Team 5401 -
The Fightin' Robotic Owls
Wiring Guide

Updated - 2023-2024 Season

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FRC Control System Overview

This wiring guide will cover the basics of the FRC control system electronics, the equipment, and how the robot gets wired together. With all wiring, it is important to always pull on connectors to make sure wire is secured inside. If the wire comes out when pulled, then that connection needs to be redone. As you are wiring the robot, it is very beneficial to label all wires going into and out of the piece of equipment. This is extremely critical when quickly trying to troubleshoot issues or replace failed pieces of equipment.

Key pieces of equipment:

Power Distribution (PDH or PDP)

- This equipment takes the electricity provided from the battery and splits it to the various equipment used to make the robot move, think, and function.
- There are two manufacturers for the power distribution equipment. Both provide a similar overall function but depending on your specific robot, one may be better suited for you.
    - PDH – Power Distribution Hub by Rev Robotics

        - LED Status Lights:
            - https://docs.revrobotics.com/rev-11-1850/status-led-patterns
            -

General LED	
Blue - Solid	Power but no communication
Green - Solid	Communication with roboRio is good
Magenta - Blinking	Keep Alive Timeout
Cyan - Solid	Secondary Heartbeat (Connected to Rev hardware client
Orange/Blue - Blinking	Low battery
Orange/Yellow - Blinking	CAN Fault
Orange/Cyan - Blinking	Hardware Fault
Orange/Magenta - Blinking	Device Over Current
Channel LED	
LED Off	Channel has voltage and is operating as expected
Red Solid	Channel has NO voltage and there is an active fault. Check for blown or missing fuse
Red Blinking	Sticky fault on the channel. Check for blown fuse

- Pros:
  - Updated software to aid in troubleshooting
  - More flexibility in the number/type of breakers used
  - Easier Wago style connections for connecting wires
  - Current battery voltage display
- Cons:
  - Breakers are proprietary
  - Software/data can be challenging to figure out

- PDP - Power Distribution Panel by CTR Electronics

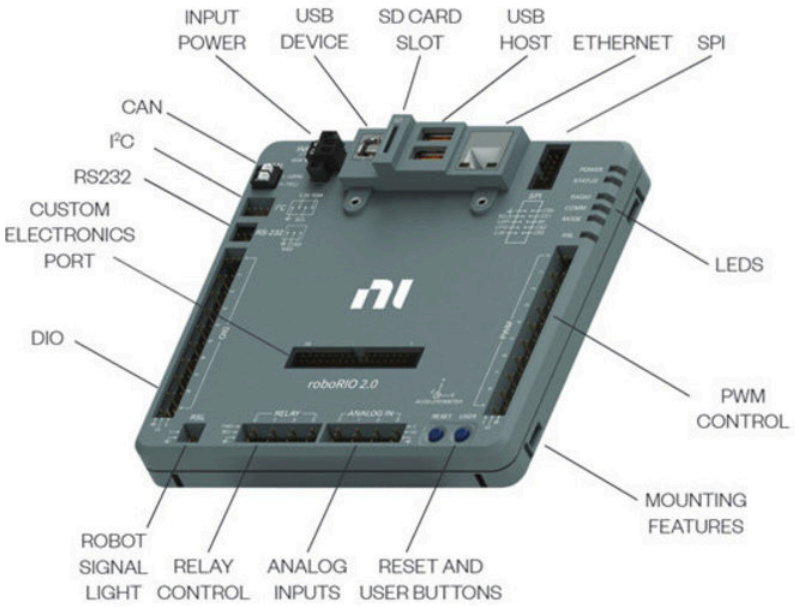
- LED Status Lights:

Status LED	
Green - Fast Blinking	Robot is enabled
Green - Slow Blinking	Robot is disabled
Orange - Slow Blinking	Robot is disabled, Sticky fault
Red - Slow Blinking	No CAN

- Pros:
  - Common breakers
  - No complicated software
- Cons:
  - Limited to 8 40amp breakers
  - Minimal data for troubleshooting

roboRio

- This is the “brains” of the robot. The roboRio is what distributes the programming code and sends signals out to the various parts of the robot telling them what to do.
- The roboRIO is a reconfigurable robotics controller that includes built-in ports for inter-integrated circuits (I2C), serial peripheral interfaces (SPI), RS232, USB, Ethernet, pulse width modulation (PWM), and relays to quickly connect the common sensors and actuators used in robotics. The controller features LEDs, buttons, an onboard accelerometer, and a custom electronics port. It has an onboard dual-core ARM real-time Cortex-A9 processor and customizable Xilinx FPGA.
- A NavX2 sensor is commonly installed ontop of the roboRIO and plugs into the Custom Electronics Port. This is a 9-Axis Inertial/Magnetic Sensor (Gyro / Accelerometer / Magnetometer) that can aid in the positioning of the robot. If you didn’t want to use a NavX2 sensor, then a CTRE Pigeon can be installed on the robot. This ties into the CAN network and gets powered from the PDH/PDP low power/low amp channels or the 12V/500 mA port on a VRM.



- LED Status Lights:
  - https://www.ni.com/docs/en-US/bundle/roborio-20-umanual/page/umanual.html#GUID-3A063E02-2CCB-4F04-AAF8-0D25BE7136F7

Power LED	
Blue - Solid	Power with no faults
Red - Solid	Power with brownout condition detected
Status LED	
2 flashes	Software Error, reinstall software
3 flashes	Device in safe mode
4 flashes	Software crashed twice without rebooting, device may be out of memory
Continuous Flashing/Solid	Unrecoverable error
Radio LED / Comm LED / Mode LED	
Green - Solid	Green enabled
Red - Solid	Red enabled
Yellow - Solid	Green and Red enabled
Eth Link	
Yellow - Solid	RSL Enabled

12V Battery

- All robots need power to move and operate their components. A single 12V Sealed Lead Acid (SLA) battery is capable of meeting the high current demands of an FRC robot.
- Battery Basics:
    - Never carry or install/remove a battery by the wires/cables
    - Always inspect the wires for loose connections, damage, etc. A battery is always “On”, so damaged connections create a safety issue
    - If a battery is leaking, do not touch it. Contact a mentor and use a battery spill kit to clean up the battery and the area.
    - A Battery Beak/Tester can be used to quickly test the battery quality. Longer testing can be completed with a battery analyzer to determine the battery characterization.
- https://docs.wpilib.org/en/latest/docs/hardware/hardware-basics/robot-battery.html#robot-battery-basics

120A Circuit Breaker/Power Switch

- This is the robot’s primary on/off switch. The switch should be turned off prior to disconnecting the battery when it needs to be changed.
- This is also a circuit breaker that will protect all downstream equipment (roboRio, PDH, motors, etc) from damage caused by overcurrent.

- Wiring:
    - This gets wired between the positive (red) wire of the battery and the PDH/PDP.

Voltage Regulator Module (VRM)

- This module is used to regulate the incoming 12V power from the PDP down to 4 different power/amperage combinations.
    - Connections:
        - Two 12V/2A (1.5A limit/2A peak)
        - Two 12V/500 mA
        - Two 5V/2A (1.5A limit/2A peak)
        - Two 5V/500 mA
    - LED Status Lights:

Status LED	
12V Light On	12V/500mA channel is powered
5V Light On	5V/500mA channel is powered

        - *Note the 2A channels do not impact the status lights*
- This is commonly used for powering the radio, vision cameras, and custom circuits.
    - 

- Wiring:
    - This gets wired from the 20Amp Connectors labeled Vbat VRM PCP PWR on the PDP to the 12V input on the VRM.

Robot Signal Light (RSL)

- This is a required light that needs to be prominently displayed on the robot where it can be easily seen. It indicates when the robot is powered and/or enabled
- Wiring:
    - This is wired directly from the light to the RSL port on the roboRio.
- LED Status Lights:
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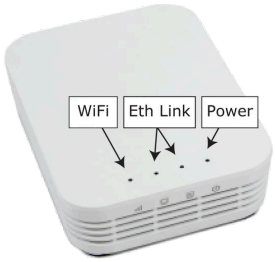
Status LED	
Solid Light	Robot is powered on
Blinking Light	Robot is enabled

Radio

- The radio is how the robot communicates wirelessly with the driver station laptop.
- Wiring Connections/Powering the Radio



    - There are two ways to connect and power the radio on the robot

- Connection #1 Rev Radio Power Module:
  - Utilizing a Rev Radio Power Module (RPM)
    - 
  - Wiring:
    - The Rev RPM uses two ethernet cables with RJ45 connectors. One is connected between the radio and the Rev RPM. The second is connected between the Rev RPM and the roboRIO.
    - The Rev RPM is powered directly from the PDH low current
    - connection to the Rev RPM. Match the black to black (negative) and red to red (positive)connections.
  - Pros:
    - Simple/Direct connection between the PDH and the Radio
    - Easy to mount anywhere on the robot because the length of the power and ethernet wires can be customized
  - Cons:
    - No secondary/redundant power connection
    - Rev RPM is fairly new (within the last 2 years) - longevity not proven
- Connection #2 POE injector cable and VRM:
  - Utilizing the VRM and POE injector cable
    - 
  - Wiring:
    - The POE injector cable power connects to the VRM 12V/2A connection. Match the black to black (negative) and red to red (positive)connections.
    - The RJ45 ethernet connector of the POE injector should be plugged into the radio
    - A separate ethernet cable with the RJ45 connectors should be connected between the POE injector cable and the roboRio.
    - A secondary/redundant power connection can be used between the VRM 12V/2A connection and the barrel connector on the radio
    - *Note: No other connection can be used on the VRM 12V/2A connectors if using the POE injector cable outside of the secondary/redundant barrel connector. This means the extra 12V/2A connection cannot be used for a camera or any other piece of equipment.*

        - Pros:
            - Able to have secondary/redundant power supply
            - Preferred wiring method for many years, longevity/reliability is proven
        - Cons:
            - Limited sometimes by where it can be mounted due to the POE injector cable length
            - More complicated wiring setup, ie requires the VRM to be used
- LED Status Lights:
    -

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

Motors

Types

- These are the most common types of motors that we use on our robot. The exact motor that is selected will depend on the task we want the robot to complete. A motor will allow the robot to achieve motion whether it is on the drive train, arm, flywheel, intake, or any other part of the robot.
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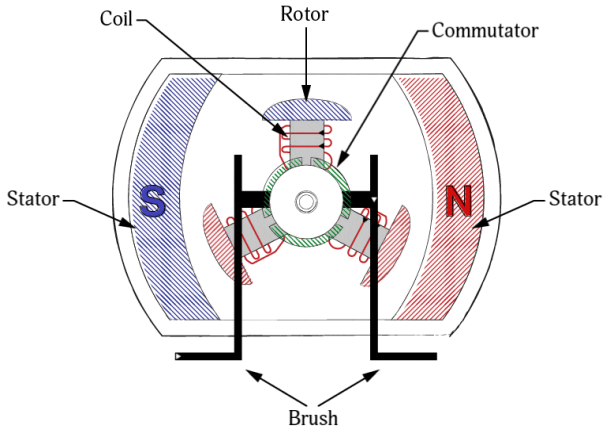
- Brushless vs Brushed:
  - Brushed motors have brushes, which are used to commutate the motor to cause it to spin.



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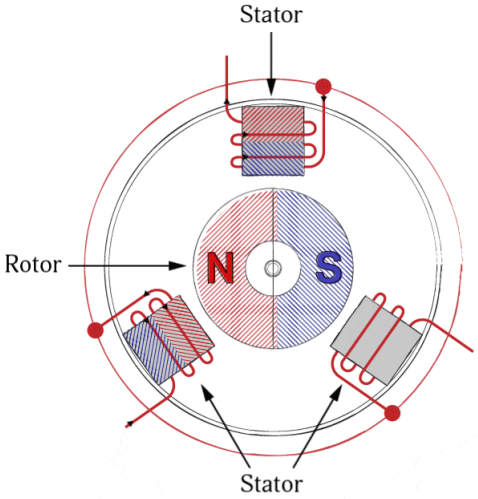
  - Brushless motors replace the mechanical commutation function with electronic control.



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  - More information: https://motors.vex.com/brushed-brushless
- Higher Torque/High Duty application recommendations
  - NEO 1650, Falcon 500, CIM
  - Good for drive trains, shooter wheels, large arm movements
- Lower Torque/Low Duty application recommendations
  - NEO 550, 775pro, BAG
  - Good for intakes, belt drives, small arm movements

Rev NEO 1650 Brushless Motor

Rev NEO 550 Brushless Motor

Vex Falcon 500 Brushless Motor

Vex 775pro Brushed Motor

Vex BAG Brushed Motor

(Smaller)

Vex CIM Brushed Motor

(Larger)

Wiring

- All motors will have power wires to connect. This will be your red and black wires. These wires will be connected directly to the wires on the speed controller with the exception of the Falcon550 motors. The exact color the wire matches to will depend on the speed controller that is used.
    - **For Falcon550 motors:** This motor already has a built in speed controller directly on the motor. The red and black wires exiting the motor will be wired directly to the PDP or PDH. When connecting Motors to the PDP or PDH, always match red to red and black to black.
    - **For Rev Spark Max Speed Controllers:** Motors connect to the red "A" and black "B" wires on the speed controller. When connecting Motors to the speed controllers, always match red to red and black to black.
    - **For Vex Talon and Victor Speed Controllers:** Motors connect to the green "m-" and white "m+" wires on the speed controllers. When connecting Motors to speed controllers, always match red to white and green to black.
- Some motors, especially the brushless motors, may come with additional wires that need to be connected.
    - **NEO 550 and NEO 1650 motors:**
        - These are brushless motors and therefore will require 3 power wires to provide the necessary electronic communication to the speed controller. This is why there is a white wire coming out of the motor. This will be connected to the white "C" wire on the Spark Max speed controller. If a different speed controller is used, then this white wire is not used and does not need to be connected.
        - These motors also have a built in encoder. This is the 6pin wire that is also coming out of the motor. This will be connected to the matching encoder port of the Spark Max speed controller. If a different speed controller is used, then the encoder wires are not used.

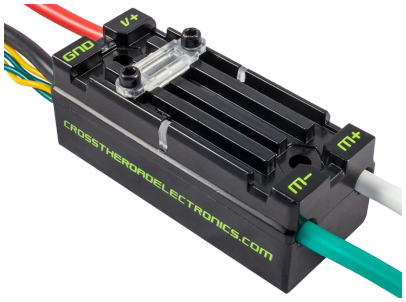
Speed Controllers

Types

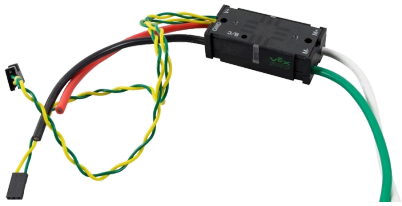
- These are the most common types of speed controllers that we use on our robot. The speed controller is designed to allow for variable voltage or power distribution to the motor it is wired to. Speed controllers allow the speed of the motors to be precisely controlled through programming.
- If a speed controller is not used, then the motor would just run at 100% all of the time when the robot is turned on. With a speed controller, one can adjust the speed the motor turns as needed depending on the motor use on the robot.
    - Note: Connecting a brushless motor directly to the power source (PDP/PDH) and not using a speed controller will destroy the motor.

- Although it may not matter if you mix and match speed controllers and motor companies, there would be a benefit of using the same speed controller that the motor manufacturer makes. This is because the companies design and optimize the features based on the equipment that they make.

Rev Spark Max



Vex Talon SRX



Vex Victor SPX

Wiring

- Specific wiring will depend on the speed controller that is selected.
- **For Rev Spark Max:**
  - Speed controllers have two sets of wires coming out of them, red, black, and white power, red and black power.
    - The set of three wires (red, black, and white) labeled “A”, “B”, “C” will go directly to the motor that you want the speed controller to control. If the motor is a brushless motor, then all 3 wires will be used. If the motor is brushed, only the red and black wires will be used.
    - The set of two wires (red and black) labeled “V+” and “V-” will be wired directly to the power distribution (PDH/PDP).
  - If using a Rev 1650 or Rev 550 motor, the built in encoder on the motor will be connected to the 6pin connection on the side with the “A”, “B”, and “C” on the speed controller.
  - If a different encoder or sensor is being used, this can be connected to the data port located on top of the speed controller.
  - The provided CAN wires (green and yellow) will be plugged into the 4pin port on the side with the “V+” and “V-” on the speed controller. This will be part of the CAN loop, where one set of the green and yellow wires will be connected to the previous piece of equipment in the loop and the other set will be connected to the next piece of equipment. Make sure the green connects to green and yellow connects to yellow.
  - The Rev Spark Max speed controller can be used with Brushed or Brushless motors. It is important to specify the type of motor when programming the speed controller.
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- **For Vex Talon SRX and Vex Victor SPX:**
  - Speed controllers have three sets of wires coming out of them, red and black power, green and white power, and a CAN wiring - green and yellow.
    - The set of two wires (green and white) labeled “m-” and “m+” will be wired directly to the motor you want the speed controller to control. You will match the red wire to white wire of the motor and green wire to black wire of the motor.
    - The set of two wires (red and black) labeled “GND” and “V+” will be wired directly to the power distribution (PDH/PDP).
    - The third set of wires are the CAN wires (green and yellow). This will be part of the CAN loop, where one set of the green and yellow wires will be connected to the previous piece of equipment in the loop and the other set will be connected to the next piece of equipment. Make sure the green connects to green and yellow connects to yellow.
  - **For the Talon SRX Only:** If an encoder or sensor is being used, this can be connected to the data port located on top of the speed controller.
  - The Vex Talon and Victor speed controllers cannot be used with Brushless motors.

LED Status Lights

Rev Spark Max:

- https://docs.revrobotics.com/sparkmax/status-led

Status LEDs Blink Code	Spark Max Operating State
Blue - Solid	Brushed Motor Brake - Valid Signal
Blue - Blinking	Brushed Motor Brake - No Signal
Yellow - Solid	Brushed Motor Coast - Valid Signal
Yellow - Blinking	Brushed Motor Coast - No Signal
Cyan - Solid	Brushless Motor Brake - Valid Signal
Cyan - Blinking	Brushless Motor Brake - No Signal
Magenta - Solid	Brushless Motor Coast - Valid Signal
Magenta - Blinking	Brushless Motor Coast - No Signal
Green - Solid	Full Forward
Green - Blinking	Partial Forward
Red - Solid	Full Reverse
Red - Blinking	Partial Reverse
Green /White - Blinking	Forward Limit
Red/White - Blinking	Reverse Limit
Magenta/White - Fast Blinking	Device Identify

Status LEDs Blink Code	Spark Fault State
Orange/Blue - Blinking	12V Missing
Orange/Magenta - Blinking	Sensor Fault
Orange/Cyan - Blinking	Gate Driver Fault
Orange/Yellow - Blinking	CAN Fault
Dark (LED off)	Corrupt Firmware

Vex Talon SRX / Victor SPX:

- https://link.vex.com/vexpro/pdf/217-8080-Talon-SRX-Users-Guide&embedded=true
- https://content.vexrobotics.com/vexpro/pdf/VictorSPX-UserGuide-20190117.pdf

Status LEDs Blink Code	Talon SRX / Victor SPX Operating State
Dark (LED off)	No power is being applied to the speed controller
Green - Blinking	Forward throttle is applied. Blink rate is proportional to Duty Cycle
Red - Blinking	Reverse throttle is applied. Blink rate is proportional to Duty Cycle
LEDs Alternate - Off / Orange	CAN Bus detected, robot disabled
LEDs Alternate - Off / Slow Red	CAN/PWM is not detected
LEDs Alternate - Off / Fast Red	Fault detected **(Victor SPX only)**
LEDs Alternate - Red/Orange	Damaged Hardware
LEDs Strobe towards m+ - Off / Red	Forward Limit Switch or Forward Soft Limit
LEDs Strobe towards m- - Off / Red	Reverse Limit Switch or Reverse Soft Limit
LED1 (closest to m+/V+) Only - Green /Orange	In Bootloader
Orange - Solid	Neutral throttle is applied. Throttle is zero or is within dead band. **(Talon SRX only)**
Status LEDs Blink Code	**Talon SRX / Victor SPX B/C Cal Button State**
Red - Solid	Brake Mode
Dark (LED off)	Coast Mode

CAN Network

- The CAN network is the wiring system that allows the various parts of the robot to “talk” to the roboRIO. This is a two wire network (typically green and yellow wires) that is commonly connected in a daisy chain configuration. Usually starting at the roboRIO CAN port and ending at the power distribution PDP/PDH CAN port. In between the wiring will go from the in and out of each device in a chain formation.
- The yellow wire acts as the CAN High signal and the green acts as the CAN Low signal. Make sure the green connects to green and yellow connects to yellow.
- The CAN network is required to be terminated by 120 Ω resistors and these are built into the roboRIO and PDP/PDH. If you want to place the PDP/PDH in the middle of the CAN Loop - move the jumper (PDP) or switch (PDH) to the “OFF” position on the PDP/PDH and place your own 120 Ω terminating resistor at the end of your CAN bus chain.

Pneumatic System

- The compressor is what builds pneumatic (air) pressure on the robot. Pneumatic pressure can be used to shift the drive motors from Low to High gear, operate pneumatic cylinders for arms/intake units, etc.
- https://www.firstinspires.org/sites/default/files/uploads/resource_library/frc/technical-resources/frc_pneumatics_manual.pdf

Parts of a Pneumatic System

- **Compressor** - Generates the pneumatic (air) pressure to be used and stored by the robot.
- **Pneumatics Controller** - There are two manufacturers for the pneumatics controller - Rev Pneumatics Hub (PH) and CTRE Pressure Control Module (PCM). Both provide a similar overall function but depending on your specific robot, one may be better suited for you.
- **Digital Pressure Switch** - Sensor that monitors the air pressure and lets the pneumatic controller turn the compressor on and off. The digital pressure switch will turn the compressor off when 115 psi pressure is reached and will turn the compressor back on when the pressure drops to 95 psi. This is required on FRC robots.
- **Analog Pressure Sensor -** An analog pressure sensor is used in addition to the digital pressure switch when the measured pressure wants to be tracked and trended on the driver station. This is optional on FRC robots.
- **Pressure Relief Valve** - Safety valve that will release the pressure in the system if it gets above the maximum pressure (120 psig). This has to be directly connected to the air outlet of the compressor.
- **Air Tanks** - Storage tank to hold the compressed air to use during the robot match. The exact number of Air Tanks used will depend on the demand of the pneumatic system.

- **Pressure Regulator** - This device will allow you to lower the stored air pressure (120 psig) in the system to allowable working pressure (60 psig) that feeds the pneumatic equipment on the robot.
- **Pressure Gauges** - Indication of what the air pressure is at that point in the system. There is a minimum of two gauges on the robot - one to tell the stored pressure and the working (operating) pressure.
- **Vent Valve** - Valve connected in the pneumatic system when opened will release the stored air pressure on the robot.
- **Solenoid Valve** - Electromechanical switch that turns the air flow on or off to a specific device in the pneumatic system.

- There are two ways to connect and power the pneumatic system on the robot.

Connection #1 Rev Pneumatic Hub

- The Rev Pneumatic Hub (PH) is the primary controller and hub for the wiring and control of the pneumatic system.

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Wiring

- **Compressor Power** - The red and black wires from the compressor will be wired to the “Compressor” ports on the PH. Match the black to black (negative) and red to red (positive)connections.
- **Pneumatics Controller Power** - Red and black wires will connect from either the PDP 20 amp VRM/PCM port or PDH 20 amp port to the “Power” port on the PH. Match the black to black (negative) and red to red (positive) connections.
- **Digital Pressure Switch** - Wires will go from the digital pressure switch top (ring terminal) to the “Digital” Pressure Sensor port on the PH. There is no polarity on the input terminals, so the color and specific wire connections do not matter.
- **Analog Pressure Sensor** - Wires will connect from the analog pressure switch wire to the “Analog” Pressure Sensor port on the PH. Match the black to black (-), red to red (+), and white to white (s) pin connections.
-

- **Solenoid(s) Power** - The red and black wires from the solenoid will be wired to the “Solenoid” ports on the PH. Match the black to black (negative) and red to red (positive) connections. Set the “Solenoid Voltage” switch to match the proper voltage of the solenoid being used (either 12V or 24V).
  - Note - Single or Double acting solenoids can be wired. Single acting solenoids will have 1 pair of red /black wires. Double acting solenoids will have 2 pairs of red /black wires.
  - Note - All solenoids on the robot must be the same voltage, either 12V or 24V.
- **CAN Ports**- This will be part of the CAN loop, where one set of the green and yellow wires will be connected to the previous piece of equipment in the loop and the other set will be connected to the next piece of equipment. Make sure the green connects to green and yellow connects to yellow.

- Pros:
  - The PH will allow for 16 single acting or 8 double acting solenoid connections
  - Updated software to aid in troubleshooting
  - There is an analog pressure sensor port on the PH.
- Cons:
  - Solenoid connections are very close together making it difficult to connect the wires to the ports.
  - Requires more programming to get it to function properly.
  - Rev PH is fairly new (within the last 2 years) - longevity not proven.

LED Status Lights

- https://docs.revrobotics.com/rev-11-1852/status-led-patterns

General LED	
Blue - Solid	Power but no communication
Green - Solid	Main communication established
Magenta - Blinking	Keep Alive Timeout
Cyan - Solid	Secondary Heartbeat
Orange/Cyan - Blinking	Hardware Fault
Orange/Yellow - Blinking	CAN Fault
Orange/Magenta - Blinking	Device Over Current
Orange/Green - Blinking	Compressor Over Current
Compressor / Solenoid Status LED	
LED Off	Compressor / Solenoid Off
Green - Solid	Compressor / Solenoid On

Connection #2 CTRE Pneumatics Control Module

- The CTRE Pneumatics Control Module (PCM) is the primary controller and hub for the wiring and control of the pneumatic system.

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  ### Wiring

  - **Compressor Power** - The red and black wires from the compressor will be wired to the PCM ports labeled COMPRESSOR OUT. Match the black to black (negative) and red to red (positive)connections.
  - **Pneumatics Controller Power** - Red and black wires will connect from either the PDP 20 amp VRM/PCM port or PDH 20 amp port to the “Vin” port on the PCM. Match the black to black (negative) and red to red (positive) connections.
  - **Digital Pressure Switch** - Wires will go from the digital pressure switch top (ring terminal) to the PRESSURE SW port on the PCM. There is no polarity on the input terminals, so the color and specific wire connections do not matter.
  - **Analog Pressure Sensor** - Wires will connect from the analog pressure switch wire to any “Analog In” port on the roboRIO. Match the black to black (G/”⏥”), red to red (5V), and yellow or white to white (S) pin connections.
  - **Solenoid(s) Power** - The red and black wires from the solenoid will be wired to the “Solenoid” ports on the PCM. Match the black to black (negative) and red to red (positive) connections. Set the “VSol” jumper to match the proper voltage of the solenoid being used (either 12V or 24V).
    - Note - Single or Double acting solenoids can be wired. Single acting solenoids will have 1 pair of red /black wires. Double acting solenoids will have 2 pairs of red /black wires.
    - Note - All solenoids on the robot must be the same voltage, either 12V or 24V.
  - **CAN Ports**- This will be part of the CAN loop, where one set of the green and yellow wires will be connected to the previous piece of equipment in the loop and the other set will be connected to the next piece of equipment. Make sure the green connects to green and yellow connects to yellow.
- Pros:
  - No complicated programming
  - Easier wiring ports to make the connections
  - Established equipment and well tested and reliable.
-

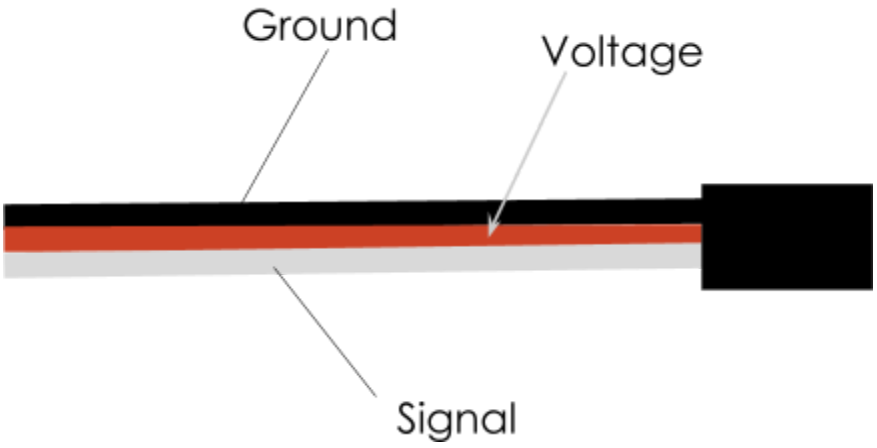
- Cons:
  - Limited to 8 single acting or 4 double acting solenoid connections
  - More difficult to troubleshoot issues

LED Status Lights

- https://docs.google.com/gview?url=http://link.vex.com/vexpro/pdf/217-4243-PCM-Users-Guide&embedded=true

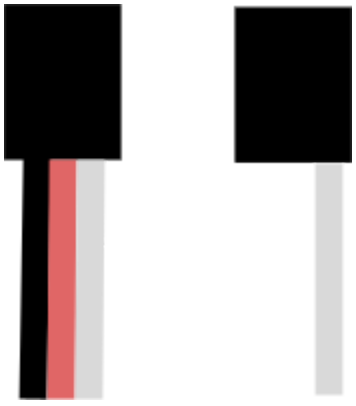
Status LED	
Green - Fast Blinking	No Fault - Robot is enabled
Green - Slow Blinking	No Fault - Robot is disabled
Orange - Slow Blinking	Robot is disabled, Sticky Fault
Red - Slow Blinking	No CAN Communication OR Compressor Fault OR Solenoid Fault
Red - Long Blinking	Compressor Fault
Special States Status LED	
LEDs Alternate - Red/Orange	Damaged Hardware
LEDs Alternate - Green / Orange	In Bootloader
LED Off	No Power / Incorrect Polarity
Compressor “Comp” Status LED	
Green - Solid	Compressor On / Active
LED Off	Compressor Off / Not Active
Solenoid Status LED	
Red - Solid	Solenoid Enabled
LED Off	Solenoid Disabled

PWM's



PWM's always get plugged into the PWM ports on the RoboRIO. These wires allow the roboRIO to send information telling the speed controllers how to control the motors. The white side of the wire always gets plugged into the "S" side of the PWM ports on the RIO. This functions the same way as the CAN network functions.

DIO's



DIO's (Digital Input Output) allow for discrete or digital signals to be sent to/from the equipment from/to the roboRIO. Discrete signals are typically "on" ("1" or "true") or "off" ("0" or "false") states. The roboRIO DIO ports function on 5V, so "on" represents 5V and "off" represents 0V. Some examples of sensors that use DIO ports are encoders, LIDAR, and limit switches.

Suggested Wire Sizes/Breakers

In each year's Game Manual the suggested or minimum wire size is provided as a guide when you are building your robot. This was the recommendation from the 2022-2023 season. Be sure to check the latest Game Manual for the most up to date information.

The larger the number the wider/fatter the wire is and the more load the wire can support. The largest gauge wire used on the robot is 6 AWG and this is used to wire the battery to the PDP/PDH. A larger gauge (ie smaller number) can be used at any time. For example: 18AWG can be used for something that has a minimum wire size of 22AWG.

Table 9-4 Breaker and wire sizing

Application	Minimum Wire Size
31 – 40A breaker protected circuit	12 AWG (13 SWG or 4 mm^2)
21 – 30A breaker protected circuit	14 AWG (16 SWG or 2.5 mm^2)
6 – 20A breaker protected circuit **11-20A fuse protected circuit** **Between the PDP dedicated terminals and the VRM/RPM or PCM/PH** **Compressor outputs from the PCM/PH** **Between the PDH and PCM/PH**	18 AWG (19 SWG or 1 mm^2)
Between the PDP/PDH and the roboRIO **Between the PDH and VRM/RPM** **≤5A breaker protected circuit** **≤10A fuse protected circuit**	22 AWG (22 SWG or 0.5 mm^2)
VRM 2A circuits	24 AWG (24 SWG or .25 mm^2)
roboRIO PWM port outputs	26 AWG (27 SWG or 0.14 mm^2)
SIGNAL LEVEL circuits (i.e. circuits which draw ≤1A continuous and have a source incapable of delivering >1A, including but not limited to roboRIO non-PWM outputs, CAN signals, PCM/PH Solenoid outputs, VRM 500mA outputs, RPM outputs, and Arduino outputs)	28 AWG (29 SWG or .08 mm^2)

Table 9-3 Branch circuit protection requirements

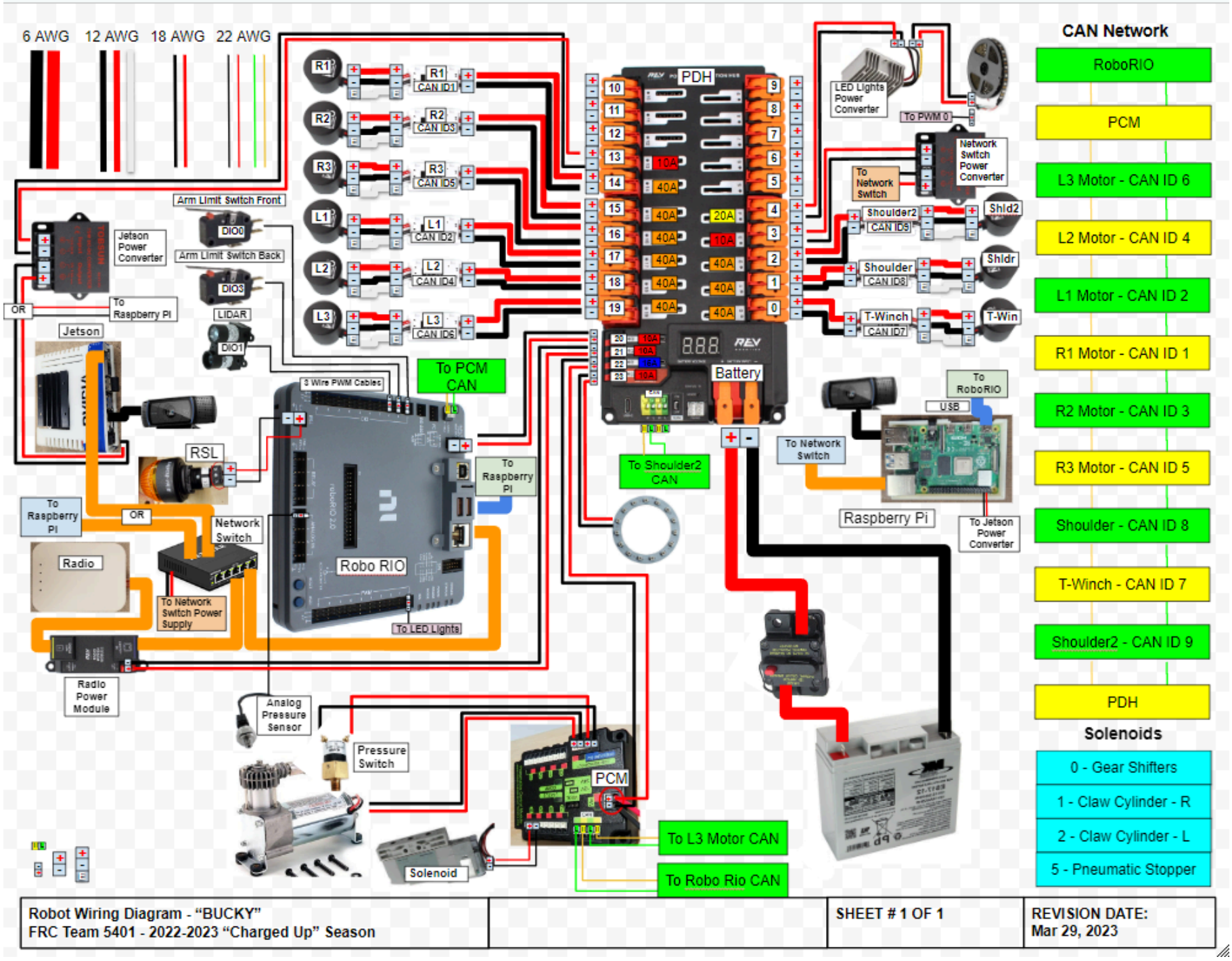
Branch Circuit	Circuit Breaker Value	Quantity Allowed Per Breaker
Motor Controller	Up to 40A	1
CUSTOM CIRCUIT	Up to 40A	No limit
Automation Direct Relay 40A (*6M40*)	Up to 40A	1
Fans permitted per R501 and not already part of COTS computing devices	Up to 20A	No limit
Spike Relay Module	Up to 20A	1
Automation Direct Relay 25A (*6M25*)	Up to 20A	1
PCM/PH – with compressor	Up to 20A	1
Additional VRM (non-radio)/Additional PCM/PH (non-compressor)	Up to 20A	3 total
Automation Direct Relay 12A (*6M12*)	Up to 10A	1

Wiring diagram

Wiring diagrams are a one page summary of how the robot electronics are wired. This will be different for each robot and is a key part to quickly troubleshooting issues that may come up on the robot.

A wiring diagram typically shows:

- What is wired to each channel on the PDP/PDH
- What is wired to the VRM ports
- What is wired to the PCM/PH ports
- The wire size used for each item on the robot
- The CAN Network and order of the CAN daisy chain
- The CAN ID number and what is programmed to it
- What is wired to each Solenoid
- The naming convention and the latest revision date for the drawing


6 AWG
12 AWG
18 AWG
22 AWG
PDH
Battery
Robo RIO
PCM
Jetson
Jetson Power Converter
To Raspberry PI
OR
Arm Limit Switch Front
Arm Limit Switch Back
LIDAR
DIO0
DIO3
DIO1
R1
R2
R3
L1
L2
L3
CAN ID1
CAN ID3
CAN ID5
CAN ID2
CAN ID4
CAN ID6
To PCM CAN
3 Wire PWM Cables
RSL
To Raspberry PI
Network Switch
Radio
To Network Switch Power Supply
Radio Power Module
To LED Lights
Analog Pressure Sensor
Pressure Switch
Solenoid
To L3 Motor CAN
To Robo Rio CAN
To Shoulder2 CAN
LED Lights Power Converter
To PWM 0
Network Switch Power Converter
To Network Switch
Shoulder2
CAN ID9
Shld2
Shoulder
CAN ID8
Shldr
T-Winch
CAN ID7
T-Win
To RoboRIO
USB
To Network Switch
Raspberry Pi
To Jetson Power Converter
CAN Network
RoboRIO
PCM
L3 Motor - CAN ID 6
L2 Motor - CAN ID 4
L1 Motor - CAN ID 2
R1 Motor - CAN ID 1
R2 Motor - CAN ID 3
R3 Motor - CAN ID 5
Shoulder - CAN ID 8
T-Winch - CAN ID 7
Shoulder2 - CAN ID 9
PDH
Solenoids
0 - Gear Shifters
1 - Claw Cylinder - R
2 - Claw Cylinder - L
5 - Pneumatic Stopper
Robot Wiring Diagram - "BUCKY"
FRC Team 5401 - 2022-2023 "Charged Up" Season
SHEET # 1 OF 1
REVISION DATE:
Mar 29, 2023

References

- Current FRC Game Manual
  - https://www.firstinspires.org/resource-library/frc/competition-manual-qa-system
- FRC Technical Resources Website
  - https://www.firstinspires.org/resource-library/frc/technical-resources
- WPILib FRC Documentations
  - Hardware Component Overview: https://docs.wpilib.org/en/latest/docs/controls-overviews/control-system-hardware.html
  - Hardware Basics: https://docs.wpilib.org/en/latest/docs/hardware/hardware-basics/index.html
- Parts Websites:
  - AndyMark: https://www.andymark.com/pages/first-robotics-competition
  - RevRobotics: https://www.revrobotics.com/frc/
  - Vex: https://www.vexrobotics.com/pro