NFPA Fluid Power VEHICLE Challenge

NFPA Education and Technology Foundation

FINAL PRESENTATION

WILDCAT FLUID POWER, SUNY POLY
Dr AHMED ABDELAAL

APRIL 2024

The Team

					
Josh Archanian Junior, MET	**Henry Miller** Junior, MET	**Pascal Harrison** Junior, MET	**Thiha Soe** Senior, MET	**Chris Lam** Junior, MET	**Kyle Vedder** Junior, MET
• Mechanical Design Lead • SolidWorks specialist	• Hydraulic Circuit Design • Hydraulic system builder and technician • Rider 2	• Hydraulic systems, circuit, and manifold design • Systems integration and fabrication mastermind • Rider 1	• Mechanical design • Part selection and integration • Graphic design authority	• Electrical Design Lead • Master programmer	• Fabrication guru • Electronics trouble shooting wizard

Design Review

CAD Model

- CAD is an extremely versatile tool.
- The CAD model was used to visualize how components would be integrated.
- It was essential to our success designing and manufacturing.

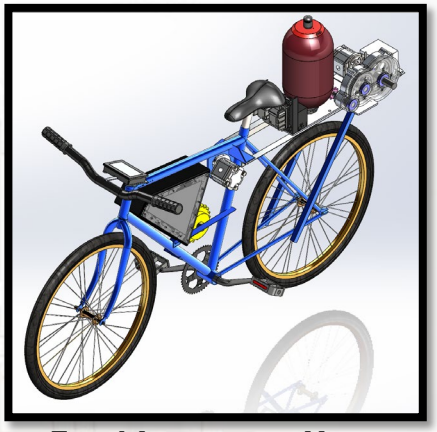


Fig. 1 Isometric View

Fig. 2 Completed Bike

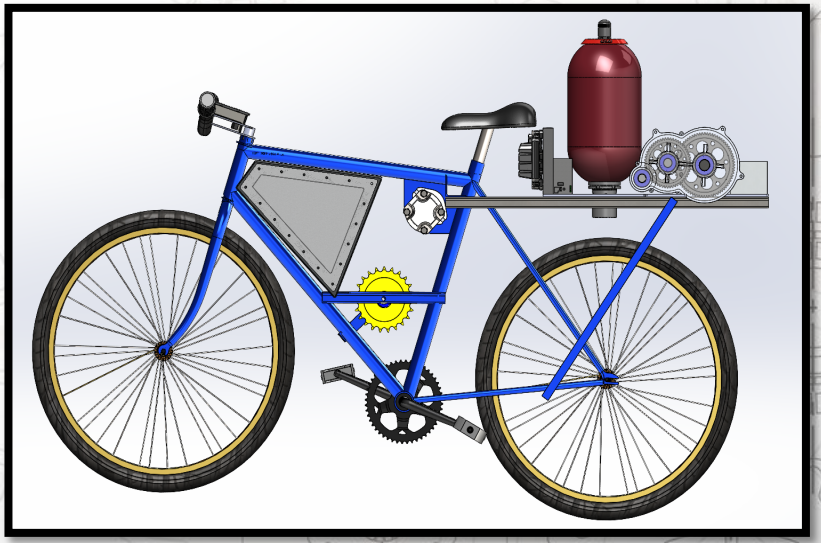


Fig. 3 CAD Model

Major Mechanical components

Fig. 4 Chain Drive System

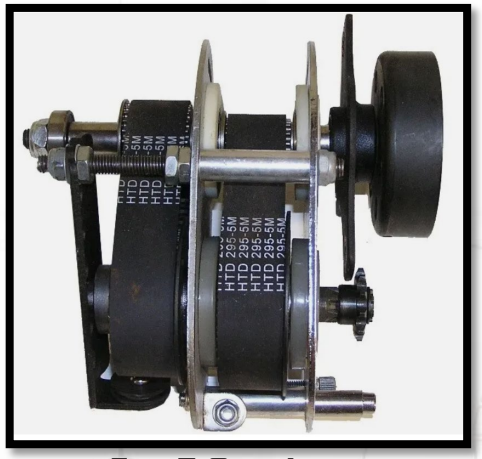


Fig. 5 Gearbox

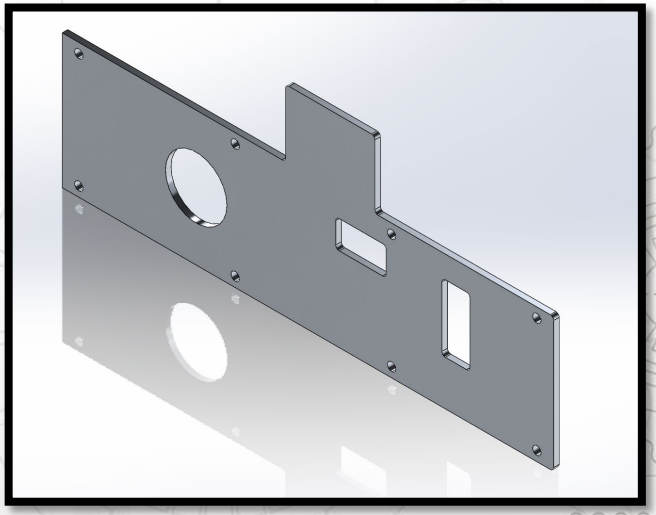


Fig. 6 3D Model of Back Plate

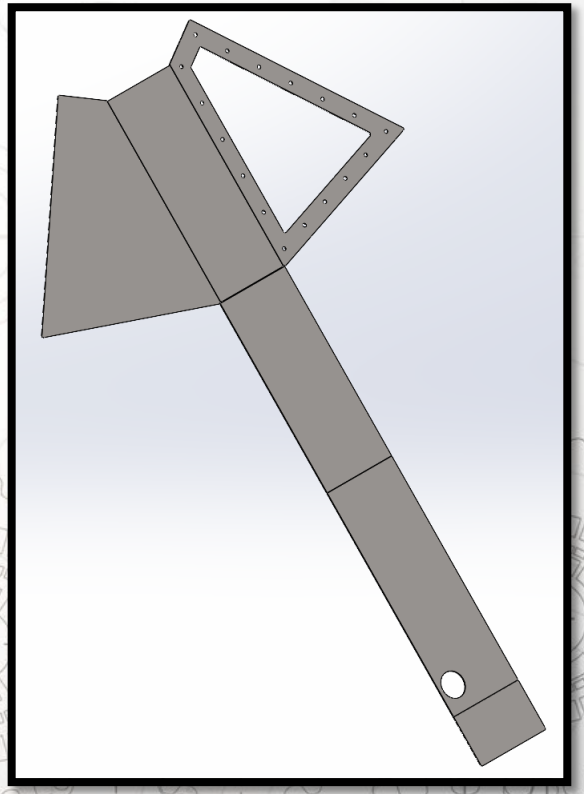


Fig. 7 Flattened Model of Reservoir

Gearbox

2-Speed Gearbox

- Cable-controlled
- Low range for starting (3.78:1)
- High range for cruising and regen (6.22:1)

Fig. 8 Gear Selector

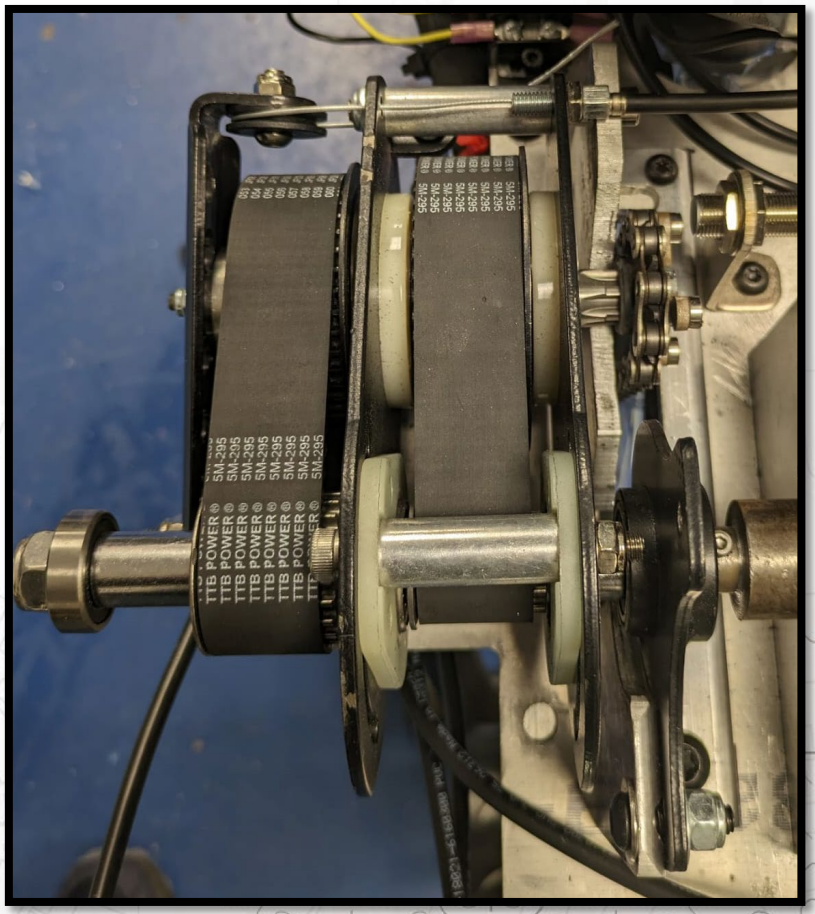


Fig. 9 2-Speed Gearbox

Calculations

Sprocket ratio

- Our ideal ratio was 1:10

$$CR = \frac{N_1}{N_2} * \frac{N_3}{N_4}$$

- CR = Compound Ratio
- N_i = Number of teeth on respective sprocket

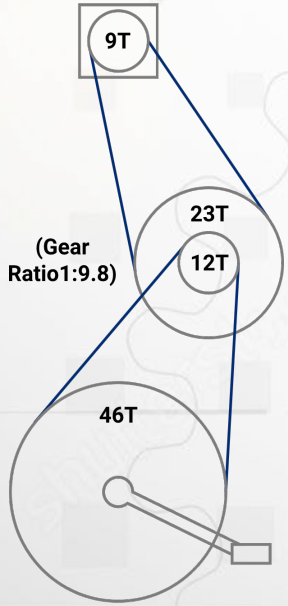


Fig. 10 Drive Chain Sketch

$$CR = \frac{46}{12} * \frac{23}{9}$$

$$CR = 1:9.8$$

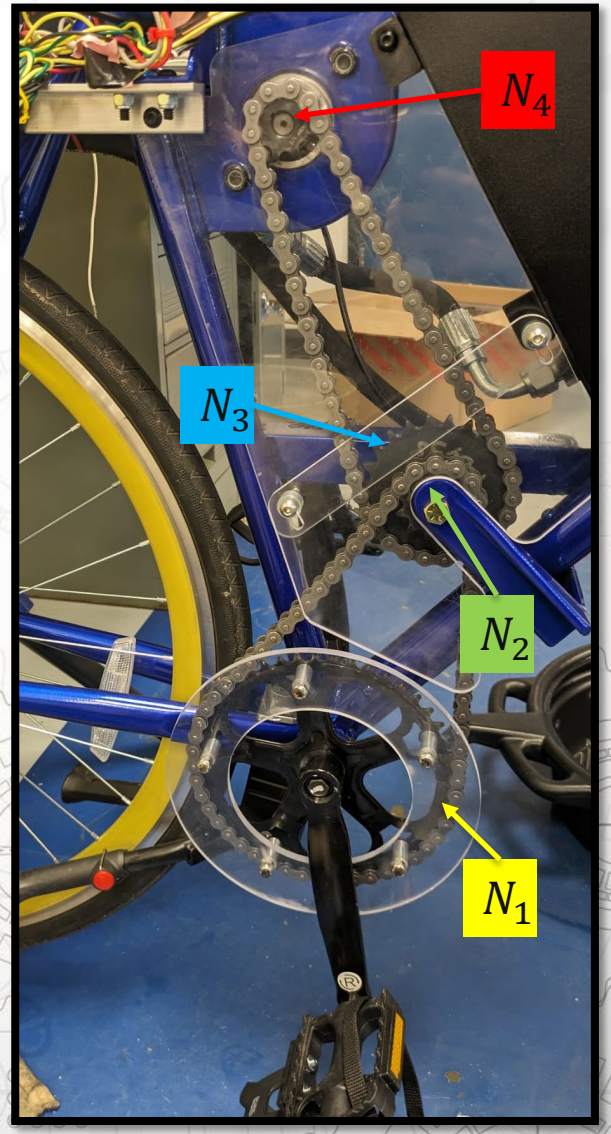
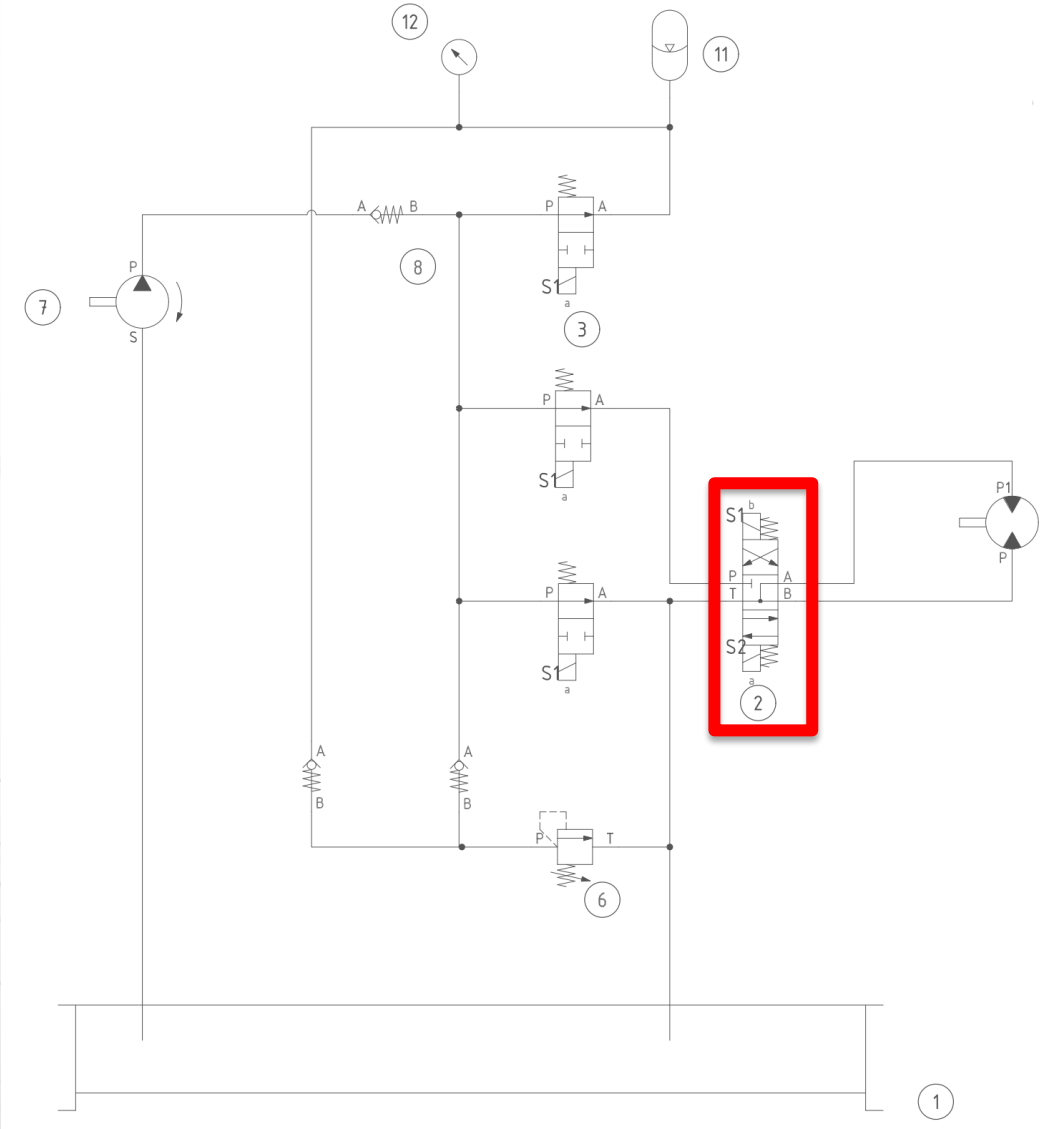
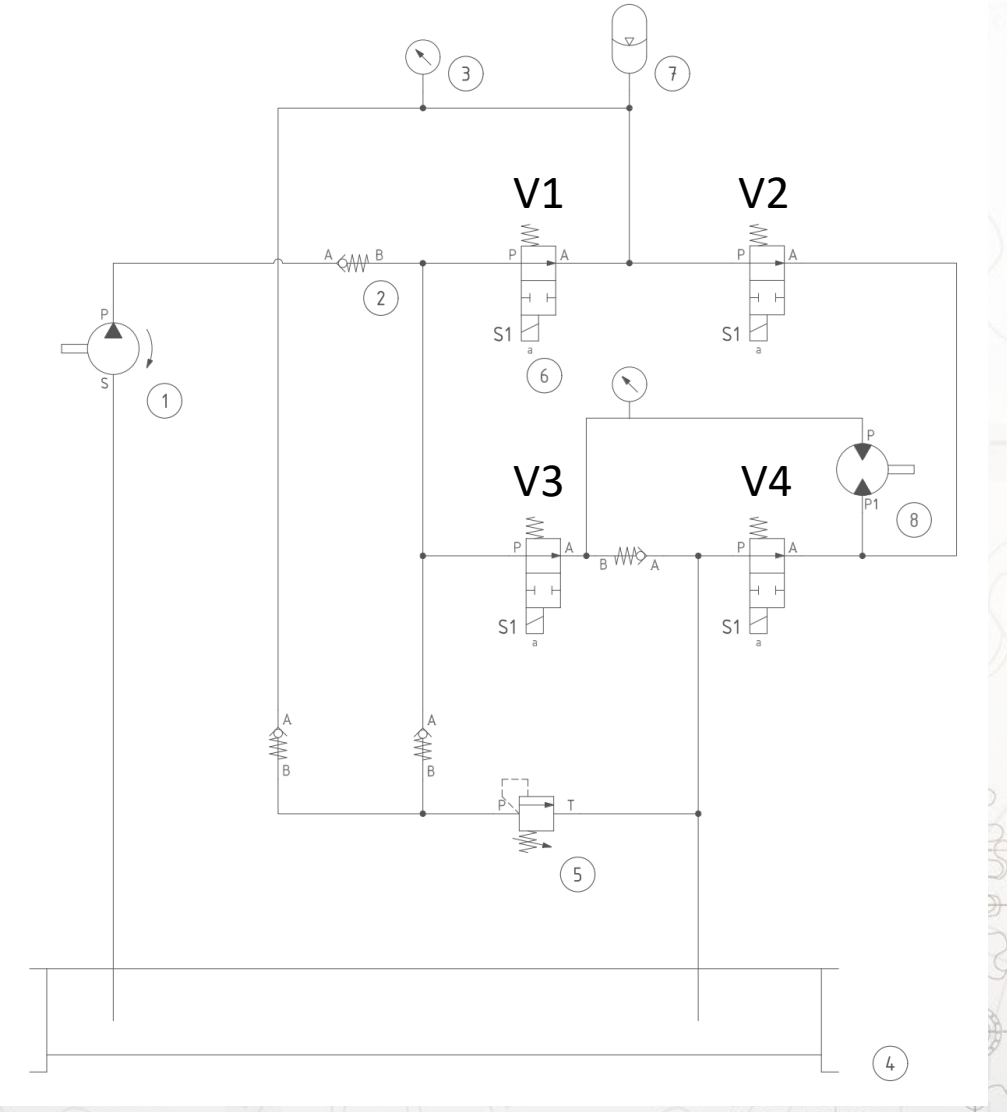


Fig. 11 Drive Chain System

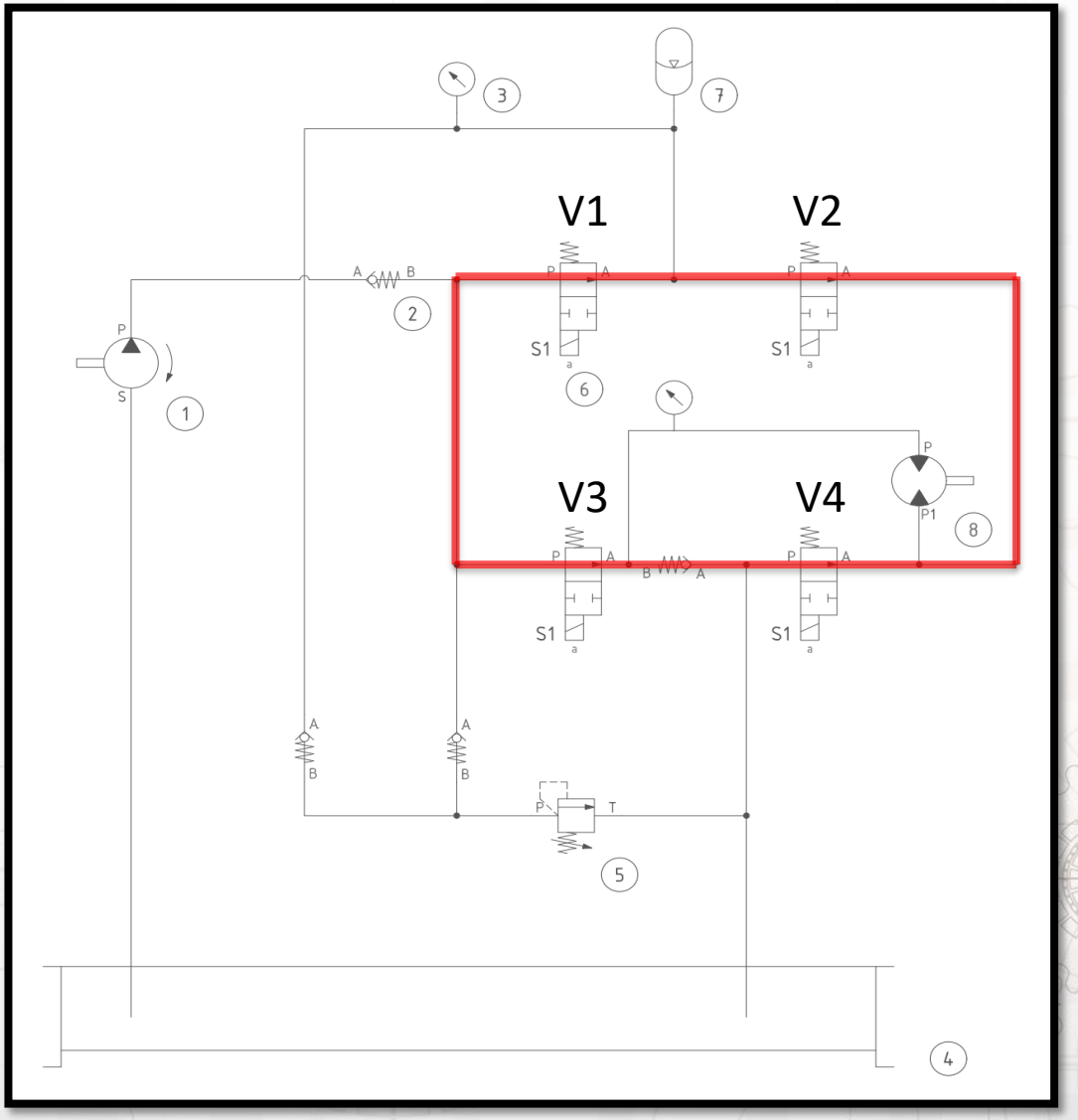
Initial Circuit



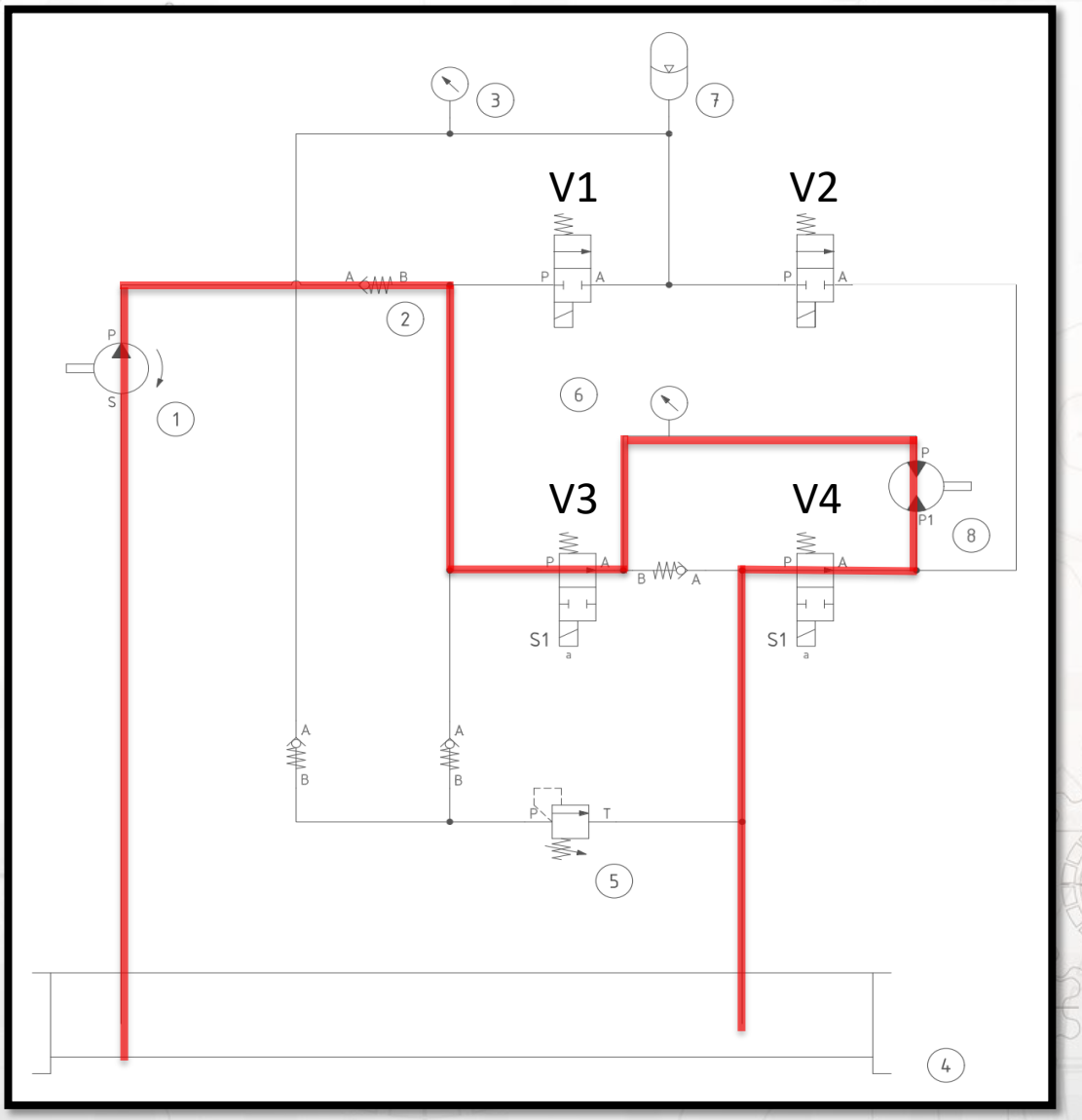
Circuit Redesign



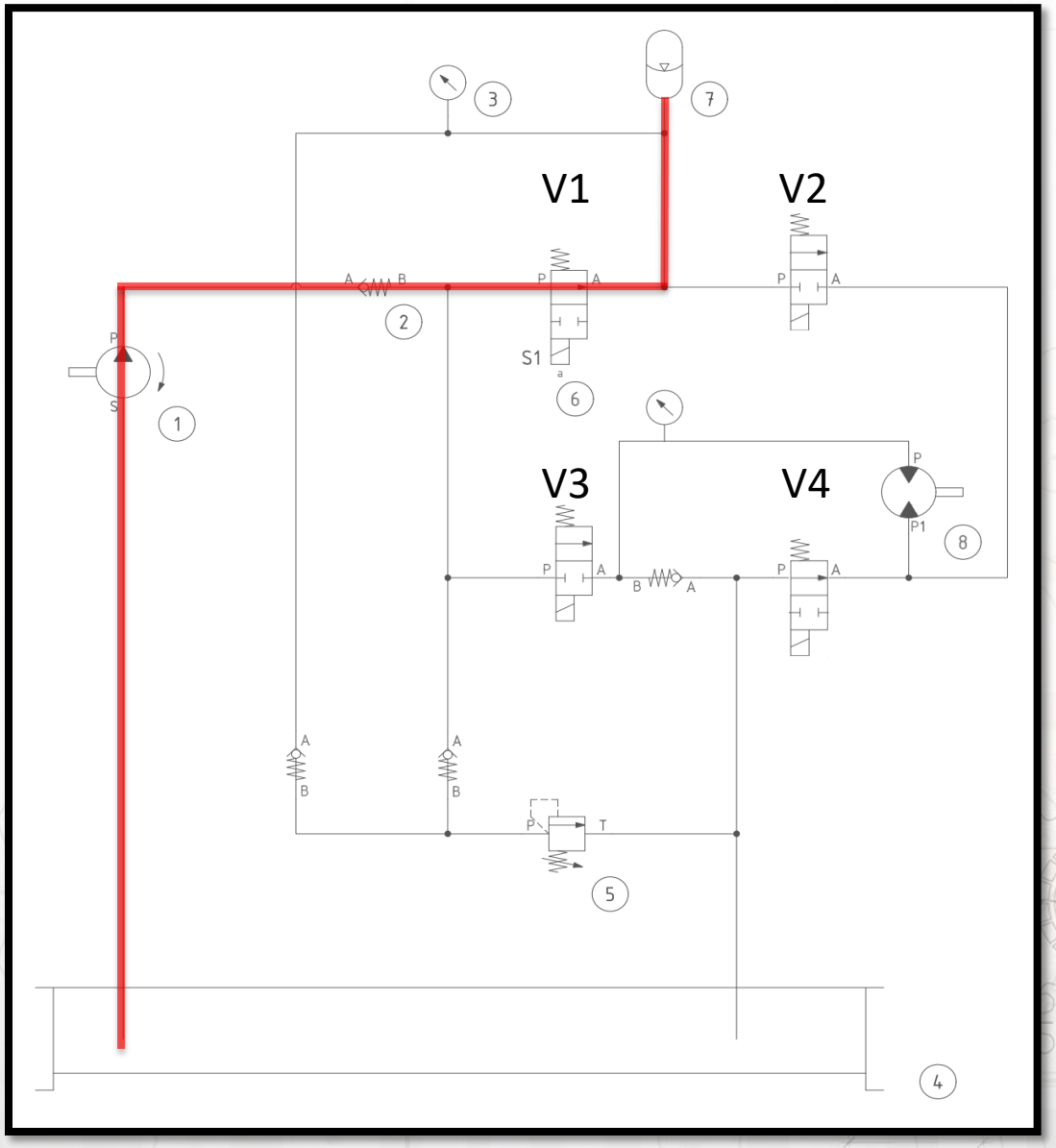
Coast



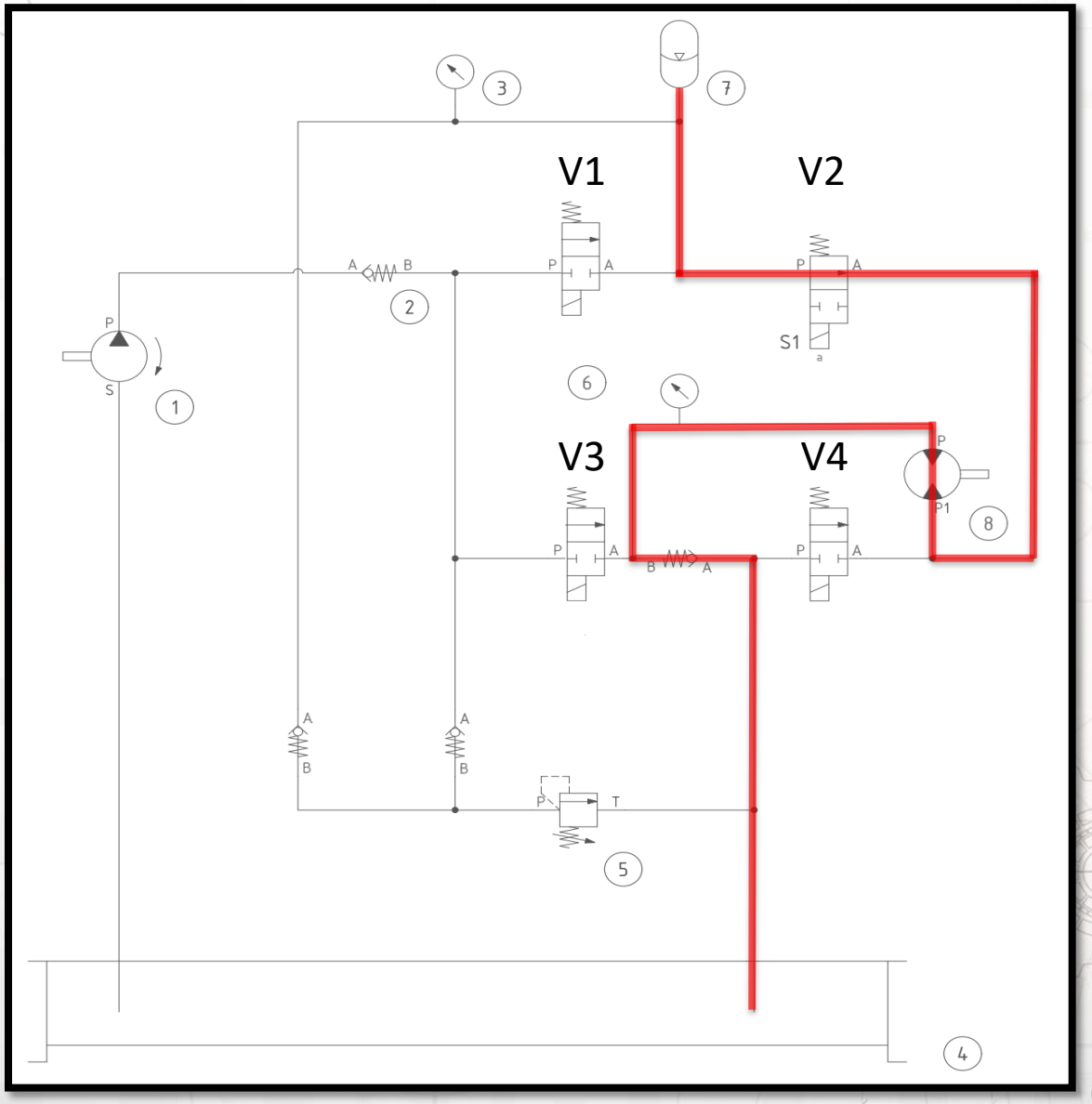
Drive Mode



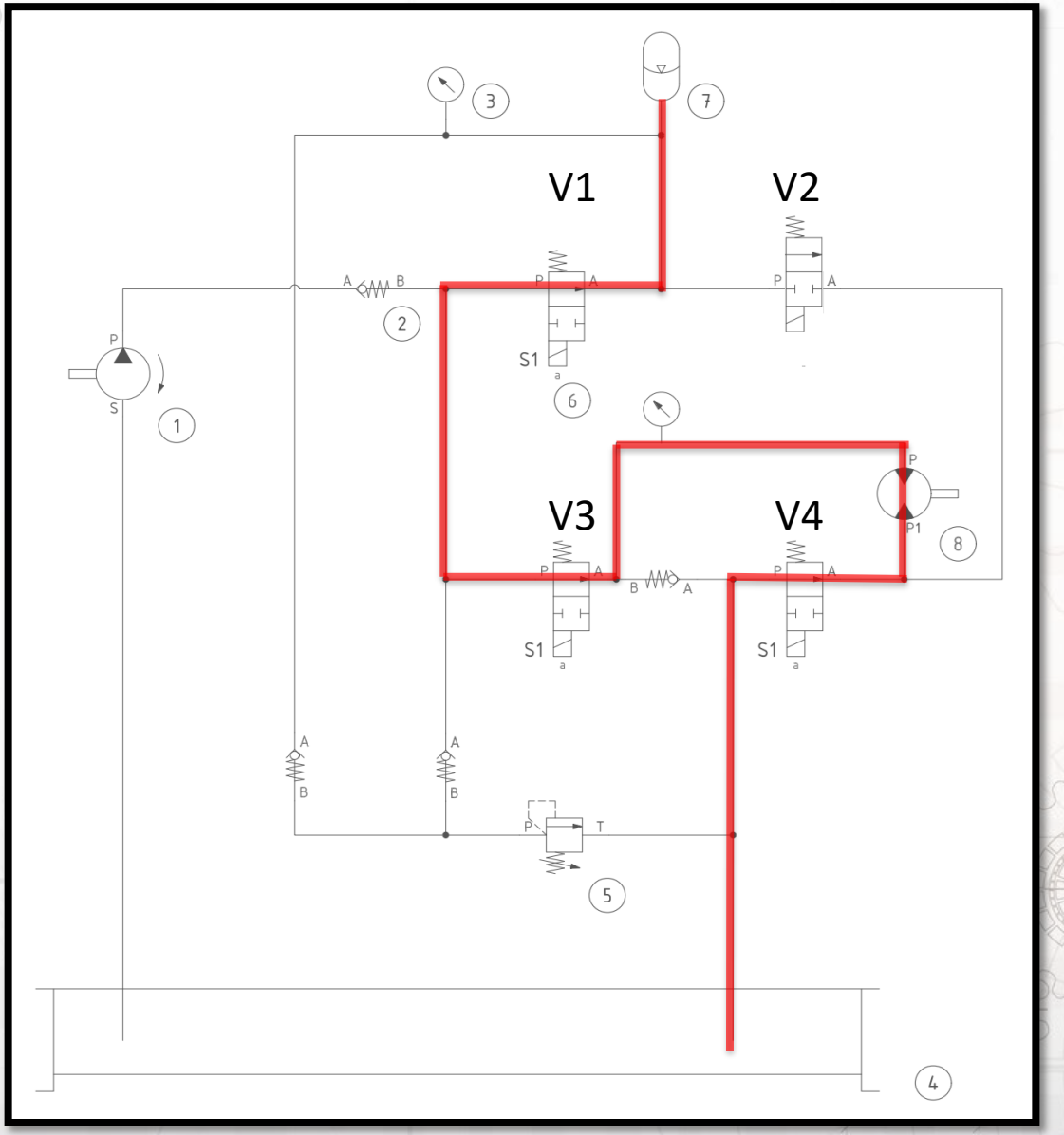
Charging Mode



Regenerative Mode



Discharging Mode



Major hydraulic components

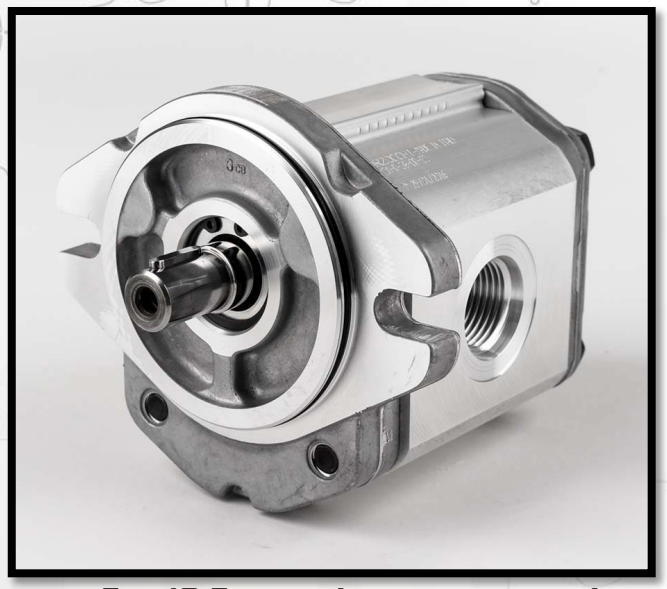


Fig. 12 External gear pump and motor

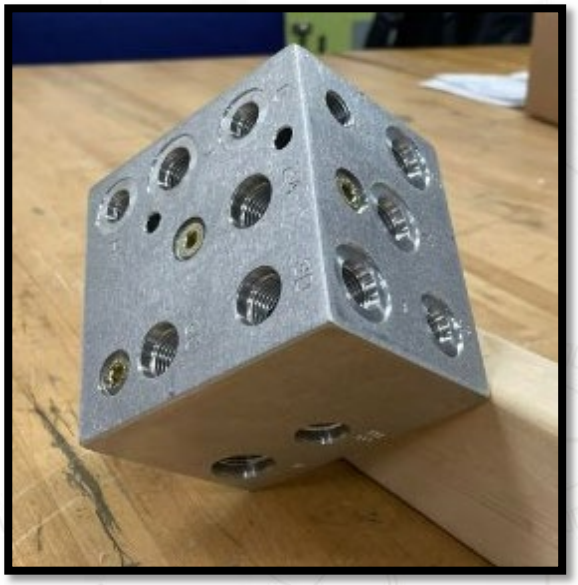


Fig. 13 Custom Manifold

Fig. 15 Bladder Accumulator

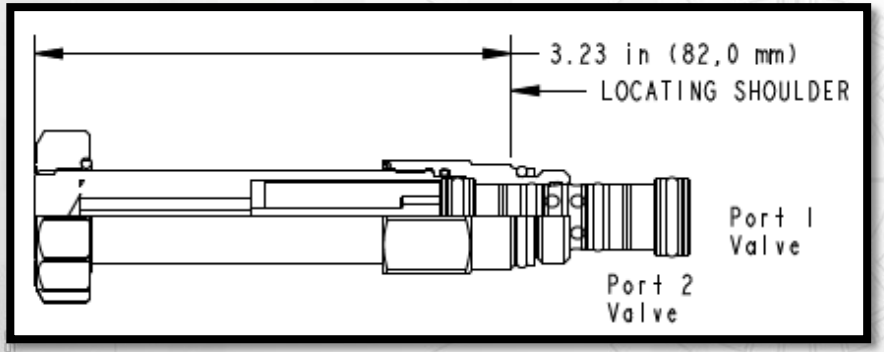
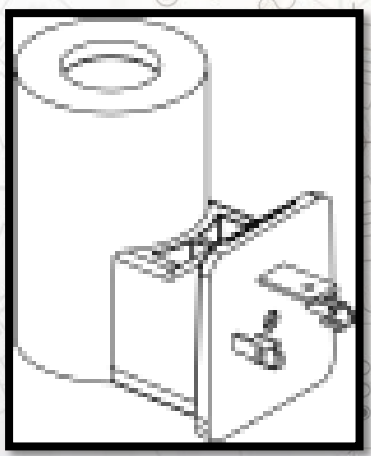
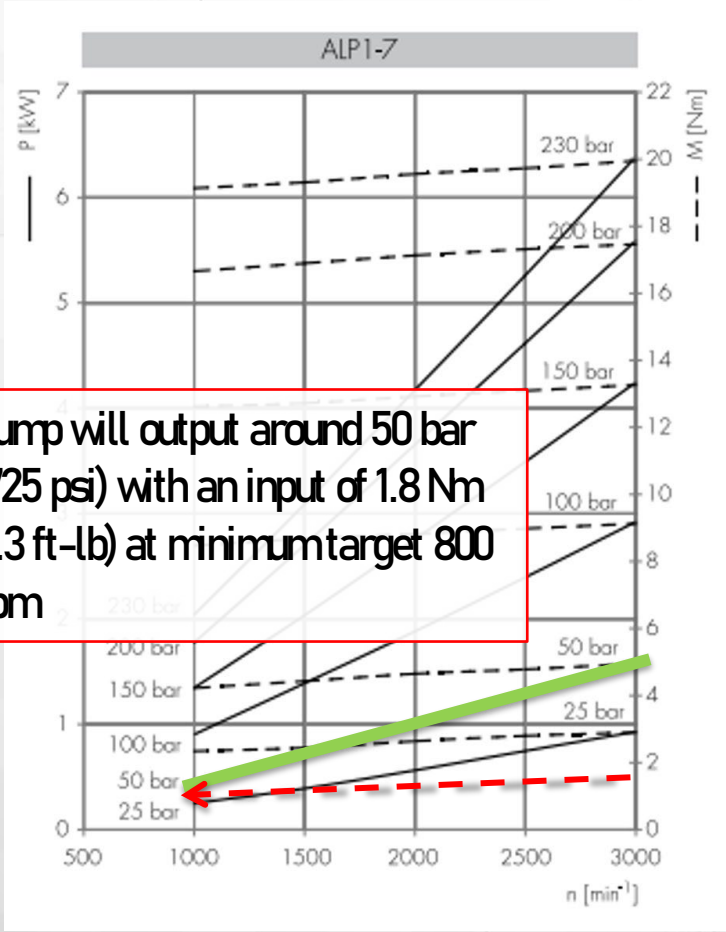


Fig. 14 Normally open Solenoid valve



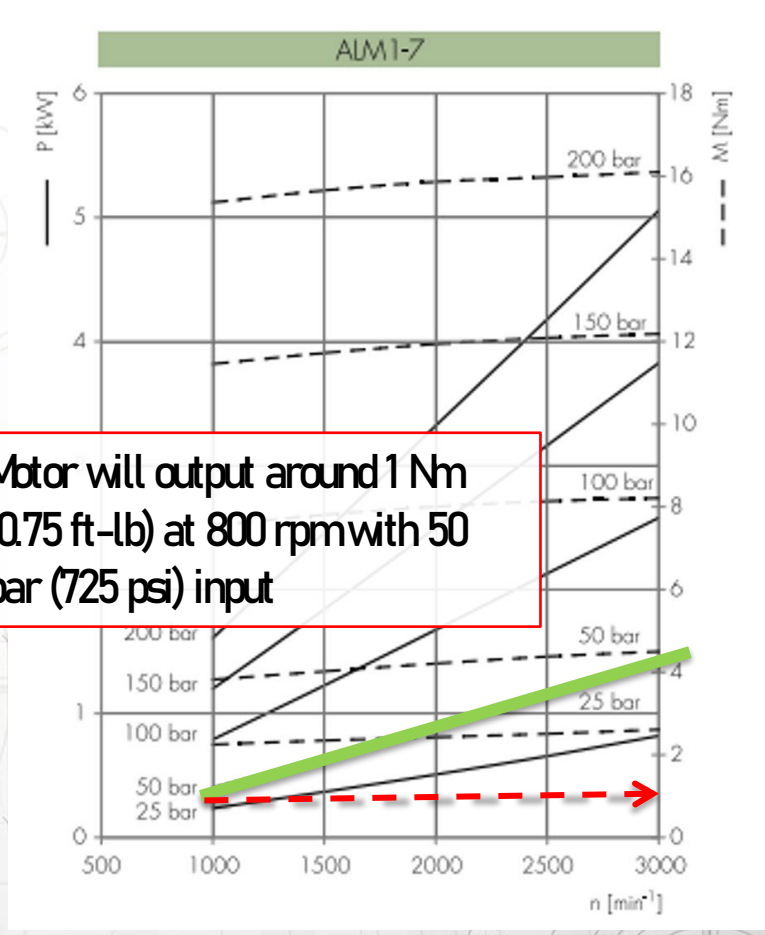
Pump and Motor Selection

Pump



Pump will output around 50 bar (725 psi) with an input of 1.8 Nm (1.3 ft-lb) at minimum target 800 rpm

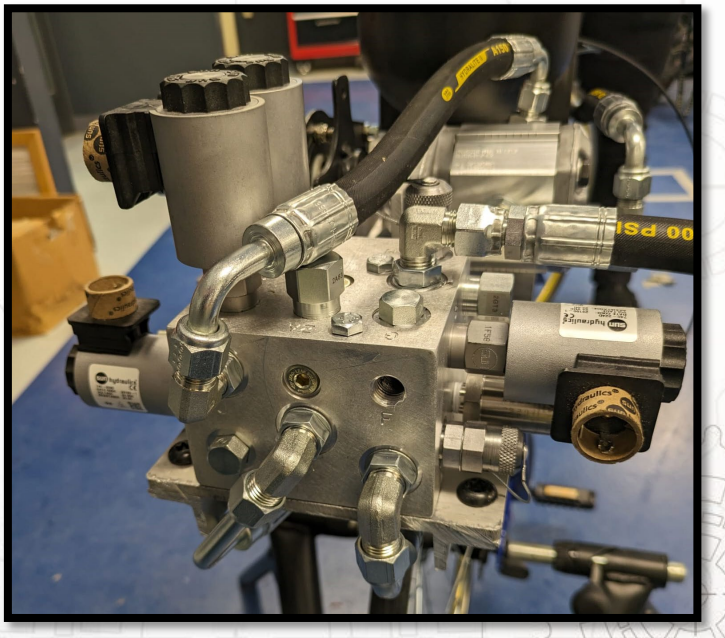
Motor



Motor will output around 1 Nm (0.75 ft-lb) at 800 rpm with 50 bar (725 psi) input

Hose Supplier

- Marcy Hydraulics was kind enough to sponsor our custom hoses



MARCY Hydraulics & EQUIPMENT
A DIVISION OF UTICA MACK INC.

Electrical Components

Fig. 16 Mobile PLC

Fig. 17 Balluf pressor sensor

Fig. 18 LED Buttons

Fig. 19 PowerView 500 Screen

Fig. 20 Talentcell 12V/24V Battery

Vehicle Build

Hydraulic Reservoir

- 2 pieces bent stainless steel
- Designed for construction with a single continuous weld
- ¼ inch polycarbonate viewing window to monitor level and condition of fluid
- Vented cap

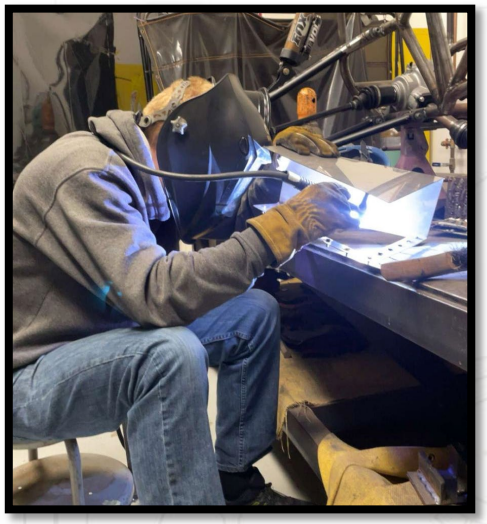


Fig. 21 TIG Welding

Fig. 22 Welded Reservoir

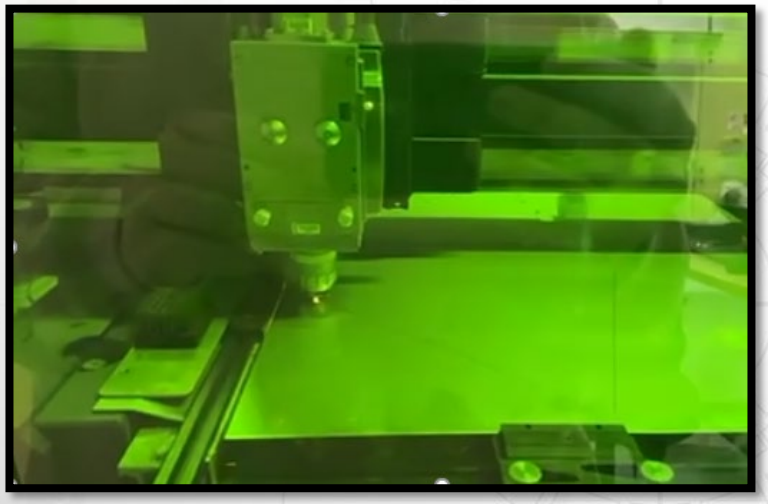


Fig. 23 Laser cutting parts

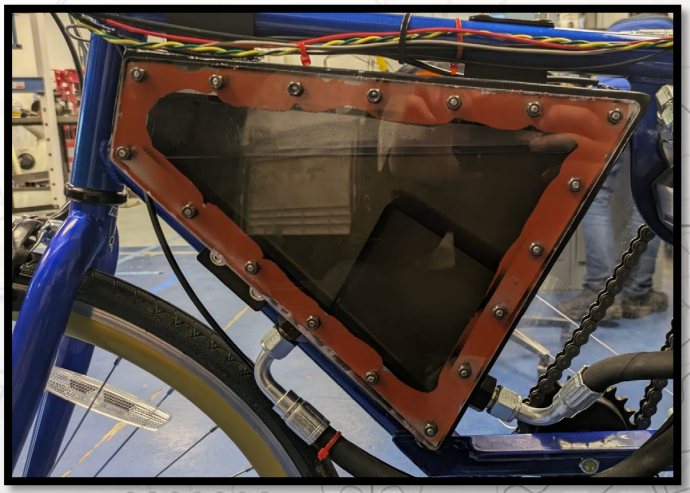


Fig. 24 Finished Reservoir

Chassis Development

Fig. 25 Stock Frame

Fig. 26 Modified Frame

Fig. 27 Powdercoat Process

Rider Interface Components Assembly

Mounted Components

- Gear Shifter
- Mode Selector
- Display Screen

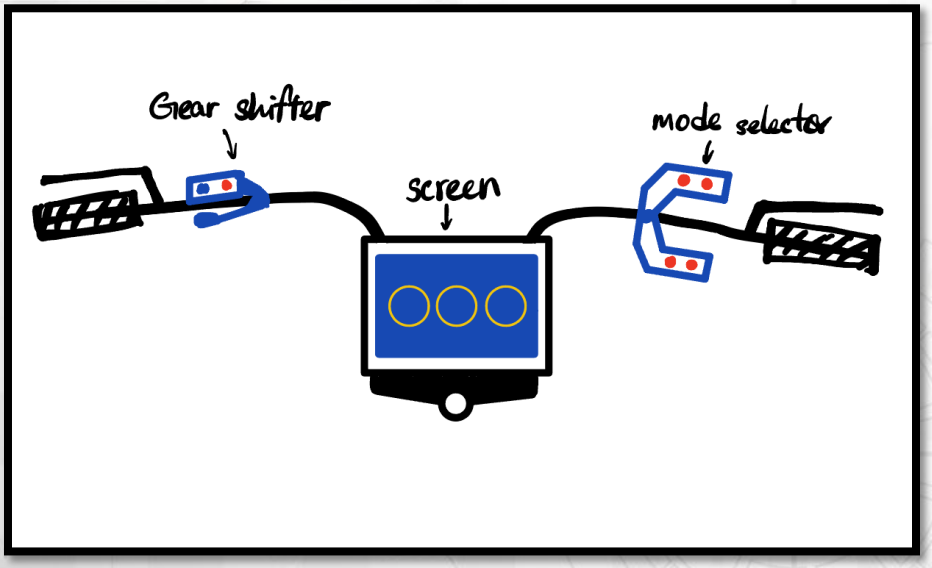


Fig.28 Initial Design Sketch

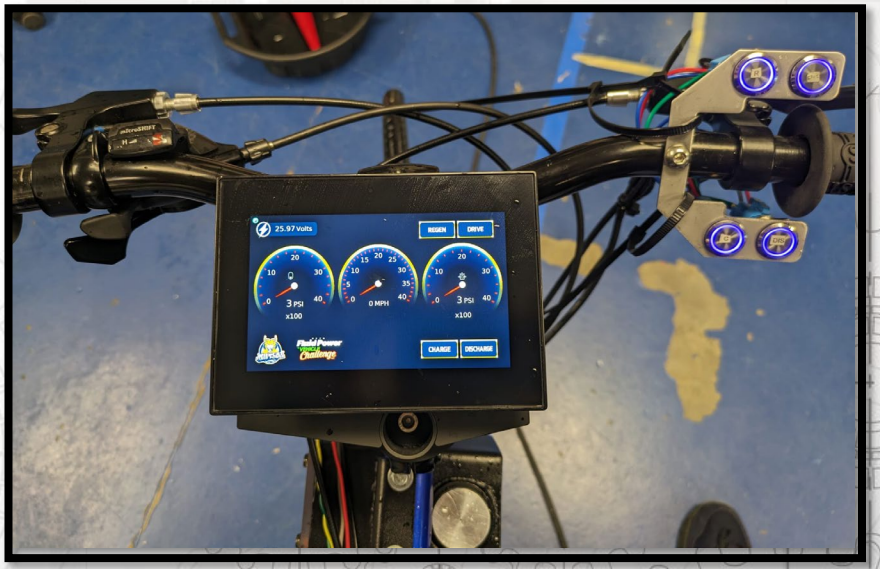


Fig.29 Final Assembly

Core Drive Components Assembly

Mounted Components

- Pump
- Chains and Sprockets
- Reservoir

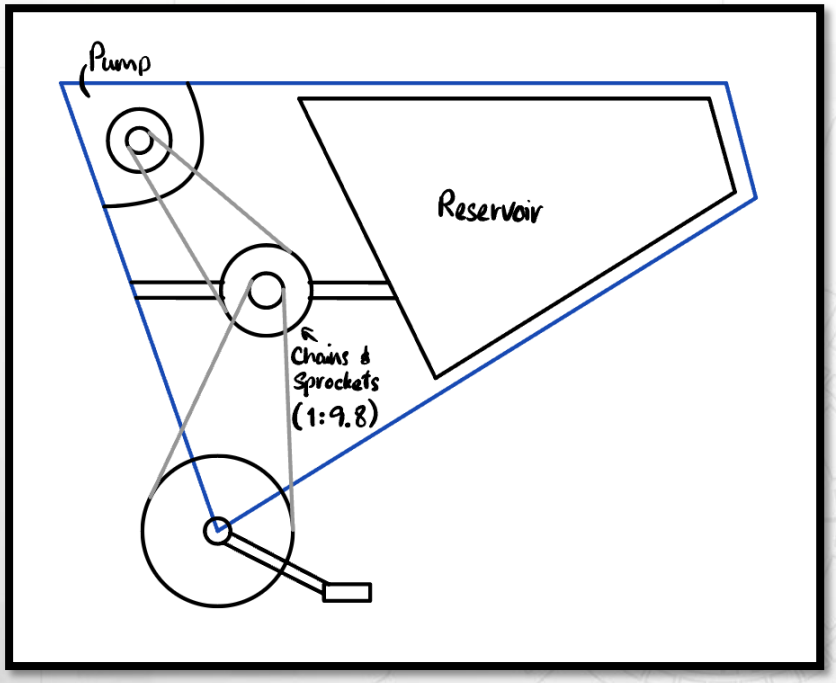


Fig. 30 Initial Design Sketch

Fig. 31 Final Assembly

Center Components Assembly (Cont.)

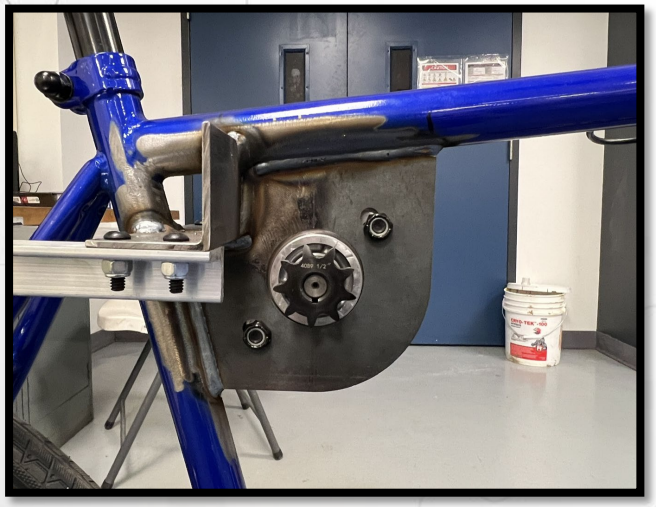


Fig. 32 Mounted Pump

Fig. 33 Mounted Reservoir

Fig. 34 Mounted Chains and Sprockets with Chainguards

Back Rack Components Assembly

Components

- Accumulator
- PLC
- Batter
- Gearbox
- Speedometer
- Motor
- Manifold
- Hoses

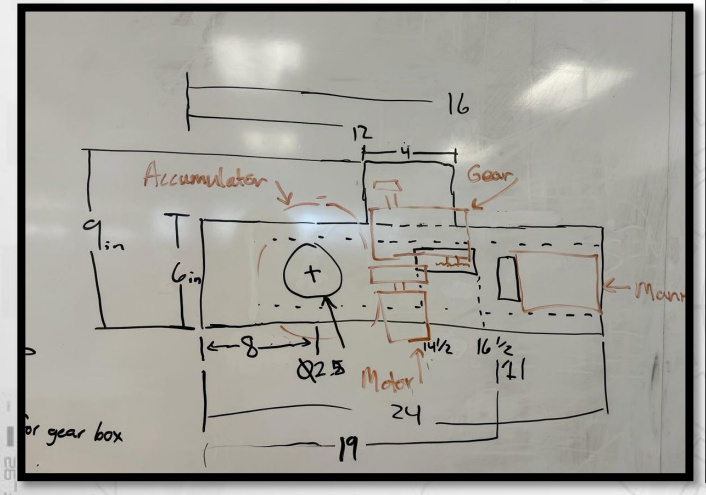


Fig. 35 Initial Design Sketch

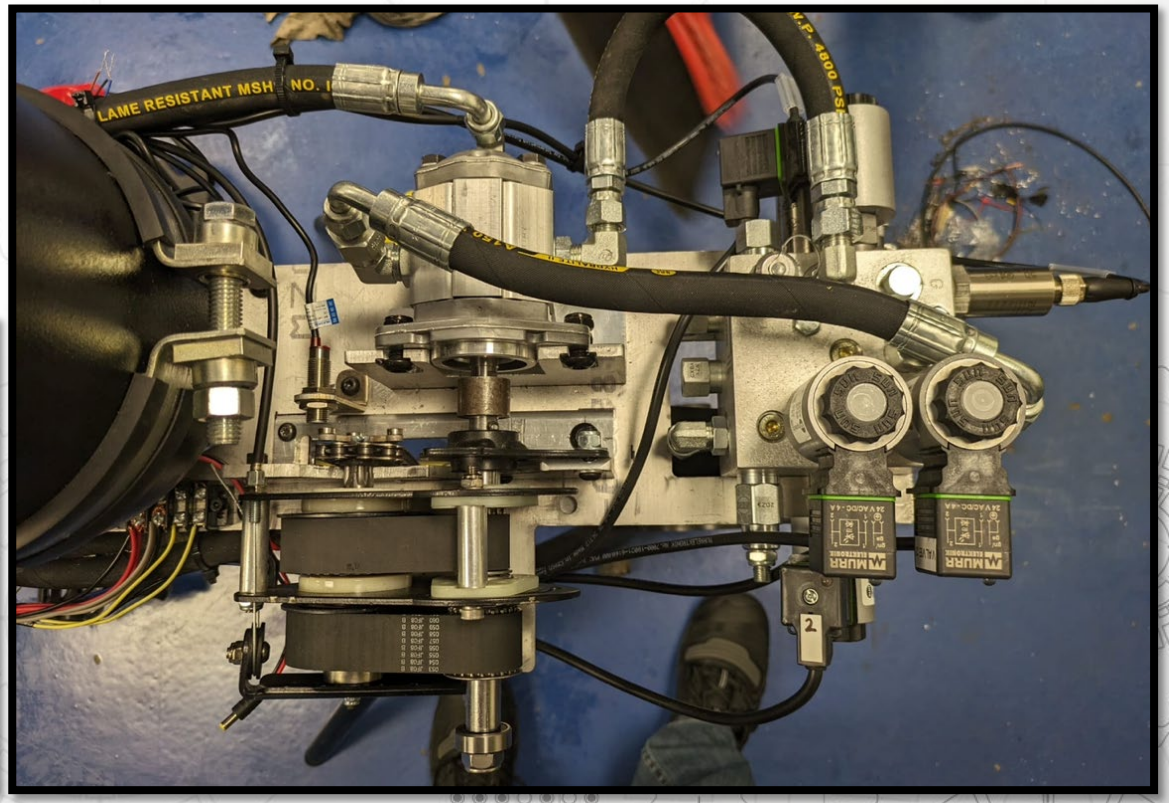


Fig. 36 Final Assembly

Back Rack Components Assembly (Cont.)

Fig. 37 Mounted accumulator PLC and battery

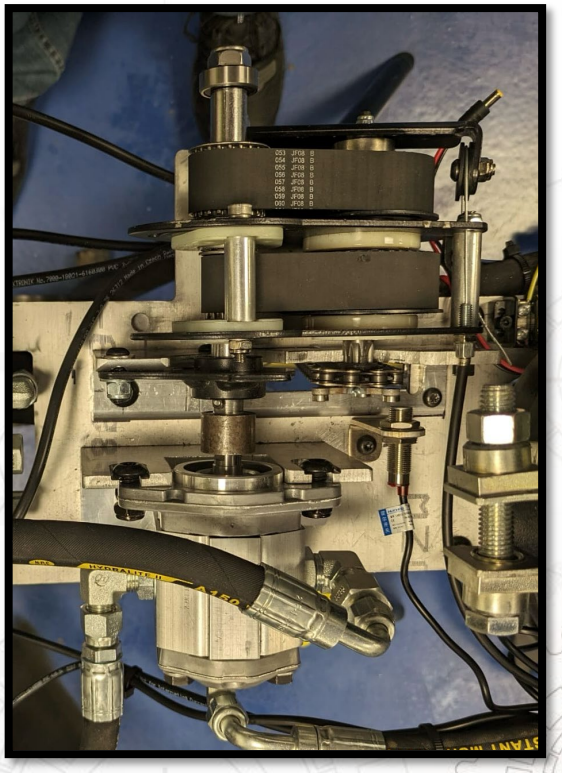


Fig. 38 Mounted gearbox & motor assembly

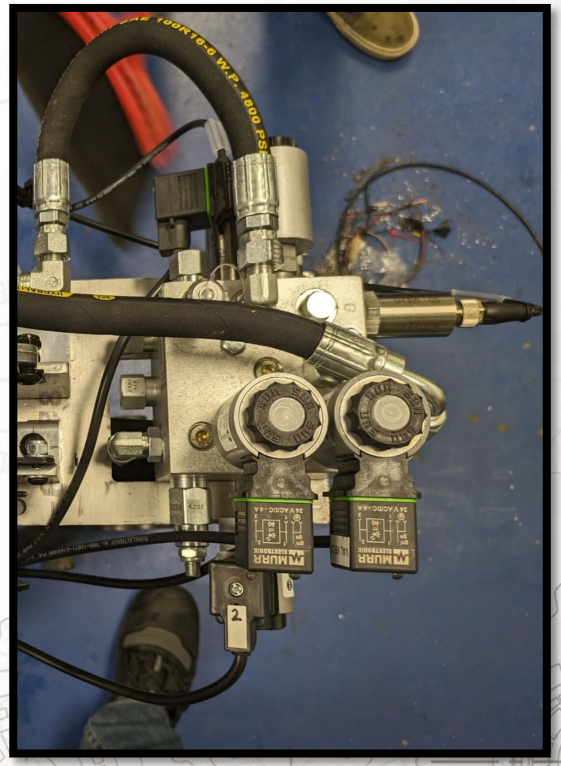
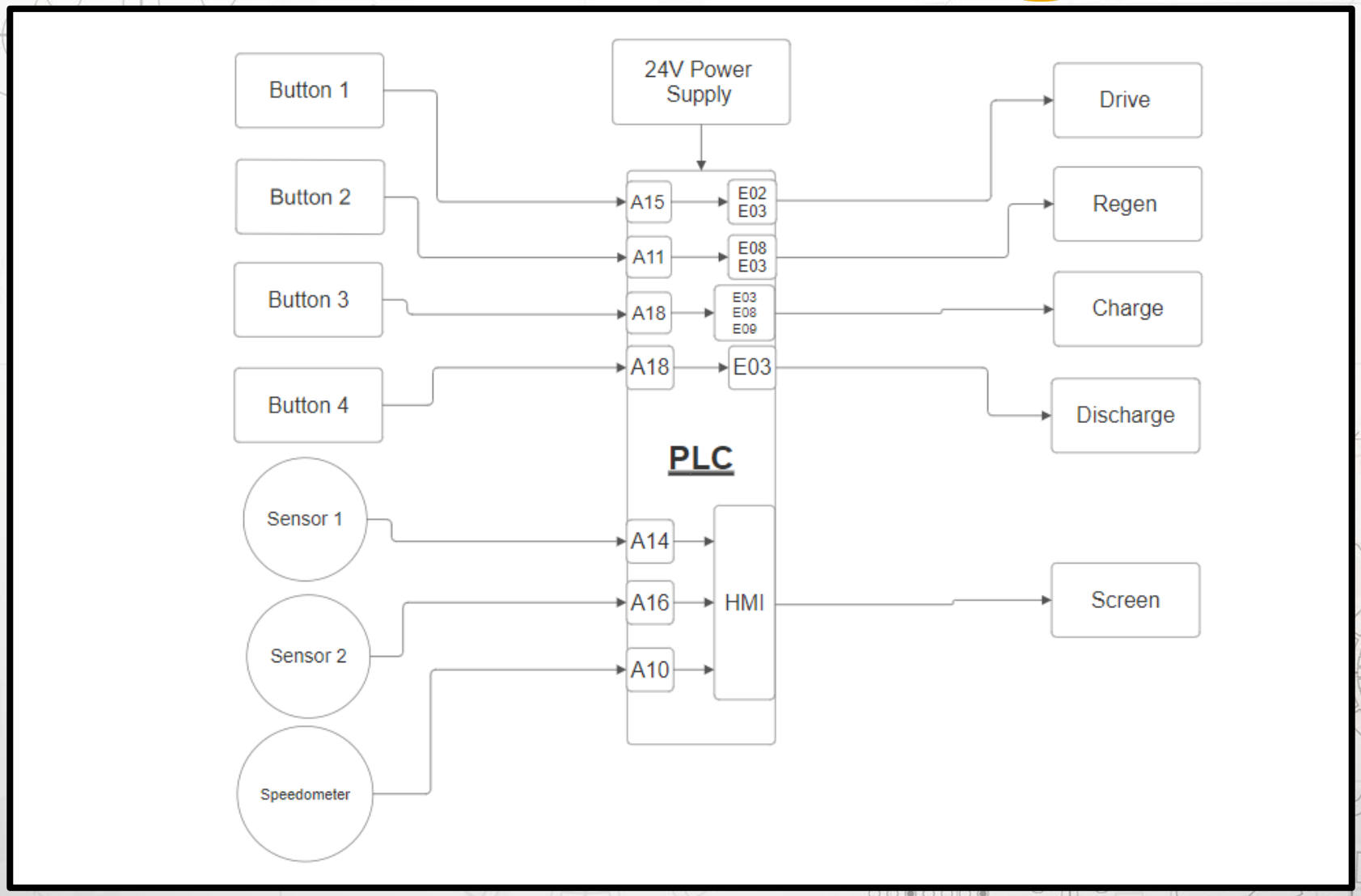


Fig. 39 Mounted manifold

Controller Logic

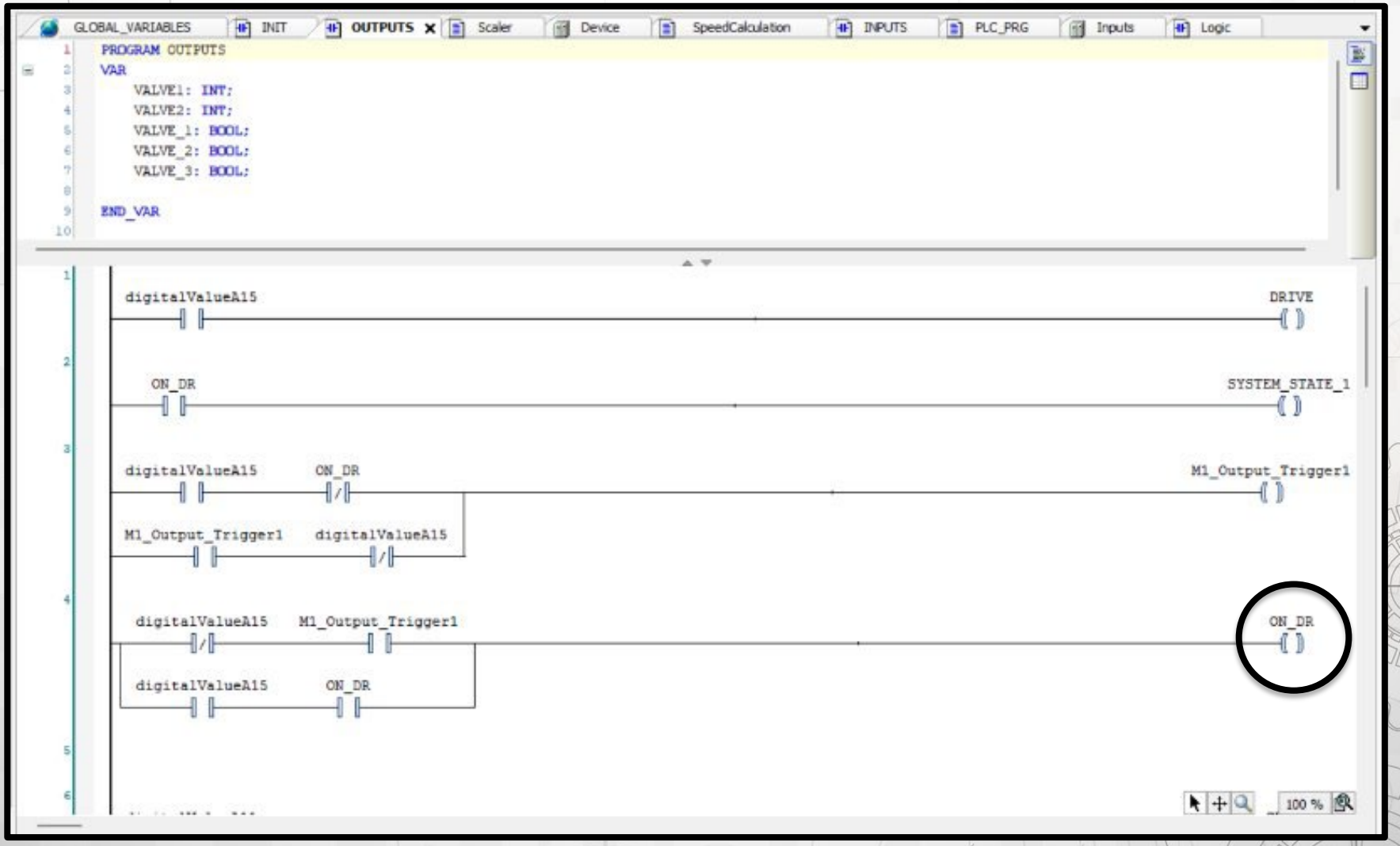


PLC Input/Output Logic

Programing

Controller

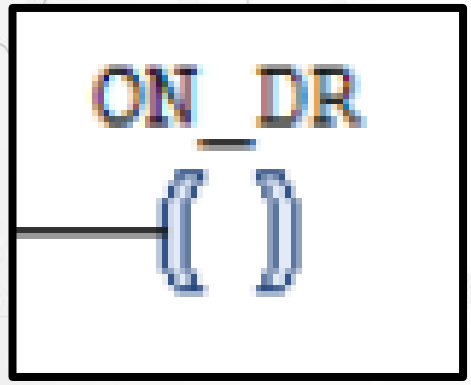
CODESYS



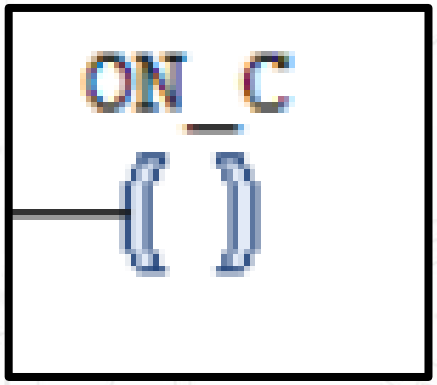
Programing

Controller

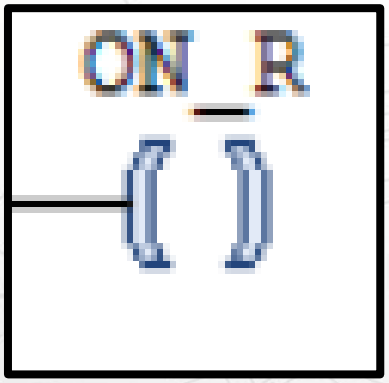
CODESYS



Drive



Charge



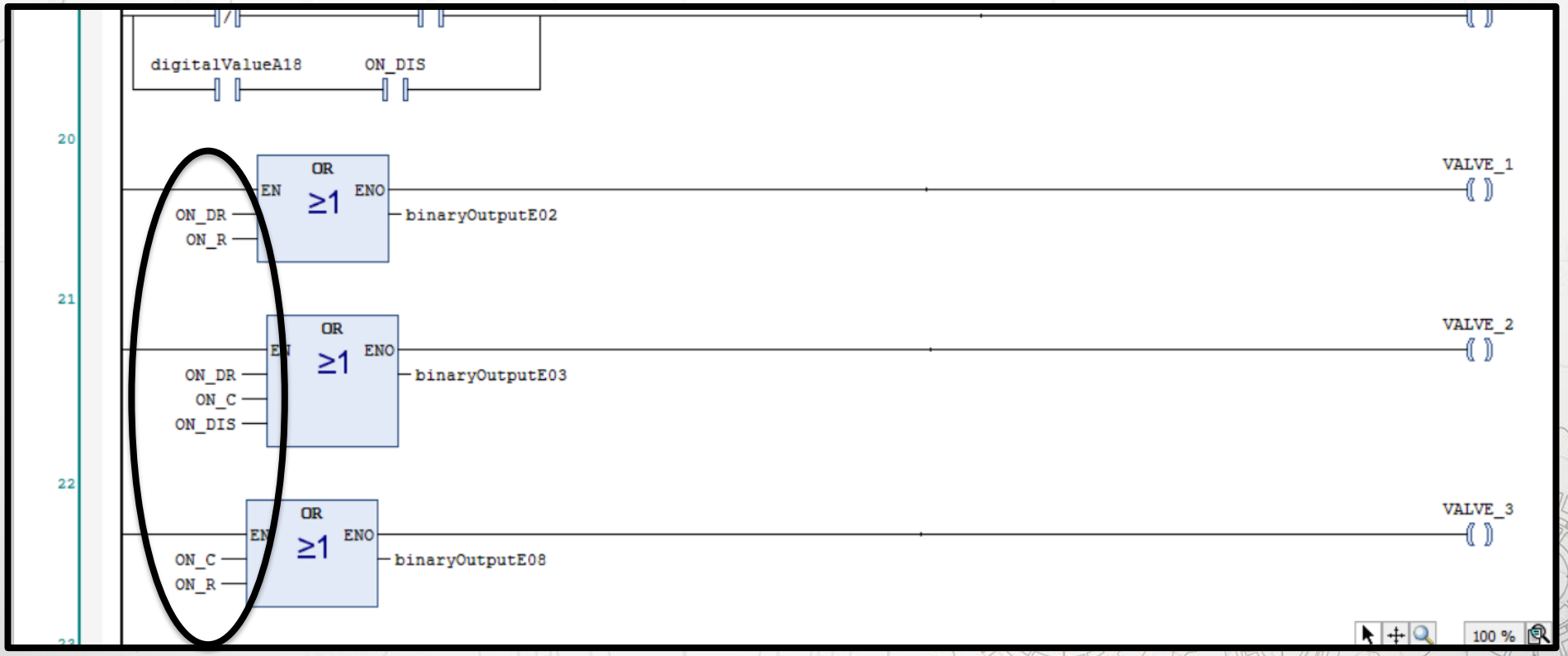
Regen

Discharge

Programing

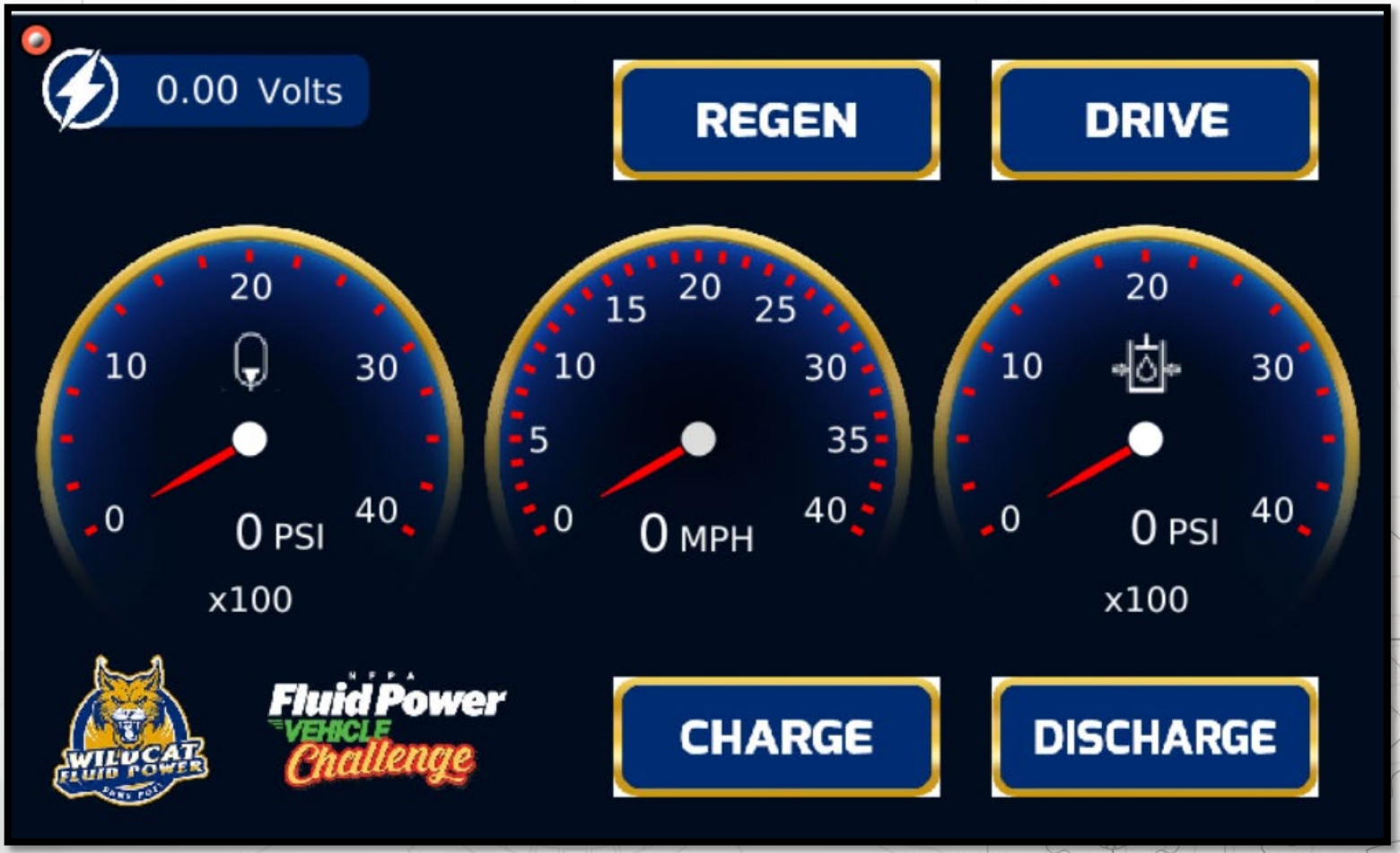
Controller

CODESYS



Programing

User Interface



Programing

User Interface

Testing

Ride Testing

Modifications After Testing

Gearbox Gremlins

- We needed to flip the entire mounting plate over after realizing the gearbox had a one-way bearing

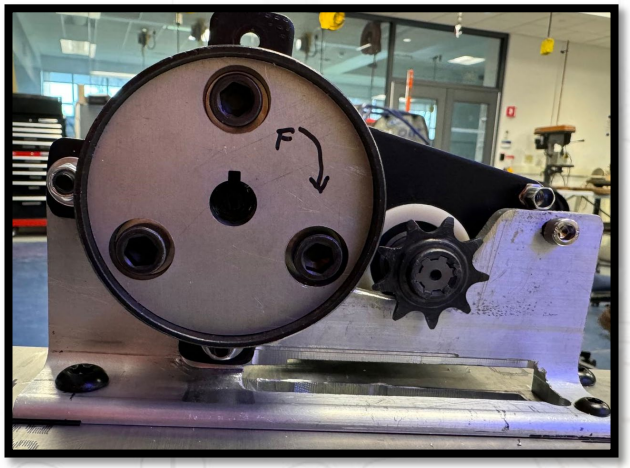


Fig.40 Clutch Delete Coupling

Fig.41 Manufacturing Improved Coupling

- Original motor to gearbox connection was threaded, to our surprise it came loose during testing
- Manufactured new coupling
- Manufactured ½ inch pitch sprocket to fit 9 tooth spline output shaft

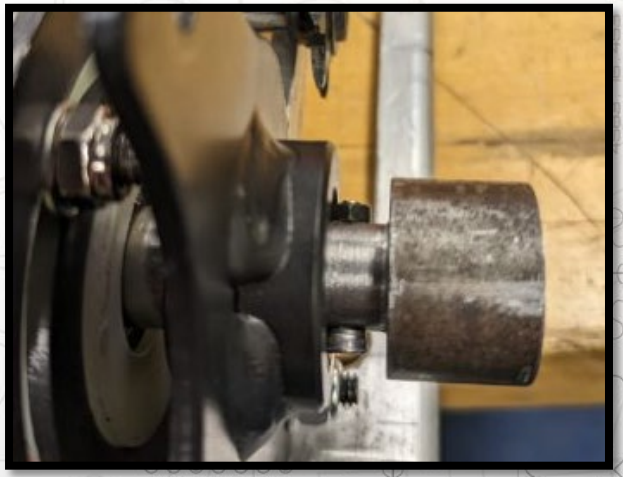


Fig. 42 Improved Coupling

Modifications After Testing

- **Speedometer Problems**
- Sensor from consumer grade bicycle speedometer worked intermittently and could not respond at a high enough frequency (1680 Hz – 1900 Hz)
- Replaced with a magnetic hall sensor(15 kHz rated)

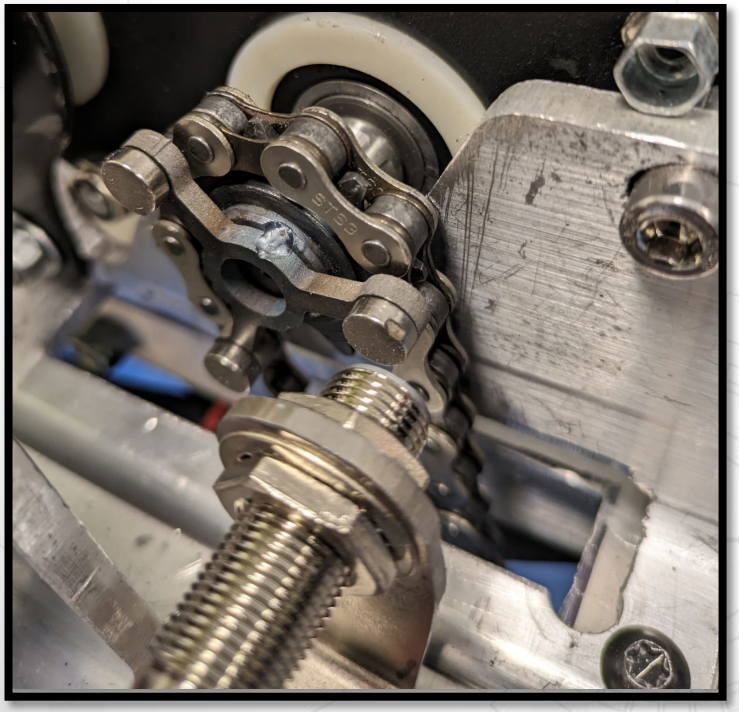


Fig. 43 Magnetic Hall Sensor

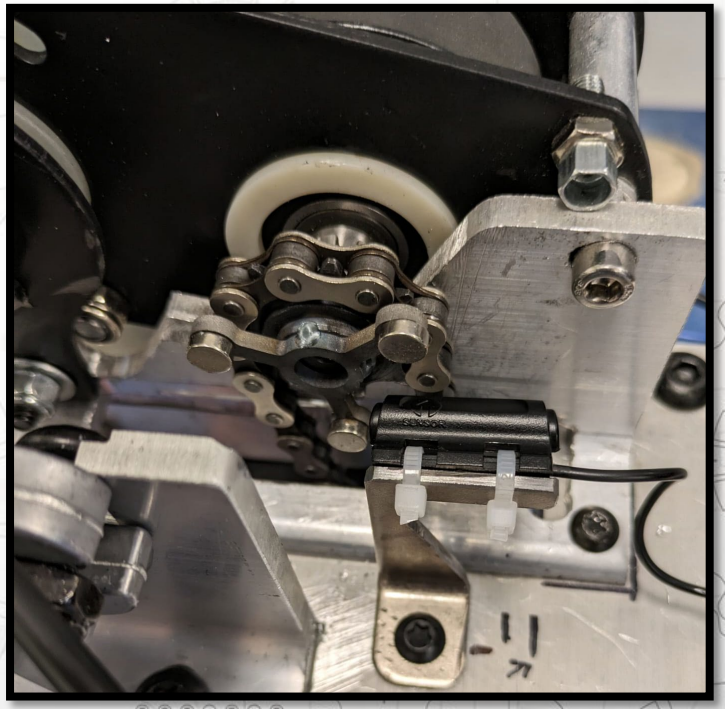


Fig. 44 Low Quality Reed Switch

Modifications After Testing

- **Chain tensioner**
  - Fabricated custom rear chain tensioner to mitigate derailing issues

Fig. 45 Drive Chain System

- **Larger rear sprocket**
  - Increased diameter of rear sprocket to increase acceleration, regen pressure, and ease of riding

$$MPH = \frac{wheel\ circumference \times \frac{motor\ speed}{drive\ ratio} \times 60\ min/hr}{63360\ inches/mile}$$

18T (Drive Ratio of 2.428:1) = Theoretical Top speed of 27.45 MPH

28T (Drive Ratio of 3.775:1) = Theoretical Top speed of 17.67 MPH

Lessons Learned

Lessons Learned

- Components and parts do not always function as expected (check valves, gearbox, reed switch, accumulator charging kit)
- Purchasing lead times must be considered when scheduling.
- Scope creep is a big factor during fabrication especially for new or unfamiliar processes and when building from the ground up.
- Fluid powered bikes are inherently difficult to ride and do not balance themselves.

Fig.46 Attempting to diagnose regen issue

Acknowledgements

- We would like to extend our heartfelt appreciation to the NFPA for making this competition possible and believing in SUNY Polytechnic.

- We thank all of our mentors and sponsors for your invaluable contributions, it goes without saying, but we could never have done it without you.

- There are those to whom we owe a particular debt of gratitude
  - Josh Scarbrough and Jeff McCarthy for your exemplary and ever-ready assistance and expertise.
  - Dr. Ahmed Abdelaal, our team advisor, biggest fan, and unwavering supporter through the highs and the lows of our first year.

Dr. Ahmed Abdelaal
Faculty Advisor

Questions?

WILDCAT FLUID POWER
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NFPA Fluid Power Vehicle Challenge