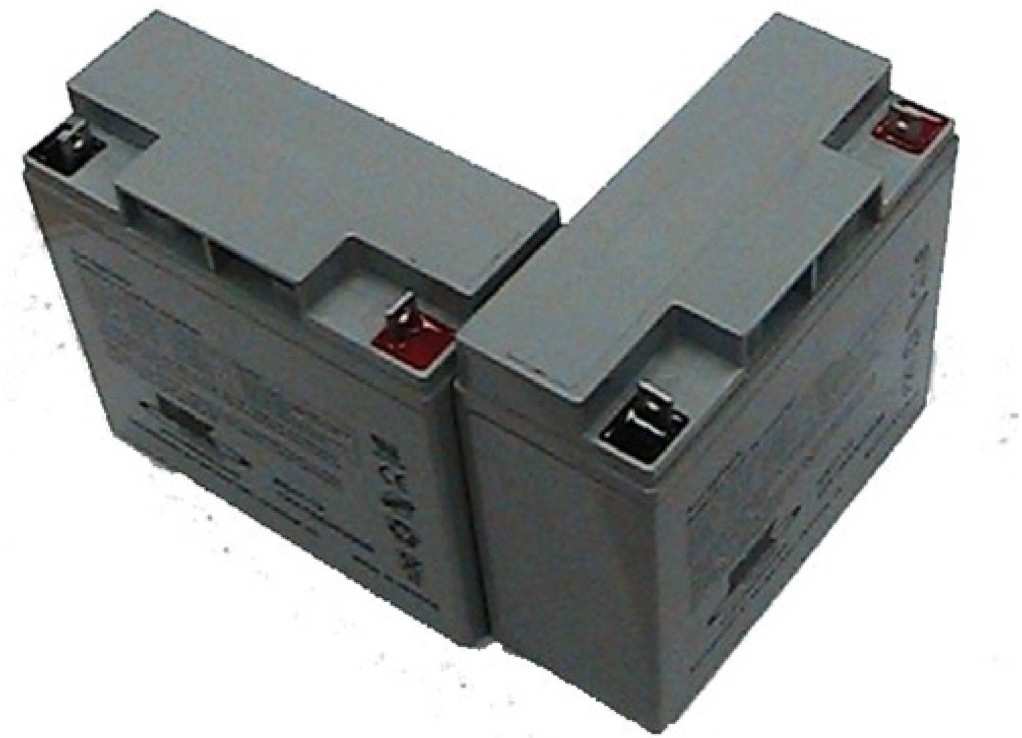
120A Circuit Breaker

The 120A Main Circuit Breaker serves two roles on the robot: the main robot power switch and a protection device for downstream robot wiring and components. The 120A circuit breaker is wired to the positive terminals of the robot battery and Power Distribution boards. For more information, please see the Cooper Bussmann 18X Series Datasheet (PN: 185120F)

Snap Action Circuit Breakers

The Snap Action circuit breakers, MX5-A40 and VB3 series, are used with the Power Distribution Panel to limit current to branch circuits. The MX5-A40 40A MAXI style circuit breaker is used with the larger channels on the Power Distribution Panel to power loads which draw current up to 40A continuous. The VB3 series are used with the smaller channels on the PDP to power circuits drawing current of 30A or less continuous. For more information, see the Datasheeets for the [MX5 series]() and [VB3 Series.]()

Robot Battery



The power supply for an FRC robot is a single 12V 18Ah battery. The batteries used for FRC are sealed lead acid batteries capable of meeting the high current demands of an FRC robot. For more information, see the Datasheets for the MK ES17-12 and Enersys NP18-12. Note that other battery part numbers may be legal, consult the 2015 FRC Manual for a complete list.

Image credits

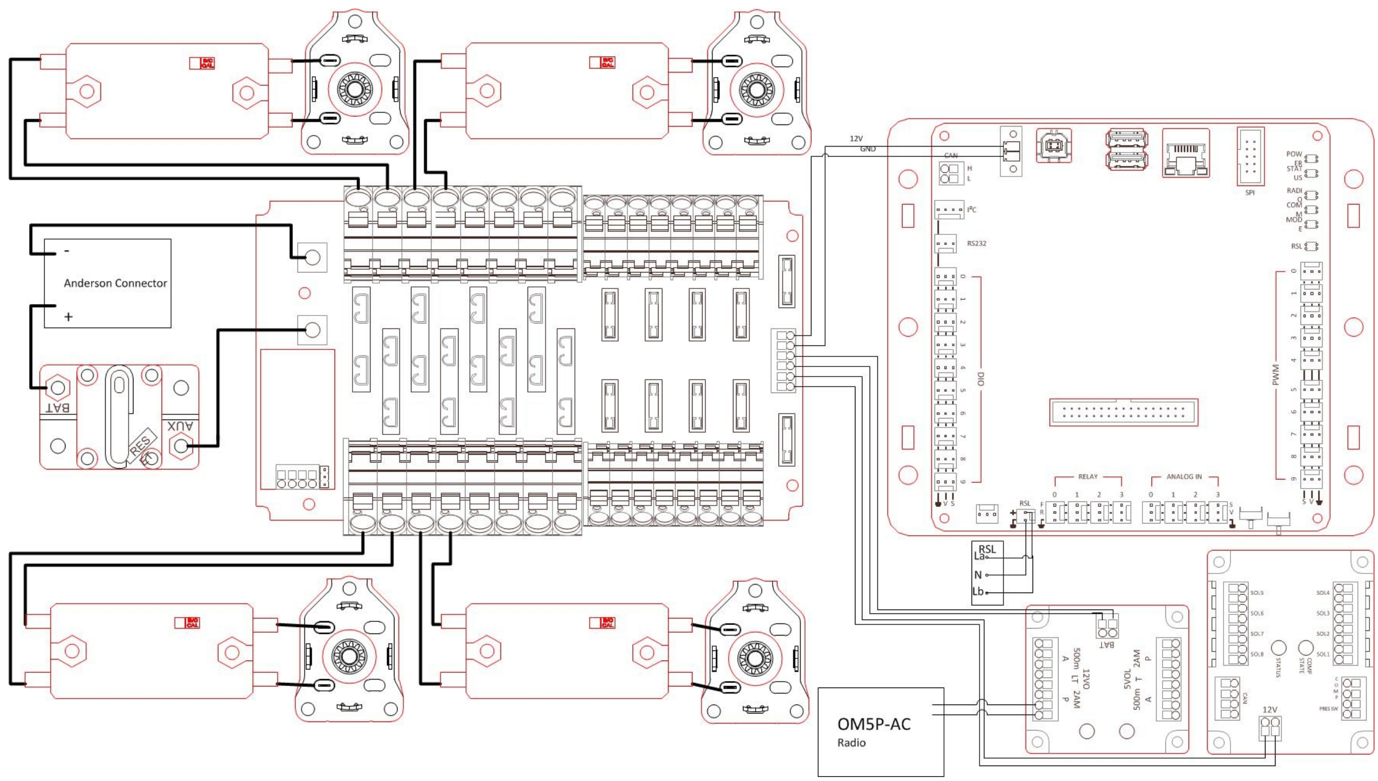
Image of roboRIO courtesy of National Instruments. Image of DMC-60 courtesy of Digilent. Image of SD540 courtesy of Mindsensors. Images of Jaguar Motor Controller, Talon SRX, Victor 888 Motor Controller, Victor SP Motor Controller, and Spike H-Bridge Relay courtesy of VEX Robotics, Inc. Lifecam, PDP, PCM, SPARK, and VRM photos courtesy of FIRST. All other photos courtesy of AndyMark Inc.

Wiring the 2017 FRC Control System

This document details the wiring of a basic electronics board for bench-top testing.

Some images shown in this section reflect the setup for a Robot Control System using VictorSP motor controllers. Wiring diagram and layout should be similar for other motor controllers. Where appropriate, a second set of images shows the wiring steps for using PWM controllers without integrated wires.

Gather Materials



Locate the following control system components and tools

Note: If using motor controllers without integrated wires, there are not enough ring/fork terminals in the kickoff kit to complete setup. You will need additional 12/14 AWG ring or fork terminals to complete the setup. They can typically be found at your local hardware or electronics parts store.

- Kit Materials:
    - Power Distribution Panel (PDP)

- roboRIO
- Pneumatics Control Module (PCM)
- Voltage Regulator Module (VRM)
- OM5P-AC radio (with power cable and Ethernet cable)
- Robot Signal Light (RSL)
- 4x Victor SP or other speed controllers
- 2x PWM y-cables
- 120A Circuit breaker
- 4x 40A Circuit breaker
- 6 AWG Red wire
- 10 AWG Red/Black wire
- 18 AWG Red/Black wire
- 22AWG yellow/green twisted CAN cable
- 2x Andersen SB50 battery connectors
- 6AWG Terminal lugs
- 12V Battery
- Red/Black Electrical tape
- Dual Lock material or fasteners
- Zip ties
- 1/4" or 1/2" plywood

- Tools Required:
  - Wago Tool or small flat-head screwdriver
  - Very small flat head screwdriver (eyeglass repair size)
  - Philips head screw driver
  - 5mm Hex key (3/16" may work if metric is unavailable)
  - 1/16" Hex key
  - Wire cutters, strippers, and crimpers
  - 7/16” box end wrench or nut driver

Create the Base for the Control System

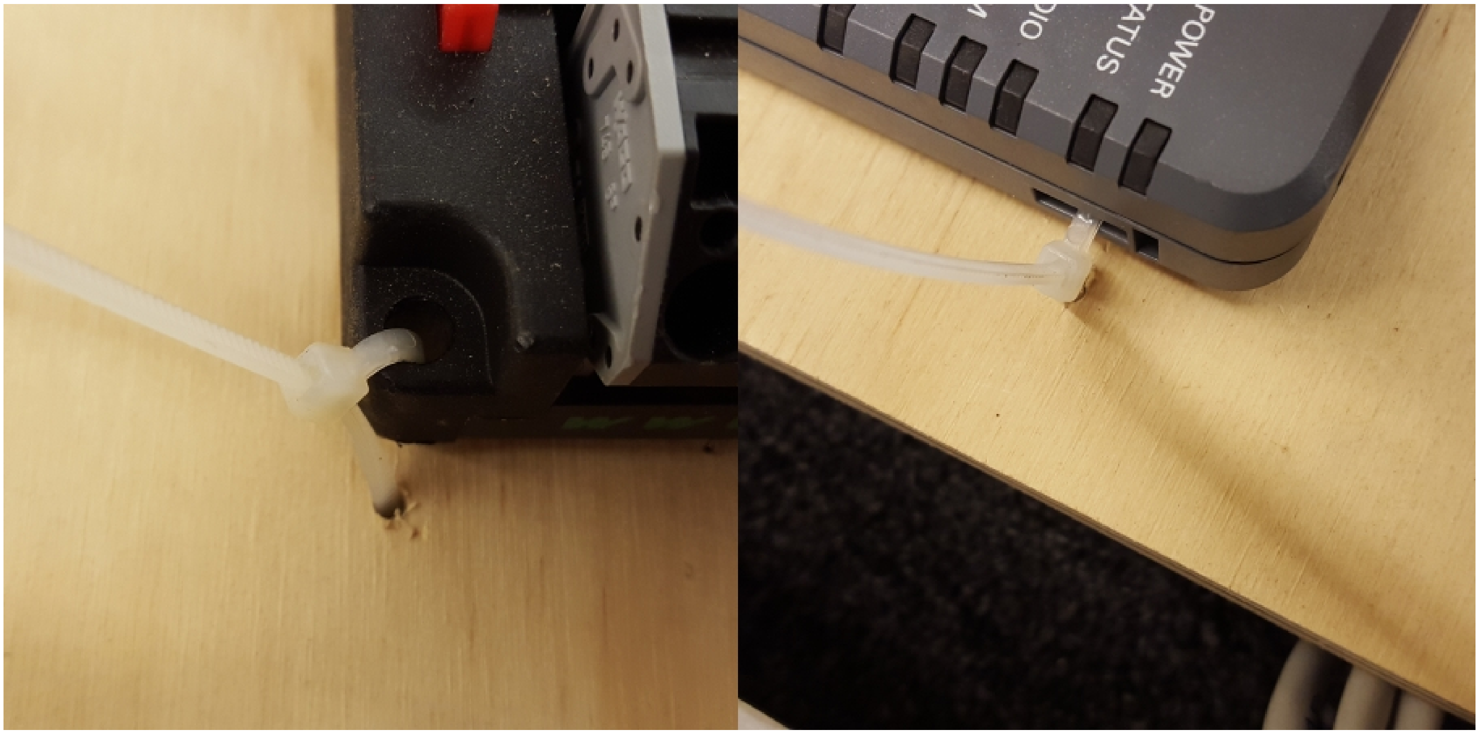
For a benchtop test board, cut piece of 1/4” or 1/2" material (wood or plastic) approximately 24" x 16". For a Robot Quick Build control board see the supporting documentation for the proper size board for the chosen chassis configuration.

Layout the Core Control System Components

Layout the components on the board. One layout that should work is shown in the images above.

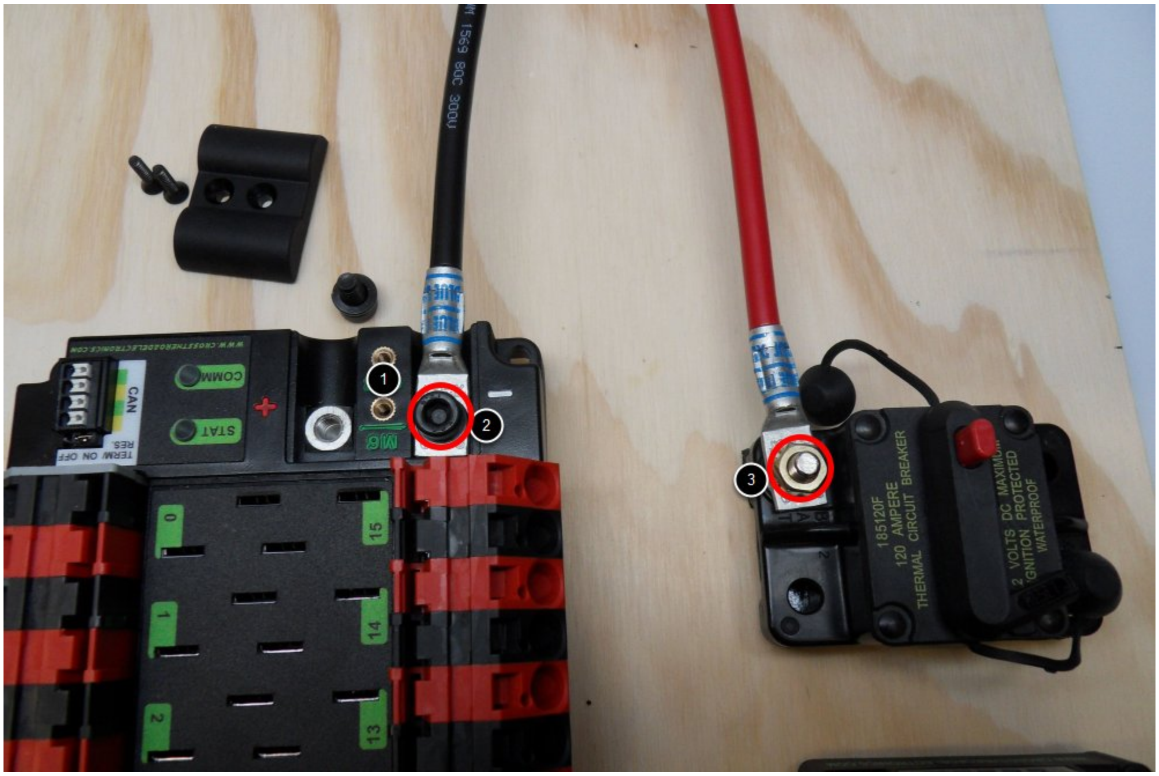
Note: If creating the board for a robot chassis, per the QuickBuild instructions for the long orientation, you may wish to turn the battery 90 degrees clockwise compared to the image above and spread the components on each side accordingly in order to accommodate building a box to retain the battery without hitting the CIM motors.

Fasten components



Using the Dual Lock or hardware, fasten all components to the board. Note that in many FRC games robot-to-robot contact may be substantial and Dual Lock alone is unlikely to stand up as a fastener for many electronic components. Teams may wish to use nut and bolt fasteners or (as shown in the image above) cable ties, with or without Dual Lock to secure devices to the board.

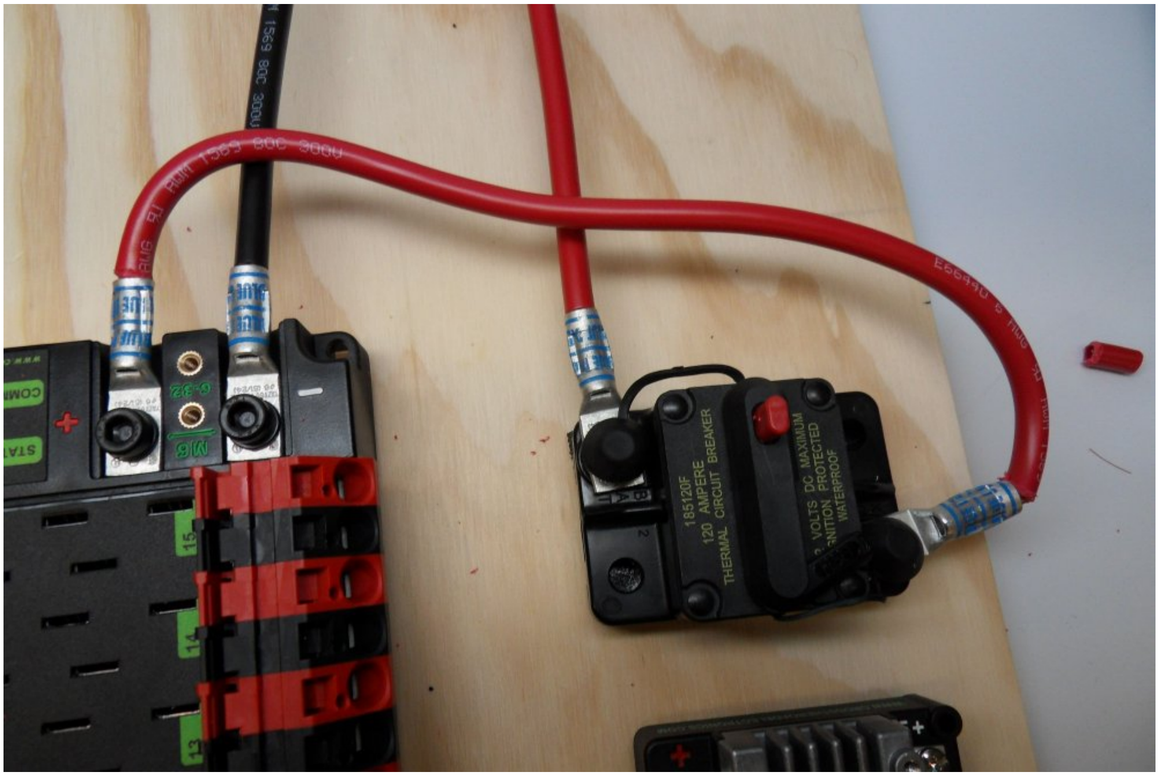
Attach Battery Connector to PDP



Requires: Battery Connector, 6AWG terminal lugs, 1/16" Allen, 5mm Allen, 7/16" Box end

1. Attach terminal lugs to battery connector.
2. Using a 1/16" Allen wrench, remove the two screws securing the PDP terminal cover.
3. Using a 5mm Allen wrench (3/16" will work if metric is not available), remove the negative (-) bolt and washer from the PDP and fasten the negative terminal of the battery connector.
4. Using a 7/16" box end wrench, remove the nut on the "Batt" side of the main breaker and secure the positive terminal of the battery conentor

Wire Breaker to PDP

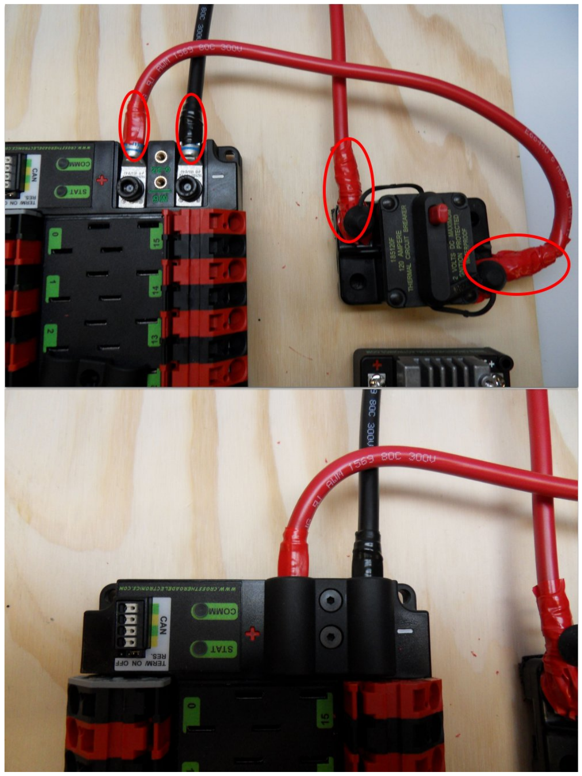


Requires: 6AWG red wire, 2x 6AWG terminal lugs, 5mm Allen, 7/16" box end

Secure one terminal lug to the end of the 6AWG red wire. Using the 7/16" box end, remove the nut from the "AUX" side of the 120A main breaker and place the terminal over the stud. Loosely secure the nut (you may wish to remove it shortly to cut, strip, and crimp the other end of the wire). Measure out the length of wire required to reach the positive terminal of the PDP.

1. Cut, strip, and crimp the terminal to the 2nd end of the red 6AWG wire.
2. Using the 7/16" box end, secure the wire to the "AUX" side of the 120A main breaker.
3. Using the 5mm, secure the other end to the PDP positive terminal.

Insulate PDP connections



Requires: 1/16" Allen, Electrical tape

1. Using electrical tape, insulate the two connections to the 120A breaker. Also insulate any part of the PDP terminals which will be exposed when the cover is replaced. One method for insulating the main breaker connections is to wrap the stud and nut first, then use the tape wrapped around the terminal and wire to secure the tape.
2. Using the 1/16" Allen wrench, replace the PDP terminal cover

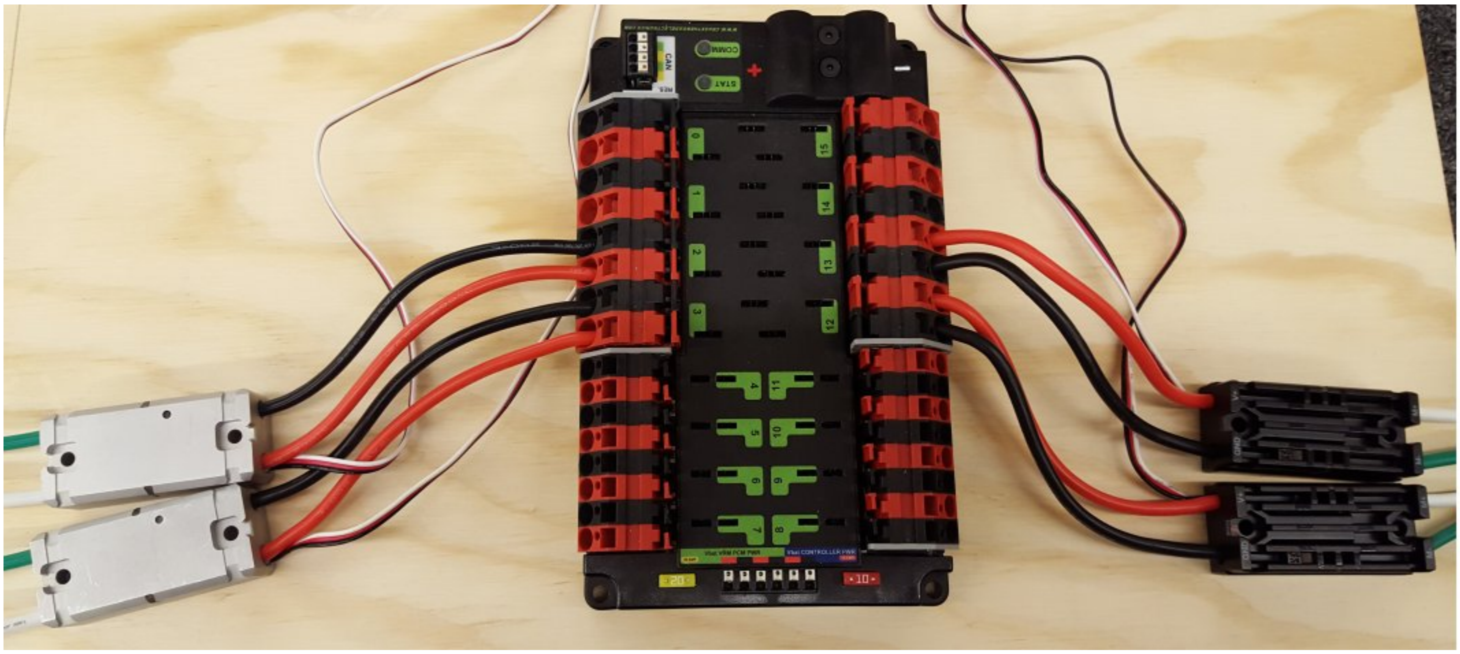
Wago connectors

The next step will involve using the Wago connectors on the PDP. To use the Wago connectors, insert a small flat blade screwdriver into the rectangular hole at a shallow angle then angle the screwdriver upwards as you continue to press in to actuate the lever, opening the terminal. Two sizes of Wago connector are found on the PDP:

- Small Wago connector: Accepts 10AWG-24AWG, strip 11-12mm (~7/16")
- Large Wago connector: Accepts 6AWG-12AWG, strip 12-13mm(~1/2")

To maximize pullout force and minimize connection resistance wires should not be tinned (and ideally not twisted) before inserting into the Wago connector.

Motor Controller Power



Requires: Wire Stripper, Small Flat Screwdriver,

Requires (for non-wire-integrated controllers): 10 or 12 AWG wire, 10 or 12 AWG fork/ring terminals, wire crimper

For each of the 4 Victor SP motor controllers:

1. Cut and strip the red and black power input wires wire, then insert into one of the 40A (larger) Wago terminal pairs.

For other controllers:

1. Cut red and black wire to appropriate length to reach from one of the 40A (larger) Wago terminal pairs to the input side of the speed controller (with a little extra for the length that will be inserted into the terminals on each end)
2. Strip one end of each of the wires, then insert into the Wago terminals.
3. Strip the other end of each wire, and crimp on a ring or fork terminal
4. Attach the terminal to the speed controller input terminals (red to +, black to -)

Weidmuller Connectors

The correct strip length is ~5/16" (8mm), not the 5/8" mentioned in the video.

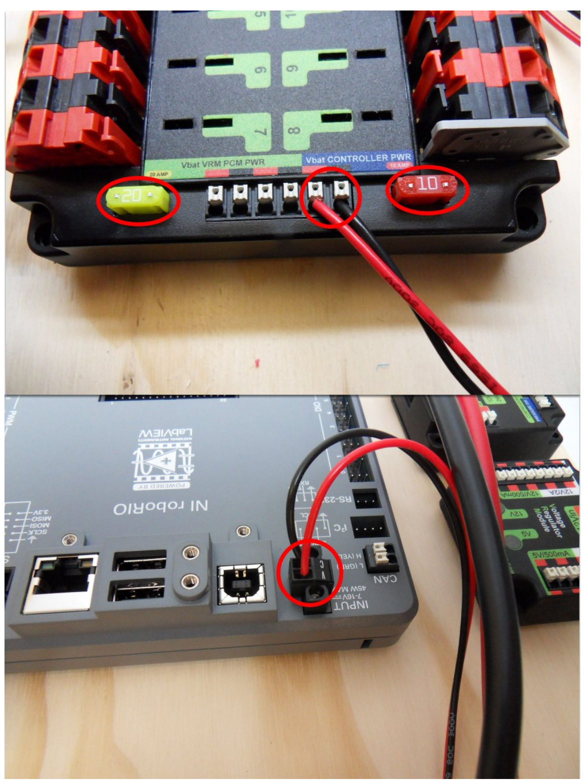
A number of the CAN and power connectors in the system use a Weidmuller LSF series wire-to-board connector. There are a few things to keep in mind when using this connector for best results:

- Wire should be 16AWG to 24AWG (consult rules to verify required gauge for power wiring)
- Wire ends should be stripped approximately 5/16"
- To insert or remove the wire, press down on the corresponding "button" to open the terminal

After making the connection check to be sure that it is clean and secure:

- Verify that there are no "whiskers" outside the connector that may cause a short circuit
- Tug on the wire to verify that it is seated fully. If the wire comes out and is the correct gauge it needs to be inserted further and/or stripped back further.

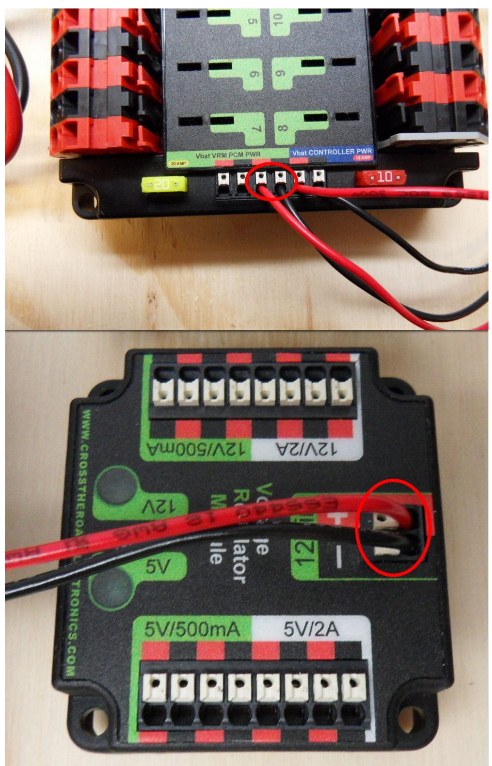
roboRIO Power



Requires: 10A/20A mini fuses, Wire stripper, very small flat screwdriver, 18AWG Red and Black

1. Insert the 10A and 20A mini fuses in the PDP in the locations shown on the silk screen (and in the image above)
2. Strip ~5/16" on both the red and black 18AWG wire and connect to the "Vbat Controller PWR" terminals on the PDB
3. Measure the required length to reach the power input on the roboRIO. Take care to leave enough length to route the wires around any other components such as the battery and to allow for any strain relief or cable management.
4. Cut and strip the wire.
5. Using a very small flat screwdriver connect the wires to the power input connector of the roboRIO (red to V, black to C). **Also make sure that the power connector is screwed down securely to the roboRIO.**

Voltage Regulator Module Power

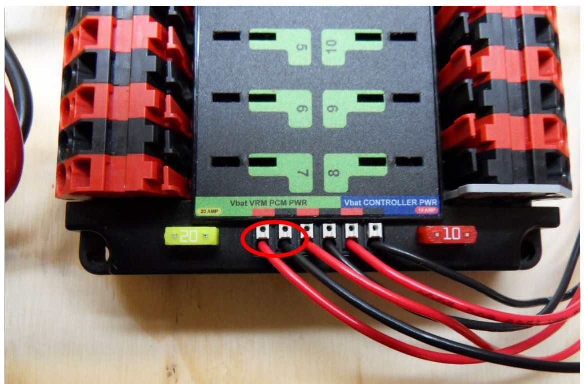


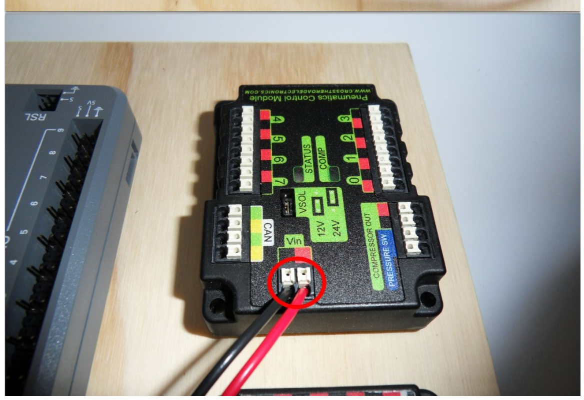
Requires: Wire stripper, small flat screwdriver (optional), 18AWG red and black wire

1. Strip ~5/16" on the end of the red and black 18AWG wire.
2. Connect the wire to one of the two terminal pairs labeled "Vbat VRM PCM PWR" on the PDP.

3. Measure the length required to reach the "12Vin" terminals on the VRM. Take care to leave enough length to route the wires around any other components such as the battery and to allow for any strain relief or cable management.
4. Cut and strip ~5/16" from the end of the wire.
5. Connect the wire to the VRM 12Vin terminals.

Pneumatics Control Module Power (Optional)



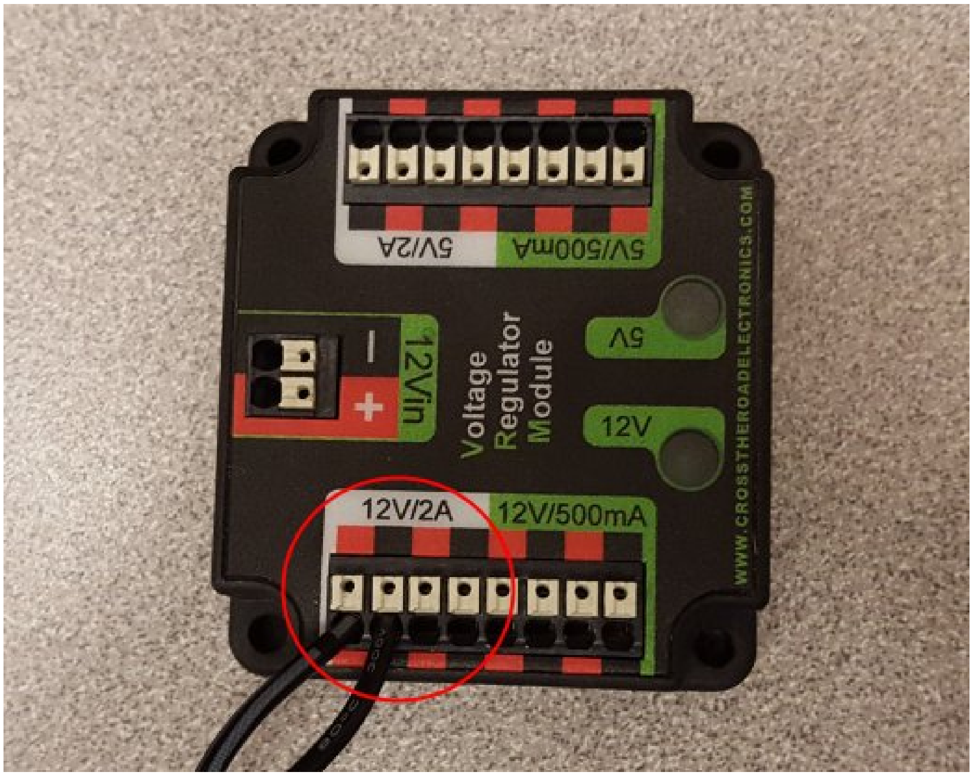


Requires: Wire stripper, small flat screwdriver (optional), 18AWG red and black wire

Note: The PCM is an optional component used for controlling pneumatics on the robot.

1. Strip ~5/16" on the end of the red and black 18AWG wire.
2. Connect the wire to one of the two terminal pairs labeled "Vbat VRM PCM PWR" on the PDP.
3. Measure the length required to reach the "Vin" terminals on the VRM. Take care to leave enough length to route the wires around any other components such as the battery and to allow for any strain relief or cable management.
4. Cut and strip ~5/16" from the end of the wire.
5. Connect the wire to the VRM 12Vin terminals.

Radio Power and Ethernet



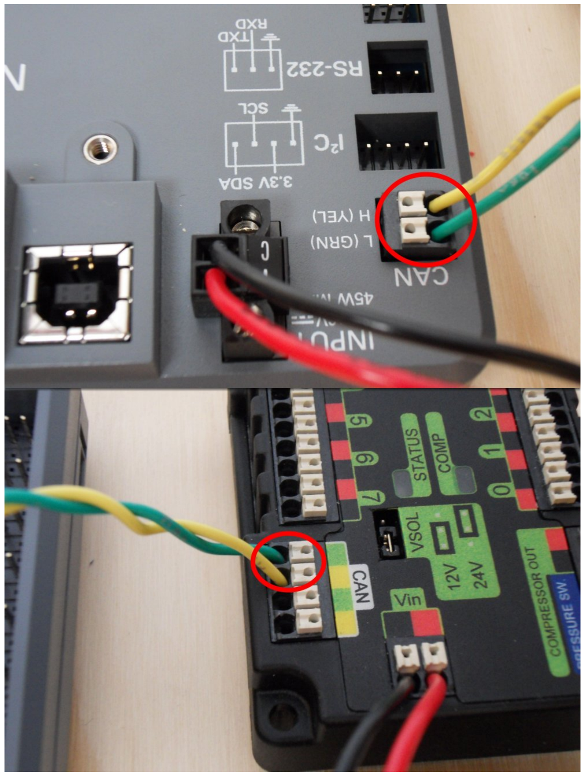
Note: This is different than the 2015 radio!!!!!

Requires: Wire stripper, small flat screwdriver (optional), OM5P-AN power wiring, Ethernet cable

1. Strip ~5/16" off of each wire on the power cord.
2. Locate the wire with the white stripes on it (one wire has white stripes, the other has writing) and attach it to either of the two red terminals on the "12V/2A" supply of the VRM.
3. Connect the other wire (with writing on it) to the black terminal immediately to the right of the red terminal used above.
4. Plug the barrel connector into the back of the OM5P-AN
5. Plug the Ethernet cable into either port on the back of the OM5P-AN and into the roboRIO.

Note: If you wish to verify the polarity of the radio power connection using a DMM or Continuity tester, the connector is center pin positive. This means that the wire connecting to the red terminal should be connected to the center of the connector, the wire connecting to the black terminal should be connected to the outside of the connector.

RoboRIO to PCM CAN

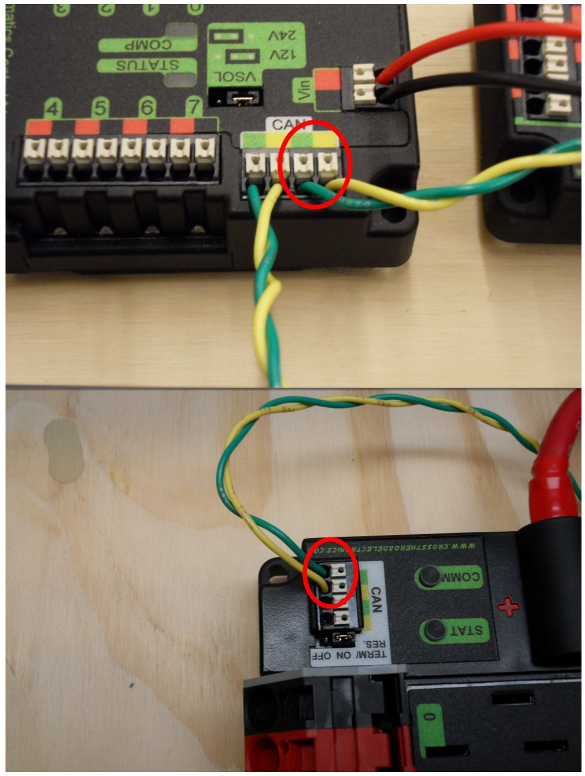


Requires: Wire stripper, small flat screwdriver (optional), yellow/green twisted CAN cable

Note: The PCM is an optional component used for controlling pneumatics on the robot. If you are not using the PCM, wire the CAN connection directly from the roboRIO (shown in this step) to the PDP (show in the next step).

1. Strip ~5/16" off of each of the CAN wires.
2. Insert the wires into the appropriate CAN terminals on the roboRIO (Yellow->YEL, Green->GRN).
3. Measure the length required to reach the CAN terminals of the PCM (either of the two available pairs). Cut and strip ~5/16" off this end of the wires.
4. Insert the wires into the appropriate color coded CAN terminals on the PCM. You may use either of the Yellow/Green terminal pairs on the PCM, there is no defined in or out.

PCM to PDP CAN



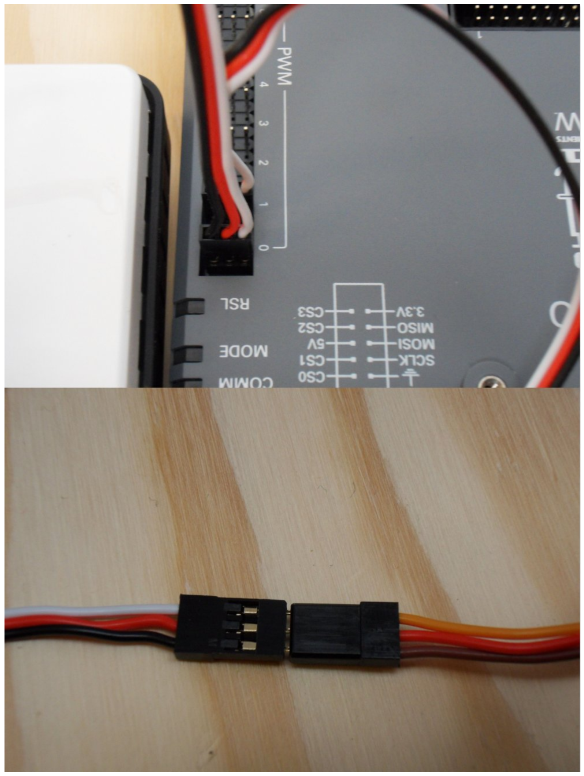
Requires: Wire stripper, small flat screwdriver (optional), yellow/green twisted CAN cable

Note: The PCM is an optional component used for controlling pneumatics on the robot. If you are not using the PCM, wire the CAN connection directly from the roboRIO (shown in the above step) to the PDP (show in this step).

1. Strip ~5/16" off of each of the CAN wires.
2. Insert the wires into the appropriate CAN terminals on the PCM.
3. Measure the length required to reach the CAN terminals of the PDP (either of the two available pairs). Cut and strip ~5/16" off this end of the wires.
4. Insert the wires into the appropriate color coded CAN terminals on the PDP. You may use either of the Yellow/Green terminal pairs on the PDP, there is no defined in or out.

Note: The PDP ships with the CAN bus terminating resistor jumper in the "ON" position. It is recommended to leave the jumper in this position and place any additional CAN nodes between the roboRIO and the PDP (leaving the PDP as the end of the bus). If you wish to place the PDP in the middle of the bus (utilizing both pairs of PDP CAN terminals) move the jumper to the "OFF" position and place your own 120 ohm terminating resistor at the end of your CAN bus chain.

PWM Cables



Requires: (Optional) 2x PWM Y-cable

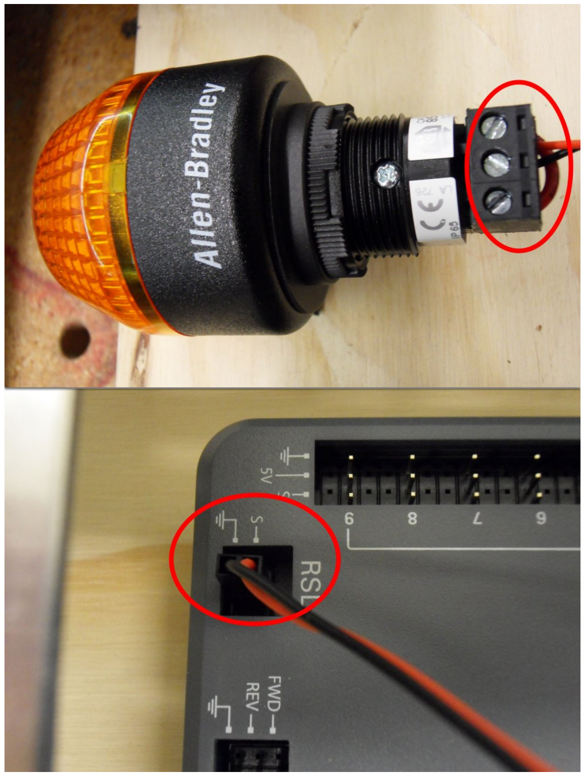
Option 1 (Direct connect):

1. Connect the PWM cables from each Victor SP directly to the roboRIO. The black wire should be towards the outside of the roboRIO. It is recommended to connect the left side to PWM 0 and 1 and the right side to PWM 2 and 3 for the most straightforward programming experience, but any channel will work as long as you note which side goes to which channel and adjust the code accordingly.

Option 2 (Y-cable):

1. Connect 1 PWM Y-cable to the PWM cables for the Victor SPs controlling one side of the robot. The brown wire on the Y-cable should match the black wire on the PWM cable.
2. Connect the PWM Y-cables to the PWM ports on the roboRIO. The brown wire should be towards the outside of the roboRIO. It is recommended to connect the left side to PWM 0 and the right side to PWM 1 for the most straightforward programming experience, but any channel will work as long as you note which side goes to which channel and adjust the code accordingly.

Robot Signal Light

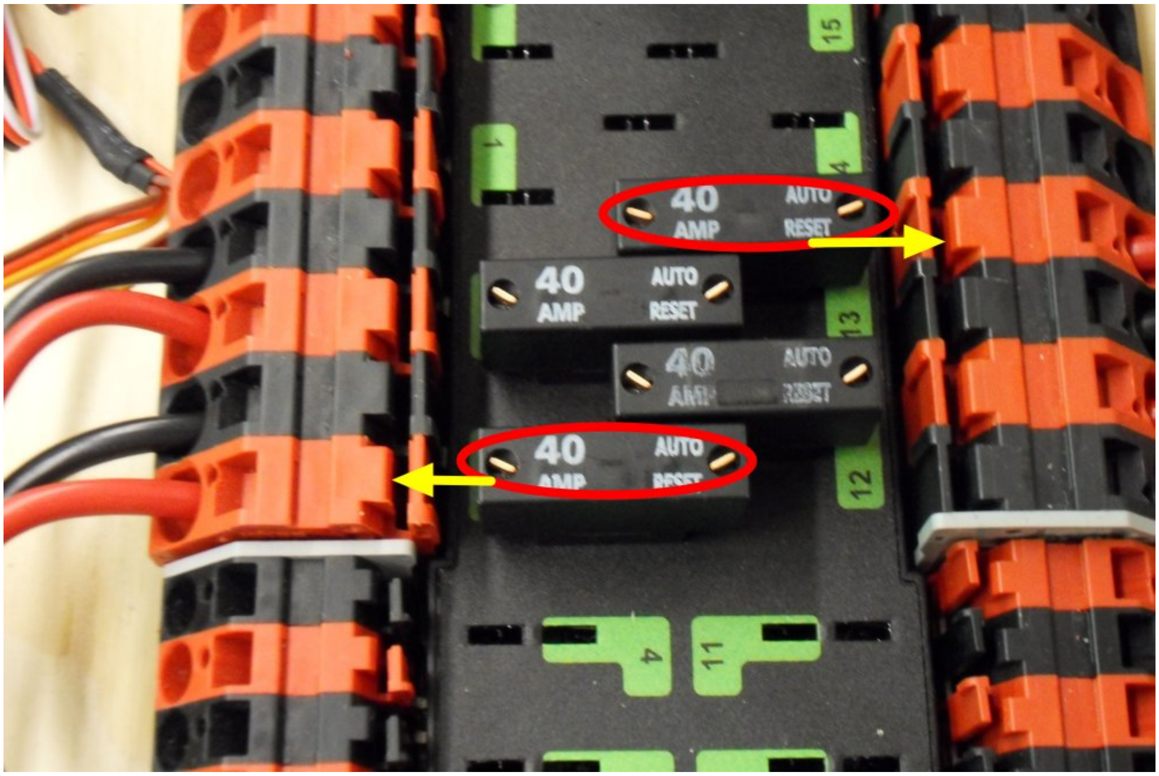


Requires: Wire stripper, 2 pin cable, Robot Signal Light, 18AWG red wire, very small flat screwdriver

1. Cut one end off of the 2 pin cable and strip both wires
2. Insert the black wire into the center, "N" terminal and tighten the terminal.
3. Strip the 18AWG red wire and insert into the "La" terminal and tighten the terminal.
4. Cut and strip the other end of the 18AWG wire to insert into the "Lb" terminal
5. Insert the red wire from the two pin cable into the "Lb" terminal with the 18AWG red wire and tighten the terminal.
6. Connect the two-pin connector to the RSL port on the roboRIO. The black wire should be closest to the outside of the roboRIO.

You may wish to temporarily secure the RSL to the control board using zipties or Dual Lock (it is recommended to move the RSL to a more visible location as the robot is being constructed)

Circuit Breakers

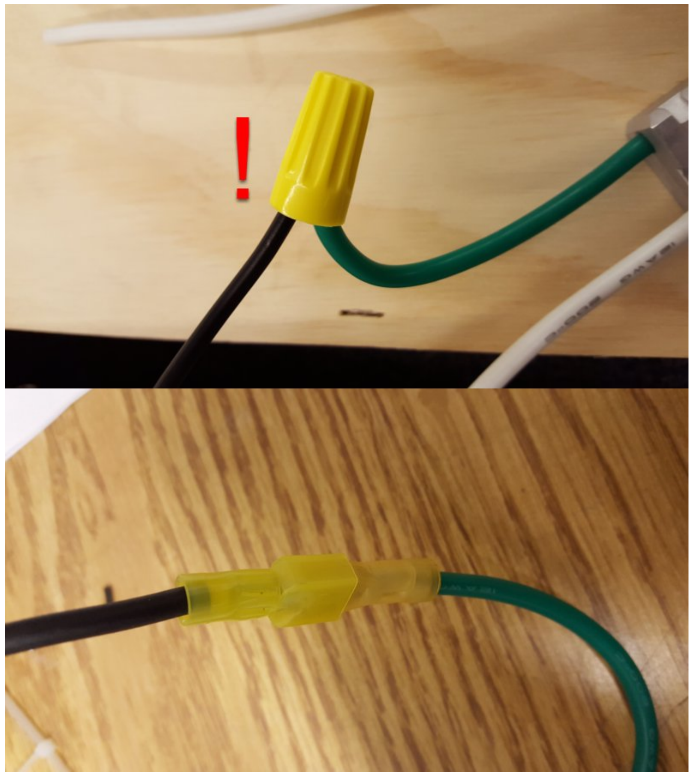


Requires: 4x 40A circuit breakers

Insert 40-amp Circuit Breakers into the positions on the PDP corresponding with the Wago connectors the Talons are connected to. Note that, for all breakers, the breaker corresponds with the nearest positive (red) terminal (see graphic above). All negative terminals on the board are directly connected internally.

If working on a Robot Quick Build, stop here and insert the board into the robot chassis before continuing.

Motor Power



Requires: Wire stripper, wire crimper, phillips head screwdriver, wire connecting hardware

For each CIM motor:

1. Strip the ends of the red and black wires from the CIM

For integrated wire controllers:

1. Strip the white and green wires from the Victor SP
2. Connect the motor wires to the Victor SP output wires (it is recommended to connect the red wire to the white M+ output). The images above show examples using wirenuts or quick disconnect terminals.

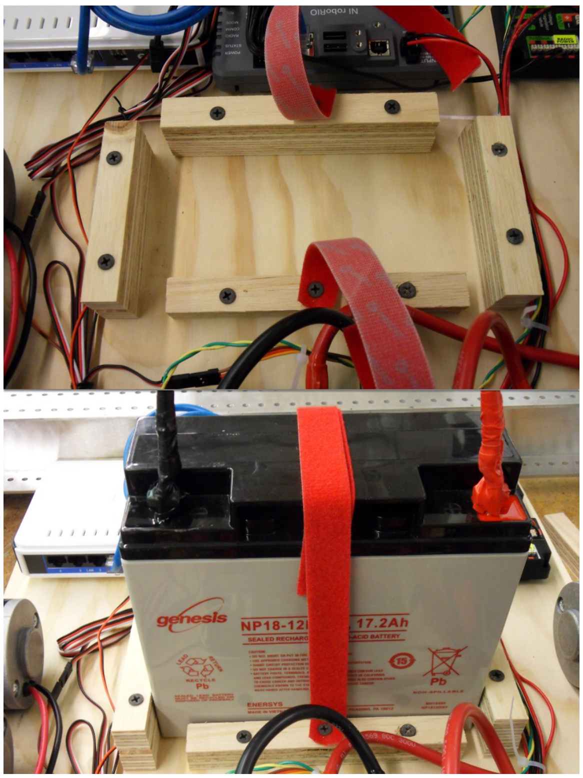
For non-integrated-wire controllers:

1. Crimp a ring/fork terminal on each of the motor wires.
2. Attach the wires to the output side of the motor controller (red to +, black to -)

Warning: Wire nuts are not recommended for permanent FRC use as they are not intended for vibration environments. They are shown only as an example of a possible temporary solution.

The Digikey, or TE Connectivity vouchers in the Virtual Kit can be used to purchase suitable quick-disconnecting or splice connectors or they can typically be found at your local hardware or electronics parts store.

Battery Box



Requires: Plywood Scraps, plywood cutting tool (e.g. saw), 10x 2" wood screws, drill, 1/8" drill but, Philips head driver bit or philips head screwdriver, velcro wrap

Construct a battery box. the design shown uses scraps of plywood left over from cutting out the electronics board (4 pieces 4"x1.5" for the short sides of the battery stacked 2 high, 3 pieces 6"x1.5" for the front and back stacked 2 high in the back). Use the velcro wrap to make a pair of straps which will overlap to secure the battery.

Note: The battery box shown here is an example, sufficient for driving the robot. Teams should ensure that their battery will be securely held in their final design in the face of potentially violent robot-to-robot collision.

STOP

STOP!!

Before plugging in the battery, make sure all connections have been made with the proper polarity. Ideally have someone that did not wire the robot check to make sure all connections are correct.

- Start with the battery and verify that the red wire is connected to the positive terminal
- Check that the red wire passes through the main breaker and to the + terminal of the PDP and that the black wire travels directly to the - terminal.
- For each motor controller, verify that the red wire goes from the red PDP terminal to the Talon input labeled with the red + (not the white M+!!!!)
- For each device on the end of the PDP, verify that the red wire connects to the red terminal on the PDP and the red terminal on the component.
- Verify that the wire with the white stripe on the radio power supply is connected to the red terminal of the Radio supply on the VRM

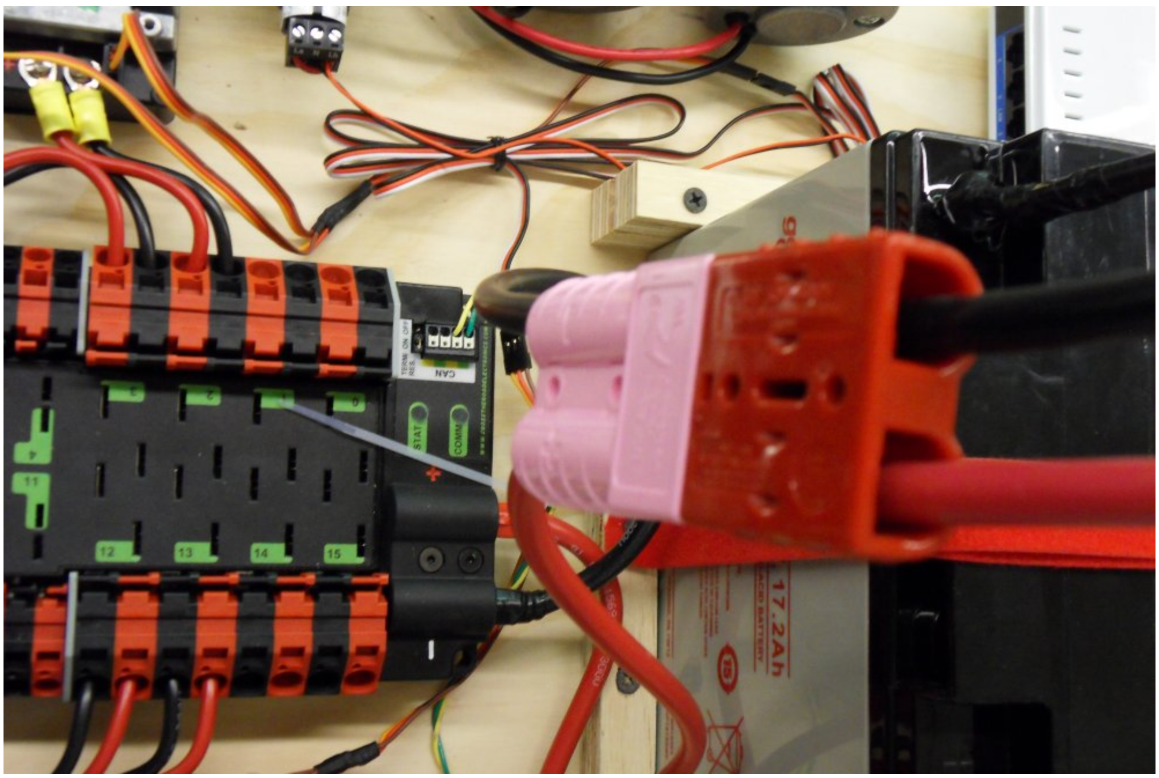
It is also recommended to put the robot on blocks so the wheels are off the ground before proceeding. This will prevent any unexpected movement from becoming dangerous.

Manage Wires

Requires: Zip ties

Now may be a good time to add a few zip ties to manage some of the wires before proceeding. This will help keep the robot wiring neat.

Connect Battery

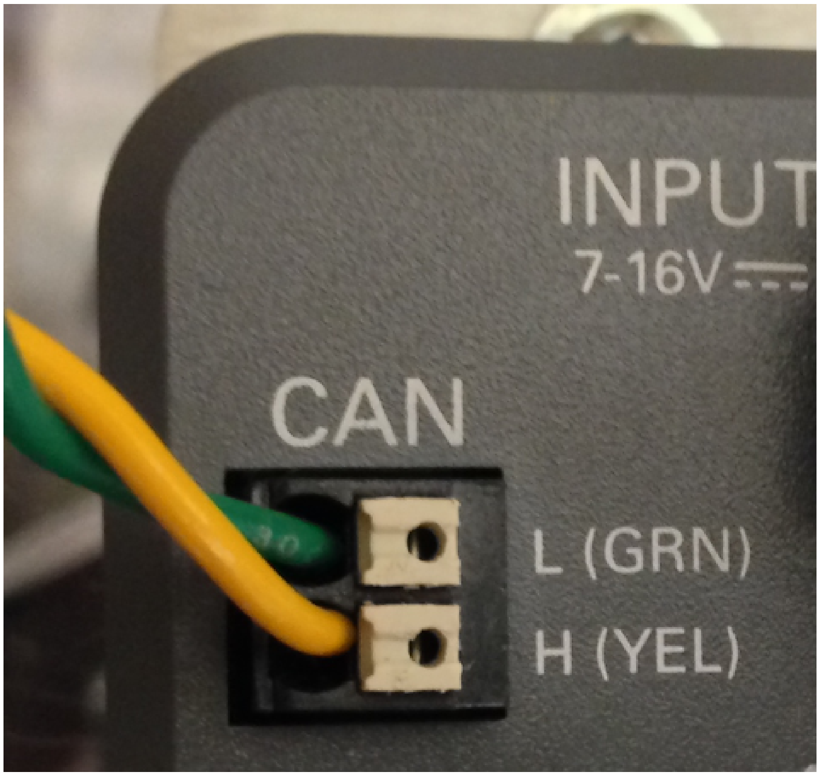


Connect the battery to the robot side of the Andersen connector. Power on the robot by moving the lever on the top of the 120A main breaker into the ridge on the top of the housing.

Wiring CAN Jaguars

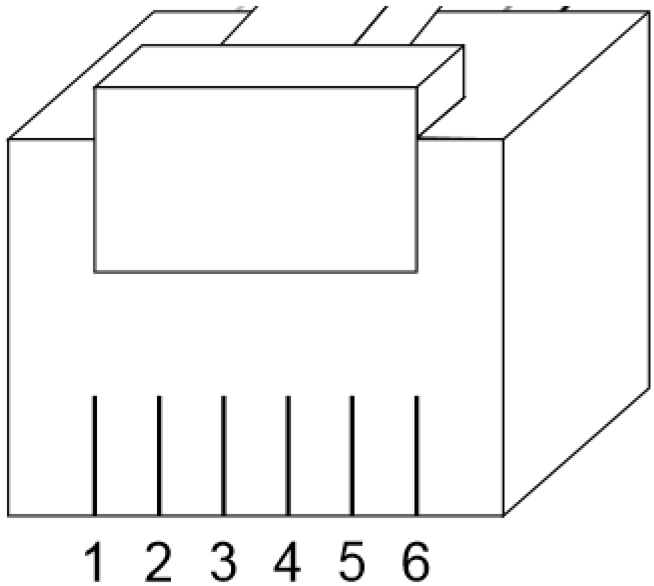
This article describes how to connect Jaguar speed controllers to the CAN bus of the 2015 FRC Control System

2015 FRC Control System CAN wiring



The 2015 FRC Control System uses simple twisted pair wiring for the CAN connections with Weidmuller wire-to-board connectors on the components allowing you to wire to them directly. The wiring is labeled with CAN High (CANH) as Yellow and CAN Low (CANL) as Green.

Jaguar CAN Wiring



The Jaguar uses an RJ-45 connector for the CAN connection. The center two pins of the connector are used for the CAN wiring. If crimping to a 6P6C connector, pin 3 is CANH and pin 4 is CANL. If using a 6P4C connector, pin 2 is CANH and pin 3 is CANL. If connecting to a standard telephone cable with standard wire colors, Red will be CANH and Green will be CANL

Wiring Jaguars into 2015 FRC Control System

The recommended method of wiring the 2015 FRC Control System CAN Bus is to utilize the built-in termination of the roboRIO on one end of the bus and the selectable termination (set to On) of the

Power Distribution Panel on the other end of the bus. To do this with CAN Jaguars you will need to create two adapter cables from the twisted pair wiring to the RJ-45 connector of the Jaguar. Use the descriptions of the color schemes and pinouts above to connect CANH from your twisted pair to CANH of the RJ45 and CANL to CANL. After the first Jaguar you can add additional Jaguars to the bus using a straight-pinned (sometime called a reverse-cable because the tabs will face opposite directions) 6P4C or 6P6C telephone cable as described in the Jaguar Getting Started Guide. After the last Jaguar in the chain you will use another adapter cable to wire from the Jaguar to the PDP.

Alternate termination

If you do not wish to use the built-in termination on the PDP you may set the PDP termination to Off. You will the need to terminate the end of the bus with your own 120 ohm termination resistor. This can be crimped directly into the RJ connector and plugged into the last Jag on the bus or (recommended) connected to stub wires which are crimped into the connector (the stub wires crimp into the contacts more securely and provide better insulation than crimping the resistor directly).

RS-232 Adapter

Though the 2015 Control System has a native CAN interface, an RS-232 to RJ-45 adapter is still necessary for updating Jaguar firmware from a PC using BDC-Comm (more details on this process in the next article). Details on making this adapter can be found in the Jaguar Getting Started Guide.

Updating CAN Jaguar Firmware

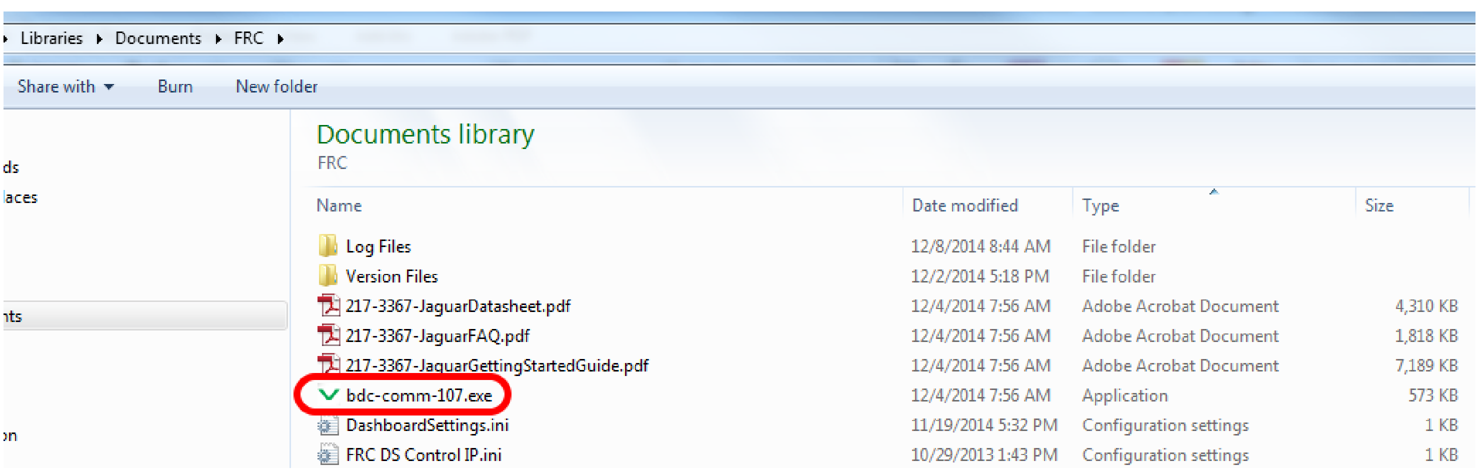
To use CAN Jaguars with the 2015 Control system, teams will have to update them to the latest version of the firmware. The recommended method to do so is by using the serial interface and the BDC-Comm software tool.

Cable and configuration

Using BDC-Comm requires a serial port (or USB->Serial adapter) on a Windows PC. You will also need a DB-9 to RJ-11 adapter cable. Instructions for building this cable if necessary can be found on page 24 and 25 of the [Jaguar Getting Started Guide.]

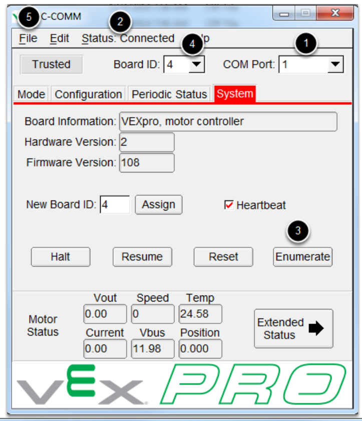
For updating firmware it is recommended to have the minimum number of devices on the bus. For Black Jaguars this means that you should connect the DB-9 to RJ-11 cable directly to the left RJ-11 port (when looking at the Jaguar with the fan housing at the back) on the Jaguar being updated and nothing should be connected to the right port. For Grey Jaguars, you will need to have one Black Jaguar serve as the RS232 to CAN bridge; connect the DB-9 to RJ-11 cable to the left port of a Black Jaguar and a RJ-11 to RJ-11 "reverse" cable between the right port of the Black Jaguar and either port of the Grey Jaguar (for details on this cable, see the CAN cable section on Page 23 of the [Jaguar Getting Started Guide].)

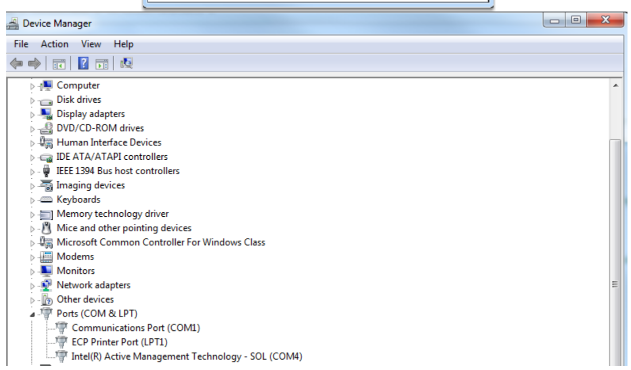
Running BDC-Comm



Navigate to **C:\Users\Public\Documents\FRC** and double click on the BDC-Comm executable.

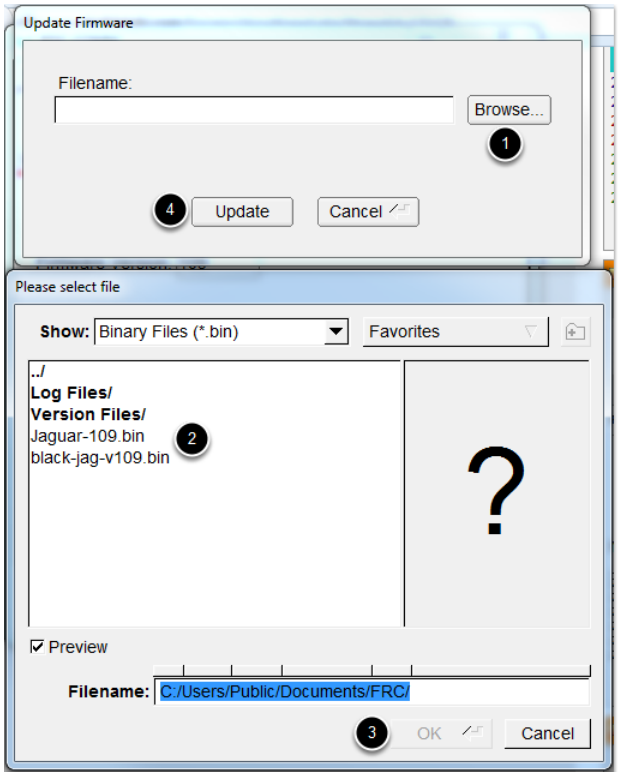
Using BDC-Comm





1. Select the correct COM port to match the serial connection you are using. If you're unsure, you can open Control-Panel->Device Manager and expand the "Ports (COM&LPT)" listing to view descriptions of all of the ports. In the second image above, you can see that COM1 is the regular serial port and COM4 is an internal port for some Intel technology that's part of the computer.
2. Verify that this menu title reads "Status: Connected". If not, click on the menu and select the Connect button
3. Click Enumerate
4. Verify that a Board ID shows up in this box. If you are updating a Grey Jag (so you have 2 Jags on the bus), select the Board ID for the Jag you want to update.
5. Select File->Update Firmware

Selecting Firmware



1. Click the browse button
2. Select the correct firmware to upload (Jaguar for Grey Jaguars, black-jag for Black Jaguars)
3. Click OK
4. Click Update

A progress bar should appear indicating the status of the update process. When the update completes, the progress bar dialog will disappear and the Firmware Version field on the BDC-Comm page should update to reflect the new firmware.

Troubleshooting

The section lists troubleshooting steps for some common issues encountered when attempting to update Jaguar firmware.

Unable to Connect to Serial Port

If BDC-Comm is unable to connect to the serial port it may be because the port is already in use by another program, cannot be accessed by the user running the program or it may indicate an issue with the driver for the port or adapter.

1. Restart the computer, then re-open BDC-Comm and try again.
2. Close as many programs as possible, restart BDC-Comm and try again.
3. Re-open BDC-Comm by right clicking on it and selecting Run as Administrator and try again.
4. Follow any vendor instructions to re-install the drivers for your USB to Serial converter and try again.

Board ID does not appear

If the lights on the Jaguar are behaving normally but the device will not enumerate (Board ID does not appear in the box), check that all cables are correctly made and properly secured. Check if you can contact another Jaguar using the same cables and computer, if another Jaguar works properly you need to verify that the spring contacts of the Jaguar CAN port are not bent or pressed in. Carefully pulling these contacts outwards may result in better connection, causing the Jaguar to function properly again.

Jaguar LED off

If the Jaguar is properly powered and the Jaguar LED does not light at all, there are two possible causes:

1. The Jaguar has been damaged to the point it does not properly power on.
2. The Jaguar firmware has been erased or corrupted and the Jaguar is stuck in the bootloader.

Jaguars in the second scenario can be revived by using the Recover Device menu option from inside BDC-comm

Wiring Pneumatics

Wiring pneumatics has been made very simple in the 2015 Control System. A single Pneumatics Control Module is all that will be needed for many pneumatics applications, with additional PCMs supporting more complex designs including more than 8 solenoid channels or a mix of 12V and 24V solenoids.

Wiring Overview

A single PCM will support many pneumatics applications, providing an output for the compressor, input for the pressure switch and outputs for up to 8 solenoid channels (12V or 24V selectable). The module is connected to the roboRIO over the CAN bus and powered via 12V from the PDP.

PCM Power and Control Wiring

The first PCM on your robot can be wired from the PDP VRM/PCM connectors on the end of the PDP. The PCM is connected to the roboRIO via CAN and can be placed anywhere in the middle of the CAN chain (or on the end with a custom terminator). For more details on wiring a single PCM see Wiring the 2015 FRC Control System. Additional PCMs can be wired to a standard Wago connector on the side of the PDP and protected with a 20A or smaller circuit breaker. Additional PCMs should also be placed anywhere in the middle of the CAN chain.

The Compressor

The compressor can be wired directly to the Compressor Out connectors on the PCM. If additional length is required, make sure to use 18 AWG wire or larger for the extension.

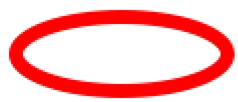
The Pressure Switch

The pressure switch should be connected directly to the pressure switch input terminals on the PCM. There is no polarity on the input terminals or on the pressure switch itself, either terminal on the PCM can be connected to either terminal on the switch. Ring or spade terminals are recommended for the connection to the switch screws (note that the screws are slightly larger than #6, but can be threaded through a ring terminal with a hole for a #6 screw such as the terminals shown in the image).

Solenoids

Each solenoid channel should be wired directly to a numbered pair of terminals on the PCM. A single acting solenoid will use one numbered terminal pair. A double acting solenoid will use two pairs (as shown in the image above). If your solenoid does not come with color coded wiring, check the datasheet to make sure to wire with the proper polarity.

Solenoid Voltage Jumper



The PCM is capable of powering either 12V or 24V solenoids, but all solenoids connected to a single PCM must be the same voltage. The PCM ships with the jumper in the 12V position as shown in the image. To use 24V solenoids move the jumper from the left two pins (as shown in the image) to the right two pins. The overlay on the PCM also indicates which position corresponds to which voltage. You may need to use a tool such as a small screwdriver, small pair of pliers, or a pair of tweezers to remove the jumper.

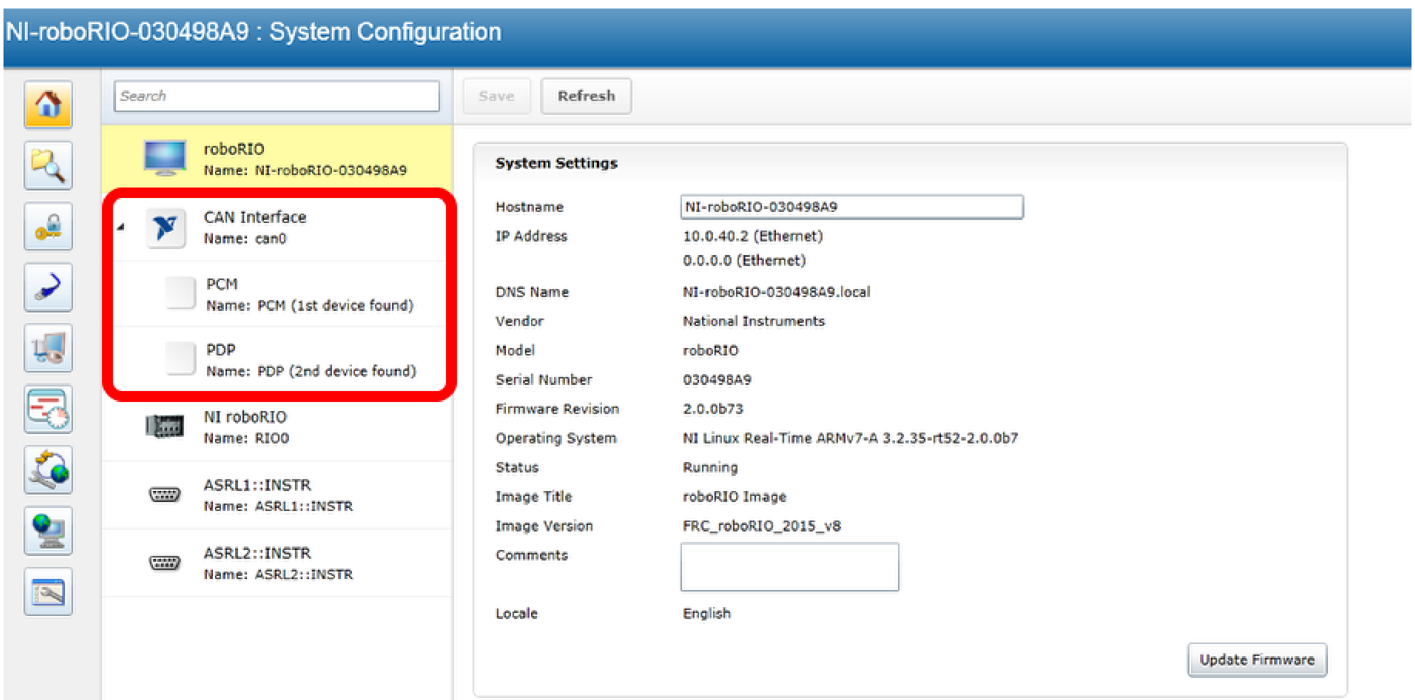
Updating and Configuring Pneumatics Control Module and Power Distribution Panel

This document describes the process of updating the firmware on the Cross the Road Electronics CAN devices.

Note: Google Chrome is removing support for the Silverlight plugin. You will need to use a different browser such as Internet Explorer to access the roboRIO webdashboard.

Note: The mDNS address for the roboRIO has changed for 2016. Please pay close attention to the new address when attempting to access the roboRIO webdashboard.

Accessing CAN Node Settings



Open the WebDash by using a browser to navigate to the roboRIO's address (172.22.11.2 for USB, or "roboRIO-####-FRC.local where #### is your team number, with no leading zeroes, for either interface). You should see a page that looks like the image above, with the CAN devices listed out below the CAN Interface.

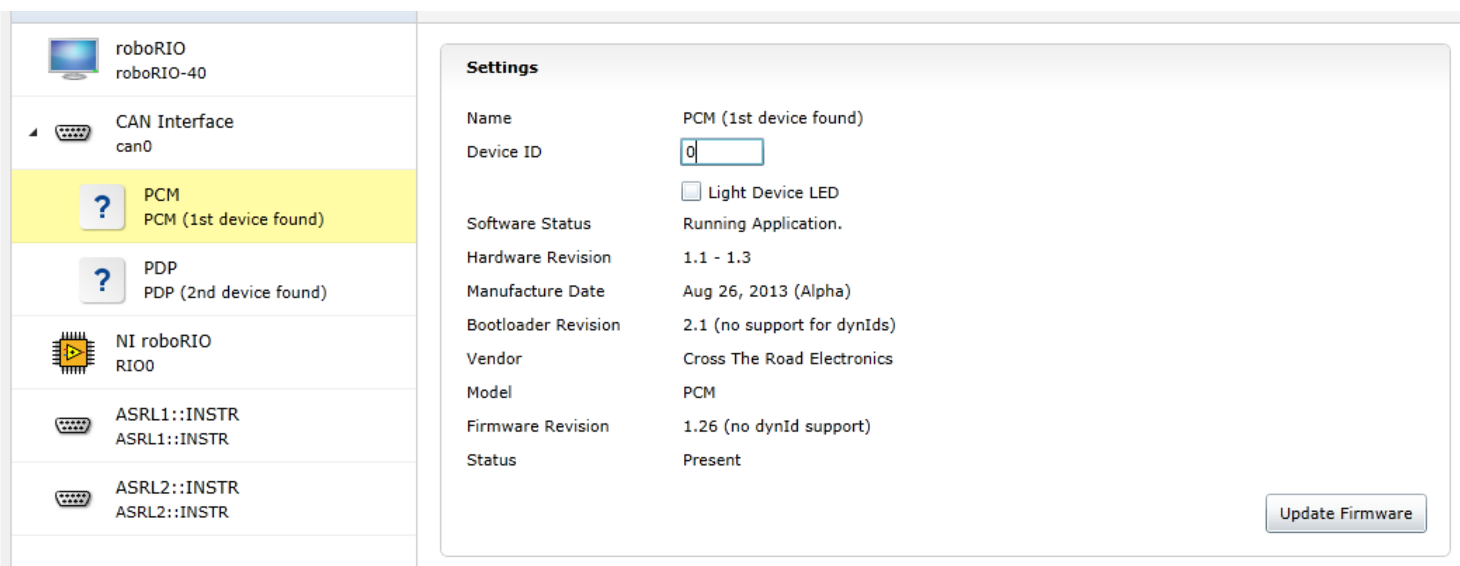
Note: The discovery order (e.g. "1st device found") is needed to separate devices of the same type but has no actual significance. You may see the PDP or a Jaguar or Talon SRX discovered first on your CAN network, even if the PCM is the first node in your CAN chain.

Troubleshooting

If you do not see any nodes below the CAN Interface entry try the following:

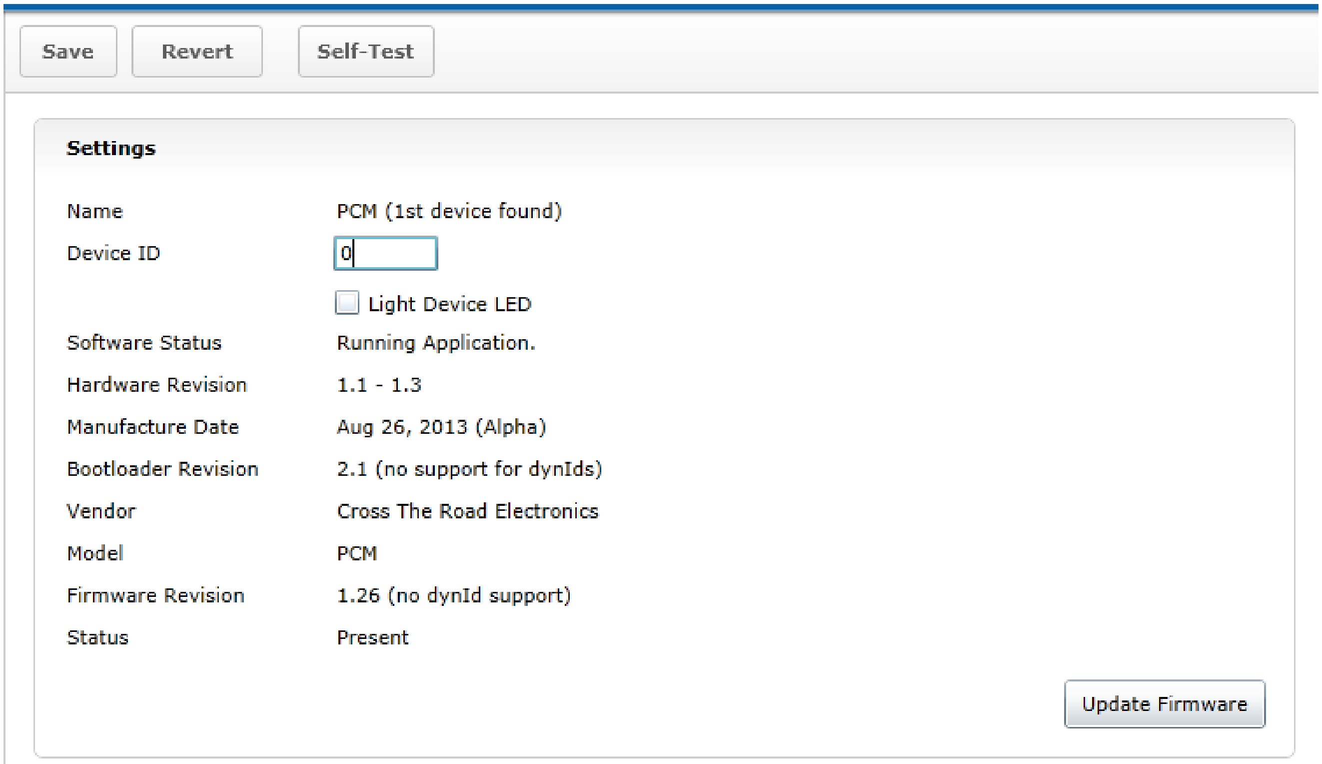
- Check the CAN cabling. If the LEDs on the PCM and PDP are red then they are not seeing CAN. Note that just because the LEDs on the devices are green does not mean the CAN cabling to the roboRIO are correct, they will turn green if the two other devices can see each other on the CAN network.
- Try refreshing the page. The device polling is done once every five seconds and the webpage itself doesn't always react to the Refresh button so if in doubt force a refresh by using the browser's refresh button or closing and re-opening the page.
- Make sure the CAN Interface is expanded. Double clicking the CAN Interface entry (or clicking the triangle to the left of the entry if present) will collapse the tree, repeating will expand it.
- Try restarting the browser. Occasionally the Silverlight plugin may crash or lock up resulting in the CAN devices silently not refreshing.

Settings



To access the Settings page of one of the CAN nodes, select the node by clicking on it's entry in the list. The settings for that node will then be displayed in the right pane.

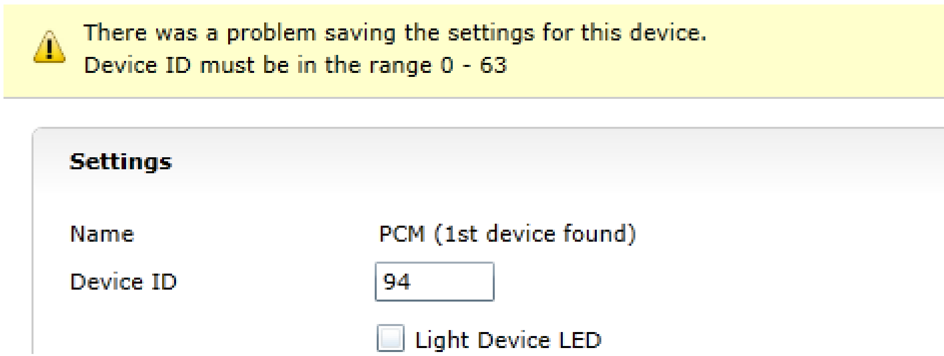
Setting CAN IDs



Each device comes with the CAN ID set to a default value of 0. If using only a single device of that type it is recommended to leave the ID at the default value to allow for the use of default Opens/ Constructors. If using multiples of a particular device type (I.E. 2 PCMs or 4 Talon SRXs) you will need to change the node ID of all but one device. To change the node ID:

- Highlight/Select the Device ID and replace it with your desired ID.
- Press "Save". The "Save button will depress and the "Refresh" button will appear.
- The PDP, PCM and Talon SRX require no additional action to save the new ID. For CAN Jaguars, a notice will appear instructing you to push the user button within 5 seconds. After doing so, click Refresh and verify that the new Device ID has been set.

ID Ranges



The valid ID ranges for each type of device are:

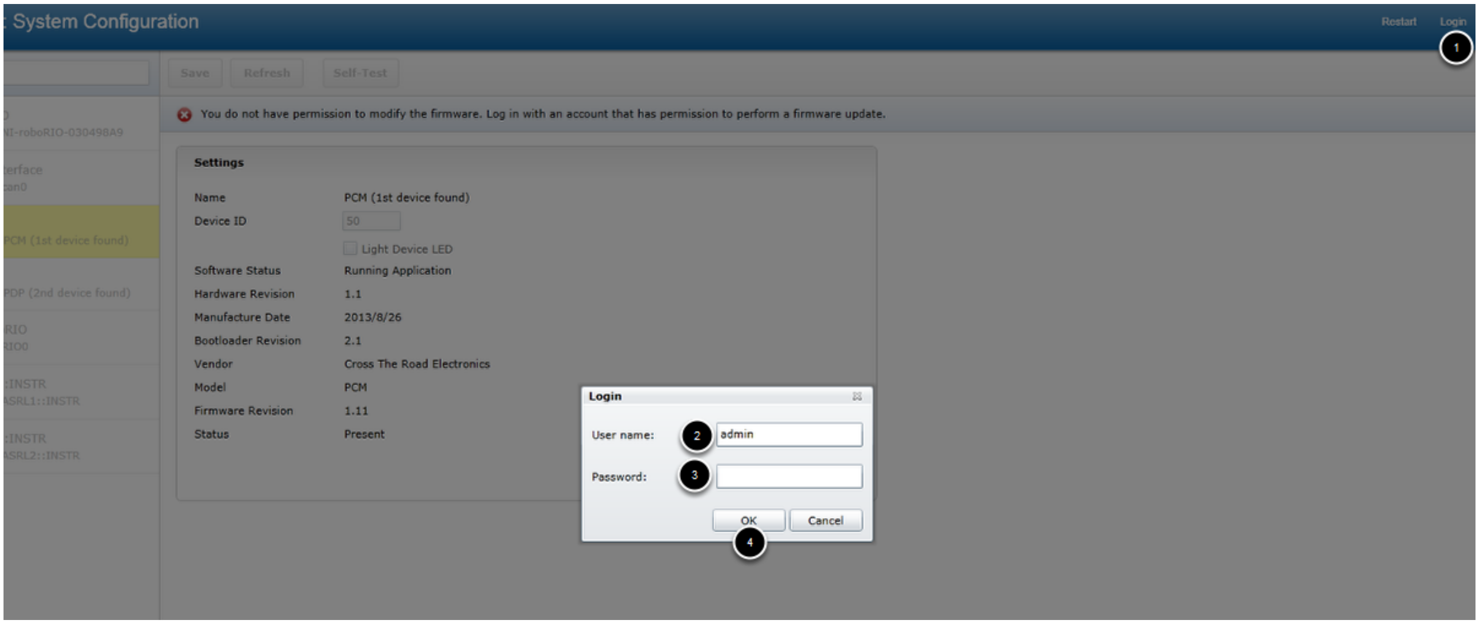
- Pneumatics Control Module (PCM) ID - 0 to 62 (inclusive)
- Power Distribution Panel (PDP) ID - 0 to 62 (inclusive)
- Jaguar ID- 1 to 63 (inclusive)
- Talon SRX ID- 0 to 62 (inclusive)

Since the ID ranges for different products don't overlap there is no issue with two or more CAN nodes of different types having the same Device ID (e.g. a PDP with ID=0, a PCM with ID=0, and a Talon SRX with ID=0 on the same bus). Using multiple devices of the same type, such as multiple PCMs or multiple Jaguars with the same node ID will result in a conflict. The web plugin supports a strategy that will allow for recovery of this condition for all devices other than Jaguars, but the devices are not properly usable from within a robot program while in this state. To recover Jaguars which have been set to the same ID you will have to remove all but one of the devices from the bus, then set the devices to non-conflicting IDs.

If you select an invalid ID you will get an immediate prompt like the one shown above.

Changing the PDP ID while using C++\Java WPILib is not recommended as there is no way to change the desired node ID in the library. PCM node IDs may be set as desired and addressed using the appropriate Open or Constructor of the Solenoid or Double Solenoid class.

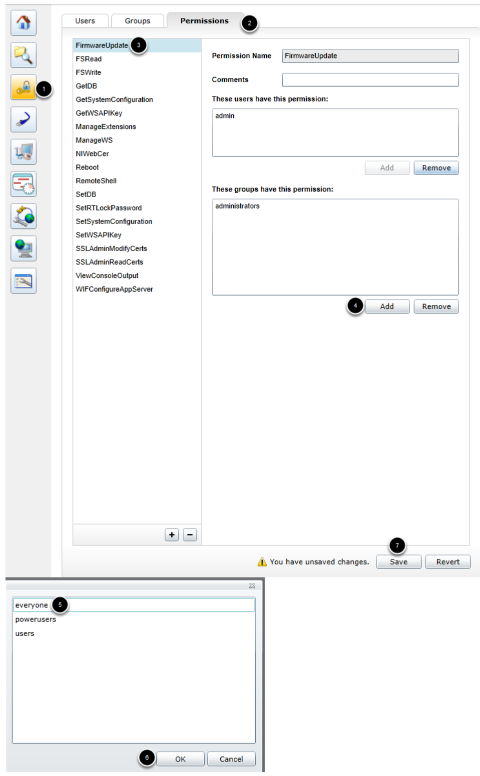
Updating CAN Node Firmware



This page can also be used to update the device firmware. To load new firmware you must be logged in:

1. Click "Login" at the top right of the page.
2. Enter the User Name "admin"
3. Leave the Password field blank.
4. Click Ok.

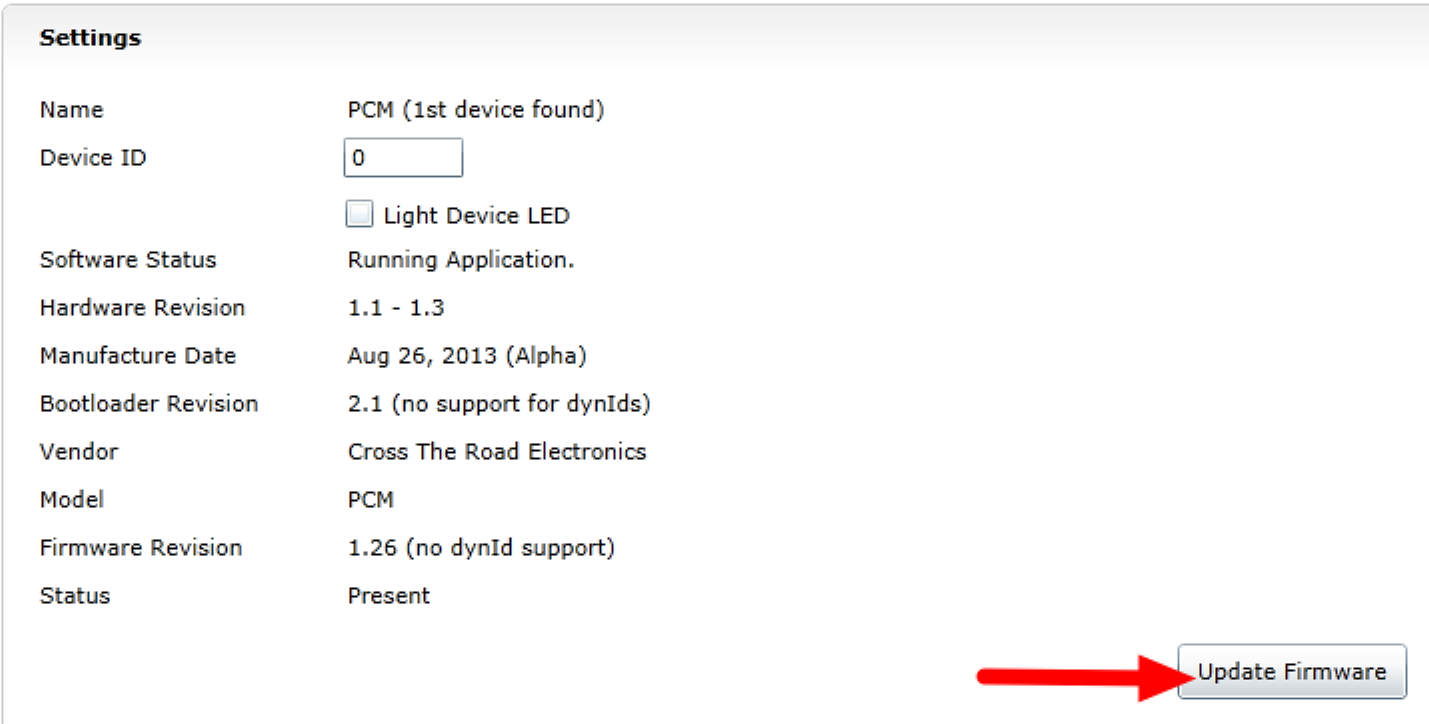
Updating Permissions



If you would like to skip the Login step in the future you can set up Permissions to allow firmware updates:

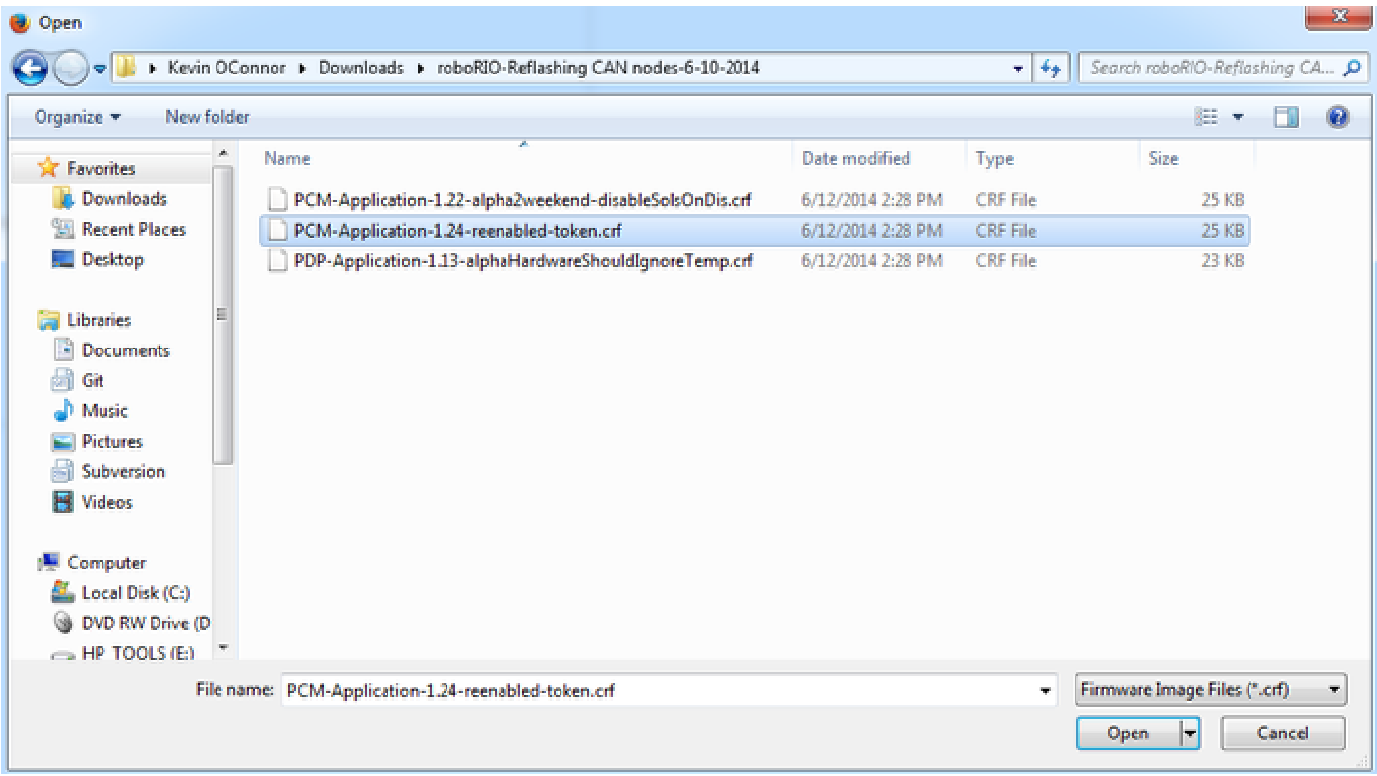
1. Click the Lock Icon in the far left pane.
2. Click the Permissions tab.
3. Select Firmware Update from the list.
4. Click Add below the second large box.
5. Select "everyone"
6. Click Ok.
7. Click Save.

Update Firmware



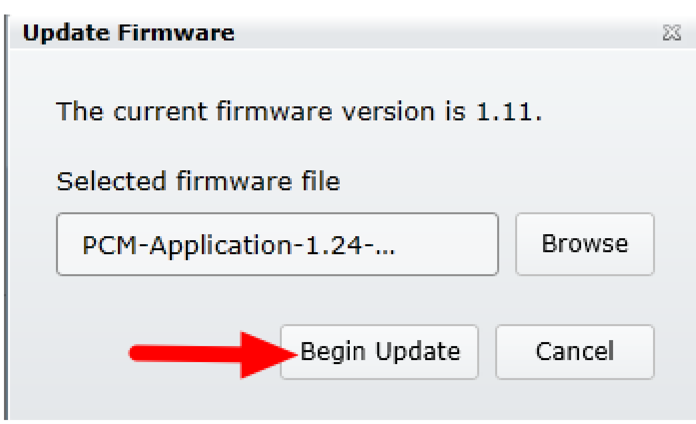
The firmware on a CAN Node is updated from the Setting's page for that node. To update the firmware of a CAN Node, press the Update Firmware button.

Select New Firmware



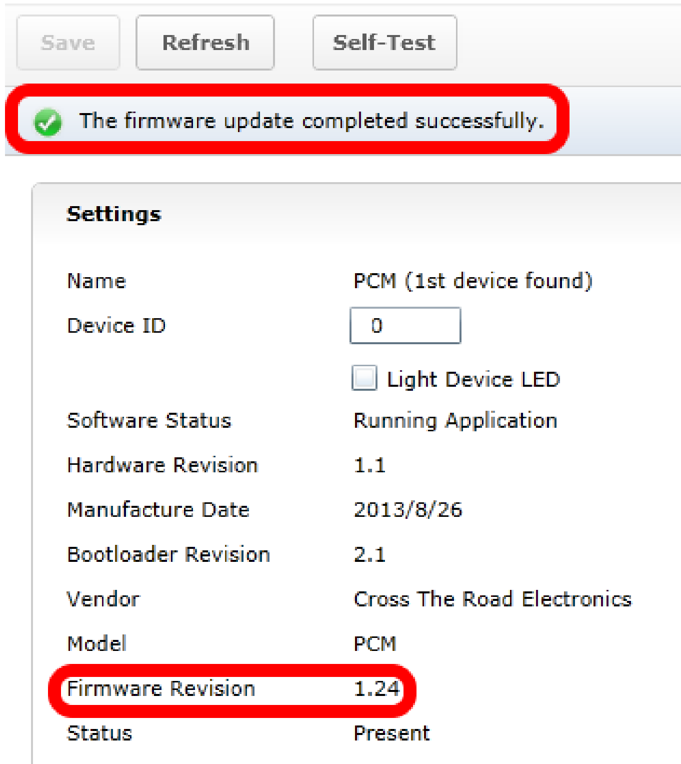
CTRE Devices use a file format call CRF (Cross The Road Firmware). Using the dialog, browse to the correct location on your computer and select the new firmware file, then click Open. Firmware for CTRE devices can be found in the C:\Users\Public\Public Documents\FRC folder.

Confirmation



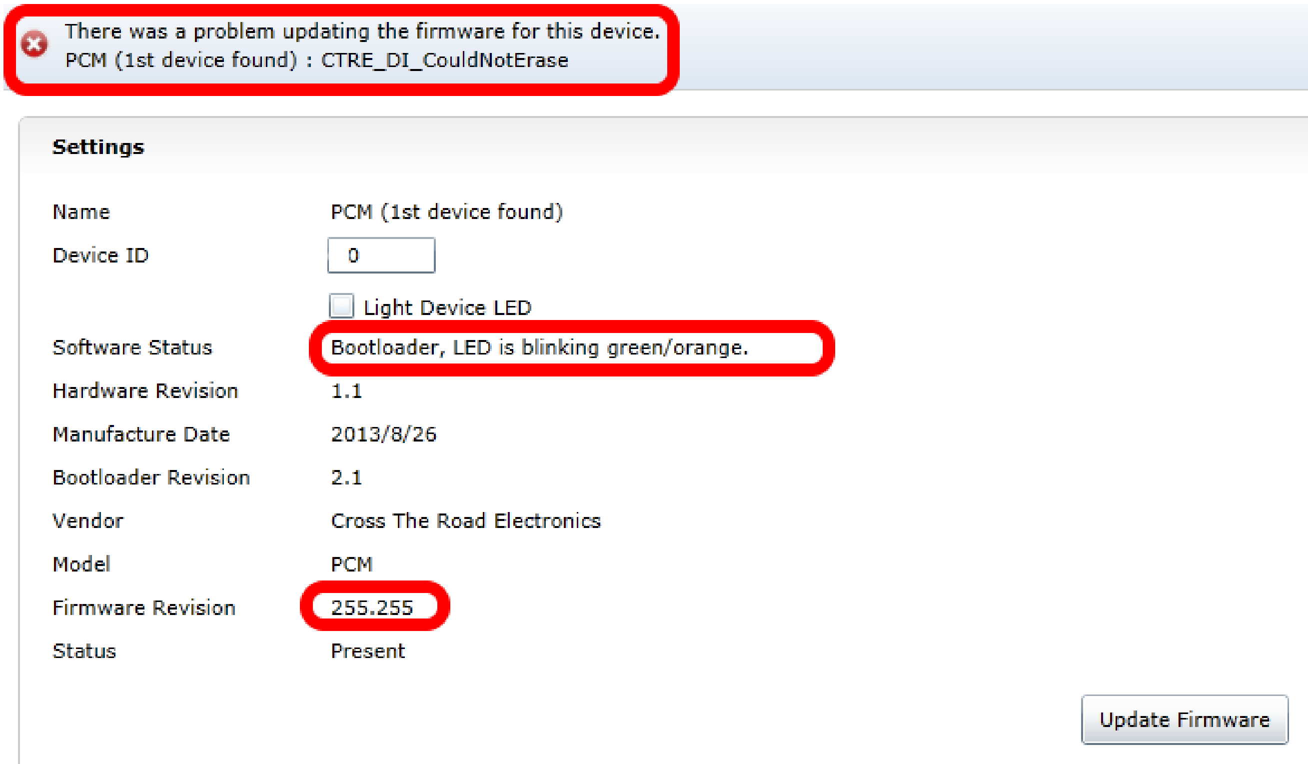
On the dialog that appears, click Begin Update.

Update Complete



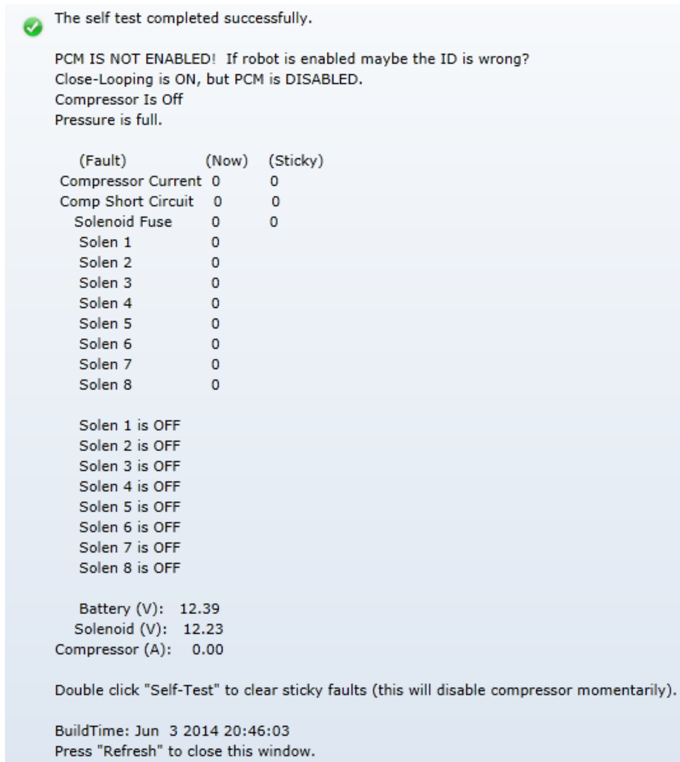
If the update completes successfully, you should see a confirmation message near the top of the page and the Firmware Revision should update to match the new file.

Troubleshooting



Since ten seconds is plenty of time for power/CAN to be disconnected, an error code will be reported if a reflash is interrupted or fails. Additionally the Software Status will report “Bootloader” and Firmware Revision will be 255.255 (blank). If a CAN Device has no firmware, it’s bootloader will take over and blink green/yellow on the device’s corresponding LED. It will also keep it’s device ID, so the RIO can still be used to set device ID and reflash the application firmware (crf). This means you can reflash again using the same web interface (there is no need for a recovery button).

Self-Test

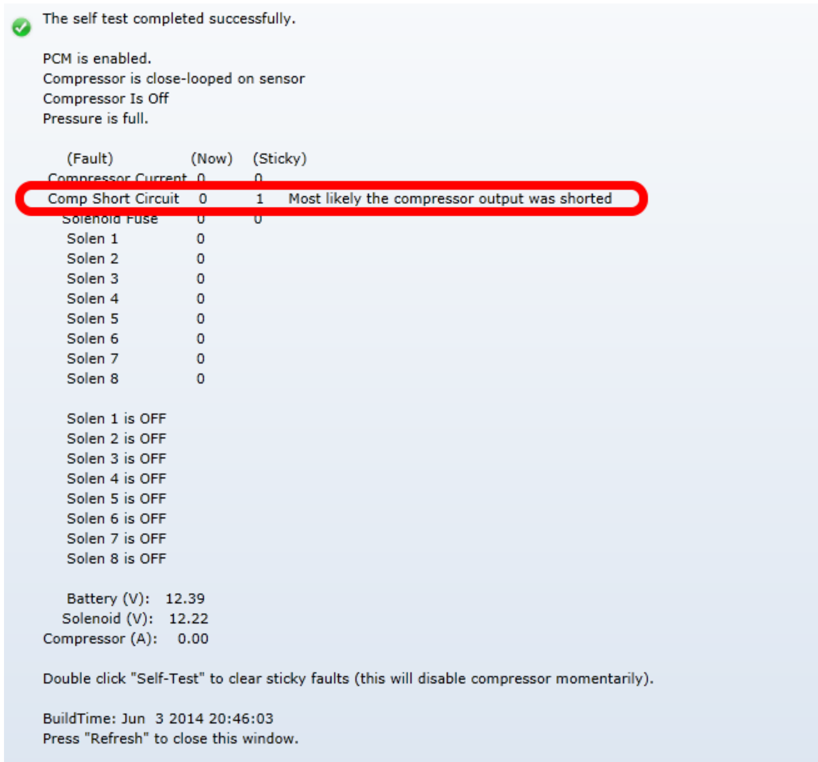


```
The self test completed successfully.

PCM IS NOT ENABLED!  If robot is enabled maybe the ID is wrong?
Close-Looping is ON, but PCM is DISABLED.
Compressor Is Off
Pressure is full.

   (Fault)              (Now)   (Sticky)
 Compressor Current  0        0
 Comp Short Circuit   0        0
   Solenoid Fuse      0        0
    Solen 1           0
    Solen 2           0
    Solen 3           0
    Solen 4           0
    Solen 5           0
    Solen 6           0
    Solen 7           0
    Solen 8           0

    Solen 1 is OFF
    Solen 2 is OFF
    Solen 3 is OFF
    Solen 4 is OFF
    Solen 5 is OFF
    Solen 6 is OFF
    Solen 7 is OFF
    Solen 8 is OFF

    Battery (V):   12.39
   Solenoid (V):   12.23
Compressor (A):    0.00

Double click "Self-Test" to clear sticky faults (this will disable compressor momentarily).

BuildTime: Jun  3 2014 20:46:03
Press "Refresh" to close this window.
```

Pressing Self Test will display data captured from CAN Bus at time of press. This can include fault states, sensor inputs, output states, measured battery voltage,etc...

At the bottom of the section, the build time is displayed for checking what firmware revision is installed. The image above is an example of pressing “SelfTest” with PCM. Be sure to check if PCM is ENABLED or DISABLED. If PCM is DISABLED then either the robot is disabled or team code is talking to the wrong PCM device ID (or not talking to the PCM at all).

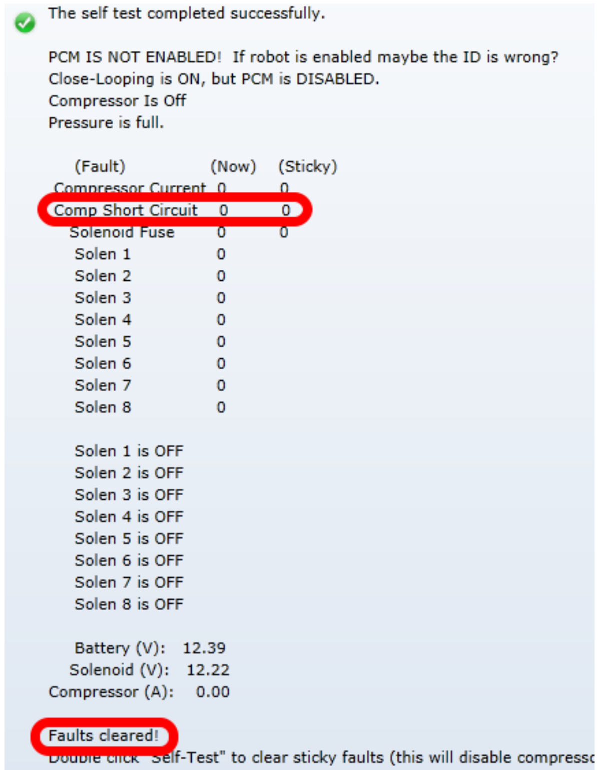
Sticky Faults



After enabling the robot and repressing “SelfTest” we see the PCM is enabled but an intermittent short on the compressor output reveals itself in a sticky fault.

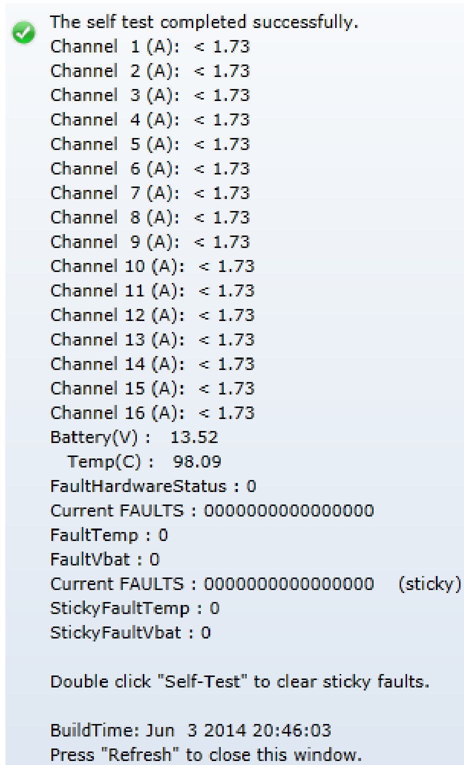
Sticky faults persist across power cycles. They also cause orange blinks on the device LED. The PCM will orange blink to signal a sticky fault only when the robot is disabled. The PDP will orange blink anytime it sees a sticky fault (since PDPs are not output devices they don’t care if robot is enabled or not).

Clearing Sticky Faults



To clear Sticky Faults, double click Self Test in a rapid fashion. If the faults don’t clear you may need to triple click, or rapidly click until you see the "Faults cleared!" text appear.

PDP Self-Test

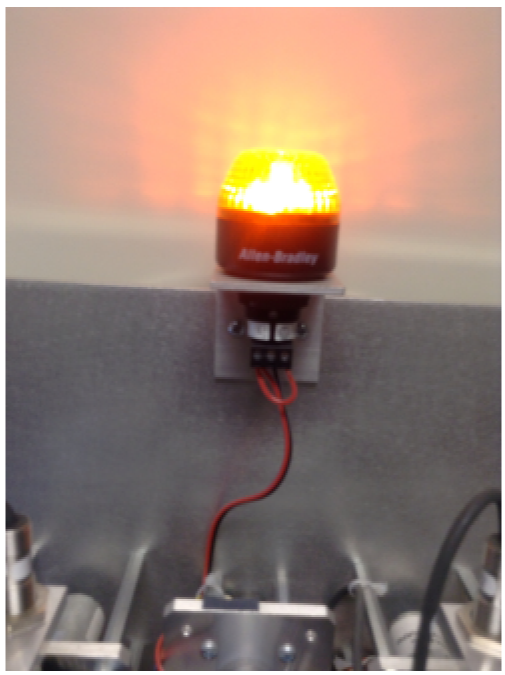


Here’s an example for PDP. Notice here this PDP sees a temperature of 98.09C (don’t worry this board does not have the temp sensor populated). With this firmware, no temp fault is recorded because this hardware revision does not have the temp sensor populated.

Status Light Quick Reference

Many of the components of the FRC Control System have indicator lights that can be used to quickly diagnose problems with your robot. This guide shows each of the hardware components and describes the meaning of the indicators. Photos and information from Innovation FIRST and Cross the Road Electronics.

Robot Signal Light (RSL)



- Solid ON - Robot On and Disabled
- Blinking - Robot On and Enabled
- Off - Robot Off, roboRIO not powered or RSL not wired properly.

RoboRIO

Power

- Green - Power is good
- Amber - Brownout protection tripped, outputs disabled
- Red - Power fault, check user rails for short circuit

Status

- On while the controller is booting, then should turn off
- 2 blinks - Software error, reimage roboRIO
- 3 blinks - Safe Mode, restart roboRIO, reimage if not resolved
- 4 blinks - Software crashed twice without rebooting, reboot roboRIO, reimage if not resolved
- Constant flash or stays solid on - Unrecoverable error

Radio

Not currently implemented

2017 Control System Hardware

Comm

- Off - No Communication
- Red Solid - Communication with DS, but no user code
- Red Blinking - E-stop
- Green Solid - Good communication with DS

Mode

- Off - Outputs disabled (robot in Disabled, brown-out, etc.)
- Amber/Orange - Autonomous Enabled
- Green - Teleop Enabled
- Red - Test Enabled

RSL

See above

OpenMesh Radio

Power	
Blue	On or Powering Up
Blue Blinking	Powering Up
Eth Link	
Blue	Link Up
Blue Blinking	Traffic Present
WiFi	
Off	Bridge Mode, Unlinked or non-FRC firmware
Red	AP, Unlinked
Yellow\Orange	AP, Linked
Green	Bridge Mode, Linked

WiFi light only works after radio has been power cycled.

Power

- Blue - On or Powering Up
- Blue Blinking - Powering Up

Eth Link

- Blue - Link Up
- Blue Blinking - Link Up + Traffic Present

WiFi

- Off - Bridge Mode Unlinked or Non-FRC Firmware
- Red - AP Mode Unlinked
- Yellow\Orange - AP Mode Linked
- Green - Bridge Mode Linked

Power Distribution Panel

LED Fault Table

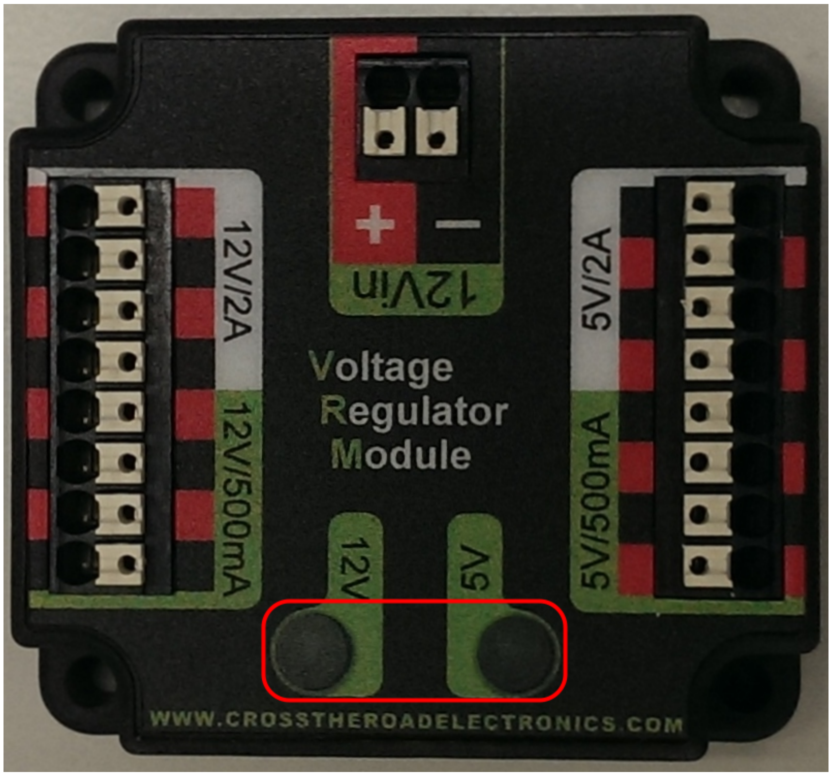
LED	Strobe	Slow	Long
Green	No Fault - Robot Enabled	No Fault - Robot Disabled	NA
Orange	NA	Sticky Fault	NA
Red	NA	No CAN Comm	NA

*If PCM LED contains more than one color, see LED Special States Table

LED Special States Table

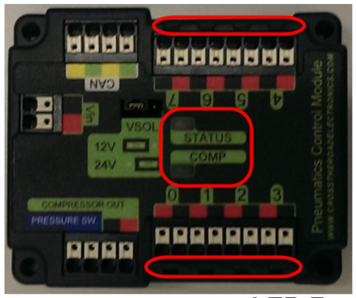
LED Colors	Problem
Red/ Orange	Damaged Hardware
Green/ Orange	In Bootloader
No LED	No Power / Incorrect Polarity

Voltage Regulator Module



The status LEDs on the VRM indicate the state of the two power supplies. If the supply is functioning properly the LED should be lit bright green. If the LED is not lit or is dim, the output may be shorted or drawing too much current.

Pneumatics Control Module



LED Fault Table

LED	Strobe	Slow	Long
Green	No Fault - Robot Enabled	No Fault - Robot Disabled	NA
Orange	NA	Sticky Fault	NA
Red	NA	No CAN Comm OR Solenoid Fault (Blinks Solenoid Index)	Compressor Fault

*If PCM LED contains more than one color, see LED Special States Table

LED Special States Table

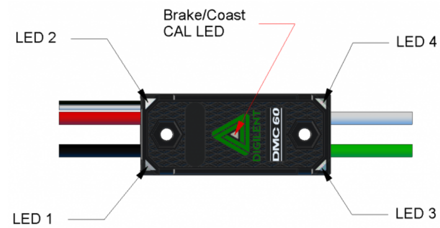
LED Colors	Problem
Red/ Orange	Damaged Hardware
Green/ Orange	In Bootloader
No LED	No Power / Incorrect Polarity

Solenoid Channel LEDs - These LEDs are lit red if the Solenoid channel is enabled and not lit if it is disabled.

Comp - This is the Compressor LED. This LED is green when the compressor output is active (compressor is currently on) and off when the compressor output is not active.

Status - The status LED indicates device status as indicated by the two tables above. For more information on resolving PCM faults see the PCM User Manual. Note that the No CAN Comm fault will not occur only if the device cannot see communicate with any other device, if the PCM and PDP can communicate with each other, but not the roboRIO you will NOT see a No Can Comm fault.

Digilent DMC-60



At power-on the RGB LEDs will display a progressive blue color, which continually gets brighter. This lasts for approximately five seconds. During this time the motor controller will not respond to an input signal, nor will the output drivers be enabled. After the initial power-on has completed the device will begin normal operation and what gets displayed on the RGB LEDs will be a function of the input signal being applied, as well as the current fault state. Assuming that no faults have occurred the RGB LEDs will function as follows:

Servo Input Signal Applied	LED State
No input signal or invalid input pulse width	Alternate between top (LED1 and LED2) and bottom (LED3 and LED4) LEDs being on and off. When on, the LEDs display color is orange.
Neutral input pulse width	All 4 LEDs on solid orange
Positive input pulse width	LEDs blink green in a clockwise circular pattern (LED1→LED2→LED3→LED4→LED1). The rate at which the LEDs update is proportional to the duty cycle of the output and increases with increased duty cycle. At 100% duty cycle, all four LEDs turn on solid green.
Negative input pulse width	LEDs blink red in a counter-clockwise circular pattern (LED1→LED4→LED3→LED2→LED1). The rate at which the LEDs update is proportional to the duty cycle of the output and increases with increased duty cycle. At 100% duty cycle, all four LEDs turn on solid red.

9 Fault Indicators

When a fault condition is detected the output duty cycle is reduced to 0% and a fault is signaled. The output will remain disabled for 3 seconds. During this time the onboard LEDs (LED1, LED2, LED3, and LED4) are used to indicate the fault condition. The fault condition is indicated by toggling between the top (LED1 and LED2) and bottom (LED3 and LED4) LEDs being on and off. The top LEDs will be Red during them on state. The color of the bottom LEDs depends on which faults are presently active. The table below describes how the color of the bottom LEDs maps to the presently active faults.

Color	Over Temperature	Under Voltage
Green	✓	X
Blue	X	✓
Cyan/Aqua	✓	✓

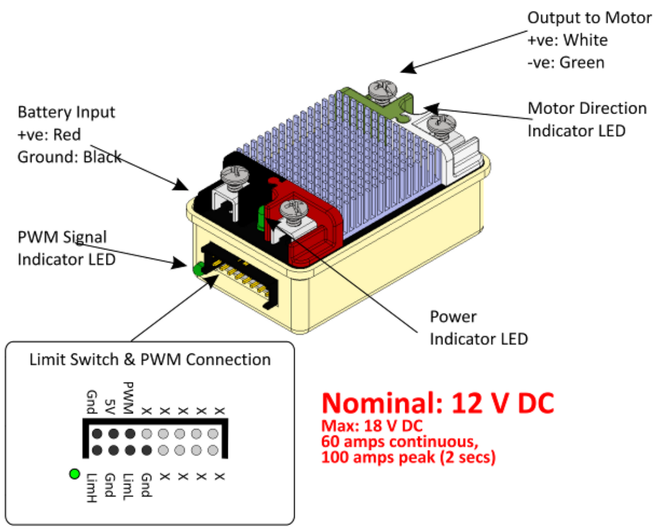
When the center LED is off the device is operating in coast mode. When the center LED is illuminated the device is operating in brake mode. The Brake/Coast mode can be toggled by pressing down on the center of the triangle and then releasing the button.

Jaguar speed controllers

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

Mindsensors SD 540



Power LED

This LED will turn Red when Power is supplied.

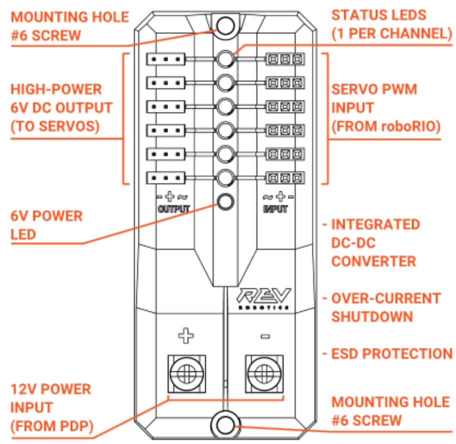
Motor LED

This LED turns Red in Forward direction and Green in Reverse direction.

PWM Signal LED

This LED turns Red when no valid PWM signal is detected, and turns Green when valid PWM signal is detected.

REV Robotics Servo Power Module



STATUS LEDs

Each channel has a corresponding status LED that will indicate the sensed state of the connected PWM signal. The table below describes each state's corresponding LED pattern.

State	Pattern
No Signal	Blinking Amber
Left/Reverse Signal	Solid Red
Center/Neutral Signal	Solid Amber
Right/Forward Signal	Solid Green

6V Power LED off, dim or flickering with power applied = Over-current shutdown

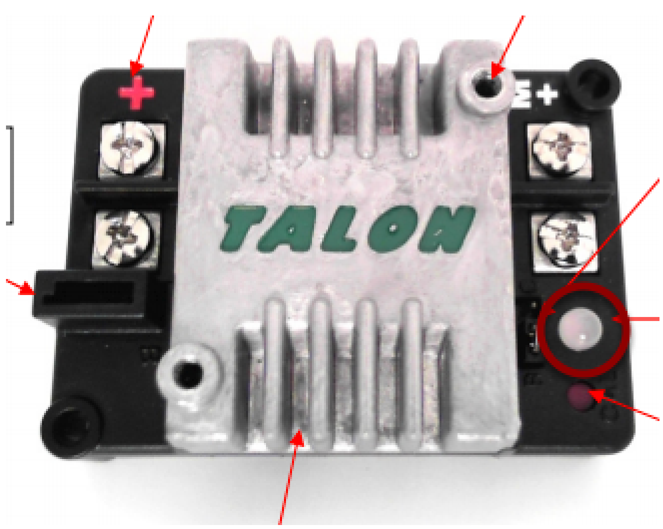
REV Robotics SPARK

2.6 STATUS LED

The SPARK can display information about its current mode of operation via its tri-colored STATUS LED. The STATUS LED is located next to the motor output terminals and is labeled as STATUS with raised lettering on the SPARK housing.

Figure 2-6 shows the status codes associated with each operating state of the SPARK.

Talon speed controllers



The LED is used to indicate the direction and percentage of throttle and state of calibration. The LED may be one of three colors; red, orange or green. A solid green LED indicates positive output voltage equal to the input voltage of the Talon. A solid Red LED indicates an output voltage that is equal to the input voltage multiplied by -1(input voltage = 12 volts, output equals -12 volts). The LED will blink it's corresponding color for any throttle less than 100% (red indicates negative polarity, green indicates positive). The rate at which the led blinks is proportional to the percent throttle. The faster the LED blinks the closer the output is to 100% in either polarity.

The LED will blink orange any time the Talon is in the disabled state. This will happen if the PWM input signal is lost, or in FRC, when the robot is disabled. If the Talon is in the enabled state and the throttle is within the 4% dead band, the LED will remain solid orange.

Flashing Red/Green indicate ready for calibration. Several green flashes indicates successful calibration, and red several times indicates unsuccessful calibration.

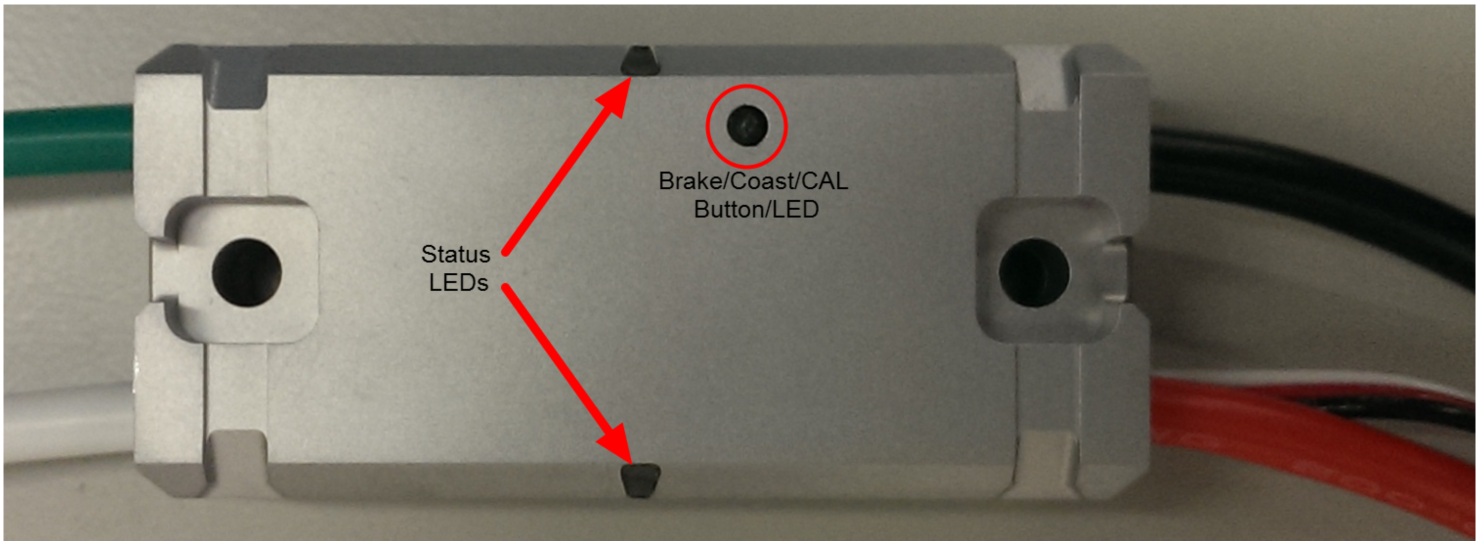
Victor speed controllers

LED Indicator Status:

Green - full forward
Orange - neutral / brake
Red - full reverse
Flashing orange - no PWM signal
Flashing red/green - calibration mode

Flashing green - successful calibration
Flashing red - unsuccessful calibration

Victor-SP speed controllers



Brake/Coast/Cal Button/LED - Red if the controller is in brake mode, off if the controller is in coast mode

Status

The Status LEDs are used to indicate the direction and percentage of throttle and state of calibration. The LEDs may be one of three colors; red, orange or green. Solid green LEDs indicate positive output voltage equal to the input voltage of the Victor-SP. Solid Red LEDs indicate an output voltage that is equal to the input voltage multiplied by -1(input voltage = 12 volts, output equals -12 volts). The LEDs will blink in the corresponding color for any throttle less than 100% (red indicates negative polarity, green indicates positive). The rate at which the LEDs blink is proportional to the percent throttle. The faster the LEDs blink the closer the output is to 100% in either polarity.

The LEDs will blink orange any time the Victor-SP is in the disabled state. This will happen if the PWM input signal is lost, or in FRC, when the robot is disabled. If the Victor-SP is in the enabled state and the throttle is within the 4% dead band, the LED will remain solid orange.

Flashing Red/Green indicate ready for calibration. Several green flashes indicates successful calibration, and red several times indicates unsuccessful calibration.

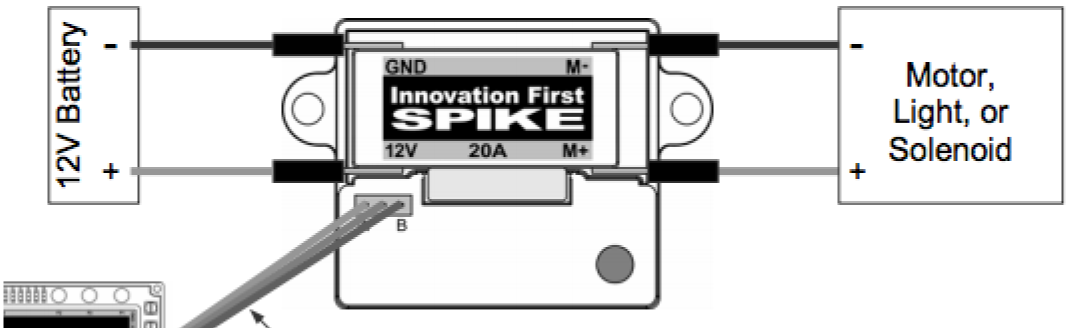
Talon-SRX speed controllers

Blink Codes During Calibration	
Status LEDs Blink Code	**Talon SRX State**
Flashing Red/Green	Calibration Mode
Blinking Green	Successful Calibration
Blinking Red	Failed Calibration

Blink Codes During Normal Operation		
LEDs	**Colors**	**Talon SRX State**
Both	Blinking Green	Forward throttle is applied. Blink rate is proportional to Duty Cycle
Both	Blinking Red	Reverse throttle is applied. Blink rate is proportional to Duty Cycle
None	None	No Power is being applied to Talon SRX
LEDs Alternate[1]	Off/Orange	CAN bus detected, robot disabled
LEDs Alternate[1]	Off/Slow Red	CAN bus/PWM is not detected
LEDs Alternate[1]	Off/Fast Red	Fault Detected
LEDs Alternate[1]	Red/Orange	Damaged Hardware
LEDs Strobe "towards" (M+)[2]	Off/Red	Forward Limit Switch or Forward Soft Limit
LEDs Strobe "towards" (M-)[2]	Off/Red	Reverse Limit Switch or Reverse Soft Limit
LED1 Only "closest" to M+/V+	Green/Orange	In Boot-loader

B/C CAL Blink Codes	
B/C CAL Button Color	**Talon SRX State**
Solid Red	Brake Mode
Off	Coast Mode

Spike relay configured as a motor, light, or solenoid switch

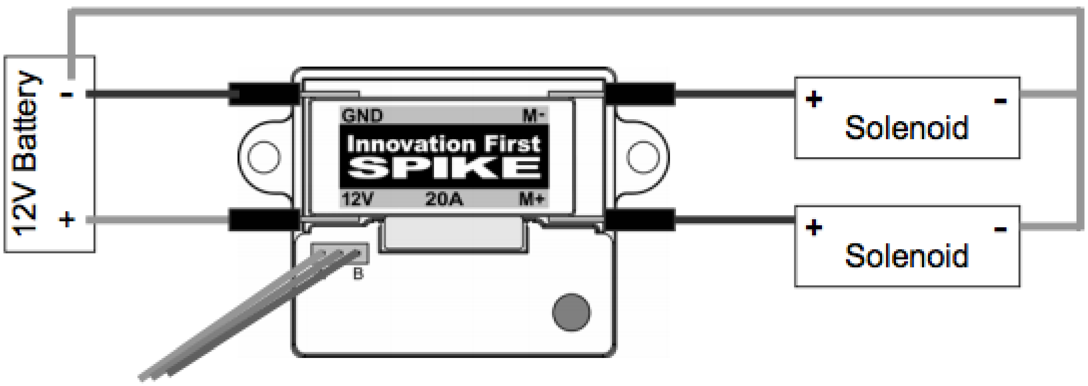


INPUTS		OUTPUTS			
Fwd(Wht)	**Rev(Red)**	**M+**	**M-**	**Indicator**	**Motor Function**
0	0	GND	GND	Orange	OFF / Brake Condition (default)
1	0	+12v	GND	Green	Motor rotates in one direction
0	1	GND	+12v	Red	Motor rotates in opposite direction
1	1	+12v	+12v	Off	OFF / Brake Condition

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).

Spike relay configured as for one or two solenoids



INPUT		OUTPUTS			
Fwd(Wht)	**Rev(Red)**	**M+**	**M-**	**Indicator**	**Solenoid Function**
0	0	GND	GND	Orange	Both Solenoids OFF (default)
1	0	+12v	GND	Green	Solenoid connected to M+ is ON
0	1	GND	+12v	Red	Solenoid connected to M- is ON
1	1	+12v	+12v	Off	Both Solenoids ON

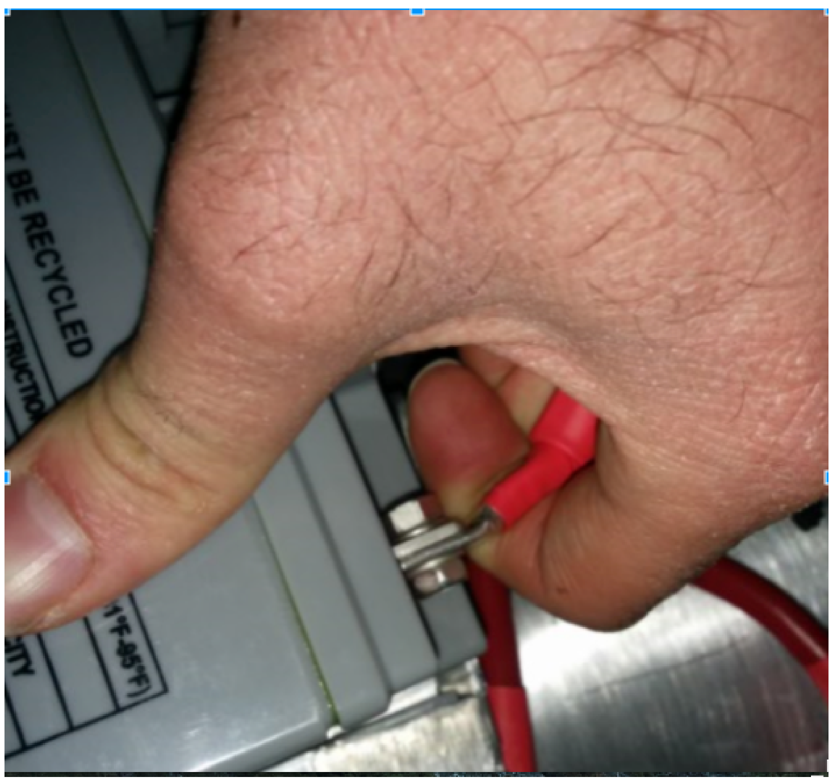
Note:

1. The INPUT Fwd and Rev are defined as follows: 0 (Off) and 1 (On).

Robot Preemptive Troubleshooting

In FIRST Robotics Competion, robots take a lot of stress while driving around the field. It is important to make sure that connections are tight, parts are bolted securely in place and that everthing is mounted so that a robot bouncing around the field does not break.

Check battery connections

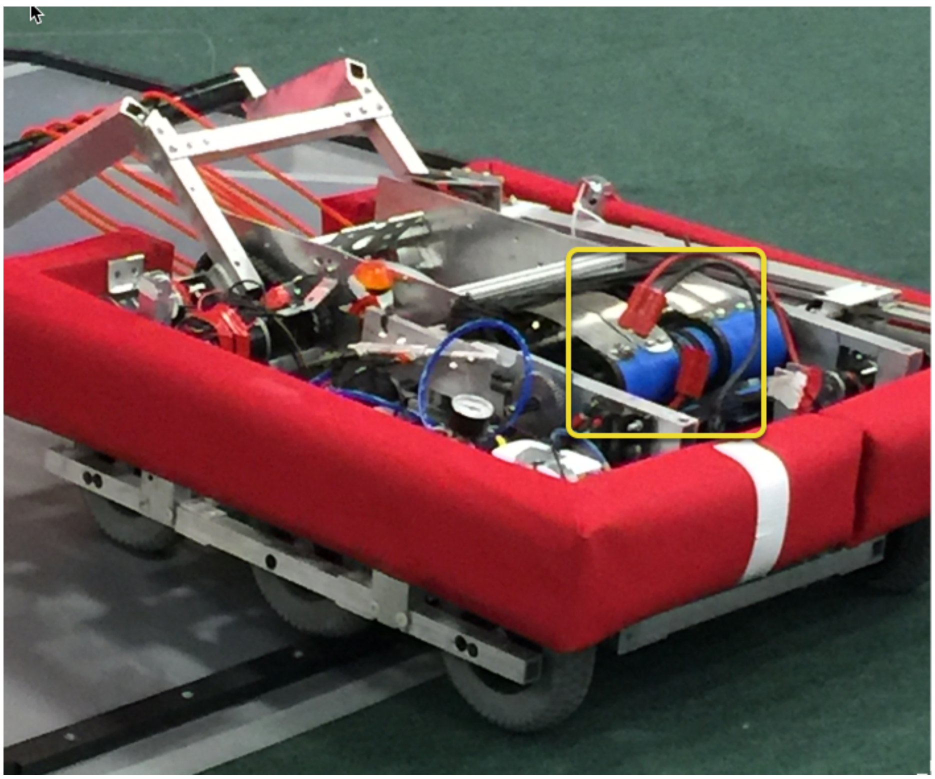


The tape the should be covering the battery connection in these examples has been removed to illustrate what is going on. On your robots, the connections should be covered.

Wiggle battery harness connector. Often these are loose because the screws loosen, or sometimes the crimp is not completely closed. You will only catch the really bad ones though because often the electrical tape stiffens the connection to a point where it feels stiff. Using a voltmeter or Battery Beak will help with this.

Apply considerable force onto the battery cable at 90 degrees to try to move the direction of the cable leaving the battery, if successful the connection was not tight enough to begin with and it should be redone.

Secure the battery to robot connection



In almost every event we see at least one robot where a not properly secured battery connector (the large Anderson) comes apart and disconnects power from the robot. This has happened in championship matches on the Einstein and everywhere else. Its an easy to ensure that this doesn't happen to you by securing the two connectors by wrapping a tie wrap around the connection. 10 or 12 tie wraps for the piece of mind during an event is not a high price to pay to guarantee that you will not have the problem of this robot from an actual event after a bumpy ride over a defense.

120 Amp circuit breaker

Apply a twisting force onto the cable to rotate the harness. If you are successful then the screw is not tight enough. Split washers might help here, but in the mean time, these require checking every few matches.

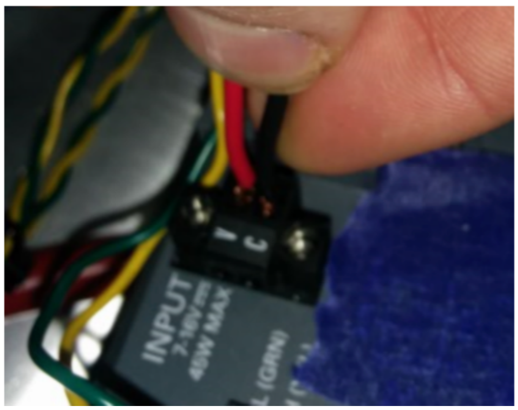
Because the metal is just molded into the case, every once in awhile you will break off the bolt, ask any veteran team and they'll tell you they go through a number of these every few seasons. After tightening the nut, retest by once again trying to twist the cable.

Power Distribution Panel (PDP)

Just by removing the battery cover, often you can confirm the washer.

Make sure that split washers were placed under the PDP screws, but it is not easy to visually confirm, and sometimes you can't. You can check by removing the case.   Also if you squeeze the red and black wires together, sometimes you can catch the really lose connections.

Tug test everything

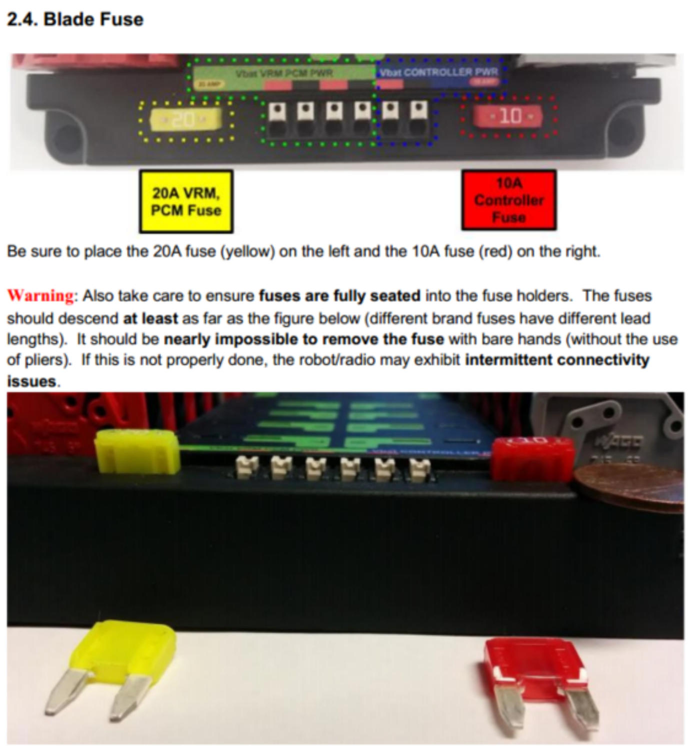


The **Weidmuller** contacts for power, compressor output, **roboRIO power connector**, and **radio power** are important to verify by tugging on the connections as shown. Make sure that none of the connections pull out.

Look for possible or impending shorts with Weidmuller connections that are close to each other, and have too-long wire-lead lengths (wires that are stripped extra long).

Spade connectors can also fail due to improper crimps, so tug-test those as well.

Blade fuses


2.4. Blade Fuse

Be sure to place the 20A fuse (yellow) on the left and the 10A fuse (red) on the right.

Warning: Also take care to ensure **fuses are fully seated** into the fuse holders. The fuses should descend **at least** as far as the figure below (different brand fuses have different lead lengths). It should be **nearly impossible to remove the fuse** with bare hands (without the use of pliers). If this is not properly done, the robot/radio may exhibit **intermittent connectivity issues**.

If you can remove the blade fuses by hand then they are not in completely. Make sure that they are completely seated in the PDP so that they don't pop out during robot operation.

RoboRIO swarf

Swarf is: fine chips or filings of stone, metal, or other material produced by a machining operation. Often modifications must be made to a robot while the control system parts are in place. The circuit board for the roboRIO is conformally coated, but that doesn't absolutely guarantee that metal chips won't short out traces or components inside the case. In this case, you must exercise care in making sure that none of the chips end up in the roboRIO or any of the other components. In particular, the exposed 3 pin headers are a place where chips can enter the case. A quick sweep through each of the four sides with a flashlight is usually sufficient to find the really bad areas of infiltration.

Radio barrel jack

Make sure the correct barrel jack is used, not one that is too small and falls out for no reason. This isn't common, but ask an FTA and every once in awhile a team will use some random barrel jack that is not sized correctly, and it falls out in a match on first contact.

Ethernet cable

If the RIO to radio ethernet cable is missing the clip that locks the connector in, get another cable. This is a common problem that will happen several times in every competition. Make sure that your cables are secure. The clip often breaks off, especially when pulling it through a tight path, it snags on something then breaks.

Cable slack

Cables must be tightened down, particularly the radio power and ethernet cable. The radio power cables don't have a lot of friction force and will fall out (even if it is the correct barrel) if the weight of the cable-slack is allowed to swing freely.

Ethernet cable is also pretty heavy, if it's allowed to swing freely, the plastic clip may not be enough to hold the ethernet pin connectors in circuit.

Reproducing problems in the pit

Beyond the normal shaking and rattling of all cables while the robot is power and tethered, you might try picking up one side of the robot off the ground and drop it, and see if you lose connection. The driving on the field, especially when trying to breach defenses will often be very violent. It's better to see it fail in the pit rather than in a critical match.

When doing this test it's important to be ethernet tethered and not USB tethered, otherwise you are not testing all of the critical paths.

Check firmware and versions

Robot inspectors do this, but you should do it as well, it helps robot inspectors out and they appreciate it. And it guarantees that you are running with the most recent, bug fixed code. You wouldn't want to lose a match because of an out of date piece of control system software on your robot.

Driver station checks

We often see problems with the Drivers Station. You should:

- ALWAYS bring the laptop power cable to the field, it doesn't matter how good the battery is, you are allowed to plug in at the field.
- Check the power and sleep settings, turn off sleep and hybernate, screen savers, etc.
- Turn off power management for USB devices (dev manager)
- Turn off power management for ethernet ports (dev manager)
- Turn off windows defender
- Turn off firewall
- Close all apps except for DS/Dashboard when out on the field.
- Verify that there is nothing unnecessary running in the application tray in the start menu (bottom right side)

Handy tools

There never seems to be enough light inside robots, at least not enough to scrutinize the critical connection points, so consider using a handheld LED flashlight to inspect the connections on your robot. They're available from home depot or any hardware/automotive store.

Wago tool is nice to for redoing weidmuller connections with stranded wires. Often I'll do one to show the team, and then have them do the rest using the WAGO tool to press down the white-plunger while they insert the stranded wire. The angle of the WAGO tool makes this particularly helpful.

RoboRIO

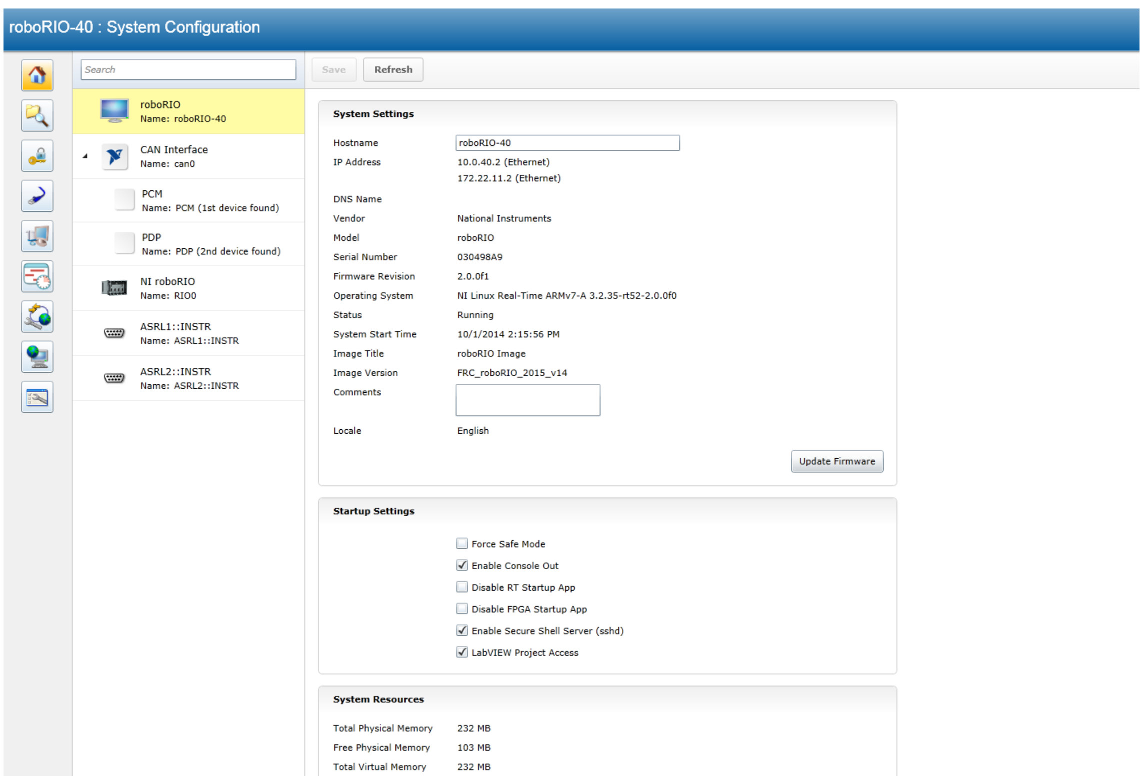
RoboRIO Webdashboard

The roboRIO web dashboard is a webpage built into the roboRIO that can be used for checking status and updating settings of the roboRIO.

Note: Google Chrome is removing support for the Silverlight plugin. You will need to use a different browser such as Internet Explorer to access the roboRIO webdashboard.

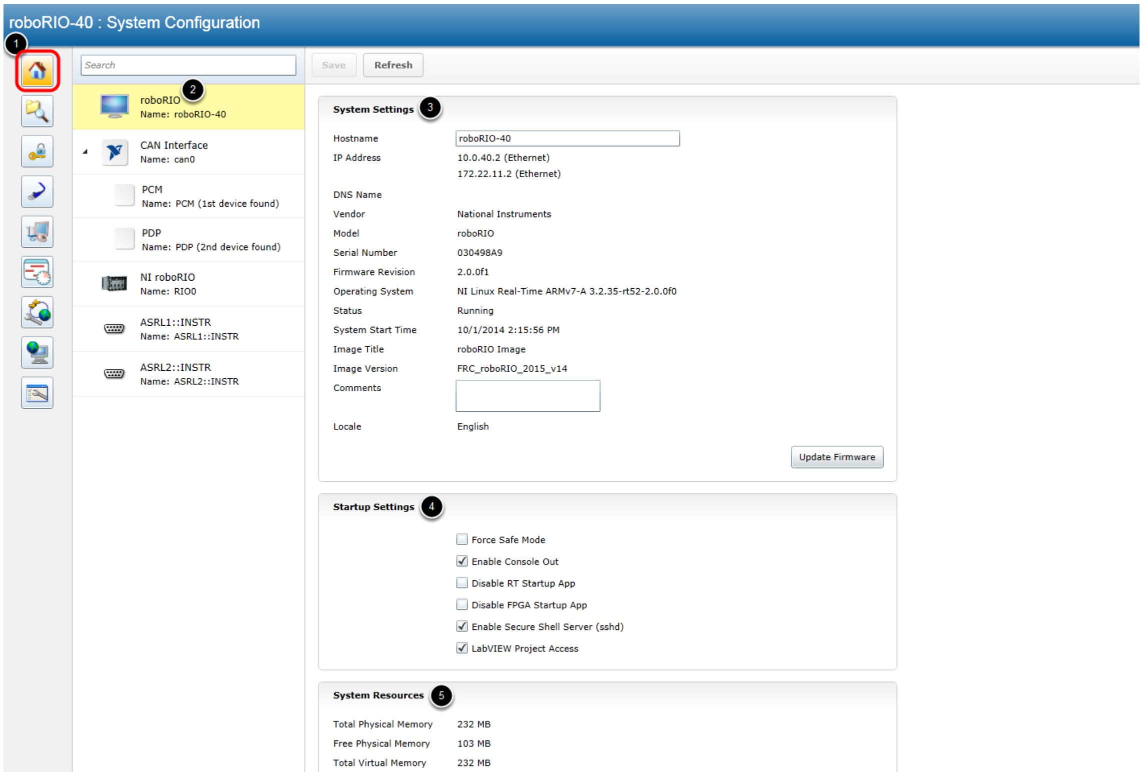
Note: The mDNS address of the roboRIO has changed for 2016. Please pay close attention to the address when accessing the roboRIO webdashboard.

Opening the WebDash



To open the myRIO web dashboard, open a web browser and enter the address of the roboRIO into the address bar (172.22.11.2 for USB, or "roboRIO-####-FRC.local where #### is your team number, with no leading zeroes, for either interface). See this document for more details about mDNS and roboRIO networking: RoboRIO Networking

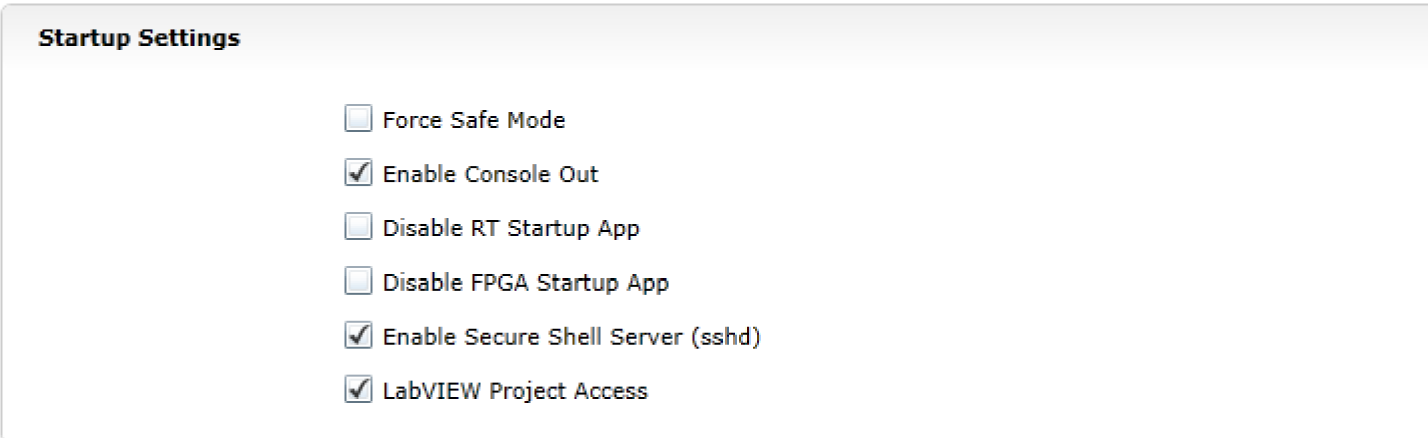
Home Tab



The home tab of the web dashboard has 5 main sections:

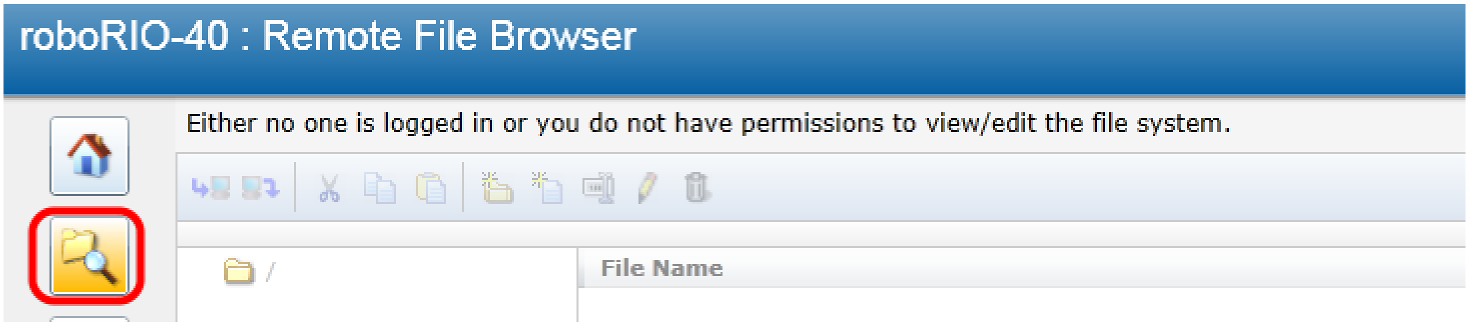
1. Navigation Bar - This section allows you to navigate to different sections of the web dashboard. The different pages accessible through this navigation bar are discussed below.
2. Device listing - This section lists out the roboRIO devices. The primary use of this section is for selecting and configuring CAN devices as shown on this page: Updating and Configuring Pneumatics Control Module and Power Distribution Panel
3. System Settings - This section contains information about the System Settings. The Hostname field should not be modified manually use the roboRIO Imaging tool to set the Hostname based on your team number. This section contains information such as the device IP, firmware version and image version.
4. Startup Settings - This section contains Startup settings for the roboRIO. These are described in the sub-step below
5. System Resources - This section provides a snapshot of system resources such as memory and CPU load.

Startup Settings



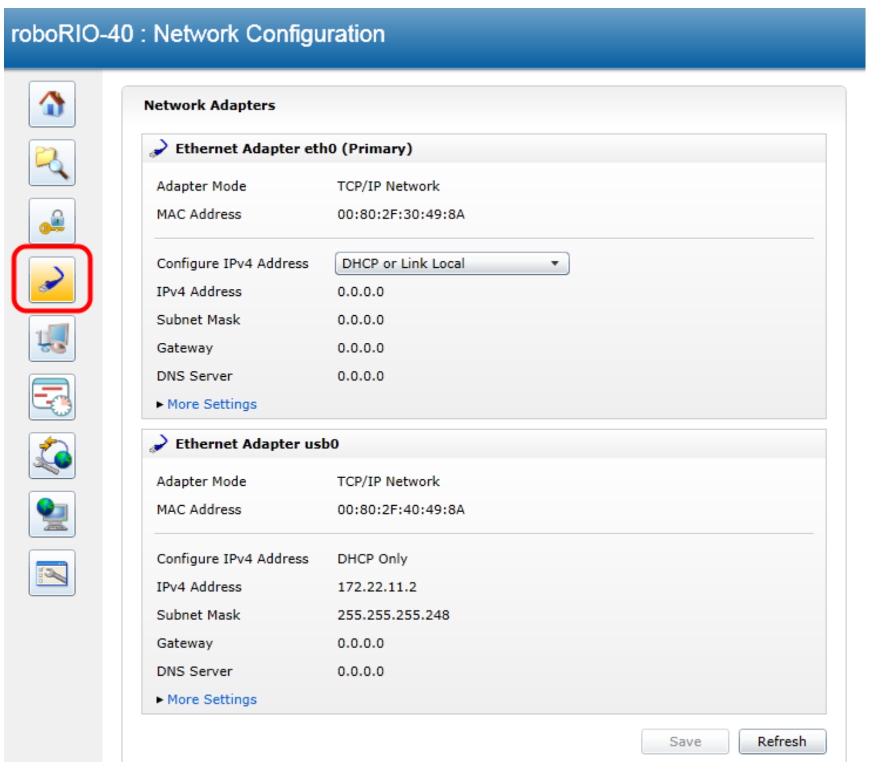
- Force Safe Mode - Forces the controller into Safe Mode. This can be used with troubleshooting imaging issues, but it is recommended to use the Reset button on the roboRIO to put the device into Safe Mode instead (with power already applied, hold the rest button for 5 seconds). **Default is unchecked.**
- Enable Console Out - This enables the on-board RS232 port to be used as a Console output. It is recommended to leave this enabled unless you are using this port to talk to a serial device (note that this port uses RS232 levels and and should not be connected to many microcontrollers which use TTL levels). **Default is checked.**
- Disable RT Startup App - Checking this box disables code from running at startup. This may be used for troubleshooting if you find the roboRIO is unresponsive to new program download. **Default is unchecked**
- Disable FPGA Startup App - **This box should not be checked.**
- Enable Secure Shell Server (sshd) - **It is recommended to leave this box checked.** This setting enables SSH which is a way to remotely access a console on the roboRIO. Unchecking this box will prevent C++ and Java teams from loading code onto the roboRIO using the Eclipse plugins.
- LabVIEW Project Access - **It is recommended to leave this box checked.** This setting allows LabVIEW projects to access the roboRIO.

Remote File Browser



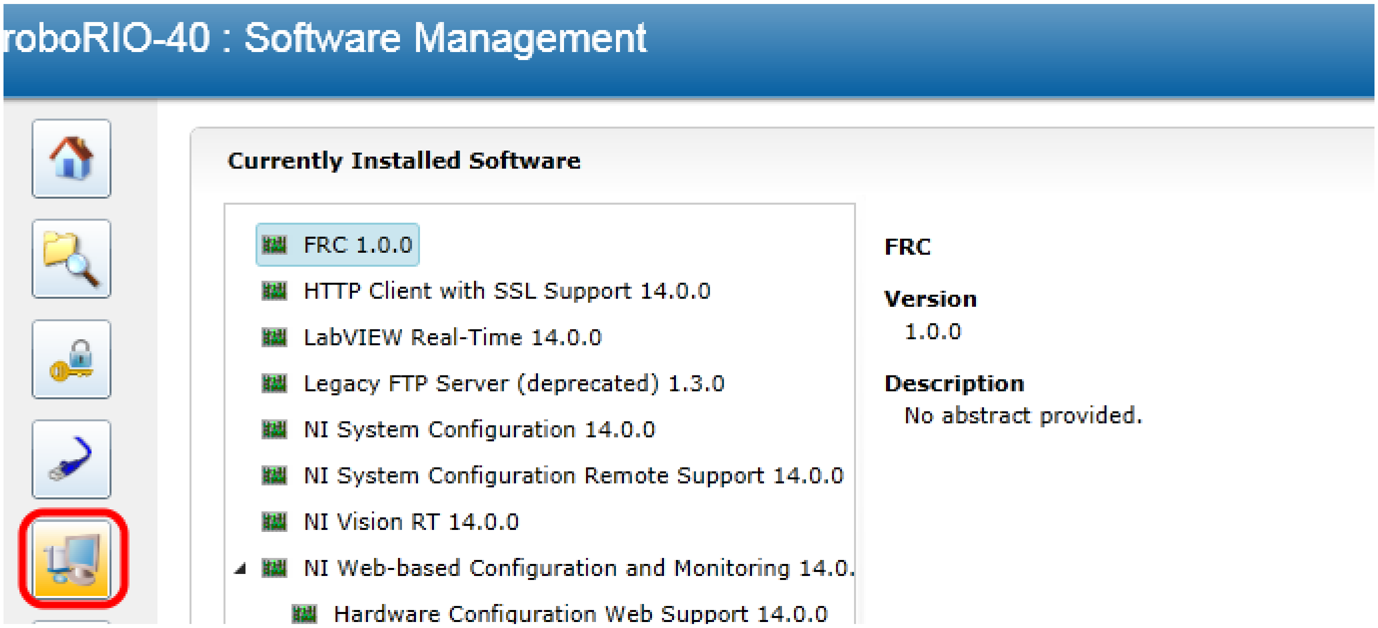
Using the Remote File Browser requires setting a password for the admin account, which is not recommended (it will break C++ and Java program download/execution). Use FTP instead.

Network Configuration



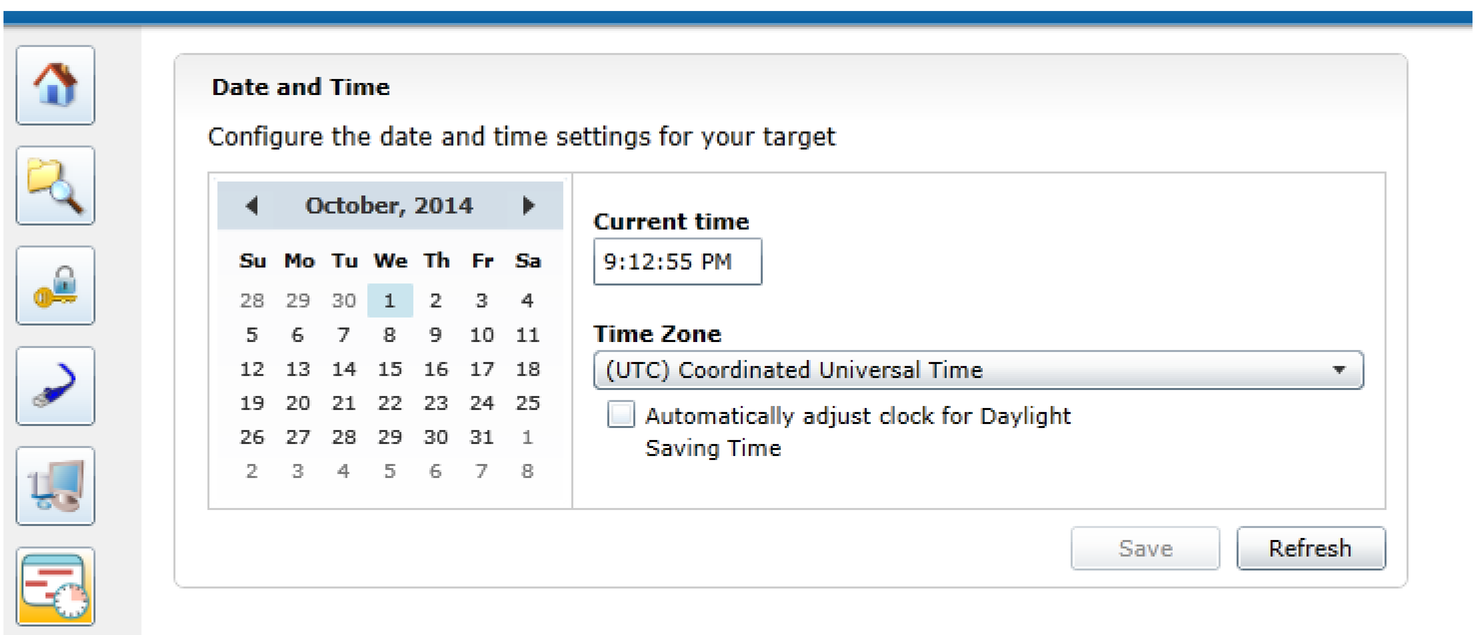
This page shows the configuration of the roboRIO's network adapters. **It is not recommended to change any settings on this page.** For more information on roboRIO networking see this article: RoboRIO Networking

Software Management



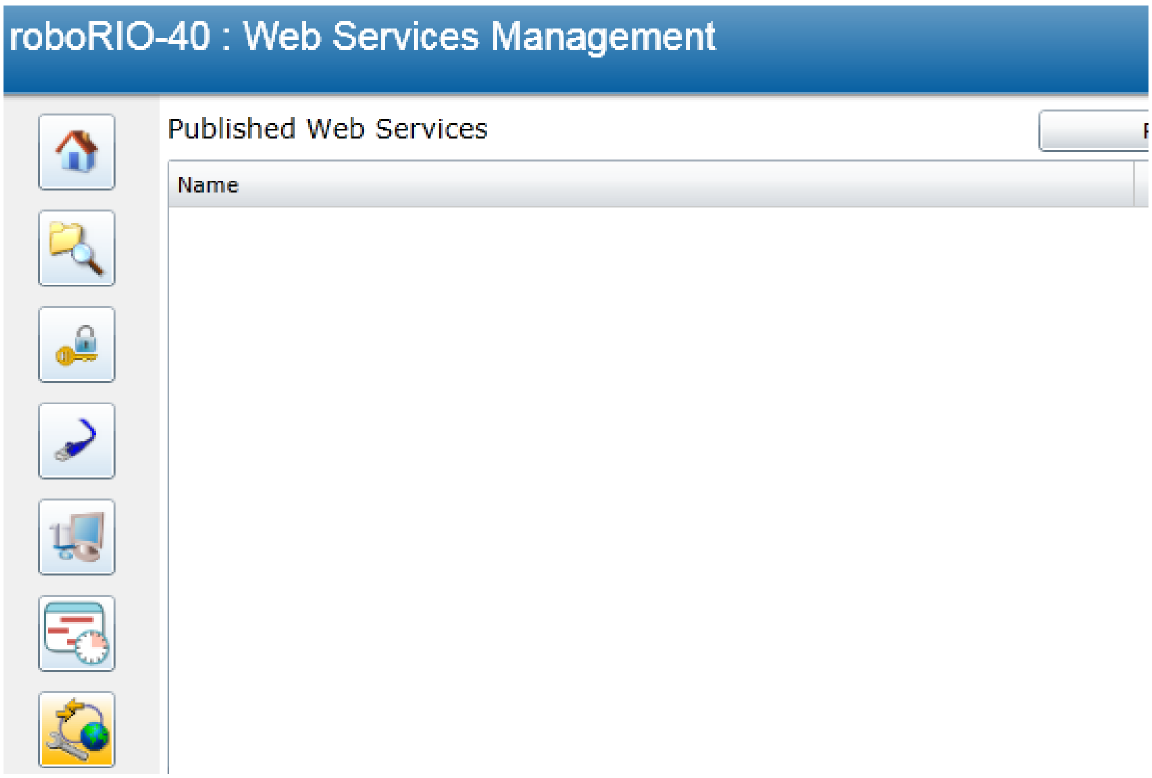
This tab shows the NI software installed on the roboRIO. It is not recommended to make any changes on this page.

Time Configuration



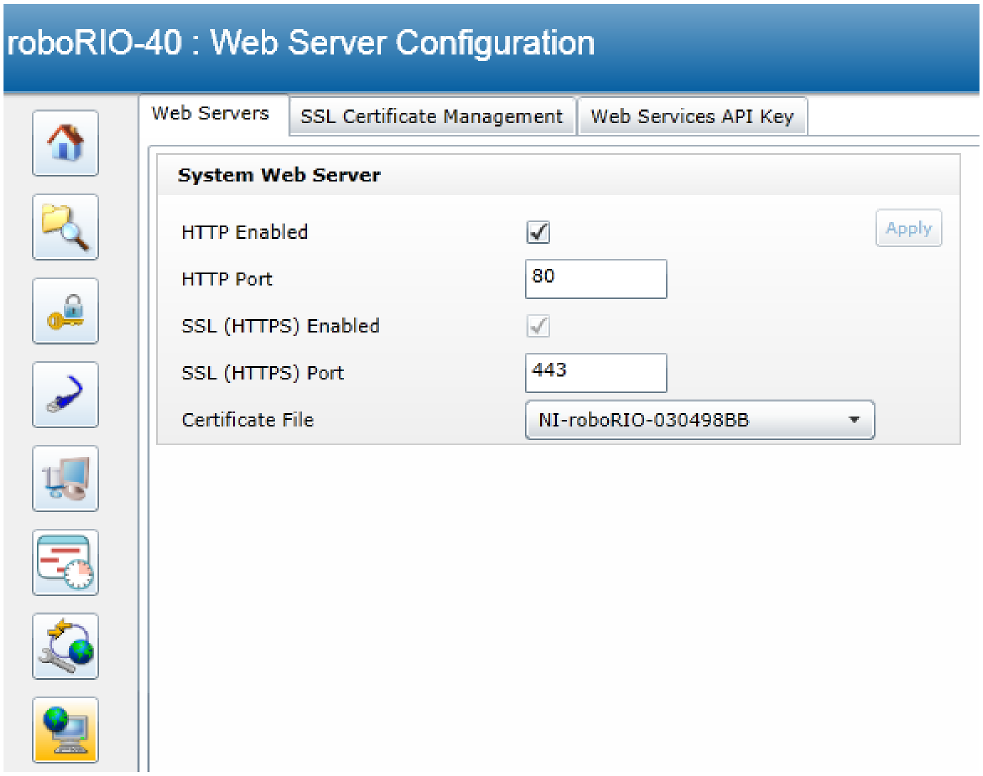
The roboRIO has no battery backup so time configuration is lost each time the device boots. **It is not recommended to make any changes on this page.**

Web Services Managaement



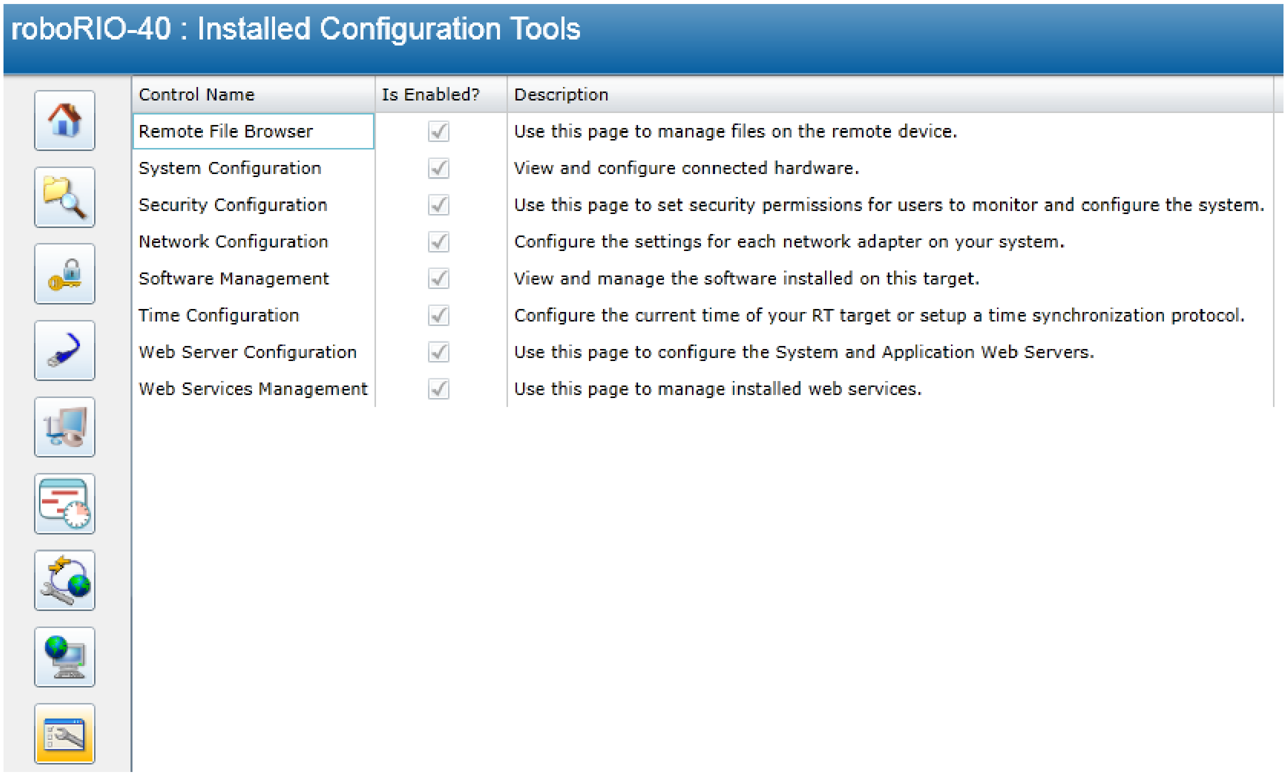
This section shows the Web Services running on the roboRIO. **It is not recommended to make any changes on this page.**

Web Server Configuration



This page shows the configuration of the roboRIO webserver. It is not recommended to make any changes on this page.

Installed Configuration Tools



This page shows the configuration tools installed and enabled on the roboRIO. It is not recommended to make any changes on this page.

RoboRIO FTP

The roboRIO has both SFTP and anonymous FTP enabled. This article describes how to use each to access the roboRIO file system.

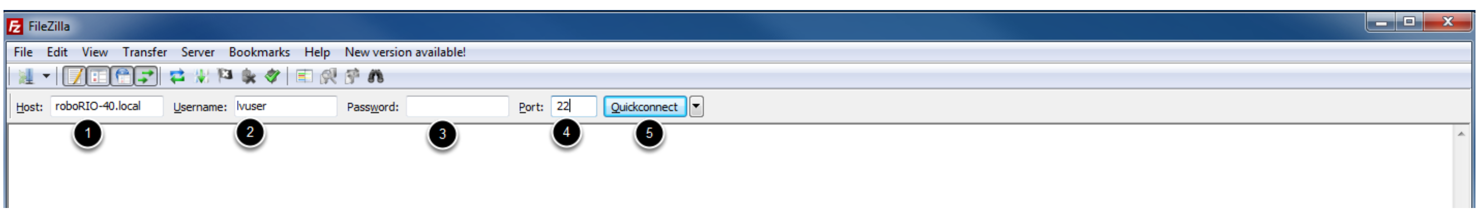
SFTP

SFTP is the recommended way to access the roboRIO file system. Because you will be using the same account that your program will run under, files copied over should always have permissions compatible with your code.

Software

There are a number of freely available programs for SFTP. This article will discuss using FileZilla. You can either download and install FileZilla before proceeding or extrapolate the directions below to your SFTP client of choice.

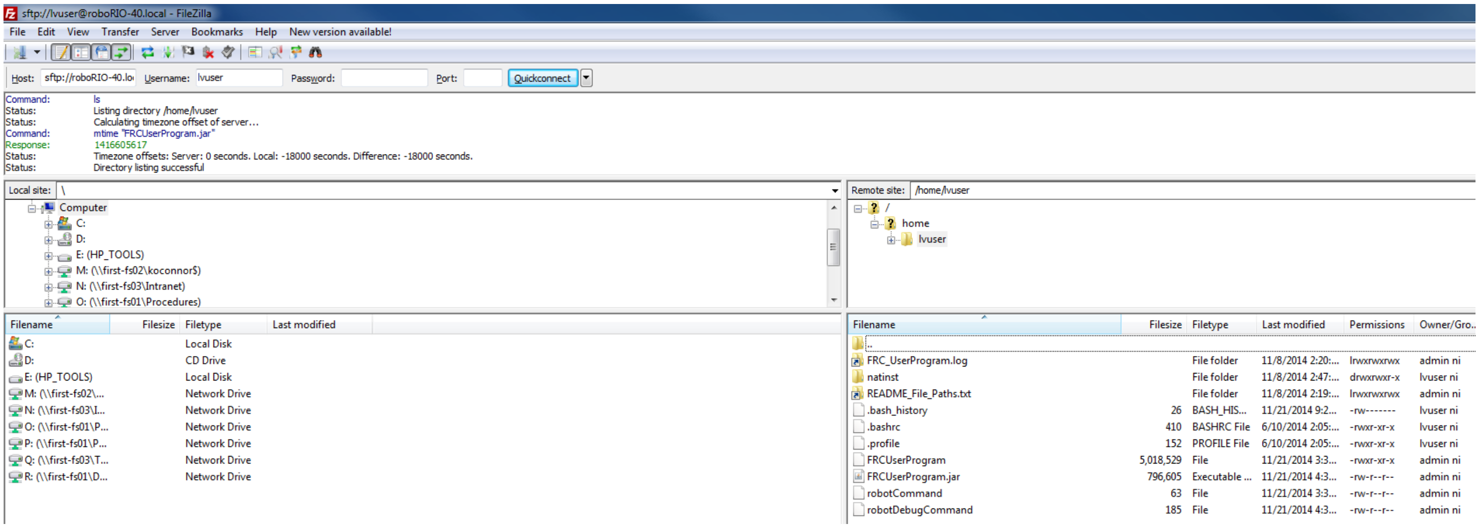
Connecting to the roboRIO



To connect to your roboRIO:

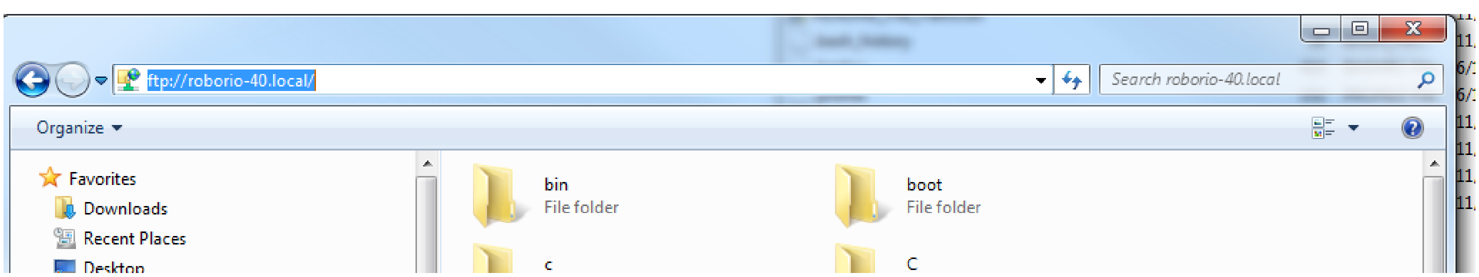
1. Enter the mDNS name (roboRIO-TEAM.local) in the "Host" box
2. Enter "lvuser" in the Username box (this is the account your program runs under)
3. Leave the Password box blank
4. Enter "22" in the port box (the SFTP default port)
5. Click Quickconnect

Browsing the roboRIO filesystem



After connecting to the roboRIO, Filezilla will open to the \home\lvuser directory. The right pane is the remote system (the roboRIO), the left pane is the local system (your computer). The top section of each pane shows you the hierarchy to the current directory you are browsing, the bottom pane shows contents of the directory. To transfer files, simply click and drag from one side to the other. To create directories on the roboRIO, right click and select "Create Directory".

FTP



The roboRIO also has anonymous FTP enabled. It is recommended to use SFTP as described above, but depending on what you need FTP may work in a pinch with no additional software required. To FTP to the roboRIO, open a Windows Explorer window (on Windows 7, you can click Start->My Computer). In the address bar, type ftp://roboRIO-TEAM.local and press enter. You can now browse the roboRIO file system just like you would browse files on your computer.

RoboRIO User Accounts and SSH

Note: This document contains advanced topics not required for typical FRC programming

The roboRIO image contains a number of accounts, this article will highlight the two used for FRC and provide some detail about their purpose. It will also describe how to connect to the roboRIO over SSH.

RoboRIO User Accounts

The roboRIO image contains a number of user accounts, but there are two of primary interest for FRC.

Admin

The "admin" account has root access to the system and can be used to manipulate OS files or settings. Teams should take caution when using this account as it allows for the modification of settings and files that may corrupt the operating system of the roboRIO. The credentials for this account are:

Username: admin

Password:

Note: The password is intentionally blank.

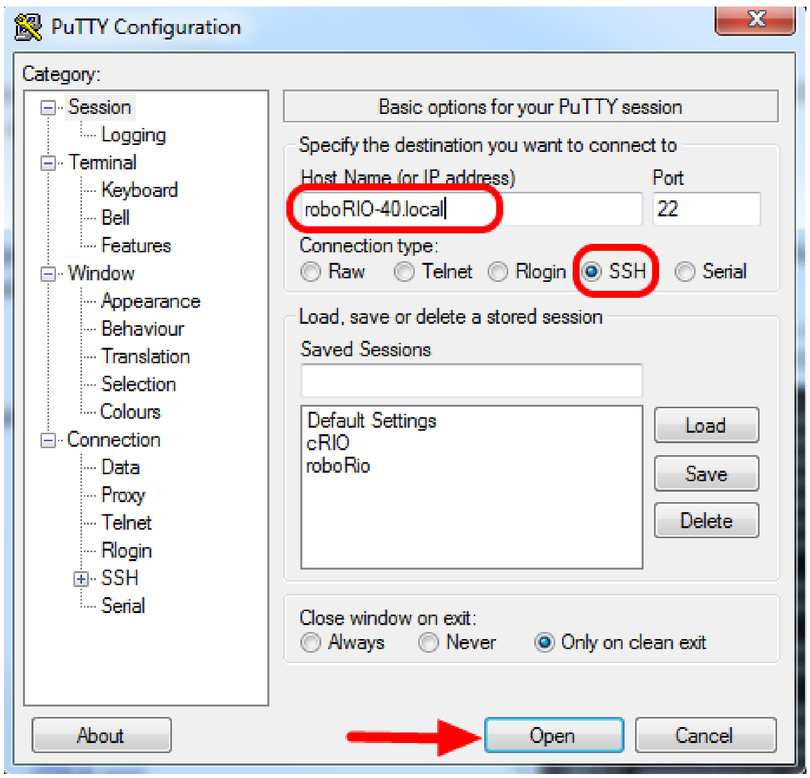
Lvuser

The "lvuser" account is the account used to run user code for all three languages. The credentials for this account should not be changed. Teams may wish to use this account (via ssh or sftp) when working with the roboRIO to ensure that any files or settings changes are being made on the same account as their code will run under.

SSH

SSH (Secure SHell) is a protocol used for secure data communication. When broadly referred to regarding a Linux system (such as the one running on the roboRIO) it generally refers to accessing the command line console using the SSH protocol. This can be used to execute commands on the remote system. A free client which can be used for SSH is PuTTY: http://www.chiark.greenend.org.uk/~sgtatham/putty/download.html

Open Putty



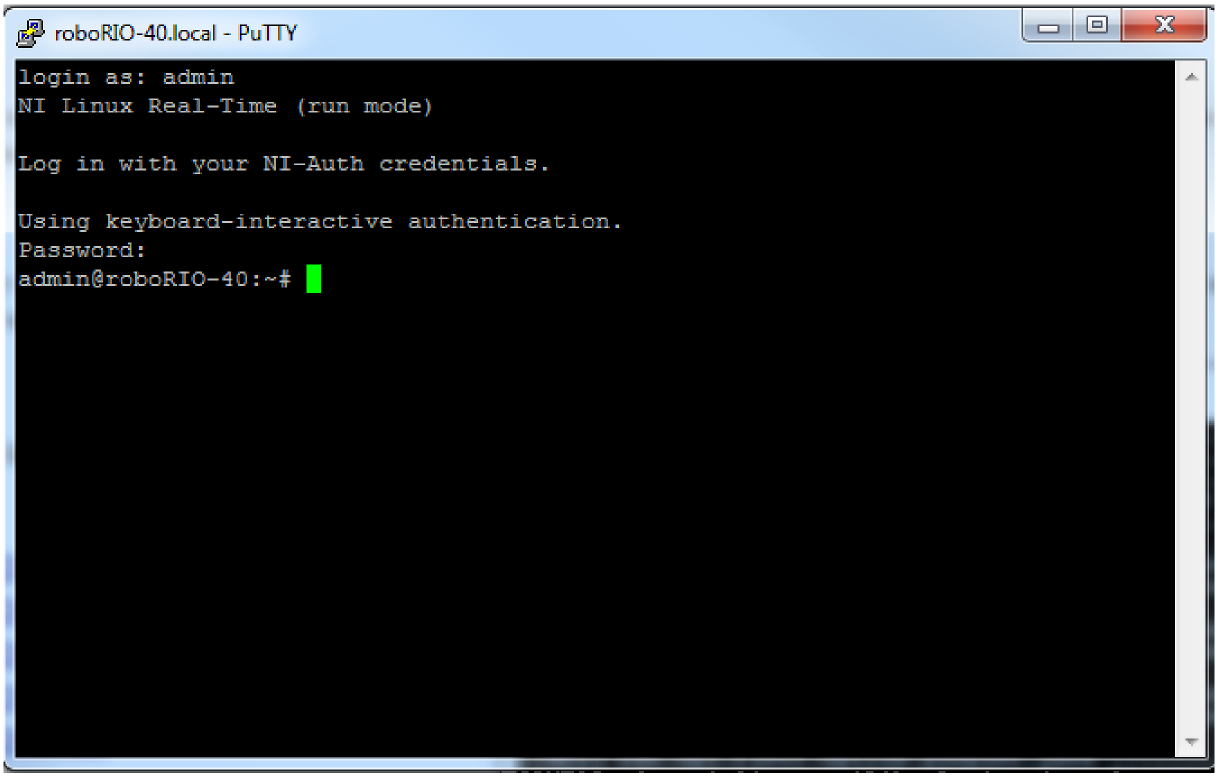
Open Putty (clicking OK at any security prompt). Then set the following settings:

1. Host Name: roboRIO-TEAM-frc.local (where TEAM is your team number)
2. Connection Type: SSH

Other settings can be left at defaults. Click Open to open the connection. If you see a prompt about SSH keys, click OK.

If you are connected over USB you can use 172.22.11.2 as the hostname. If your roboRIO is set to a static IP you can use that IP as the hostname if connected over Ethernet/wireless.

Log in



When you see the prompt, enter the desired username (see above for description) then press enter. At the password prompt press enter (password for both accounts is blank).

RoboRIO Brownout and Understanding Current Draw

In order to help maintain battery voltage to preserve itself and other control system components such as the radio during high current draw events, the roboRIO contains a staged brownout protection scheme. This article describes this scheme, provides information about proactively planning for system current draw, and describes how to use the new functionality of the PDP as well as the DS Log File Viewer to understand brownout events if they do happen on your robot.

roboRIO Brownout Protection

The roboRIO uses a staged brownout protection scheme to attempt to preserve the input voltage to itself and other control system components in order to prevent device resets in the event of large current draws pulling the battery voltage dangerously low.

Stage 1 - Output Disable

Voltage Trigger - 6.8V

When the voltage drops below 6.8V, the controller will enter the brownout protection state. The following indicators will show that this condition has occurred:

- Power LED on the roboRIO will turn Amber
- Background of the voltage display on the Driver Station will turn red
- Mode display on the Driver Station will change to Voltage Brownout
- The CAN\Power tab of the DS will increment the 12V fault counter by 1.
- The DS will record a brownout event in the DS log.

The controller will take the following steps to attempt to preserve the battery voltage:

- PWM outputs will be disabled. For PWM outputs which have set their neutral value (all speed controllers in WPILib) a single neutral pulse will be sent before the output is disabled.
- 6V User Rail disabled (this is the rail that powers servos on the PWM header bank)
- GPIO configured as outputs go to High-Z
- Relay Outputs are disabled (driven low)
- CAN-based motor controllers are sent an explicit disable command

The controller will remain in this state until the voltage rises to greater than 7.5V or drops below the trigger for the next stage of the brownout

Stage 2 - User Voltage Rail Disable

Voltage Trigger - 6.3V

When the voltage drops below 6.3V, the User Voltage Rails are disabled. This includes the 5V pins (or 3.3V is the jumper has been set) in the DIO connector bank, the 5V pins in the Analog bank, the 3.3V pins in the SPI and I2C bank and the 5V and 3.3V pins in the MXP bank.

The controller will remain in this state until the voltage rises above 6.3V (return to Stage 2) or drops below the trigger for the next stage of the brownout

Stage 3 - Device Blackout

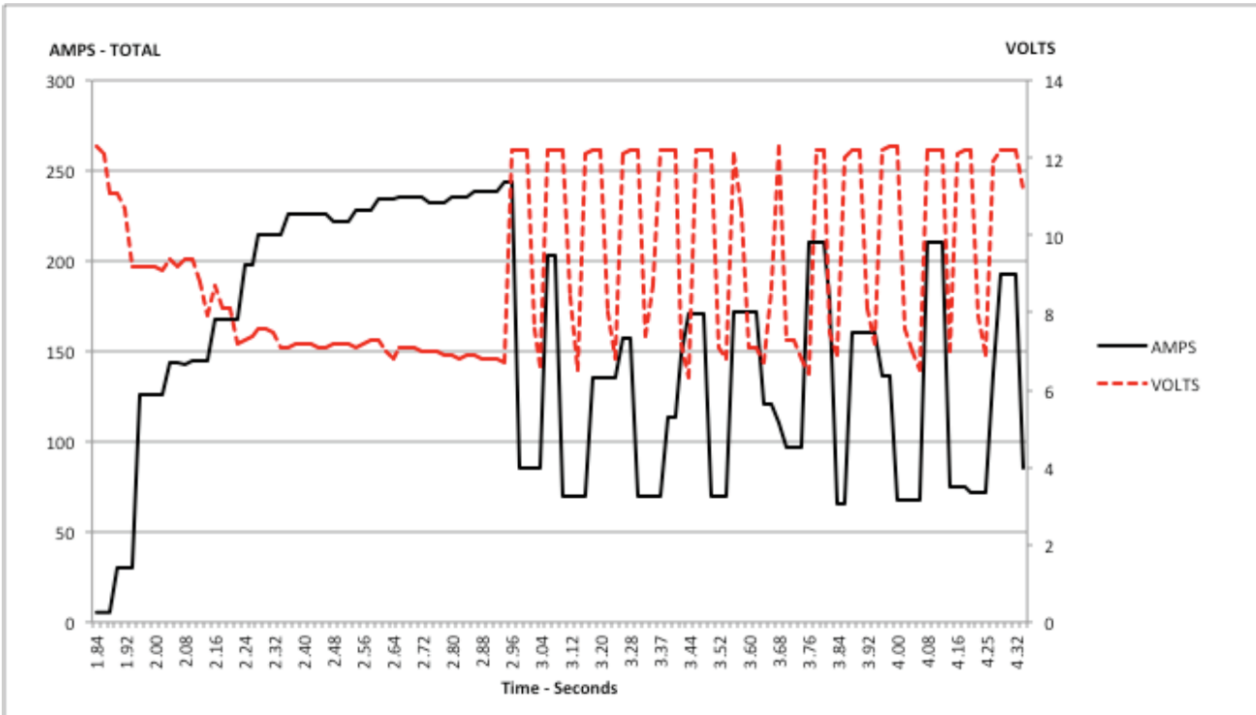
Voltage Trigger - 4.5V

Below 4.5V the device may blackout. The exact voltage may be lower than this and depends on the load on the device.

The controller will remain in this state until the voltage rises above 4.65V when the device will begin the normal boot sequence.

Avoiding Brownout - Proactive Current Draw planning

PLOT 1 – AMPS and VOLTS v. Time – 2.5 Second Window



The key to avoiding a brownout condition is to proactively plan for the current draw of your robot. The best way to do this is to create some form of power budget. This can be a complex document that attempts to quantify both estimated current draw and time in an effort to most completely understand power usage and therefore battery state at the end of a match, or it can be a simple inventory of current usage. To do this:

1. Establish the max "sustained" current draw (with sustained being loosely defined here as not momentary). This is probably the most difficult part of creating the power budget. The exact current draw a battery can sustain while maintaining a voltage of 7+ volts is dependent on a variety of factors such as battery health and state of charge. As shown in the NP18-12 data sheet, the terminal voltage chart gets very steep as state of charge decreases, especially as current draw increases. This datasheet shows that at 3CA continuous load (54A) a brand new battery can be continuously run for over 6 minutes while maintaining a terminal voltage of over 7V. As shown in the image above (used with permission from Team 234's Drive System Testing document), even with a fresh battery, drawing 240A for more than a second or two is likely to cause an issue. This gives us some bounds on setting our sustained current draw. For the purposes of this exercise, we'll set our limit at 180A.

2. List out the different functions of your robot such as drivetrain, manipulator, main game mechanism, etc.
3. Start assigning your available current to these functions. You will likely find that you run out pretty quickly. Many teams gear their drivetrain to have enough torque to slip their wheels at 40-50A of current draw per motor. If we have 4 motors on the drivetrain, that eats up most, or even exceeds, our power budget! This means that we may need to put together a few scenarios and understand what functions can (and need to be) be used at the same time. In many cases, this will mean that you really need to limit the current draw of the other functions if/while your robot is maxing out the drivetrain (such as trying to push something). Benchmarking the "driving" current requirements of a drivetrain for some of these alternative scenarios is a little more complex, as it depends on many factors such as number of motors, robot weight, gearing, and efficiency. Current numbers for other functions can be done by calculating the power required to complete the function and estimating efficiency (if the mechanism has not been designed) or by determining the torque load on the motor and using the torque-current curve to determine the current draw of the motos.
4. If you have determined mutually exclusive functions in your analysis, consider enforcing the exclusion in software. You may also use the current monitoring of the PDP (covered in more detail below) in your robot program to provide output limits or exclusions dynamically (such as don't run a mechanism motor when the drivetrain current is over X or only let the motor run up to half output when the drivetrain current is over Y).

Measuring Current Draw using the PDP

The FRC Driver Station works in conjunction with the roboRIO and PDP to extract logged data from the PDP and log it on your DS PC. A viewer for this data is still under development.

In the meantime, teams can use their robot code and manual logging, a LabVIEW front panel or the SmartDashboard to visualize current draw on their robot as mechanisms are developed. In LabVIEW, you can read the current on a PDP channel using the PDP Channel Current VI found on the Power pallete. For C++ and Java teams, use the PowerDistributionPanel class as described in the Power Distribution Panel article. Plotting this information over time (easiest with a LV Front Panel or with the SmartDashboard by using a Graph indicator can provide information to compare against and update your power budget or can locate mechanisms which do not seem to be performing as expected (due to incorrect load calculation, incorrect efficiency assumptions, or mechanism issues such as binding).

Identifying Brownouts

The easiest way to identify a brownout is by clicking on the CAN\Power tab of the DS and checking the 12V fault count. Alternately, you can review the Driver Station Log after the fact using the Driver Station Log Viewer. The log will identify brownouts with a bright orange line, such as in the image above (note that these brownouts were induced with a benchtop supply and may not reflect the duration and behavior of brownouts on a typical FRC robot).