Electrical Overview Training
2021-2022

Electronics
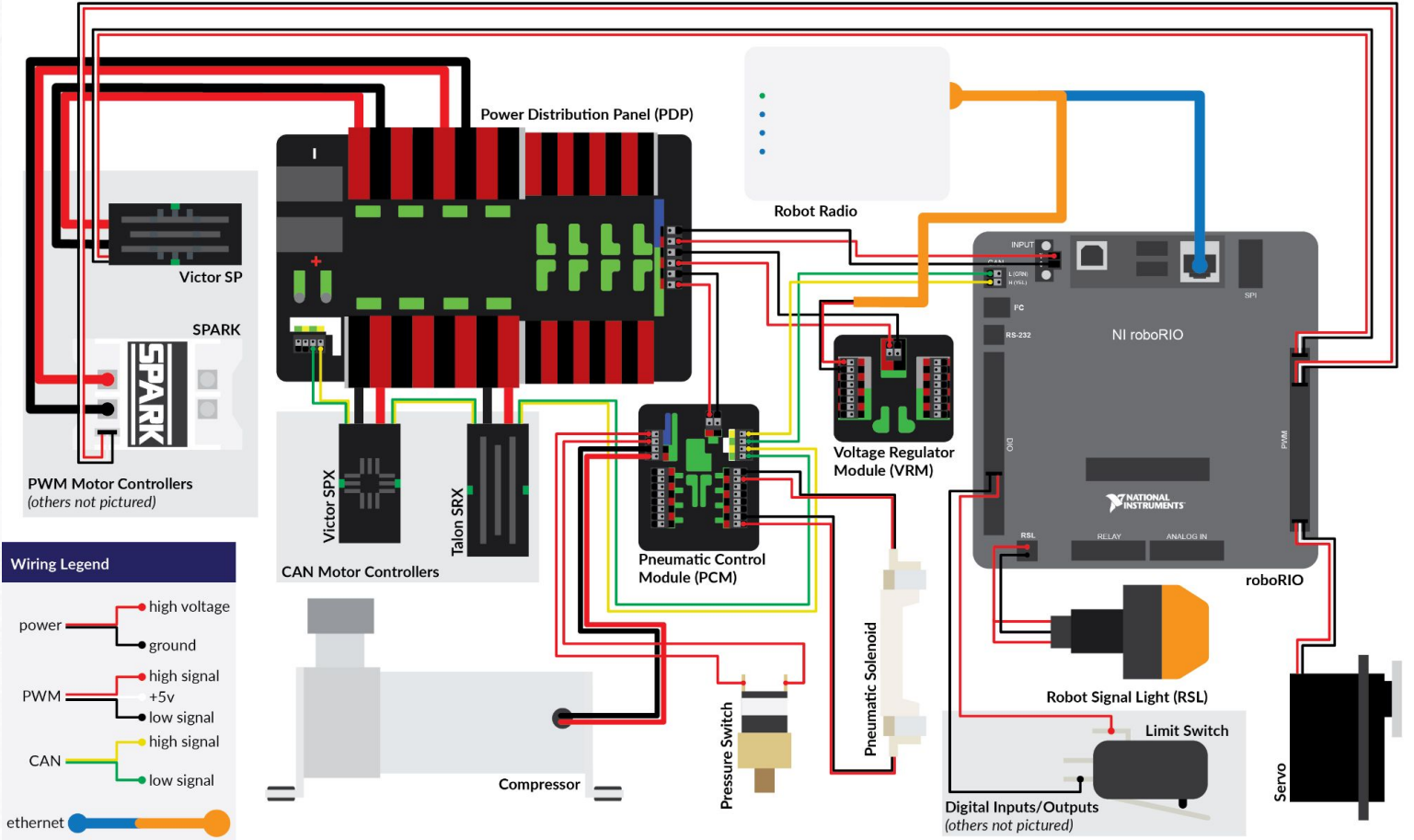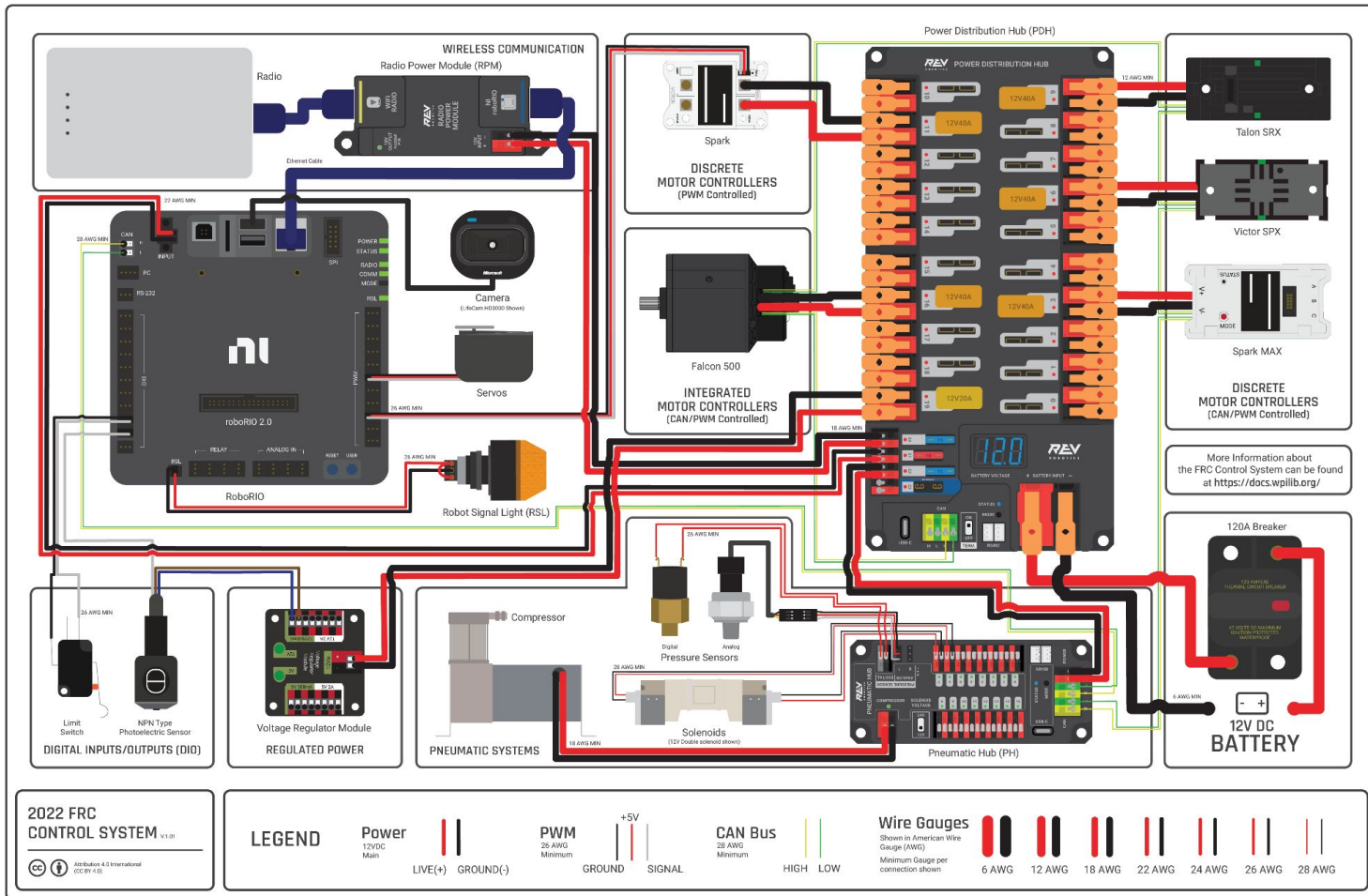

[Wiring Manual](#)

Required Components

FRC Control System Layout

3128 aluminum narwhals

Power Distribution Panel (PDP)

Robot Radio

Victor SP

SPARK

PWM Motor Controllers
(others not pictured)

Victor SPX

Talon SRX

CAN Motor Controllers

Pneumatic Control Module (PCM)

Voltage Regulator Module (VRM)

INPUT

NI roboRIO

PC

RS-232

CAN

SPI

DIO

PWM

NATIONAL INSTRUMENTS

RSL

RELAY

ANALOG IN

roboRIO

Robot Signal Light (RSL)

Limit Switch

Digital Inputs/Outputs
(others not pictured)

Servo

Pneumatic Solenoid

Pressure Switch

Compressor

Wiring Legend

power — high voltage / ground

PWM — high signal +5v / low signal

CAN — high signal / low signal

ethernet

WIRELESS COMMUNICATION
Radio Power Module (RPM)
Radio
WIFI RADIO
RADIO POWER MODULE
Ethernet Cable

Power Distribution Hub (PDH)
POWER DISTRIBUTION HUB

12V40A
12V20A

Talon SRX
Victor SPX
Spark MAX

DISCRETE
MOTOR CONTROLLERS
(CAN/PWM Controlled)

Spark
DISCRETE
MOTOR CONTROLLERS
(PWM Controlled)

22 AWG MIN
28 AWG MIN
CAN
INPUT
PC
RS-232
SPI
POWER
STATUS
RADIO
COMM
MODE
RSL
PWM
RELAY
ANALOG IN
RSL
RESET
USER

Camera
(LifeCam HD3000 Shown)

Servos

roboRIO 2.0
RoboRIO

26 AWG MIN

Robot Signal Light (RSL)

Falcon 500
INTEGRATED
MOTOR CONTROLLERS
(CAN/PWM Controlled)

18 AWG MIN

12.0
BATTERY VOLTAGE   BATTERY INPUT
CAN
REV
USB-C

More Information about
the FRC Control System can be found
at https://docs.wpilib.org/

120A Breaker

12V DC
BATTERY

6 AWG MIN

26 AWG MIN
Limit
Switch
NPN Type
Photoelectric Sensor
DIGITAL INPUTS/OUTPUTS (DIO)

Voltage Regulator Module
REGULATED POWER

Compressor
PNEUMATIC SYSTEMS
18 AWG MIN

Digital   Analog
Pressure Sensors
26 AWG MIN

Solenoids
(12V Double solenoid shown)

Pneumatic Hub (PH)

2022 FRC
CONTROL SYSTEM V.1.01
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(CC BY 4.0)

LEGEND

Power
12VDC
Main
LIVE(+) GROUND(-)

PWM
26 AWG
Minimum
+5V
GROUND   SIGNAL

CAN Bus
28 AWG
Minimum
HIGH   LOW

Wire Gauges
Shown in American Wire
Gauge (AWG)
Minimum Gauge per
connection shown
6 AWG 12 AWG 18 AWG 22 AWG 24 AWG 26 AWG 28 AWG

Battery

- Every robot is required to use one 12V SLA battery
- Batteries are rechargeable
- Competition batteries need to be replaced every 2-3 years (older batteries can be used for testing)

Battery

Charger

Main Breaker

- Used to turn the robot on/off
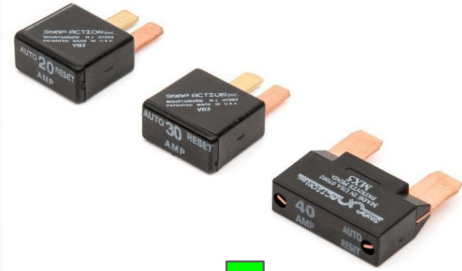

TURN ON:

Push black lever inwards until it clicks

TURN OFF:

Push Red Button

185120F
120 AMPERE
THERMAL CIRCUIT BREAKER

RESET

Power Distribution

- Distributes power from the battery to everything else in the robot

2022

Power Distribution Panel (PDP)

2022
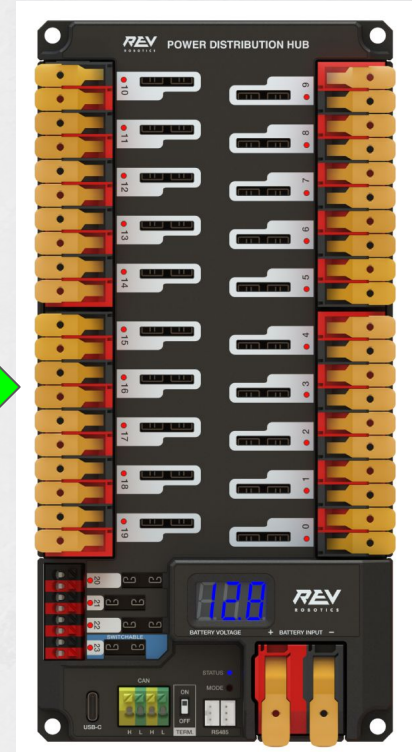
Power Distribution Hub (PDH)

Power Distribution

- Almost everything that gets power on the robot plugs into the power distributor
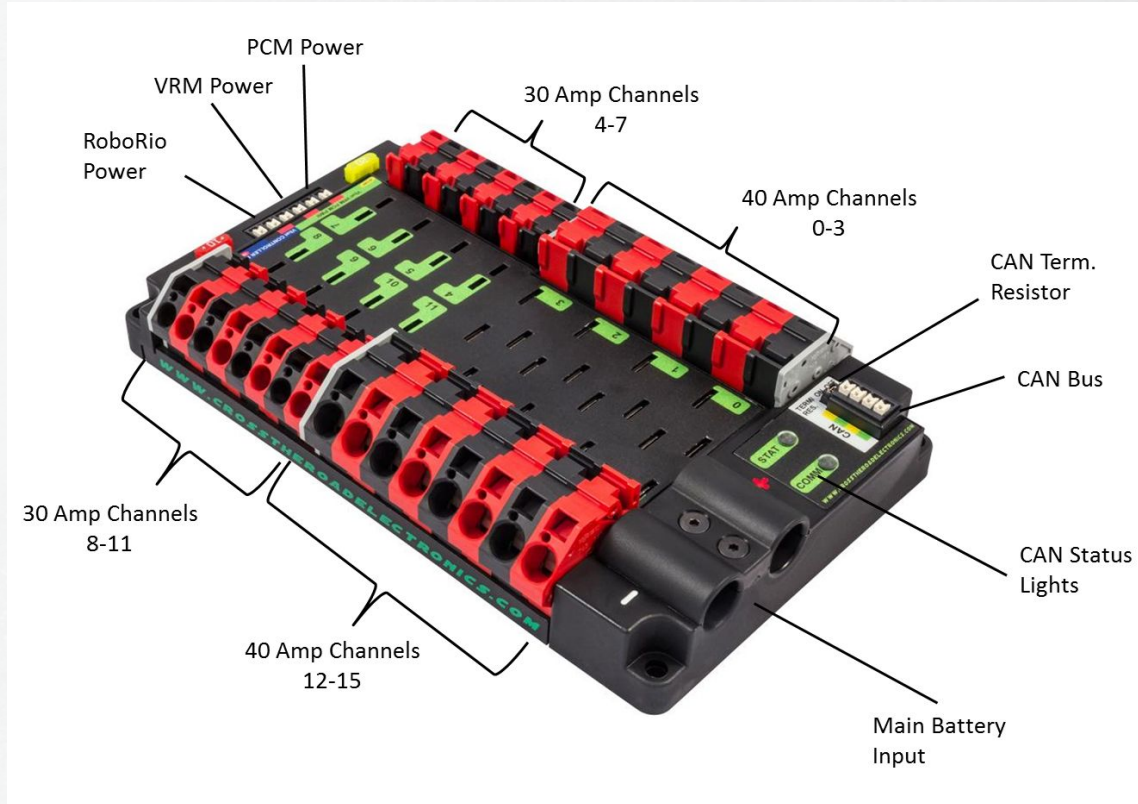
RoboRio

- Receives and runs code for the robot
- Sends signals to devices
- Handles all the processing to make the robot function

RoboRio

RoboRio 2.0

2022
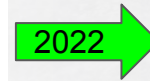
RoboRio

- Tons of different communication methods supported
- PWM: LED's & Motor Controllers
- CAN: Motor Controllers (maybe sensors)
- SPI: Gyro
- DIO: Limit Switches
- USB: USB Cameras
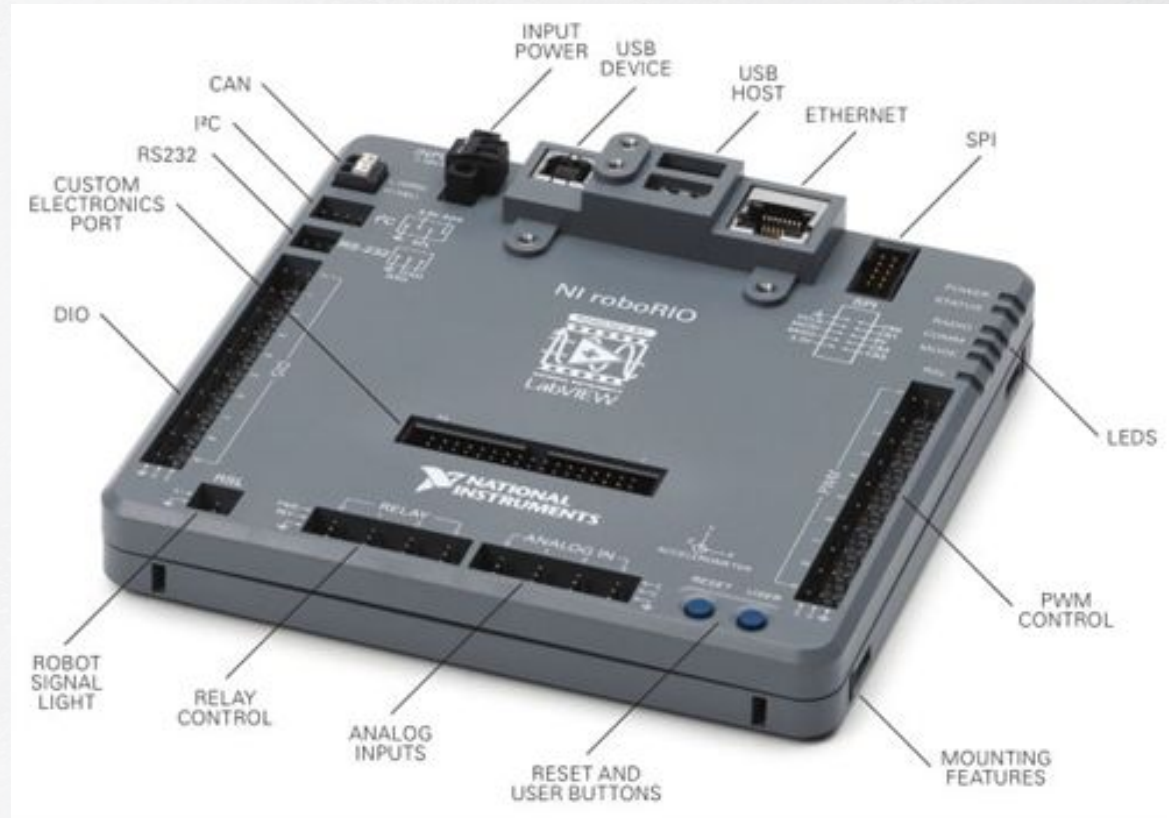
FRC Electrical: Analog vs Digital
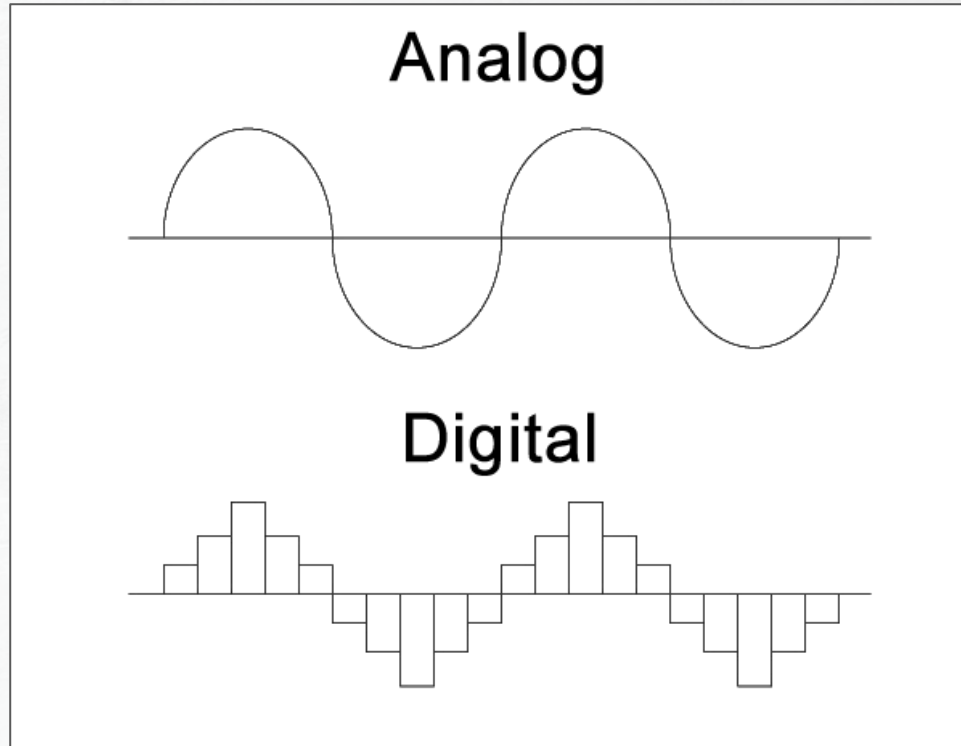
Radio

- Basically just a tiny wifi router
- Used to communicate between a laptop and the robot
- Plugs into the RoboRio and the Limelight
- Can be powered through the barrel jack port or through a Power over Ethernet cable (PoE)
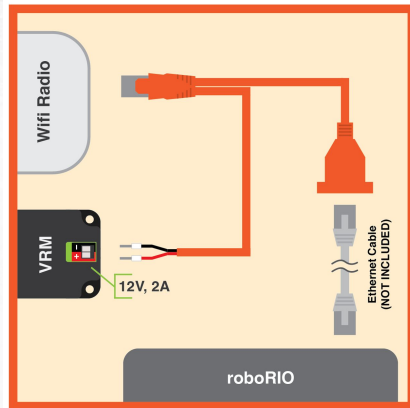
RoboRio

External Devices

Voltage Regulator

- Takes the battery voltage and regulates it down into other voltages, helps provide stable power to sensitive devices
- No longer required for 2022

Unregulated 12V Input

Regulated 5V 2A Peak

Regulated 5V 500mA Peak

Regulated 12V 2A Peak

Regulated 12V 500mA Peak

Regulator Circuit Status Lights
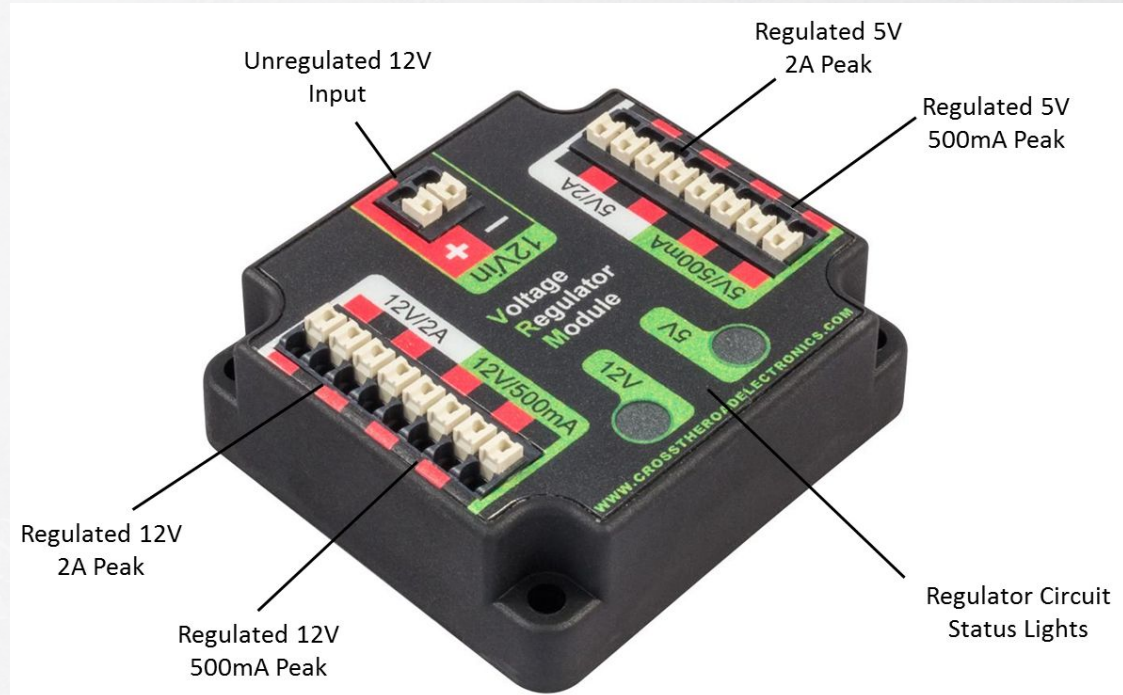
Radio Power Module (RPM)

- New for 2022
- Provides power exclusively to the radio

Robot Signal Light (RSL)

- Indicates the status of the robot
    - OFF: Robot is unpowered
    - ON-SOLID: Robot is powered but disabled
    - ON-BLINKING: Robot is powered and enabled

FRC Control System Layout

3128 aluminum narwhals

WIRELESS COMMUNICATION

Radio Power Module (RPM)

Radio

WIFI RADIO

RADIO POWER MODULE

Ethernet Cable

22 AWG MIN
28 AWG MIN
CAN
INPUT
PC
RS-232
RSL

POWER
STATUS
RADIO
COMM
MODE
RSL
SPI

Camera
(LifeCam HD3000 Shown)

Servos

roboRIO 2.0

RoboRIO

RELAY   ANALOG IN
RESET USER
RSL   VOLTAGE

26 AWG MIN

Robot Signal Light (RSL)

Power Distribution Hub (PDH)

POWER DISTRIBUTION HUB

12 AWG MIN

12V40A
12V40A
12V40A
12V40A
12V40A
12V20A

18 AWG MIN

12.0
BATTERY VOLTAGE   BATTERY INPUT

REV

STATUS
CAN
USB-C

Spark

DISCRETE
MOTOR CONTROLLERS
(PWM Controlled)

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120A Breaker

6 AWG MIN

12V DC
BATTERY

26 AWG MIN

Limit
Switch

NPN Type
Photoelectric Sensor

DIGITAL INPUTS/OUTPUTS (DIO)

Voltage Regulator Module

REGULATED POWER

Compressor

PNEUMATIC SYSTEMS

Digital   Analog
Pressure Sensors

26 AWG MIN

Solenoids
(12V Double solenoid shown)

18 AWG MIN

PNEUMATIC HUB

Pneumatic Hub (PH)

26 AWG MIN

2022 FRC
CONTROL SYSTEM V.1.01

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LEGEND

Power
12VDC
Main
LIVE(+) GROUND(-)

PWM
26 AWG
Minimum
+5V
GROUND SIGNAL

CAN Bus
28 AWG
Minimum
HIGH   LOW

Wire Gauges
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Gauge (AWG)
Minimum Gauge per
connection shown

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Motor Controllers

Motor Controllers - PWM Controllers

- Receive signal at a frequency, motor goes at a speed in a direction
- Historically cheap, most of them are discontinued at this point
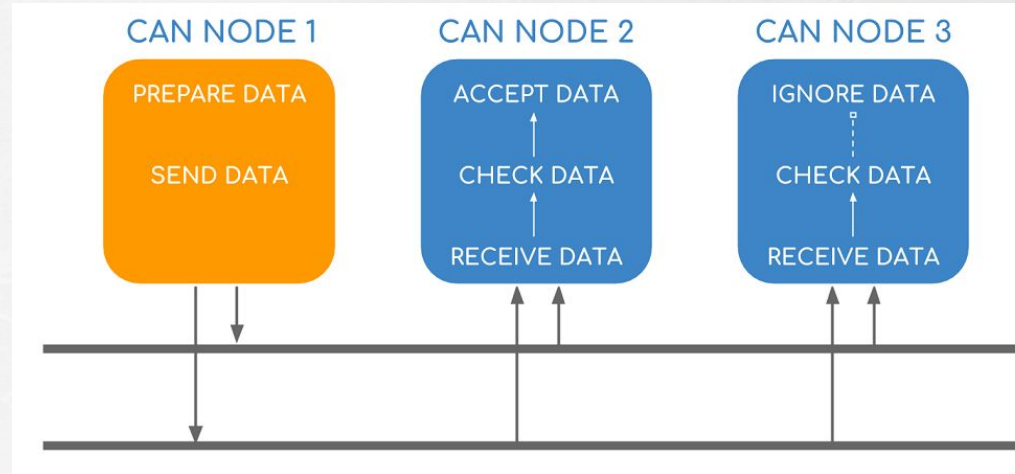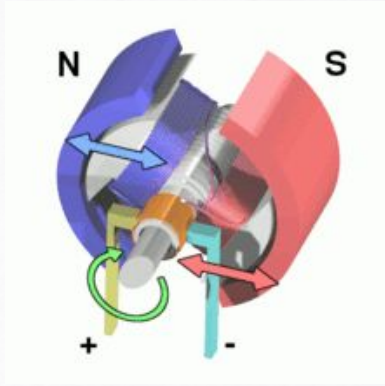- Still circling around in FRC

FRC Legal
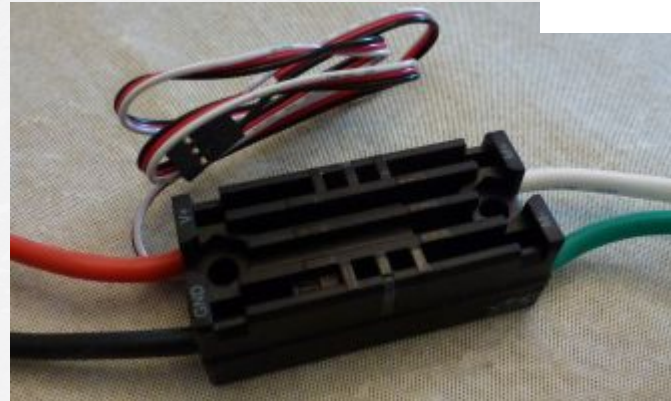
What is PWM?
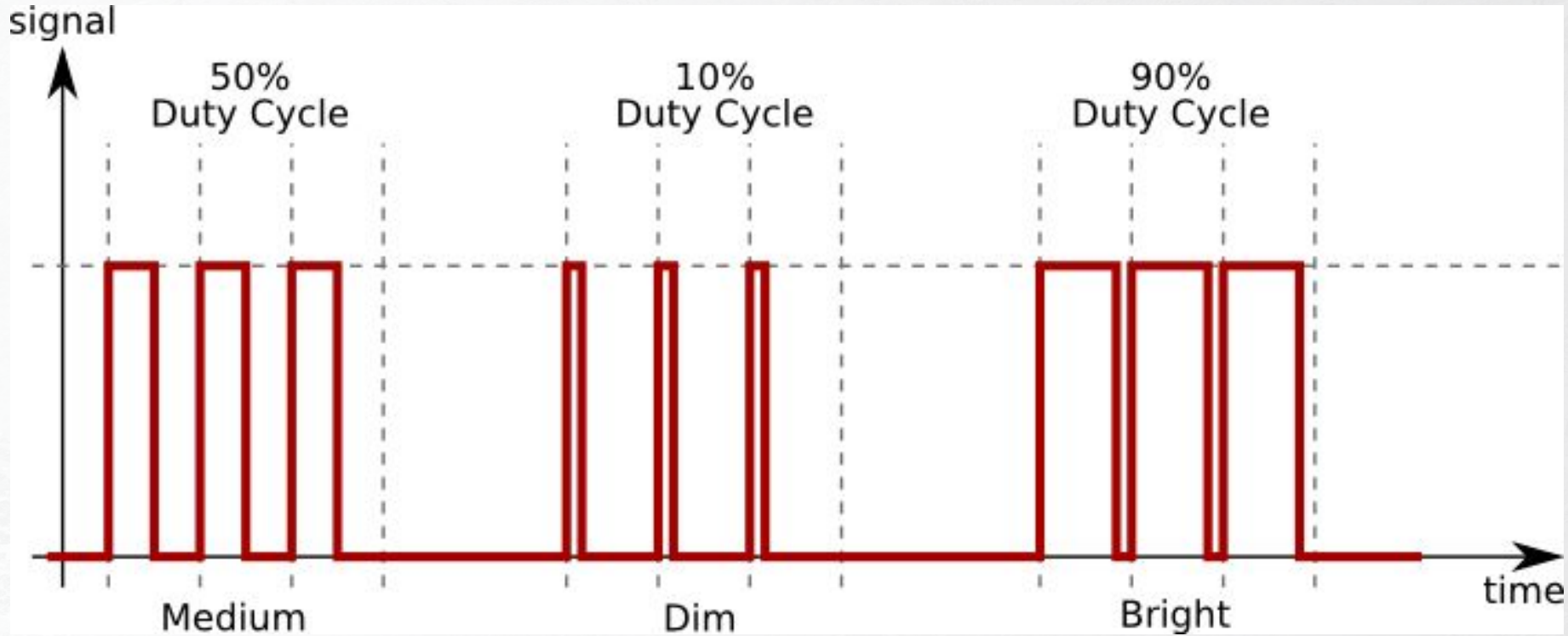
What is CAN Bus?

- Communication is 2 way
- Typically works in a loop
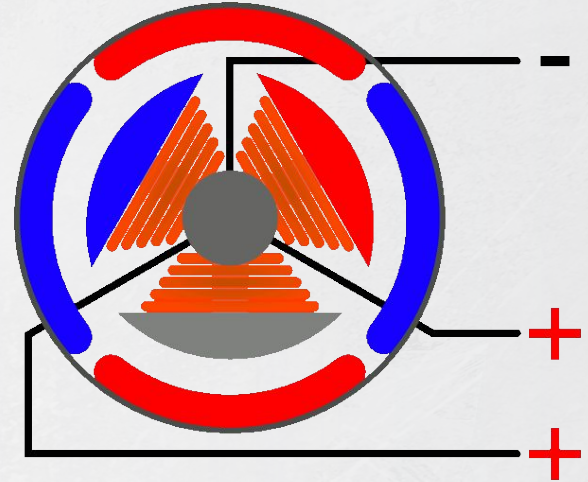- RoboRio sends signal, devices all look at it to determine if they need to act

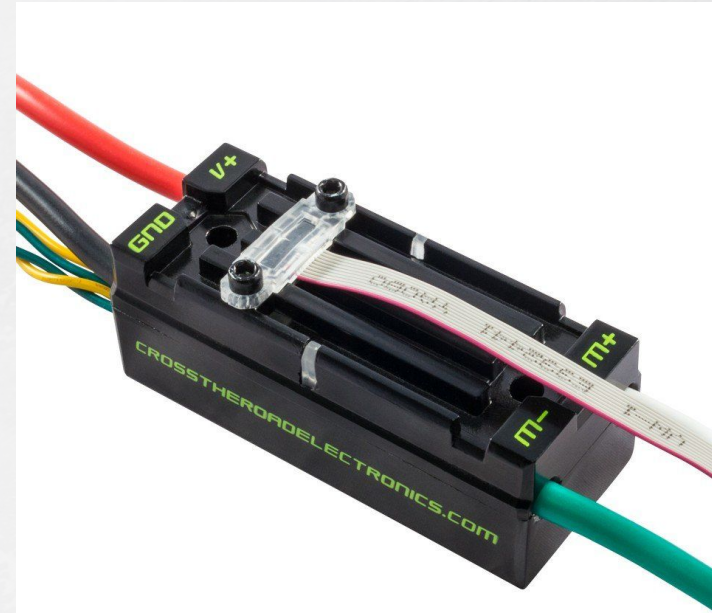# Brushed Vs. Brushless Motors

BRUSHED

- Simple
- Larger

BRUSHLESS

- More efficient
- Better with heat management
- Smaller
- More complicated

Motor Controllers - Talon SRX

- Brushed motors only
- Has a port to connect external sensors
- Communicates via CAN bus

Motor Controllers - Victor SPX

- Brushed motors only
- Does not have an external encoder port
- Communicates via CAN bus

Motor Controllers - SPARK MAX

- Compatible with brushed and brushless motors
- Primarily used for NEO and NEO 550 brushless motors, need to have an encoder cable plugged in between the two
- NEO's have a built in encoder
- Has a port to connect external sensors
- Communicates via CAN bus

Motor Controllers - Talon FX

- Built into Falcon 500 brushless motors
- Has a built in encoder
- Has a port to connect external sensors
- Communicates via CAN bus

Other Electronics

Cameras

- USB Cameras
  - Used to see far away areas of the field or internal parts of the robot
- Limelight
  - Built in hardware for processing vision data, black box solution for vision tracking field elements or objects on the field

Blinkin

- Used to control cosmetic LED's on robots
- Programmed like a motor controller
- Has a bunch of preset patterns that you can select from

Sensors: Buttons and Limit Switches

- Sends values based on if it is pressed or not
- Used to detect contact
- Good for zeroing position sensitive mechanisms, such as shooter hoods or elevators
- Not designed to handle abuse, will break if contacted too hard

Sensors: Infrared Sensors

- Can detect if an object is nearby without directly touching it
- Good for detecting if the robot has a game piece loaded

Sensors: Gyro

- Measure the rotation of the robot
- Particularly helpful for autonomous functions on the robot
- Can plug directly into the SPI port on the RoboRio

Connections

Electrical Connectors: Anderson Powerpoles

- Used for almost every power connection on the robot
- Consists of a crimped on metal insert and a plastic housing that the insert clips into

Electrical Connectors: Ferrules

- Keep stranded wires together
- Help them insert into Wago or Weidmuller connections
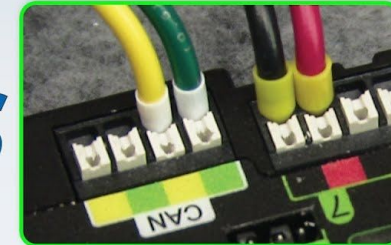- Kits are cheap on Amazon, work really well

FIRST - AID

*Wiring Solutions : Ferrules*

AUTOMATIONDIRECT

VS

CAN

CAN
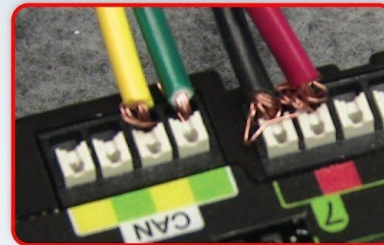
Electrical Connectors: WAGO's

- WAGO lever nuts connect all low voltage and CAN communication wires
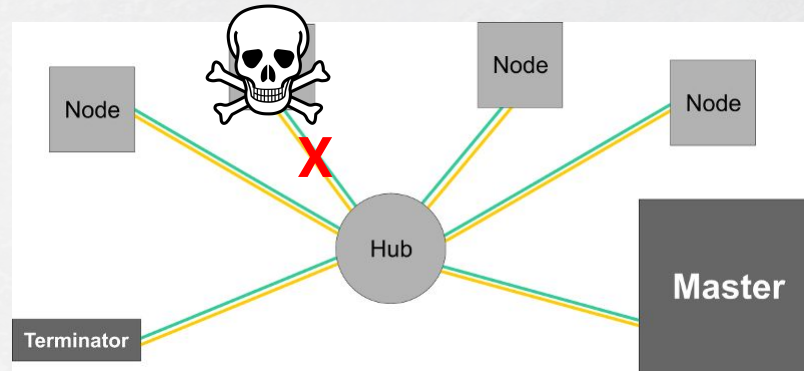- Tons of different options, easily found on Amazon

CAN Topology

- CAN devices can be connected in either loop or star topology
- FIRST recommends that teams use loop configuration, however if there is a break in the line all devices after the break will lose communication
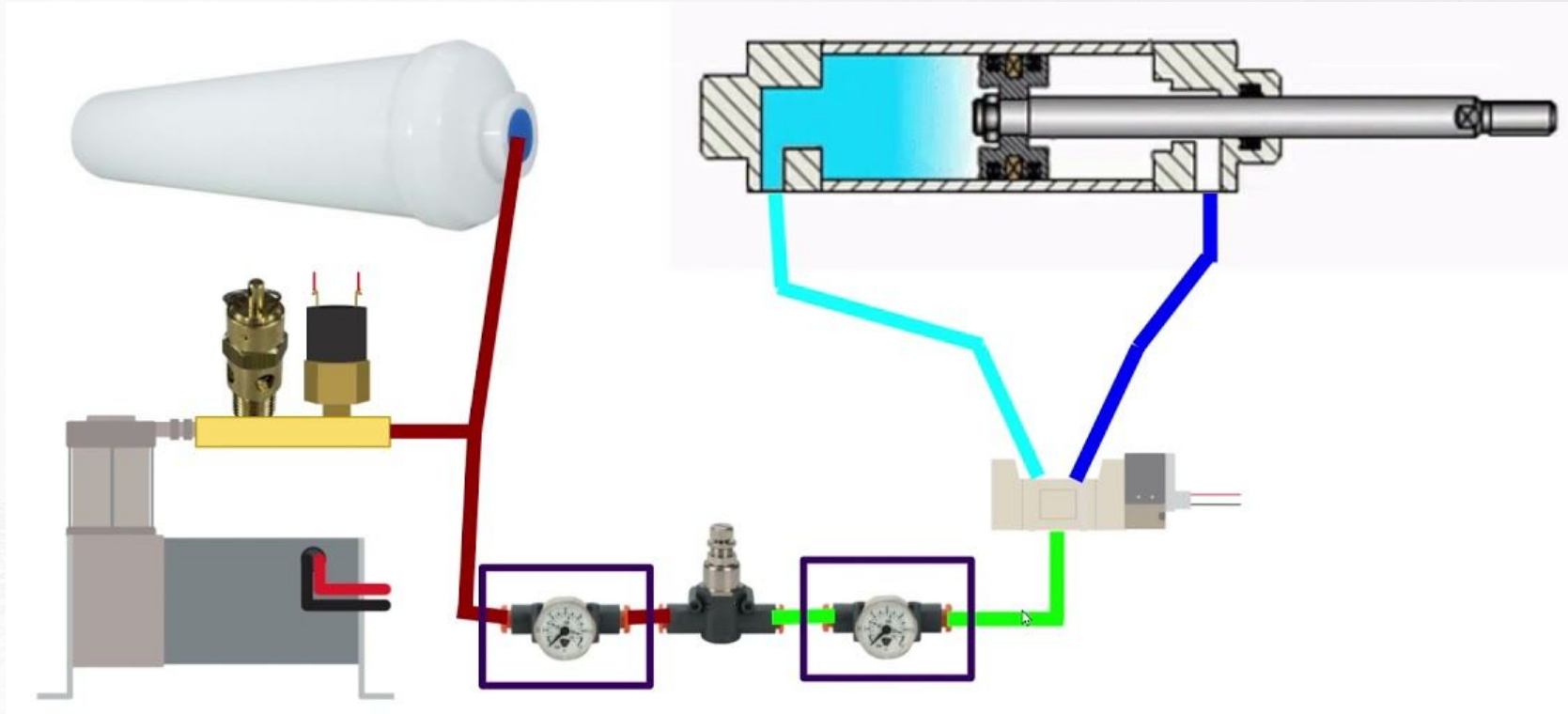

YEAH! LET'S BREAK SOME RULES!
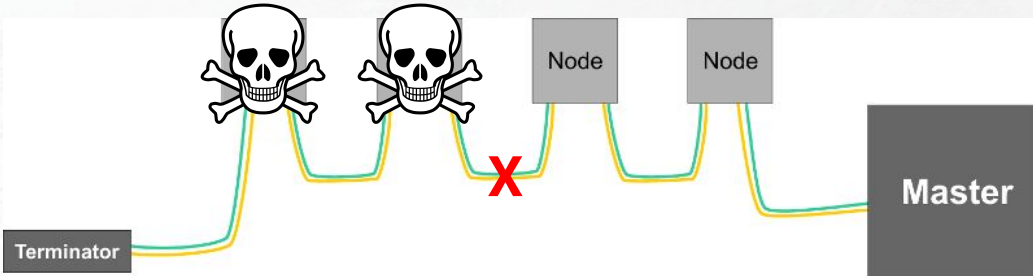
Loop Topology

Star Topology

Pneumatics

[Pneumatics Manual](#)

FRC Pneumatics: Overview

FRC Pneumatics: Tubing, Connectors, Plugs

- Pneumatics connect tubing with connectors
- Some connectors go between two pieces of tubing, can be used to change directions or to branch air
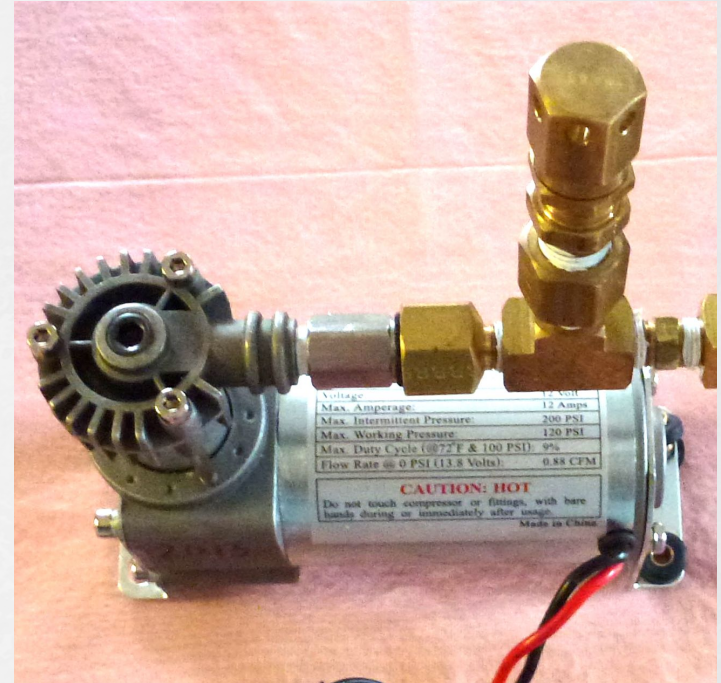- Some connectors thread on to pistons or solenoids and need teflon tape so they don't leak

FRC Pneumatics: Compressor

- Compresses air
- Turns on only when the system is below 120 PSI
- Turning it on/off can be controlled in code

FRC Pneumatics: Emergency Pressure Relief Valve

- Safety feature that allows air to escape the system when the pressure goes above 120 PSI

FRC Pneumatics: Pressure Switch

- Monitors the pressure in the system

FRC Pneumatics: Release Valve

- Manual release for the air in the system
- Air should be released when not in use
- Bunch of different ones

FRC Pneumatics: Air Tank

- Stores the compressed air to keep it ready to use at 120 PSI

FRC Pneumatics: Primary Pressure Regulator

- Regulates air pressure from 120 PSI stored pressure to 60 PSI working pressure
- Needs to be paired with a gauge on each side to verify the stored and working pressures

FRC Pneumatics: Solenoid

- Direct air into pistons, makes pistons extend/retract
- Single solenoids have a neutral state and a positive state, when the robot is disabled it always returns to neutral
- Double solenoids have a negative state and a positive state, it can start/ end in either position

Double Solenoid

FRC Pneumatics: Piston

- Extends/retracts via air power
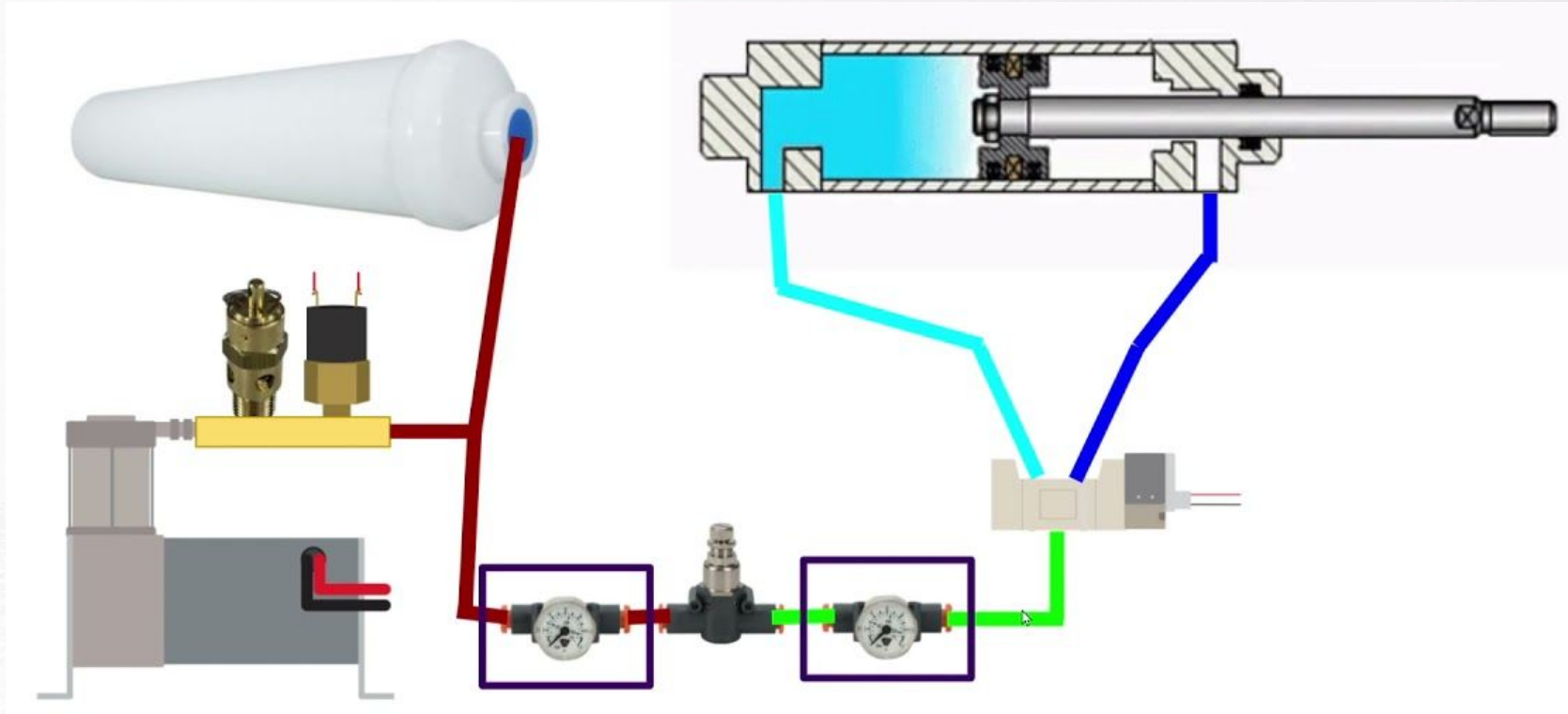- Comes in tons of different sizes and lengths

FRC Pneumatics: Pneumatics Control Module

- Handles all pneumatic functions on the robot
- Powers the compressor when needed
- Monitors the pressure of the system
- Controls solenoid directions
- Can control up to 16 solenoids in 2022 (previously 8)

2022

FRC Pneumatics: Overview

Big Takeaways

- DO - Setup your electronics off of your robot first, set all CAN ID's

- DO - Document where things are plugged in

- DO - Make sure all of your devices have their updated firmwares

- DO - Plan where the big things are going on the robot early

- DO - Keep an eye on your amps

- DON'T - Settle for bad connections

- DON'T - Settle for 'that was weird'

- DON'T - Be afraid to ask for help from others

- DON'T - Skimp on the zipties (make sure that you spend time on organization)