NFPA Fluid Power VEHICLE Challenge

NFPA Education and Technology Foundation

FINAL PRESENTATION
Iowa State University
04/13/2026

Overview

- **Purpose**
  - Build a fluid powered bike for the NFPA FPVC
  - Demonstrate hydraulic energy storage and propulsion
- **Key Features**
  - Hydraulic drive system (pump and motor)
  - Accumulator for energy storage
  - Regenerative braking capability
  - Pedal-powered and stored energy propulsion
  - Pneumatic clutch
- **Design Goals & Constraints**
  - Operate below 3000 psi
  - Meet the speed and distance requirements
  - Meet safety and weight requirements
- **Final Outcome**
  - Efficient bike with energy recovery

Team Members

Jack Smith

Stuart Satterwhite

Madison Bergman

Joshua Tai

Dr. Ryan

Chase Goodwin

Anthony Schneider

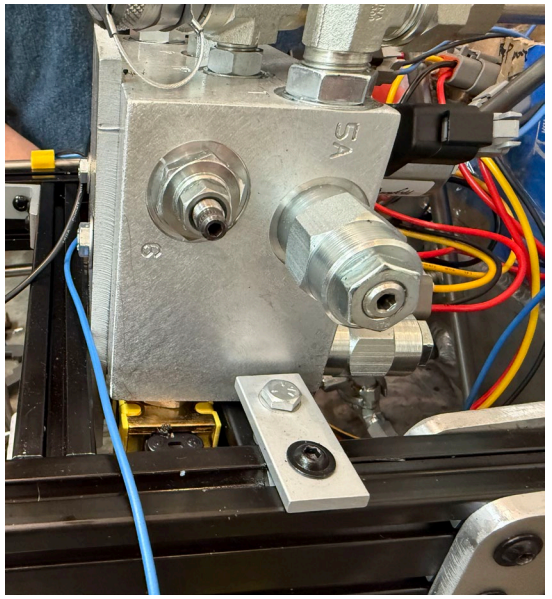
Daniel Wong

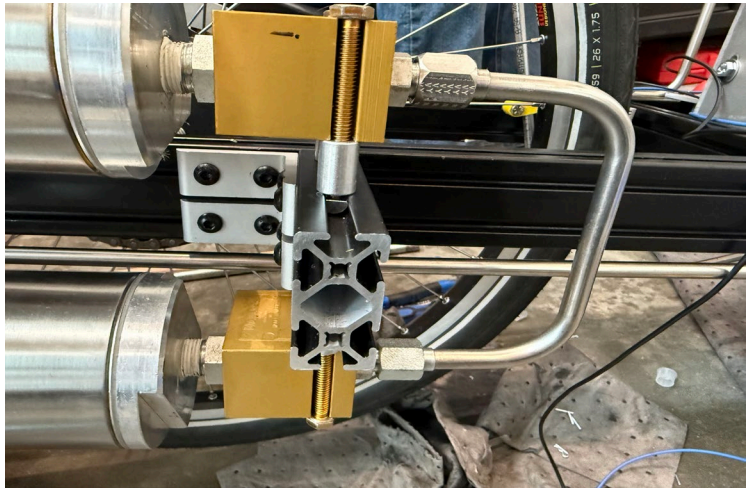
Dr. Steward

System Overview

- 1 - 1.21 CIR Gerotor Motor
- 2 - Gear Pumps (.3172 CIR & .1708 CIR)
- 2 - Pneumatic Clutch Assemblies
- 2 - Hand Pumps (.39 CID)
- Electronic Display with Microcontroller

Vehicle Construction





Testing and Iteration

- Originally used motor for regen – Force required was higher than expected, so added a pump with a smaller displacement.
- Tested multiple pump sizes – ended up using the smallest on the front and largest on the back.
- Electronic Display and Clutch Button –Printed a few versions as well as getting a button with the correct position sequence to match the clutch.

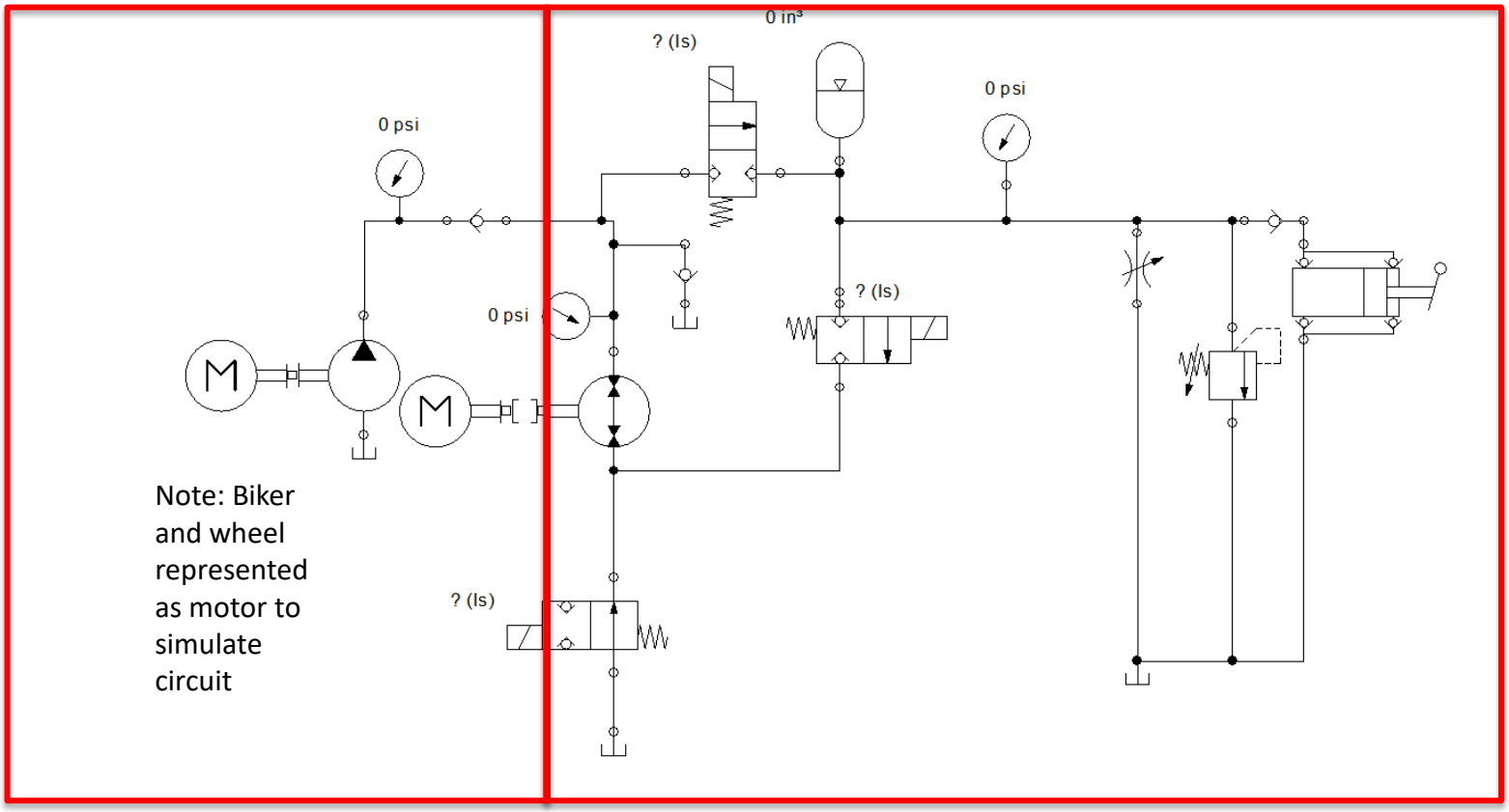
Final Vehicle Performance

- Charged accumulator via pedals, hand pump, and regen modes.
- Accumulator discharge propelled the bike a sufficient distance.
- Pedaling propelled the bike with reasonable effort
- Able to visually see pressure, speed and volumetric efficiency in real time.

Previous Years Circuit

Pedal Circuit

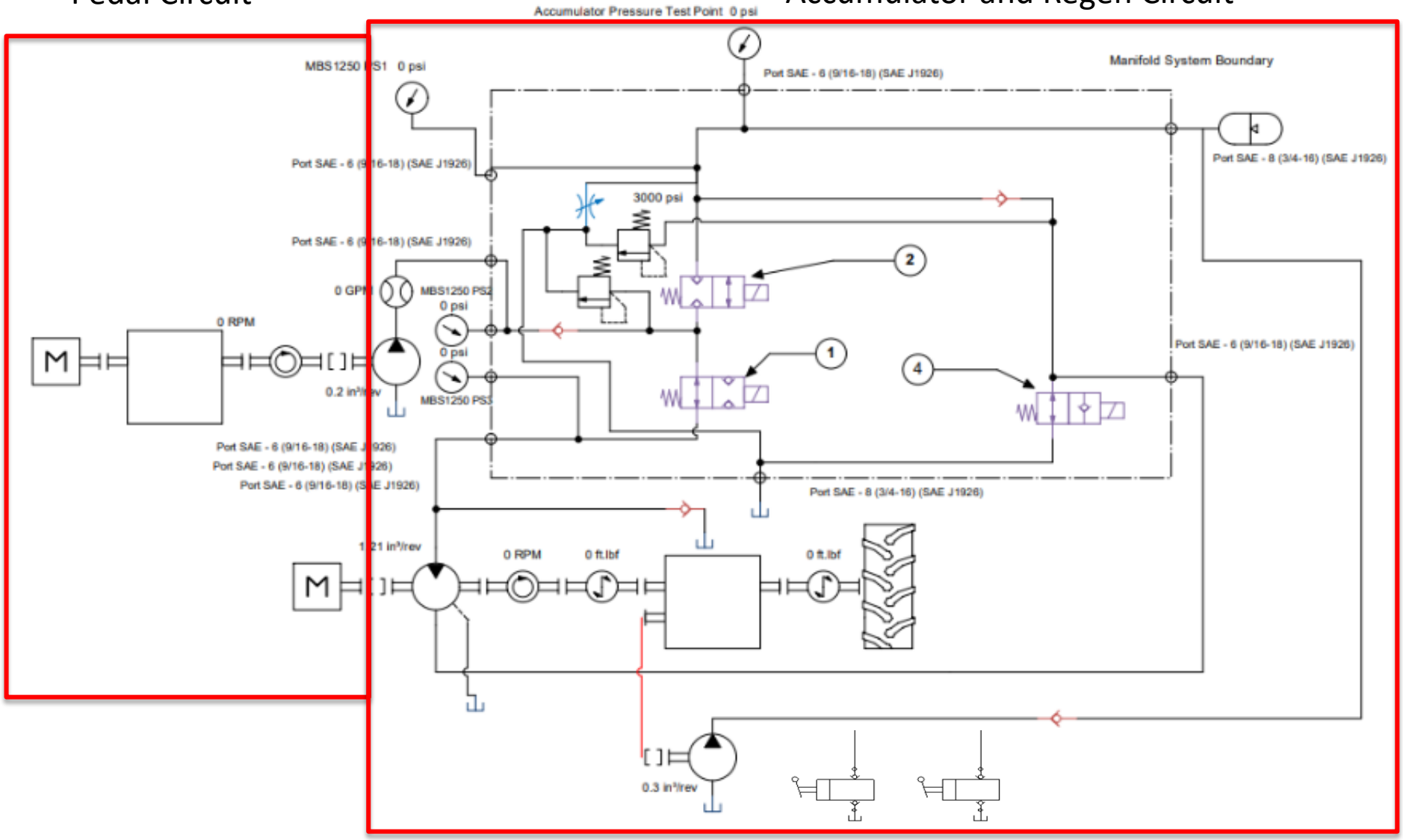
Accumulator and Regen Circuit



Current Years Circuit

Pedal Circuit

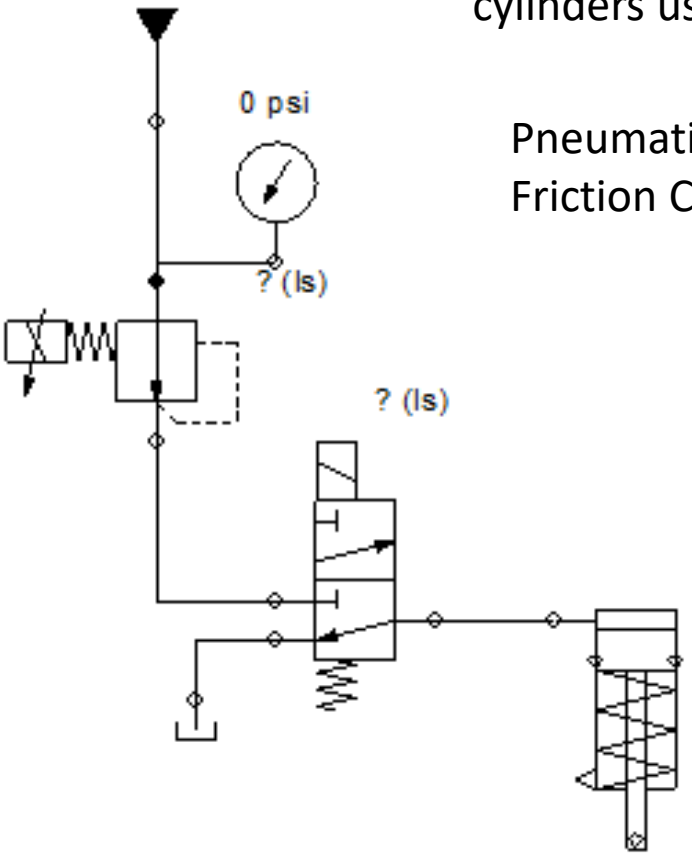
Accumulator and Regen Circuit



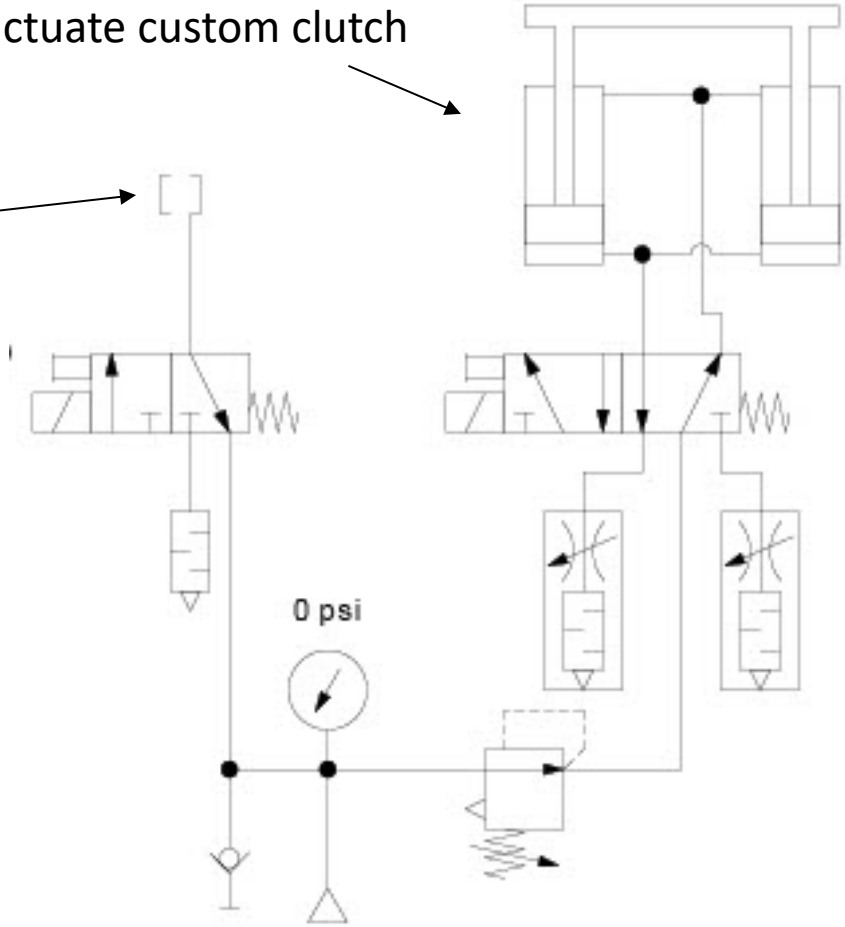
Revised Pneumatic circuit

Mechanically linked double acting cylinders used to actuate custom clutch

Pneumatic Friction Clutch

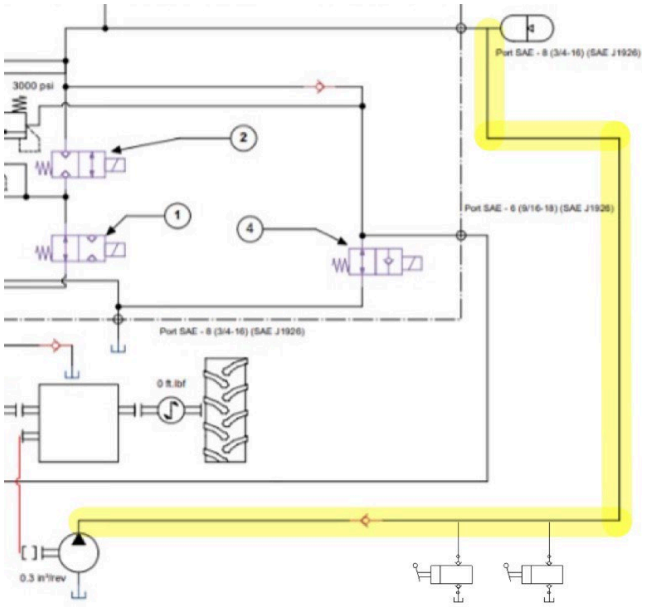


Old Circuit

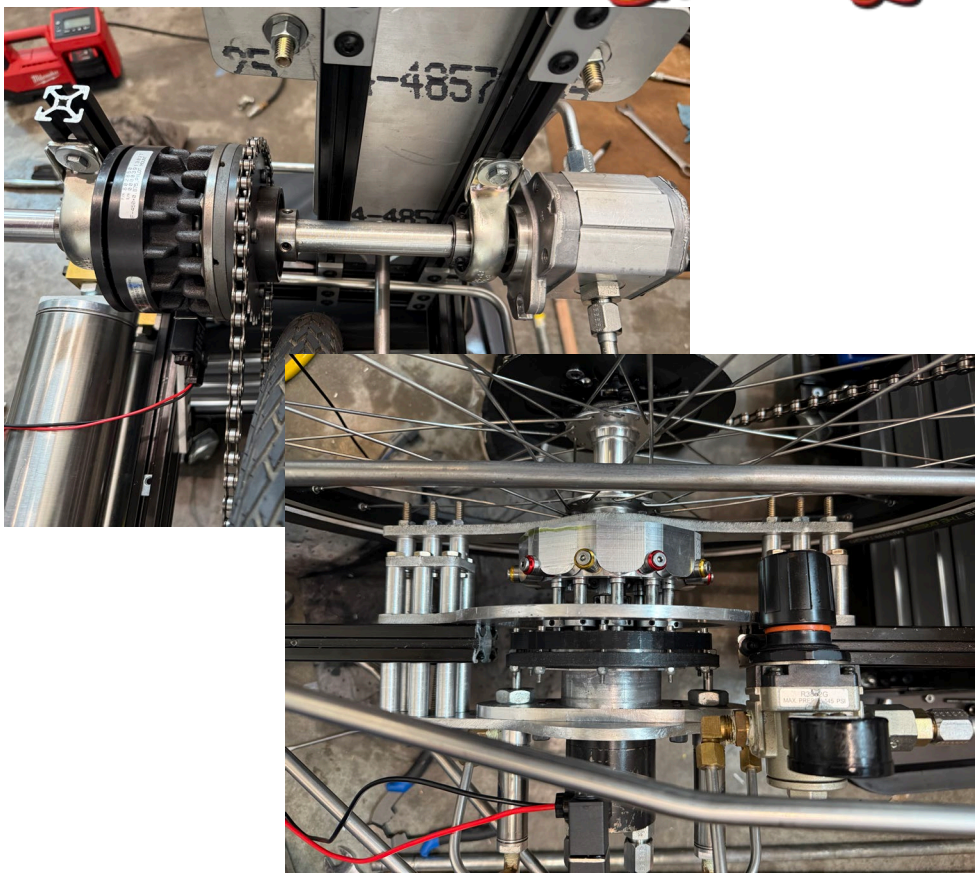


New Circuit

Regenerative Braking



Regen Circuit



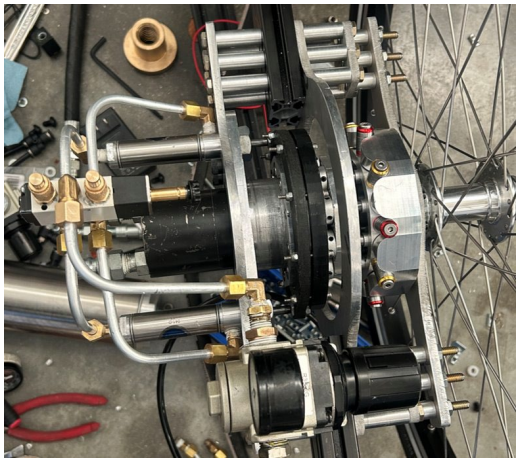
Pneumatic Clutches

Design Decisions (What we did to improve)

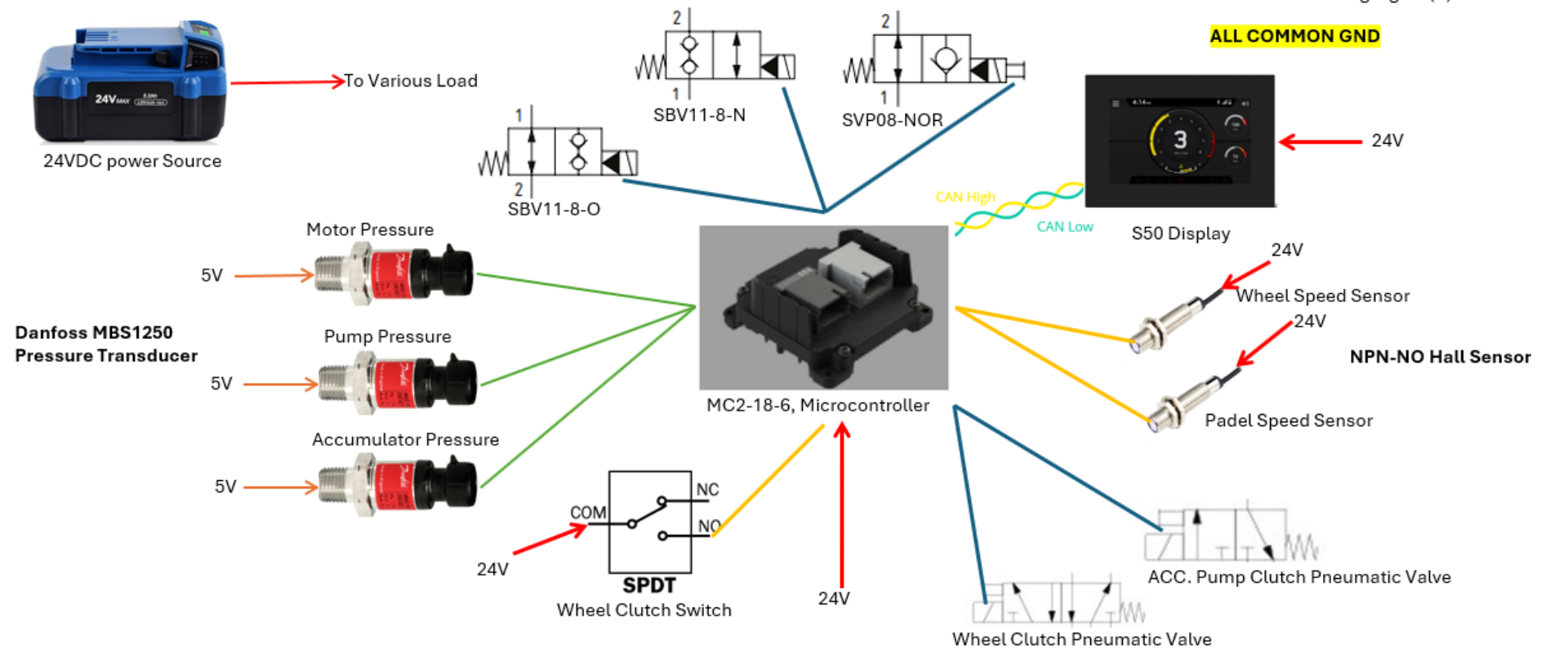
- Sized up pump
- Custom planetary gear set from motor to wheel
- Shortened wheelbase for smaller turn radius & less frame flex
- Positioned seat for better leverage over pedals.
- 2 handpumps for redundancy

Innovation

- Dual Clutch System
  - Entirely custom design for clutch with integrated planetary gearset, fabricated in house at Iowa State
- Display System
  - Real Time Feedback and control of modes and clutch.



Integrated Electro-Hydraulic Control System Diagram



Lessons Learned

- Hydraulic
- Pneumatic
- Mechanical
- Electrical & Controls
  - We learned how to use CODESYS to systematically setup and program a microcontroller for IEHCS and instrumenting sensors on our vehicle.
- Team Communications

NFPA Fluid Power Vehicle Challenge

Thank you!