Training L2

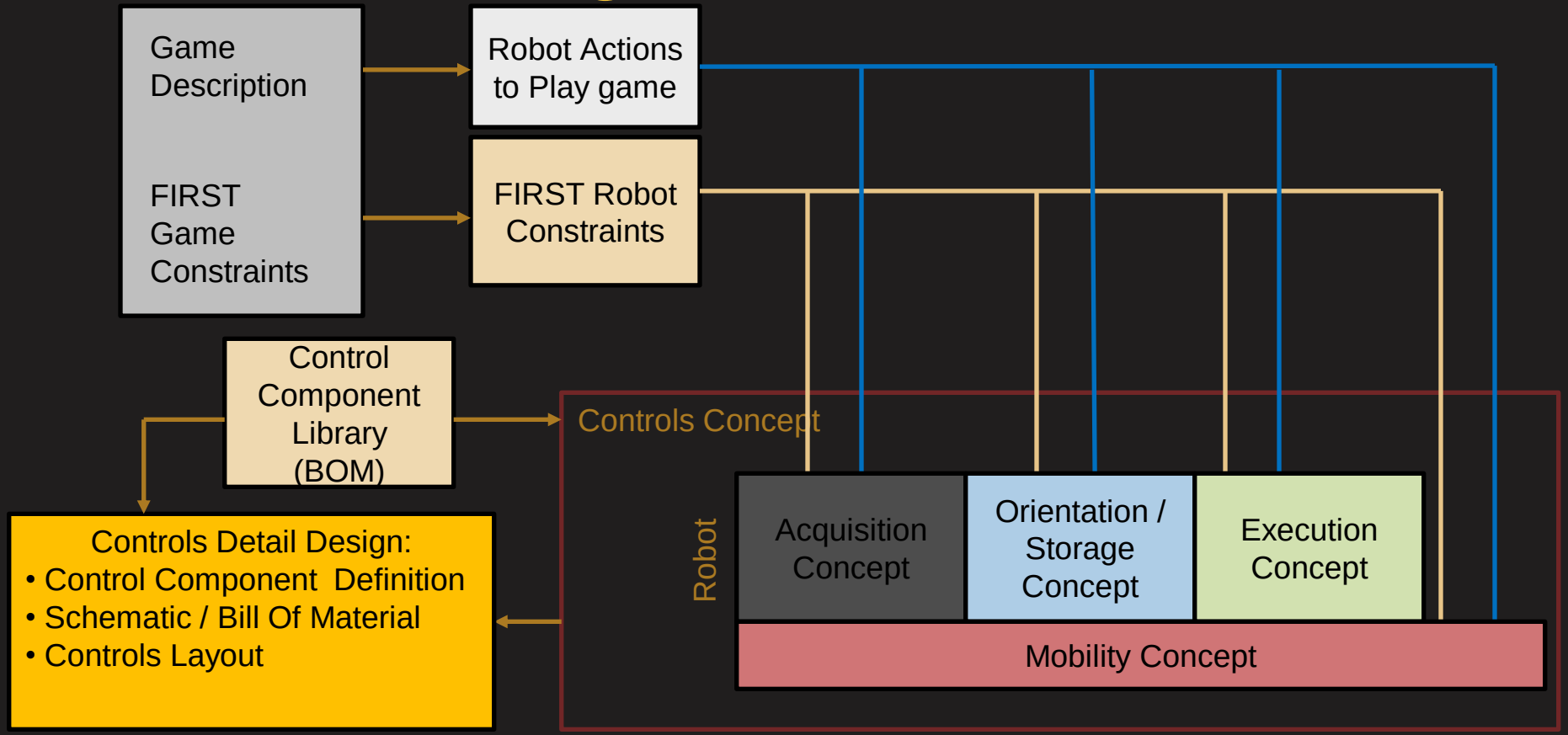
Electrical Design and Control System Wiring

Objectives

Understand:

- ❑ Understand the electrical design process
- ❑ Understand the control system wiring architecture
- ❑ Understand how to do power and control wiring
- ❑ Understand troubleshooting process and questions to ask

Electrical Design Process Flow



Electrical Design Process

Prototype Steps:
1 Determine Motors
2 Determine Sensors
3 Determine Control Structure

Prelim Steps:
1 Prelim layout
2 Prelim CID
3 Prelim BOM – order parts

Final Design Steps:
1 Develop Schematics
2 Develop Layout drawings
3 Complete BOM
4 Complete CID

Robot Strategy | Robot Design | Robot Build | Robot Eval

Game Description → Game Analysis → Functional Requirements → Concept / Prototype → Prelim Design → Detailed Design → Fabrication / Assembly / Test → Robot Competition

Prototype Evaluation / Improvement

Game Object → **Input** (Acquisition Module) | **Process** (Orientation Module) | **Output** (Execution Module) → Game Object (Placed in Goal)

Mobility Module(Drive Base)
(Drive Train Mechanism)

Control Interface Document (CID)

1) Item Number
2) Module Name: (e.g. lift)
3) I/O device name (e.g. lift Motor)
4) I/O device type: (e.g. switch, motor, solenoid, encoder, ultrasonic, optical switch)
5) Device ID: (e.g. M1, SW3, ENC1, US1, SOL1)
6) Controller ID: (e.g. PWM0, K3,
7) Cable ID: From Tag - To Tag: (e.g. PWM1 - M3)

Electrical Design Process Steps

CONCEPT PHASE

- Develop control strategy during the robot concept phase
- Define the control hardware
- Work with mechanical team to develop a control hardware layout concept

DETAILED DESIGN

- Develop the robot controller Interface Document(CIM)
- Develop robot schematic / Develop Bill Of Materials (BOM) with weights
- Collect data sheets and component manuals (Electronic “PDF” preferred)
- Develop final electrical layout, cable routing diagram, fuse map

FABRICATION

- From the BOM collect control hardware
- Mount control hardware and wire

TEST

- Check connections and measure for shorts
- Power up / Verify all LED status lights

IF IT IS NOT WRITTEN IT DOES NOT EXIST

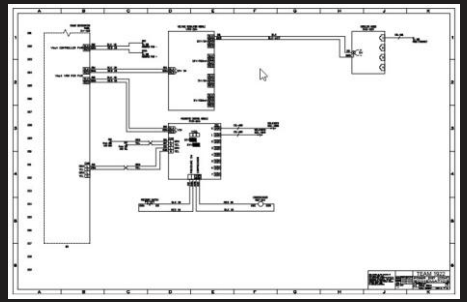
Computer Interface Document

Electrical Design Documentation Tools

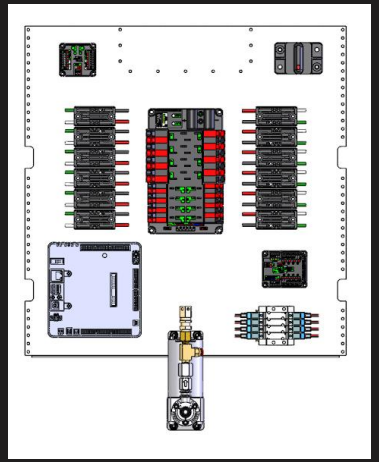
Control Interface Document(CIM)

- Bill Of Materials
- Data Sheets
- Manuals

Schematic(Power/Signal)



Controls Layout / Harness, Fuse diagram



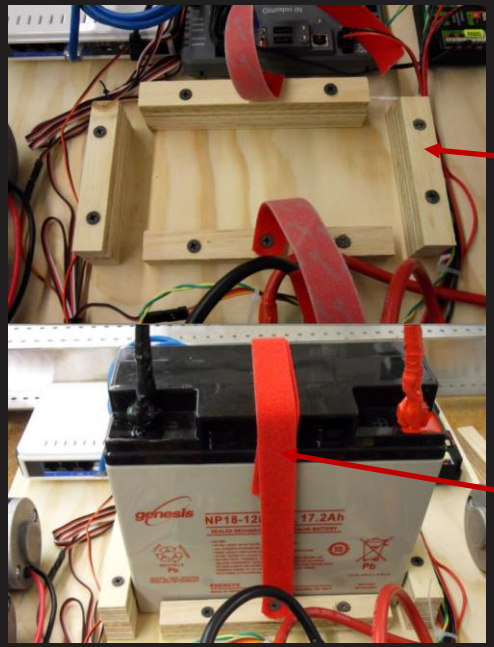
(See Electrical handbook for details)

Electrical Layout Considerations

- The control panel should be designed such that it can be assembled independent of the robot and installed on the robot at the end of the robot build
- Allow for component access to troubleshoot or replace
- All status LED’s should be visible for troubleshooting
- Battery should be mounted securely and placed for easy replacement
- Place motor controllers close to the PDP
- The power switch should be place such that it has easy access
- Place electrical components such that they can not be damaged from mechanical operations on the robot

Battery Installation

- Battery must be place for easy replacement
- Battery must be mounted securely in the robot



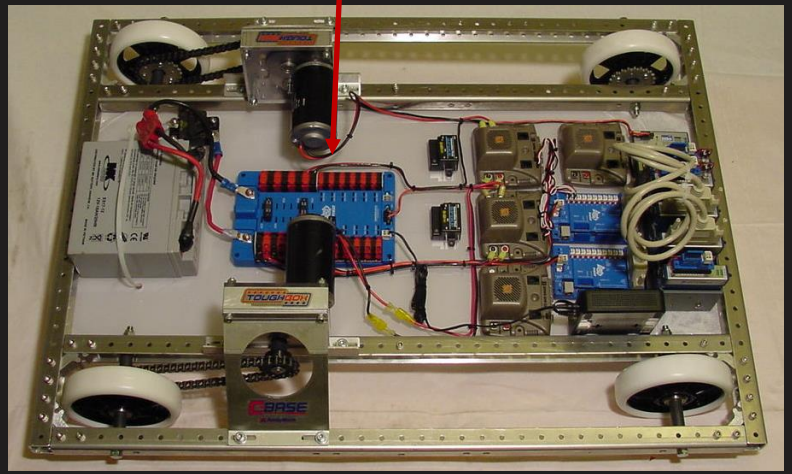
Battery Holder

Velcro straps to secure and for easy removal

Control System Layout Examples

Battery Wiring
(Short Leads)

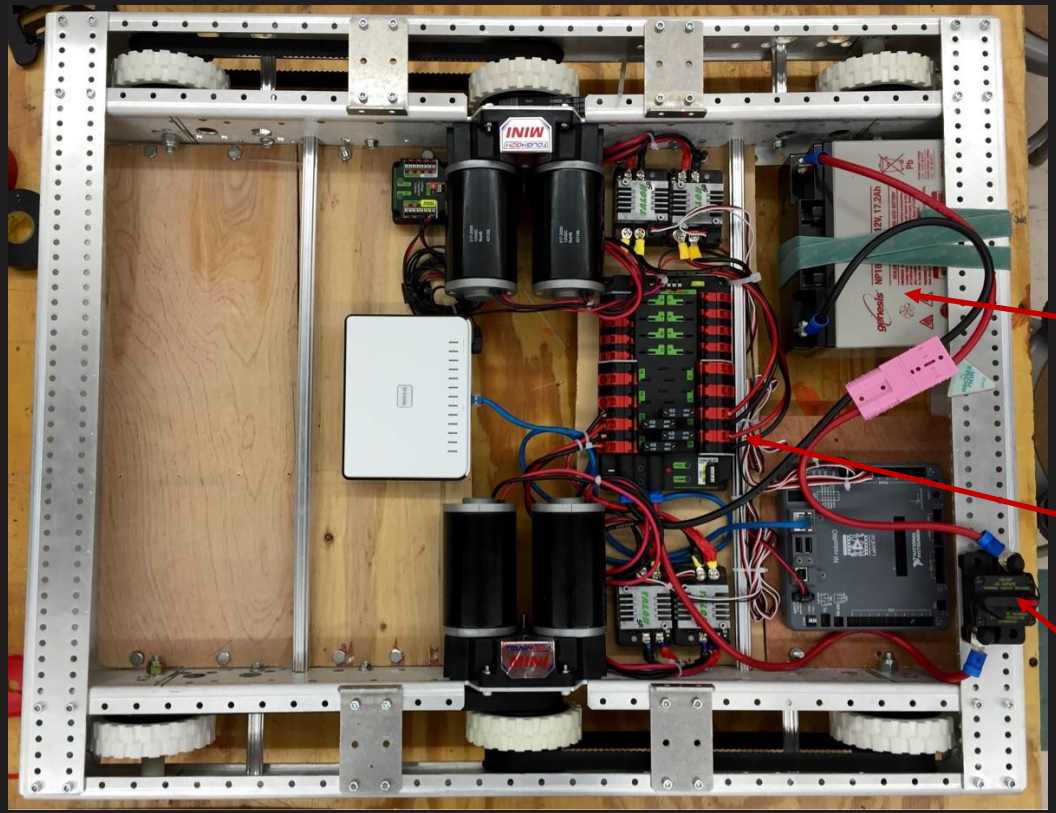
2013



Power Wires
(At the lower level)

2006

Control System Layout Examples



Battery Holder / Strap

Signal wires (At a Different Level from power)

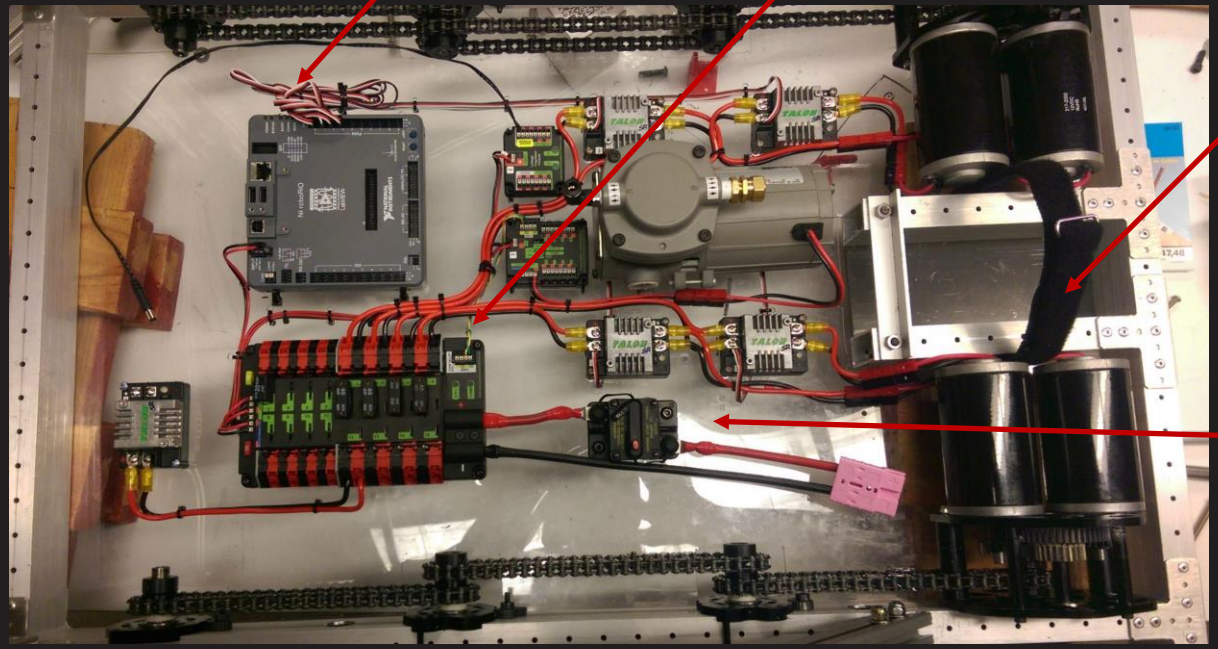
Robot Power Switch

Control System Layout Examples

Excess cable spooled and tie wrapped

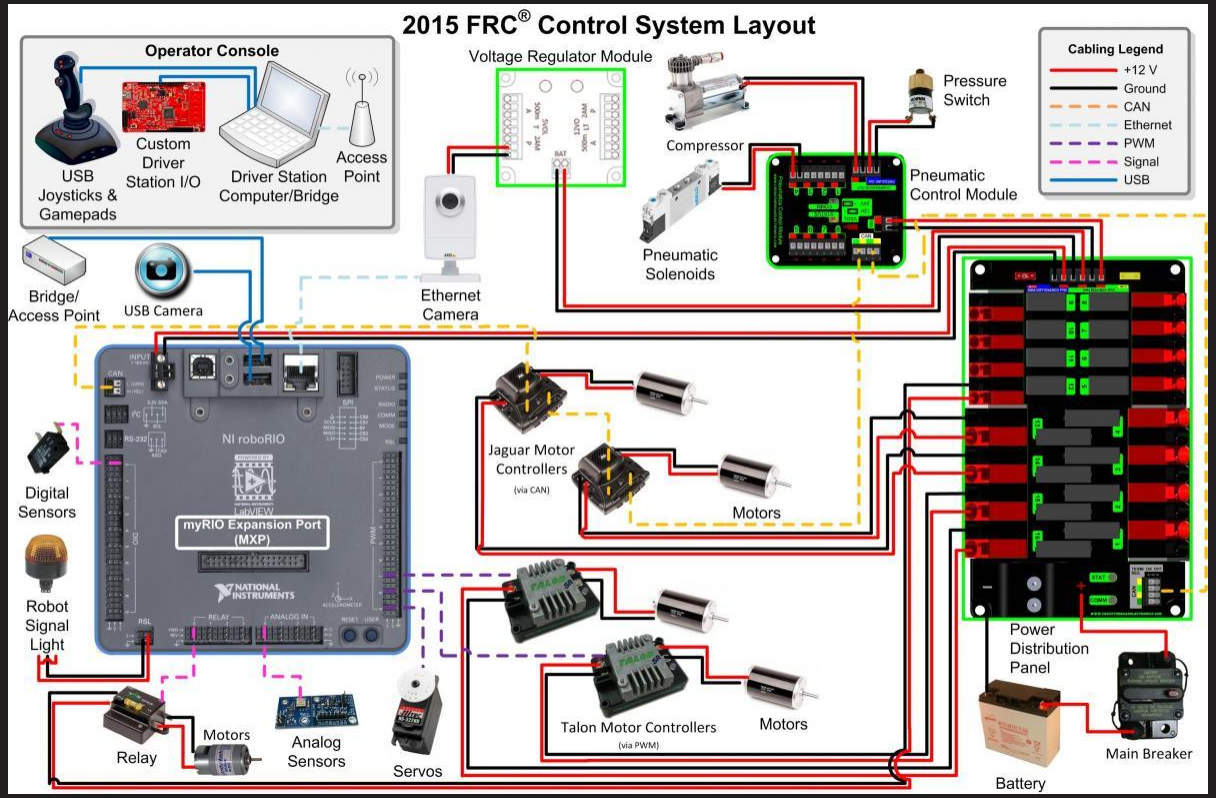
Motor-Module Power cable bundle

Battery Holder / Strap

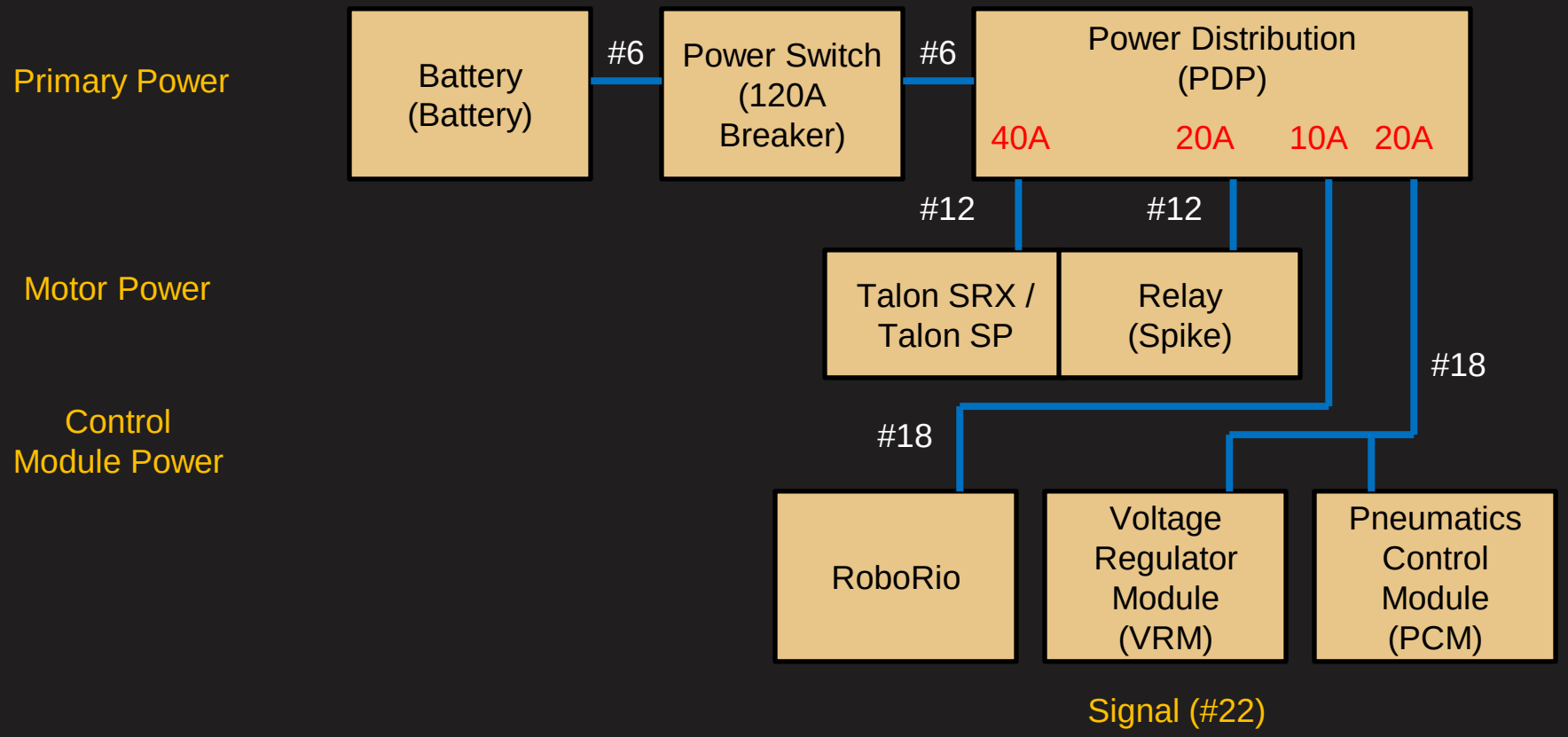


Battery Wiring (Short Leads)

FIRST Pictorial Control System Wiring



Wire Level Architecture



Selecting the correct wire gauge

Read the Game Manual!!

Application	Minimum Wire Size
31 – 40A protected circuit	12 AWG (2.052mm)
21 – 30A protected circuit	14 AWG (1.628mm)
6 – 20A protected circuit	18 AWG (1.024mm)
Between the PDP dedicated terminals and the VRM or PCM	18 AWG (1.024mm)
Compressor outputs from the PCM	18 AWG (1.024mm)
Between the PDP and the roboRIO	22 AWG (0.645mm)
VRM 2A circuits	22 AWG (0.645mm)
δ5A protected circuit	22 AWG (0.645mm)
roboRIO PWM port outputs	26 AWG (0.404mm)
SIGNAL LEVEL circuits (i.e. circuits which draw δ1A continuous and have a source incapable of delivering >1A, including but not limited to roboRIO non-PWM outputs, CAN signals, PCM Solenoid outputs, VRM 500mA outputs and Arduino outputs)	28 AWG (0.321mm)

(2015 Manual R38)

Wire Color Code and Sizing

- Battery – power switch – PDP(#6)
  - +Voltage: RED
  - - Voltage: BLACK

- Motor Power: (#10, #12)
  - +Voltage: RED
  - -Voltage: BLACK

- Control Module Power: (#18)
  - +Voltage: RED
  - -Voltage: BLACK

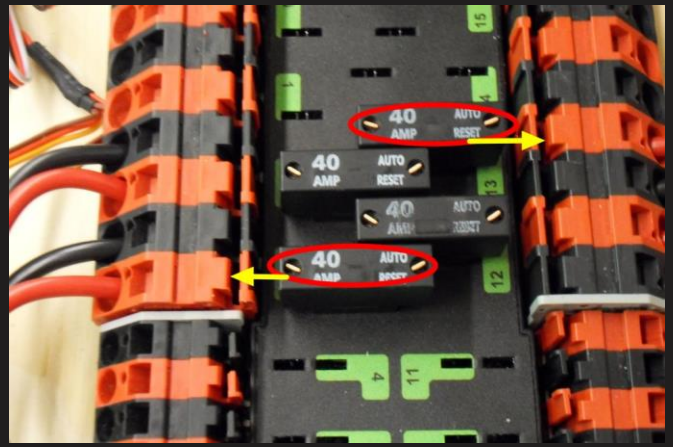
- CAN: (#22)
  - CANHigh: YELLOW
  - CANLow: GREEN

- Signal: (#26)
  - Typically white in cables

Circuit Fusing

Branch Circuit Breaker	Circuit Breaker Value	Quantity Allowed Per
Motor Controller	Up to 40A	1
CUSTOM CIRCUIT	Up to 40A	1
Relay Module	Up to 20A	1
Additional PCM – with compressor	20A	1
Additional VRM (non-radio)/Additional PCM (non-compressor)	20A	3 total

(2015 Manual R37)



Component Wiring Best Practices

- Develop a harness diagram that shows wire routing
- Separate wires by current level(wires of different current levels should not run parallel to each other
- If high current and low current wires should cross, they should be placed perpendicular to each other
- Secure wire in such a way that prevents mechanical impact of any kind from pulling wires
- Check all wire crimps for a good connection / Insulate all connectors
- Allow slack in wire to replace control component
- Do not run wires through frame members
- Battery cables short as possible to PDP / Place motor controllers close to the PDP
- Label all cables that go to the RoboRio
- NEATNESS COUNTS – tie up cable runs and tie wrap spooled excess wires/cables

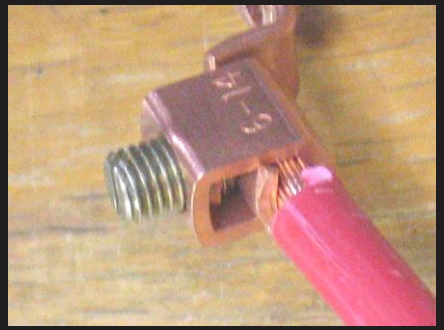
Battery Terminal Wiring

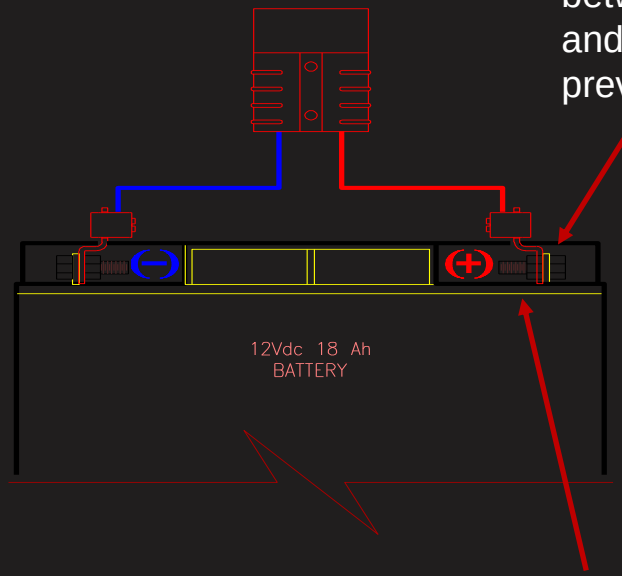
Battery Terminal Wiring:

- Wire is stripped back the length of the terminal, about ¾”.

- Insert wire between the shell and the terminal <u>Do not insert wire under screw!</u> The screw pushes on the copper clamp, not the wire.

- When terminated properly, the wire should take on the shape of the shell and cannot be moved.

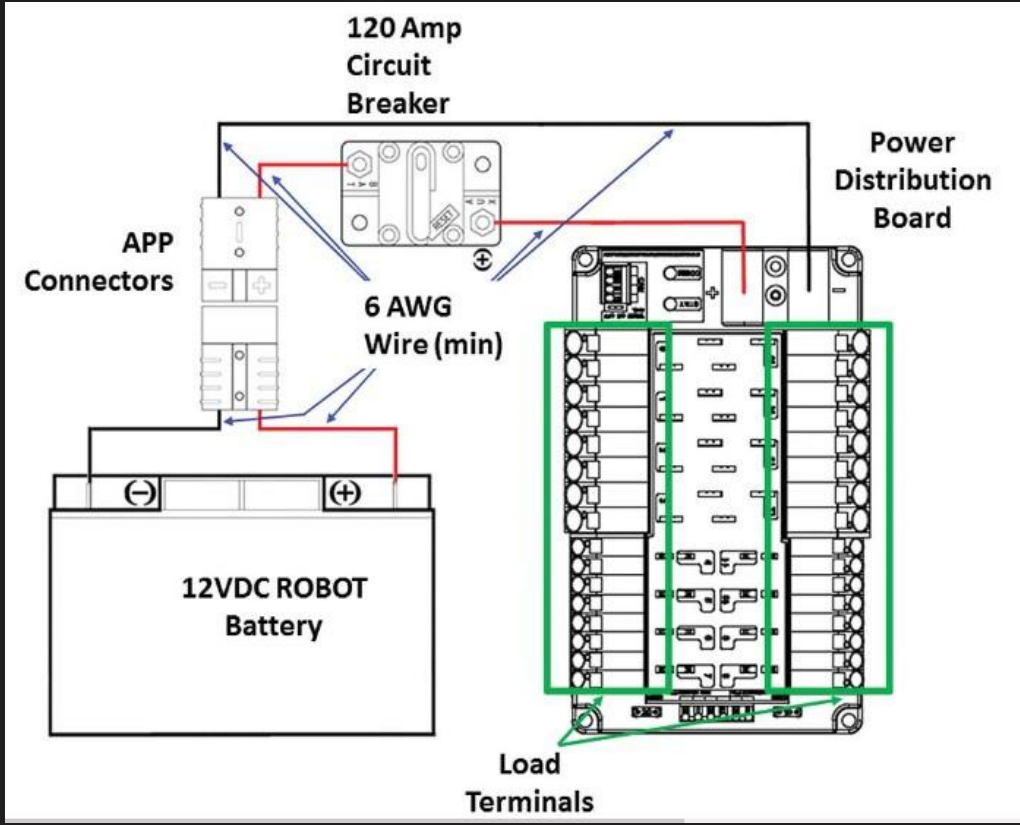




Insert a star washer between the wire terminal and the battery terminal to prevent slipping.

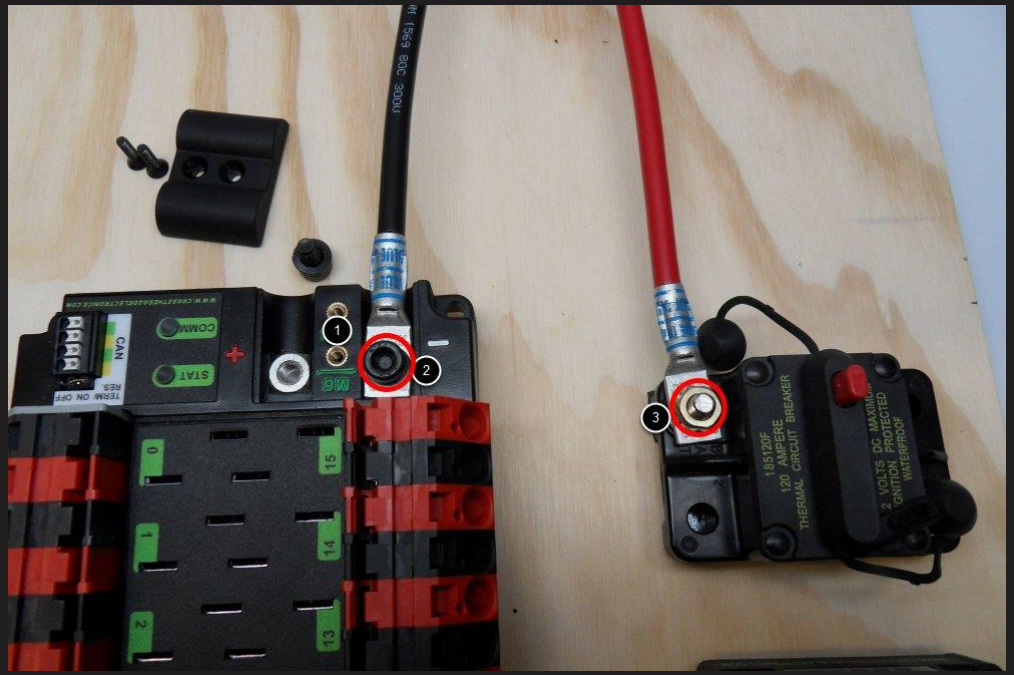
Terminals are turned to inside and are mounted on inside of terminal, allowing battery case to shield them from abrasion.

Battery – PDP Wiring



Wiring Main Robot Power Switch To PDP

See - FIRST Wiring the 2015 FRC Control System.pdf for detailed wiring instructions



Wiring Main Robot Power Switch To PDP

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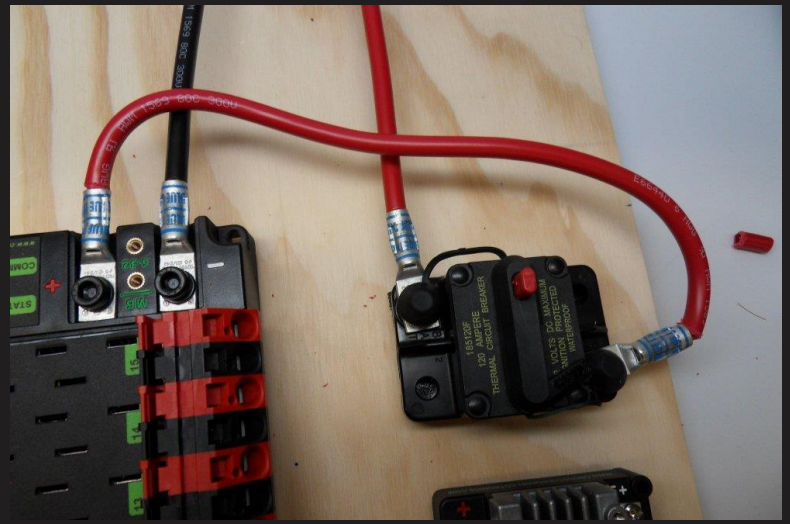
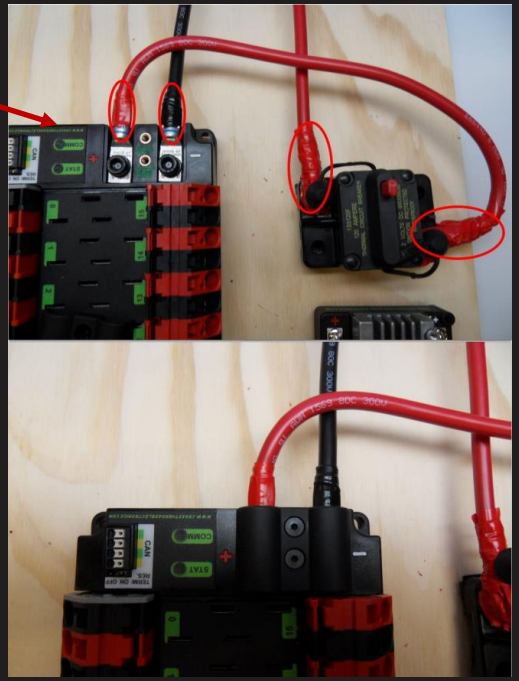
Insulate terminals





Weidmuller/Wago Connectors

See - FIRST Wiring the 2015 FRC Control System.pdf for detailed wiring instructions

- 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.

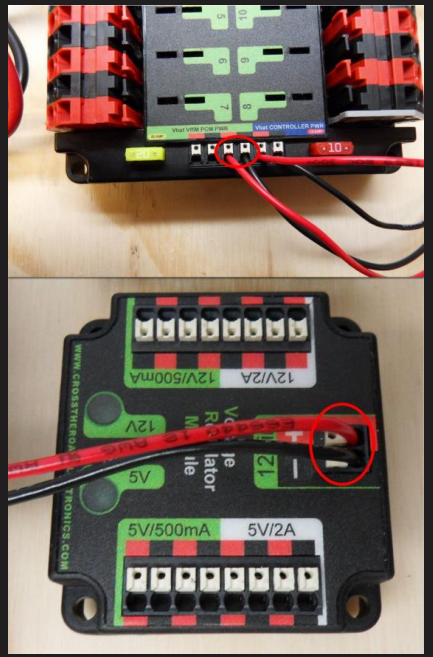
- Look for stray wire whiskers after inserting the wire

Wiring Power to Control Modules

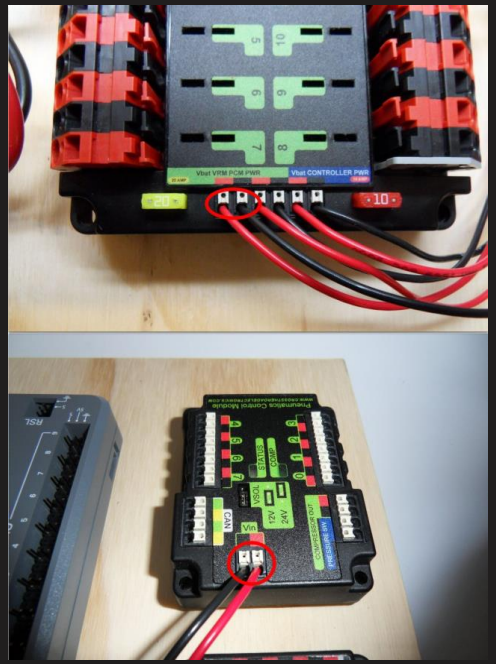
See - FIRST Wiring the 2015 FRC Control System.pdf for detailed wiring instructions

PDP to RoboRio

PDP to VRM

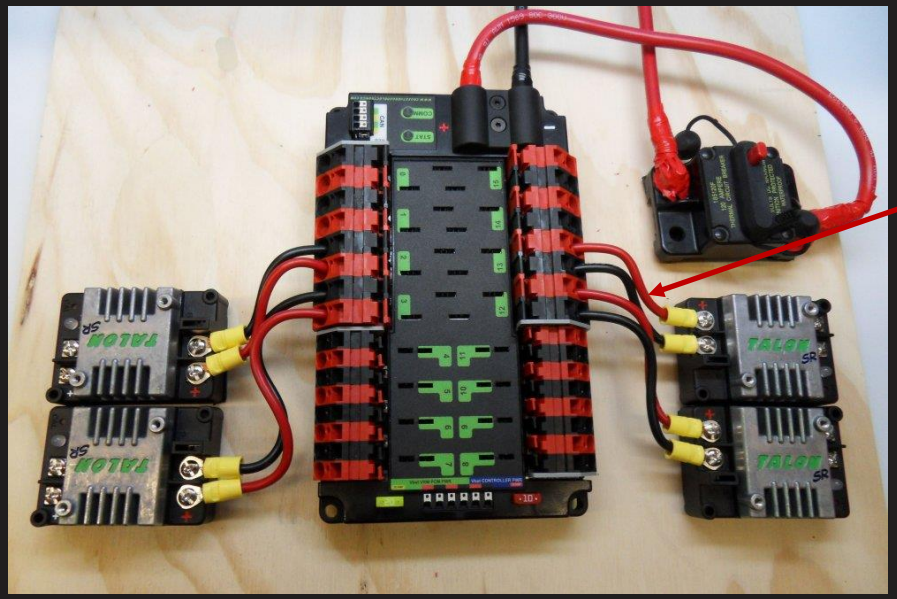


PDP to PCM



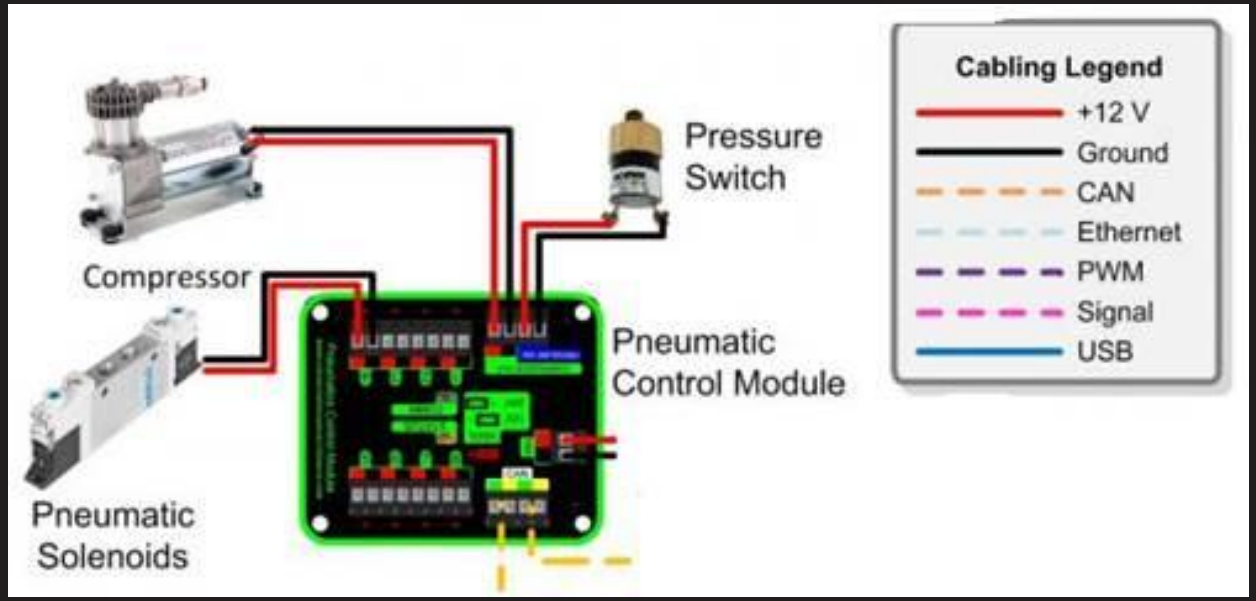
PDP to Motor Controllers

See - FIRST Wiring the 2015 FRC Control System.pdf for detailed wiring instructions



Length to motors to be short as possible

Wiring the Pneumatics Control Module(PCM)



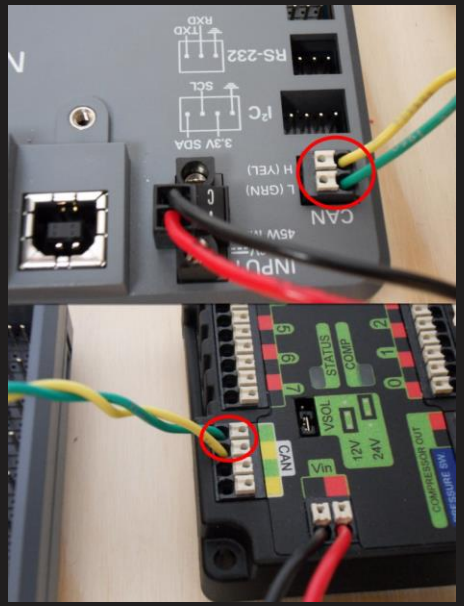
Wiring the Radio Power and Ethernet

See - FIRST Wiring the 2015 FRC Control System.pdf for detailed wiring instructions

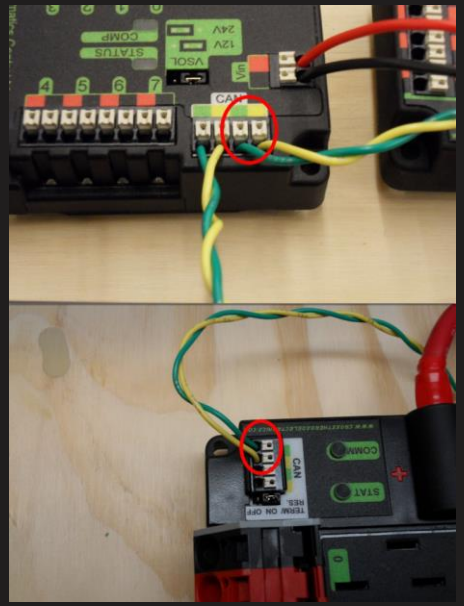
Wiring the CAN Bus

See - FIRST Wiring the 2015 FRC Control System.pdf for detailed wiring instructions

RoboRIO to PCM

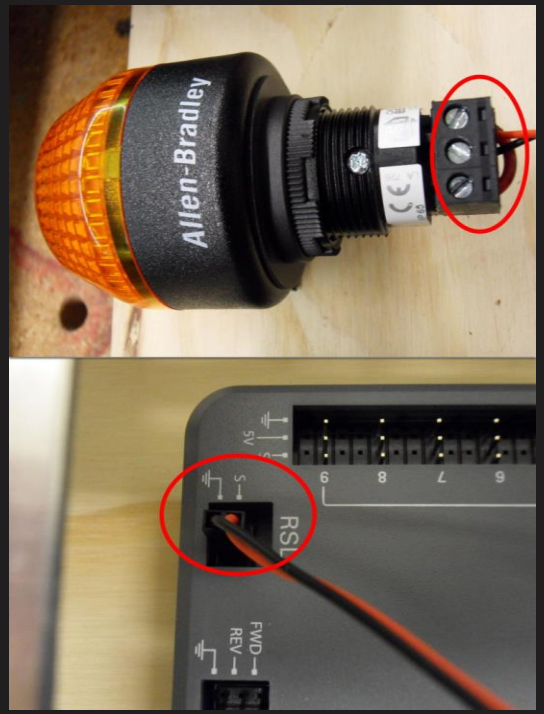


PCM to PDP



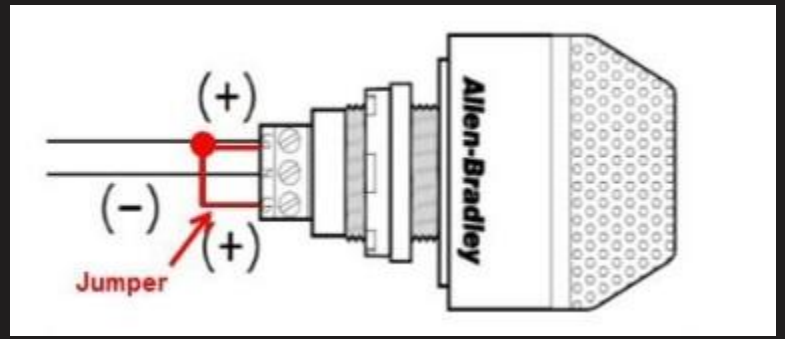
Robot Signal Light

See - FIRST Wiring the 2015 FRC Control System.pdf for detailed wiring instructions

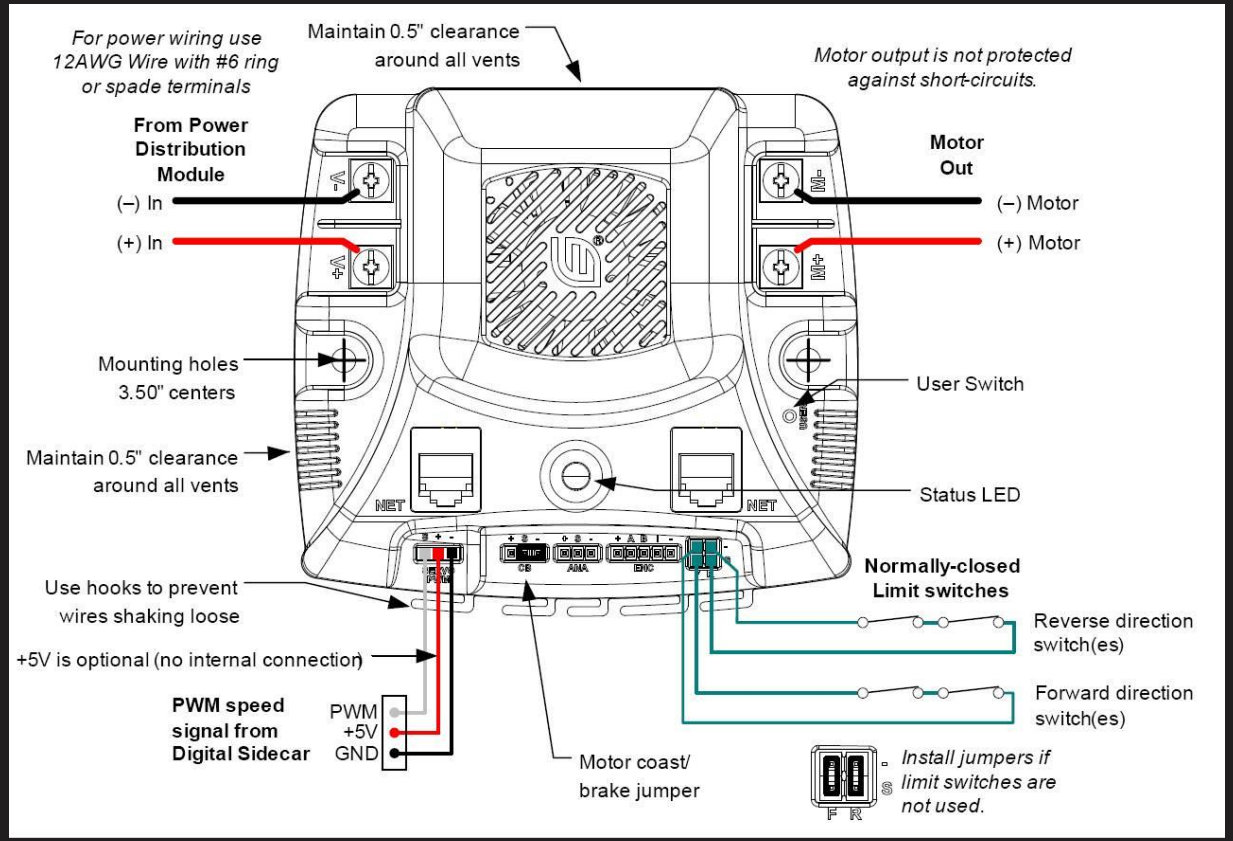


Robot Signal Light (RSL) Wiring:

- Use 2-wire cable from Digital Sidecar to RSL Cut connector off of cable end at RSL
- Connect (-) to center (N), (+) to (La) or (Lb)
- jumper between (La) and (Lb) RSL connection

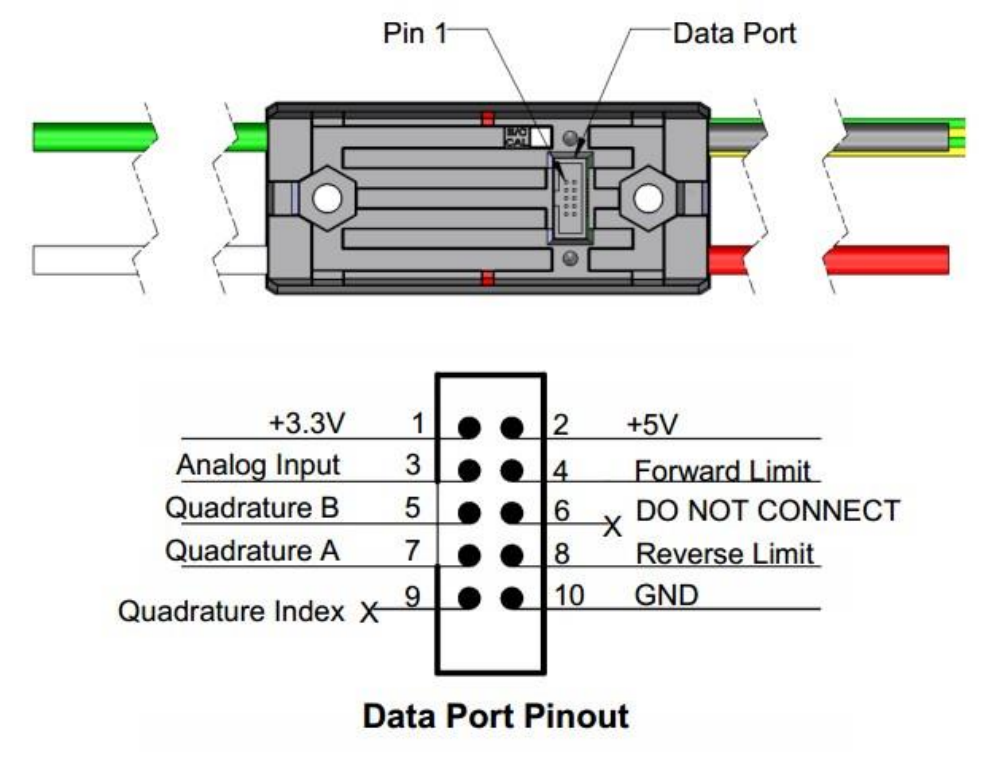


Jaguar Wiring



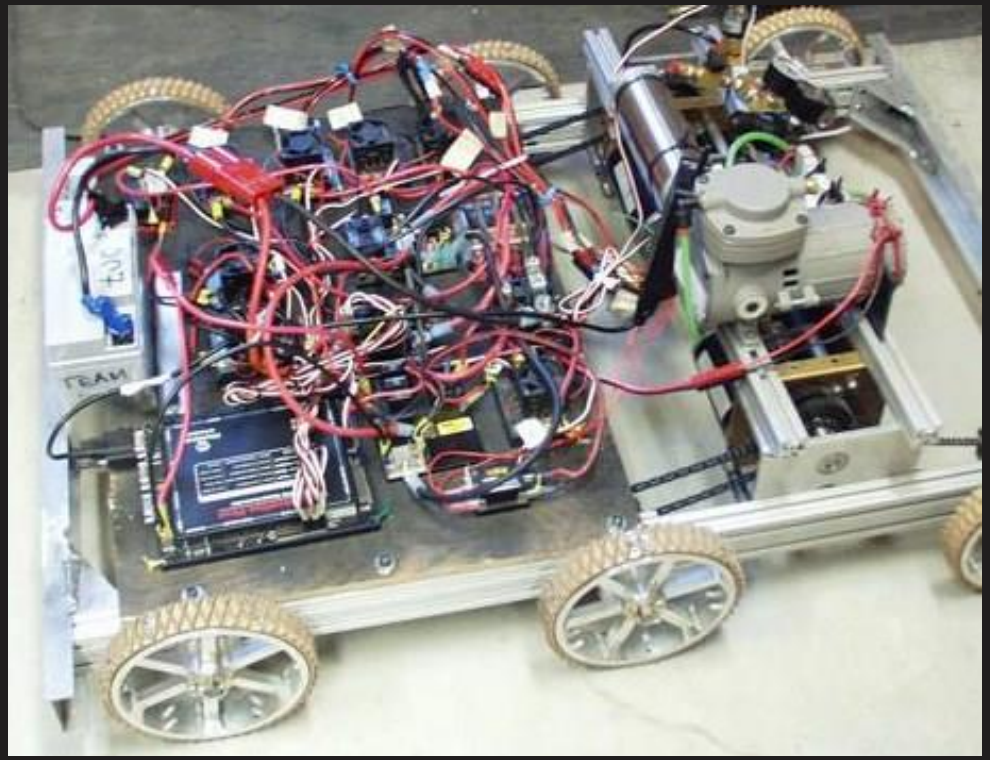
Talon SRX Wiring

CAN Wiring

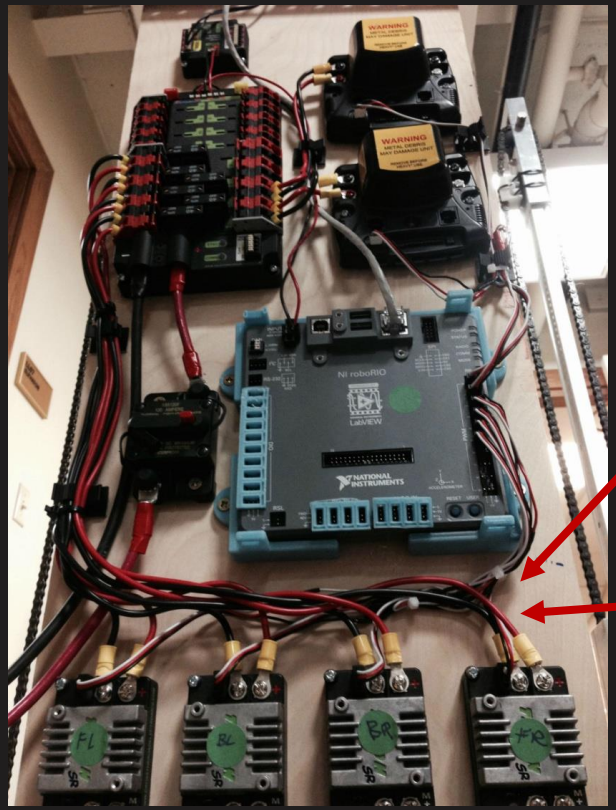


Cable Management

Where is the Robot power switch?????

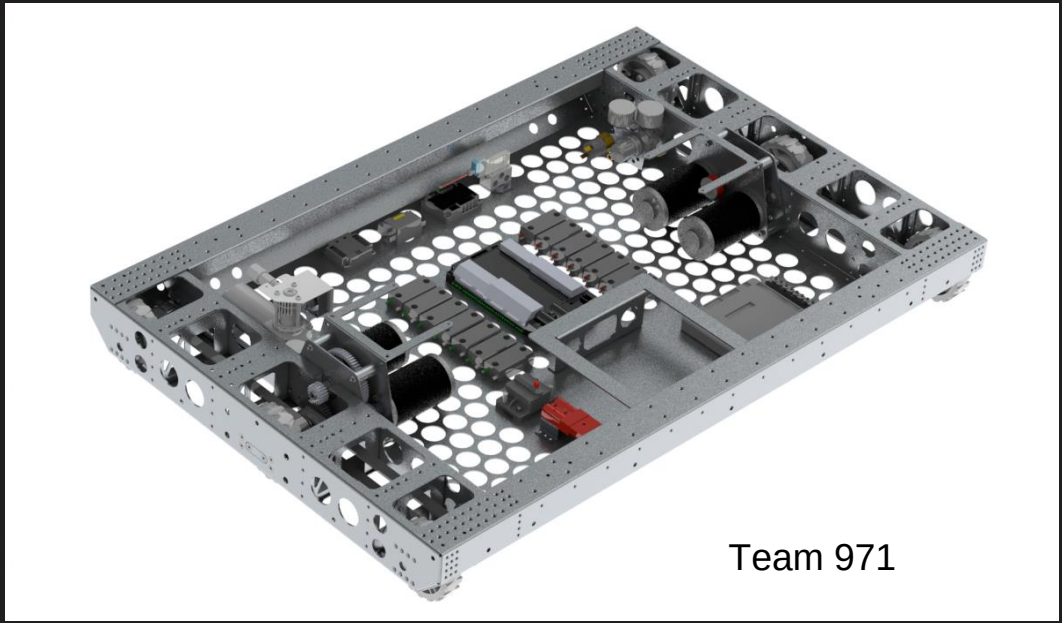


Cable Management Example

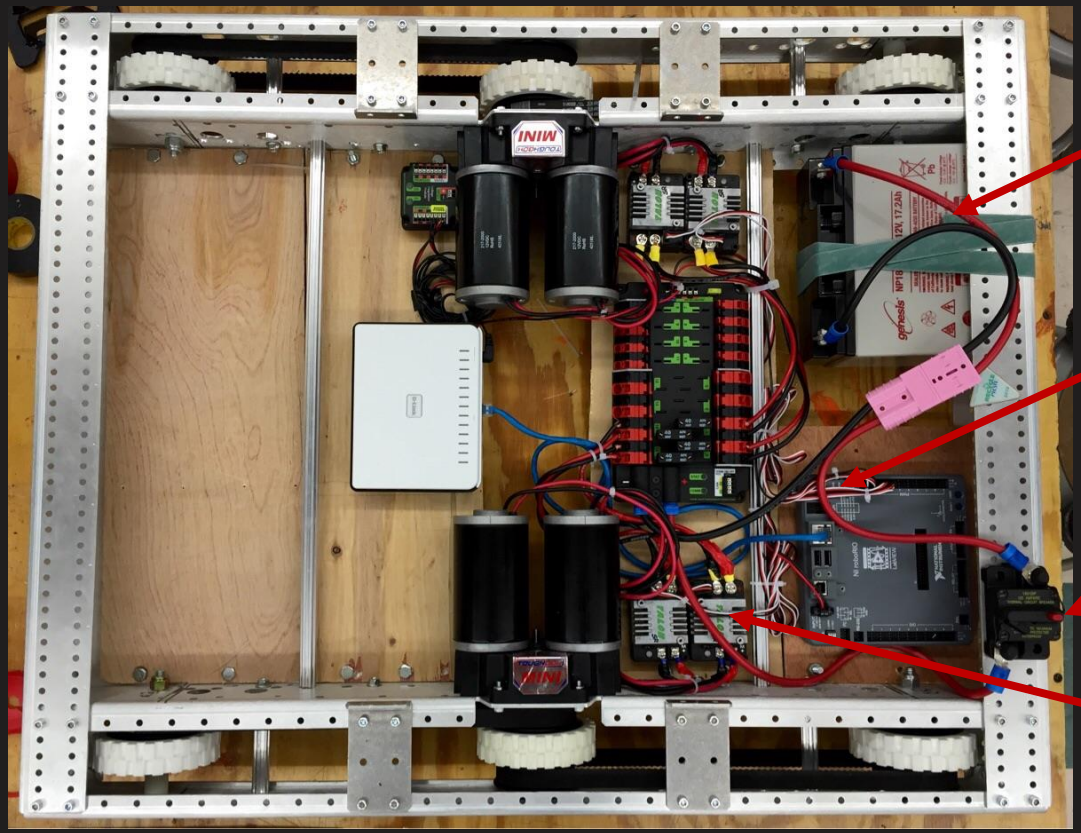


- Signal wires should be isolated from power and motor wires
- Signal wires should cross power wires at right angles

Power wires to motor controllers are to long


Team 971

Cable Management Example



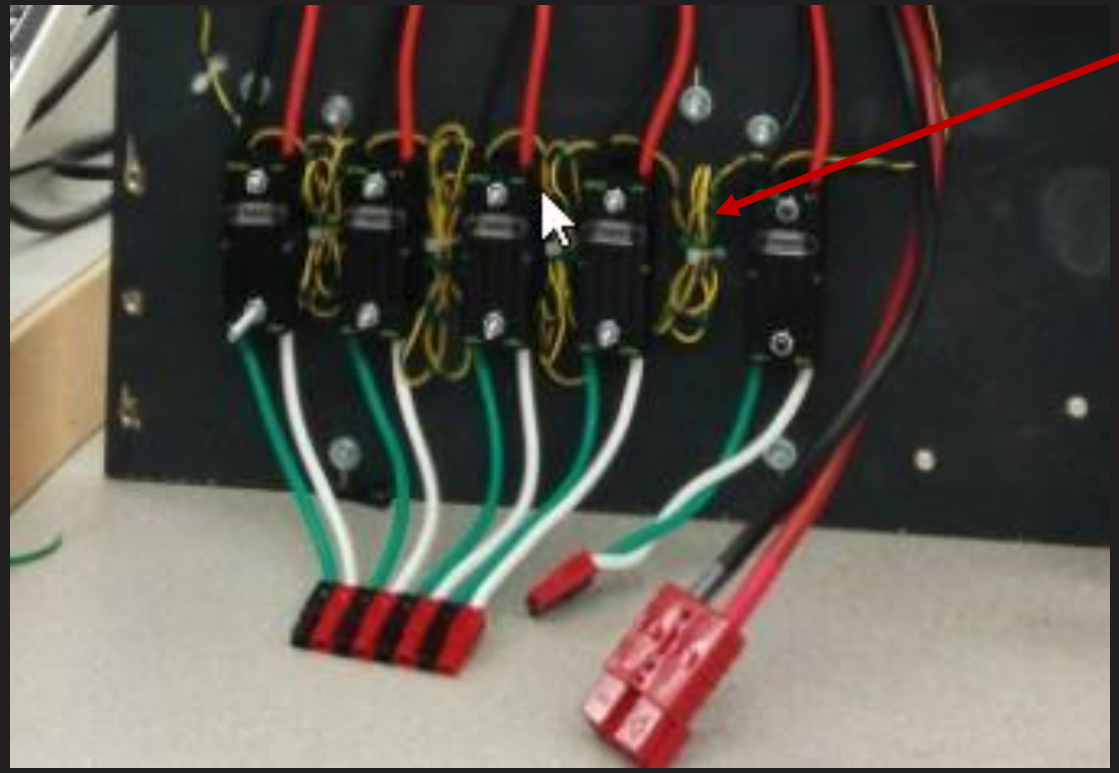
Length for battery wires are to long

Signal wires appear to be isolated from power wires

Power switch in an accessible location

Motor power wires are short

Excess Cable Management



Cable Grouped and tie wrapped

Powering Up the Control System

- Make sure power switch is off

- Before plugging in the battery, make sure that all connections have been made correctly to the power switch and the PDP module and that all connections are secure
- Check the motor wiring is correct and that all connections are secure
- Check power wiring to control modules is correct and that all connections are secure
- Check signal wiring is correct and that all connects are secure
- Measure the resistance on the main power lines to the PDP for any shorts in the system

It is also recommended to put the robot on blocks so the wheels are off the ground before proceeding.

Potential Electrical Problems

- Metal shavings may have shorted out control component
- Power connections are not secure
- Signal cables are not secure and have come loose
- Fuse is blown or circuit breaker is bad
- Control component has gone bad
- Control component has overheated
- Motor controllers are not calibrated

Troubleshooting

- On power up check all module LED status lights and correct any issues (i.e. bad components)

See - FIRST Status LED troubleshooting.pdf

- Set up the communications to the RoboRio and down load Input/Output (I/O) software to test control hardware

- Trouble shooting questions:

✓ If it was running and is not now What has changed?
✓Does the control hardware component have power?
✓ Are all connections secure?
✓ Is LED status correct?
✓ Is their a signal if sensor is actuated?

Revisions

V160610 – RJV –Reformatted to team format
V150914 – RJV- Corrected action module to execution module
V150826 - Original