OPERATION P.E.A.C.C.E. ROBOTICS

4-H FIRST ROBOTICS TEAM 3461

ELECTRICAL MANUAL

2022 - 2023

STRETCH

OPENING STATEMENT

PREFACE

The purpose of this doucment is to guide new generations with an up-to-date, focused, and organized document for Operation P.E.A.C.C.E. Robotics' robot wiring for the 2023 season. This includes an overview of sensors, electric outputs, and more. This plan's goal is not only to guide the future of the team, but also help service our machine at competition..

This document contains information regarding the 2023 Robot's electrical and CAN wiring. It will contain the following information, PDP slot number, correct breaker, wire gauge, CAN ID and physical location on the robot. This document is split into 3 separate overall sections, one for device information, one for only sensor information, and one for CAN bus connection information. It will also have a subsection for each subsystem that requires additional information aside from the general information regarding its electrical components.

This documentation is highly encouraged to be referenced upon for future team members, sponsors, and fellow robotics teams. However, parties cannot forge or copy our documentation without the consent of the team.

There is also an up-to-date service log in the back of this document, encouraging members to update it as they progress through competition.

TABLE OF CONTENTS

Opening Statement 1

Table of Contents 2

Reference Diagram 3

FIRST Wiring Rules 4
- Rule 610
- Rule 611
- Rule 612
- Rule 613
- Rule 618 5
- Rule 619
- Rule 620
- Rule 621
- Rule 622 6
- Rule 623 7
- Rule 624

Electrical Panels 8
- Driver's Side
- Passenger Side

Device Information 9

Sensor Information 10

CAN Bus Links 11

Pneumatics 12

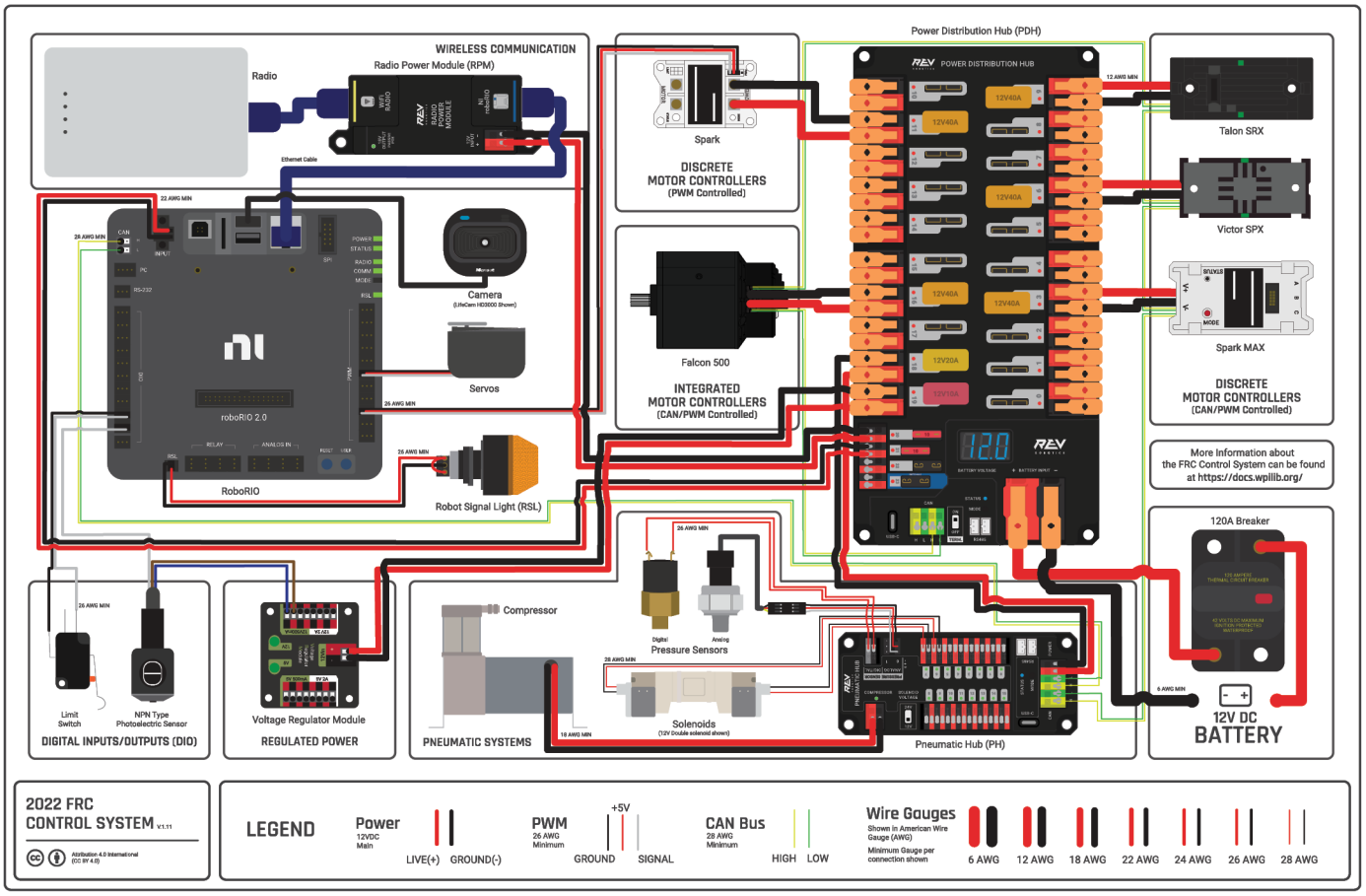
Additional Info 13
- Drivetrain
- Turret
- Miscellanous 14

Vocabulary 15

Motors & Controls 16

REFERENCE DIAGRAM

The following diagram illustrates how to properly wire FRC robots and can be found along with WPILib documentation. The robot was wired according to this diagram and the 2023 game manual. Note: not all depicted devices are employed on the 2023 Robot, this diagram attempts to show every use case any team might have



Currently the Robot employs devices from the following categories of the diagram

- Battery
- Discrete Motor Controllers
- Digital Input/Output
- Integrated Motor Controllers
- Pneumatics Systems
- Regulated Power
- Pneumatics System
- Pneumatics Sensors
- Solenoids

FIRST WIRING RULES

FIRST Electrical rules for 2023 can be found in Section 9.6 Power Distribution of the Charged Up game manual. The most important rules are below for quick reference

R610 *1 breaker per circuit.

All circuits, with the exceptions of those listed in R615 and R617, must connect to, and have power sourced solely by, a single protected 12VDC WAGO connector pair (i.e. the load terminals, as shown in Figure 9-10) of the PDP/PDH, not the M6 cap screws.

R611 *The ROBOT frame is not a wire.

All wiring and electrical devices shall be electrically isolated from the ROBOT frame. The ROBOT frame must not be used to carry electrical current.

Compliance with this rule is checked by observing a >120Ω resistance between either the (+) or (-) post within the APP connector that is attached to the PDP/PDH and any point on the ROBOT. All legal motor controllers with metal cases are electrically isolated. They may be mounted directly to ROBOT frame COMPONENTS. Note that some cameras, decorative lights, and sensors (e.g. some encoders, some IR sensors, etc.) have grounded enclosures or are manufactured with conductive plastics. These devices must be electrically isolated from the ROBOT frame to ensure compliance with this rule.

R612 *Must be able to turn ROBOT on and off safely.

The 120A circuit breaker must be quickly and safely accessible from the exterior of the ROBOT. This is the only 120A circuit breaker allowed on the ROBOT.

Examples considered not “quickly and safely accessible” include breakers covered by an access panel or door, or mounted on, underneath or immediately adjacent to moving COMPONENTS. It is strongly recommended that the 120A circuit breaker location be clearly and obviously labeled so it can be easily found by FIELD STAFF during a MATCH. R613 *Electrical system must be inspectable. The PDP/PDH, associated wiring, and all circuit breakers must be visible for inspection. “Visible for inspection” does not require that the items be visible when the ROBOT is in STARTING CONFIGURATION, provided the team can make the items viewable during the inspection process.

R613 *Electrical system must be inspectable.

The PDP/PDH, associated wiring, and all circuit breakers must be visible for inspection.

“Visible for inspection” does not require that the items be visible when the ROBOT is in STARTING CONFIGURATION, provided the team can make the items viewable during the inspection process.

R618 *Use PDP/PDH terminals as designed.

Only 1 wire shall be connected to each terminal on the PDP/PDH.

If multi-point distribution of circuit power is needed (e.g. to provide power to multiple PCMs and/or VRMs from 1 20A circuit), then all incoming wires may be appropriately spliced into the main lead (e.g. using an insulated terminal block, crimped splice or soldered wire splice), and the single main lead inserted into the terminal to power the circuit.

R619 *Only use specified circuit breakers in PDP/PDH.

The only circuit breakers permitted for use in the PDP/PDH are:

A. Snap Action VB3-A Series or AT2-A, terminal style F57, 40A rating or lower,

B. Snap Action MX5-A or MX5-L Series, 40A rating or lower, and

C. REV Robotics ATO auto-resetting breakers 40A rating or lower.

R620 *Only use specified fuses in PDP/PDH.

The only fuses permitted for use in the PDP/PDH are mini automotive blade fuses (ATM style) with the following values:

A. for the PDP, values matching the value printed on the device's corresponding fuse holder and

B. for the PDH, 15A or lower with the exception of a single 20A fuse for powering a PCM or PH.

Note that these fuses must be pressed very firmly to seat properly. Improper seating can cause a device to reboot upon impact.

R621 *Protect circuits with appropriate circuit breakers.

Each branch circuit must be protected by 1 and only 1 circuit breaker or fuse on the PDP/PDH per Table 9-3. No other electrical load can be connected to the breaker or fuse supplying this circuit.

Branch Circut	Circut Breaker Value	Quantity Allowed Per Breaker
Motor Controller	Up to 40A	1
Custom Circut	Up to 40A	No Limit
Automation Direct Relay 40A (*6m40*)	Up to 40A	1
Fans permitted per R501 and not 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

R622 *Use appropriately sized wire.

All circuits shall be wired with appropriately sized insulated copper wire (SIGNAL LEVEL cables don't have to be copper):

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	18 AWG (19 SWG or 1 $mm^{2)}$
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	
Between the PDP/PDH and the roboRIO	22 AWG (22 SWG or 0.5 mm^2
Between the PDH and the VRM/RPM	
≤5A breaker protected circuit	
≤10A fuse protected circuit	
VRM 2A circuits	24 AWG (24 SWG or 0.25 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 mm2)

Wires that are recommended by the device manufacturer or originally attached to legal devices are considered part of the device and by default legal. Such wires are exempt from this rule.

In order to show compliance with these rules, teams should use wire with clearly labeled sizes if possible. If unlabeled wiring is used, teams should be prepared to demonstrate that the wire used meets the requirements of this rule (e.g. wire samples and evidence that they are the required size)

R623 *Use only appropriate connectors.

Branch circuits may include intermediate elements such as COTS connectors, splices, COTS flexible/rolling/sliding contacts, and COTS slip rings, as long as the entire electrical pathway is via appropriately gauged/rated elements.

Slip rings containing mercury are prohibited per R203.

R624 *Use specified wire colors (mostly).

All non-SIGNAL LEVEL wiring with a constant polarity (i.e., except for outputs of relay modules, motor controllers, or sensors) shall be color-coded along their entire length from the manufacturer as follows:

A. red, yellow, white, brown, or black-with-stripe on the positive (e.g. +24VDC, +12VDC, +5VDC, etc.) connections

B. black or blue for the common or negative side (-) of the connections Exceptions to this rule include:

Exceptions to this rule include:

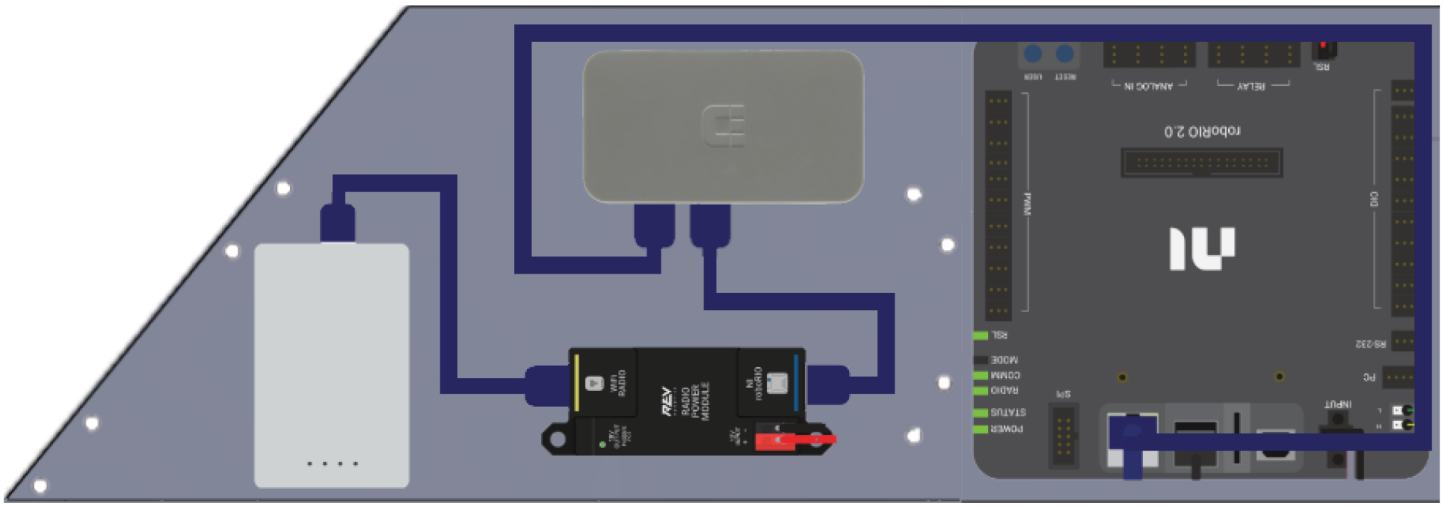
C. wires that are originally attached to legal devices and any extensions to these wires using the same color as the manufacturer

D. Ethernet cable used in POE cables

ELECTRICAL PANELS

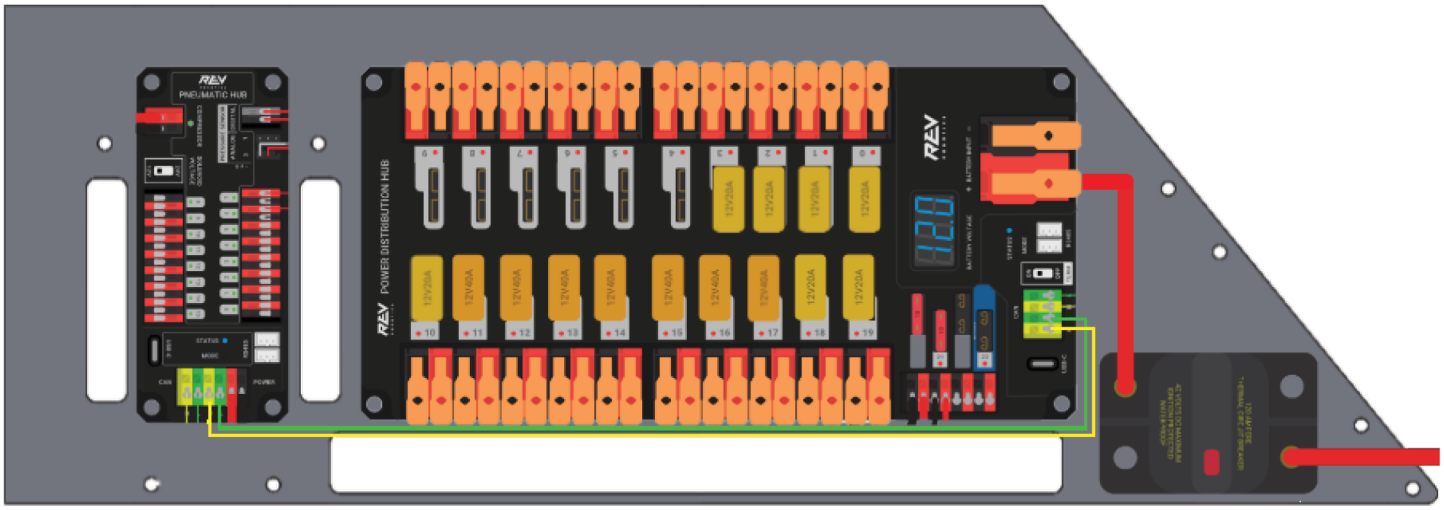
This year, the robot has two electrical panels instead of just one. For consistency, this document will reference the two based on the side of the robot they are mounted on. (see the “vocabulary” section for definitions.)

Driver’s Side Electrical Panel



From Left to Right:
Radio, Network Switch, REV Radio Power Module, RoboRio v2

Passenger’s Side Electrical Panel



From Left to Right:
REV Pneumatics Hub, REV Power Distribution Hub, Main Breaker

DEVICE INFORMATION

DEVICE	PDH SLOT	BREAKER	INPUT VOLTAGE	WIRE GAUGE	PHYSICAL LOCATION
CTRE Pneumatics Control Module	0	12v20a	12v	18 AWG	Turret Tower Side Panel
Drive Falcon 0*	12	12v40a	12v	12 AWG	Driver Side Gearbox
Drive Falcon 1*	11	12v40a	12v	12 AWG	Driver Side Gearbox
Drive Falcon 2*	13	12v40a	12v	12 AWG	Passenger Side Gearbox
Drive Falcon 3*	14	12v40a	12v	12 AWG	Passenger Side Gearbox
Ethernet Switch*	22	12v5a	5v0.55a	18* AWG	Driver Side Elec. Panel
IGUS Drive Falcon 0	3	12v20a	12v	12 AWG	Behind Middle Stage of Slider
Limelight 0	VRM 12v	12v20a	12v	22 AWG	Edge of robot by drive gearboxes
Limelight 1	TBD	12v20a	12v	22 AWG	Mounted on arm
Main Breaker	V+	12v120a	12v	6 AWG	Passenger Side Elec. Panel
PigeonIMU*	VRM 12v	VRM 500mA	12v	18 AWG	Underneath Turret Gear
Voltage Regulator Module	22	12v10a	12v	18 AWG	Front Support Beam, Passenger Side
Pivot Falcon 0	16	12v40a	12v	12 AWG	Inside Tower, Near Bottom
Pivot Falcon 1	17	12v40a	12v	12 AWG	Inside Tower, Near Bottom
Pneumatics Hub	10	12v20a	12v	18 AWG	Passenger Side Elec. Panel
REV Radio Power Module	21	12v5a	12v	18 AWG	Driver Side Elec. Panel
REV Mini Power Module	18	12v20a	12v	18 AWG	Turret Tower Side Panel
RoboRio v2	20	12v10a	12v	18 AWG	Driver Side Elec. Panel
Spark MAX 0*	1	12v20a	12v	18 AWG	Inside Intake/ Manipulator System
Spark MAX 1*	2	12v20a	12v	18 AWG	Inside Intake/ Manipulator System

DEVICE	PDP SLOT	BREAKER	INPUT VOLTAGE	WIRE GAUGE	PHYSICAL LOCATION
Turret Falcon 0	15	12v40a	12v	12 AWG	Behind Lower Turret Gear
Wrist Falcon 0	19	12v40a	12v	12 AWG	Inside Wrist Mechanism

*additional data about this device's connection contained within its subsystem section
The color of the cells in the Breaker column is associated with the physical color of the breaker that is rated as such

SENSOR INFORMATION

Device	Input Voltage	Protocol	ID	Connection	Sub-system	Physical Location
Analog Pressure Switch	5.0V	Analog	N/A	REV Pneumatics Hub	Pneumatics	Compressor Manifold
CANCoder 0	12v0.06a	CAN	CAN 10	Can Bus	Turret	Turret Lower Gear
CANCoder 1	12v0.06a	CAN	CAN 12	Can Bus	Pivot	Pivot Output Shaft
Limit Switch 0	3.3v	DIO	N/A	TBD	Arm	IGUS 2nd Stage Top
Limelight 0	12v20A	IP	10.34.61.11:5801	POE Harness**	Misc	Edge of Robot by Drive Gearboxes
Limelight 1	12v20A	IP	10.34.61.12:5801	POE Harness**	Misc	Mounted on edge of arm
Limit Switch 0	3.3v	DIO	N/A	IGUS Drive Falcon Limit Switch Port	Arm	IGUS 2nd Stage Bottom
Limit Switch 1	5v	DIO	N/A	IGUS Drive Falcon Limit Switch Port	Arm	IGUS 2nd Stage Bottom
Pigeon IMU	12v	CAN	CAN 20	CAN Bus	Misc	Bellypan Near Center

*Does not contain built-in encoders within the Falcon 500 motors as those are handled internally by the Falcon's TalonFX Controller and requires no wiring outside of the CAN Bus connection to the motor, which is documented in the "CAN Bus Connections" table.

**More Information in the associated subsystem section

CAN BUS LINKS

CAN ID	DEVICE	PREVIOUS DEVICE IN BUS
Bus Origin	**RoboRio v2**	n/a
0	**Drive Falcon 0**	RoboRio v2
1	**Drive Falcon 1**	Drive Falcon 0
2	**Drive Falcon 2**	Drive Falcon 1
3	**Drive Falcon 3**	Drive Falcon 2
4	**Turret Falcon 0**	Drive Falcon 3
5	**Pigeon IMU**	Turret Falcon 0
6	**REV Pneumatics Hub**	Pigeon IMU
7	**REV Power Distribution**	REV Pneumatics Hub
50	**CTRE Pneumatics Control Module**	REV Power Distribution Hub
8	CANCoder 0	**CTRE Pneumatics Control Module**
9	**Pivot Falcon 0**	CANCoder 0
10	**Pivot Falcon 1**	Pivot Falcon 0
11	**CANCoder 1**	Pivot Falcon 1
12	IGUS Exension Falcon 0	CANCoder 1
13	Wrist Falcon 0	IGUS Extension Falcon 0
14	Intake Spark 0	Wrist Falcon 0
15	Intake Spark 1	Intake Spark 0
N/A	Termination Resistor	Intake Spark 1

Displayed in the order the devices are connected from the bus origin (RoboRio) to the bus termination point (TBD)

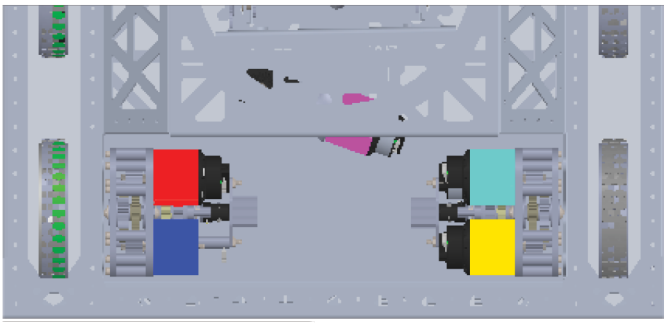
ADDITIONAL INFO

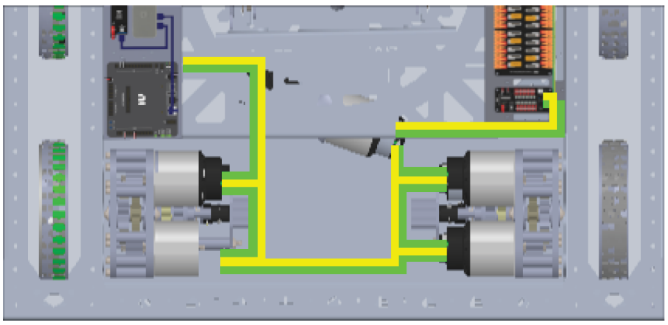
DRIVETRAIN

Motors

- Drive Falcon 0
  - Attached to Driver Side Gearbox
  - Controls the other motor attached to this gearbox in code (Master Controller)
- Drive Falcon 1
  - Attached to Driver Side Gearbox
  - Is controlled by the other motor attached to this gearbox (Slave Controller)
- Drive Falcon 2
  - Attached to Passenger Side Gearbox
  - Is controlled by the other motor attached to this gearbox (Slave Controller)
- Drive Falcon 3
  - Attached to Passenger Side Gearbox
  - Controls the other motor attached to this gearbox in code (Master Controller)

Diagram





TURRET

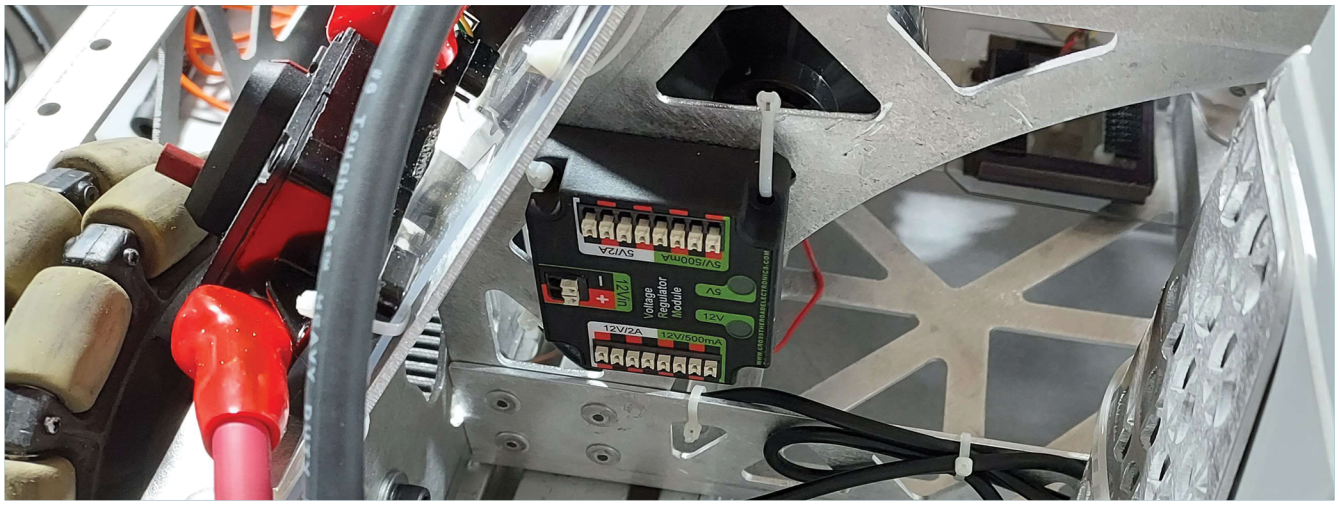
Motors

- Turret Falcon 0
- Attached at the back of the robot
  - Located in the front of the air compressor
- CANCoder0 attached to center of the shaft

MISCELLANEOUS

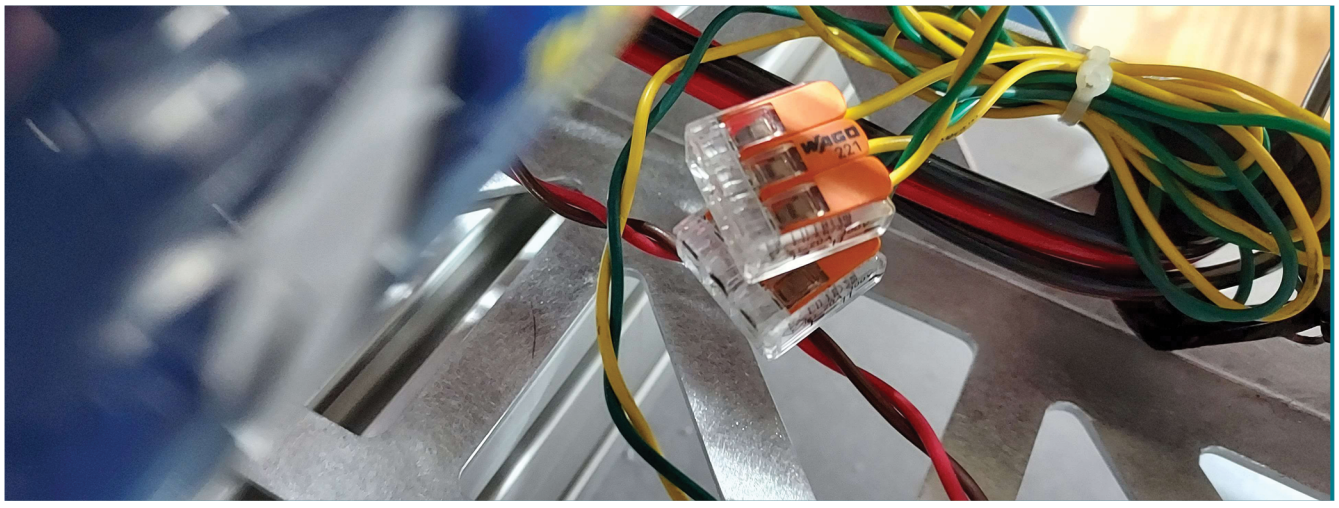
Ethernet Switch

- Located on Driver Side Electrical panel
- Connected to VRM located at behind the Passenger Side Electrical Panel on the support beam, next to the battery



Pigeon IMU

- Connected to one of the 12v500mA ports on the VRM
- Only has CAN input, used a 3 way wago to connect to CAN and pass the bus on to the Rev Pneumatics hub



VOCABULARY

1. “Passenger Side Electrical Panel” - Refers to the 1/16 Polycarbonate panel mounted on the Right side of the Robot assuming the Battery is the front of the Robot; Therefore “Passenger Side” will always be intelligible no matter what side you are on, because the passenger sits on the right side of a car, you can interpret the position of the panel from any reference point on the robot.

2. “Driver Side Electrical Panel” - Same definition as Passenger Side, except on the left side instead of the right side.

3. “Passenger Side” - Refers to any object in which there are two with one on each side of the robot, referring to the object on the passenger side from the reference point of the Battery being in the front of the robot.

4. “Driver Side” - Same definition as “Passenger Side” except on the left side instead of the right side.

5. “CAN Bus” - The CAN Bus is a communication protocol that allows the RoboRio to communicate with microcontrollers and sensors, such as the Falcon 500’s internal motor controller (TalonFX), the Spark MAX that controls the Neo 550 motors and the CANCoder absolute encoder. It can be easily identified by the twisted Yellow and Green wires.

6. “PWM” - PWM is a communication protocol that operates using Pulse-Width Modulation as its signal method, using this signal, the RoboRio can communicate with microcontrollers and sensors such as the Dual Channel Encoder, PWM can be easily identified by its three joined wires in the order of White, Red, Black

7. “PDH” - Abbreviation for the REV Power Distribution Hub

8. “VRM” - Abbreviation for the CTRE Voltage Regulator Module

9. “PH” - Abbreviation for REV Pneumatics Hub & CTRE Pneumatics Hub

10. “POE” - Abbreviation for Power Over Ethernet

11. “POE Harness” (or injector) - A POE Harness delivers power over Ethernet through 1 wire and one connection. The polarity is relevant, accidental reversal of the polarity will cause damage to the device it’s connected to.

MOTORS & CONTROLS

Motors are not simple electrical devices that you can just plug in, a motor will spin as fast as the electrical input it is supplied, and reversing the polarity (red to red black to black or red to black and black to red) will change the direction of the motor. In order to control the motor a device must be placed in between the voltage input and the motor. This device is called a motor controller. The motor controller will vary the voltage and polarity delivered to the motor allowing for fine control. Some motors have motor controllers built into their housing, therefore the motor must only be connected to power in the correct polarity and the controller connected to the appropriate bus (CAN or PWM).

Falcon 500

A Falcon 500 is a brushless motor with an integrated motor controller (TalonFX). It has a red V+ (voltage in) and a black V- (common or "negative" or "ground") lead. Although the motor controller has integrated reverse polarity protection, do not plug the motor in backwards because the protection is meant for accidental polarity reversal, not actual use. The integrated motor controller connects to the CAN bus for signal.

Neo 550

A Neo 550 is a brushless motor without an integrated motor controller. It has a red, white, and black three-phase power connection leads. Because the motor is driven by PWM and does not have an integrated controller, you must use a discrete controller, namely a REV Spark MAX. The Spark MAX takes power in (red and black leads) and outputs 3-Phase power to the Neo 550 using the red white and black leads. You can not reverse the polarity of the motor or it will short out and break. The Spark MAX connects to the CAN bus for signal.

Limelight

Limelight is a plug-and-play smart camera, built for the cause of the robots knowing its position on the field, by Limelight For FRC . This camera, however extraordinary it is, weighs only a quarter of a pound, while its dimensions are: 3.819 x 2.194 x 0.984 in. How this object works is that it shines a green LED on command and captures bright images. These ‘images’ that will appear are made by the green light shining onto retroreflective vision tape. This, in turn, sends the bright images back to the camera.