NFPA Fluid Power Vehicle Challenge

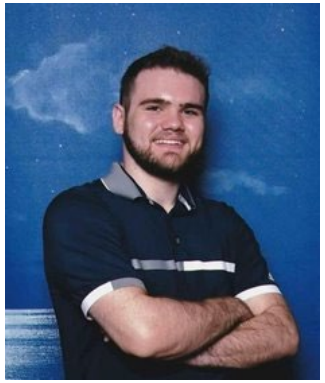
NFPA Education and Technology Foundation

FINAL PRESENTATION & DESIGN REVIEW

Purdue University - WL
Advisor: Jose Garcia-Bravo

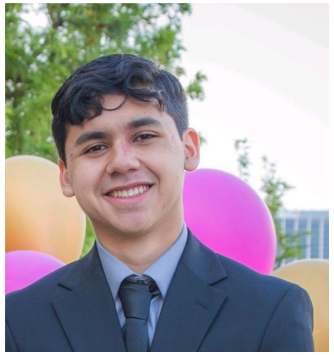
4/24/2025

Team Introductions



Austin Hahn
Mechanical/Hydraulic

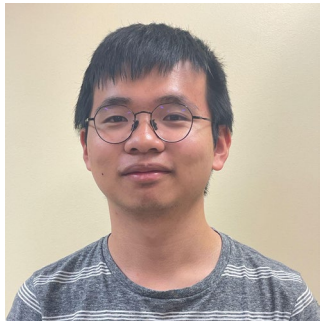
Teddy Becker
Mechanical



Anthony Pineda Hercules
Mechanical

Luke Ellington
Hydraulic/Pneumatic

Connor Harriss
Electrical



Yu-Hung (Thomas) Wang
Electrical/Pneumatic

Outline

- Last Years Bike
- Vehicle Construction
  - Mechanical
  - Hydraulic
  - Pneumatic
  - Electronic
- Vehicle Testing
- Lessons Learned

Design from previous year - Mechanical System

Pros:

- Won Judges' Choice: Safety Award
- Jack of all Trades
- Modular - 8020 Rails

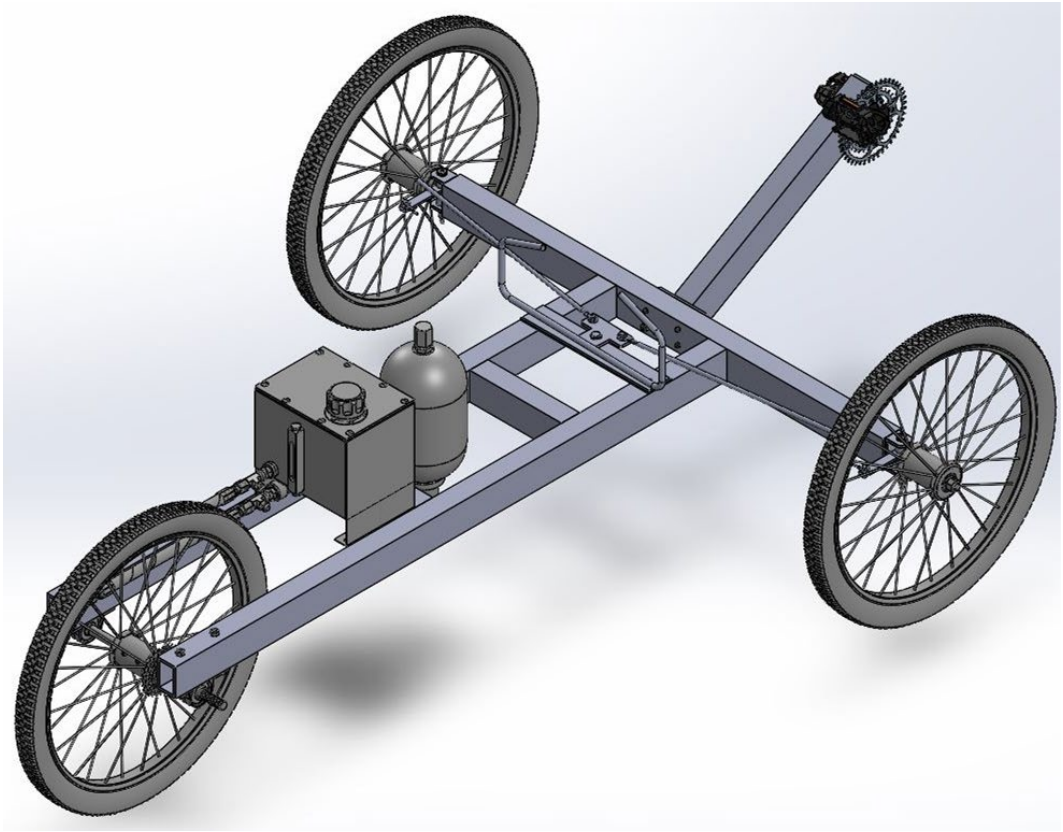
Cons:

- Heavy Weight
- Difficulty in starting to pedal
- Internal hub slipping during operation
- Steering - Stiff turning of the wheels

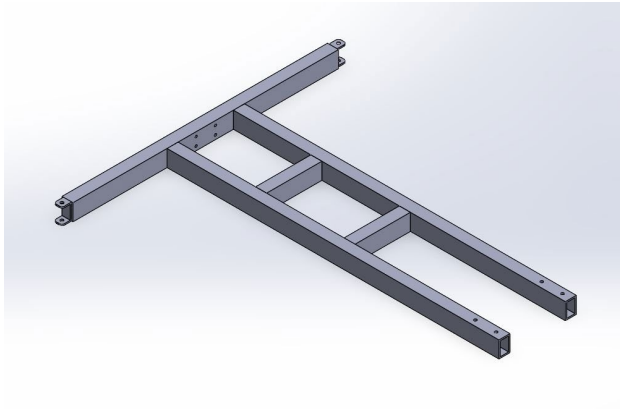
Vehicle Design - Overview

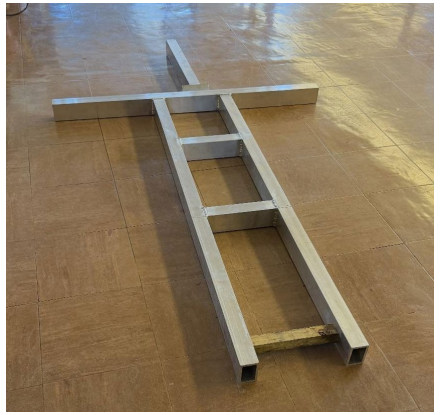
The 2025 vehicle is very similar to the previous bike with a few key upgrades:

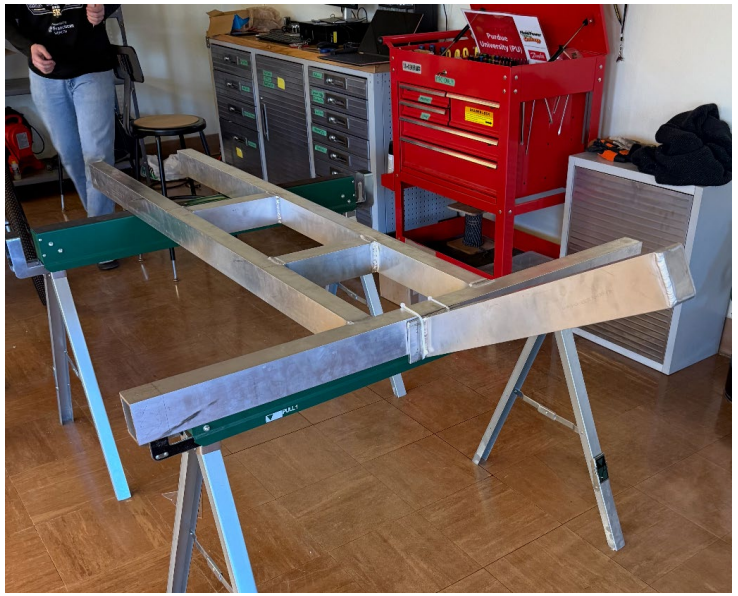
- Aluminum rectangular tube frame
- More robust steering components
- New internal hub for the rear wheel



Vehicle Design - Frame



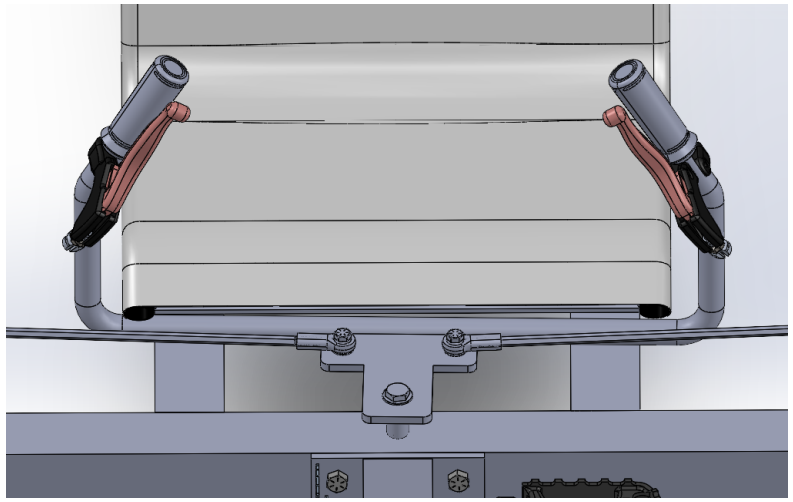




- The frame consists of ¼” thick rectangular aluminum tubing
- Intention was to reduce weight but keep req. strength
- Modularity becomes a problem due to thickness

Vehicle Design - Steering

- Ackerman style steering for improved agility
- Addition of thrust bearings to improve the ease of use
- Improved handlebars
- 160mm brake rotors on both front wheels



Spindles and Brakes

- Design inspired by Tony Kart spindles
- Fabricated out of aluminum
- Wheels made with a 15 mm size hub and disc brake mounts

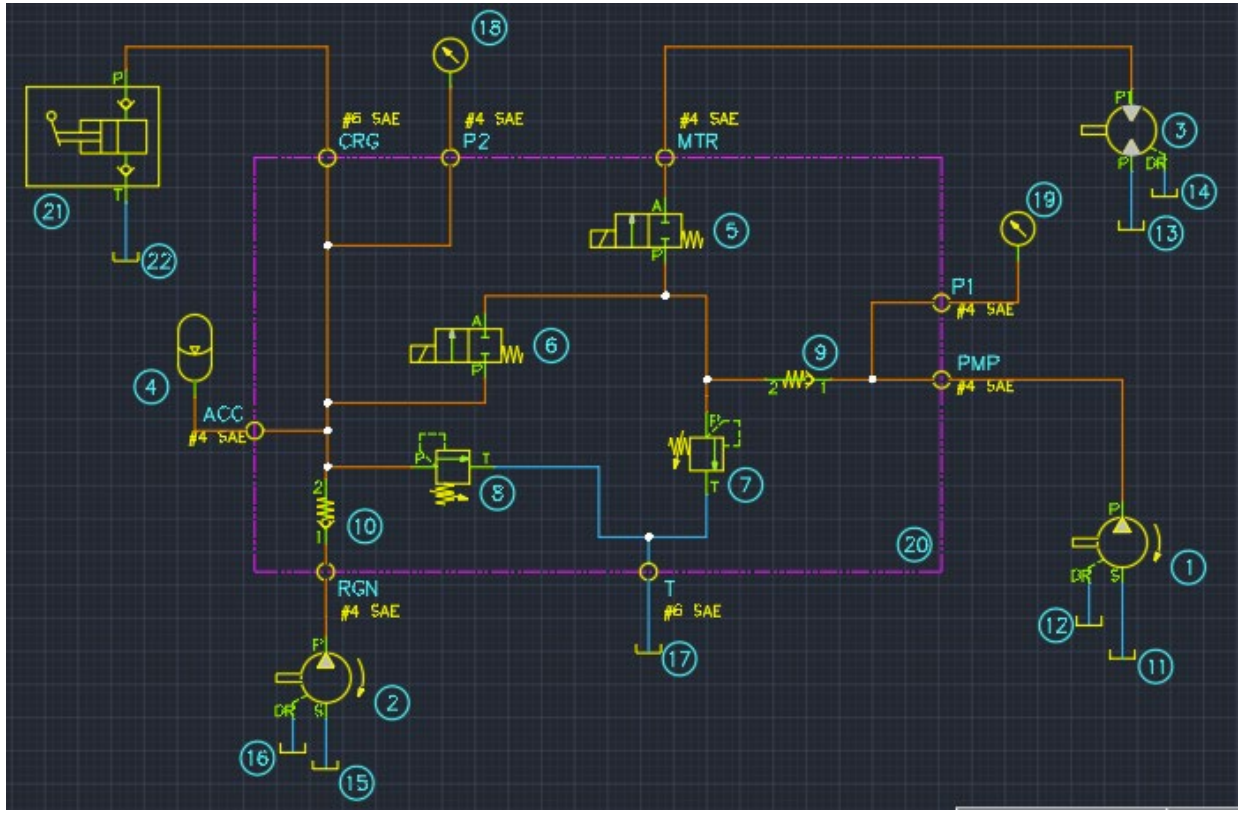
Hydraulic Design Concept: Variable Displacement Pump

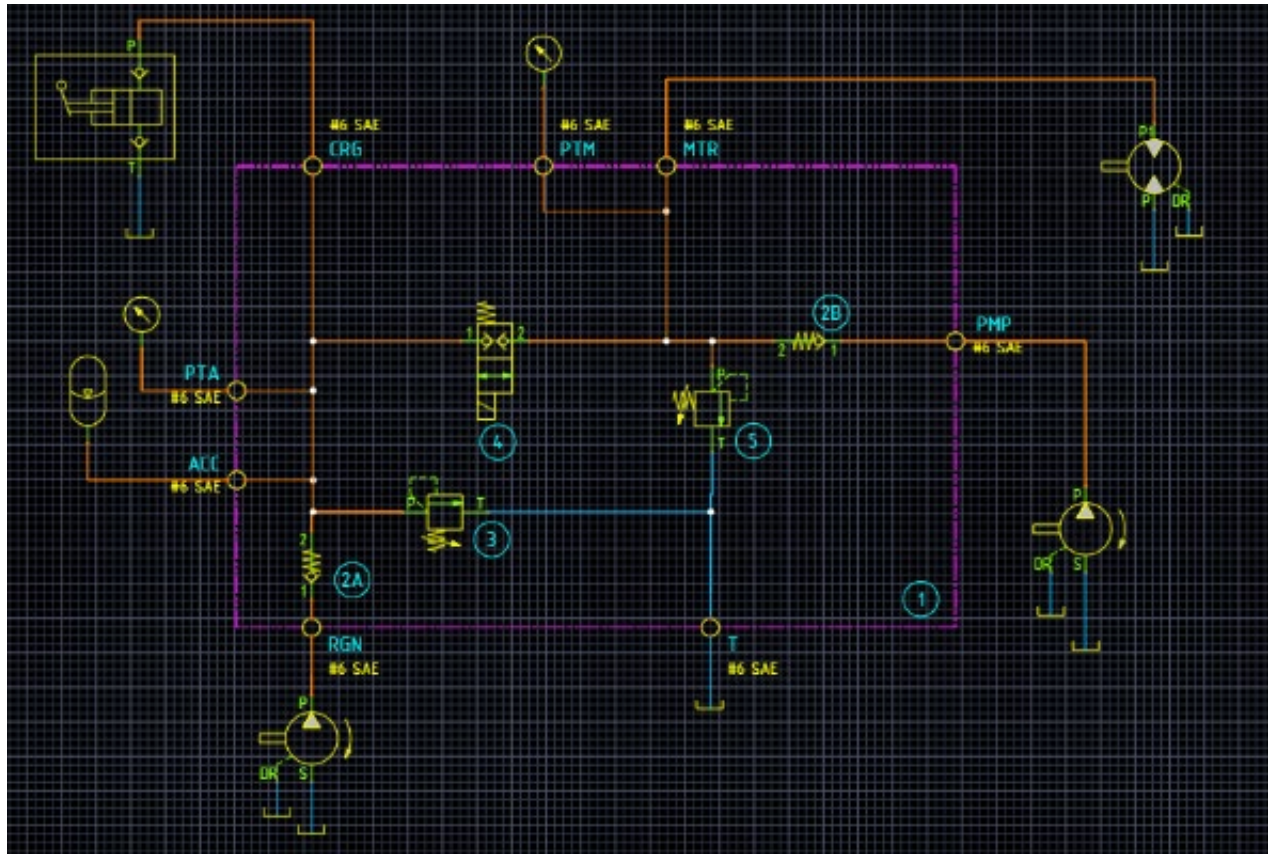
- 10.3 cc maximum displacement
- would allow for flexibility in pump displacement during pedalling

Issues:

- 1800 rpm minimum rated input speed
- need for a closed loop circuit

Hydraulic Circuit





Old

New

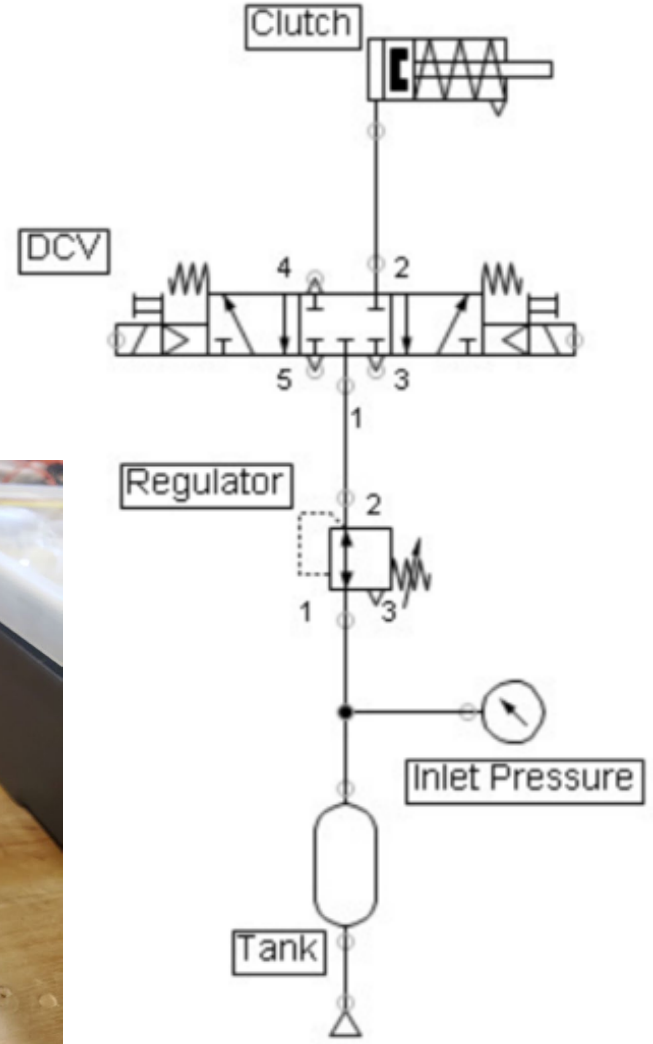
Hydraulic System

- Hydraulic lines color-coded for clarity during assembly and testing
- Most hoses and hardlines sized at -6; -8 used for tank supply to bent axis pump
- Hardlines used on high-pressure sections and areas with tight bends to prevent hose strain

Pneumatic System

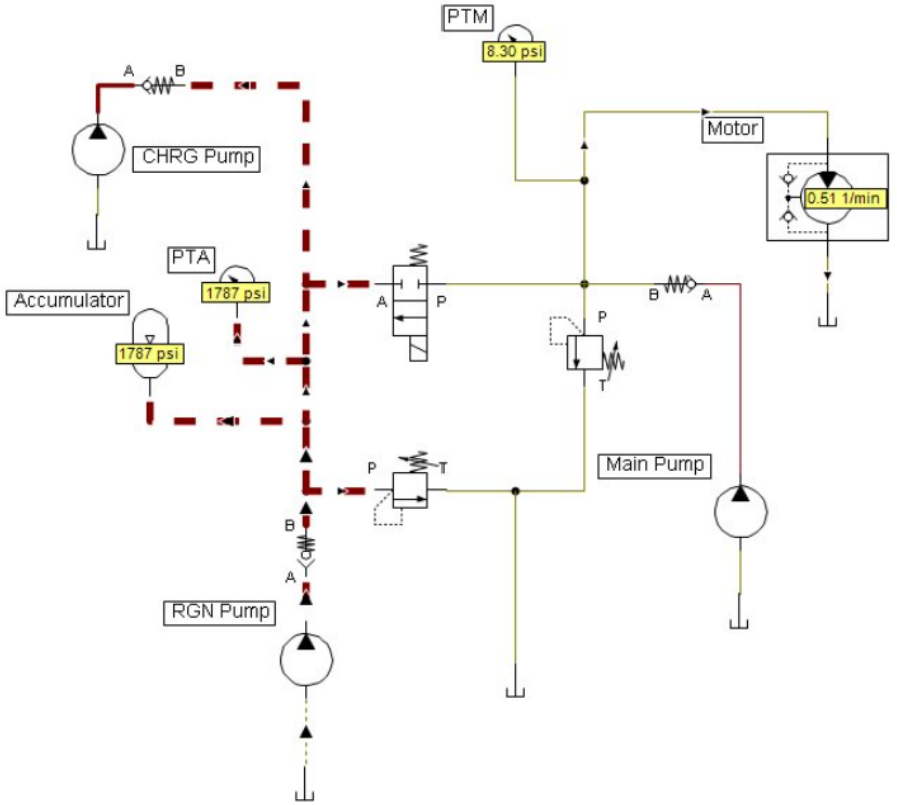
- DCV actuated through electronics to engage clutch
- clutch used to enter regenerative braking mode

- Intended to use electronic pressure regulator to control air flow
  - Too difficult and limited resources to use in conjunction with PLC



Regenerative Braking

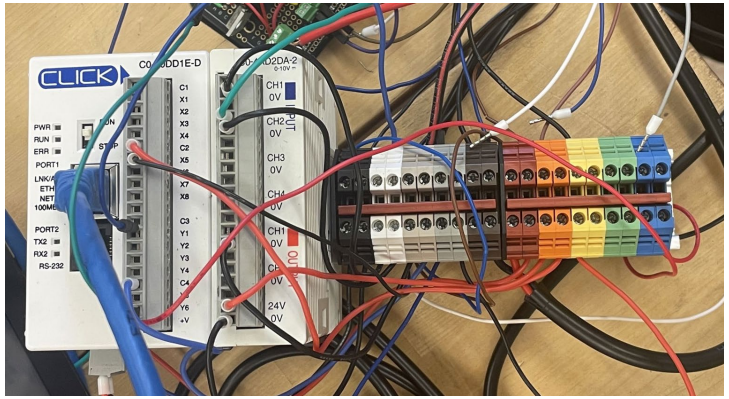
- stores kinetic energy while braking into pressure for the accumulator
  - pressure later used through hydraulic boost function
- mode engaged by clutch, allowing flow through regen pump

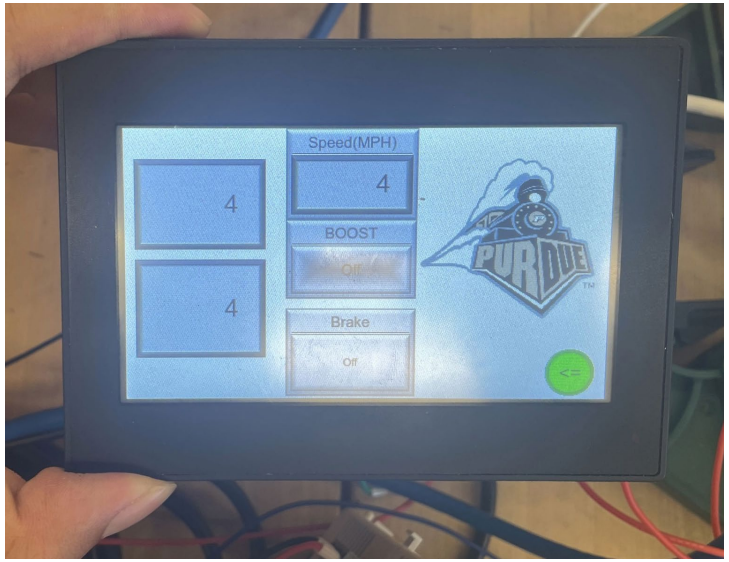


Regen Braking

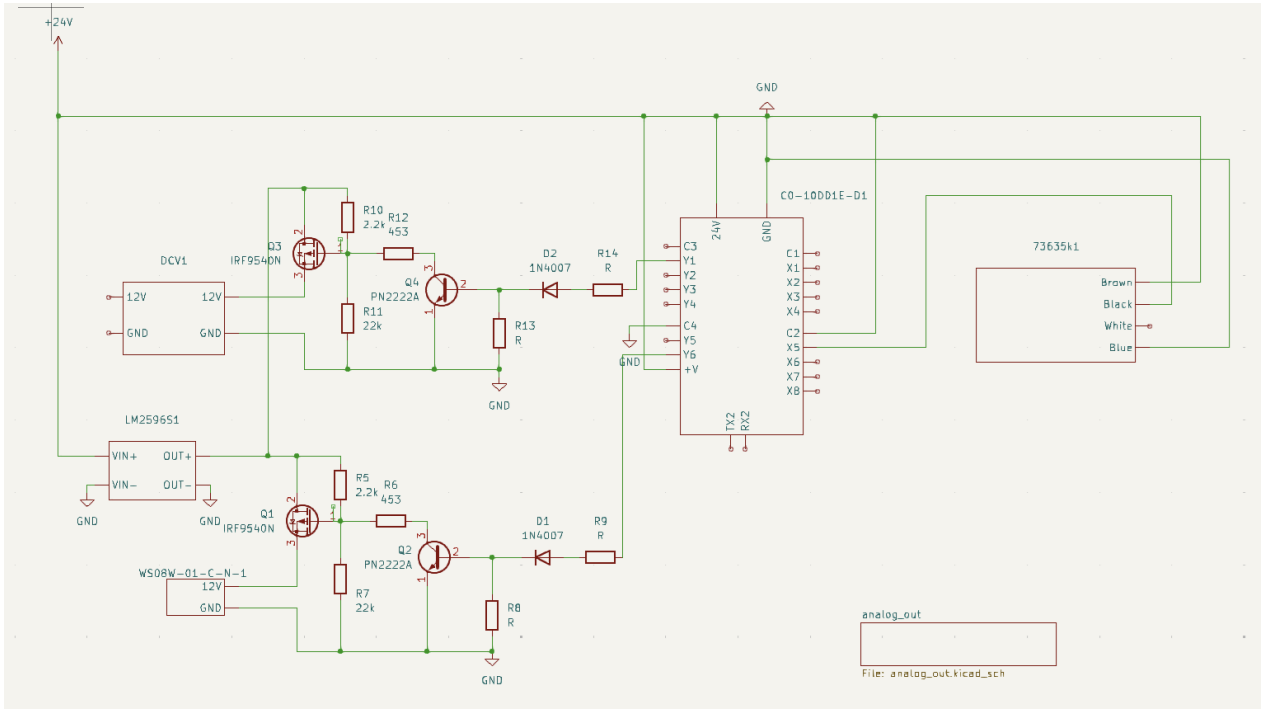
Electronic System

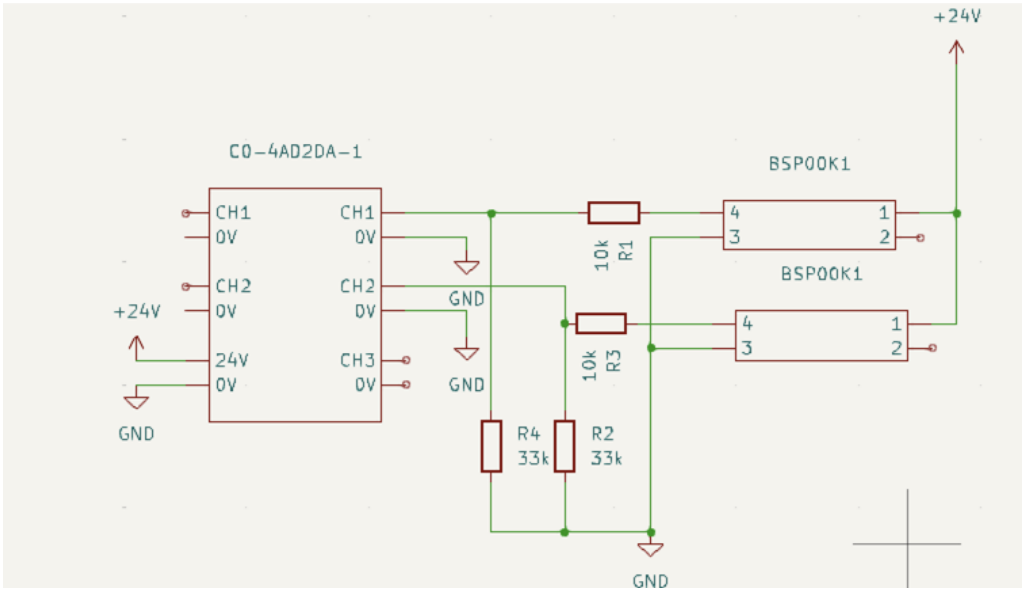
- Click PLC (C0-10DD1E)
  - Industrial Grade PLC
  - Modular design
  - Serial communication via ethernet protocol
- C-more HMI (CM-T4W)
  - Speed monitoring
  - Accumulator pressure monitoring
  - Main hydraulic pressure monitoring
  - Boost DCV control





Electronic System





Vehicle Testing

- Performed initial testing on previous vehicle to guide improvements
  - Identified issues beyond visual inspection (e.g., steering usability)
- Verified proper assembly of components
- Calculated and tested drivetrain performance to ensure sufficient torque and RPM for the pump, internal hub, and rear wheel
- Conducted stress testing to confirm material strength under competition conditions

Lessons Learned

- Begin bike assembly earlier to allow more time for testing
- Prioritize hydraulic system decisions, especially motor and pump sizing and gear ratios
- Reassess material strength since the steering pipe and prototype spindles failed under load
- Account more accurately for total weight since the final assembly was heavier than expected
- Improve modularity because the thick frame material made adjustments and modifications difficult

Thank you!

NFPA Danfoss DTS Dr. Jose Garcia

Questions?

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